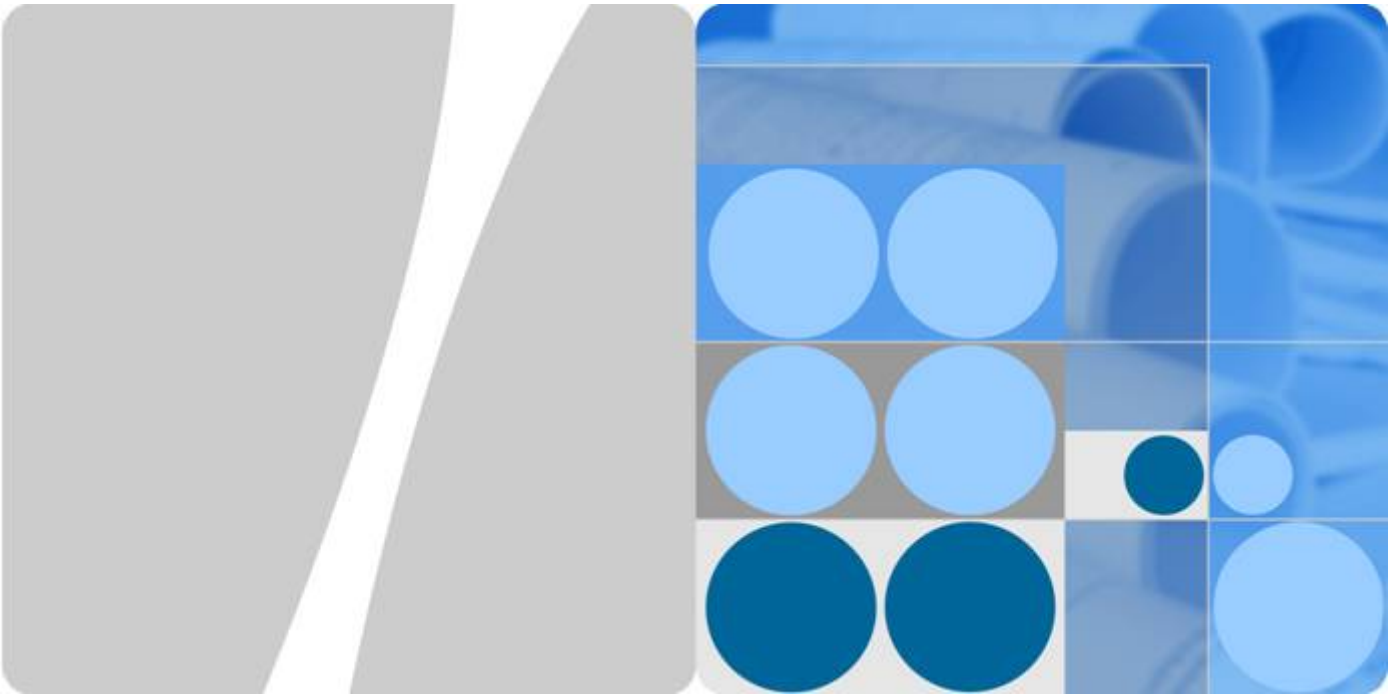


Cloud Container Engine

User Guide

Date **2024-07-27**

Contents

1 Service Overview

1.1 What Is CCE?

Cloud Container Engine (CCE) is a scalable, enterprise-class hosted Kubernetes service. With CCE, you can easily deploy, manage, and scale containerized applications in the cloud.

Why CCE?

CCE is a one-stop platform integrating compute (ECS), networking (VPC, EIP, and ELB), storage (EVS, OBS, and SFS), and many other services. Multi-AZ, multi-region disaster recovery ensures high availability of **Kubernetes** clusters.

For more information, see **Product Advantages** and **Application Scenarios**.

CCE Cluster Types

CCE provides CCE clusters.

Category	Subcategory	CCE
Positioning	-	Standard clusters that provide highly reliable and secure containers for commercial use
Application scenario	-	For users who expect to use container clusters to manage applications, obtain elastic computing resources, and enable simplified management on computing, network, and storage resources
Specification difference	Network model	Cloud-native network 1.0: applies to common, smaller-scale scenarios. • Tunnel network • Virtual Private Cloud (VPC) network

Category	Subcategory	CCE
	Network performance	Overlays the VPC network with the container network, causing certain performance loss.
	Network isolation	• Tunnel network model: supports network policies for intra-cluster communications. • VPC network model: supports no isolation.
	Security isolation	Runs common containers, isolated by cgroups.
	Edge infrastructure management	None

1.2 Product Advantages

Why CCE?

CCE is a container service built on Docker and Kubernetes. A wealth of features enables you to run container clusters at scale. CCE eases containerization thanks to its reliability, performance, and open source engagement.

Easy to Use

- Creating a Kubernetes cluster is as easy as a few clicks on the web console. You can deploy and manage VMs and BMSs together.
- CCE automates deployment and O&M of containerized applications throughout their lifecycle.
- You can resize clusters and workloads by setting auto scaling policies. In-the-moment load spikes are no longer headaches.
- The console walks you through the steps to upgrade Kubernetes clusters.
- CCE supports turnkey Helm charts.

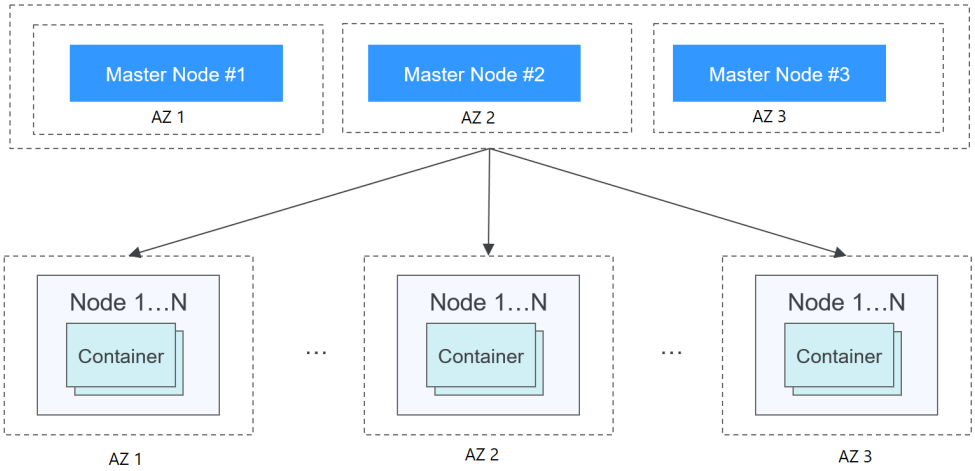
High Performance

- CCE draws on years of field experience in compute, networking, storage, and heterogeneous infrastructure and provides you high-performance cluster services. You can concurrently launch containers at scale.
- AI computing is 3x to 5x better with NUMA BMSs and high-speed InfiniBand network cards.

Highly Available and Secure

- HA: Three master nodes in different AZs for your cluster control plane. Multi-active DR for your nodes and workloads. All these ensure service continuity when one of the nodes is down or an AZ gets hit by natural disasters.

Figure 1-1 High-availability setup of clusters



- Secure: Integrating IAM and Kubernetes RBAC, CCE clusters are under your full control. You can set different RBAC permissions for IAM users on the console.

Open and Compatible

- CCE runs on Docker that automates container deployment, discovery, scheduling, and scaling.
- CCE is compatible with native Kubernetes APIs and kubectl. Updates from Kubernetes and Docker communities are regularly incorporated into CCE.

Comparative Analysis of CCE and On-Premises Kubernetes Cluster Management Systems

Table 1-1 CCE clusters versus on-premises Kubernetes clusters

Area of Focus	On-Premises Kubernetes Cluster	CCE
Ease of use	You have to handle all the complexity in deploying and managing Kubernetes clusters. Cluster upgrades are often a heavy burden to O&M personnel.	**Easy to manage and use clusters** You can create and update a Kubernetes container cluster in a few clicks. No need to set up Docker or Kubernetes environments. CCE automates deployment and O&M of containerized applications throughout their lifecycle. CCE supports turnkey Helm charts. Using CCE is as simple as choosing a cluster and the workloads that you want to run in the cluster. CCE takes care of cluster management and you focus on app development.

Area of Focus	On-Premises Kubernetes Cluster	CCE
Scalability	You have to assess service loads and cluster health before resizing a Kubernetes cluster.	**Managed scaling service** CCE auto scales clusters and workloads according to resource metrics and scaling policies.
Reliability	There might be security vulnerabilities or configuration errors may occur in the OS of an on-premises Kubernetes cluster, which may cause security issues such as unauthorized access and data leakage.	**Enterprise-class security and reliability** CCE provides various container-optimized OS images with additional stability tests and security hardening based on native Kubernetes clusters and runtime versions, reducing management costs and risks and improving the reliability and security of applications.
Efficiency	You have to either build an image repository or turn to a third-party one. Images are pulled in serial.	**Rapid deployment with images** CCE connects to SWR to pull images in parallel. Faster pulls, faster container build.
Cost	Heavy upfront investment in installing, managing, and scaling cluster management infrastructure.	**Cost effective** You only pay for master nodes and the resources used to run and manage applications.

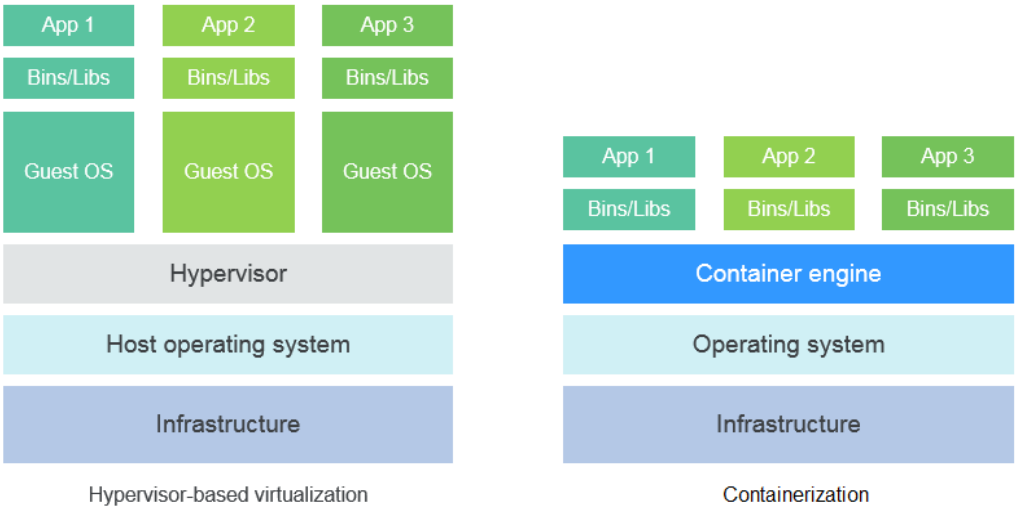
Why Containers?

Docker is written in the Go language designed by Google. It provides operating-system-level virtualization. Linux Control Groups (cgroups), namespaces, and UnionFS (for example, AUFS) isolate each software process. A Docker container packages everything needed to run a software process. Containers are independent from each other and from the host.

Docker has moved forward to enhance container isolation. Containers have their own file systems. They cannot see each other's processes or network interfaces. This simplifies container creation and management.

VMs use a hypervisor to virtualize and allocate hardware resources (such as memory, CPU, network, and disk) of a host machine. A complete operating system runs on a VM. Each VM needs to run its own system processes. On the contrary, a container does not require hardware resource virtualization. It runs an application process directly in the the host machine OS kernel. No resource overheads are incurred by running system processes. Therefore, Docker is lighter and faster than VMs.

Figure 1-2 Comparison between Docker containers and VMs



To sum up, Docker containers have many advantages over VMs.

Resource use

Containers have no overheads for virtualizing hardware and running a complete OS. They are faster than VMs in execution and file storage, while having no memory loss.

Start speed

It takes several minutes to start an application on a VM. Docker containers run on the host kernel without needing an independent OS. Apps in containers can start in seconds or even milliseconds. Development, testing, and deployment can be much faster.

Consistent environment

Different development, testing, and production environments sometimes prevent bug discovery before rollout. A Docker container image includes everything needed to run an application. You can deploy the same copy of configurations in different environments.

Continuous delivery and deployment

"Deploy once, run everywhere" would be great for DevOps personnel.

Docker supports CI/CD by allowing you to customize container images. You compile Dockerfiles to build container images and use CI systems for testing. The Ops team can deploy images into production environments and use CD systems for auto deployment.

The use of Dockerfiles makes the DevOps process visible to everyone in a DevOps team. Developers can better understand both user needs and the O&M headaches faced by the Ops team. The Ops team can also have some knowledge of the must-met conditions to run the application. The knowledge is helpful when the Ops personnel deploy container images in production.

Portability

Docker ensures environmental consistency across development, testing, and production. Portable Docker containers work the same, regardless of their running environments. Physical machines, VMs, or even laptops, you name it. Apps are now free to migrate and run anywhere.

Application update

Docker images consist of layers. Each layer is only stored once and different images can contain the exact same layers. When transferring such images, those same layers get transferred only once. This makes distribution efficient. Updating a containerized application is also simple. Either edit the top-most writable layer in the final image or add layers to the base image. Docker joins hands with many open source projects to maintain a variety of high-quality official images. You can directly use them in the production environment or easily build new images based on them.

Table 1-2 Containers versus traditional VMs

Feature	Containers	VMs
Start speed	In seconds	In minutes
Disk capacity	MB	GB
Performance	Near-native performance	Weak
Per-machine capacity	Thousands of containers	Tens of VMs

1.3 Application Scenarios

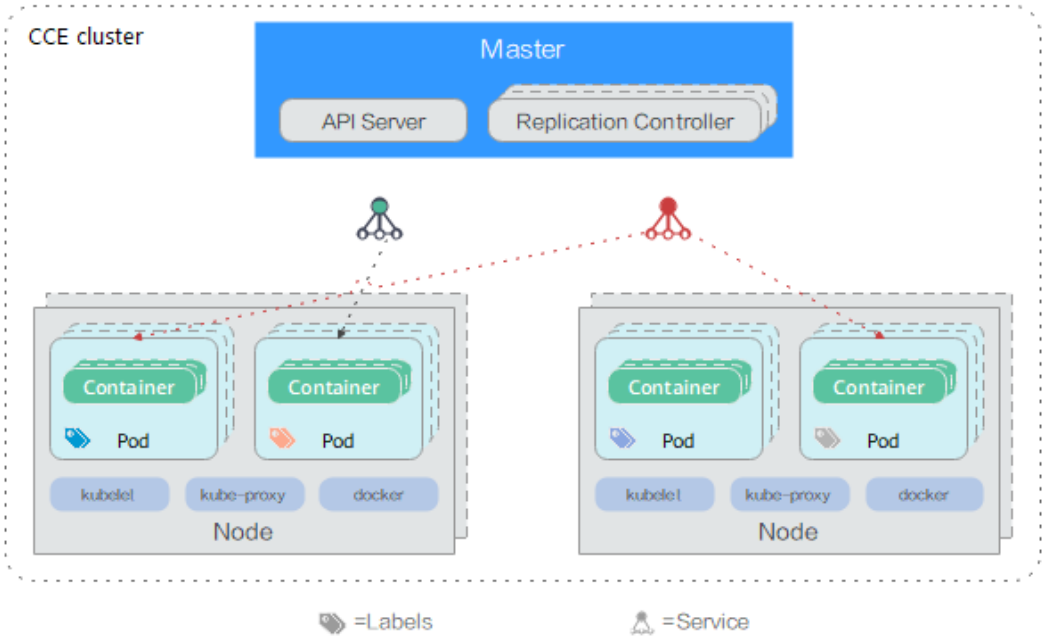
1.3.1 Containerized Application Management

Application Scenarios

In CCE, you can run clusters with x86 and Arm nodes. Create and manage Kubernetes clusters. Deploy containerized applications in them. All done in CCE.

- Containerized web applications: CCE clusters interconnect with middleware (such as GaussDB and Redis) and support HA DR, auto scaling, public network release, and gray upgrade, helping you quickly deploy web service applications.
- Middleware deployment platform: CCE clusters can be used as middleware deployment platforms to implement stateful applications with StatefulSets and PVCs. In addition, load balancers can be used to expose middleware services.
- Jobs and cron jobs: Job and cron job applications can be containerized to reduce the dependency on the host system. Global resource scheduling secures the resource usage during task running and improves the overall resource usage in the cluster.

Figure 1-3 CCE cluster



Benefits

Containerization requires less resources to deploy application. Services are not uninterrupted during upgrades.

Advantages

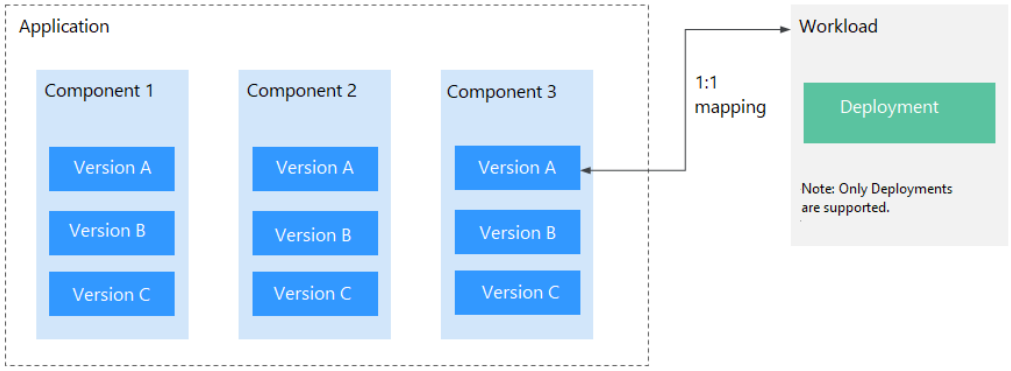
- Multiple types of workloads

  Runs Deployments, StatefulSets, DaemonSets, jobs, and cron jobs to meet different needs.
- Application upgrade

  Upgrades your apps in replace or rolling mode (by proportion or by number of pods), or rolls back the upgrades.
- Auto scaling

  Auto scales your nodes and workloads according to the policies you set.

Figure 1-4 Workload



1.3.2 Auto Scaling in Seconds

Application Scenarios

- Shopping apps and websites, especially during promotions
- Live streaming, where service loads often fluctuate
- Games, where many players may go online in certain time periods

Benefits

CCE auto adjusts capacity to cope with service surges according to the policies you set. CCE adds or reduces cloud servers and containers to scale your cluster and workloads. Your applications will always have the right resources at the right time.

Advantages

- Flexible

  Allows diverse types of scaling policies and scales containers within seconds once triggered.
- Highly available

  Monitors pod running and replaces unhealthy pods with new ones.
- Lower costs

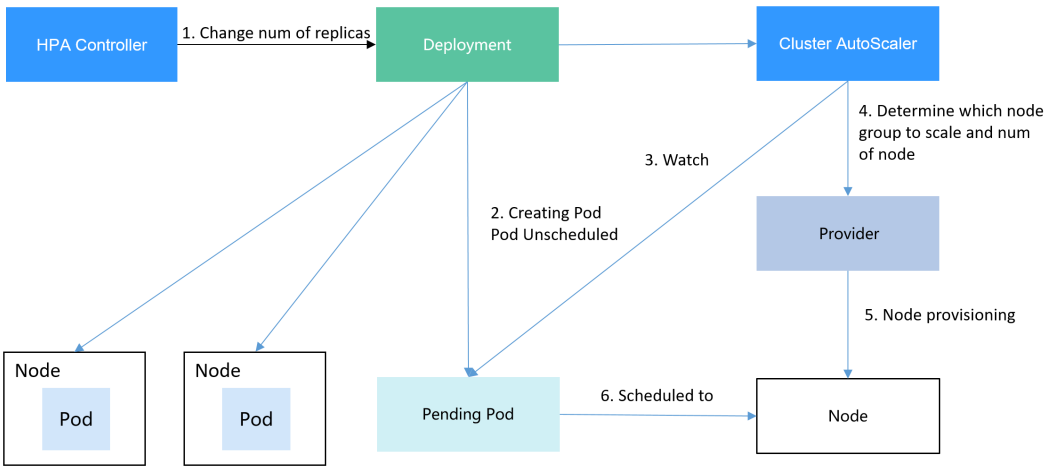
  Bills you only for the scaled cloud servers as you use.

Related Services

Add-ons: autoscaler and cce-hpa-controller

- Auto scaling for workloads: HPA (Horizontal Pod Autoscaling)
- Auto scaling for clusters: CA (Cluster AutoScaling)

Figure 1-5 How auto scaling works



1.3.3 DevOps and CI/CD

Application Scenario

You may receive a lot feedback and requirements for your apps or services. You may want to boost user experience with new features. Continuous integration (CI) and delivery (CD) can help. CI/CD automates builds, tests, and merges, making app delivery faster.

Benefits

CCE works with SWR to support DevOps and CI/CD. A pipeline automates coding, image build, grayscale release, and deployment based on code sources. Existing CI/CD systems can connect to CCE to containerize legacy applications.

Advantages

- Efficient process

  Reduces scripting workload by more than 80% through streamlined processes.
- Flexible integration

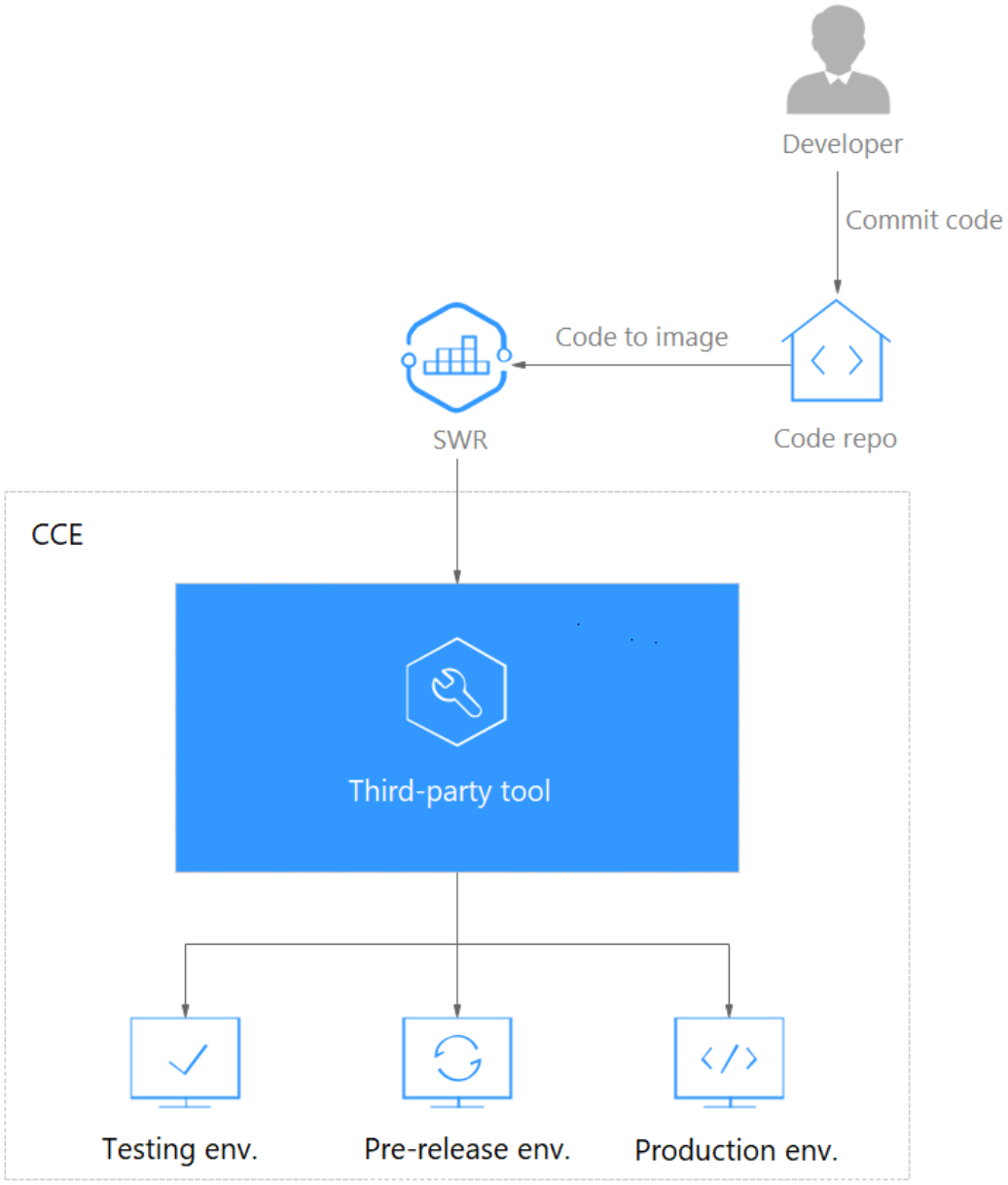
  Provides various APIs to integrate with existing CI/CD systems for in-depth customization.
- High performance

  Enables flexible scheduling with a containerized architecture.

Related Services

Software Repository for Container (SWR), Object Storage Service (OBS), Virtual Private Network (VPN)

Figure 1-6 How DevOps works



1.3.4 Hybrid Cloud

Application Scenarios

- Multi-cloud deployment and disaster recovery

  Running apps in containers on different clouds can ensure high availability. When a cloud is down, other clouds respond and serve.

- Traffic distribution and auto scaling

  Large organizations often span cloud facilities in different regions. They need to communicate and auto scale — start small and then scale as system load grows. CCE takes care of these for you, cutting the costs of maintaining facilities.

- Migration to the cloud and local database hosting

  Industries like finance and security have a top concern on data protection. They want to run critical systems in local IDCs while moving others to the cloud. They also expect one unified dashboard to manage all systems.

- Environment decoupling

  To ensure IP security, you can decouple development from production. Set up one on the cloud and the other in the local IDC.

Benefits

Thanks to containers' environment-independent feature, CCE manages containers in a unified manner, and these containers can access each other on CCE. You can seamlessly migrate your apps and data on and off the cloud. This meets complex services' requirements for auto scaling, flexibility, security, and compliance. Additionally, resources in different cloud environments can be operated and maintained in a unified manner, providing easier resource scheduling and DR.

Advantages

- On-cloud DR

  Multicloud prevents systems from outages. When a cloud is faulty, CCE auto diverts traffic to other clouds to ensure service continuity.

- Unified architecture and auto scaling

  Unified architecture on and off the cloud can flexibly implement auto scaling, smooth migration to cope with traffic peaks.

- Decoupling and sharing

  CCE decouples data, environments, and compute capacity. Sensitive data vs general data. Development vs production. Compute-intensive services vs general services. Apps running on-premises can burst to the cloud. Your resources on and off the cloud can be better used.

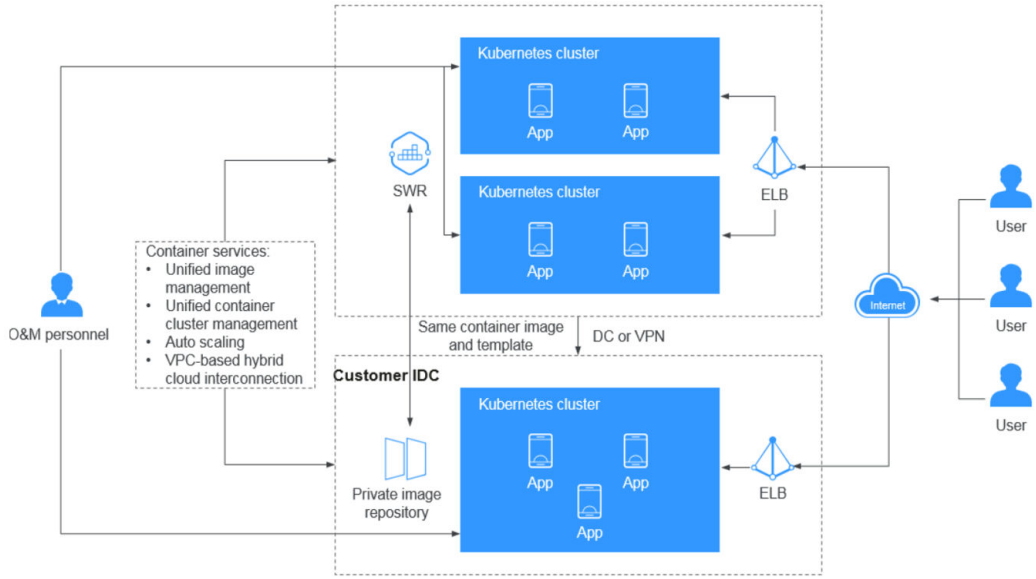
- Lower costs

  Cloud resource pools, backed by auto scaling, can respond to load spikes in time. Manual operations are no longer needed and you can save big.

Related Services

Elastic Cloud Server (ECS), Direct Connect (DC), Virtual Private Network (VPN), SoftWare Repository for Container (SWR)

Figure 1-7 How hybrid cloud works



1.4 Constraints

This section describes the notes and constraints on using CCE.

Clusters and Nodes

- After a cluster is created, the following items cannot be changed:
  - Number of master nodes: For example, a non-HA cluster (with one master node) cannot be changed to an HA cluster (with three master nodes).
  - AZ where a master node is deployed
  - Network configuration of the cluster, such as the VPC, subnet, container CIDR block, Service CIDR block, and kube-proxy (forwarding) settings
  - Network model: For example, a container tunnel network cannot be changed to a VPC network.
- CCE underlying resources such as ECS nodes are limited by quota and their inventory. It is possible that only some nodes are created during cluster creation, cluster scaling, or auto scaling.
- ECS node specifications: CPU ≥ 2 cores, memory ≥ 4 GiB
- To access a CCE cluster through a VPN, ensure that the VPN CIDR block does not conflict with the VPC CIDR block where the cluster resides and the container CIDR block.

Networks

- By default, a NodePort Service is accessed within a VPC. To access a NodePort Service through the Internet, bind an EIP to the node in the cluster beforehand.
- LoadBalancer Services allow workloads to be accessed from public networks through ELB. This access mode has the following restrictions:

  - Automatically created load balancers should not be used by other resources. Otherwise, these load balancers cannot be completely deleted.
  - Do not change the listener name for the load balancer in clusters of v1.15 and earlier. Otherwise, the load balancer cannot be accessed.
- Constraints on network policies:
  - Only clusters that use the tunnel network model support network policies. Network policies are classified into the following types:
    - Ingress: All versions support this type.
    - Egress: This rule type cannot be set currently.
  - Network isolation is not supported for IPv6 addresses.

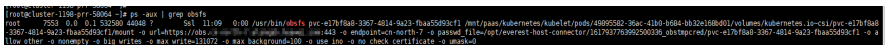
Storage Volumes

- Constraints on EVS volumes:
  - EVS disks cannot be attached across AZs and cannot be used by multiple workloads, multiple pods of the same workload, or multiple tasks. Data sharing of a shared disk is not supported between nodes in a CCE cluster. If an EVS disk is attacked to multiple nodes, I/O conflicts and data cache conflicts may occur. Therefore, create only one pod when creating a Deployment that uses EVS disks.
  - For clusters earlier than v1.19.10, if an HPA policy is used to scale out a workload with EVS disks attached, the existing pods cannot be read or written when a new pod is scheduled to another node.

    For clusters of v1.19.10 and later, if an HPA policy is used to scale out a workload with EVS disks attached, a new pod cannot be started because EVS disks cannot be attached.
- Constraints on SFS volumes:
  - Multiple PVs can use the same SFS or SFS Turbo file system with the following restrictions:
    - If multiple PVCs/PVs use the same underlying SFS or SFS Turbo file system, when you attempt to mount these PVCs/PVs to the same pod, all PVCs cannot be mounted to the pod and the pod startup fails. This is because the **volumeHandle** values of these PVs are the same.
    - The **persistentVolumeReclaimPolicy** parameter in the PVs must be set to **Retain**. Otherwise, when a PV is deleted, the associated underlying volume may be deleted. In this case, other PVs associated with the underlying volume malfunction.
    - When the underlying volume is repeatedly used, enable isolation and protection for ReadWriteMany at the application layer to prevent data overwriting and loss.
- Constraints on OBS volumes:
  - If OBS volumes are used, the owner group and permission of the mount point cannot be modified.
  - CCE allows parallel file systems to be mounted using OBS SDKs or PVCs. If PVC mounting is used, the obsfs tool provided by OBS must be used.

An obsfs resident process is generated each time an object storage volume generated from the parallel file system is mounted to a node, as shown in the following figure.

Figure 1-8 obsfs resident process



Reserve 1 GiB of memory for each obsfs process. For example, for a node with 4 vCPUs and 8 GiB of memory, an obsfs parallel file system should be mounted to **no more than** eight pods.

NOTE

- An obsfs resident process runs on a node. If the consumed memory exceeds the upper limit of the node, the node malfunctions. On a node with 4 vCPUs and 8 GiB of memory, if more than 100 pods are mounted to a parallel file system, the node will be unavailable. Control the number of pods mounted to a parallel file system on a single node.

- Constraints on local PVs:
  - Local PVs are supported only when the cluster version is v1.21.2-r0 or later and the everest add-on version is 2.1.23 or later. Version 2.1.23 or later is recommended.
  - Deleting, removing, resetting, or scaling in a node will cause the PVC/PV data of the local PV associated with the node to be lost, which cannot be restored or used again. In these scenarios, the pod that uses the local PV is evicted from the node. A new pod will be created and stay in the pending state. This is because the PVC used by the pod has a node label, due to which the pod cannot be scheduled. After the node is reset, the pod may be scheduled to the reset node. In this case, the pod remains in the creating state because the underlying logical volume corresponding to the PVC does not exist.
  - Do not manually delete the corresponding storage pool or detach data disks from the node. Otherwise, exceptions such as data loss may occur.
  - A local PV cannot be mounted to multiple workloads or jobs at the same time.
- Constraints on local EVs:
  - Local EVs are supported only when the cluster version is v1.21.2-r0 or later and the everest add-on version is 1.2.29 or later.
  - Do not manually delete the corresponding storage pool or detach data disks from the node. Otherwise, exceptions such as data loss may occur.
  - Ensure that the **/var/lib/kubelet/pods/** directory is not mounted to the pod on the node. Otherwise, the pod, mounted with such volumes, may fail to be deleted.
- Constraints on snapshots and backups:
  - The snapshot function is available **only for clusters of v1.15 or later** and requires the CSI-based Everest add-on.
  - The subtype (common I/O, high I/O, or ultra-high I/O), disk mode (SCSI or VBD), data encryption, sharing status, and capacity of an EVS disk created from a snapshot must be the same as those of the disk

associated with the snapshot. These attributes cannot be modified after being queried or set.

- Snapshots can be created only for EVS disks that are available or in use, and a maximum of seven snapshots can be created for a single EVS disk.
- Snapshots can be created only for PVCs created using the storage class (whose name starts with csi) provided by the Everest add-on. Snapshots cannot be created for PVCs created using the Flexvolume storage class whose name is ssd, sas, or sata.
- Snapshot data of encrypted disks is stored encrypted, and that of non-encrypted disks is stored non-encrypted.

Add-ons

CCE uses Helm charts to deploy add-ons. To modify or upgrade an add-on, perform operations on the **Add-ons** page or use open add-on management APIs. Do not directly modify add-on resources on the backend. Otherwise, add-on exceptions or other unexpected problems may occur.

CCE Cluster Resources

There are resource quotas for your CCE clusters in each region.

Item	Constraints on Common Users
Total number of clusters in a region	50
Number of nodes in a cluster (cluster management scale)	A maximum of 50, 200, 1000, or 2000 nodes can be selected.
Maximum number of pods on a node	256
Maximum number of pods managed by a cluster	100,000 pods

Dependent Underlying Cloud Resources

Category	Item	Constraints on Common Users
Compute	Pods	1000
	Cores	8000
	RAM capacity (MB)	16,384,000
Networking	VPCs per account	5
	Subnets per account	100
	Security groups per account	100

Category	Item	Constraints on Common Users
	Security group rules per account	5000
	Routes per route table	100
	Routes per VPC	100
	VPC peering connections per region	50
	Network ACLs per account	200
	Layer 2 connection gateways per account	5
Load balancing	Elastic load balancers	50
	Load balancer listeners	100
	Load balancer certificates	120
	Load balancer forwarding policies	500
	Load balancer backend host group	500
	Load balancer backend server	500

1.5 Permissions

CCE allows you to assign permissions to IAM users and user groups under your tenant accounts. CCE combines the advantages of IAM and RBAC to provide a variety of authorization methods, including IAM fine-grained/token authorization and cluster-/namespace-scoped authorization.

CCE permissions are described as follows:

- **Cluster-level permissions**: Cluster-level permissions management evolves out of the system policy authorization feature of IAM. IAM users in the same user group have the same permissions. On IAM, you can configure system policies to describe which IAM user groups can perform which operations on cluster resources. For example, you can grant user group A to create and delete cluster X, add a node, or install an add-on, while granting user group B to view information about cluster X.

  Cluster-level permissions involve CCE non-Kubernetes APIs and support fine-grained IAM policies and enterprise project management capabilities.
- **Namespace-level permissions**: You can regulate users' or user groups' access to **Kubernetes resources**, such as workloads, jobs, and Services, in a single namespace based on their Kubernetes RBAC roles. CCE has also been enhanced based on open-source capabilities. It supports RBAC authorization based on IAM user or user group, and RBAC authentication on access to APIs using IAM tokens.

Namespace-level permissions involve CCE Kubernetes APIs and are enhanced based on the Kubernetes RBAC capabilities. Namespace-level permissions can be granted to IAM users or user groups for authentication and authorization, but are independent of fine-grained IAM policies. For details, see **Using RBAC Authorization**.

CAUTION

- **Cluster-level permissions** are configured only for cluster-related resources (such as clusters and nodes). You must also configure **namespace permissions** to operate Kubernetes resources (such as workloads, jobs, and Services).
- After you create a cluster, CCE automatically assigns the cluster-admin permission to you, which means you have full control on all resources in all namespaces in the cluster.
- When viewing CCE resources on the console, the resources displayed depend on the namespace permissions. If no namespace permissions are granted, the console will not show you the resources.

Cluster-level Permissions (Assigned by Using IAM System Policies)

By default, new IAM users do not have permissions assigned. Add a user to one or more groups, and attach permissions policies or roles to these groups. Users inherit permissions from the groups to which they are added and can perform specified operations on cloud services based on the permissions.

CCE is a project-level service deployed and accessed in specific physical regions. To assign CCE permissions to a user group, specify the scope as region-specific projects and select projects for the permissions to take effect. If **All projects** is selected, the permissions will take effect for the user group in all region-specific projects. When accessing CCE, the users need to switch to a region where they have been authorized to use the CCE service.

You can grant users permissions by using roles and policies.

- Roles: A type of coarse-grained authorization mechanism that defines permissions related to user responsibilities. This mechanism provides only a limited number of service-level roles for authorization. When using roles to assign permissions, assign other roles on which the permissions depend to take effect. However, roles are not an ideal choice for fine-grained authorization and secure access control.
- Policies: A type of fine-grained authorization mechanism that defines permissions required to perform operations on specific cloud resources under certain conditions. This mechanism allows for more flexible policy-based authorization, meeting requirements for secure access control. For example, you can assign users only the permissions for managing a certain type of clusters and nodes.

Table 1-3 lists all the system permissions supported by CCE.

Table 1-3 System permissions supported by CCE

Role/ Policy Name	Description	Type	Dependency
CCE Administrator	Read and write permissions for CCE clusters and all resources (including workloads, nodes, jobs, and Services) in the clusters	System-defined roles	Users granted permissions of this policy must also be granted permissions of the following policies: **Global service project**: OBS Buckets Viewer and OBS Administrator **Region-specific projects**: Tenant Guest, Server Administrator, ELB Administrator, SFS Administrator, SWR Admin, and APM FullAccess **NOTE** • If you are assigned with both **CCE Administrator** and **NAT Gateway Administrator** permissions, you can use NAT Gateway functions for clusters. • If an IAM user is required to grant cluster namespace permissions to other users or user groups, the user must have the IAM read-only permission.
CCE FullAccess	Common operation permissions on CCE cluster resources, excluding the namespace-level permissions for the clusters (with Kubernetes RBAC enabled) and the privileged administrator operations, such as agency configuration and cluster certificate generation	Policy	None

Role/ Policy Name	Description	Type	Dependency
CCE ReadOnly Access	Permissions to view CCE cluster resources, excluding the namespace-level permissions of the clusters (with Kubernetes RBAC enabled)	Policy	None

Table 1-4 Common operations supported by CCE system policies

Operation	CCE ReadOnlyAccess	CCE FullAccess	CCE Administrator
Creating a cluster	x	√	√
Deleting a cluster	x	√	√
Updating a cluster, for example, updating cluster node scheduling parameters and providing RBAC support to clusters	x	√	√
Upgrading a cluster	x	√	√
Waking up a cluster	x	√	√
Hibernating a cluster	x	√	√
Listing all clusters	√	√	√
Querying cluster details	√	√	√
Adding a node	x	√	√
Deleting one or more nodes	x	√	√
Updating a cluster node, for example, updating the node name	x	√	√
Querying node details	√	√	√
Listing all nodes	√	√	√
Listing all jobs	√	√	√

Operation	CCE ReadOnlyAccess	CCE FullAccess	CCE Administrator
Deleting one or more cluster jobs	x	√	√
Querying job details	√	√	√
Creating a storage volume	x	√	√
Deleting a storage volume	x	√	√
Performing operations on all Kubernetes resources	√ (Kubernetes RBAC required)	√ (Kubernetes RBAC required)	√
Viewing all CIA resources	√	√	√
Performing operations on all CIA resources	x	√	√
Performing all operations on ECSs	x	√	√
Performing all operations on EVS disks EVS disks can be attached to cloud servers and scaled to a higher capacity whenever needed.	x	√	√
Performing all operations on VPC A cluster must run in a VPC. When creating a namespace, create or associate a VPC for the namespace so that all containers in the namespace will run in the VPC.	x	√	√
Viewing details of all resources on an ECS In CCE, a node is an ECS with multiple EVS disks.	√	√	√
Listing all resources on an ECS	√	√	√

Operation	CCE ReadOnlyAccess	CCE FullAccess	CCE Administrator
Viewing details about all EVS disk resources EVS disks can be attached to cloud servers and scaled to a higher capacity whenever needed.	√	√	√
Listing all EVS resources	√	√	√
Viewing details about all VPC resources A cluster must run in a VPC. When creating a namespace, create or associate a VPC for the namespace so that all containers in the namespace will run in the VPC.	√	√	√
Listing all VPC resources	√	√	√
Viewing details about all ELB resources	x	x	√
Listing all ELB resources	x	x	√
Viewing details about all SFS resources	√	√	√
Listing all SFS resources	√	√	√
Viewing details about all AOM resources	√	√	√
Listing AOM resources	√	√	√
Performing all operations on AOM auto scaling rules	√	√	√

Namespace-level Permissions (Assigned by Using Kubernetes RBAC)

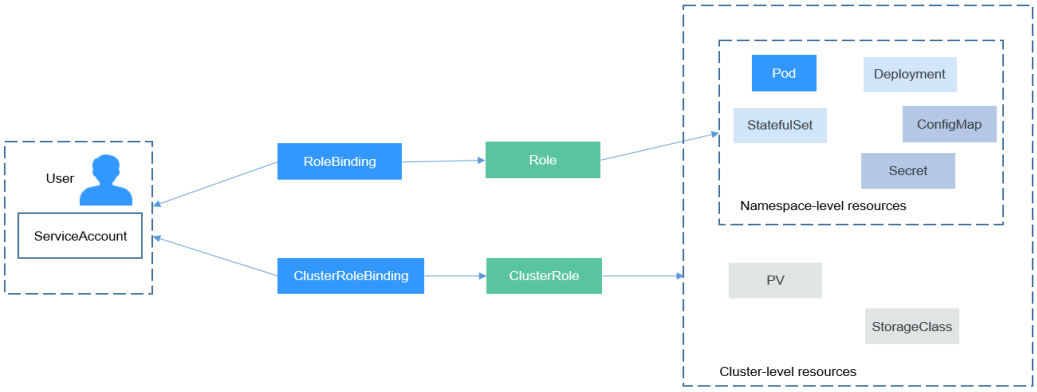
You can regulate users' or user groups' access to Kubernetes resources in a single namespace based on their Kubernetes RBAC roles. The RBAC API declares four kinds of Kubernetes objects: Role, ClusterRole, RoleBinding, and ClusterRoleBinding, which are described as follows:

- 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 1-9 Role binding



On the CCE console, you can assign permissions to a user or user group to access resources in one or multiple namespaces. By default, the CCE console provides the following ClusterRoles:

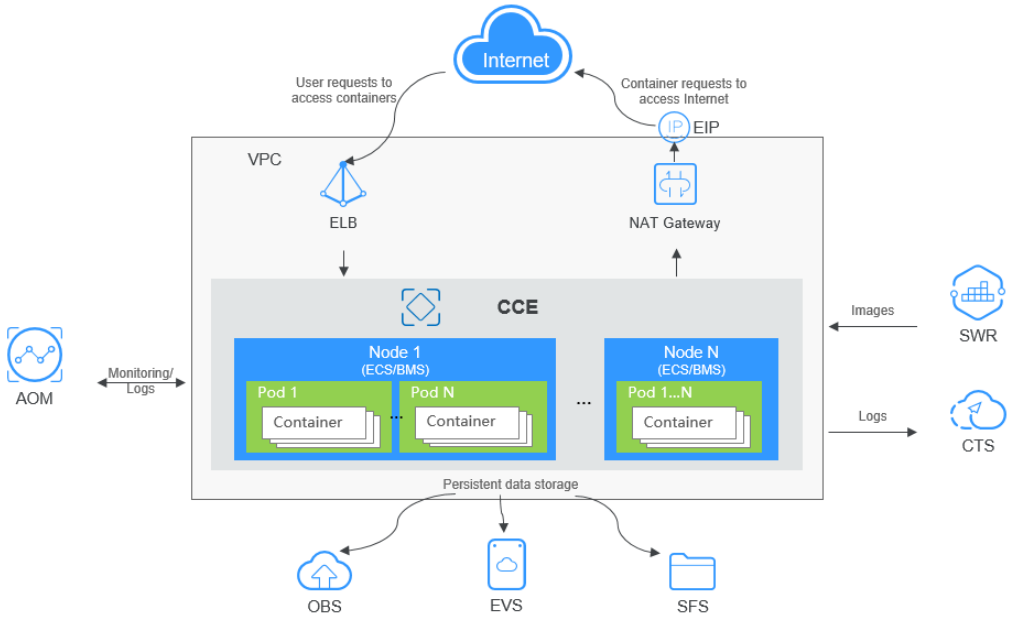
- view (read-only): read-only permission on most resources in all or selected namespaces.
- edit (development): read and write permissions on most resources in all or selected namespaces. If this ClusterRole is configured for all namespaces, its capability is the same as the O&M permission.
- admin (O&M): read and write permissions on most resources in all namespaces, and read-only permission on nodes, storage volumes, namespaces, and quota management.
- cluster-admin (administrator): read and write permissions on all resources in all namespaces.

In addition to the preceding typical ClusterRoles, you can define Role and RoleBinding to grant the permissions to add, delete, modify, and obtain global resources (such as nodes, PVs, and CustomResourceDefinitions) and different resources (such as pods, Deployments, and Services) in namespaces for refined permission control.

1.6 Related Services

CCE works with the following cloud services and requires permissions to access them.

Figure 1-10 Relationships between CCE and other services



Relationships Between CCE and Other Services

Table 1-5 Relationships between CCE and other services

Service	Relationship
ECS	An ECS with multiple EVS disks is a node in CCE. You can choose ECS specifications during node creation.
VPC	For security reasons, all clusters created by CCE must run in VPCs. When creating a namespace, create a VPC or bind an existing VPC to the namespace so all containers in the namespace will run in this VPC.
ELB	CCE works with ELB to load balance a workload's access requests across multiple pods.
NAT Gateway	The NAT Gateway service provides source network address translation (SNAT), which translates private IP addresses to a public IP address by binding an elastic IP address (EIP) to the gateway.
SWR	An image repository is used to store and manage Docker images.
EVS	EVS disks can be attached to cloud servers and scaled to a higher capacity whenever needed. An ECS with multiple EVS disks is a node in CCE. You can choose ECS specifications during node creation.

Service	Relationship
OBS	OBS provides stable, secure, cost-efficient, and object-based cloud storage for data of any size. With OBS, you can create, modify, and delete buckets, as well as uploading, downloading, and deleting objects. CCE allows you to create an OBS volume and attach it to a path inside a container.
SFS	SFS is a shared, fully managed file storage service. Compatible with the Network File System protocol, SFS file systems can elastically scale up to petabytes, thereby ensuring top performance of data-intensive and bandwidth-intensive applications. You can use SFS file systems as persistent storage for containers and attach the file systems to containers when creating a workload.
AOM	AOM collects container log files in formats like .log from CCE and dumps them to AOM. On the AOM console, you can easily query and view log files. In addition, AOM monitors CCE resource usage. You can define metric thresholds for CCE resource usage to trigger auto scaling.
Cloud Trace Service (CTS)	CTS records operations on your cloud resources, allowing you to obtain, audit, and backtrack resource operation requests initiated from the management console or open APIs as well as responses to these requests.

1.7 Regions and AZs

Definition

A region and availability zone (AZ) identify the location of a data center. You can create resources in a specific region and AZ.

- Regions are divided based on geographical location and network latency. Public services, such as Elastic Cloud Server (ECS), Elastic Volume Service (EVS), Object Storage Service (OBS), Virtual Private Cloud (VPC), Elastic IP (EIP), and Image Management Service (IMS), are shared within the same region. Regions are classified as universal regions and dedicated regions. A universal region provides universal cloud services for common domains. A dedicated region provides services of the same type only or for specific domains.
- An AZ contains one or more physical data centers. Each AZ has independent cooling, fire extinguishing, moisture-proof, and electricity facilities. Within an AZ, computing, network, storage, and other resources are logically divided into multiple clusters. AZs in a region are interconnected through high-speed

optic fibers. This is helpful if you will deploy systems across AZs to achieve higher availability.

Cloud services are available in many regions around the world. You can select a region and AZ as needed.

How to Select a Region?

When selecting a region, consider the following factors:

- Location

  Select a region close to you or your target users to reduce network latency and improve access rate.

Selecting an AZ

When deploying resources, consider your applications' requirements on disaster recovery (DR) and network latency.

- For high DR capability, deploy resources in different AZs within the same region.
- For lower network latency, deploy resources in the same AZ.

Regions and Endpoints

When using an API to access resources, you must specify a region and endpoint.

2 CCE Console Upgrade

Dear users,

We are pleased to announce that a brand-new CCE console is available. The new console is modern, visually appealing, and concise, providing a more comfortable and enjoyable user experience.

We have optimized the UI, including the colors, fonts, and icons. This makes the entire console clearer and easier to operate. Additionally, we have added some new interaction pages to help you use your clusters more efficiently and conveniently.

We believe that the new CCE console will improve your user experience. If you have any questions or suggestions, feel free to contact our customer service. Thank you for your support and trust.

The upgrade involves the following:

- **Optimized Cluster Management Page**
- **New Cluster Settings Page**
- **Optimized Add-ons Page**

Optimized Cluster Management Page

The cluster management page has been optimized:

- New cluster classification

  The CCE service is upgraded. It now provides CCE standard clusters. The original CCE clusters are renamed the CCE standard clusters. This kind of cluster is not a new cluster type.
- New design of the cluster panes

  Cluster panes are now simpler and more practical. The button icons on the original cluster panes are canceled. All entries are labeled in words, and infrequently used buttons are hidden.
- New classification of cluster functions

  The **Resources** and **O&M** categories in the navigation pane of the cluster console have been removed. The new categories are classified based on the Kubernetes native functions and the CCE cluster management and O&M observation functions.

New Cluster Settings Page

This is a brand-new page for cluster settings that provides a unified portal for configuring the control plane in an efficient and convenient manner.

More capabilities will be added to the **Settings** page. Stay tuned for more.

Optimized Add-ons Page

CCE has made the following changes to the **Add-ons** page:

- The classification of CCE add-ons is now more concise, helping you quickly locate the needed add-ons.
- The new add-on names and introductions will help you understand the scenarios where these add-ons can be used and provide effective usage guidance.

Table 2-1 Add-on classification and names

Category	New Name	Original Name	Remarks
Scheduling and elasticity	CCE Cluster Autoscaler	autoscaler	CCE proprietary
	CCE Advanced HPA	cce-hpa-controller	CCE proprietary
	Volcano Scheduler	volcano	CCE proprietary
Cloud native observability	Cloud Native Cluster Monitoring	kube-prometheus-stack	CCE proprietary
	CCE Node Problem Detector	npd	CCE proprietary
	CCE Network Metrics Exporter	dolphin	CCE proprietary
	Kubernetes Metrics Server	metrics-server	Featured open source
	Prometheus	prometheus	CCE proprietary
Cloud native heterogeneous computing	CCE AI Suite (NVIDIA GPU)	gpu-device-plugin (gpu-beta)	CCE proprietary
	CCE AI Suite (Ascend NPU)	huawei-npu	CCE proprietary
Network	CoreDNS	coredns	CCE proprietary
	NodeLocal DNSCache	node-local-dns	Featured open source
	NGINX Ingress Controller	nginx-ingress	Featured open source

Category	New Name	Original Name	Remarks
Storage	CCE Container Storage (Everest)	everest	CCE proprietary
Security	CCE Secrets Manager for DEW	dew-provider	CCE proprietary
Other	Kubernetes Dashboard	dashboard	Featured open source
	Kubernetes Web Terminal	web-terminal	Featured open source

3 Getting Started

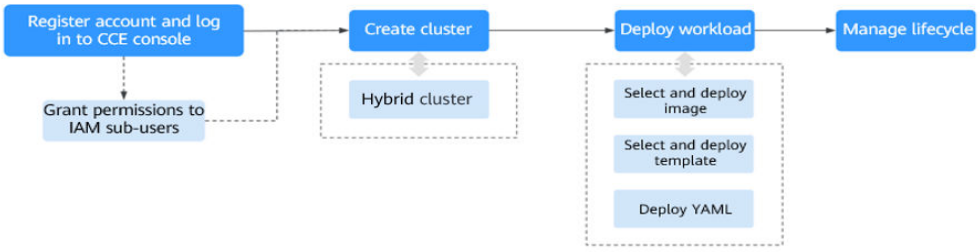
3.1 Introduction

This section describes how to use Cloud Container Engine (CCE) and provides frequently asked questions (FAQs) to help you quickly get started with CCE.

Procedure

Complete the following tasks to get started with CCE.

Figure 3-1 Procedure for getting started with CCE



Step 1 **Register an account and grant permissions to IAM users.**

An account has the permissions to use CCE. However, IAM users created by an account do not have permissions. You need to manually grant the permissions to IAM users..

Step 2 Create a cluster.

For details on how to create a Kubernetes cluster, see **Creating a Kubernetes Cluster**.

Step 3 Create a workload from an image or chart.

- **Creating a Deployment (Nginx)**
- **Deploying WordPress and MySQL That Depend on Each Other**

Step 4 View workload status and logs. Upgrade, scale, and monitor the workload.

----End

FAQs

1. **Is CCE suitable for users who are not familiar with Kubernetes?**

   Yes. The CCE console is easy-to-use, and the *Getting Started* guide helps you quickly understand and use CCE.

2. **Is CCE suitable for users who have little experience in building images?**

   Yes. CCE not only helps store your own images in **My Images** but also allows you to create containerized applications using open source images. For details, see **Creating a Deployment (Nginx)**.

3. **How do I create a workload using CCE?**

   To create a workload, you need to create a cluster first. For details on how to create a workload, see **Creating a Deployment (Nginx)**.

4. **How do I create a workload accessible to public networks?**

   CCE provides different workload access types to address diverse scenarios.

5. **How can I allow multiple workloads in the same cluster to access each other?**

   You can create a service of the ClusterIP type. The ClusterIP Services allow workloads in the same cluster to access each other using their cluster-internal domain names.

   Cluster-internal domain names are in the format of *<A custom service name>*.*<The workload's namespace>*.**svc.cluster.local:***<Port number>*. For example, **nginx.default.svc.cluster.local:80**.

3.2 Preparations

Before using CCE, make the following preparations:

- **Creating an IAM user**
- **Obtaining Resource Permissions**
- **(Optional) Creating a VPC**
- **(Optional) Creating a Key Pair**

Creating an IAM user

If you want to allow multiple users to manage your resources without sharing your password or private key, you can create users using IAM and grant permissions to the users. These users can use specified links and their own accounts and help you manage resources efficiently. You can also configure account security policies to ensure the security of these accounts.

Your accounts have the permissions to use CCE. However, IAM users created by your accounts do not have the permissions. You need to manually assign the permissions to IAM users.

Obtaining Resource Permissions

CCE works closely with multiple cloud services to support computing, storage, networking, and monitoring functions. When you log in to the CCE console for the first time, CCE automatically requests permissions to access those cloud services in the region where you run your applications. Specifically:

- Compute services

  When you create a node in a cluster, a cloud server is created accordingly. The prerequisite is that CCE has obtained the permissions to access Elastic Cloud Service (ECS) and Bare Metal Server (BMS).

- Storage services

  CCE allows you to mount storage volumes to nodes and containers in a cluster. The prerequisite is that CCE has obtained the permissions to access services such as Elastic Volume Service (EVS), Scalable File Service (SFS), and Object Storage Service (OBS).

- Networking services

  CCE allows containers in a cluster to be published as services that can be accessed by external systems. The prerequisite is that CCE has obtained the permissions to access services such as Virtual Private Cloud (VPC) and Elastic Load Balance (ELB).

- Container and monitoring services

  CCE supports functions such as container image pull, monitoring, and logging. The prerequisite is that CCE has obtained the permissions to access services such as SoftWare Repository for Container (SWR) and Application Operations Management (AOM).

After you agree to delegate the permissions, an agency named **cce_admin_trust** will be created for CCE in Identity and Access Management (IAM). The system account **op_svc_cce** will be delegated the **Tenant Administrator** role to perform operations on other cloud service resources. Tenant Administrator has the permissions on all cloud services except IAM, which calls the cloud services on which CCE depends. The delegation takes effect only in the current region.

To use CCE in multiple regions, request for cloud resource permissions in each region. You can go to the IAM console, choose **Agencies**, and click **cce_admin_trust** to view the delegation records of each region.

NOTE

CCE may fail to run as expected if the Tenant Administrator role is not assigned. Therefore, do not delete or modify the **cce_admin_trust** agency when using CCE.

(Optional) Creating a VPC

A VPC provides an isolated, configurable, and manageable virtual network for CCE clusters.

Before creating the first cluster, ensure that a VPC has been created.

If you already have a VPC available, skip this step.

Step 1 Log in to the management console.

Step 2 Click in the upper left corner and select a region and a project.

Step 3 Under **Networking**, click **Virtual Private Cloud**.

Step 4 Click **Create VPC**.

Step 5 On the **Create VPC** page, configure parameters as prompted.

A default subnet will be created together with a VPC. You can click **Add Subnet** to create more subnets for the VPC.

Step 6 Click **Create Now**.

----End

(Optional) Creating a Key Pair

The cloud platform uses public key cryptography to protect the login information of your CCE nodes. Passwords or key pairs are used for identity authentication during remote login to nodes.

- If you choose the key pair login mode, you need to specify the key pair name when creating a node and provide the private key when logging to the node using SSH.
- If you choose the password login mode, skip this task.

NOTE

If you want to create pods in multiple regions, you need to create a key pair in each region.

Creating a Key Pair on the Management Console

If you have no key pair, create one on the management console. The procedure is as follows:

Step 1 Log in to the management console.

Step 2 Click in the upper left corner and select a region and a project.

Step 3 Under **Compute**, click **Elastic Cloud Server**.

Step 4 In the navigation pane, choose **Key Pair**.

Step 5 On the displayed page, click **Create Key Pair**.

Step 6 Enter the key pair name and click **OK**.

Step 7 A key pair name consists **KeyPair** and four random digits. You can enter an easy-to-remember name, for example, **KeyPair-xxxx_ecs**.

Step 8 Manually or automatically download the private key file. The file name is a specified key pair name with a suffix of .pem. Securely store the private key file. In the dialog box displayed, click **OK**.

NOTE

The private key file can be downloaded only once. Keep it secure. When creating an ECS, provide the name of your desired key pair. Each time you SSH into the ECS, provide the private key.

----End

3.3 Creating a Kubernetes Cluster

Context

This section describes how to quickly create a CCE cluster. In this example, the default or simple configurations are in use.

Creating a Cluster

Step 1 Log in to the CCE console.

- If you have no clusters, click **Buy Cluster** on the wizard page.
- If your have CCE clusters, choose **Clusters** in the navigation pane, click **Buy Cluster** and select the CCE standard cluster.

Step 2 On the page displayed, configure parameters following instructions.

In this example, a majority of parameters retain default values. Only mandatory parameters are described. For details, see **Table 3-1**.

Table 3-1 Parameters for creating a cluster

Parameter	Description
Basic Settings	
*Cluster Name	Name of the cluster to be created. A cluster name contains 4 to 128 characters starting with a lowercase letter and not ending with a hyphen (-). Only lowercase letters, digits, and hyphens (-) are allowed.
*Enterprise Project	This parameter is displayed only for enterprise users who have enabled Enterprise Project Management.
*Cluster Version	Choose the latest version.
*Cluster Scale	Maximum number of **worker nodes** that can be managed by the cluster. If you select **Nodes: 50**, the cluster can manage a maximum of 50 worker nodes.
Network Settings	
*Network Model	You can select **VPC network** or **Tunnel network**. Retain the default value.
*VPC	VPC where the cluster will be located. If no VPC is available, click **Create VPC** to create one. After the VPC is created, click the refresh icon.
*Subnet	Select a subnet for worker nodes. If no subnet is available, click **Create Subnet**. This configuration cannot be modified after the cluster is created.

Parameter	Description
*Container CIDR Block	CIDR block used by containers. The value determines the maximum number of containers in the cluster. Retain the default value.
*Service CIDR Block	CIDR block for Services used by containers in the same cluster to access each other. The value determines the maximum number of Services you can create. The value cannot be changed after creation. Retain the default value.

Step 3 Click **Next: Select Add-on**. On the page displayed, select the add-ons to be installed during cluster creation.

Step 4 Click **Next: Add-on Configuration**.

Step 5 Click **Next: Confirm configuration**. After confirming the information, click **Submit**.

It takes about 6 to 10 minutes to create a cluster.

The created cluster will be displayed on the **Clusters** page, and the number of nodes in the cluster is 0.

----End

Creating a Node

After a cluster is created, you need to create nodes in the cluster to run workloads.

Step 1 Log in to the CCE console.

Step 2 Click the name of the created cluster to access the cluster console.

Step 3 In the navigation pane, choose **Nodes**. Click the **Nodes** tab, click **Create Node** in the upper right corner, and configure parameters as prompted.

The following describes only important parameters. For other parameters, retain the defaults.

Compute Settings

- **AZ**: Keep the default.
- **Node Type**: Select **Elastic Cloud Server (VM)**.
- **Specifications**: Select node specifications that fit your business needs.
- **Container Engine**: Select a container engine as required.
- **OS**: Select the operating system (OS) of the nodes to be created.
- **Node Name**: Enter a node name.
- **Login Mode**:
  - If the login mode is **Password**, the default username is **root**. Enter the password for logging to the node and confirm the password.

Keep the password secure. If you forget the password, the system is unable to retrieve it and you will have to reset the password.

- If the login mode is **Key Pair**, select a key pair for logging to the node and select the check box to acknowledge that you have obtained the key file and without this file you will not be able to log in to the node.

  A key pair is used for identity authentication when you remotely log in to a node. If no key pair is available, click **Create Key Pair**.

Storage Settings

- **System Disk**: Configure the disk type and capacity based on your requirements. The default disk capacity is 50 GiB.
- **Data Disk**: Configure the disk type and capacity based on your requirements. The default disk capacity is 100 GiB.

Network Settings

- **VPC**: Use the default VPC, which is, the subnet selected during cluster creation.
- **Node Subnet**: Select a subnet in which the node runs.
- **Node IP**: Select **Automatic**. The node IP indicates the private IP address of the node.
- **EIP**: enables public network access. After an EIP is bound, the node can access the Internet, for example, downloading images from an external repository.

  The default value is **Do not use**. You can also select **Use existing** or **Auto create**.

Step 4 At the bottom of the page, select the node quantity, and click **Next: Confirm**.

Step 5 Review the node specifications, read the instructions, select **I have read and understand the preceding information**, and click **Submit**.

It takes about 6 to 10 minutes to create a node.

The created node will be displayed on the **Nodes** page.

----End

3.4 Creating a Deployment (Nginx)

You can use images to quickly create a single-pod workload that can be accessed from public networks. This section describes how to use CCE to quickly deploy an Nginx application and manage its lifecycle.

Prerequisites

You have created a CCE cluster that contains a node with 4 vCPUs and 8 GiB memory. The node is bound with an EIP.

A cluster is a logical group of cloud servers that run workloads. Each cloud server is a node in the cluster.

For details on how to create a cluster, see **Creating a Kubernetes Cluster**.

Nginx Overview

Nginx is a lightweight web server. On CCE, you can quickly set up a Nginx web server.

This section uses the Nginx application as an example to describe how to create a workload. The creation takes about 5 minutes.

After Nginx is created, you can access the Nginx web page.

Figure 3-2 Accessed the Nginx web page

Creating Nginx on the CCE Console

The following is the procedure for creating a containerized workload from a container image.

Step 1 Log in to the CCE console.

Step 2 Click the name of the target cluster to access the cluster console.

Step 3 In the navigation pane, choose **Workloads**. Then, click **Create Workload**.

Step 4 Configure the following parameters and retain the default value for other parameters:

Basic Info

- **Workload Type**: Select **Deployment**.
- **Workload Name**: Set it to **nginx**.
- **Namespace**: Select **default**.
- **Pods**: Set the quantity of pods to **1**.

Container Settings

In the **Container Information** area, click **Basic Info** and click **Select Image**. In the dialog box displayed, click the **Open Source Images** tab, search for **nginx**, and select the **nginx** image.

Service Settings

Click the plus sign (+) to create a Service for accessing the workload from an external network. This example shows how to create a LoadBalancer. Configure the following parameters in the window that slides out from the right:

- **Service Name**: Enter **nginx**. The name of the Service is exposed to external networks.
- **Service Type**: Select **LoadBalancer**.
- **Service Affinity**: Retain the default value.
- **Load Balancer**: If a load balancer is available, select an existing load balancer. If not, select **Auto create** to create one.
- **Ports**:
  - **Protocol**: Select **TCP**.
  - **Service Port**: Set this parameter to **8080**, which is mapped to the container port.
  - **Container Port**: port on which the application listens. For containers created using the nginx image, set this parameter to **80**. For other applications, set this parameter to the port of the application.

Step 5 Click **Create Workload**.

Wait until the workload is created.

The created Deployment will be displayed on the **Deployments** tab.

----End

Accessing Nginx

Step 1 Obtain the external access address of Nginx.

Click the Nginx workload name to enter its details page. On the page displayed, click the **Access Mode** tab, view the IP address of Nginx. The public IP address is the external access address.

Step 2 Enter the **external access address** in the address box of a browser. The following shows the welcome page if you successfully access the workload.

Figure 3-3 Accessing Nginx

----End

3.5 Deploying WordPress and MySQL That Depend on Each Other

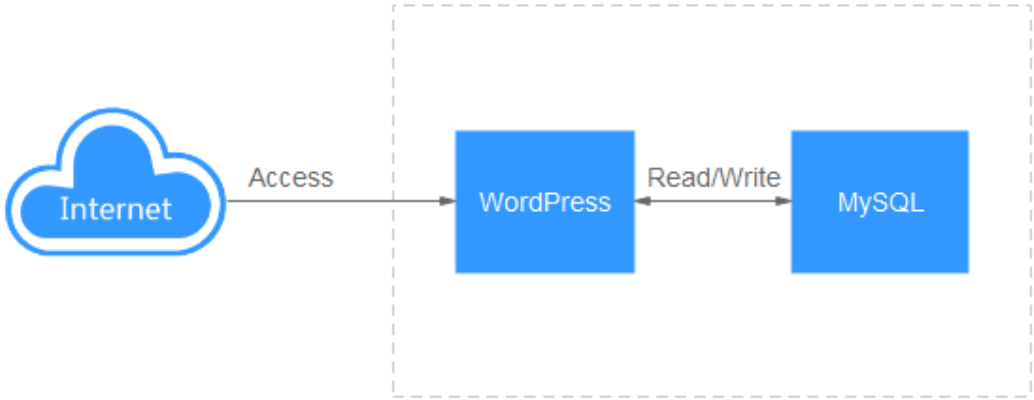
3.5.1 Overview

WordPress was originally a blog platform based on PHP and MySQL. It is gradually evolved into a content management system. You can set up your own blog website on any server that supports PHP and MySQL. Thousands of plug-ins and countless theme templates are available for WordPress and easy to install.

WordPress is a blog platform developed in hypertext preprocessor (PHP). You can set up your websites on the services that support PHP and MySQL databases, or use WordPress as a content management system. For more information about WordPress, visit **https://wordpress.org/**.

WordPress must be used together with MySQL. WordPress runs the content management program while MySQL serves as a database to store data. Generally, WordPress and MySQL run in different containers, as shown in the following figure.

Figure 3-4 WordPress



In this example, two container images are involved.

- **WordPress**: Select wordpress:php7.3 in this example.
- **MySQL**: Select mysql:5.7 in this example.

When WordPress accesses MySQL in a cluster, Kubernetes provides a resource object called Service for the workload access. In this example, a Service is created for MySQL and WordPress, respectively. For details about how to create and configure a Service, see the following sections.

3.5.2 Creating a MySQL Workload

WordPress must be used together with MySQL. WordPress runs the content management program while MySQL serves as a database to store data.

Prerequisites

You have created a CCE cluster that contains a node with 4 vCPUs and 8 GiB memory. For details on how to create a cluster, see **Creating a Kubernetes Cluster**.

Operations on the Console

Step 1 Log in to the CCE console.

Step 2 Click the name of the target cluster to access the cluster console.

Step 3 In the navigation pane, choose **Workloads**. Then, click **Create Workload** in the upper right corner.

Step 4 Configure the basic information about the workload.

- **Workload Type**: Select **StatefulSet**.
- **Workload Name**: Set it to **mysql**.
- **Namespace**: Select **default**.
- **Pods**: In this example, change the quantity to 1, which means, there is only one pod running in the **mysql** workload.

Step 5 Configure the basic information about the container.

In the **Container Settings** area, click **Basic Info** and click **Select Image** next to **Image Name**. In the dialog box displayed, select **Open Source Images**, search for **mysql**, select the **mysql** image, and select **5.7** from the drop-down list for **Image Tag**.

Step 6 Click **Environment Variables** and add four environment variables. You can check **MySQL** to view the environment variables that can be configured.

- **MYSQL_ROOT_PASSWORD**: password of the **root** user of the MySQL database, which can be customized.
- **MYSQL_DATABASE**: name of the database to be created when the image is started, which can be customized.
- **MYSQL_USER**: database user name, which can be customized.
- **MYSQL_PASSWORD**: database user password, which can be customized.

Step 7 Click **Lifecycle** and configure **Startup Command**.

- Command:
  ```
  /bin/bash
  ```
- Running parameters:
  ```
  -c
  rm -rf /var/lib/mysql/lost+found;docker-entrypoint.sh mysqld;
  ```

Step 8 Click **Data Storage**, click **Add Volume**, select **VolumeClaimTemplate (VTC)** from the drop-down list, and add an EVS disk for MySQL.

Click **Create PVC** and configure the following parameters (Keep default for other parameters):

- **PVC Type**: Select **EVS**.
- **PVC Name**: Enter a name, for example, **mysql**.
- **Creation Mode**: Only **Dynamically provision** is supported.
- **Storage Classes**: The default value is **csi-disk**.
- **AZ**: Select an AZ. The EVS disk can only be attached to nodes in the same AZ. After an EVS disk is created, the AZ where the disk locates cannot be changed.
- **Disk Type**: Select a proper type as required.

- **Capacity (GiB)**: Enter the capacity as required. The default value is **10** GiB.

Click **Create** and enter the path for mounting the storage volume to the container. The default path used by MySQL is **/var/lib/mysql**.

Step 9 In the **Headless Service Parameters** area, configure a headless Service.

A headless Service needs to be configured for the StatefulSet networking. The headless Service generates DNS name for each pod for accessing a specific StatefulSet pod. For a replicated MySQL database, the headless Service needs to be used to read and write the MySQL primary server, and copies existing data from other running replicas. In this example, there is only one pod running in the MySQL workload. Therefore, the headless Service is not used. In this case, enter **3306** for both the Service port and container port. For details about the replicated MySQL examples, see **Run a Replicated Stateful Application**.

Step 10 In the **Service Settings** area, click the plus sign (+) and create a Service for accessing MySQL from WordPress.

Select **ClusterIP** for **Service Type**, enter **mysql**in the **Service Name** text box, set both the **Container Port** and **Service Port** to **3306**, and click **OK**.

The default access port in the MySQL image is 3306. In this example, both the container port and Service port are set to **3306** for convenience. The access port can be changed to another port.

In this way, the MySQL workload can be accessed through *{Service name}*:*{Access port}* (for example, **mysql:3306**) from within the cluster.

Step 11 Click **Create Workload**.

Wait until the workload is created.

The created Deployment will be displayed on the **StatefulSets** tab.

----End

3.5.3 Creating a WordPress Workload

WordPress was originally a blog platform based on PHP and MySQL. It is gradually evolved into a content management system. You can set up your own blog website on any server that supports PHP and MySQL. Thousands of plug-ins and countless theme templates are available for WordPress and easy to install.

This section describes how to create a public WordPress website from images.

Prerequisites

- You have created a CCE cluster that contains a node with 4 vCPUs and 8 GiB memory. For details on how to create a cluster, see **Creating a Kubernetes Cluster**.
- The MySQL database has been created by following the instructions in **Creating a MySQL Workload**. In this example, WordPress data is stored in the MySQL database.

Operations on the Console

Step 1 Log in to the CCE console.

Step 2 Click the name of the target cluster to access the cluster console.

Step 3 In the navigation pane, choose **Workloads**. Then, click **Create Workload**.

Step 4 Configure parameters as promoted.

Basic Info

- **Workload Type**: Select **Deployment**.
- **Workload Name**: Enter **wordpress** in the text box.
- **Namespace**: Select **default**.
- **Pods**: Set this parameter to **2** in this example.

Container Settings

In the **Container Information** area, click **Basic Info** and click **Select Image** next to **Image Name**. In the dialog box displayed, select **Open Source Images**, search for **wordpress**, select the **wordpress** image, and select **php7.3** from the drop-down list for **Image Tag**.

Add environment variables.

WordPress will get the information about the MySQL database with the following variables.

- **WORDPRESS_DB_HOST**: address for accessing the database, which can be found in the Service (on the **Services** tab page) of the MySQL workload. You can use the internal domain name **mysql.default.svc.cluster.local:3306** to access the database, or use only **mysql:3306** omitting **.default.svc.cluster.local**.
- **WORDPRESS_DB_USER**: username for accessing the database. The value must be the same as that of **MYSQL_USER** in **Creating a MySQL Workload**, which is used to access MySQL.
- **WORDPRESS_DB_PASSWORD**: password for accessing the database. The value must be the same as that of **MYSQL_PASSWORD** in **Creating a MySQL Workload**.
- **WORDPRESS_DB_NAME**: name of the database to be accessed. The value must be the same as that of **MYSQL_DATABASE** in **Creating a MySQL Workload**.

Service Settings

Click the plus sign (+) to create a Service for accessing the workload from an external network. This example shows how to create a LoadBalancer. Configure the following parameters in the window that slides out from the right:

- **Service Name**: name of the Service exposed to external networks. In this example, the Service name is **wordpress**.
- **Service Type**: Select **LoadBalancer**.
- **Service Affinity**: Retain the default value.
- **Load Balancer**: If a load balancer is available, select an existing load balancer. If not, click **Create Load Balancer** to create one on the ELB console.

- **Ports**:
  - **Protocol**: Select **TCP**.
  - **Service Port**: Set this parameter to **80**, which is mapped to the container port.
  - **Container Port**: port on which the application listens. For containers created using the wordpress image, set this parameter to **80**. For other applications, set this parameter to the port of the application.

Step 5 Click **Create Workload**.

Wait until the workload is created.

The created Deployment will be displayed on the **Deployments** tab.

----End

Accessing WordPress

Step 1 Obtain the external access address of WordPress.

Click the wordpress workload name to enter its details page. On the page displayed, click the **Access Mode** tab, view the IP address of WordPress. The public IP address is the external access address.

Step 2 Enter the external access address in the address box of a browser to access WordPress.

The following figure shows the accessed WordPress page.

Figure 3-5 WordPress

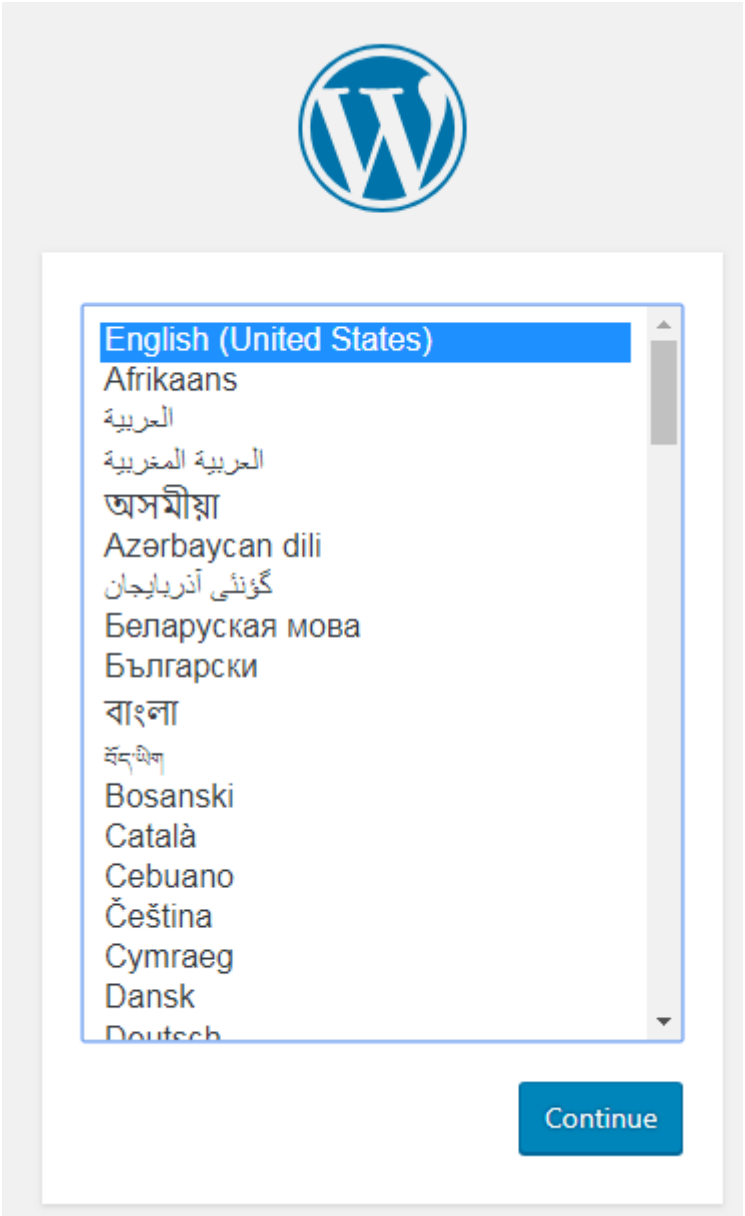
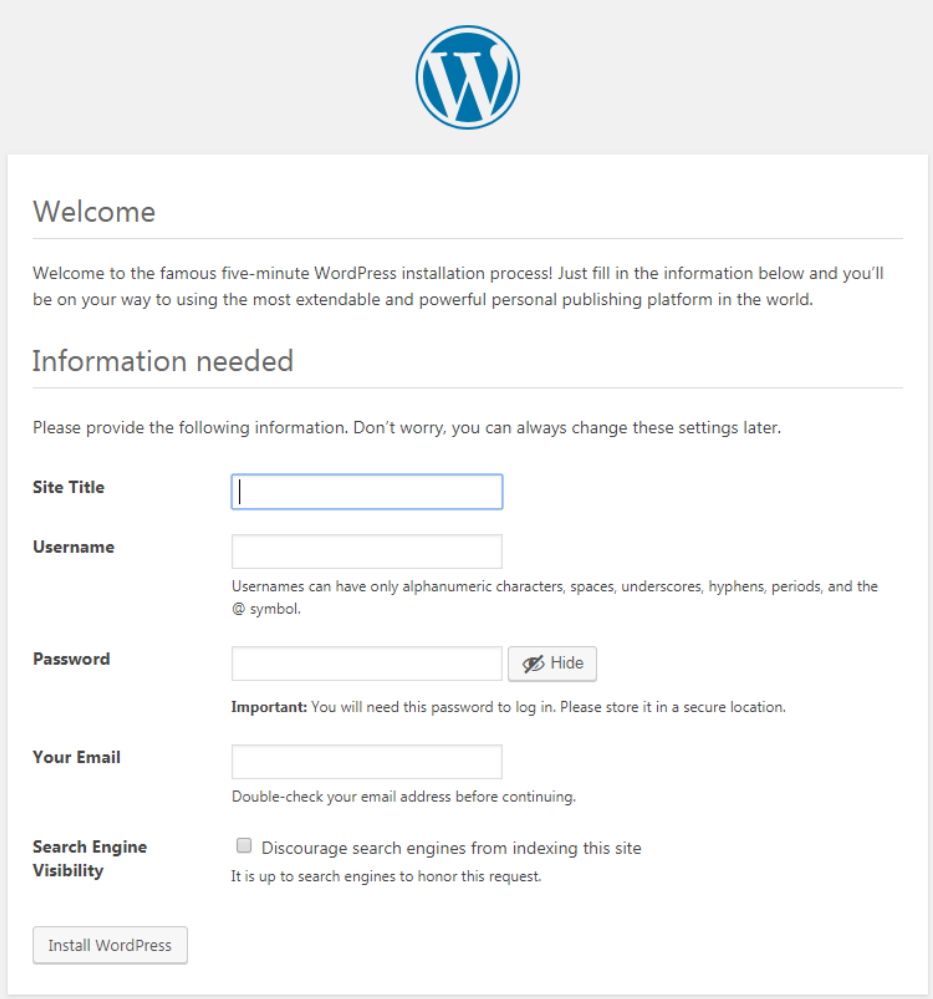


Figure 3-6 WordPress



----End

Deleting Resources

Until now, you have completed all the Getting Started walkthroughs and have understood how to use CCE. Fees are incurred while nodes are running. If you will continue the CCE walkthroughs, retain the clusters. If the clusters used in the walkthroughs are no longer in use, perform the following steps to delete them:

Step 1 Log in to the CCE console.

Step 2 In the navigation pane, choose **Clusters**.

Step 3 Click ▪▪▪ next to the cluster to be deleted, select **Delete Cluster**, and confirm the information as prompted.

----End

4 High-Risk Operations and Solutions

During service deployment or running, you may trigger high-risk operations at different levels, causing service faults or interruption. To help you better estimate and avoid operation risks, this section introduces the consequences and solutions of high-risk operations from multiple dimensions, such as clusters, nodes, networking, load balancing, logs, and EVS disks.

Clusters and Nodes

Table 4-1 High-risk operations and solutions

Category	Operation	Impact	Solution
Master node	Modifying the security group of a node in a cluster **NOTE** Naming rule of a security group: *Cluster name*-**cce-control**-*Random digits*	The master node may be unavailable.	Restore the security group by referring to "Creating a Cluster" and allow traffic from the security group to pass through.
	Letting the node expire or destroying the node	The master node will be unavailable.	This operation cannot be undone.
	Reinstalling the OS	Components on the master node will be deleted.	This operation cannot be undone.
	Upgrading components on the master or etcd node	The cluster may be unavailable.	Roll back to the original version.

Category	Operation	Impact	Solution
	Deleting or formatting core directory data such as **/etc/kubernetes** on the node	The master node will be unavailable.	This operation cannot be undone.
	Changing the node IP address	The master node will be unavailable.	Change the IP address back to the original one.
	Modifying parameters of core components (such as etcd, kube-apiserver, and docker)	The master node may be unavailable.	Restore the parameter settings to the recommended values. For details, see **Cluster Configuration Management**.
	Replacing the master or etcd certificate	The cluster may be unavailable.	This operation cannot be undone.
Worker node	Modifying the security group of a node in a cluster **NOTE** Naming rule of a security group: *Cluster name*-**cce-node**-*Random digits*	The node may be unavailable.	Restore the security group and allow traffic from the security group to pass through.
	Modifying the DNS configuration (**/etc/resolv.conf**) of a node	Internal domain names cannot be accessed, which may lead to errors in functions such as add-on errors or errors in in-place node upgrade. **NOTE** If your service needs to use an on-premises DNS, configure the DNS in the workload. Do not change node's DNS address. For details, see **DNS Configuration**.	Restore the DNS configuration based on the DNS configuration of a new node.
	Deleting the node	The node will become unavailable.	This operation cannot be undone.

Category	Operation	Impact	Solution
	Reinstalling the OS	Node components are deleted, and the node becomes unavailable.	Reset the node. For details, see **Resetting a Node**.
	Upgrading the kernel or components on which the container platform depends (such as Open vSwitch, IPvlan, Docker, and containerd)	The node may be unavailable or the network may be abnormal. **NOTE** Node running depends on the system kernel version. Do not use the **yum update** command to update or reinstall the operating system kernel of a node unless necessary. (Reinstalling the operating system kernel using the original image or other images is a risky operation.)	For details, see **Resetting a Node**.
	Changing the node IP address	The node will become unavailable.	Change the IP address back to the original one.
	Modifying parameters of core components (such as kubelet and kube-proxy)	The node may become unavailable, and components may be insecure if security-related configurations are modified.	Restore the parameter settings to the recommended values. For details, see **Configuring a Node Pool**.
	Modifying OS configuration	The node may be unavailable.	Restore the configuration items or reset the node. For details, see **Resetting a Node**.
	Deleting or modifying the **/opt/cloud/cce** and **/var/paas** directories, and deleting the data disk	The node will become unavailable.	Reset the node. For details, see **Resetting a Node**.
	Modifying the node directory permission and the container directory permission	The permissions will be abnormal.	Do not modify the permissions. Restore the permissions if they have been modified.

Category	Operation	Impact	Solution
	Formatting or partitioning system disks, Docker disks, and kubelet disks on nodes.	The node may be unavailable.	Reset the node. For details, see **Resetting a Node**.
	Installing other software on nodes	This may cause exceptions on Kubernetes components installed on the node, and make the node unavailable.	Uninstall the software that has been installed and restore or reset the node. For details, see **Resetting a Node**.
	Modifying NetworkManager configurations	The node will become unavailable.	Reset the node. For details, see **Resetting a Node**.
	Deleting system images such as **cce-pause** from the node	Containers cannot be created and system images cannot be pulled.	Copy the image from a functional node for restoration.
	Changing the flavor of a node in a node pool on the ECS console	If a node flavor is different from the flavor specified in the node pool where the node resides, the increased number of nodes in a node pool scale-out is different from the expected number.	Change the node flavor to the one specified in the node pool, or delete the node and perform a node pool scale-out again.

Network

Table 4-2 Network

Operation	Impact	Solution
Changing the value of the kernel parameter **net.ipv4.ip_forward** to **0**	The network becomes inaccessible.	Change the value to **1**.
Changing the value of the kernel parameter **net.ipv4.tcp_tw_recycle** to **1**	The NAT service becomes abnormal.	Change the value to **0**.

Operation	Impact	Solution
Changing the value of the kernel parameter **net.ipv4.tcp_tw_reuse** to **1**	The network becomes abnormal.	Change the value to **0**.
Not configuring the node security group to allow UDP packets to pass through port 53 of the container CIDR block	The DNS in the cluster cannot work properly.	Restore the security group by referring to **Buying a CCE Standard Cluster** and allow traffic from the security group to pass through.
Deleting CRD resources of network-attachment-definitions of default-network	The container network is disconnected, or the cluster fails to be deleted.	If the resources are deleted by mistake, use the correct configurations to create the default-network resources.
Enabling the iptables firewall	By default, the iptables firewall is disabled on CCE. Enabling the firewall can leave the network inaccessible. **NOTE** Do not enable the iptables firewall. If the iptables firewall must be enabled, check whether the rules configured in **/etc/sysconfig/iptables** and **/etc/sysconfig/ip6tables** in the test environment will affect the network.	Disable the iptables firewall and check the rules configured in **/etc/sysconfig/iptables** and **/etc/sysconfig/ip6tables**.

Load Balancing

Table 4-3 Service ELB

Operation	Impact	Solution
Deleting a load balancer that has been bound to a CCE cluster on the ELB console	Accessing the target Service or ingress will fail.	Do not delete such a load balancer.
Disabling a load balancer that has been bound to a CCE cluster on the ELB console	Accessing the target Service or ingress will fail.	Do not disable such a load balancer. If a load balancer has been disabled, enable it.

Operation	Impact	Solution
Changing the private IPv4 address of a load balancer on the ELB console	• The network traffic forwarded using the private IPv4 addresses will be interrupted. • The IP addresses in the **status** field of Service or ingress YAML files will be changed.	Do not change private IPv4 addresses of load balancers. Change them back if they have been changed.
Unbinding the IPv4 EIP from a load balancer on the ELB console	After the EIP is unbound from the load balancer, the load balancer will not be able to forward Internet traffic.	Restore the EIP binding.
Creating a custom listener on the ELB console for the load balancer managed by CCE	If a load balancer is automatically created when a Service or an ingress is created, the custom listener of the load balancer cannot be deleted when the Service or ingress is deleted. In this case, the load balancer cannot be automatically deleted.	Use the listener automatically created when a Service or an ingress is created. If a custom listener is used, manually delete the target load balancer.
Deleting a listener automatically created by CCE on the ELB console	• Accessing the target Service or ingress will fail. • After master nodes are restarted, for example, due to a cluster upgrade, all your modifications will be reset by CCE.	Re-create or update the Service or ingress.
Modifying the basic configurations such as the name, access control, timeout, or description of a listener created by CCE on the ELB console	After master nodes are restarted, for example, due to a cluster upgrade, all your modifications will be reset by CCE if the listener is deleted.	Do not modify the basic configurations of the listener created by CCE. Restore the configurations if they have been modified.

Operation	Impact	Solution
Modifying the backend server group of a listener created by CCE on the ELB console, including adding or deleting backend servers to or from the server group	• Accessing the target Service or ingress will fail. • After master nodes are restarted, for example, due to a cluster upgrade, all your modifications will be reset by CCE. – Deleted backend servers will be restored. – Added backend servers will be removed.	Re-create or update the Service or ingress.
Replacing the backend server group of a listener created by CCE on the ELB console	• Accessing the target Service or ingress will fail. • After master nodes are restarted, for example, due to a cluster upgrade, all servers in the backend server group will be reset by CCE.	Re-create or update the Service or ingress.
Modifying the forwarding policy of a listener created by CCE on the ELB console, including adding or deleting forwarding rules	• Accessing the target Service or ingress will fail. • After master nodes are restarted, for example, due to a cluster upgrade, all your modifications will be reset by CCE if the forwarding rules are added using an ingress.	Do not modify the forwarding policy of such a listener. Restore the configurations if they have been modified.
Changing the ELB certificate on the ELB console for a load balancer managed by CCE	After master nodes are restarted, for example, due to a cluster upgrade, all servers in the backend server group will be reset by CCE.	Use the YAML file of the ingress to automatically manage certificates.

Logs

Table 4-4 High-risk operations and solutions

Operation	Impact	Solution
Deleting the **/tmp/ccs-log-collector/pos** directory on the host machine	Logs are collected repeatedly.	None
Deleting the **/tmp/ccs-log-collector/buffer** directory on the host machine	Logs are lost.	None

EVS Disks

Table 4-5 High-risk operations and solutions

Operation	Impact	Solution	Remarks
Manually unmounting an EVS disk on the console	An I/O error occurs when data is written into a pod.	Delete the mount path from the node and schedule the pod again.	The file in the pod records the location where files are to be collected.
Unmounting the disk mount path on the node	Pod data is written into a local disk.	Remount the corresponding path to the pod.	The buffer contains log cache files to be consumed.
Operating EVS disks on the node	Pod data is written into a local disk.	None	None

Add-ons

Table 4-6 Add-ons

Operation	Impact	Solution
Modifying add-on resources on the backend	The add-on becomes malfunctional or other unexpected issues occur.	Perform operations on the add-on configuration page or using open add-on management APIs.

5 Clusters

5.1 Cluster Overview

5.1.1 Basic Cluster Information

Kubernetes is an open source container orchestration engine for automating deployment, scaling, and management of containerized applications.

For developers, Kubernetes is a cluster operating system. Kubernetes provides service discovery, scaling, load balancing, self-healing, and even leader election, freeing developers from infrastructure-related configurations.

Cluster Network

A cluster network can be divided into three network types:

- Node network: IP addresses are assigned to nodes in a cluster.
- Container network: IP addresses are assigned to containers in a cluster for communication. Currently, multiple container network models are supported, and each model has its own working mechanism.
- Service network: A Service is a Kubernetes object used to access containers. Each Service has a static IP address.

When you create a cluster, select a proper CIDR block for each network. Ensure that the CIDR blocks do not conflict with each other and have sufficient available IP addresses. **You cannot change the container network model after the cluster is created.** Plan the container network model properly in advance.

You are advised to learn about the cluster network and container network models before creating a cluster. For details, see **Container Network Models**.

Master Nodes and Cluster Scale

When you create a cluster on CCE, you can have one or three master nodes. Three master nodes will be deployed in a cluster for HA.

The master node specifications decide the number of nodes that can be managed by a cluster. You can select the cluster management scale, for example, 50 or 200 nodes.

Cluster Lifecycle

Table 5-1 Cluster status

Status	Description
Creating	A cluster is being created and is requesting for cloud resources.
Running	A cluster is running properly.
Hibernating	A cluster is hibernating.
Awaking	A cluster is being woken up.
Upgrading	A cluster is being upgraded.
Resizing	The cluster flavor is being changed.
Unavailable	A cluster is unavailable.
Deleting	A cluster is being deleted.

5.1.2 Kubernetes Version Release Notes

5.1.2.1 Kubernetes 1.27 Release Notes

CCE has passed the Certified Kubernetes Conformance Program and is a certified Kubernetes offering. CCE allows you to create clusters of Kubernetes 1.27. This section describes the changes made in Kubernetes 1.27 compared with Kubernetes 1.25.

Indexes

New Features

Kubernetes 1.27

- SeccompDefault is stable.

  To use SeccompDefault, add the **--seccomp-default** command line flag using kubelet on each node. If this feature is enabled, the **RuntimeDefault** profile will be used for all workloads by default, instead of the **Unconfined** (seccomp disabled) profile.

- Jobs' scheduling directives are configurable.

  This feature was introduced in Kubernetes 1.22 and is stable in Kubernetes 1.27. In most cases, you use a Job to influence where the pods will run, like all in the same AZ. This feature allows scheduling directives to be modified before a Job starts. You can use the **suspend** field to suspend a Job. In the suspension phase, the scheduling directives (such as the node selector, node affinity, anti-affinity, and tolerations) in the Job's pod template can be modified. For details, see **Mutable Scheduling Directives**.

- Downward API hugepages are stable.

  In Kubernetes 1.20, **requests.hugepages-***<pagesize>* and **limits.hugepages-***<pagesize>* were introduced to the **downward API**. Requests and limits can be configured for hugepages like other resources.

- Pod scheduling readiness moves to beta.

  After a pod is created, the Kubernetes scheduler selects an appropriate node to run the pod in the pending state. In practice, some pods may stay in the pending state for a long period due to insufficient resources. These pods may affect the running of other components like Cluster Autoscaler in the cluster. By specifying or deleting **.spec. schedulingGates** for a pod, you can control when the pod is ready for scheduling. For details, see **Pod Scheduling Readiness**.

- Accessing node logs using Kubernetes APIs is supported.

  This function is in the alpha phase. The cluster administrator can directly query node logs to help debug malfunctioning services running on the node. To use this function, ensure that the NodeLogQuery **feature gate** is enabled for that node and the kubelet configuration options **enableSystemLogHandler** and **enableSystemLogQuery** are set to **true**.

- ReadWriteOncePod access mode moves to beta.

  Kubernetes 1.22 introduced a ReadWriteOncePod access mode for PVs and PVCs. This feature has evolved into the beta phase. A volume can be mounted to a single pod in read/write mode. Use this access mode if you want to ensure that only one pod in the cluster can read that PVC or write to it. For details, see **Access Modes**.

- The **matchLabelKeys** field in the pod topology spread constraint moves to beta.

  matchLabelKeys is a list of pod label keys. It is used to select a group of pods over which spreading will be calculated. With **matchLabelKeys**, you do not need to update **pod.spec** between different revisions. The controller or operator just needs to set different values to the same label key for different revisions. The scheduler will automatically determine the values based on **matchLabelKeys**. For details, see **Pod Topology Distribution Constraints**.

- The function of efficiently labeling SELinux volumes moves to beta.

  By default, the container runtime recursively assigns the SELinux label to all files on all pod volumes. To speed up this process, Kubernetes uses the mount option **-o context=***<label>* to immediately change the SELinux label of the volume. For details, see **Efficient SELinux volume relabeling**.

- VolumeManager reconstruction goes to beta.

  After the VolumeManager is reconstructed, if the NewVolumeManagerReconstruction **feature gate** is enabled, mounted volumes will be obtained in a more effective way during kubelet startup.

- Server side field validation and OpenAPI V3 are stable.

  OpenAPI V3 was added in Kubernetes 1.23. In Kubernetes 1.24, it moved to beta. In Kubernetes 1.27, it is stable.

- StatefulSet start ordinal moves to beta.

  Kubernetes 1.26 introduced a new, alpha-level feature for StatefulSets to control the ordinal numbering of pod replicas. Since Kubernetes 1.27, this feature moves to beta. The ordinals can start from arbitrary non-negative numbers. For details, see **Kubernetes 1.27: StatefulSet Start Ordinal Simplifies Migration**.

- **ContainerResource** metric in HorizontalPodAutoscaler moves to beta.

  Kubernetes 1.20 introduced the **ContainerResource** metric in HorizontalPodAutoscaler (HPA). In Kubernetes 1.27, this feature moves to beta, and the HPAContainerMetrics feature gate is enabled by default.

- StatefulSet PVC auto deletion moves to beta.

  Kubernetes 1.27 provides a new policy to control the lifecycle of PVCs of StatefulSets. This policy allows users to specify if the PVCs generated from the StatefulSet spec template should be automatically deleted or retrained when the StatefulSet is deleted or replicas in the StatefulSet are scaled down. For details, see **PersistentVolumeClaim retention**.

- Volume group snapshots are introduced.

  Volume group snapshots are introduced as an alpha feature in Kubernetes 1.27. This feature allows users to create snapshots for multiple volumes to ensure data consistency when a fault occurs. It uses a label selector to group multiple PVCs for snapshot. This feature only supports CSI volume drivers. For details, see **Kubernetes 1.27: Introducing an API for Volume Group Snapshots**.

- **kubectl apply** pruning is more secure and efficient.

  In Kubernetes 1.5, the **--prune** flag was introduced in **kubectl apply** to delete resources that are no longer needed. This allowed **kubectl apply** to automatically clear resources removed from the current configuration. However, the existing implementation of **--prune** has design defects that degrade its performance and lead to unexpected behaviors. In Kubernetes 1.27, **kubectl apply** provides ApplySet-based pruning, which is in the alpha phase. For details, see **Declarative Management of Kubernetes Objects Using Configuration Files**.

- Conflicts during port allocation to NodePort Service can be avoided.

  In Kubernetes 1.27, you can enable a new **feature gate** ServiceNodePortStaticSubrange to use different port allocation policies for NodePort Services. This mitigates the risk of port conflicts. This feature is in the alpha phase.

- Resizing resources assigned to pods without restarting the containers is supported.

  Kubernetes 1.27 allows users to resize CPU and memory resources assigned to pods without restarting the container. This feature is in the alpha phase. For details, see **Kubernetes 1.27: In-place Resource Resize for Kubernetes Pods (alpha)**.

- Pod startup is accelerated.

  A series of parameter adjustments like parallel image pulls and increased default API query limit for kubelet per second are made in Kubernetes 1.27 to

accelerate pod startup. For details, see **Kubernetes 1.27: updates on speeding up Pod startup**.

- KMS V2 moves to beta.

  The key management KMS V2 API goes to beta. This has greatly improved the performance of the KMS encryption provider. For details, see **Using a KMS provider for data encryption**.

Kubernetes 1.26

- CRI v1alpha2 is removed.

  Kubernetes 1.26 does not support CRI v1alpha2 any longer. Use CRI v1 (containerd version must be later than or equal to 1.5.0). containerd 1.5.x or earlier is not supported by Kubernetes 1.26. Update the containerd version to 1.6.x or later before upgrading kubelet to 1.26.

  NOTE

  The containerd version used by CCE is 1.6.14, which meets the requirements. If the existing nodes do not meet the containerd version requirements, reset them to the latest version.

- Alpha API for dynamic resource allocation is added.

  In Kubernetes 1.26, **Dynamic Resource Allocation** is added to request and share resources between pods and between containers in a pod. Resources can be initialized based on parameters provided by the user. This function is still in the alpha phase. You need to enable the DynamicResourceAllocation feature gate and the **resource.k8s.io/v1alpha1** API group. You need to install drivers for specific resources to be managed. For details, see **Kubernetes 1.26: Alpha API for Dynamic Resource Allocation**.

- The non-graceful node shutdown feature goes to beta.

  In Kubernetes 1.26, the non-graceful node shutdown feature goes to beta and is enabled by default. A node shutdown can be graceful only if the kubelet's node shutdown manager can detect the upcoming node shutdown action. For details, see **Non-graceful node shutdown handling**.

- Passing pod **fsGroup** to CSI drivers during mounting is supported.

  In Kubernetes 1.22, delegation of **fsGroup** to CSI drivers was first introduced as an alpha feature. In Kubernetes 1.25, it moved to beta. In Kubernetes 1.26, this feature enters the official release phase. For details, see **Delegating volume permission and ownership change to CSI driver**.

- Pod scheduling readiness is introduced.

  Kubernetes 1.26 introduces a new feature schedulingGates, which enables the scheduler to detect when pod scheduling can be performed. For details, see **Pod Scheduling Readiness**.

- CPU manager is officially released.

  The CPU manager is a part of kubelet. Since Kubernetes 1.10, it has moved to **beta**. The CPU manager can allocate exclusive CPUs to containers. This feature is stable in Kubernetes 1.26. For details, see **Control CPU Management Policies on the Node**.

- Kubernetes traffic engineering is advanced.

  Internal node-local traffic optimization and **EndpointSlice conditions** are upgraded to the official release version. **ProxyTerminatingEndpoints** moves to beta.

- Cross-namespace volume data sources are supported.

  This feature allows you to specify a data source that belongs to different namespaces for a PVC. This feature is in the alpha phase. For details, see **Cross namespace data sources**.

- Retroactive default StorageClass assignment moves to beta.

  In Kubernetes 1.25, an alpha feature was introduced to change the way how a default StorageClass is allocated to a PVC. After this feature is enabled, you no longer need to create a default StorageClass and then create a PVC to assign the class. Additionally, any PVCs without a StorageClass assigned can be updated later. This feature moves to beta in Kubernetes 1.26. For details, see **Retroactive default StorageClass assignment**.

- PodDisruptionBudget allows users to specify the eviction policies for unhealthy pods.

  You are allowed to specify unhealthy pod eviction policies for **PodDisruptionBudget** (PDB). This feature helps ensure node availability during node management. This feature is in the beta phase. For details, see **Unhealthy Pod Eviction Policy**.

- The number of Horizontal Pod Autoscaler (HPA) can be configured.

  kube-controller-manager allows **--concurrent-horizontal-pod-autoscaler-syncs** to configure the number of worker nodes of the pod autoscaler for horizontal scaling.

Deprecations and Removals

Kubernetes 1.27

- In Kubernetes 1.27, the feature gates that are used for volume extension and in the General Availability (GA) status, including ExpandCSIVolumes, ExpandInUsePersistentVolumes, and ExpandPersistentVolumes are removed and can no longer be referenced in the **--feature-gates** flag.
- The **--master-service-namespace** parameter is removed. This parameter specifies where to create a Service named **kubernetes** to represent the API server. This parameter was deprecated in Kubernetes 1.26 and is removed from Kubernetes 1.27.
- The ControllerManagerLeaderMigration feature gate is removed. **Leader Migration** provides a mechanism for HA clusters to safely migrate "cloud specific" controllers using a resource lock shared between kube-controller-manager and cloud-controller-manager when upgrading the replicated control plane. This feature has been enabled unconditionally since its release in Kubernetes 1.24. In Kubernetes 1.27, this feature is removed.
- The **--enable-taint-manager** parameter is removed. The feature that it supports, taint-based eviction, is enabled by default and will continue to be implicitly enabled when the flag is removed.
- The **--pod-eviction-timeout** parameter is removed from kube-controller-manager.
- The CSIMigration feature gate is removed. The **CSI migration** program allows smooth migration from the in-tree volume plug-ins to the out-of-tree CSI drivers. This feature was officially released in Kubernetes 1.16.
- The CSIInlineVolume feature gate is removed. The feature (**CSI Ephemeral Volume**) allows CSI volumes to be specified directly in the pod specification

for ephemeral use cases. They can be used to inject arbitrary states, such as configuration, secrets, identity, variables, or similar information, directly inside the pod using a mounted volume. This feature graduated to GA in Kubernetes 1.25 and is removed in Kubernetes 1.27.

- The EphemeralContainers feature gate is removed. For Kubernetes 1.27, API support for ephemeral containers is unconditionally enabled.
- The LocalStorageCapacityIsolation feature gate is removed. This feature gate (**Local Ephemeral Storage Capacity Isolation**) moved to GA in Kubernetes 1.25. The feature provides support for capacity isolation of local ephemeral storage between pods, such as emptyDir volumes, so that a pod can be limited in its consumption of shared resources. The kubelet will evict a pod if its consumption of local ephemeral storage exceeds the configured limit.
- The NetworkPolicyEndPort feature gate is removed. In Kubernetes 1.25, **endPort** in NetworkPolicy moved to GA. NetworkPolicy providers that support the **endPort** field can be used to specify a range of ports to apply NetworkPolicy.
- The StatefulSetMinReadySeconds feature gate is removed. For a pod that is part of a StatefulSet, Kubernetes marks the pod as read-only when the pod is available (and passes the check) at least within the period specified in the **minReadySeconds**. This feature was officially released in Kubernetes 1.25. It is locked to **true** and removed from Kubernetes 1.27.
- The IdentifyPodOS feature gate is removed. If this feature is enabled, you can specify an OS for a pod. It has been stable since Kubernetes 1.25. This feature is removed from Kubernetes 1.27.
- The DaemonSetUpdateSurge feature gate is removed. In Kubernetes 1.25, this feature was stable. It was implemented to minimize DaemonSet downtime during deployment, but it is removed from Kubernetes 1.27.
- The **--container-runtime** parameter is removed. kubelet accepts a deprecated parameter **--container-runtime**, and the only valid value will be **remote** after the dockershim code is removed. This parameter was deprecated in 1.24 and later versions and is removed from Kubernetes 1.27.

Kubernetes 1.26

- HorizontalPodAutoscaler API for v2beta2 is removed.

  The autoscaling/v2beta2 API of HorizontalPodAutoscaler is no longer available in Kubernetes 1.26. For details, see **Removed APIs by release**. Use autoscaling/v2 API instead.
- The **flowcontrol.apiserver.k8s.io/v1beta1** API is removed.

  In Kubernetes 1.26 and later versions, the API of the **flowcontrol.apiserver.k8s.io/v1beta1** version for FlowSchema and PriorityLevelConfiguration is no longer served. For details, see **Removed APIs by release**. The **flowcontrol.apiserver.k8s.io/v1beta2** version is available in Kubernetes 1.23 and later versions, and the **flowcontrol.apiserver.k8s.io/v1beta3** version is available in Kubernetes 1.26 and later versions.
- The cloud service vendors' in-tree storage drivers are removed.
- The kube-proxy userspace mode is removed.

  The deprecated userspace mode is no longer supported by Linux or Windows. Linux users can use Iptables or IPVS, and Windows users can use the Kernelspace mode. Errors are returned if you use **--mode userspace**.

  - Windows winkernel kube-proxy no longer supports Windows HNS v1 APIs.

- **--prune-whitelist** flag is deprecated.

  The **--prune-whitelist** flag is **deprecated** and replaced by **--prune-allowlist** to support **Inclusive Naming Initiative**. This deprecated flag will be completely removed in later versions.

- The DynamicKubeletConfig feature gate is removed.

  The kubelet configuration of nodes can be dynamically updated through the API. The feature gate is removed from the kubelet in Kubernetes 1.24 and removed from the API server in Kubernetes 1.26. This simplifies the code and improves stability. It is recommended that you modify the kubelet configuration file instead and then restart the kubelet. For details, see **Remove DynamicKubeletConfig feature gate from the code**.

- A kube-apiserver command line parameter is removed.

  The **--master-service-namespace** parameter is deprecated. It is unused in the API Server.

- Several **kubectl run** parameters are deprecated.

  Several unused kubectl subcommands are marked as **deprecated** and will be removed in later versions. These subcommands include **--cascade**, **--filename**, **--force**, **--grace-period**, **--kustomize**, **--recursive**, **--timeout**, and **--wait**.

- Some command line parameters related to logging are removed.

  Some logging-related command line parameters are **removed**. These parameters were **deprecated** in earlier versions.

Enhanced Kubernetes 1.27 on CCE

During a version maintenance period, CCE periodically updates Kubernetes 1.27 and provides enhanced functions.

For details about cluster version updates, see **Release Notes for CCE Cluster Versions**.

References

For more details about the performance comparison and function evolution between Kubernetes 1.27 and other versions, see the following documents:

- **Kubernetes v1.27 Release Notes**
- **Kubernetes v1.26 Release Notes**

5.1.2.2 Kubernetes 1.25 Release Notes

CCE has passed the Certified Kubernetes Conformance Program and is a certified Kubernetes offering. This section describes the changes made in Kubernetes 1.25 compared with Kubernetes 1.23.

Indexes

- **New Features**
- **Deprecations and Removals**

- **Enhanced Kubernetes 1.25 on CCE**
- **References**

New Features

Kubernetes 1.25

- Pod Security Admission is stable. PodSecurityPolicy is deprecated.

  PodSecurityPolicy is replaced by Pod Security Admission. For details about the migration, see **Migrate from PodSecurityPolicy to the Built-In PodSecurity Admission Controller**.

- The ephemeral container is stable.

  An **ephemeral container** is a container that runs temporarily in an existing pod. It is useful for troubleshooting, especially when kubectl exec cannot be used to check a container that breaks down or its image lacks a debugging tool.

- Support for cgroups v2 enters the stable phase.

  Kubernetes supports cgroups v2. cgroups v2 provides some improvements over cgroup v1. For details, see **About cgroup v2**.

- SeccompDefault moves to beta.

  To enable this feature, add the startup parameter **--seccomp-default=true** to kubelet. In this way, **seccomp** is set to **RuntimeDefault** by default, improving system security. Clusters of v1.25 no longer support **seccomp.security.alpha.kubernetes.io/pod** and **container.seccomp.security.alpha.kubernetes.io/annotation**. Replace them with the **securityContext.seccompProfile** field in pods or containers. For details, see **Configure a Security Context for a Pod or Container**.

  NOTE

  After this feature is enabled, the system calls required by the application may be restricted by the runtime. Ensure that the debugging is performed in the test environment, so that application is not affected.

- The EndPort in the network policy moves to stable.

  EndPort in Network Policy is stable. This feature is incorporated in version 1.21. EndPort is added to NetworkPolicy. You can specify a port range.

- Local ephemeral storage capacity isolation is stable.

  This feature provides support for capacity isolation of local ephemeral storage between pods, such as EmptyDir. If a pod's consumption of shared resources exceeds the limit, it will be evicted.

- The CRD verification expression language moves to beta.

  This makes it possible to declare how to validate custom resources using **Common Expression Language (CEL)**. For details, see **Extend the Kubernetes API with CustomResourceDefinitions**.

- KMS v2 APIs are introduced.

  The KMS v2 alpha1 API is introduced to add performance, rotation, and observability improvements. This API uses AES-GCM to replace AES-CBC and uses DEK to encrypt data at rest (Kubernetes Secrets). No additional operation is required during this process. Additionally, data can be read

through AES-GCM and AES-CBC. For details, see **Using a KMS provider for data encryption**.

- Pod network readiness is introduced.

  Kubernetes 1.25 introduces Alpha support for PodHasNetwork. This status is in the **status** field of the pod. For details, see **Pod network readiness**.

- The two features used for application rollout are stable.
  - In Kubernetes 1.25, **minReadySeconds** for StatefulSets is stable. It allows each pod to wait for an expected period of time to slow down the rollout of a StatefulSet. For details, see **Minimum ready seconds**.
  - In Kubernetes 1.25, **maxSurge** for DaemonSets is stable. It allows a DaemonSet workload to run multiple instances of the same pod on one node during a rollout. This minimizes DaemonSet downtime for users. DaemonSet does not allow **maxSurge** and **hostPort** to be used at the same time because two active pods cannot share the same port on the same node. For details, see **Perform a Rolling Update on a DaemonSet**.
- Alpha support for running pods with user namespaces is provided.

  This feature maps the **root** user in a pod to a non-zero ID outside the container. In this way, the container runs as the **root** user and the node runs as a regular unprivileged user. This feature is still in the internal test phase. The UserNamespacesStatelessPodsSupport gate needs to be enabled, and the container runtime must support this function. For details, see **Kubernetes 1.25: alpha support for running Pods with user namespaces**.

Kubernetes 1.24

- Dockershim is removed from kubelet.

  Dockershim was marked deprecated in Kubernetes 1.20 and officially removed from kubelet in Kubernetes 1.24. If you want to use Docker container, switch to cri-dockerd or other runtimes that support CRI, such as containerd and CRI-O.

  NOTE

  Check whether there are agents or applications that depend on Docker Engine. For example, if **docker ps**, **docker run**, and **docker inspect** are used, ensure that multiple runtimes are compatible and switch to the standard CRI.

- Beta APIs are disabled by default.

  The Kubernetes community found 90% cluster administrators did not care about the beta APIs and left them enabled. However, the beta features are not recommended because these APIs enabled in the production environment by default incur risks. Therefore, in 1.24 and later versions, beta APIs are disabled by default, but the existing beta APIs will retain the original settings.

- OpenAPI v3 is supported.

  In Kubernetes 1.24 and later versions, OpenAPI V3 is enabled by default.

- Storage capacity tracking is stable.

  In Kubernetes 1.24 and later versions, the CSIStorageCapacity API supports exposing the available storage capacity. This ensures that pods are scheduled to nodes with sufficient storage capacity, which reduces pod scheduling delay caused by volume creation and mounting failures. For details, see **Storage Capacity**.

- gRPC container probe moves to beta.

  In Kubernetes 1.24 and later versions, the gRPC probe goes to beta. The feature gate GRPCContainerProbe is available by default. For details about how to use this probe, see **Configure Probes**.

- LegacyServiceAccountTokenNoAutoGeneration is enabled by default.

  LegacyServiceAccountTokenNoAutoGeneration moves to beta. By default, this feature is enabled, where no secret token is automatically generated for a service account. To use a token that never expires, create a secret to hold the token. For details, see **Service account token Secrets**.

- IP address conflict is prevented.

  In Kubernetes 1.24, **an IP address pool is soft reserved for the static IP addresses of Services**. After you manually enable this function, Service IP addresses will be automatically from the IP address pool to minimize IP address conflict.

- Clusters are compiled based on Go 1.18.

  Kubernetes clusters of versions later than 1.24 are compiled based on Go 1.18. By default, the SHA-1 hash algorithm, such as SHA1WithRSA and ECDSAWithSHA1, is no longer supported for certificate signature verification. Use the certificate generated by the SHA256 algorithm instead.

- The maximum number of unavailable StatefulSet replicas is configurable.

  In Kubernetes 1.24 and later versions, the **maxUnavailable** parameter can be configured for StatefulSets so that pods can be stopped more quickly during a rolling update.

- Alpha support for non-graceful node shutdown is introduced.

  The non-graceful node shutdown is introduced as alpha in Kubernetes v1.24. A node shutdown is considered graceful only if kubelet's node shutdown manager can detect the upcoming node shutdown action. For details, see **Non-graceful node shutdown handling**.

Deprecations and Removals

Kubernetes 1.25

- The iptables chain ownership is cleared up.

  Kubernetes typically creates iptables chains to ensure data packets can be sent to the destination. These iptables chains and their names are for internal use only. These chains were never intended to be part of any Kubernetes API/ABI guarantees. For details, see **Kubernetes's IPTables Chains Are Not API**.

  In versions later than Kubernetes 1.25, Kubelet uses IPTablesCleanup to migrate the Kubernetes-generated iptables chains used by the components outside of Kubernetes in phases so that iptables chains such as KUBE-MARK-DROP, KUBE-MARK-MASQ, and KUBE-POSTROUTING will not be created in the NAT table. For more details, see **Cleaning Up IPTables Chain Ownership**.

- In-tree volume drivers from cloud service vendors are removed.

Kubernetes 1.24

- In Kubernetes 1.24 and later versions, Service.Spec.LoadBalancerIP is deprecated because it cannot be used for dual-stack protocols. Instead, use custom annotations.

- In Kubernetes 1.24 and later versions, the **--address**, **--insecure-bind-address**, **--port**, and **--insecure-port=0** parameters are removed from **kube-apiserver**.
- In Kubernetes 1.24 and later versions, startup parameters **--port=0** and **--address** are removed from **kube-controller-manager** and **kube-scheduler**.
- In Kubernetes 1.24 and later versions, **kube-apiserver --audit-log-version** and **--audit-webhook-version** support only **audit.k8s.io/v1**. In Kubernetes 1.24, **audit.k8s.io/v1[alpha|beta]1** is removed, and only **audit.k8s.io/v1** can be used.
- In Kubernetes 1.24 and later versions, the startup parameter **--network-plugin** is removed from kubelet. This Docker-specific parameter is available only when the container runtime environment is **Docker** and it is deleted with Dockershim.
- In Kubernetes 1.24 and later versions, dynamic log clearance has been discarded and removed accordingly. A log filter is introduced to the logs of all Kubernetes system components to prevent sensitive information from being leaked through logs. However, this function may block logs and therefore is discarded. For more details, see **Dynamic log sanitization** and **KEP-1753**.
- VolumeSnapshot v1beta1 CRD is discarded in Kubernetes 1.20 and removed in Kubernetes 1.24. Use VolumeSnapshot v1 instead.
- In Kubernetes 1.24 and later versions, **service annotation tolerate-unready-endpoints** discarded in Kubernetes 1.11 is replaced by **Service.spec.publishNotReadyAddresses**.
- In Kubernetes 1.24 and later versions, the **metadata.clusterName** field is discarded and will be deleted in the next version.
- In Kubernetes 1.24 and later versions, the logic for kube-proxy to listen to NodePorts is removed. If NodePorts conflict with **kernel net.ipv4.ip_local_port_range**, TCP connections may fail occasionally, which leads to a health check failure or service exception. Before the upgrade, ensure that cluster NodePorts do not conflict with **net.ipv4.ip_local_port_range** of all nodes in the cluster. For more details, see **Kubernetes PR**.

Enhanced Kubernetes 1.25 on CCE

During a version maintenance period, CCE periodically updates Kubernetes 1.25 and provides enhanced functions.

For details about cluster version updates, see **Release Notes for CCE Cluster Versions**.

References

For more details about the performance comparison and function evolution between Kubernetes 1.25 and other versions, see the following documents:

- **Kubernetes v1.25 Release Notes**
- **Kubernetes v1.24 Release Notes**

5.1.2.3 Kubernetes 1.23 Release Notes

CCE has passed the Certified Kubernetes Conformance Program and is a certified Kubernetes offering. This section describes the updates in CCE Kubernetes 1.23.

Resource Changes and Deprecations

Kubernetes 1.23 Release Notes

- FlexVolume is deprecated. Use CSI.
- HorizontalPodAutoscaler v2 is promoted to GA, and HorizontalPodAutoscaler API v2 is gradually stable in version 1.23. The HorizontalPodAutoscaler v2beta2 API is not recommended. Use the v2 API.
- **PodSecurity** moves to beta, replacing the deprecated PodSecurityPolicy. PodSecurity is an admission controller that enforces pod security standards on pods in the namespace based on specific namespace labels that set the enforcement level. PodSecurity is enabled by default in version 1.23.

Kubernetes 1.22 Release Notes

- Ingresses no longer support networking.k8s.io/v1beta1 and extensions/v1beta1 APIs. If you use the API of an earlier version to manage ingresses, an application cannot be exposed to external services. Use networking.k8s.io/v1.
- CustomResourceDefinitions no longer support the apiextensions.k8s.io/v1beta1 API. If you use the API of an earlier version to create a CRD, the creation will fail, which affects the controller that reconciles this CRD. Use apiextensions.k8s.io/v1.
- ClusterRoles, ClusterRoleBindings, Roles, and RoleBindings no longer support the rbac.authorization.k8s.io/v1beta1 API. If you use the API of an earlier version to manage RBAC resources, application permissions control is affected and even cannot work in the cluster. Use rbac.authorization.k8s.io/v1.
- The Kubernetes release cycle is changed from four releases a year to three releases a year.
- StatefulSets support **minReadySeconds**.
- During scale-in, pods are randomly selected and deleted based on the pod UID by default (LogarithmicScaleDown). This feature enhances the randomness of the pods to be deleted and alleviates the problems caused by pod topology spread constraints. For more information, see **KEP-2185** and **issue 96748**.
- The **BoundServiceAccountTokenVolume** feature is stable, which has changed the method of mounting tokens into pods for enhanced token security of the service account. This feature is enabled by default in Kubernetes clusters of v1.21 and later versions.

References

For more details about the performance comparison and function evolution between Kubernetes 1.23 and other versions, see the following documents:

- **Kubernetes v1.23 Release Notes**
- **Kubernetes v1.22 Release Notes**

5.1.2.4 Kubernetes 1.21 Release Notes

CCE has passed the Certified Kubernetes Conformance Program and is a certified Kubernetes offering. This section describes the updates in CCE Kubernetes 1.21.

Resource Changes and Deprecations

Kubernetes 1.21 Release Notes

- CronJob is now in the stable state, and the version number changes to batch/v1.
- The immutable Secret and ConfigMap have now been upgraded to the stable state. A new immutable field is added to these objects to reject changes. The rejection protects clusters from accidental updates that may cause application outages. As these resources are immutable, kubelet does not monitor or poll for changes. This reduces the load of kube-apiserver and improves scalability and performance of your clusters. For more information, see **Immutable ConfigMaps**.
- Graceful node shutdown has been upgraded to the test state. With this update, kubelet can detect that a node is shut down and gracefully terminate the pods on the node. Prior to this update, when the node was shut down, its pod did not follow the expected termination lifecycle, which caused workload problems. Now kubelet can use systemd to detect the systems that are about to be shut down and notify the running pods to terminate them gracefully.
- For a pod with multiple containers, you can use **kubectl.kubernetes.io/** to pre-select containers.
- PodSecurityPolicy is deprecated. For details, see **https://kubernetes.io/blog/2021/04/06/podsecuritypolicy-deprecation-past-present-and-future/**.
- The **BoundServiceAccountTokenVolume** feature is in beta testing, which has changed the method of mounting tokens into pods for enhanced token security of the service account. This feature will be enabled by default in Kubernetes clusters of v1.21 and later versions.

Kubernetes 1.20 Release Notes

- The API priority and fairness have reached the test state and are enabled by default. This allows kube-apiserver to classify incoming requests by priority. For more information, see **API Priority and Fairness**.
- The bug of **exec probe timeouts** is fixed. Before this bug is fixed, the exec probe does not consider the **timeoutSeconds** field. Instead, the probe will run indefinitely, even beyond its configured deadline. It will stop until the result is returned. Now, if no value is specified, the default value is used, that is, one second. If the detection time exceeds one second, the application health check may fail. Update the **timeoutSeconds** field for the applications that use this feature during the upgrade. The repair provided by the newly introduced ExecProbeTimeout feature gating enables the cluster operator to restore the previous behavior, but this behavior will be locked and removed in later versions.
- RuntimeClass enters the stable state. RuntimeClass provides a mechanism to support multiple runtimes in a cluster and expose information about the container runtime to the control plane.
- kubectl debugging has reached the test state. kubectl debugging provides support for common debugging workflows.
- Dockershim was marked as deprecated in Kubernetes 1.20. Currently, you can continue to use Docker in the cluster. This change is irrelevant to the container image used by clusters. You can still use Docker to build your images. For more information, see **Dockershim Deprecation FAQ**.

References

For more details about the performance comparison and function evolution between Kubernetes 1.21 and other versions, see the following documents:

- **Kubernetes v1.21 Release Notes**
- **Kubernetes v1.20 Release Notes**

5.1.2.5 Kubernetes 1.19 (EOM) Release Notes

CCE has passed the Certified Kubernetes Conformance Program and is a certified Kubernetes offering. This section describes the updates in CCE Kubernetes 1.19.

Resource Changes and Deprecations

Kubernetes v1.19 Release Notes

- vSphere in-tree volumes can be migrated to vSphere CSI drivers. The in-tree vSphere Volume plugin is no longer used and will be deleted in later versions.
- **apiextensions.k8s.io/v1beta1** has been deprecated. You are advised to use **apiextensions.k8s.io/v1**.
- **apiregistration.k8s.io/v1beta1** has been deprecated. You are advised to use **apiregistration.k8s.io/v1**.
- **authentication.k8s.io/v1beta1** and **authorization.k8s.io/v1beta1** have been deprecated and will be removed from Kubernetes 1.22. You are advised to use **authentication.k8s.io/v1** and **authorization.k8s.io/v1**.
- **autoscaling/v2beta1** has been deprecated. You are advised to use **autoscaling/v2beta2**.
- **coordination.k8s.io/v1beta1** has been deprecated in Kubernetes 1.19 and will be removed from version 1.22. You are advised to use **coordination.k8s.io/v1**.
- kube-apiserver: The **componentstatus** API has been deprecated.
- kubeadm: The **kubeadm config view** command has been deprecated and will be deleted in later versions. Use **kubectl get cm -o yaml -n kube-system kubeadm-config** to directly obtain the kubeadm configuration.
- kubeadm: The **kubeadm alpha kubelet config enable-dynamic** command has been deprecated.
- kubeadm: The **--use-api** flag in the **kubeadm alpha certs renew** command has been deprecated.
- Kubernetes no longer supports **hyperkube** image creation.
- The **--export** flag is removed from the **kubectl get** command.
- The alpha feature **ResourceLimitsPriorityFunction** has been deleted.
- **storage.k8s.io/v1beta1** has been deprecated. You are advised to use **storage.k8s.io/v1**.

Kubernetes v1.18 Release Notes

- kube-apiserver
  - All resources in the **apps/v1beta1** and **apps/v1beta2** API versions are no longer served. You can use the **apps/v1** API version.

  - DaemonSets, Deployments, and ReplicaSets in the **extensions/v1beta1** API version are no longer served. You can use the **apps/v1** API version.
  - NetworkPolicies in the **extensions/v1beta1** API version are no longer served. You can use the **networking.k8s.io/v1** API version.
  - PodSecurityPolicies in the **extensions/v1beta1** API version are no longer served. Migrate to use the **policy/v1beta1** API version.
- kubelet
  - **--redirect-container-streaming** is not recommended and will be deprecated in v1.20.
  - The resource measurement endpoint **/metrics/resource/v1alpha1** and all measurement standards under this endpoint have been deprecated. Use the measurement standards under the endpoint **/metrics/resource** instead:
    - scrape_error --> scrape_error
    - node_cpu_usage_seconds_total --> node_cpu_usage_seconds
    - node_memory_working_set_bytes --> node_memory_working_set_bytes
    - container_cpu_usage_seconds_total --> container_cpu_usage_seconds
    - container_memory_working_set_bytes --> container_memory_working_set_bytes
    - scrape_error --> scrape_error
  - In future releases, kubelet will no longer create the target directory **CSI NodePublishVolume** according to the CSI specifications. You may need to update the CSI driver accordingly to correctly create and process the target path.
- kube-proxy
  - You are not advised to use the **--healthz-port** and **--metrics-port** flags. Use **--healthz-bind-address** and **--metrics-bind-address** instead.
  - The **EndpointSliceProxying** function option is added to control the use of EndpointSlices in kube-proxy. This function is disabled by default.
- kubeadm
  - The **--kubelet-version** flag of **kubeadm upgrade node** has been deprecated and will be deleted in later versions.
  - The **--use-api** flag in the **kubeadm alpha certs renew** command has been deprecated.
  - kube-dns has been deprecated and will no longer be supported in future versions.
  - The ClusterStatus structure in the kubeadm-config ConfigMap has been deprecated and will be deleted in later versions.
- kubectl
  - You are not advised to use boolean and unset values for **--dry-run**. **server|client|none** is used in the new version.
  - **--server-dry-run** has been deprecated for **kubectl apply** and replaced by **--dry-run=server**.

- add-ons

The cluster-monitoring add-on is deleted.

- kube-scheduler
  - The **scheduling_duration_seconds** metric has been deprecated.
  - The **scheduling_algorithm_predicate_evaluation_seconds** and **scheduling_algorithm_priority_evaluation_seconds** metrics are no longer used and are replaced by **framework_extension_point_duration_seconds[extension_point="Filter"]** and **framework_extension_point_duration_seconds[extension_point="Score"]**.
  - The scheduler policy AlwaysCheckAllPredictes has been deprecated.
- Other changes
  - The k8s.io/node-api component is no longer updated. Instead, you can use the **RuntimeClass** type in **k8s.io/api** and the generated clients in **k8s.io/client-go**.
  - The **client** label has been deleted from **apiserver_request_total**.

References

For more details about the performance comparison and function evolution between Kubernetes 1.19 and other versions, see the following documents:

- **Kubernetes v1.19.0 Release Notes**
- **Kubernetes v1.18.0 Release Notes**

5.1.2.6 Kubernetes 1.17 (EOM) Release Notes

CCE has passed the Certified Kubernetes Conformance Program and is a certified Kubernetes offering. This section describes the updates in CCE Kubernetes 1.17.

Resource Changes and Deprecations

- All resources in the **apps/v1beta1** and **apps/v1beta2** API versions are no longer served. Migrate to use the **apps/v1** API version.
- DaemonSets, Deployments, and ReplicaSets in the **extensions/v1beta1** API version are no longer served. You can use the **apps/v1** API version.
- NetworkPolicies in the **extensions/v1beta1** API version are no longer served. Migrate to use the **networking.k8s.io/v1** API version.
- PodSecurityPolicies in the **extensions/v1beta1** API version are no longer served. Migrate to use the **policy/v1beta1** API version.
- Ingresses in the **extensions/v1beta1** API version will no longer be served in v1.20. Migrate to use the **networking.k8s.io/v1beta1** API version.
- PriorityClass in the **scheduling.k8s.io/v1beta1** and **scheduling.k8s.io/v1alpha1** API versions is no longer served in v1.17. Migrate to use the **scheduling.k8s.io/v1** API version.
- The **event series.state** field in the **events.k8s.io/v1beta1** API version has been deprecated and will be removed from v1.18.

- **CustomResourceDefinition** in the **apiextensions.k8s.io/v1beta1** API version has been deprecated and will no longer be served in v1.19. Use the **apiextensions.k8s.io/v1** API version.
- **MutatingWebhookConfiguration** and **ValidatingWebhookConfiguration** in the **admissionregistration.k8s.io/v1beta1** API version have been deprecated and will no longer be served in v1.19. You can use the **admissionregistration.k8s.io/v1** API version.
- The **rbac.authorization.k8s.io/v1alpha1** and **rbac.authorization.k8s.io/v1beta1** API versions have been deprecated and will no longer be served in v1.20. Use the **rbac.authorization.k8s.io/v1** API version.
- The **CSINode** object of **storage.k8s.io/v1beta1** has been deprecated and will be removed in later versions.

Other Deprecations and Removals

- **OutOfDisk node condition** is removed in favor of **DiskPressure**.
- The **scheduler.alpha.kubernetes.io/critical-pod** annotation is removed in favor of **priorityClassName**.
- **beta.kubernetes.io/os** and **beta.kubernetes.io/arch** have been deprecated in v1.14 and will be removed in v1.18.
- Do not use **--node-labels** to set labels prefixed with **kubernetes.io** and **k8s.io**. The **kubernetes.io/availablezone** label in earlier versions is removed in v1.17 and changed to **failure-domain.beta.kubernetes.io/zone**.
- The **beta.kubernetes.io/instance-type** is deprecated in favor of **node.kubernetes.io/instance-type**.
- Remove the **{kubelet_root_dir}/plugins** path.
- Remove the built-in cluster roles **system:csi-external-provisioner** and **system:csi-external-attacher**.

References

For more details about the performance comparison and function evolution between Kubernetes 1.17 and other versions, see the following documents:

- **Kubernetes v1.17.0 Release Notes**
- **Kubernetes v1.16.0 Release Notes**

5.1.3 Patch Version Release Notes

Version 1.27

NOTICE

In CCE v1.27 and later versions, all nodes support only the containerd container engine.

Table 5-2 Release notes for the v1.27 patch

CCE Cluster Patch Version	Kubernetes Version	Feature Updates	Optimization	Vulnerability Fixing
v1.27.3-r4	v1.27.4	None	None	Fixed CVE-2024-21626 issues.
v1.27.2-r0	v1.27.2	• Volcano supports node pool affinity scheduling. • Volcano supports workload rescheduling.	None	Fixed some security issues.
v1.27.1-r10	v1.27.2	None	Optimized the events generated during node pool scaling.	Fixed some security issues.
v1.27.1-r0	v1.27.2	CCE clusters of v1.27 are released for the first time. For more information, see Kubernetes 1.27 Release Notes. • Both soft eviction and hard eviction are supported in node pool configurations.	None	None

Version 1.25

NOTICE

All nodes in the CCE clusters of version 1.25, except the ones running EulerOS 2.5, use containerd by default.

Table 5-3 Release notes for the v1.25 patch

CCE Cluster Patch Version	Kubernetes Version	Feature Updates	Optimization	Vulnerability Fixing
v1.25.6-r4	v1.25.10	None	None	Fixed CVE-2024-21626 issues.
v1.25.5-r0	v1.25.5	• Volcano supports node pool affinity scheduling. • Volcano supports workload rescheduling.	None	Fixed some security issues.
v1.25.4-r10	v1.25.5	None	Optimized the events generated during node pool scaling.	Fixed some security issues.
v1.25.4-r0	v1.25.5	• Both soft eviction and hard eviction are supported in node pool configurations. • TMS tags can be added to automatically created EVS disks to facilitate cost management.	None	Fixed some security issues.
v1.25.3-r10	v1.25.5	The timeout interval can be configured for a load balancer.	High-frequency parameters of kube-apiserver are configurable.	Fixed some security issues.
v1.25.1-r0	v1.25.5	CCE clusters of v1.25 are released for the first time. For more information, see **Kubernetes 1.25 Release Notes**.	None	None

Version 1.23

Table 5-4 Release notes for the v1.23 patch

CCE Cluster Patch Version	Kubernetes Version	Feature Updates	Optimization	Vulnerability Fixing
v1.23.11-r4	v1.23.17	None	None	Fixed CVE-2024-21626 issues.
v1.23.10-r0	v1.23.11	• Volcano supports node pool affinity scheduling. • Volcano supports workload rescheduling.	None	Fixed some security issues.
v1.23.9-r10	v1.23.11	None	Optimized the events generated during node pool scaling.	Fixed some security issues.
v1.23.9-r0	v1.23.11	• Both soft eviction and hard eviction are supported in node pool configurations. • TMS tags can be added to automatically created EVS disks to facilitate cost management.	None	Fixed some security issues.
v1.23.8-r10	v1.23.11	The timeout interval can be configured for a load balancer.	High-frequency parameters of kube-apiserver are configurable.	Fixed some security issues.
v1.23.8-r0	v1.23.11	None	• Enhanced Docker reliability during upgrades. • Optimized node time synchronization.	Fixed some security issues.

CCE Cluster Patch Version	Kubernetes Version	Feature Updates	Optimization	Vulnerability Fixing
v1.23.5-r0	v1.23.11	• Fault detection and isolation are supported on GPU nodes. • Security groups can be customized by cluster. • containerd is supported.	• Upgraded the etcd version of the master node to the Kubernetes version 3.5.6. • Optimized scheduling so that pods are evenly distributed across AZs after pods are scaled in. • Optimized the memory usage of kube-apiserver when CRDs are frequently updated.	Fixed some security issues and the following CVE vulnerabilities: • CVE-2022-3294 • CVE-2022-3162 • CVE-2022-3172 • CVE-2021-25749
v1.23.1-r0	v1.23.4	CCE clusters of v1.23 are released for the first time. For more information, see Kubernetes 1.23 Release Notes.	None	None

Version 1.21

Table 5-5 Release notes for the v1.21 patch

CCE Cluster Patch Version	Kubernetes Version	Feature Updates	Optimization	Vulnerability Fixing
v1.21.12-r4	v1.21.14	None	None	Fixed CVE-2024-21626 issues.
v1.21.11-r20	v1.21.14	• Volcano supports node pool affinity scheduling. • Volcano supports workload rescheduling.	None	Fixed some security issues.
v1.21.11-r10	v1.21.14	None	Optimized the events generated during node pool scaling.	Fixed some security issues.
v1.21.11-r0	v1.21.14	• Both soft eviction and hard eviction are supported in node pool configurations. • TMS tags can be added to automatically created EVS disks to facilitate cost management.	None	Fixed some security issues.
v1.21.10-r10	v1.21.14	The timeout interval can be configured for a load balancer.	High-frequency parameters of kube-apiserver are configurable.	Fixed some security issues.

CCE Cluster Patch Version	Kubernetes Version	Feature Updates	Optimization	Vulnerability Fixing
v1.21.10-r0	v1.21.14	None	• Enhanced Docker reliability during upgrades. • Optimized node time synchronization. • Enhanced the stability of the Docker runtime for pulling images after nodes are restarted.	Fixed some security issues.
v1.21.7-r0	v1.21.14	• Fault detection and isolation are supported on GPU nodes. • Security groups can be customized by cluster.	Improved the stability of LoadBalancer Services/ingresses with a large number of connections.	Fixed some security issues and the following CVE vulnerabilities: • CVE-2022-3294 • CVE-2022-3162 • CVE-2022-3172
v1.21.1-r0	v1.21.7	CCE clusters of v1.21 are released for the first time. For more information, see Kubernetes 1.21 Release Notes.	None	None

Version 1.19

Table 5-6 Release notes for the v1.19 patch

CCE Cluster Patch Version	Kubernetes Version	Feature Updates	Optimization	Vulnerability Fixing
1.19.16-r84	v1.19.16	None	None	Fixed CVE-2024-21626 issues.
v1.19.16-r60	v1.19.16	• Volcano supports node pool affinity scheduling. • Volcano supports workload rescheduling.	None	Fixed some security issues.
v1.19.16-r50	v1.19.16	None	Optimized the events generated during node pool scaling.	Fixed some security issues.
v1.19.16-r40	v1.19.16	• Both soft eviction and hard eviction are supported in node pool configurations. • TMS tags can be added to automatically created EVS disks to facilitate cost management.	None	Fixed some security issues.
v1.19.16-r30	v1.19.16	The timeout interval can be configured for a load balancer.	High-frequency parameters of kube-apiserver are configurable.	Fixed some security issues.
v1.19.16-r20	v1.19.16	None	• Enhanced the stability of the Docker runtime for pulling images after nodes are restarted.	Fixed some security issues.

CCE Cluster Patch Version	Kubernetes Version	Feature Updates	Optimization	Vulnerability Fixing
v1.19.16-r4	v1.19.16	• Fault detection and isolation are supported on GPU nodes. • Security groups can be customized by cluster.	• Scheduling is optimized on taint nodes. • Enhanced the long-term running stability of containerd when cores are bound. • Improved the stability of LoadBalancer Services/ingresses with a large number of connections. • Optimized the memory usage of kube-apiserver when CRDs are frequently updated.	Fixed some security issues and the following CVE vulnerabilities: • CVE-2022-3294 • CVE-2022-3162 • CVE-2022-3172
v1.19.16-r0	v1.19.16	None	Enhanced the stability in updating LoadBalancer Services when workloads are upgraded and nodes are scaled in or out.	Fixed some security issues and the following CVE vulnerabilities: • CVE-2021-25741 • CVE-2021-25737
v1.19.10-r0	v1.19.10	CCE clusters of v1.19 are released for the first time. For more information, see Kubernetes 1.19 Release Notes.	None	None

5.2 Buying a Cluster

5.2.1 Buying a CCE Standard Cluster

On the CCE console, you can easily create Kubernetes clusters. After a cluster is created, the master node is hosted by CCE. You only need to create worker nodes. In this way, you can implement cost-effective O&M and efficient service deployment.

Constraints

- During the node creation, software packages are downloaded from OBS using the domain name. A private DNS server must be used to resolve the OBS domain name. Therefore, the DNS server address of the subnet where the node resides must be set to the private DNS server address so that the node can access the private DNS server. When you create a subnet, the private DNS server is used by default. If you change the subnet DNS, ensure that the DNS server in use can resolve the OBS domain name.
- You can create a maximum of 50 clusters in a single region.
- After a cluster is created, the following items cannot be changed:
  - Cluster type
  - Number of master nodes in the cluster
  - AZ of a master node
  - Network configurations of the cluster, such as the VPC, subnet, Service CIDR block, and kube-proxy settings.
  - Network model. For example, change **Tunnel network** to **VPC network**.

Step 1: Log In to the CCE Console

Step 1 Log in to the CCE console.

Step 2 On the **Clusters** page, click **Buy Cluster** in the upper right corner.

----End

Step 2: Configure the Cluster

On the **Buy Cluster** page, configure the parameters.

Basic Settings

Parameter	Description
Billing Mode	Select a billing mode for the cluster as required. • **Pay-per-use**: a postpaid billing mode. It is suitable in scenarios where resources will be billed based on usage frequency and duration. You can provision or delete resources at any time.

Parameter	Description
Cluster Name	Enter a cluster name. Cluster names under the same account must be unique.
Enterprise Project	This parameter is available only for enterprise users who have enabled an enterprise project. After an enterprise project (for example, **default**) is selected, the cluster, nodes in the cluster, cluster security groups, node security groups, and EIPs of the automatically created nodes will be created in this enterprise project. After the cluster is created, do not modify the enterprise projects of nodes, cluster security groups, and node security groups in the cluster. Enterprise projects facilitate project-level management and grouping of cloud resources and users.
Cluster Version	Select the Kubernetes version used by the cluster.
Cluster Scale	Select a cluster scale for your cluster as required. These values specify the maximum number of nodes that can be managed by the cluster.
Master Nodes	Select the number of master nodes. The master nodes are automatically hosted by CCE and deployed with Kubernetes cluster management components such as kube-apiserver, kube-controller-manager, and kube-scheduler. ● **3 Masters**: Three master nodes will be created for high cluster availability. ● **Single**: Only one master node will be created in your cluster. You can also select AZs for the master nodes. By default, AZs are allocated automatically for the master nodes. ● **Automatic**: Master nodes are randomly distributed in different AZs for cluster DR. If the number of available AZs is less than the number of nodes to be created, CCE will create the nodes in the AZs with sufficient resources to preferentially ensure cluster creation. In this case, AZ-level DR may not be ensured. ● **Custom**: Master nodes are deployed in specific AZs. If there is one master node in your cluster, you can select one AZ for the master node. If there are multiple master nodes in your cluster, you can select multiple AZs for the master nodes. – **AZ**: Master nodes are deployed in different AZs for cluster DR. – **Host**: Master nodes are deployed on different hosts in the same AZ for cluster DR. – **Custom**: Master nodes are deployed in the AZs you specified.

Network Settings

The network settings cover nodes, containers, and Services. For details about the cluster networking and container network models, see **Overview**.

Table 5-7 Network settings

Parameter	Description
VPC	Select the VPC to which the cluster belongs. If no VPC is available, click **Create VPC** to create one. The value cannot be changed after the cluster is created.
Subnet	Select the subnet to which the master nodes belong. If no subnet is available, click **Create Subnet** to create one. The value cannot be changed after the cluster is created.
Default Security Group	Select the security group automatically generated by CCE or use the existing one as the default security group of the node. **NOTICE** The default security group must allow traffic from certain ports to ensure normal communication. Otherwise, the node cannot be created.

Table 5-8 Network settings

Parameter	Description
Network Model	Select **VPC network** or **Tunnel network** for your CCE standard cluster. For more information about their differences, see **Overview**.
Container CIDR Block (configured for CCE standard clusters)	Configure the CIDR block used by containers. The value determines the maximum number of containers in your cluster.

Table 5-9 Service network

Parameter	Description
Service CIDR Block	Configure the Service CIDR blocks for containers in the same cluster to access each other. The value determines the maximum number of Services you can create. The value cannot be changed after the cluster is created.

Parameter	Description
Request Forwarding	Select **IPVS** or **iptables** for your cluster. For details, see **Comparing iptables and IPVS**. • iptables is the traditional kube-proxy mode. This mode applies to the scenario where the number of Services is small or a large number of short connections are concurrently sent on the client. IPv6 clusters do not support iptables. • IPVS allows higher throughput and faster forwarding. This mode applies to scenarios where the cluster scale is large or the number of Services is large.

(Optional) Advanced Settings

Parameter	Description
Certificate Authentication	• If **Automatically generated** is selected, the X509-based authentication mode will be enabled by default. X509 is a commonly used certificate format. • If **Bring your own** is selected, the cluster can identify users based on the header in the request body for authentication. Upload your CA root certificate, client certificate, and private key. **CAUTION** • Upload a file **smaller than 1 MB**. The CA certificate and client certificate can be in **.crt** or **.cer** format. The private key of the client certificate can only be uploaded **unencrypted**. • The validity period of the client certificate must be longer than five years. • The uploaded CA root certificate is used by the authentication proxy and for configuring the kube-apiserver aggregation layer. **If any of the uploaded certificates is invalid, the cluster cannot be created.** • Starting from v1.25, Kubernetes no longer supports certificate authentication generated using the SHA1WithRSA or ECDSAWithSHA1 algorithm. The certificate authentication generated using the SHA256 algorithm is supported instead.
CPU Management	If enabled, exclusive CPU cores can be allocated to workload pods. For details, see **CPU Policy**.
Overload Control	After this function is enabled, concurrent requests 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**.

Parameter	Description
Resource Tag	You can add resource tags to classify resources. You can create **predefined tags** on the TMS console. The predefined tags are available to all resources that support tags. You can use predefined tags to improve the tag creation and resource migration efficiency. Key specifications: • Cannot be empty. Contains 1 to 128 single-byte characters. • Do not enter labels starting with **_sys_**, which are system labels. • Can contain UTF-8 letters, digits, spaces, and the following characters: _. : / = + - @ Recommended regular expression: ^((?!_sys_)[\\p{L}\\p{Z}\\p{N}_.:\\/=+\\-@]*)$ Value specifications: • Can contain up to 255 characters. • Can contain UTF-8 letters, digits, spaces, and the following characters: _. : / = + - @ Recommended regular expression: ^([\p{L}\p{Z}\p{N}_.:\/=+\-@]*)$ • The value can be empty or null. • The value of a predefined tag cannot be empty or null.
Description	You can enter description for the cluster. A maximum of 200 characters are allowed.

Step 3: Select Add-ons

Click **Next: Select Add-on**. On the page displayed, select the add-ons to be installed during cluster creation.

Basic capabilities

Add-on Name	Description
CCE Container Network (Yangtse CNI)	This is the basic cluster add-on. It provides network connectivity, Internet access, and security isolation for pods in your cluster.
CCE Container Storage (Everest)	This add-on (**CCE Container Storage (Everest)**) is installed by default. It is a cloud native container storage system based on CSI and supports cloud storage services such as EVS.
CoreDNS	This add-on (**CoreDNS**) is installed by default. It provides DNS resolution for your cluster and can be used to access the in-cloud DNS server.

Add-on Name	Description
NodeLocal DNSCache	(Optional) If selected, this add-on (**NodeLocal DNSCache**) will be automatically installed. NodeLocal DNSCache improves cluster DNS performance by running a DNS caching agent on cluster nodes.

Observability

Add-on Name	Description
CCE Node Problem Detector	(Optional) If selected, this add-on (**CCE Node Problem Detector**) will be automatically installed to detect faults and isolate nodes for prompt cluster troubleshooting.

Step 4: Configure Add-ons

Click **Next: Add-on Configuration**.

Basic capabilities

Add-on Name	Description
CCE Container Network (Yangtse CNI)	This add-on is unconfigurable.
CCE Container Storage (Everest)	This add-on is unconfigurable. After the cluster is created, choose **Add-ons** in the navigation pane of the cluster console and modify the configuration.
CoreDNS	This add-on is unconfigurable. After the cluster is created, choose **Add-ons** in the navigation pane of the cluster console and modify the configuration.
NodeLocal DNSCache	This add-on is unconfigurable. After the cluster is created, choose **Add-ons** in the navigation pane of the cluster console and modify the configuration.

Observability

Add-on Name	Description
CCE Node Problem Detector	This add-on is unconfigurable. After the cluster is created, choose **Add-ons** in the navigation pane of the cluster console and modify the configuration.

Step 5: Confirm the Configuration

After the parameters are specified, click **Next: Confirm configuration**. The cluster resource list is displayed. Confirm the information and click **Submit**.

It takes about 5 to 10 minutes to create a cluster. You can click **Back to Cluster List** to perform other operations on the cluster or click **Go to Cluster Events** to view the cluster details.

Related Operations

- After creating a cluster, you can use the Kubernetes command line (CLI) tool kubectl to connect to the cluster. For details, see **Connecting to a Cluster Using kubectl**.
- Add nodes to the cluster. For details, see **Creating a Node**.

5.2.2 Comparing iptables and IPVS

kube-proxy is a key component of a Kubernetes cluster. It is used for load balancing and forwarding data between a Service and its backend pods.

CCE supports the iptables and IP Virtual Server (IPVS) forwarding modes.

Feature Difference	iptables	IPVS
Positioning	iptables is a mature and stable kube-proxy mode, but its performance is average. It applies to scenarios where the number of services is small (less than 1000) or there are a large number of short concurrent connections on the client. For details, see **iptables**.	IPVS is a high-performance kube-proxy mode. It applies to scenarios where the cluster scale is large or the number of Services is large. For details, see **IPVS**.
Throughput	Relatively low	Relatively high
Complexity	O(n). *n* increases with the number of Services and backend pods in the cluster.	O(1). In most cases, the connection processing efficiency is irrelevant to the cluster scale.

Feature Difference	iptables	IPVS
Load balancing algorithm	iptables has only one algorithm for random selection.	IPVS involves multiple load balancing algorithms, such as round-robin, shortest expected delay, least connections, and various hashing methods.
ClusterIP connectivity	The internal IP address in the cluster cannot be pinged.	The internal IP address in the cluster can be pinged. **NOTE** The IP address in clusters of v1.27 or later cannot be pinged due to **security hardening**.
Additional restrictions	When there are more than 1000 Services in the cluster, network delay may occur.	• If an ingress and a Service use the same load balancer, the ingress cannot be accessed from the nodes and containers in the cluster because kube-proxy mounts the LoadBalancer Service address to the ipvs-0 bridge. This bridge intercepts the traffic of the load balancer used by the ingress. Use different load balancers for the ingress and Service.

iptables

iptables is a Linux kernel function for processing and filtering a large amount of data packets. It allows flexible sequences of rules to be attached to various hooks in the packet processing pipeline. When iptables is used, kube-proxy implements NAT and load balancing in the NAT pre-routing hook. For each Service, kube-proxy installs an iptables rule which captures the traffic destined for the Service's ClusterIP and ports and redirects the traffic to one of the backend pods. By default, iptables randomly selects a backend pod. For details, see **iptables proxy mode**.

IPVS

IPVS is constructed on top of Netfilter and balances transport-layer loads as part of the Linux kernel. IPVS can direct requests for TCP- or UDP-based services to the real servers, and make services of the real servers appear as virtual services on a single IP address.

In the IPVS mode, kube-proxy uses IPVS load balancing instead of iptables. IPVS is designed to balance loads for a large number of Services. It has a set of optimized APIs and uses optimized search algorithms instead of simply searching for rules from a list. For details, see **IPVS proxy mode**.

5.3 Connecting to a Cluster

5.3.1 Connecting to a Cluster Using kubectl

Scenario

This section uses a CCE standard cluster as an example to describe how to access a CCE cluster using kubectl.

Permissions

When you access a cluster using kubectl, CCE uses **kubeconfig** generated on the cluster for authentication. This file contains user information, based on which CCE determines which Kubernetes resources can be accessed by kubectl. The permissions recorded in a **kubeconfig** file vary from user to user.

For details about user permissions, see **Cluster Permissions (IAM-based) and Namespace Permissions (Kubernetes RBAC-based)**.

Using kubectl

To connect to a Kubernetes cluster from a PC, you can use kubectl, a Kubernetes command line tool. You can log in to the CCE console and click the name of the target cluster to access the cluster console. On the **Overview** page, view the access address and kubectl connection procedure.

CCE allows you to access a cluster through a private network or a public network.

- Intranet access: The client that accesses the cluster must be in the same VPC as the cluster.
- Public access: The client that accesses the cluster must be able to access public networks and the cluster has been bound with a public network IP.

NOTICE

To bind an EIP to the cluster, go to the **Overview** page and click **Bind** next to **EIP** in the **Connection Information** area. In a cluster with an EIP bound, kube-apiserver will be exposed to the Internet and may be attacked. To solve this problem, you can configure Advanced Anti-DDoS for the EIP of the node on which kube-apiserver runs.

Download kubectl and the configuration file. Copy the file to your client, and configure kubectl. After the configuration is complete, you can access your Kubernetes clusters. Procedure:

Step 1 Download kubectl.

Prepare a computer that can access the public network and install kubectl in CLI mode. You can run the **kubectl version** command to check whether kubectl has been installed. If kubectl has been installed, skip this step.

This section uses the Linux environment as an example to describe how to install and configure kubectl. For details, see **Installing kubectl**.

1. Log in to your client and download kubectl.
   ```
   cd /home
   curl -LO https://dl.k8s.io/release/{v1.25.0}/bin/linux/amd64/kubectl
   ```
   {v1.25.0} specifies the version number. Replace it as required.
2. Install kubectl.
   ```
   chmod +x kubectl
   mv -f kubectl /usr/local/bin
   ```

Step 2 Obtain the kubectl configuration file (kubeconfig).

On the **Overview** page, locate the **Connection Info** area, click **Configure** next to **kubectl**. On the page displayed, download the configuration file.

NOTE

- The kubectl configuration file **kubeconfig** is used for cluster authentication. If the file is leaked, your clusters may be attacked.
- The Kubernetes permissions assigned by the configuration file downloaded by IAM users are the same as those assigned to the IAM users on the CCE console.
- If the KUBECONFIG environment variable is configured in the Linux OS, kubectl preferentially loads the KUBECONFIG environment variable instead of **$home/.kube/config**.

Step 3 Configure kubectl.

Configure kubectl (A Linux OS is used).

1. Log in to your client and copy the **kubeconfig.yaml** file downloaded in **Step 2** to the **/home** directory on your client.
2. Configure the kubectl authentication file.
   ```
   cd /home
   mkdir -p $HOME/.kube
   mv -f kubeconfig.yaml $HOME/.kube/config
   ```
3. Switch the kubectl access mode based on service scenarios.
   - Run this command to enable intra-VPC access:
     ```
     kubectl config use-context internal
     ```
   - Run this command to enable public access (EIP required):
     ```
     kubectl config use-context external
     ```
   - Run this command to enable public access and two-way authentication (EIP required):
     ```
     kubectl config use-context externalTLSVerify
     ```
     For details about the cluster two-way authentication, see **Two-Way Authentication for Domain Names**.

----End

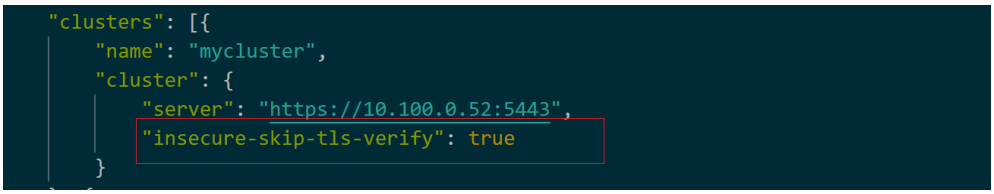
Two-Way Authentication for Domain Names

CCE supports two-way authentication for domain names.

- After an EIP is bound to an API Server, two-way domain name authentication is disabled by default if kubectl is used to access the cluster. You can run **kubectl config use-context externalTLSVerify** to enable the two-way domain name authentication.

- When an EIP is bound to or unbound from a cluster, or a custom domain name is configured or updated, the cluster server certificate will be added the latest cluster access address (including the EIP bound to the cluster and all custom domain names configured for the cluster).
- Asynchronous cluster synchronization takes about 5 to 10 minutes. You can view the synchronization result in **Synchronize Certificate** in **Operation Records**.
- For a cluster that has been bound to an EIP, if the authentication fails (x509: certificate is valid) when two-way authentication is used, bind the EIP again and download **kubeconfig.yaml** again.
- If the two-way domain name authentication is not supported, **kubeconfig.yaml** contains the **"insecure-skip-tls-verify": true** field, as shown in **Figure 5-1**. To use two-way authentication, download the **kubeconfig.yaml** file again and enable two-way authentication for the domain names.

Figure 5-1 Two-way authentication disabled for domain names



FAQs

- **Error from server Forbidden**

  When you use kubectl to create or query Kubernetes resources, the following output is returned:

  ```
  # 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"
  ```

  The cause is that the user does not have the permissions to operate the Kubernetes resources. For details about how to assign permissions, see **Namespace Permissions (Kubernetes RBAC-based)**.

- **The connection to the server localhost:8080 was refused**

  When you use kubectl to create or query Kubernetes resources, the following output is returned:

  ```
  The connection to the server localhost:8080 was refused - did you specify the right host or port?
  ```

  The cause is that cluster authentication is not configured for the kubectl client. For details, see **Step 3**.

5.3.2 Connecting to a Cluster Using an X.509 Certificate

Scenario

This section describes how to obtain the cluster certificate from the console and use it access Kubernetes clusters.

Procedure

Step 1 Log in to the CCE console and click the cluster name to access the cluster console.

Step 2 On the **Overview** page, locate the **Connection Info** area, and click **Download** next to **X.509 certificate**.

Step 3 In the **Obtain Certificate** dialog box displayed, select the certificate expiration time and download the X.509 certificate of the cluster as prompted.

NOTICE

- The downloaded certificate contains three files: **client.key**, **client.crt**, and **ca.crt**. Keep these files secure.
- Certificates are not required for mutual access between containers in a cluster.

Step 4 Call native Kubernetes APIs using the cluster certificate.

For example, run the **curl** command to call an API to view the pod information. In the following information, *192.168.0.18:5443* indicates the IP address of the API server in the cluster.

```
curl --cacert ./ca.crt --cert ./client.crt --key ./client.key  https://192.168.0.18:5443/api/v1/namespaces/default/pods/
```

For more cluster APIs, see **Kubernetes APIs**.

----End

5.3.3 Accessing a Cluster Using a Custom Domain Name

Scenario

Subject Alternative Name (SAN) allows multiple values (including IP addresses, domain names, and so on) to be associated with certificates. A SAN is usually used by the client to verify the server validity in TLS handshakes. Specifically, the validity check includes whether the server certificate is issued by a CA trusted by the client and whether the SAN in the certificate matches the IP address or DNS domain name that the client actually accesses.

If the client cannot directly access the private IP or EIP of the cluster, you can sign the IP address or DNS domain name that can be directly accessed by the client into the cluster server certificate as a SAN to enable two-way authentication on the client, which improves security. Typical use cases include DNAT access and domain name access.

If you have particular proxy access requirements or need to access resources in other regions, you can customize a SAN. Typical domain name access scenarios:

- Add the response domain name mapping when specifying the DNS domain name address in the host domain name configuration on the client, or configuring **/etc/hosts** on the client host.
- Use domain name access in the intranet. DNS allows you to configure mappings between cluster EIPs and custom domain names. After an EIP is updated, you can continue to use two-way authentication and the domain

name to access the cluster without downloading the **kubeconfig.json** file again.

- Add A records on a self-built DNS server.

Constraints

This feature is available only to clusters of v1.19 and later.

Customizing a SAN

Step 1 Log in to the CCE console.

Step 2 Click the target cluster in the cluster list to go to the cluster details page.

Step 3 In the **Connection Information** area, click next to **Custom SAN**. In the dialog box displayed, enter the IP address or domain name and click **Save**.

NOTE

1. This operation will restart kube-apiserver and update the **kubeconfig.json** file for a short period of time. Do not perform operations on the cluster during this period.

2. A maximum of 128 domain names or IP addresses, separated by commas (,), are allowed.

3. If a custom domain name needs to be bound to an EIP, ensure that an EIP has been configured.

----End

Connecting to a Cluster Using the SAN

Using kubectl to access the cluster

Step 1 Download the **kubeconfig.json** file again after the SAN is modified.

1. Log in to the CCE console and click the cluster name to access the cluster console.
2. On the **Overview** page, locate the **Connection Info** area, click **Configure** next to **kubectl**. On the page displayed, download the configuration file.

Step 2 Configure kubectl.

1. Log in to your client and copy the **kubeconfig.json** file downloaded in **Step 1.2** to the **/home** directory on your client.
2. Configure the kubectl authentication file.
   ```
   cd /home
   mkdir -p $HOME/.kube
   mv -f kubeconfig.json $HOME/.kube/config
   ```
3. Change the kubectl access mode and use the SAN to access the cluster.
   ```
   kubectl config use-context customSAN-0
   ```
   In the preceding command, *customSAN-0* indicates the configuration name of the custom SAN. If multiple SANs are configured, the number in the configuration name of each SAN starts from **0** and increases in ascending order, for example, *customSAN-0*, *customSAN-1*, and so on.

----End

Using an X.509 certificate to access the cluster

Step 1 After the SAN is modified, download the X509 certificate again.

1. Log in to the CCE console and click the cluster name to access the cluster console.
2. On the **Overview** page, locate the **Connection Info** area, and click **Download** next to **X.509 certificate**.
3. In the **Obtain Certificate** dialog box displayed, select the certificate expiration time and download the X.509 certificate of the cluster as prompted.

Step 2 Call native Kubernetes APIs using the cluster certificate.

For example, run the **curl** command to call the APIs to view the pod information. In the following information, *example.com:5443* indicates the custom SAN.

```
curl --cacert ./ca.crt --cert ./client.crt --key ./client.key  https://example.com:5443/api/v1/namespaces/default/pods/
```

For more cluster APIs, see **Kubernetes API**.

----End

5.4 Upgrading a Cluster

5.4.1 Upgrade Overview

CCE strictly complies with community consistency authentication. It releases three Kubernetes versions each year and offers a maintenance period of at least 24 months after each version is released. CCE ensures the stable running of Kubernetes versions during the maintenance period.

To ensure your service rights and benefits, upgrade your Kubernetes clusters before a maintenance period ends. You can check the Kubernetes version of your cluster on the cluster list page and check whether a new version is available. Proactive cluster upgrades help you:

1. Reduce security and stability risks: During the iteration of Kubernetes versions, known security and stability vulnerabilities are continuously fixed. Long-term use of EOS clusters will result in security and stability risks to services.
2. Experience the latest functions: During the iteration of Kubernetes versions, new functions and optimizations are continuously released. For details about the features of the latest version, see **Release Notes for CCE Cluster Versions**.
3. Minimize compatibility risks: During the iteration of Kubernetes versions, APIs are continuously modified and functions are deprecated. If a cluster has not been upgraded for a long time, more O&M assurance investment will be required when the cluster is upgraded. Periodic upgrades can effectively mitigate compatibility risks caused by accumulated version differences. It is a good practice to upgrade a patch version every quarter and upgrade a major version to the latest version every year.

4. Obtain more effective technical support: CCE does not provide security patches or issue fixing for EOS Kubernetes cluster versions, and does not ensure technical support for the EOS versions.

Cluster Upgrade Path

CCE clusters evolve iteratively based on the community Kubernetes version. A CCE cluster version consists of the community Kubernetes version and the CCE patch version. Therefore, two cluster upgrade paths are provided.

- Upgrading a Kubernetes version

Source Kubernetes Version	Target Kubernetes Version
v1.13 or earlier	Not supported
v1.15	v1.19
v1.17	v1.19
v1.19	v1.21 or v1.23
v1.21	v1.23 or v1.25
v1.23	v1.25 or v1.27
v1.25	v1.27

  NOTE

  - A version that has been end of maintenance cannot be directly upgraded to the latest version. You need to upgrade such a version for multiple times, for example, from v1.15 to v1.19, v1.23, and then to v1.27/v1.28.
  - A Kubernetes version can be upgraded only after the patch is upgraded to the latest version. CCE will automatically generate an optimal upgrade path on the console based on the current cluster version.

- Upgrading a patch version

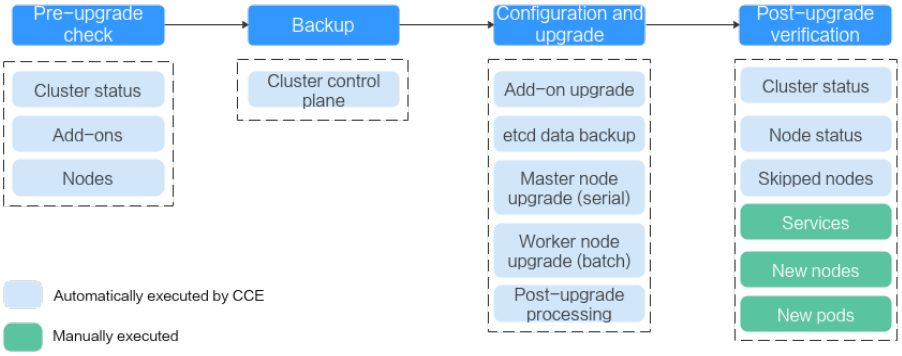
  Patch version management is available for CCE clusters of v1.19 or later to provide new features and fix bugs and vulnerability for in-maintenance clusters without requiring a major version upgrade.

  After a new patch version is released, you can directly upgrade any patch version to the latest patch version. For details about the release history of patch versions, see **Patch Version Release Notes**.

Cluster Upgrade Process

The cluster upgrade process involves pre-upgrade check, backup, upgrade, and post-upgrade verification.

Figure 5-2 Process of upgrading a cluster



After determining the target version of the cluster, read the **precautions** carefully and prevent function incompatibility during the upgrade.

1. **Pre-upgrade check**

   Before a cluster upgrade, CCE checks mandatory items such as the cluster status, add-ons, and nodes to ensure that the cluster meets the upgrade requirements. For more details, see **Pre-upgrade Check**. If any check item is abnormal, rectify the fault as prompted on the console.

2. **Backup**

   You can use disk snapshots to back up master node data, including CCE component images, component configurations, and etcd data. Back up data before an upgrade. If unexpected cases occur during an upgrade, you can use the backup to quickly restore the cluster.

Backup Type	Backup Object	Backup Mode	Backup Time	Rollback Time	Description
etcd data backup	etcd data	Automatic backup during an upgrade	1-5 minutes	2 hours	Mandatory. The data is automatically backed up during an upgrade.
CBR cloud server backup	Master node disks, including component images, configurations, logs, and etcd data	One-click backup on web pages (manually triggered)	20 minutes to 2 hours (based on the cloud backup tasks in the current region)	20 minutes	This function is gradually replaced by EVS snapshot backup.

3. **Configuration and upgrade**

Configure parameters before an upgrade. CCE has provided default settings, which can be modified as needed. After the configuration, upgrade add-ons, master nodes, and worker nodes in sequence.

- **Add-on Upgrade Configuration**: Add-ons that have been installed in your cluster are listed. During the cluster upgrade, CCE automatically upgrades the selected add-ons to be compatible with the target cluster version. You can click **Set** to re-define the add-on parameters.

  NOTE

  If an add-on is marked with ⚠ on its right side, the add-on cannot be compatible with both the source and target versions of the cluster upgrade. In this case, CCE will upgrade the add-on after the cluster upgrade. The add-on may be unavailable during the cluster upgrade.

- **Node Upgrade Configuration**

  - **Max. Nodes for Batch Upgrade**: You can configure the maximum number of nodes to be upgraded in a batch.

    Node pools will be upgraded in sequence. Nodes in node pools will be upgraded in batches. One node is upgraded in the first batch, two nodes in the second batch, and the number of nodes to be upgraded in each subsequent batch increases by a power of 2 until the maximum number of nodes to be upgraded in each batch is reached. The next cluster is upgraded after the previous one is upgraded. By default, 20 nodes are upgraded in a batch, and the number can be increased to the maximum of 60.

  - **Node Priority**: You can customize node upgrade priorities. If the priorities are not specified, CCE will perform the upgrade based on the priorities generated by the default policy.
    - **Add Upgrade Priority**: You can custom the priorities for upgrading node pools. If the priorities are not specified, CCE will preferentially upgrade the node pool with the least number of nodes based on the default policy.
    - **Add Node Priority**: You can custom the priorities for upgrading nodes in a node pool. If the priorities are not specified, CCE will preferentially upgrade the node with lightest load (calculated based on the number of pods, resource request rate, and number of PVs) based on the default policy.

4. **Post-upgrade verification**

   After an upgrade, CCE will automatically check items including the cluster status and node status. You need to manually check services, new nodes, and new pods to ensure that the cluster functions properly after the upgrade. For details, see **Performing Post-Upgrade Verification**.

Upgrade Modes

Table 5-10 Upgrade modes

Upgrade Mode	Description	Upgrade Scope	Advantage	Constraint
In-place upgrade	Kubernetes components, network components, and CCE management components are upgraded on nodes. During an upgrade, service pods and networks are not affected. Nodes are upgraded in batches. Only the nodes that have been upgraded can be used to schedule services.	• Node OSs are not upgraded. • The add-ons that are incompatible with the target cluster version will be automatically upgraded. • Kubernetes components will be automatically upgraded.	The one-click upgrade does not need to migrate services, which ensures service continuity.	In-place upgrade is supported only in clusters of v1.15 or later.

5.4.2 Before You Start

Before the upgrade, you can check whether your cluster can be upgraded and which versions are available on the CCE console. For details, see **Upgrade Overview**.

Precautions

Before upgrading a cluster, pay attention to the following points:

- **Perform an upgrade during off-peak hours to minimize the impact on your services.**
- Before upgrading a cluster, learn about the features and differences of each cluster version in **Kubernetes Release Notes** to prevent exceptions due to the use of an incompatible cluster version. For example, check whether any APIs deprecated in the target version are used in the cluster. Otherwise, calling the APIs may fail after the upgrade. For details, see **Deprecated APIs**.

During a cluster upgrade, pay attention to the following points that may affect your services:

- During a cluster upgrade, do not perform any operation on the cluster. Do not **stop, restart, or delete nodes** during cluster upgrade. Otherwise, the upgrade will fail.
- Before upgrading a cluster, **ensure no high-risk operations are performed in the cluster**. Otherwise, the cluster upgrade may fail or the configuration may be lost after the upgrade. Common high-risk operations include modifying cluster node configurations locally and modifying the configurations of the listeners managed by CCE on the ELB console. Instead, modify configurations on the CCE console so that the modifications can be automatically inherited during the upgrade.
- During a cluster upgrade, the running workloads will not be interrupted, but access to the API server will be temporarily interrupted.
- By default, application scheduling is not restricted during a cluster upgrade. During an upgrade of the following early cluster versions, the **node.kubernetes.io/upgrade** taint (equivalent to **NoSchedule**) will be added to the nodes in the cluster. The taint will be removed after the cluster is upgraded:
  - All v1.15 clusters
  - All v1.17 clusters
  - v1.19 clusters with patch versions earlier than or equal to v1.19.16-r4
  - v1.21 clusters with patch versions earlier than or equal to v1.21.7-r0
  - v1.23 clusters with patch versions earlier than or equal to v1.23.5-r0

Constraints

- If an error occurred during a cluster upgrade, the cluster can be rolled back using the backup data. If you perform other operations (for example, modifying cluster specifications) after a successful cluster upgrade, the cluster cannot be rolled back using the backup data.
- When clusters using the tunnel network model are upgraded to v1.19.16-r4, v1.21.7-r0, v1.23.5-r0, v1.25.1-r0, or later, the SNAT rule whose destination address is the container CIDR block but the source address is not the container CIDR block will be removed. If you have configured VPC routes to directly access all pods outside the cluster, only the pods on the corresponding nodes can be directly accessed after the upgrade.
- For more details, see **Version Differences**.

Version Differences

Upgrade Path	Version Difference	Self-Check
v1.23 or v1.25 Upgraded to v1.27	Docker is no longer recommended. Use containerd instead. For details, see **Container Engine**.	This item has been included in the pre-upgrade check.

Upgrade Path	Version Difference	Self-Check
v1.23 to v1.25	Since Kubernetes v1.25, PodSecurityPolicy has been replaced by pod Security Admission. For details, see **Configuring Pod Security Admission**.	• To migrate PodSecurityPolicy capabilities to pod Security Admission, perform the following steps: 1. Ensure that the cluster is of the latest CCE v1.23 version. 2. Migrate PodSecurityPolicy capabilities to pod Security Admission. For details, see **Configuring Pod Security Admission**. 3. After confirming that the functions are running properly after the migration, upgrade the CCE cluster to v1.25. • If you no longer need PodSecurityPolicy, delete PodSecurityPolicy from the cluster and upgrade the cluster to v1.25.
v1.21 or v1.19 Upgraded to v1.23	For the Nginx Ingress Controller of an earlier version (community version v0.49 or earlier, or CCE nginx-ingress version v1.x.x), the created ingresses can be managed by the Nginx Ingress Controller even if **kubernetes.io/ingress.class: nginx** is not set in the ingress **annotations**. However, for the Nginx Ingress Controller of a later version (community version v1.0.0 or later, or CCE nginx-ingress version v2.x.x), the ingresses created without specifying the Nginx type will not be managed by the Nginx Ingress Controller, and ingress rules will become invalid, which interrupts services.	This item has been included in the pre-upgrade check. You can also perform the self-check by referring to **nginx-ingress**.

Upgrade Path	Version Difference	Self-Check
v1.19 to v1.21	The bug of **exec probe timeouts** is fixed in Kubernetes 1.21. Before this bug is fixed, the exec probe does not consider the **timeoutSeconds** field. Instead, the probe will run indefinitely, even beyond its configured deadline. It will stop until the result is returned. If this field is not specified, the default value **1** is used. This field takes effect after the upgrade. If the probe runs over 1 second, the application health check may fail and the application may restart frequently.	Before the upgrade, check whether the timeout is properly set for the exec probe.
	kube-apiserver of CCE 1.19 or later requires that the Subject Alternative Names (SANs) field be configured for the certificate of your webhook server. Otherwise, kube-apiserver fails to call the webhook server after the upgrade, and containers cannot be started properly. Root cause: X.509 **CommonName** is discarded in Go 1.15. kube-apiserver of CCE 1.19 is compiled using Go 1.15. If your webhook certificate does not have SANs, kube-apiserver does not process the **CommonName** field of the X.509 certificate as the host name by default. As a result, the authentication fails.	Before the upgrade, check whether the SAN field is configured in the certificate of your webhook server. • If you do not have your own webhook server, you can skip this check. • If the field is not set, use the SAN field to specify the IP address and domain name supported by the certificate.

Table 5-11 QoS class changes before and after the upgrade

Init Container (Calculated Based on spec.initContainers)	Service Container (Calculated Based on spec.containers)	Pod (Calculated Based on spec.containers and spec.initContainers)	Impacted or Not
Guaranteed	Besteffort	Burstable	Yes

Init Container (Calculated Based on spec.initContainers)	Service Container (Calculated Based on spec.containers)	Pod (Calculated Based on spec.containers and spec.initContainers)	Impacted or Not
Guaranteed	Burstable	Burstable	No
Guaranteed	Guaranteed	Guaranteed	No
Besteffort	Besteffort	Besteffort	No
Besteffort	Burstable	Burstable	No
Besteffort	Guaranteed	Burstable	Yes
Burstable	Besteffort	Burstable	Yes
Burstable	Burstable	Burstable	No
Burstable	Guaranteed	Burstable	Yes

Deprecated APIs

With the evolution of Kubernetes APIs, APIs are periodically reorganized or upgraded, and old APIs are deprecated and finally deleted. The following tables list the deprecated APIs in each Kubernetes community version. For details about more deprecated APIs, see **Deprecated API Migration Guide**.

- **APIs Deprecated in Kubernetes v1.27**
- **APIs Deprecated in Kubernetes v1.25**
- **APIs Deprecated in Kubernetes v1.22**
- **APIs Deprecated in Kubernetes v1.16**

NOTE

When an API is deprecated, the existing resources are not affected. However, when you create or edit the resources, the API version will be intercepted.

Table 5-12 APIs deprecated in Kubernetes v1.27

Resource Name	Deprecated API Version	Substitute API Version	Change Description
CSIStorageCapacity	storage.k8s.io/v1beta1	storage.k8s.io/v1 (This API is available since v1.24.)	None

Resource Name	Deprecated API Version	Substitute API Version	Change Description
FlowSchema and PriorityLevelConfiguration	flowcontrol.apiserver.k8s.io/v1beta1	flowcontrol.apiserver.k8s.io/v1beta3 (This API is available since v1.26.)	None
HorizontalPodAutoscaler	autoscaling/v2beta2	autoscaling/v2 (This API is available since v1.23.)	None

Table 5-13 APIs deprecated in Kubernetes v1.25

Resource Name	Deprecated API Version	Substitute API Version	Change Description
CronJob	batch/v1beta1	batch/v1 (This API is available since v1.21.)	None
EndpointSlice	discovery.k8s.io/v1beta1	discovery.k8s.io/v1 (This API is available since v1.21.)	Pay attention to the following changes: • In each endpoint, the **topology["kubernetes.io/hostname"]** field has been deprecated. Replace it with the **nodeName** field. • In each endpoint, the **topology["kubernetes.io/zone"]** field has been deprecated. Replace it with the **zone** field. • The **topology** field is replaced with **deprecatedTopology** and cannot be written in v1.

Resource Name	Deprecated API Version	Substitute API Version	Change Description
Event	events.k8s.io/v1beta1	events.k8s.io/v1 (This API is available since v1.19.)	Pay attention to the following changes: • The **type** field can only be set to **Normal** or **Warning**. • The **involvedObject** field is renamed **regarding**. • The **action**, **reason**, **reportingController**, and **reportingInstance** fields are mandatory for creating a new **events.k8s.io/v1** event. • Use **eventTime** instead of the deprecated **firstTimestamp** field (this field has been renamed **deprecatedFirstTimestamp** and is not allowed to appear in the new **events.k8s.io/v1** event object). • Use **series.lastObservedTime** instead of the deprecated **lastTimestamp** field (this field has been renamed **deprecatedLastTimestamp** and is not allowed to appear in the new **events.k8s.io/v1** event object). • Use **series.count** instead of the deprecated **count** field (this field has been renamed **deprecatedCount** and is not allowed to appear in the new **events.k8s.io/v1** event object). • Use **reportingController** instead of the deprecated **source.component** field (this field has been renamed **deprecatedSource.component** and is not allowed to appear in the new

Resource Name	Deprecated API Version	Substitute API Version	Change Description
			events.k8s.io/v1 event object). • Use **reportingInstance** instead of the deprecated **source.host** field (this field has been renamed **deprecatedSource.host** and is not allowed to appear in the new **events.k8s.io/v1** event object).
HorizontalPodAutoscaler	autoscaling/v2beta1	autoscaling/v2 (This API is available since v1.23.)	None
PodDisruptionBudget	policy/v1beta1	policy/v1 (This API is available since v1.21.)	If **spec.selector** is set to null (**{}**) in **PodDisruptionBudget** of **policy/v1**, all pods in the namespace are selected. (In **policy/v1beta1**, an empty **spec.selector** means that no pod will be selected.) If **spec.selector** is not specified, pod will be selected in neither API version.
PodSecurityPolicy	policy/v1beta1	None	Since v1.25, the PodSecurityPolicy resource no longer provides APIs of the **policy/v1beta1** version, and the PodSecurityPolicy access controller is deleted. Use **Pod Security Admission** instead.
RuntimeClass	node.k8s.io/v1beta1	node.k8s.io/v1 (This API is available since v1.20.)	None

Table 5-14 APIs deprecated in Kubernetes v1.22

Resource Name	Deprecated API Version	Substitute API Version	Change Description
MutatingWebhookConfiguration ValidatingWebhookConfiguration	admissionregistration.k8s.io/v1beta1	admissionregistration.k8s.io/v1 (This API is available since v1.16.)	• The default value of **webhooks[*].failurePolicy** is changed from **Ignore** to **Fail** in v1. • The default value of **webhooks[*].matchPolicy** is changed from **Exact** to **Equivalent** in v1. • The default value of **webhooks[*].timeoutSeconds** is changed from **30s** to **10s** in v1. • The default value of **webhooks[*].sideEffects** is deleted, and this field must be specified. In v1, the value can only be **None** or **NoneOnDryRun**. • The default value of **webhooks[*].admissionReviewVersions** is deleted. In v1, this field must be specified. (**AdmissionReview** v1 and v1beta1 are supported.) • **webhooks[*].name** must be unique in the list of objects created through **admissionregistration.k8s.io/v1**.

Resource Name	Deprecated API Version	Substitute API Version	Change Description
CustomResourceDefinition	apiextensions.k8s.io/v1beta1	apiextensions/v1 (This API is available since v1.16.)	• The default value of **spec.scope** is no longer **Namespaced**. This field must be explicitly specified. • **spec.version** is deleted from v1. Use **spec.versions** instead. • **spec.validation** is deleted from v1. Use **spec.versions[*].schema** instead. • **spec.subresources** is deleted from v1. Use **spec.versions[*].subresources** instead. • **spec.additionalPrinterColumns** is deleted from v1. Use **spec.versions[*].additionalPrinterColumns** instead. • **spec.conversion.webhookClientConfig** is moved to **spec.conversion.webhook.clientConfig** in v1. • **spec.conversion.conversionReviewVersions** is moved to **spec.conversion.webhook.conversionReviewVersions** in v1. • **spec.versions[*].schema.openAPIV3Schema** becomes a mandatory field when the **CustomResourceDefinition** object of the v1 version is created, and its value must be a **structural schema**. • **spec.preserveUnknownFields: true** cannot be specified when the **CustomResourceDefinition** object of the v1 version is created. This configuration must be specified using **x-kubernetes-preserve-**

Resource Name	Deprecated API Version	Substitute API Version	Change Description
			unknown-fields: true in the schema definition. • In v1, the **JSONPath** field in the **additionalPrinterColumns** entry is renamed **jsonPath** (patch **#66531**).
APIService	apiregistration/v1beta1	apiregistration.k8s.io/v1 (This API is available since v1.10.)	None
TokenReview	authentication.k8s.io/v1beta1	authentication.k8s.io/v1 (This API is available since v1.6.)	None
LocalSubjectAccessReview SelfSubjectAccessReview SubjectAccessReview SelfSubjectRulesReview	authorization.k8s.io/v1beta1	authorization.k8s.io/v1 (This API is available since v1.16.)	**spec.group** was renamed **spec.groups** in v1 (patch **#32709**).

Resource Name	Deprecated API Version	Substitute API Version	Change Description
CertificateSigningRequest	certificates.k8s.io/v1beta1	certificates.k8s.io/v1 (This API is available since v1.19.)	Pay attention to the following changes in **certificates.k8s.io/v1**: • For an API client that requests a certificate: – **spec.signerName** becomes a mandatory field (see **Known Kubernetes Signers**). In addition, the **certificates.k8s.io/v1** API cannot be used to create requests whose signer is **kubernetes.io/legacy-unknown**. – **spec.usages** now becomes a mandatory field, which cannot contain duplicate string values and can contain only known usage strings. • For an API client that needs to approve or sign a certificate: – **status.conditions** cannot contain duplicate types. – The **status.conditions[*].status** field is now mandatory. – The **status.certificate** must be PEM-encoded and can contain only the **CERTIFICATE** data block.
Lease	coordination.k8s.io/v1beta1	coordination.k8s.io/v1 (This API is available since v1.14.)	None

Resource Name	Deprecated API Version	Substitute API Version	Change Description
Ingress	networking.k8s.io/v1beta1 extensions/v1beta1	networking.k8s.io/v1 (This API is available since v1.19.)	• The **spec.backend** field is renamed **spec.defaultBackend**. • The **serviceName** field of the backend is renamed **service.name**. • The backend **servicePort** field represented by a number is renamed **service.port.number**. • The backend **servicePort** field represented by a string is renamed **service.port.name**. • The **pathType** field is mandatory for all paths to be specified. The options are **Prefix**, **Exact**, and **ImplementationSpecific**. To match the behavior of not defining the path type in v1beta1, use **ImplementationSpecific**.
IngressClass	networking.k8s.io/v1beta1	networking.k8s.io/v1 (This API is available since v1.19.)	None
ClusterRole ClusterRoleBinding Role RoleBinding	rbac.authorization.k8s.io/v1beta1	rbac.authorization.k8s.io/v1 (This API is available since v1.8.)	None
PriorityClass	scheduling.k8s.io/v1beta1	scheduling.k8s.io/v1 (This API is available since v1.14.)	None

Resource Name	Deprecated API Version	Substitute API Version	Change Description
CSIDriver CSINode StorageClass VolumeAttachment	storage.k8s.io/v1beta1	storage.k8s.io/v1	• CSIDriver is available in **storage.k8s.io/v1** since v1.19. • CSINode is available in **storage.k8s.io/v1** since v1.17. • StorageClass is available in **storage.k8s.io/v1** since v1.6. • VolumeAttachment is available in **storage.k8s.io/v1** since v1.13.

Table 5-15 APIs deprecated in Kubernetes v1.16

Resource Name	Deprecated API Version	Substitute API Version	Change Description
NetworkPolicy	extensions/v1beta1	networking.k8s.io/v1 (This API is available since v1.8.)	None
DaemonSet	extensions/v1beta1 apps/v1beta2	apps/v1 (This API is available since v1.9.)	• The **spec.templateGeneration** field is deleted. • **spec.selector** is now a mandatory field and cannot be changed after the object is created. The label of an existing template can be used as a selector for seamless migration. • The default value of **spec.updateStrategy.type** is changed to **RollingUpdate** (the default value in the **extensions/v1beta1** API version is **OnDelete**).

Resource Name	Deprecated API Version	Substitute API Version	Change Description
Deployment	extensions/v1beta1 apps/v1beta1 apps/v1beta2	apps/v1 (This API is available since v1.9.)	• The **spec.rollbackTo** field is deleted. • **spec.selector** is now a mandatory field and cannot be changed after the Deployment is created. The label of an existing template can be used as a selector for seamless migration. • The default value of **spec.progressDeadlineSeconds** is changed to 600 seconds (the default value in **extensions/v1beta1** is unlimited). • The default value of **spec.revisionHistoryLimit** is changed to **10**. (In the **apps/v1beta1** API version, the default value of this field is **2**. In the **extensions/v1beta1** API version, all historical records are retained by default.) • The default values of **maxSurge** and **maxUnavailable** are changed to **25%**. (In the **extensions/v1beta1** API version, these fields default to **1**.)
StatefulSet	apps/v1beta1 apps/v1beta2	apps/v1 (This API is available since v1.9.)	• **spec.selector** is now a mandatory field and cannot be changed after the StatefulSet is created. The label of an existing template can be used as a selector for seamless migration. • The default value of **spec.updateStrategy.type** is changed to **RollingUpdate** (the default value in the **apps/v1beta1** API version is **OnDelete**).

Resource Name	Deprecated API Version	Substitute API Version	Change Description
ReplicaSet	extensions/v1beta1 apps/v1beta1 apps/v1beta2	apps/v1 (This API is available since v1.9.)	**spec.selector** is now a mandatory field and cannot be changed after the object is created. The label of an existing template can be used as a selector for seamless migration.
PodSecurityPolicy	extensions/v1beta1	policy/v1beta1 (This API is available since v1.10.)	PodSecurityPolicy for the **policy/v1beta1** API version will be removed in v1.25.

Upgrade Backup

How to back up a node:

Backup Type	Backup Object	Backup Mode	Backup Time	Rollback Time	Description
etcd data backup	etcd data	Automatic backup during an upgrade	1-5min	2h	Mandatory. The backup is automatically performed during the upgrade.
CBR cloud server backup	Master node disks, including component images, configurations, logs, and etcd data	One-click backup on web pages (manually triggered)	20 minutes to 2 hours (based on the cloud backup tasks in the current region)	20min	This function is gradually replaced by EVS snapshot backup.

5.4.3 Performing Post-Upgrade Verification

5.4.3.1 Pod Check

Check Items

- Check whether there are unexpected pods in the cluster.
- Check whether there are any pods that ran properly originally in the cluster restart unexpectedly.

Procedure

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 **Workloads**. On the displayed page, select all namespaces, click the **Pods** tab, and check whether there are abnormal pods.

Step 3 Check the **Restarts** column for the pods that are restarted unexpectedly.

----End

Solution

If there are abnormal pods in your cluster after the cluster upgrade, contact technical support.

5.4.3.2 Node and Container Network Check

Check Items

- Check whether nodes are running properly.
- Check whether the node network is functional.
- Check whether the container network is functional.

Procedure

If the container network malfunctions, services will be abnormal. Check whether your services are running properly.

If a node component or the node network malfunctions, the node will be abnormal. Perform the following steps to check the node status:

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 **Nodes**. On the displayed page, click the **Nodes** tab and check whether there are abnormal nodes (which can be filtered in the **Status** column).

----End

Solution

If the node status is abnormal, contact technical support.

If the container network is abnormal and your services are affected, contact technical support and confirm the abnormal network access path.

Source	Destination	Destination Type	Possible Fault
• Pods (inside a cluster) • Nodes (inside a cluster) • Cloud servers outside the cluster but in the same VPC as the cluster • Outside the VPC to which the cluster belongs	Public IP address of Service ELB	Cluster traffic load balancing entry	None
	Private IP address of Service ELB	Cluster traffic load balancing entry	None
	Public IP address of ingress ELB	Cluster traffic load balancing entry	None
	Private IP address of ingress ELB	Cluster traffic load balancing entry	None
	Public IP address of NodePort Service	Cluster traffic entry	The kube proxy configuration is overwritten. This fault has been rectified in the upgrade process.
	Private IP address of NodePort Service	Cluster traffic entry	None
	ClusterIP Service	Service network plane	None
	Non NodePort Service port	Container network	None
	Cross-node pods	Container network plane	None
	Pods on the same node	Container network plane	None
	Service and pod domain names are resolved by CoreDNS.	Domain name resolution	None
	External domain names are resolved based on the CoreDNS hosts configuration.	Domain name resolution	After CoreDNS is upgraded, the configuration is overwritten. This fault has been rectified in the add-on upgrade process.

Source	Destination	Destination Type	Possible Fault
	External domain names are resolved based on the CoreDNS upstream server.	Domain name resolution	After CoreDNS is upgraded, the configuration is overwritten. This fault has been rectified in the add-on upgrade process.
	External domain names are not resolved by CoreDNS.	Domain name resolution	None

5.4.3.3 Node Label and Taint Check

Check Items

- Check whether custom node labels are lost.
- Check whether there are any unexpected taints newly added on the node, which will affect workload scheduling.

Procedure

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 **Nodes**. On the displayed page, click the **Nodes** tab, select all nodes, and click **Labels and Taints** to view the labels and taints of the current node.

----End

Solution

Custom labels will not be changed during a cluster upgrade. If you find that labels are lost or added unexpectedly, contact technical support.

If you find a new taint (**node.kubernetes.io/upgrade**) on a node, the node may be skipped during the upgrade. For details, see **Node Skipping Check**.

If you find that other taints are added to the node, contact technical support.

5.4.3.4 Cluster Status Check

Check Items

After a cluster is upgraded, check whether the cluster is in the **Running** state.

Procedure

CCE automatically checks your cluster status. Go to the cluster list page and confirm the cluster status based on the diagnosis result.

Solution

If your cluster malfunctions, contact technical support.

5.4.3.5 Node Status Check

Check Items

After a cluster is upgraded, check whether nodes in the cluster are in the **Running** state.

Procedure

CCE automatically checks your node statuses. Go to the node list page and confirm the node statuses based on the diagnosis result.

Solution

If a node malfunctions, **reset the node**. If the fault persists, contact technical support.

5.4.3.6 Node Skipping Check

Check Items

After a cluster is upgraded, check whether there are any nodes that skip the upgrade in the cluster. These nodes may affect the proper running of the cluster.

Procedure

CCE automatically checks whether there are nodes that skip the upgrade in the cluster. Go to the node list page and confirm the nodes based on the diagnosis result. The skipped nodes are labeled with **upgrade.cce.io/skipped=true**.

Solution

The skipped nodes are displayed on the upgrade details page. Reset the skipped nodes after the upgrade is complete. For details about how to reset a node, see **Resetting a Node**.

NOTE

Resetting a node will reset all node labels, which may affect workload scheduling. Before resetting a node, check and retain the labels that you have manually added to the node.

5.4.3.7 Service Check

Check Items

After a cluster is upgraded, check whether its services are running properly.

Procedure

Different services have different verification mode. Select a suitable one and verify the service before and after the upgrade.

You can verify the service from the following aspects:

- The service page is available.
- No alarm or event is generated on the normal platform.
- No error log is generated for key processes.
- The API dialing test is normal.

Solution

If your online services malfunction after the cluster upgrade, contact technical support.

5.4.3.8 New Node Check

Check Items

Check whether nodes can be created in the cluster.

Procedure

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 **Nodes**. On the displayed page, click the **Nodes** tab and then **Create Node**. For details about the node configuration, see **Creating a Node**.

----End

Solution

If nodes cannot be created in your cluster after the cluster is upgraded, contact technical support.

5.4.3.9 New Pod Check

Check Items

- Check whether pods can be created on the existing nodes after the cluster is upgraded.
- Check whether pods can be created on new nodes after the cluster is upgraded.

Procedure

After creating a node based on **New Node Check**, create a DaemonSet workload to create pods on each node.

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 **Workloads**. On the displayed page, click **Create Workload** or **Create from YAML** in the upper right corner. For details about how to create a DaemonSet, see **Creating a DaemonSet**.

It is a good practice to use the image for routine tests as the base image. You can deploy minimum pods for an application by referring to the following YAML file.

NOTE

In this test, YAML deploys DaemonSet in the default namespace, uses **ngxin:perl** as the base image, requests 10m vCPUs and 10 MiB memory, and limits 100 MB CPU and 50 MiB memory.

```
apiVersion: apps/v1
kind: DaemonSet
metadata:
  name: post-upgrade-check
  namespace: default
spec:
  selector:
    matchLabels:
      app: post-upgrade-check
      version: v1
  template:
    metadata:
      labels:
        app: post-upgrade-check
        version: v1
    spec:
      containers:
        - name: container-1
          image: nginx:perl
          imagePullPolicy: IfNotPresent
          resources:
            requests:
              cpu: 10m
              memory: 10Mi
            limits:
              cpu: 100m
              memory: 50Mi
```

Step 3 After the workload is created, check whether the pods of the workload are running properly.

Step 4 After the check is complete, choose **Workloads** in the navigation pane. On the displayed page, click the **DaemonSets** tab, locate the **post-upgrade-check** workload, and choose **More** > **Delete** in the **Operation** column to delete the test workload.

----End

Solution

If the pod cannot be created or the pod status is abnormal, contact technical support and specify whether the exception occurs on new nodes or existing nodes.

5.4.4 Migrating Services Across Clusters of Different Versions

Application Scenarios

This section describes how to migrate services from a cluster of an earlier version to a cluster of a later version in CCE.

This operation is applicable when a cross-version cluster upgrade is required (for example, upgrade from v1.7.* or v1.9.* to 1.17.*) and new clusters can be created for service migration.

Prerequisites

Table 5-16 Checklist before migration

Category	Description
Cluster	NodeIP-related: Check whether node IP addresses (including EIPs) of the cluster before the migration have been used in other configurations or whitelists.
Workloads	Record the number of workloads for post-migration check.
Storage	1. Check whether the storage resources in use are provisioned by the cloud or by your organization. 2. Change the automatically created storage to the existing storage in the new cluster.
Network	1. Pay special attention to the ELB and ingress. 2. Clusters of an earlier version support only the classic load balancer. To migrate services to a new cluster, change load balancer type to shared load balancer. Then, the corresponding ELB service will be re-established.
O&M	Private configuration: Check whether kernel parameters or system data have been configured on nodes in the cluster.

Procedure

Step 1 Create a CCE cluster.

Create a cluster with the same specifications and configurations as the cluster of the earlier version. For details, see **Buying a CCE Standard Cluster**.

Step 2 Add a node.

Add a node with the same specifications and manual configuration items. For details, see **Creating a Node**.

Step 3 Create a storage volume in the new cluster.

Use the existing storage to create a PVC in the new cluster. The PVC name remains unchanged. For details, see **Using an Existing OBS Bucket Through a Static PV** or **Using an Existing SFS Turbo File System Through a Static PV**.

NOTE

Storage switching supports only OBS buckets and SFS Turbo file systems. If non-shared storage is used, suspend the workloads in the old cluster to switch the storage resources. As a result, services will be unavailable.

Step 4 Create a workload in the new cluster.

Create a workload in the new cluster. The name and specifications remain unchanged. For details, see **Creating a Deployment** or **Creating a StatefulSet**.

Step 5 Mount the storage again.

Remount the existing storage in the workload. For details, see **Using an Existing OBS Bucket Through a Static PV** or **Using an Existing SFS Turbo File System Through a Static PV**.

Step 6 Create a Service in the new cluster.

The Service name and specifications remain unchanged. For details about how to create a Service, see **Service**.

Step 7 Commission services.

After all resources are created, commission the containerized services. If the commissioning is successful, migrate the services to the new cluster.

Step 8 Delete the old cluster.

When all functions of the new cluster are stable, delete the old cluster. For details about how to delete a cluster, see **Deleting a Cluster**.

----End

5.4.5 Troubleshooting for Pre-upgrade Check Exceptions

5.4.5.1 Pre-upgrade Check

The system automatically checks a cluster before its upgrade. If the cluster does not meet the pre-upgrade check conditions, the upgrade cannot continue. To avoid risks, you can perform pre-upgrade check according to the check items and solutions described in this section.

Table 5-17 Check items

No.	Check Item	Description
1	**Node Restrictions**	• Check whether the node is available. • Check whether the node OS supports the upgrade. • Check whether the node is marked with unexpected node pool labels. • Check whether the Kubernetes node name is the same as the ECS name.
2	**Upgrade Management**	Check whether the target cluster is under upgrade management.
3	**Add-ons**	• Check whether the add-on status is normal. • Check whether the add-on support the target version.
4	**Helm Charts**	Check whether the current HelmRelease record contains discarded Kubernetes APIs that are not supported by the target cluster version. If yes, the Helm chart may be unavailable after the upgrade.
5	**SSH Connectivity of Master Nodes**	Check whether CCE can connect to your master nodes.
6	**Node Pools**	Check the node pool status.
7	**Security Groups**	Check whether the **Protocol & Port** of the worker node security groups are set to **ICMP: All** and whether the security group with the source IP address set to the master node security group is deleted.
8	**Arm Node Restrictions**	• Check whether the cluster contains Arm nodes.
9	**To-Be-Migrated Nodes**	Check whether the node needs to be migrated.
10	**Discarded Kubernetes Resources**	Check whether there are discarded resources in the clusters.
11	**Compatibility Risks**	Read the version compatibility differences and ensure that they are not affected. The patch upgrade does not involve version compatibility differences.
12	**CCE Agent Versions**	Check whether cce-agent on the current node is of the latest version.
13	**Node CPU Usage**	Check whether the CPU usage of the node exceeds 90%.

No.	Check Item	Description
14	CRDs	• Check whether the key CRD **packageversions.version.cce.io** of the cluster is deleted. • Check whether the cluster key CRD **network-attachment-definitions.k8s.cni.cncf.io** is deleted.
15	Node Disks	• Check whether the key data disks on the node meet the upgrade requirements. • Check whether the **/tmp** directory has 500 MB available space.
16	Node DNS	• Check whether the DNS configuration of the current node can resolve the OBS address. • Check whether the current node can access the OBS address of the storage upgrade component package.
17	Node Key Directory File Permissions	Check whether the owner and owner group of the files in the **/var/paas** directory used by the CCE are both **paas**.
18	Kubelet	Check whether the kubelet on the node is running properly.
19	Node Memory	Check whether the memory usage of the node exceeds 90%.
20	Node Clock Synchronization Server	Check whether the clock synchronization server ntpd or chronyd of the node is running properly.
21	Node OS	Check whether the OS kernel version of the node is supported by CCE.
22	Node CPUs	Check whether the number of CPUs on the master node is greater than 2.
23	Node Python Commands	Check whether the Python commands are available on a node.
24	ASM Version	• Check whether ASM is used by the cluster. • Check whether the current ASM version supports the target cluster version.
25	Node Readiness	Check whether the nodes in the cluster are ready.
26	Node journald	Check whether journald of a node is normal.
27	containerd.sock	Check whether the containerd.sock file exists on the node. This file affects the startup of container runtime in the Euler OS.

No.	Check Item	Description
28	Internal Errors	Before the upgrade, check whether an internal error occurs.
29	Node Mount Points	Check whether inaccessible mount points exist on the node.
30	Kubernetes Node Taints	Check whether the taint needed for cluster upgrade exists on the node.
31	Everest Restrictions	Check whether there are any compatibility restrictions on the current Everest add-on.
32	cce-hpa-controller Restrictions	Check whether the current cce-controller-hpa add-on has compatibility restrictions.
33	Enhanced CPU Policies	Check whether the current cluster version and the target version support enhanced CPU policy.
34	Health of Worker Node Components	Check whether the container runtime and network components on the worker nodes are healthy.
35	Health of Master Node Components	Check whether the Kubernetes, container runtime, and network components of the master nodes are healthy.
36	Memory Resource Limit of Kubernetes Components	Check whether the resources of Kubernetes components, such as etcd and kube-controller-manager, exceed the upper limit.
37	Discarded Kubernetes APIs	The system scans the audit logs of the past day to check whether the user calls the deprecated APIs of the target Kubernetes version. **NOTE** Due to the limited time range of audit logs, this check item is only an auxiliary method. APIs to be deprecated may have been used in the cluster, but their usage is not included in the audit logs of the past day. Check the API usage carefully.
38	Node NetworkManager	Check whether NetworkManager of a node is normal.
39	Node ID File	Check the ID file format.
40	Node Configuration Consistency	When you upgrade a cluster to v1.19 or later, the system checks whether the following configuration files have been modified on the backend:
41	Node Configuration File	Check whether the configuration files of key components exist on the node.

No.	Check Item	Description
42	**CoreDNS Configuration Consistency**	Check whether the current CoreDNS key configuration Corefile is different from the Helm release record. The difference may be overwritten during the add-on upgrade, **affecting domain name resolution in the cluster**.
43	**sudo Commands of a Node**	Whether the sudo commands and sudo-related files of the node are working
44	**Key Commands of Nodes**	Whether some key commands that the node upgrade depends on are working
45	**Mounting of a Sock File on a Node**	Check whether the **docker/containerd.sock** file is directly mounted to the pods on a node. During an upgrade, Docker or containerd restarts and the sock file on the host changes, but the sock file mounted to pods does not change accordingly. As a result, your services cannot access Docker or containerd due to sock file inconsistency. After the pods are rebuilt, the sock file is mounted to the pods again, and the issue is resolved accordingly.
46	**HTTPS Load Balancer Certificate Consistency**	Check whether the certificate used by an HTTPS load balancer has been modified on ELB.
47	**Node Mounting**	Check whether the default mount directory and soft link on the node have been manually mounted or modified.
48	**Login Permissions of User paas on a Node**	Check whether user **paas** is allowed to log in to a node.
49	**Private IPv4 Addresses of Load Balancers**	Check whether the load balancer associated with a Service is allocated with a private IPv4 address.
50	**Historical Upgrade Records**	Check whether the source version of the cluster is earlier than v1.11 and the target version is later than v1.23.
51	**CIDR Block of the Cluster Management Plane**	Check whether the CIDR block of the cluster management plane is the same as that configured on the backbone network.
52	**GPU Add-on**	The GPU add-on is involved in the upgrade, which may affect the GPU driver installation during the creation of a GPU node.
53	**Nodes' System Parameter Settings**	Check whether the default system parameter settings on your nodes are modified.

No.	Check Item	Description
54	Residual Package Versions	Check whether there are residual package version data in the current cluster.
55	Node Commands	Check whether the commands required for the upgrade are available on the node.
56	Node Swap	Check whether swap has been enabled on cluster nodes.
57	nginx-ingress Upgrade	Check whether there are compatibility issues that may occur during nginx-ingress upgrade.
58	Upgrade of Cloud Native Cluster Monitoring	During a cluster upgrade, compatibility issues occur when the Cloud Native Cluster Monitoring add-on is upgraded from a version earlier than 3.9.0 to a version later than 3.9.0. Check whether Grafana is enabled for this add-on.
59	Check containerd pod restart risk	Check whether the service container running on the node may restart when the containerd component is upgraded on the node that uses containerd in the current cluster.
60	Key GPU Add-on Parameters	Check whether the configuration of the CCE AI Suite add-on in a cluster has been intrusively modified. If so, upgrading the cluster may fail.
61	GPU or NPU Pod Rebuild Risks	Check whether GPU or NPU service pods are rebuilt in a cluster when kubelet is restarted during the upgrade of the cluster.

5.4.5.2 Node Restrictions

Check Items

Check the following items:

- Check whether the node is available.
- Check whether the node OS supports the upgrade.
- Check whether the node is marked with unexpected node pool labels.
- Check whether the Kubernetes node name is the same as the ECS name.

Solution

1. **The node is unavailable. Preferentially recover the node.**

   If a node is unavailable, log in to the CCE console and click the cluster name to access the cluster console. Then, choose **Nodes** in the navigation pane and click the **Nodes** tab. Ensure that the node is in the **Running** state. A node in the **Installing** or **Deleting** state cannot be upgraded.

   If a node is unavailable, recover the node and retry the check task.

2. **The node OS does not support the upgrade.**

   The following table lists the node OSs that support the upgrade. You can reset the node OS to an available OS in the list.

   Table 5-18 OSs that support the upgrade

OS	Constraint
CentOS 7.x	None
Ubuntu	If the check result shows that the upgrade is not supported due to regional restrictions, contact technical support. **NOTE** If the target version is v1.27 or later, only Ubuntu 22.04 supports the upgrade.

3. **The affected node belongs to the default node pool but it is configured with a non-default node pool label, which will affect the upgrade.**

   If a node is migrated from a common node pool to the default node pool, the **cce.cloud.com/cce-nodepool** label will affect the cluster upgrade. Check whether load scheduling on the node depends on the label.

   - If no, delete the label.
   - If yes, modify the load balancing policy, remove the dependency, and then delete the label.

4. **The node is marked with a CNIProblem taint. Preferentially recover the node.**

   The node contains a taint whose key is **node.cloudprovider.kubernetes.io/cni-problem**, and the effect is **NoSchedule**. The taint is added by the NPD add-on. Upgrade the NPD add-on to the latest version and check again. If the problem persists, contact technical support.

5. **The Kubernetes node corresponding to the affected node does not exist.**

   It is possible that the node is being deleted. Check again later.

6. **The OS running on the master node is EulerOS 2.5, which does not support the cluster to be upgraded to v1.27.5-r0.**

   You can upgrade the cluster to v1.25 or v1.28. If necessary, contact technical support.

5.4.5.3 Upgrade Management

Check Items

Check whether the target cluster is under upgrade management.

Solution

CCE may temporarily restrict the cluster upgrade due to the following reasons:

- The cluster is identified as the core production cluster.

- Other O&M tasks are being or will be performed, for example, 3-AZ reconstruction on master nodes.

To resolve this issue, contact technical support.

5.4.5.4 Add-ons

Check Items

Check the following items:

- Check whether the add-on status is normal.
- Check whether the add-on support the target version.

Solution

- **Scenario 1: The add-on malfunctions.**

  Log in to the CCE console and click the cluster name to access the cluster console. Choose **Add-ons** in the navigation pane and obtain add-ons. Then, handle malfunctional add-ons.

- **Scenario 2: The target cluster version does not support the current add-on version.**

  The add-on cannot be automatically upgraded with the cluster due to compatibility issues. In this case, log in to the CCE console and click the cluster name to access the cluster console. Choose **Add-ons** in the navigation pane and manually upgrade the add-on.

- **Scenario 3: After the add-on is upgraded to the latest version, it is still not supported by the target cluster version.**

  Log in to the CCE console and click the cluster name to access the cluster console. Choose **Add-ons** in the navigation pane and manually uninstall the add-on. For details about the supported add-on versions and substitutions, see the **Help** document.

- **Scenario 4: The add-on configuration does not meet the upgrade requirements. Upgrade the add-on and try again.**

  The following error information is displayed during the pre-upgrade check:

  ```
  please upgrade addon [ ] in the page of addon managecheck and try again
  ```

  In this case, log in to the CCE console and click the cluster name to access the cluster console. Choose **Add-ons** in the navigation pane and manually upgrade the add-on.

5.4.5.5 Helm Charts

Check Items

Check whether the current HelmRelease record contains discarded Kubernetes APIs that are not supported by the target cluster version. If yes, the Helm chart may be unavailable after the upgrade.

Solution

Convert the discarded Kubernetes APIs to APIs that are compatible with both the source and target versions.

NOTE

This item has been automatically processed in the upgrade process. You can ignore this item.

5.4.5.6 SSH Connectivity of Master Nodes

Check Items

Check whether CCE can connect to your master nodes.

Solution

Contact technical support.

5.4.5.7 Node Pools

Check Items

- Check the node pool status.
- Check whether the node pool OS or container runtime is supported after the upgrade.

Solution

- **Scenario: The node pool malfunctions.**

  Log in to the CCE console and click the cluster name to access the cluster console. Choose **Nodes** in the navigation pane and view the status of the affected node pool on the **Node Pools** tab. If the node pool is being scaled, wait until the node pool scaling is complete.

- **Scenario: The node pool OS is not supported.**

  The runtime and OS vary depending on the cluster version. This issue typically occurs when a cluster of an earlier version is upgraded to v1.27 or later.

  Log in to the CCE console and click the cluster name to access the cluster console. Choose **Nodes** in the navigation pane, view the status of the affected node pool on the **Node Pools** tab, and click **Upgrade**. Change the supported OSs based on the pre-upgrade check result, and click **OK**.

  If there are nodes in the affected node pool, choose **More** > **Synchronize** in the operation column to synchronize the OS of the existing nodes. For details, see **Synchronizing Node Pools**.

5.4.5.8 Security Groups

Check Items

Check whether the **Protocol & Port** of the worker node security groups are set to **ICMP: All** and whether the security group with the source IP address set to the master node security group is deleted.

NOTE

This check item is performed only for clusters using VPC networking. For clusters using other networking, skip this check item.

Solution

Log in to the VPC console, choose **Access Control** > **Security Groups**, and enter the target cluster name in the search box. Two security groups are expected to display:

- The security group name is **cluster name-node-*xxx***. This security group is associated with the worker nodes.
- The security group name is **cluster name-control-*xxx***. This security group is associated with the master nodes.

Click the node security group and ensure that the following rules are configured to allow the master node to access the node using **ICMP**.

If the preceding security group rule is unavailable, add the rule with the following configurations to the node security group: Set **Protocol & Port** to **Protocols/ICMP** and **All**, and **Source** to **Security group** and the master security group.

5.4.5.9 Arm Node Restrictions

Check Items

Check the following items:

- Check whether the cluster contains Arm nodes.

Solution

- **Scenario 1: The cluster contains Arm nodes.**

  Delete Arm nodes.

5.4.5.10 To-Be-Migrated Nodes

Check Items

Check whether the node needs to be migrated.

Solution

For the 1.15 cluster that is upgraded from 1.13 in rolling mode, migrate (reset or create and replace) all nodes before performing the upgrade again.

Solution 1

Log in to the CCE console and click the cluster name to access the cluster console. Choose **Nodes** in the navigation pane. Locate the row containing the target node and choose **More** > **Reset Node** in the **Operation** column. For details, see **Resetting a Node**. After the node is reset, retry the check task.

NOTE

Resetting a node will reset all node labels, which may affect workload scheduling. Before resetting a node, check and retain the labels that you have manually added to the node.

Solution 2

After creating a node, delete the faulty node.

5.4.5.11 Discarded Kubernetes Resources

Check Items

Check whether there are discarded resources in the clusters.

Solution

Scenario: The Service in the clusters of v1.25 or later has discarded annotation: tolerate-unready-endpoints.

Error log:

```
some check failed in cluster upgrade: this cluster has deprecated service list: map[***] with deprecated annotation list [tolerate-unready-endpoints]
```

Check whether the Service provided in the log information contains the annotation of **tolerate-unready-endpoints**. If yes, replace the annotation with the following fields:

```
publishNotReadyAddresses: true
```

5.4.5.12 Compatibility Risks

Check Items

Read the version compatibility differences and ensure that they are not affected. The patch upgrade does not involve version compatibility differences.

Version compatibility

Upgrade Path	Version Difference	Self-Check
v1.23 or v1.25 Upgraded to v1.27	Docker is no longer recommended. Use containerd instead. For details, see **Container Engine**.	This item has been included in the pre-upgrade check.
v1.23 to v1.25	Since Kubernetes v1.25, PodSecurityPolicy has been replaced by pod Security Admission. For details, see **Configuring Pod Security Admission**.	• To migrate PodSecurityPolicy capabilities to pod Security Admission, perform the following steps: 1. Ensure that the cluster is of the latest CCE v1.23 version. 2. Migrate PodSecurityPolicy capabilities to pod Security Admission. For details, see **Configuring Pod Security Admission**. 3. After confirming that the functions are running properly after the migration, upgrade the CCE cluster to v1.25. • If you no longer need PodSecurityPolicy, delete PodSecurityPolicy from the cluster and upgrade the cluster to v1.25.

Upgrade Path	Version Difference	Self-Check
v1.21 or v1.19 Upgraded to v1.23	For the Nginx Ingress Controller of an earlier version (community version v0.49 or earlier, or CCE nginx-ingress version v1.x.x), the created ingresses can be managed by the Nginx Ingress Controller even if **kubernetes.io/ingress.class: nginx** is not set in the ingress **annotations**. However, for the Nginx Ingress Controller of a later version (community version v1.0.0 or later, or CCE nginx-ingress version v2.x.x), the ingresses created without specifying the Nginx type will not be managed by the Nginx Ingress Controller, and ingress rules will become invalid, which interrupts services.	This item has been included in the pre-upgrade check. You can also perform the self-check by referring to **nginx-ingress**.
v1.19 to v1.21	The bug of **exec probe timeouts** is fixed in Kubernetes 1.21. Before this bug is fixed, the exec probe does not consider the **timeoutSeconds** field. Instead, the probe will run indefinitely, even beyond its configured deadline. It will stop until the result is returned. If this field is not specified, the default value **1** is used. This field takes effect after the upgrade. If the probe runs over 1 second, the application health check may fail and the application may restart frequently.	Before the upgrade, check whether the timeout is properly set for the exec probe.

Upgrade Path	Version Difference	Self-Check
	kube-apiserver of CCE 1.19 or later requires that the Subject Alternative Names (SANs) field be configured for the certificate of your webhook server. Otherwise, kube-apiserver fails to call the webhook server after the upgrade, and containers cannot be started properly. Root cause: X.509 **CommonName** is discarded in Go 1.15. kube-apiserver of CCE 1.19 is compiled using Go 1.15. If your webhook certificate does not have SANs, kube-apiserver does not process the **CommonName** field of the X.509 certificate as the host name by default. As a result, the authentication fails.	Before the upgrade, check whether the SAN field is configured in the certificate of your webhook server. • If you do not have your own webhook server, you can skip this check. • If the field is not set, use the SAN field to specify the IP address and domain name supported by the certificate.

Table 5-19 QoS class changes before and after the upgrade

Init Container (Calculated Based on spec.initContainers)	Service Container (Calculated Based on spec.containers)	Pod (Calculated Based on spec.containers and spec.initContainers)	Impacted or Not
Guaranteed	Besteffort	Burstable	Yes
Guaranteed	Burstable	Burstable	No
Guaranteed	Guaranteed	Guaranteed	No
Besteffort	Besteffort	Besteffort	No
Besteffort	Burstable	Burstable	No
Besteffort	Guaranteed	Burstable	Yes
Burstable	Besteffort	Burstable	Yes
Burstable	Burstable	Burstable	No
Burstable	Guaranteed	Burstable	Yes

5.4.5.13 CCE Agent Versions

Check Items

Check whether cce-agent on the current node is of the latest version.

Solution

- **Scenario 1: The error message "you cce-agent no update, please restart it" is displayed.**

  cce-agent does not need to be updated but is not restarted. In this case, log in to the node and manually restart cce-agent.

  Solution: Log in to the node and run the following command:

  ```
  systemctl restart cce-agent
  ```

  Perform the pre-upgrade check again.

- **Scenario 2: The error message "your cce-agent is not the latest version" is displayed.**

  cce-agent is not of the latest version, and the automatic update failed. This issue is typically caused by an invalid OBS path or the component version is outdated.

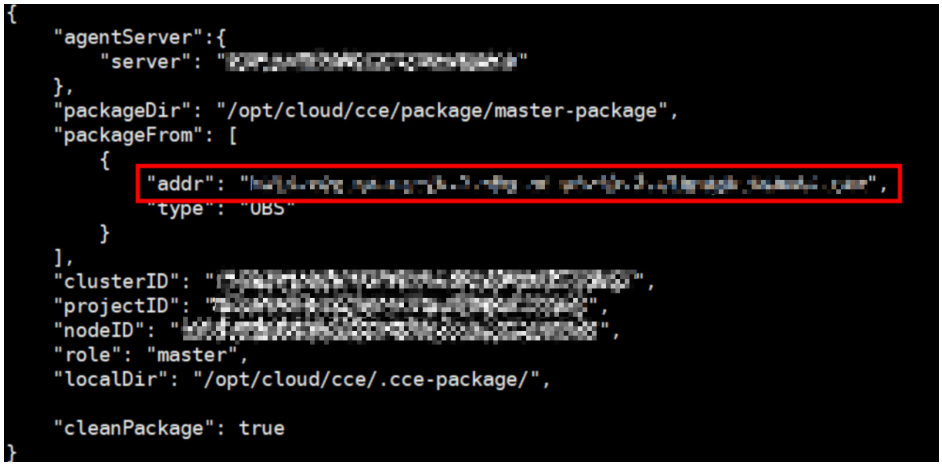
  Solution

  a. Log in to a node where the check succeeded, obtain the path of the cce-agent configuration file, and obtain the OBS address.

  ```
  cat `ps aux | grep cce-agent | grep -v grep | awk -F '-f ' '{print $2}'`
  ```

  The OBS configuration address field in the configuration file is **packageFrom.addr**.

  Figure 5-3 OBS address

  b. Log in to a where the check failed, obtain the OBS address again by referring to the previous step, and check whether the OBS addresses are the same. If they are different, change the OBS address of the abnormal node to the correct address.

  c. Run the following commands to download the latest binary file:

  - x86

    ```
    curl -k "https://{OBS address you have obtained}/cluster-versions/base/cce-agent" > /tmp/cce-agent
    ```

- Arm
  ```
  curl -k "https://{OBS address you have obtained}/cluster-versions/base/cce-agent-arm"
  > /tmp/cce-agent-arm
  ```

d. Replace the original cce-agent binary file.

- x86
  ```
  mv -f /tmp/cce-agent /usr/local/bin/cce-agent
  chmod 750 /usr/local/bin/cce-agent
  chown root:root /usr/local/bin/cce-agent
  ```
- Arm
  ```
  mv -f /tmp/cce-agent-arm /usr/local/bin/cce-agent-arm
  chmod 750 /usr/local/bin/cce-agent-arm
  chown root:root /usr/local/bin/cce-agent-arm
  ```

e. Restart cce-agent.
```
systemctl restart cce-agent
```

If you have any questions about the preceding operations, contact technical support.

5.4.5.14 Node CPU Usage

Check Items

Check whether the CPU usage of the node exceeds 90%.

Solution

- **Upgrade the cluster during off-peak hours.**
- Check whether too many pods are deployed on the node. If yes, reschedule pods to other idle nodes.

5.4.5.15 CRDs

Check Items

Check the following items:

- Check whether the key CRD **packageversions.version.cce.io** of the cluster is deleted.
- Check whether the cluster key CRD **network-attachment-definitions.k8s.cni.cncf.io** is deleted.

Solution

If check results are abnormal, contact technical support.

5.4.5.16 Node Disks

Check Items

Check the following items:

- Check whether the key data disks on the node meet the upgrade requirements.

- Check whether the **/tmp** directory has 500 MB available space.

Solution

During the node upgrade, the key disks store the upgrade component package, and the **/tmp** directory stores temporary files.

- **Scenario 1: Master node disks fail to meet the upgrade requirements.**

  Contact technical support.

- **Scenario 2: Worker node disks fail to meet the upgrade requirements.**

  Check the usage of each key disk. After ensuring that the available space meets the requirements, check again.

  - Disk partition of Docker: at least 1 GB of available space
    ```
    df -h /var/lib/docker
    ```
  - Disk partition of containerd: at least 1 GB of available space
    ```
    df -h /var/lib/containerd
    ```
  - Disk partition of kubelet: at least 1 GB of available space
    ```
    df -h /mnt/paas/kubernetes/kubelet
    ```
  - System disk: at least 2 GB of available space
    ```
    df -h /
    ```

- **Scenario 3: The available space of the /tmp directory on worker nodes is insufficient.**

  Run the following command to check the usage of the file system where the **/tmp** directory is located. Ensure that the space is greater than 500 MB and check again.

  ```
  df -h /tmp
  ```

5.4.5.17 Node DNS

Check Items

Check the following items:

- Check whether the DNS configuration of the current node can resolve the OBS address.
- Check whether the current node can access the OBS address of the storage upgrade component package.

Solution

During the node upgrade, obtain the upgrade component package from OBS. If this check fails, contact technical support.

5.4.5.18 Node Key Directory File Permissions

Check Items

Check whether the owner and owner group of the files in the **/var/paas** directory used by the CCE are both **paas**.

Solution

- **Scenario 1: The error message "xx file permission has been changed!" is displayed.**

  Solution: Enable CCE to use the **/var/paas** directory to manage nodes and store file data whose owner and owner group are both **paas**.

  During the current cluster upgrade, the owner and owner group of the files in the **/var/paas** directory are reset to paas.

  Check whether file data in the current service pod is stored in the **/var/paas** directory. If yes, do not use this directory, remove abnormal files from this directory, and check again. After the check is passed, proceed with the upgrade.

  ```
  find /var/paas -not \( -user paas -o -user root \) -print
  ```

- **Scenario 2: The error message "user paas must have at least read and execute permissions on the root directory" is displayed.**

  Solution: Change the permission on the root directory to the default permission 555. If the permission on the root directory of the node is modified, user **paas** does not have the read permission on the root directory. As a result, restarting the component failed during the upgrade.

5.4.5.19 Kubelet

Check Items

Check whether the kubelet on the node is running properly.

Solution

- **Scenario 1: The kubelet status is abnormal.**

  If the kubelet malfunctions, the node is unavailable. Restore the node and check again. For details, see **What Should I Do If a Cluster Is Available But Some Nodes Are Unavailable?**

- **Scenario 2: The cce-pause version is incorrect.**

  The version of the pause container image on which kubelet depends is not cce-pause:3.1. If you continue the upgrade, pods will restart in batches. Currently, the upgrade is not supported. Contact technical support.

5.4.5.20 Node Memory

Check Items

Check whether the memory usage of the node exceeds 90%.

Solution

- **Upgrade the cluster during off-peak hours.**
- Check whether too many pods are deployed on the node. If yes, reschedule pods to other idle nodes.

5.4.5.21 Node Clock Synchronization Server

Check Items

Check whether the clock synchronization server ntpd or chronyd of the node is running properly.

Solution

- **Scenario 1: ntpd is running abnormally.**

  Log in to the node and run the **systemctl status ntpd** command to obtain the running status of ntpd. If the command output is abnormal, run the **systemctl restart ntpd** command and obtain the status again.

  The normal command output is as follows:

  Figure 5-4 Running status of ntpd

  ```
  [root@[redacted] paas]# systemctl status ntpd
  ● ntpd.service - Network Time Service
     Loaded: loaded (/usr/lib/systemd/system/ntpd.service; enabled; vendor preset: disabled)
     Active: active (running) since Tue 2022-12-06 14:52:30 CST; 4 days ago
   Main PID: 8587 (ntpd)
      Tasks: 2
     Memory: 1.6M
     CGroup: /system.slice/ntpd.service
             └─8587 /usr/sbin/ntpd -u ntp:ntp -g -x
  ```

  If the problem persists after ntpd is restarted, contact technical support.

- **Scenario 2: chronyd is running abnormally.**

  Log in to the node and run the **systemctl status chronyd** command to obtain the running status of chronyd. If the command output is abnormal, run the **systemctl restart chronyd** command and obtain the status again.

  The normal command output is as follows:

  Figure 5-5 Running status of chronyd

  ```
  root@[redacted]# systemctl status chronyd
  ● chrony.service - chrony, an NTP client/server
     Loaded: loaded (/lib/systemd/system/chrony.service; enabled; vendor preset: enabled)
     Active: active (running) since Wed 2022-08-24 16:33:28 CST; 3 months 16 days ago
       Docs: man:chronyd(8)
             man:chronyc(1)
             man:chrony.conf(5)
    Process: 6492 ExecStartPost=/usr/lib/chrony/chrony-helper update-daemon (code=exited, status=0/SUCCESS)
    Process: 6461 ExecStart=/usr/lib/systemd/scripts/chronyd-starter.sh $DAEMON_OPTS (code=exited, status=0/SUCCESS)
   Main PID: 6488 (chronyd)
      Tasks: 1 (limit: 4915)
     CGroup: /system.slice/chrony.service
             └─6488 /usr/sbin/chronyd
  ```

  If the problem persists after chronyd is restarted, contact technical support.

5.4.5.22 Node OS

Check Items

Check whether the OS kernel version of the node is supported by CCE.

Solution

- **Case 1: The node image is not a standard CCE image.**

  CCE nodes run depending on the initial standard kernel version specified when they are created. CCE has performed comprehensive compatibility tests based on this kernel version. A non-standard kernel version may lead to unexpected compatibility issues during a node upgrade and the upgrade may fail. For details, see **High-Risk Operations and Solutions**.

  Do not directly upgrade this type of nodes. Instead, **reset the nodes** to a standard kernel version and then upgrade the nodes.

- **Case 2: An image of a special version is defective.**

  A EulerOS release 2.8 (Arm) image of v1.17 is used in the source version. Such an image is defective because the **docker exec** command will be affected after Docker is restarted. When the cluster version is upgraded, the Docker version will be updated and Docker will be restarted. To resolve this issue, do as follows:

  a. Empty and isolate the affected nodes before upgrading the cluster.

  b. Upgrade the version to v1.19 or later and reset the nodes to replace the image with one of a later version, for example, EulerOS release 2.9.

5.4.5.23 Node CPUs

Check Items

Check whether the number of CPUs on the master node is greater than 2.

Solution

If the number of CPUs on the master node is 2, contact technical support to expand the number to 4 or more.

5.4.5.24 Node Python Commands

Check Items

Check whether the Python commands are available on a node.

Check Method

```
/usr/bin/python --version
echo $?
```

If the command output is not 0, the check fails.

Solution

Install Python before the upgrade.

5.4.5.25 ASM Version

Check Items

Check the following items:

- Check whether ASM is used by the cluster.
- Check whether the current ASM version supports the target cluster version.

Solution

- Upgrade ASM and then upgrade the cluster. The adaptation rules between ASM and cluster versions are as follows:

  Table 5-20 Adaptation rules between ASM and cluster versions

ASM Version	Cluster Version
1.3	v1.13, v1.15, v1.17, or v1.19
1.6	v1.15, v1.17, v1.19, or v1.21
1.8	v1.15, v1.17, v1.19, or v1.21
1.13	v1.21 or v1.23
1.15	v1.21, v1.23, or v1.25

- If ASM is not required, delete it before the upgrade. After the upgrade, the cluster cannot be bound to ASM that does not match the table. For example, a cluster of v1.21 and ASM of v1.8 are used. If you want to upgrade the cluster to v1.23, upgrade ASM to v1.13 first.

5.4.5.26 Node Readiness

Check Items

Check whether the nodes in the cluster are ready.

Solution

- **Scenario 1: The nodes are in the unavailable status.**

  Log in to the CCE console and click the cluster name to access the cluster console. Choose **Nodes** in the navigation pane and filter out unavailable nodes, rectify the faulty nodes by referring to the suggestions provided by the console, and check again.

- **Scenario 2: The displayed node status is inconsistent with the actual status.**

  The possible causes are as follows:

  a. The node status is normal on the nodes page, but the check result shows that the node is not ready. Check again.

b. The node is not found on the nodes page, but the check result shows that the node is in the cluster. Contact technical support.

5.4.5.27 Node journald

Check Items

Check whether journald of a node is normal.

Solution

Log in to the node and run the **systemctl is-active systemd-journald** command to obtain the running status of journald. If the command output is abnormal, run the **systemctl restart systemd-journald** command and obtain the status again.

The normal command output is as follows:

Figure 5-6 Running status of journald

```
[root@ paas]# systemctl is-active systemd-journald
active
```

If the problem persists after journald is restarted, contact technical support.

5.4.5.28 containerd.sock

Check Items

Check whether the containerd.sock file exists on the node. This file affects the startup of container runtime in the Euler OS.

Solution

Scenario: The Docker used by the node is the customized Euler-docker.

Step 1 Log in to the node.

Step 2 Run the **rpm -qa | grep docker | grep euleros** command. If the command output is not empty, the Docker used on the node is Euler-docker.

Step 3 Run the **ls /run/containerd/containerd.sock** command. If the file exists, Docker startup will fail.

Step 4 Run the **rm -rf /run/containerd/containerd.sock** command and perform the cluster upgrade check again.

----End

5.4.5.29 Internal Errors

Check Items

Before the upgrade, check whether an internal error occurs.

Solution

If this check fails, contact technical support.

5.4.5.30 Node Mount Points

Check Items

Check whether inaccessible mount points exist on the node.

Solution

Scenario: There are inaccessible mount points on the node.

If NFS (such as obsfs or SFS) is used by the node and the node is disconnected from the NFS server, the mount point would be inaccessible and all processes that access this mount point are in D state.

Step 1 Log in to the node.

Step 2 Run the following commands on the node in sequence:

```
- df -h
- for dir in `df -h | grep -v "Mounted on" | awk "{print \\$NF}"`;do cd $dir; done && echo "ok"
```

Step 3 If **ok** is returned, no problem occurs.

Otherwise, start another terminal and run the following command to check whether the previous command is in the D state:

```
- ps aux | grep "D "
```

Step 4 If a process is in the D state, the problem occurs. You can restart the node to solve the problem. Restart the node and upgrade the cluster again.

NOTE

Workloads running on the node will be rescheduled after a node is restarted. Check whether services will be affected before restarting the node.

----End

5.4.5.31 Kubernetes Node Taints

Check Items

Check whether the taint needed for cluster upgrade exists on the node.

Table 5-21 Taint checklist

Taint Name	Impact
node.kubernetes.io/upgrade	NoSchedule

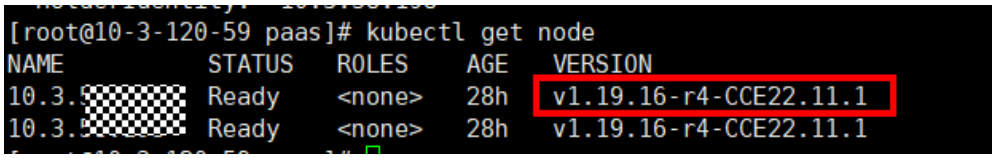
Solution

Scenario 1: The node is skipped during the cluster upgrade.

Step 1 Configure the **kubectl** command. For details, see **Connecting to a Cluster Using kubectl**.

Step 2 Check the kubelet version of the corresponding node. The following information is expected:

Figure 5-7 kubelet version



If the version of the node is different from that of other nodes, the node is skipped during the upgrade. Reset the node and upgrade the cluster again. For details about how to reset a node, see **Resetting a Node**.

NOTE

Resetting a node will reset all node labels, which may affect workload scheduling. Before resetting a node, check and retain the labels that you have manually added to the node.

----End

5.4.5.32 Everest Restrictions

Check Items

Check whether there are any compatibility restrictions on the current Everest add-on.

Table 5-22 List of Everest add-on versions with compatibility restrictions

Add-on Name	Versions Involved
everest	v1.0.2-v1.0.7 v1.1.1-v1.1.5

Solution

There are compatibility restrictions on the current Everest add-on and it cannot be upgraded with the cluster upgrade. Contact technical support.

5.4.5.33 cce-hpa-controller Restrictions

Check Items

Check whether the current cce-controller-hpa add-on has compatibility restrictions.

Solution

The current cce-controller-hpa add-on has compatibility restrictions. An add-on that can provide metric APIs, for example, metric-server, must be installed in the cluster.

5.4.5.34 Enhanced CPU Policies

Check Items

Check whether the current cluster version and the target version support enhanced CPU policy.

Solution

Scenario: Only the current cluster version supports the enhanced CPU policy function. The target version does not support the enhanced CPU policy function.

Upgrade to a cluster version that supports the enhanced CPU policy function. The following table lists the cluster versions that support the enhanced CPU policy function.

Table 5-23 List of cluster versions that support the enhanced CPU policy function

Cluster Version	Enhanced CPU Policy
Clusters of v1.17 or earlier	Not supported
Clusters of v1.19	Not supported
Clusters of v1.21	Not supported
Clusters of v1.23 or later	Supported

5.4.5.35 Health of Worker Node Components

Check Items

Check whether the container runtime and network components on the worker nodes are healthy.

Solution

If a worker node component malfunctions, log in to the node to check the status of the component and rectify the fault.

5.4.5.36 Health of Master Node Components

Check Items

Check whether the Kubernetes, container runtime, and network components of the master nodes are healthy.

Solution

If a master node component malfunctions, contact technical support.

5.4.5.37 Memory Resource Limit of Kubernetes Components

Check Items

Check whether the resources of Kubernetes components, such as etcd and kube-controller-manager, exceed the upper limit.

Solution

- Solution 1: Reduce Kubernetes resources that are needed.
- Solution 2: Modify cluster specifications. For details, see **Changing Cluster Scale**.

5.4.5.38 Discarded Kubernetes APIs

Check Items

The system scans the audit logs of the past day to check whether the user calls the deprecated APIs of the target Kubernetes version.

NOTE

Due to the limited time range of audit logs, this check item is only an auxiliary method. APIs to be deprecated may have been used in the cluster, but their usage is not included in the audit logs of the past day. Check the API usage carefully.

Solution

Check Description

Based on the check result, it is detected that your cluster calls a deprecated API of the target cluster version using kubectl or other applications. You can rectify the fault before the upgrade. Otherwise, the API will be intercepted by kube-apiserver after the upgrade. For details about each deprecated API, see **Deprecated APIs**.

Case Study

Ingresses of the extensions/v1beta1 and networking.k8s.io/v1beta1 APIs are deprecated in Kubernetes v1.22. If you upgrade a cluster from v1.19 or v1.21 to v1.23, existing resources are not affected, but the v1beta1 API may be intercepted in the creation and editing scenarios.

For details about the YAML configuration structure changes, see **Using kubectl to Create a LoadBalancer Ingress**.

5.4.5.39 Node NetworkManager

Check Items

Check whether NetworkManager of a node is normal.

Solution

Log in to the node and run the **systemctl is-active NetworkManager** command to obtain the running status of NetworkManager. If the command output is abnormal, run the **systemctl restart NetworkManager** command and obtain the status again.

If the problem persists after NetworkManager is restarted, contact technical support.

5.4.5.40 Node ID File

Check Items

Check the ID file format.

Solution

Step 1 On the **Nodes** page of the CCE console, click the name of the abnormal node to go to the ECS page.

Step 2 Copy the node ID and save it to the local host.

Step 3 Log in to the abnormal node and back up files.

```
cp /var/lib/cloud/data/instance-id /tmp/instance-id
cp /var/paas/conf/server.conf /tmp/server.conf
```

Step 4 Log in to the abnormal node and write the obtained node ID to the file.

```
echo "Node ID" > /var/lib/cloud/data/instance-id
echo "Node ID" > /var/paas/conf/server.conf
```

----End

5.4.5.41 Node Configuration Consistency

Check Items

When you upgrade a cluster to v1.19 or later, the system checks whether the following configuration files have been modified on the backend:

- /opt/cloud/cce/kubernetes/kubelet/kubelet
- /opt/cloud/cce/kubernetes/kubelet/kubelet_config.yaml
- /opt/cloud/cce/kubernetes/kube-proxy/kube-proxy
- /etc/containerd/default_runtime_spec.json
- /etc/sysconfig/docker
- /etc/default/docker
- /etc/docker/daemon.json

If you modify some parameters in these files, the cluster upgrade may fail or services may be abnormal after the upgrade. If you confirm that the modification does not affect services, continue the upgrade.

NOTE

CCE uses the standard image script to check node configuration consistency. If you use other custom images, the check may fail.

The expected modification will not be intercepted. The following table lists the parameters that can be modified.

Table 5-24 Parameters that can be modified

Component	Configuration File	Parameter	Upgrade Version
kubelet	/opt/cloud/cce/kubernetes/kubelet/kubelet_config.yaml	cpuManagerPolicy	Later than v1.19
kubelet	/opt/cloud/cce/kubernetes/kubelet/kubelet_config.yaml	maxPods	Later than v1.19
kubelet	/opt/cloud/cce/kubernetes/kubelet/kubelet_config.yaml	kubeAPIQPS	Later than v1.19
kubelet	/opt/cloud/cce/kubernetes/kubelet/kubelet_config.yaml	kubeAPIBurst	Later than v1.19
kubelet	/opt/cloud/cce/kubernetes/kubelet/kubelet_config.yaml	podPidsLimit	Later than v1.19
kubelet	/opt/cloud/cce/kubernetes/kubelet/kubelet_config.yaml	topologyManager-Policy	Later than v1.19
kubelet	/opt/cloud/cce/kubernetes/kubelet/kubelet_config.yaml	resolvConf	Later than v1.19
kubelet	/opt/cloud/cce/kubernetes/kubelet/kubelet_config.yaml	eventRecordQPS	Later than v1.21
kubelet	/opt/cloud/cce/kubernetes/kubelet/kubelet_config.yaml	topologyManager-Scope	Later than v1.21
kubelet	/opt/cloud/cce/kubernetes/kubelet/kubelet_config.yaml	allowedUnsafeSysctls	Later than v1.19
Docker	/etc/docker/daemon.json	dm.basesize	Later than v1.19

Solution

If you modify some parameters in these files, exceptions may occur after the upgrade. If you are not sure whether the modified parameters will affect the upgrade, contact technical support.

5.4.5.42 Node Configuration File

Check Items

Check whether the configuration files of key components exist on the node.

The following table lists the files to be checked.

File Name	File Content	Remarks
/opt/cloud/cce/kubernetes/kubelet/kubelet	kubelet command line startup parameters	None
/opt/cloud/cce/kubernetes/kubelet/kubelet_config.yaml	kubelet startup parameters	None
/opt/cloud/cce/kubernetes/kube-proxy/kube-proxy	kube-proxy command line startup parameters	None
/etc/sysconfig/docker	Docker configuration file	Not checked when containerd or the Debain-Group machine is used.
/etc/default/docker	Docker configuration file	Not checked when containerd or the Centos-Group machine is used.

Solution

Contact technical support to restore the configuration file and then perform the upgrade.

5.4.5.43 CoreDNS Configuration Consistency

Check Items

Check whether the current CoreDNS key configuration Corefile is different from the Helm release record. The difference may be overwritten during the add-on upgrade, **affecting domain name resolution in the cluster**.

Solution

You can upgrade CoreDNS separately after confirming the configuration differences.

Step 1 Configure the **kubectl** command. For details, see **Connecting to a Cluster Using kubectl**.

Step 2 Obtain the Corefile that takes effect currently.

```
kubectl get cm -nkube-system coredns -o jsonpath='{.data.Corefile}' > corefile_now.txt
cat corefile_now.txt
```

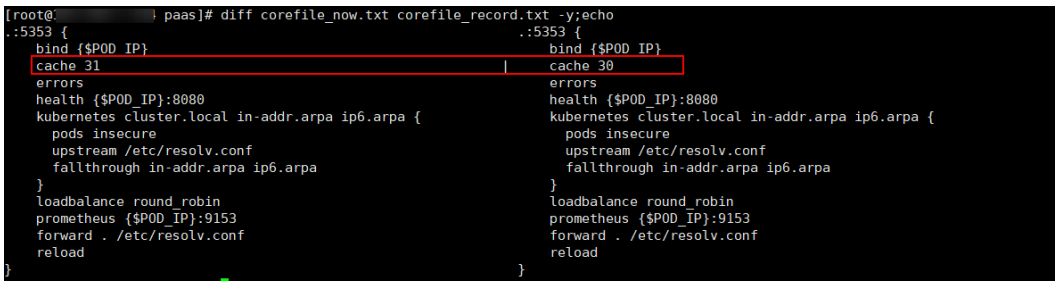
Step 3 Obtain the Corefile in the Helm Release records.

```
latest_release=`kubectl get secret -nkube-system -l owner=helm -l name=cceaddon-coredns --sort-by=.metadata.creationTimestamp | awk 'END{print $1}'`
kubectl get secret -nkube-system $latest_release -o jsonpath='{.data.release}' | base64 -d | base64 -d | gzip -d | python -m json.tool | python -c "
from __future__ import print_function
import json,sys,re,yaml;
manifests = json.load(sys.stdin)['manifest']
files = re.split('(?:^|\s*\n)---\s*',manifests)
for file in files:
    if 'coredns/templates/configmap.yaml' in file and 'Corefile' in file:
      corefile = yaml.safe_load(file)['data']['Corefile']
      print(corefile,end='')
      exit(0);
print('error')
exit(1);
" > corefile_record.txt
cat corefile_record.txt
```

Step 4 Compare the output differences between **Step 2** and **Step 3**.

```
diff corefile_now.txt corefile_record.txt -y;
```

Figure 5-8 Viewing output differences



Step 5 Return to the CCE console and click the cluster name to access the cluster console. Choose **Add-ons** in the navigation pane, select CoreDNS, and click **Upgrade**.

To retain custom configurations, use either of the following methods:

- (Recommended) Set **parameterSyncStrategy** to **inherit**. In this case, custom settings are automatically inherited. The system automatically parses, identifies, and inherits custom parameters.
- Set **parameterSyncStrategy** to **force**. Manually enter the differential configuration. For details, see **CoreDNS**.

Step 6 Click **OK**. After the add-on upgrade is complete, check whether all CoreDNS instances are available and whether Corefile meets the expectation.

```
kubectl get cm -nkube-system coredns -o jsonpath='{.data.Corefile}'
```

Step 7 Change the value of **parameterSyncStrategy** to **ensureConsistent** to enable configuration consistency verification.

In addition, it is a good practice to use the parameter configuration function of CCE add-ons to modify the Corefile configuration for consistency.

----End

5.4.5.44 sudo Commands of a Node

Check Items

Whether the sudo commands and sudo-related files of the node are working

Solution

- Scenario 1: The sudo command fails to be executed.

  During the in-place cluster upgrade, the sudo command must be available. Log in to the node and run the following command to check whether the sudo command is available:

  ```
  sudo echo hello
  ```

- Scenario 2: Key files cannot be modified.

  During the in-place cluster upgrade, the **/etc/sudoers** and **/etc/sudoers.d/sudoerspaas** files are modified to obtain the sudo permission and update the components (such as Docker and kubelet) whose owner and owner group are **root** and related configuration files on the node. Log in to the node and run the following command to check whether the file can be modified:

  ```
  lsattr -l /etc/sudoers.d/sudoerspaas /etc/sudoers
  ```

  If **immutable** is displayed in the command output, the file is locked by the **i** lock and cannot be modified. You are advised to remove the **i** lock.

  ```
  chattr -i /etc/sudoers.d/sudoerspaas /etc/sudoers
  ```

5.4.5.45 Key Commands of Nodes

Check Items

Whether some key commands that the node upgrade depends on are working

Solution

- Scenario 1: Executing the package manager command failed.

  Executing the **rpm** or **dpkg** command failed. In this case, log in to the affected node and check whether the following commands are available:

  - rpm:
    ```
    rpm -qa
    ```
  - dpkg:
    ```
    dpkg -l
    ```

- Scenario 2: The **systemctl status** command fails to be executed.

  If the **systemctl status** command on a node is unavailable, many check items will be affected. Log in to the node and check the availability of the following commands:

```
systemctl status kubelet
```

- Scenario 3: Executing the Python command failed.

  Check whether the command can be executed on the node.

  ```
  /usr/bin/python --version
  ```

5.4.5.46 Mounting of a Sock File on a Node

Check Items

Check whether the **docker/containerd.sock** file is directly mounted to the pods on a node. During an upgrade, Docker or containerd restarts and the sock file on the host changes, but the sock file mounted to pods does not change accordingly. As a result, your services cannot access Docker or containerd due to sock file inconsistency. After the pods are rebuilt, the sock file is mounted to the pods again, and the issue is resolved accordingly.

Kubernetes cluster users typically use sock files in the following scenarios:

1. Monitoring applications deployed as DaemonSets use a sock file to access Docker or containerd to obtain pod statuses on a node.
2. Compilation platform applications use a sock file to access Docker or containerd to obtain containers for compiling programs.

Solution

- Scenario 1: This issue occurred on an application, and operations need to be taken to resolve this issue.

  Mount the sock file by mounting a directory. For example, if the sock file is stored in **/var/run/docker.sock** on the host, perform the following operations to resolve this issue (the following modifications will lead to the rebuilding of pods):

  ```
  kind: Deployment
  apiVersion: apps/v1
  metadata:
    name: test
  spec:
    replicas: 1
    selector:
      matchLabels:
        app: nginx
    template:
      metadata:
        app: nginx
      spec:
        containers:
          - name: container-1
            image: 'nginx'
            imagePullPolicy: IfNotPresent
            volumeMounts:
              - name: sock-dir
                mountPath: /var/run
        imagePullSecrets:
          - name: default-secret
        volumes:
          - name: sock-dir
            hostPath:
              path: /var/run
  ```

- Scenario 2: This issue occurred on an application, and the risk that sock cannot be accessed for a short time is acceptable.

Skip this check item and perform the check again. After the cluster is upgraded, delete the existing pods to trigger pod rebuilding. Then, the access to sock will be recovered.

- Scenario 3: This issue occurred on some CCE add-ons of earlier versions.

  Upgrade the CCE add-ons to the latest version.

- Scenario 4: The "failed to execute docker ps -aq" error is displayed in the log analysis.

  This error is usually caused by a container engine exception. Submit a service ticket and contact O&M personnel.

5.4.5.47 HTTPS Load Balancer Certificate Consistency

Check Items

Check whether the certificate used by an HTTPS load balancer has been modified on ELB.

Solution

The certificate referenced by an HTTPS ingress created on CCE is modified on the ELB console. This leads to inconsistent certificate content in the CCE cluster and that required by the load balancer. After the CCE cluster is upgraded, the load balancer's certificate is overwritten.

Step 1 Log in to the ELB console, choose **Elastic Load Balance** > **Certificates**, locate the certificate, and find the **secret_id** in the certificate description.

The **secret_id** is the **metadata.uid** of the Secret in the cluster. Use this UID to obtain the Secret name in the cluster.

Run the following kubectl command to obtain the Secret name (replace *<secret_id>* with the actual value):

```
kubectl get secret --all-namespaces -o jsonpath='{range .items[*]}{"uid:"}{.metadata.uid}{" namespace:"}{.metadata.namespace}{" name:"}{.metadata.name}{"\n"}{end}' | grep <secret_id>
```

Step 2 Only clusters of v1.19.16-r2, v1.21.5-r0, v1.23.3-r0, and later versions support certificates required by load balancers. For clusters of the earlier versions, see **Solution 1**. For clusters of other versions, see **Solution 2**.

- Solution 1: Replace the certificate used by an ingress with the one used by the load balancer. Then, you can create or edit the certificate on the ELB console.

  a. Log in to the CCE console and click the cluster name to access the cluster console. Choose **Services & Ingresses** in the navigation pane, click the **Ingresses** tab, locate the row containing the ingress that uses the certificate, and choose **More** > **Update** in the **Operation** column. If multiple ingresses are using this certificate, update the certificate for all of these ingresses. To check which ingresses are using a certificate, use the **secertName** parameter in **spec.tls** of the ingress YAML files.

  Run the following kubectl command to obtain the ingresses using a certificate (replace *<secret_id>* with the actual value):

  ```
  kubectl get ingress --all-namespaces -o jsonpath='{range .items[*]}{"namespace:"}{.metadata.namespace}{" name:"}{.metadata.name}{" tls:"}{.spec.tls[*]}{"\n"}{end}' | grep <secret_name>
  ```

b. When configuring a listener, select **ELB server certificate** for **Certificate Source** and click **OK**. In this way, the certificate can be created or edited on the ELB console.

c. On the **ConfigMaps and Secrets** page, delete the target Secret. Before the deletion, back up data.

- Solution 2: Overwrite the certificate used by an ingress with the corresponding Secret resource of the cluster to prevent the certificate being updated on the ELB console during the cluster upgrade.

  Log in to the CCE console and click the cluster name to access the cluster console. Choose **ConfigMaps and Secrets** from the navigation pane, click the **Secrets** tab, locate the row containing the target Secret, click **Update** in the **Operation** column, and enter the certificate you are using.

----End

5.4.5.48 Node Mounting

Check Items

Check whether the default mount directory and soft link on the node have been manually mounted or modified.

- Non-shared disk
  - By default, **/var/lib/docker**, **containerd**, or **/mnt/paas/kubernetes/kubelet** is mounted to CCE nodes. Check whether **/var**, **/var/lib**, **/mnt**, **/mnt/paas**, and **/mnt/paas/kubernetes** have been manually mounted.
  - The soft link of **/var/lib/kubelet** to **/mnt/paas/kubernetes/kubelet** is created for CCE by default. Check whether it has been manually modified.
- Shared disk
  - By default, **/mnt/paas/** is mounted to CCE nodes. Check whether **/mnt** has been manually mounted.
  - The soft link of **/var/lib/kubelet** to **/mnt/paas/kubernetes/kubelet**, or **/var/lib/docker** or **containerd** to **/mnt/paas/runtime** is created for CCE by default. Check whether the soft links have been manually modified.

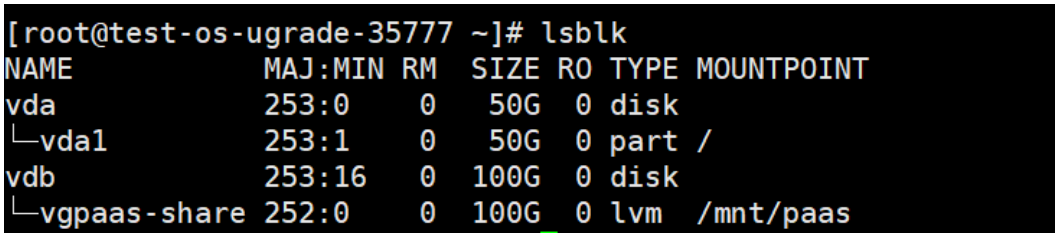
Solution

How Do I Check Whether a Disk Is Shared?

Step 1 Log in to the target node based on the check information.

Step 2 Run the **lsblk** command to check whether **vgpaas-share** is mounted to **/mnt/paas**. If yes, a shared disk is used.

Figure 5-9 Checking whether a shared disk is used



----End

What Can I Do If an Error Occurred in a Node Mounting Check?

1. Cancel the manually modified mount point.
2. Cancel the modification on the default soft link.

5.4.5.49 Login Permissions of User paas on a Node

Check Items

Check whether user **paas** is allowed to log in to a node.

Solution

Run the following command to check whether user **paas** is allowed to log in to a node:

```
sudo grep "paas" /etc/passwd
```

If the permissions assigned to user **paas** contain **nologin** or **false**, the user does not have the login permission. In this case, restore the login permission of user **paas**.

Run the following command to restore the login permission of user **paas**:

```
usermod -s /bin/bash paas
```

5.4.5.50 Private IPv4 Addresses of Load Balancers

Check Items

Check whether the load balancer associated with a Service is allocated with a private IPv4 address.

Solution

Solution 1: Delete the Service that is associated with a load balancer without a private IPv4 address.

Solution 2: Bind a private IP address to the load balancer without a private IPv4 address. The procedure is as follows:

Step 1 Obtain the load balancer associated with the target Service.

- Method 1: Obtain the load balancer ID based on the pre-upgrade check log. Go to the ELB console and filter load balancers by load balancer ID.

elbs (**ids: [*****]**) without ipv4 private ip, please bind private ip tothese elbs and try again

- Method 2: Log in to the CCE console and click the cluster name to access the cluster console. Then, choose **Services & Ingresses** in the navigation pane and click the name of the target load balancer to go to the ELB page.

Step 2 Check whether the load balancer has a private IPv4 address.

Step 3 Bind a private IP address to the load balancer without a private IPv4 address.

1. Log in to the CCE console and click the name of the target load balancer.
2. On the **Summary** tab, click **Bind** next to **Private IPv4 address**.
3. Configure the subnet and IPv4 address, and click **OK**.

----End

5.4.5.51 Historical Upgrade Records

Check Items

Check whether the source version of the cluster is earlier than v1.11 and the target version is later than v1.23.

Solution

If the source version of the cluster is earlier than v1.11, it is risky to upgrade the cluster to a version later than v1.23. In this case, contact technical support.

5.4.5.52 CIDR Block of the Cluster Management Plane

Check Items

Check whether the CIDR block of the cluster management plane is the same as that configured on the backbone network.

Solution

If the CIDR block of the cluster management plane is different from that configured on the backbone network, contact technical support.

5.4.5.53 GPU Add-on

Check Items

The GPU add-on is involved in the upgrade, which may affect the GPU driver installation during the creation of a GPU node.

Solution

The GPU add-on driver needs to be configured by yourself. Check the compatibility between the GPU add-on and the GPU driver. It is a good practice to verify the upgrade of the GPU driver to the target version in the test environment, configure the current GPU driver, and check whether the created GPU node can run properly.

Perform the following operations to check the upgrade of the GPU driver to the target version and current driver configuration of GPU add-on:

Step 1 Log in to the CCE console and click **Add-ons** to view the GPU add-on.

NOTE

gpu-beta is the same as **gpu-device-plugin**. **gpu-beta** is renamed **gpu-device-plugin** in versions later than 2.0.0.

Step 2 Click **Upgrade** of the add-on to view the target version and driver configuration of the add-on.

Step 3 Verify the upgrade of the GPU driver to the target version in the test environment, configure the current GPU driver, and check whether the created GPU node can run properly.

If the GPU add-on and the GPU driver are incompatible, install the driver of a later version. If necessary, contact technical support.

----End

5.4.5.54 Nodes' System Parameter Settings

Check Items

Check whether the default system parameter settings on your nodes are modified.

Solution

If the MTU value of the bond0 network on your BMS node is not the default value 1500, this check item failed.

Non-default parameter settings may lead to service packet loss. Change them back to the default values.

5.4.5.55 Residual Package Versions

Check Items

Check whether there are residual package version data in the current cluster.

Solution

A message is displayed indicating that there are residual 10.12.1.109 CRD resources in your cluster. This issue occurs because CRD resources are not cleared after nodes in earlier CCE versions are deleted.

Manually perform the following operations to clear the residual resources:

Step 1 Back up the residual CRD resources. Take CRD resource 10.12.1.109 as an example. Replace it with the resource displayed in the error message.

```
kubectl get packageversion 10.12.1.109 -oyaml > /tmp/packageversion-109.bak
```

Step 2 Clear the residual CRD resources.

```
kubectl delete packageversion 10.12.1.109
```

Step 3 Check residual package versions again.

----End

5.4.5.56 Node Commands

Check Items

Check whether the commands required for the upgrade are available on the node.

Solution

The cluster upgrade failure is typically caused by the lack of key node commands that are required in the cluster upgrade.

Error messages:

```
__error_code#ErrorCommandNotExist#chage command is not exists#__
__error_code#ErrorCommandNotExist#chown command is not exists#__
__error_code#ErrorCommandNotExist#chmod command is not exists#__
__error_code#ErrorCommandNotExist#mkdir command is not exists#__
__error_code#ErrorCommandNotExist#in command is not exists#__
__error_code#ErrorCommandNotExist#touch command is not exists#__
__error_code#ErrorCommandNotExist#pidof command is not exists#__
```

The preceding error messages indicate the lack of node commands such as **chage**, **chown**, and **chmod**. Add these commands and check the node commands again.

5.4.5.57 Node Swap

Check Items

Check whether swap has been enabled on cluster nodes.

Solution

By default, swap is disabled on CCE nodes. Check the necessity of enabling swap manually and determine the impact of disabling this function. Run the **swapoff -a** command to disable swap.

5.4.5.58 nginx-ingress Upgrade

Check Items

- Check whether there is an Nginx ingress route whose ingress type is not specified (**kubernetes.io/ingress.class: nginx** is not added to **annotations**) in the cluster.

Fault Locating

For an Nginx ingress, check the YAML. If the ingress type is not specified in the YAML file and the ingress is managed by the Nginx Ingress Controller, the ingress is at risk.

Step 1 Check the Ingress type.

Run the following command:

```
kubectl get ingress <ingress-name> -oyaml | grep -E ' kubernetes.io/ingress.class: | ingressClassName:'
```

- Fault scenario: If the command output is empty, the Ingress type is not specified.
- Normal scenario: The command output is not empty, indicating that the Ingress type has been specified by **annotations** or **ingressClassName**.

```
[root@ + + + + paas]# kubectl get ingress test -oyaml | grep -E ' kubernetes.io/ingress.class: | ingressClassName:' -B 1
Warning: extensions/v1beta1 Ingress is deprecated in v1.14+, unavailable in v1.22+; use networking.k8s.io/v1 Ingress
  annotations:
    kubernetes.io/ingress.class: nginx
--
spec:
  ingressClassName: nginx
```

Step 2 Ensure that the Ingress is managed by the Nginx Ingress Controller. The LoadBalancer Ingresses are not affected by this issue.

- For clusters of v1.19, confirm this issue using **managedFields**.

  ```
  kubectl get ingress <ingress-name> -oyaml | grep 'manager: nginx-ingress-controller'
  ```

  ```
  [root@192-168-0-31 paas]# kubectl get ingress test -oyaml | grep 'manager: nginx-ingress-controller'
  Warning: extensions/v1beta1 Ingress is deprecated in v1.14+, unavailable in v1.22+; use networking.k8s.io/v1 Ingress
      manager: nginx-ingress-controller
  ```

- For clusters of other versions, check the logs of the Nginx Ingress Controller pod.

  ```
  kubectl logs -nkube-system cceaddon-nginx-ingress-controller-545db6b4f7-bv74t | grep 'updating Ingress status'
  ```

  ```
  [root@ + + + + paas]# kubectl logs -nkube-system   cceaddon-nginx-ingress-controller-545db6b4f7-bv74t | grep 'updating Ingress status'
  + + + + + + + +       8 status.go:281] "updating Ingress status" namespace="default" ingress="test" currentValue=[] newValue=[{IP: + + + + + Hostname: Ports:[]} {IP: + + + + + Hostname: Ports:[]}]
  ```

If the fault persists, contact technical support personnel.

----End

Solution

Add an annotation to the Nginx ingresses as follows:

```
kubectl annotate ingress <ingress-name> kubernetes.io/ingress.class=nginx
```

NOTICE

There is no need to add this annotation to LoadBalancer ingresses. **Verify** that these ingresses are managed by Nginx Ingress Controller.

5.4.5.59 Upgrade of Cloud Native Cluster Monitoring

Check Items

During a cluster upgrade, compatibility issues occur when the Cloud Native Cluster Monitoring add-on is upgraded from a version earlier than 3.9.0 to a version later than 3.9.0. Check whether Grafana is enabled for this add-on.

Solution

In versions later than 3.9.0, Cloud Native Cluster Monitoring is not built in with Grafana capabilities anymore. Therefore, reinstall an open-source Grafana version before upgrading Cloud Native Cluster Monitoring.

NOTE

- Reinstalling Grafana does not affect existing data.
- Manually created Grafana Services and ingresses cannot be directly associate with the newly installed Grafana. To resolve this issue, manually change the selector for the affected Services and ingresses.

Solution 1: If Cloud Native Cluster Monitoring can be upgraded to 3.9.0 or later, upgrade it on the **Add-ons** page. In the displayed dialog box, click **Install Grafana**. After the request is submitted, continue to upgrade the add-on to the latest version.

Solution 2: If Cloud Native Cluster Monitoring cannot be upgraded to 3.9.0 or later, perform the following operations to manually migrate Grafana:

Step 1 Disable Grafana on Cloud Native Cluster Monitoring.

Go to the add-on list, click **Edit** of Cloud Native Cluster Monitoring. On the **Edit Add-on** page, disable Grafana.

Step 2 Install open-source Grafana.

On the **Add-ons** page, install Grafana.

----End

5.4.5.60 Check containerd pod restart risk

Check Items

Check whether the service container running on the node may restart when the containerd component is upgraded on the node that uses containerd in the current cluster.

Solution

Ensure that the cluster is upgraded when the impact on services is controllable (for example, during off-peak hours) to mitigate the impact of service container restart. If you need help, contact O&M personnel.

5.4.5.61 Key GPU Add-on Parameters

Check Items

Check whether the configuration of the CCE AI Suite add-on in a cluster has been intrusively modified. If so, upgrading the cluster may fail.

Solution

Step 1 Use kubectl to access the cluster.

Step 2 Run the following command to obtain the add-on instance details:

```
kubectl get ds nvidia-driver-installer -nkube-system -oyaml
```

Step 3 Check whether the **UpdateStrategy** value is changed to **OnDelete**. If so, change it back to **RollingUpdate**.

Step 4 Check whether the **NVIDIA_DRIVER_DOWNLOAD_URL** value is the same as the add-on IP address on the add-on details page. If no, change the value on the web page.

----End

5.4.5.62 GPU or NPU Pod Rebuild Risks

Check Items

Check whether GPU or NPU service pods are rebuilt in a cluster when kubelet is restarted during the upgrade of the cluster.

Solution

Upgrade the cluster when the impact on services is controllable (for example, during off-peak hours) to minimize the impact. If you need help, contact O&M personnel.

5.5 Managing a Cluster

5.5.1 Cluster Configuration Management

Scenario

CCE allows you to manage cluster parameters, through which you can let core components work under your requirements.

Constraints

This function is supported only in clusters of **v1.15 and later**. It is not displayed for versions earlier than v1.15.

Procedure

Step 1 Log in to the CCE console. In the navigation pane, choose **Clusters**.

Step 2 Locate the target cluster, click **...** to view more operations on the cluster, and choose **Manage**.

Step 3 On the **Manage Components** page on the right, change the values of the Kubernetes parameters listed in the following table.

Table 5-25 kube-apiserver configuration

Item	Parameter	Description	Value
Toleration time for nodes in NotReady state	default-not-ready-toleration-seconds	Specifies the default tolerance time. The configuration takes effect for all pods by default. You can configure different tolerance time for pods. In this case, the tolerance time configured for the pod is used. For details, see **Taints and Tolerations**. If the specified tolerance time is too short, pods may be frequently migrated in scenarios like a network jitter. If the specified tolerance time is too long, services may be interrupted during this period after the node is faulty.	Default: 300s
Toleration time for nodes in unreachable state	default-unreachable-toleration-seconds	Specifies the default tolerance time. The configuration takes effect for all pods by default. You can configure different tolerance time for pods. In this case, the tolerance time configured for the pod is used. For details, see **Taints and Tolerations**. If the specified tolerance time is too short, pods may be frequently migrated in scenarios like a network jitter. If the specified tolerance time is too long, services may be interrupted during this period after the node is faulty.	Default: 300s

Item	Parameter	Description	Value
Maximum Number of Concurrent Modification API Calls	max-mutating-requests-inflight	Maximum number of concurrent mutating requests. When the value of this parameter is exceeded, the server rejects requests. The value **0** indicates that there is no limitation on the maximum number of concurrent modification requests. This parameter is related to the cluster scale. You are advised not to change the value.	Manual configuration is no longer supported since cluster v1.21. The value is automatically specified based on the cluster scale. • **200** for clusters with 50 or 200 nodes • **500** for clusters with 1000 nodes • **1000** for clusters with 2000 nodes
Maximum Number of Concurrent Non-Modification API Calls	max-requests-inflight	Maximum number of concurrent non-mutating requests. When the value of this parameter is exceeded, the server rejects requests. The value **0** indicates that there is no limitation on the maximum number of concurrent non-modification requests. This parameter is related to the cluster scale. You are advised not to change the value.	Manual configuration is no longer supported since cluster v1.21. The value is automatically specified based on the cluster scale. • **400** for clusters with 50 or 200 nodes • **1000** for clusters with 1000 nodes • **2000** for clusters with 2000 nodes

Item	Parameter	Description	Value
NodePort port range	service-node-port-range	NodePort port range. After changing the value, go to the security group page and change the TCP/UDP port range of node security groups 30000 to 32767. Otherwise, ports other than the default port cannot be accessed externally. If the port number is smaller than **20106**, a conflict may occur between the port and the CCE health check port, which may further lead to unavailable cluster. If the port number is greater than **32767**, a conflict may occur between the port and the ports in **net.ipv4.ip_local_port_range**, which may further affect the network performance.	Default: 30000 to 32767 Value range: Min > 20105 Max < 32768
Request Timeout	request-timeout	Default request timeout interval of kube-apiserver. Exercise caution when changing the value of this parameter. Ensure that the changed value is proper to prevent frequent API timeout or other errors. This parameter is available only in clusters of v1.19.16-r30, v1.21.10-r10, v1.23.8-r10, v1.25.3-r10, or later versions.	Default: 1m0s Value range: Min ≥ 1s Max ≤ 1 hour

Item	Parameter	Description	Value
ServerSideApply	feature-gates: ServerSideApply	Whether to enable ServerSideApply of kube-apiserver. For details, see **Server-Side Apply**. If this function is enabled, the system stores the resource field management information in **metadata.managedFields** to record the subject, time, and fields of historical operations. This parameter is available only in clusters of v1.19.16-r30 or later patch versions, v1.21.10-r10 or later patch versions, v1.23.8-r10 or later patch versions, and v1.25.3-r10 or later patch versions. This feature is enabled by default for clusters v1.27 or later and cannot be disabled.	Default: true
Overload Control	support-overload	Cluster overload control. If enabled, concurrent requests are dynamically controlled based on the resource pressure of master nodes to keep them and the cluster available. This parameter is available only in clusters of v1.23 or later.	• false: Overload control is disabled. • true: Overload control is enabled.

Table 5-26 Scheduler configurations

Item	Parameter	Description	Value
QPS for communicating with kube-apiserver	kube-api-qps	QPS for communicating with kube-apiserver.	• If the number of nodes in a cluster is less than 1000, the default value is **100**. • If a cluster contains 1000 or more nodes, the default value is **200**.
Burst for communicating with kube-apiserver	kube-api-burst	Burst for communicating with kube-apiserver.	• If the number of nodes in a cluster is less than 1000, the default value is **100**. • If a cluster contains 1000 or more nodes, the default value is **200**.

Item	Parameter	Description	Value
Whether to enable GPU sharing	enable-gpu-share	Whether to enable GPU sharing. This parameter is supported only by clusters of v1.23.7-r10, v1.25.3-r0, and later. • When disabled, ensure that pods in the cluster do not use the shared GPU (that is, the annotation of **cce.io/gpu-decision** does not exist in pods). • When enabled, ensure that the annotation of **cce.io/gpu-decision** exists in pods that use GPU resources in the cluster.	Default: true

Table 5-27 kube-controller-manager configurations

Item	Parameter	Description	Value
Number of concurrent processing of deployment	concurrent-deployment-syncs	Number of deployment objects that are allowed to sync concurrently	Default: 5
Concurrent processing number of endpoint	concurrent-endpoint-syncs	Number of endpoint syncing operations that will be done concurrently	Default: 5
Concurrent number of garbage collector	concurrent-gc-syncs	Number of garbage collector workers that are allowed to sync concurrently	Default: 20
Number of job objects allowed to sync simultaneously	concurrent-job-syncs	Number of job objects that are allowed to sync concurrently	Default: 5

Item	Parameter	Description	Value
Number of CronJob objects allowed to sync simultaneously	concurrent-cron-job-syncs	Number of scheduled jobs that can be synchronized concurrently.	Default: 5
Number of concurrent processing of namespace	concurrent-namespace-syncs	Number of namespace objects that are allowed to sync concurrently	Default: 10
Concurrent processing number of replicaset	concurrent-replicaset-syncs	Number of replica sets that are allowed to sync concurrently	Default: 5
ResourceQuota	concurrent-resource-quota-syncs	Number of resource quotas that are allowed to sync concurrently	Default: 5
Concurrent processing number of service	concurrent-service-syncs	Number of services that are allowed to sync concurrently	Default: 10
Concurrent processing number of serviceaccount-token	concurrent-serviceaccount-token-syncs	Number of service account token objects that are allowed to sync concurrently	Default: 5
Concurrent processing of ttl-after-finished	concurrent-ttl-after-finished-syncs	Number of **ttl-after-finished-controller** workers that are allowed to sync concurrently	Default: 5
RC	concurrent-rc-syncs	Number of replication controllers that are allowed to sync concurrently **NOTE** This parameter is used only in clusters of v1.21 to v1.23. In clusters of v1.25 and later, this parameter is deprecated (officially deprecated from v1.25.3-r0 on).	Default: 5

Item	Parameter	Description	Value
HPA	concurrent-horizontal-pod-autoscaler-syncs	Number of HPA auto scaling requests that can be concurrently processed.	Default 1 for clusters earlier than v1.27 and 5 for clusters earlier than v1.27 Value range: 1 to 50
Cluster elastic computing period	horizontal-pod-autoscaler-sync-period	How often HPA audits metrics in a cluster.	Default: 15 seconds
QPS for communicating with kube-apiserver	kube-api-qps	QPS for communicating with kube-apiserver	• If the number of nodes in a cluster is less than 1000, the default value is **100**. • If a cluster contains 1000 or more nodes, the default value is **200**.
Burst for communicating with kube-apiserver	kube-api-burst	Burst for communicating with kube-apiserver.	• If the number of nodes in a cluster is less than 1000, the default value is **100**. • If a cluster contains 1000 or more nodes, the default value is **200**.

Item	Parameter	Description	Value
The maximum number of terminated pods that can be kept before the Pod GC deletes the terminated pod	terminated-pod-gc-threshold	Number of terminated pods that can exist in a cluster. If there are more terminated pods than the expected number in the cluster, the terminated pods that exceed the number will be deleted. **NOTE** If this parameter is set to **0**, all pods in the terminated state are retained.	Default: 1000 Value range: 10 to 12500 If the cluster version is v1.21.11-r40, v1.23.8-r0, v1.27.3-r0, v1.25.6-r0, or later, the value range is changed to 0 to 100000.

Table 5-28 Extended controller configurations (supported only by clusters of v1.21 and later)

Item	Parameter	Description	Value
Enable resource quota management	enable-resource-quota	Indicates whether to automatically create a ResourceQuota when creating a namespace. With quota management, you can control the number of workloads of each type and the upper limits of resources in a namespace or related dimensions. • **false**: Auto creation is disabled. • **true**: Auto creation is enabled. For details about the resource quota defaults, see **Configuring Resource Quotas**. **NOTE** In high-concurrency scenarios (for example, creating pods in batches), the resource quota management may cause some requests to fail due to conflicts. Do not enable this function unless necessary. To enable this function, ensure that there is a retry mechanism in the request client.	Default: false

Step 4 Click **OK**.

----End

References

- **kube-apiserver**
- **kube-controller-manager**
- **kube-scheduler**

5.5.2 Cluster Overload Control

Scenario

If enabled, concurrent requests are dynamically controlled based on the resource pressure of master nodes to keep them and the cluster available.

Constraints

The cluster version must be 1.23 or later.

Enabling Overload Control

Method 1: Enabling it when creating a cluster

When creating a cluster of v1.23 or later, you can enable overload control during the cluster creation.

Method 2: Enabling it in an existing cluster

Step 1 Log in to the CCE console and click the name of an existing cluster whose version is v1.23 or later.

Step 2 On the **Overview** page, check the master node information. If overload control is not enabled, a message will be displayed. You can click **Enable** to enable the function.

----End

Disabling Cluster Overload Control

Step 1 Log in to the CCE console and go to an existing cluster whose version is v1.23 or later.

Step 2 In the navigation pane, choose **Settings**.

Step 3 On the **Cluster Access** tab page, disable overload control.

Step 4 Click **OK**.

----End

5.5.3 Changing Cluster Scale

Scenario

CCE allows you to change the number of nodes managed in a cluster.

Constraints

- This function is supported for clusters of v1.15 and later versions.
- Starting from v1.15.11, the number of nodes in a cluster can be changed to 2000. The number of nodes in a single master node cannot be changed to 1000 or more.
- The number of master nodes cannot be changed when you modify cluster specifications.
- Currently, a cluster can only be scaled out to a larger specification, but cannot be scaled in.
- During the specifications change, master nodes will be powered off and on, and the cluster cannot run properly. Perform the change during off-peak hours.
- Changing the cluster scale does not affect the services running in the cluster. However, the control plane (master nodes) will be interrupted for a short period of time. You are advised not to perform any other operations (such as creating workloads) during the change.
- Change failures will trigger a cluster rollback to the normal state. If the rollback fails, submit a service ticket.

Procedure

Step 1 Log in to the CCE console. In the navigation pane, choose **Clusters**.

Step 2 Locate the cluster whose specifications need to be modified, click **...** to view more operations on the cluster, and choose **Specification change**.

Step 3 On the page displayed, select a new cluster scale.

Step 4 Click **Next** to confirm the specifications and click **OK**.

You can click **Operation Records** in the upper right corner to view the cluster change history. The status changes from **Executing** to **Successful**, indicating that the cluster specifications are successfully changed.

NOTE

After the cluster scale is changed to 1000 nodes or more, some parameter values of the cluster will be automatically adjusted to ensure the cluster performance. For details, see **Cluster Configuration Management**.

----End

5.5.4 Changing the Default Security Group of a Node

Scenario

When creating a cluster, you can customize a node security group to centrally manage network security policies. For a created cluster, you can change its default node security group.

Constraints

- Do not add more than 1000 pods to the same security group. Otherwise, the security group performance may be impacted.
- The security group of the master node cannot be specified. Exercise caution when modifying the security group rules of the master node.

Procedure

Step 1 Log in to the CCE console. In the navigation pane, choose **Clusters**.

Step 2 Click the cluster name to access the **Overview** page.

Step 3 In the **Network Configuration** area, click  next to the **Default Node Security Group**.

Step 4 Select an existing security group, confirm that the security group rules meet the cluster requirements, and click **OK**.

NOTICE

- Ensure that correct port rules are configured for the selected security group. Otherwise, the node cannot be created. The port rules that a security group must comply with vary with the cluster type.
- The new security group takes effect only for newly created or managed nodes. For existing nodes, modify the security group rules and reset the nodes in real time. The original security group is still used.

----End

5.5.5 Deleting a Cluster

Precautions

- Deleting a cluster will delete the nodes in the cluster (excluding accepted nodes), data disks attached to the nodes, workloads, and Services. Related services cannot be restored. Before performing this operation, ensure that data has been backed up or migrated. Deleted data cannot be restored.

  Resources that are not created in CCE will not be deleted:

  - Accepted nodes (only the nodes created in CCE are deleted)
  - ELB load balancers associated with Services and ingresses (only the automatically created load balancers are deleted)

  - Manually created cloud storage resources associated with PVs or imported cloud storage resources (only the cloud storage resources automatically created by PVCs are deleted)
- If you delete a cluster that is not running (for example, unavailable), associated resources, such as storage and networking resources, will remain.

Deleting a Cluster

NOTICE

A hibernated cluster cannot be deleted. Wake up the cluster and try again.

Step 1 Log in to the CCE console. In the navigation pane, choose **Clusters**.

Step 2 Locate the cluster to be deleted, click **...** to view more operations on the cluster, and choose **Delete**.

Step 3 In the displayed **Delete Cluster** dialog box, select the resources to be released.

- Delete cloud storage resources associated with workloads in the cluster.

  NOTE

  When deleting underlying cloud storage resources bound to storage volumes in a cluster, pay attention to following constraints:

  - The underlying storage resources are deleted according to the reclamation policy you defined for the storage volumes. For example, if the reclamation policy of storage volumes is **Retain**, the underlying storage resources will be retained after the cluster is deleted.
  - If there are more than 1000 files in the OBS bucket, manually clear the files and then delete the cluster.
- Delete network resources such as load balancers in a cluster. (Only automatically created load balancers will be deleted).

Step 4 Enter **DELETE** and click **Yes** to start deleting the cluster.

The delete operation takes 1 to 3 minutes to complete.

----End

5.5.6 Hibernating and Waking Up a Cluster

Scenario

If you do not need to use a cluster temporarily, hibernate the cluster.

After a cluster is hibernated, resources such as workloads cannot be created or managed in the cluster.

A hibernated cluster can be quickly woken up and used properly.

Constraints

- During cluster wakeup, the master node may fail to start due to insufficient resources, which leads to a cluster wakeup failure. In this case, wait for a while and try again.
- After a cluster is woken up, it takes 3 to 5 minutes to initialize data. Deliver services after the cluster runs properly.

Hibernating a Cluster

Step 1 Log in to the CCE console. In the navigation pane, choose **Clusters**.

Step 2 Locate the cluster to be hibernated, click **...** to view more operations on the cluster, and choose **Hibernate**.

Step 3 In the dialog box displayed, check the precautions and click **Yes**. Wait until the cluster is hibernated.

----End

Waking Up a Cluster

Step 1 Log in to the CCE console. In the navigation pane, choose **Clusters**.

Step 2 Click **Wake Up** in the row of the target cluster.

Step 3 When the cluster status changes from **Waking up** to **Running**, the cluster is woken up. It takes about 3 to 5 minutes to wake up the cluster.

----End

6 Nodes

6.1 Node Overview

Introduction

A container cluster consists of a set of worker machines, called nodes, that run containerized applications. A node can be a virtual machine (VM) or a physical machine (PM), depending on your service requirements. The components on a node include kubelet, container runtime, and kube-proxy.

NOTE

A Kubernetes cluster consists of master nodes and worker nodes. The nodes described in this section refer to **worker nodes**, which are computing nodes of a cluster that run containerized applications.

CCE uses high-performance Elastic Cloud Servers (ECSs) as nodes to build highly available Kubernetes clusters.

Supported Node Specifications

Different regions support different node flavors, and node flavors may be changed. Log in to the CCE console and check whether the required node flavors are supported on the page for creating nodes.

Underlying File Storage System of Containers

Docker

- In clusters of v1.15.6 or earlier, the underlying Docker file storage system is in XFS format.
- In clusters of v1.15.11 or later, after a node is created or reset, the underlying Docker file storage system changes to the ext4 format.

For containerized applications that use the XFS format, pay attention to the impact of the underlying file storage format change. (The sequence of files in different file systems is different. For example, some Java applications reference a JAR package, but the directory contains multiple versions of the JAR package. If

the version is not specified, the actual referenced package is determined by the system file.)

Run the **docker info | grep "Backing Filesystem"** command to check the format of the underlying Docker storage file used by the current node.

containerd

Nodes running on containerd use the ext4 file storage system.

paas User and User Group

When you create a node in a cluster, the paas user or a user group will be created on the node by default. CCE components and CCE add-ons on a node run as a non-root user (user **paas** or a user group) to minimize the running permission. If the paas user or user group is modified, CCE components and pods may fail to run properly.

NOTICE

The normal running of CCE components depends on the paas user or user group. Pay attention to the following requirements:

- Do not modify the directory permission and container directory permission on a node.
- Do not change the GID and UID of the paas user or user group.
- Do not directly use the paas user or user group to set the user and group to which the service file belongs.

Node Lifecycle

A lifecycle indicates the node statuses recorded from the time when the node is created through the time when the node is deleted or released.

Table 6-1 Node statuses

Status	Status Attribute	Description
Running	Stable state	The node is running properly and is connected to the cluster. Nodes in this state can provide services.
Unavailable	Stable state	The node is not running properly. Instances in this state no longer provide services. In this case, perform the operations in **Resetting a Node**.
Creating	Intermediate state	The node has been created but is not running.

Status	Status Attribute	Description
Installing	Intermediate state	The Kubernetes software is being installed on the node.
Deleting	Intermediate state	The node is being deleted. If this state stays for a long time, an exception occurred.
Stopped	Stable state	The node is stopped properly. A node in this state cannot provide services. You can start the node on the ECS console.
Error	Stable state	The node is abnormal. Instances in this state no longer provide services. In this case, perform the operations in **Resetting a Node**.

6.2 Container Engine

Introduction to Container Engines

Container engines, one of the most important components of Kubernetes, manage the lifecycle of images and containers. The kubelet interacts with a container runtime through the Container Runtime Interface (CRI).

CCE supports containerd and Docker. **containerd is recommended for its shorter traces, fewer components, higher stability, and less consumption of node resources**.

Table 6-2 Comparison between container engines

Item	containerd	Docker
Tracing	kubelet --> CRI plugin (in the containerd process) --> containerd	• Docker (Kubernetes v1.23 and earlier): kubelet --> dockershim (in the kubelet process) --> docker --> containerd • Docker (community solution for Kubernetes v1.24 or later): kubelet --> cri-dockerd (kubelet uses CRI to connect to cri-dockerd) --> docker--> containerd
Command	crictl/ctr	docker

Item	containerd	Docker
Kubernetes CRI	Native support	Support through dockershim or cri-dockerd
Pod delayed startup	Minor	High
kubelet CPU/ memory usage	Minor	High
Runtime's CPU/memory usage	Minor	High

Common Commands of containerd and Docker

containerd does not support Docker APIs and Docker CLI, but you can run crictl commands to implement similar functions.

Table 6-3 Image-related commands

Operation	Docker Command	containerd Command	
	docker	crictl	ctr
List local images.	docker images	crictl images	ctr -n k8s.io i ls
Pull images.	docker pull	crictl pull	ctr -n k8s.io i pull
Push images.	docker push	None	ctr -n k8s.io i push
Delete a local image.	docker rmi	crictl rmi	ctr -n k8s.io i rm
Check images.	docker inspect	crictl inspecti	None

Table 6-4 Container-related commands

Operation	Docker Command	containerd Command	
	docker	crictl	ctr
List containers.	docker ps	crictl ps	ctr -n k8s.io c ls
Create a container.	docker create	crictl create	ctr -n k8s.io c create
Start a container.	docker start	crictl start	ctr -n k8s.io run

Operation	Docker Command	containerd Command	
	docker	crictl	ctr
Stop a container.	docker stop	crictl stop	None
Delete a container.	docker rm	crictl rm	ctr -n k8s.io c del
Connect to a container.	docker attach	crictl attach	None
Access the container.	docker exec	crictl exec	None
Query container details.	docker inspect	crictl inspect	ctr -n k8s.io c info
View container logs.	docker logs	crictl logs	None
Check the resource usage of the container.	docker stats	crictl stats	None
Update container resource limits.	docker update	crictl update	None

Table 6-5 Pod-related commands

Operation	Docker Command	containerd Command	
	docker	crictl	ctr
List pods.	None	crictl pods	None
View pod details.	None	crictl inspectp	None
Start a pod.	None	crictl start	None
Run a pod.	None	crictl runp	None
Stop a pod.	None	crictl stopp	None
Delete a pod.	None	crictl rmp	None

NOTE

Containers created and started by containerd are immediately deleted by kubelet. containerd does not support suspending, resuming, restarting, renaming, and waiting for containers, nor Docker image build, import, export, comparison, push, search, and labeling. containerd does not support file copy. You can log in to the image repository by modifying the configuration file of containerd.

Differences in Tracing

- Docker (Kubernetes 1.23 and earlier):

  kubelet --> docker shim (in the kubelet process) --> docker --> containerd
- Docker (community solution for Kubernetes v1.24 or later):

  kubelet --> cri-dockerd (kubelet uses CRI to connect to cri-dockerd) --> docker--> containerd
- containerd:

  kubelet --> cri plugin (in the containerd process) --> containerd

Although Docker has added functions such as swarm cluster, docker build, and Docker APIs, it also introduces bugs. Compared with containerd, Docker has one more layer of calling. **Therefore, containerd is more resource-saving and secure.**

6.3 Creating a Node

Prerequisites

- At least one cluster has been created.
- A key pair has been created for identity authentication upon remote node login.

Constraints

- The node has at least 2 vCPUs and 4 GiB of memory.
- To ensure node stability, a certain number of CCE node resources will be reserved for Kubernetes components (such as kubelet, kube-proxy, and docker) based on the node specifications. Therefore, the total number of node resources and the number of allocatable node resources for your cluster are different. The larger the node specifications, the more the containers deployed on the node. Therefore, more node resources need to be reserved to run Kubernetes components. For details, see **Node Resource Reservation Policy**.
- Networks including VM networks and container networks of nodes are all managed by CCE. Do not add or delete ENIs, or change routes and IP addresses. Otherwise, services may be unavailable. For example, the NIC named **gw_11cbf51a@eth0** on the node is the container network gateway and cannot be modified.
- During the node creation, software packages are downloaded from OBS using the domain name. A private DNS server must be used to resolve the OBS domain name. Therefore, the DNS server address of the subnet where the node resides must be set to the private DNS server address so that the node can access the private DNS server. When you create a subnet, the private DNS server is used by default. If you change the subnet DNS, ensure that the DNS server in use can resolve the OBS domain name.
- Once a node is created, its AZ cannot be changed.

Procedure

After a cluster is created, you can create nodes for the cluster.

Step 1 Log in to the CCE console.

Step 2 In the navigation pane of the CCE console, choose **Clusters**. Click the target cluster name to access its details page.

Step 3 In the navigation pane, choose **Nodes**. On the page displayed, click the **Nodes** tab and then **Create Node** in the upper right corner. Configure node parameters.

Configurations

You can configure the flavor and OS of a cloud server, on which your containerized applications run.

Table 6-6 Node configuration parameters

Parameter	Description
Billing Mode	The following billing modes are supported: ● Pay-per-use Resources will be billed based on usage duration. You can provision or delete resources at any time.
AZ	AZ where the node is located. Nodes in a cluster can be created in different AZs for higher reliability. The value cannot be changed after the node is created. Select **Random** to deploy your node in a random AZ based on the selected node flavor. An AZ is a physical region where resources use independent power supply and networks. AZs are physically isolated but interconnected through an internal network. To enhance workload availability, create nodes in different AZs.
Node Type	Select a node type based on service requirements. Then, the available node flavors will be automatically displayed in the **Specifications** area for you to select. CCE standard clusters support the following node types: ● ECS (VM): A virtualized ECS is used as a cluster node. ● ECS (physical machine): A QingTian-backed bare metal server is used as a cluster node.
Specifications	Select node specifications that best fit your service needs. The available node flavors vary depending on AZs. Obtain the flavors displayed on the console.
Container Engine	The container engines supported by CCE include Docker and containerd, which may vary depending on cluster types, cluster versions, and OSs. Select a container engine based on the information displayed on the CCE console.

Parameter	Description
OS	Select an OS type. Different types of nodes support different OSs. • **Public image**: Select a public image for the node. • **Private image**: Select a private image for the node. **NOTE** 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.
Node Name	Name of the node. When nodes (ECSs) are created in batches, the value of this parameter is used as the name prefix for each ECS. The system generates a default name for you, which can be modified. Enter 1 to 56 characters. Only lowercase letters, digits, hyphens (-), and periods (.) are allowed. The name must start with a lowercase letter and cannot end with a hyphen (-). Only lowercase letters or digits are allowed before and after periods (.).
Login Mode	• **Password** The default username is **root**. Enter the password for logging in to the node and confirm the password. Be sure to remember the password as you will need it when you log in to the node. • **Key Pair** Select the key pair used to log in to the node. You can select a shared key. A key pair is used for identity authentication when you remotely log in to a node. If no key pair is available, click **Create Key Pair**.

Storage Settings

Configure storage resources on a node for the containers running on it. Select a disk type and configure its size based on service requirements.

Table 6-7 Configuration parameters

Parameter	Description
System Disk	System disk used by the node OS. The value ranges from 40 GiB to 1024 GiB. The default value is 50 GiB.

Parameter	Description
Data Disk	**At least one data disk is required** for the container runtime and kubelet. **The data disk cannot be deleted or uninstalled. Otherwise, the node will be unavailable.** • First data disk: used for container runtime and kubelet components. The value ranges from 20 GiB to 32768 GiB. The default value is 100 GiB. • Other data disks: You can set the data disk size to a value ranging from 10 GiB to 32768 GiB. The default value is 100 GiB. **NOTE** • If the node flavor is disk-intensive or ultra-high I/O, one data disk can be a local disk. • Local disks may break down and do not ensure data reliability. Store your service data in EVS disks, which are more reliable than local disks. **Advanced Settings** Click **Expand** and configure the following parameters: • **Data Disk Space Allocation**: allocates space for container engines, images, and ephemeral storage for them to run properly. For details about how to allocate data disk space, see **Data Disk Space Allocation**. • **Encryption**: Data disk encryption safeguards your data. Snapshots generated from encrypted disks and disks created using these snapshots automatically inherit the encryption setting. **This function is available only in certain regions.** – **Encryption** is not selected by default. – After selecting **Encryption**, you can select an existing key in the displayed dialog box. If no key is available, click **View Key List** and create a key. After the key is created, click the refresh icon next to the **Encryption** text box. **Adding data disks** A maximum of four data disks can be added. By default, raw disks are created without any processing. You can also click **Expand** and select any of the following options: • **Default**: By default, a raw disk is created without any processing. • **Mount Disk**: The data disk is attached to a specified directory. • **Use as PV**: applicable when there is a high performance requirement on PVs. The **node.kubernetes.io/local-storage-persistent** label is added to the node with PV configured. The value is **linear** or **striped**. • **Use as ephemeral volume**: applicable when there is a high performance requirement on EmptyDir.

Parameter	Description
	NOTE • Local PVs are supported only when the cluster version is v1.21.2-r0 or later and the Everest add-on version is 2.1.23 or later. Version 2.1.23 or later is recommended. • Local EVs are supported only when the cluster version is v1.21.2-r0 or later and the Everest add-on version is 1.2.29 or later. **Local Persistent Volumes** and **Local EVs** support the following write modes: • **Linear**: A linear logical volume integrates one or more physical volumes. Data is written to the next physical volume when the previous one is used up. • **Striped**: A striped logical volume stripes data into blocks of the same size and stores them in multiple physical volumes in sequence, allowing data to be concurrently read and written. A storage pool consisting of striped volumes cannot be scaled-out. This option can be selected only when multiple volumes exist.

Network Settings

Configure networking resources to allow node and containerized application access.

Table 6-8 Configuration parameters

Parameter	Description
VPC/Node Subnet	The node subnet selected during cluster creation is used by default. You can choose another subnet instead.
Node IP Address	IP address of the specified node. By default, the value is randomly allocated.
EIP	An ECS without a bound EIP cannot access the Internet or be accessed by public networks. The default value is **Do not use**. **Use existing** and **Auto create** are supported.

Advanced Settings

Configure advanced node capabilities such as labels, taints, and startup command.

Table 6-9 Advanced configuration parameters

Parameter	Description
Resource Tag	You can add resource tags to classify resources. You can create **predefined tags** on the TMS console. The predefined tags are available to all resources that support tags. You can use predefined tags to improve the tag creation and resource migration efficiency. CCE will automatically create the "CCE-Dynamic-Provisioning-Node=*node id*" tag.
Kubernetes Label	A key-value pair added to a Kubernetes object (such as a pod). After specifying a label, click **Add Label** for more. A maximum of 20 labels can be added. Labels can be used to distinguish nodes. With workload affinity settings, container pods can be scheduled to a specified node. For more information, see **Labels and Selectors**.
Taint	This parameter is left blank by default. You can add taints to configure node anti-affinity. A maximum of 20 taints are allowed for each node. Each taint contains the following parameters: • **Key**: A key must contain 1 to 63 characters, starting with a letter or digit. Only letters, digits, hyphens (-), underscores (_), and periods (.) are allowed. A DNS subdomain name can be used as the prefix of a key. • **Value**: A value must start with a letter or digit and can contain a maximum of 63 characters, including letters, digits, hyphens (-), underscores (_), and periods (.). • **Effect**: Available options are **NoSchedule**, **PreferNoSchedule**, and **NoExecute**. For details, see **Managing Node Taints**. **NOTE** For a cluster of v1.19 or earlier, the workload may have been scheduled to a node before the taint is added. To avoid such a situation, select a cluster of v1.19 or later.
Max. Pods	Maximum number of pods that can run on the node, including the default system pods. This limit prevents the node from being overloaded with pods. This number is also decided by other factors. For details, see **Maximum Number of Pods That Can Be Created on a Node**.

Parameter	Description
ECS Group	An ECS group logically groups ECSs. The ECSs in the same ECS group comply with the same policy associated with the ECS group. **Anti-affinity**: ECSs in an ECS group are deployed on different physical hosts to improve service reliability. Select an existing ECS group, or click **Add ECS Group** to create one. After the ECS group is created, click the refresh icon.
Pre-installation Command	Pre-installation script command, in which Chinese characters are not allowed. The script command will be Base64-transcoded. The script will be executed before Kubernetes software is installed. Note that if the script is incorrect, Kubernetes software may fail to be installed.
Post-installation Command	Pre-installation script command, in which Chinese characters are not allowed. The script command will be Base64-transcoded. The script will be executed after Kubernetes software is installed, which does not affect the installation. **NOTE** Do not run the **reboot** command in the post-installation script to restart the system immediately. To restart the system, run the **shutdown -r 1** command to restart with a delay of one minute.
Agency	An agency is created by the account administrator on the IAM console. By creating an agency, you can share your cloud server resources with another account, or entrust a more professional person or team to manage your resources. If no agency is available, click **Create Agency** on the right to create one.

Step 4 Configure the number of nodes to be purchased. Then, click **Next: Confirm**. Confirm the configured parameters and specifications.

Step 5 Click **Submit**.

The node list page is displayed. If the node status is **Running**, the node is created successfully. It takes about 6 to 10 minutes to create a node.

Step 6 Click **Back to Node List**. The node is created successfully if it changes to the **Running** state.

----End

6.4 Accepting Nodes for Management

Scenario

In CCE, you can create a node (**Creating a Node**) or add existing nodes (ECSs) to your cluster for management.

NOTICE

- While an ECS is being accepted into a cluster, the operating system of the ECS will be reset to the standard OS image provided by CCE to ensure node stability. The CCE console prompts you to select the operating system and the login mode during the reset.
- LVM information, including volume groups (VGs), logical volumes (LVs), and physical volumes (PVs), will be deleted from the system disks and data disks attached to the selected ECSs during management. Ensure that the information has been backed up.
- While an ECS is being accepted into a cluster, do not perform any operation on the ECS through the ECS console.

Constraints

- The cluster version must be 1.15 or later.
- If a password or key has been set when the original VM node was created, reset the password or key during management. The original password or key will become invalid.
- Data disks that have been partitioned will be ignored during node management. Ensure that there is at least one unpartitioned data disk meeting the specifications is attached to the node.

Prerequisites

A cloud server that meets the following conditions can be accepted:

- The node to be accepted must be in the **Running** state and not used by other clusters. In addition, the node to be accepted does not carry the CCE-Dynamic-Provisioning-Node tag.
- The node to be accepted and the cluster must be in the same VPC. (If the cluster version is earlier than v1.13.10, the node to be accepted and the CCE cluster must be in the same subnet.)
- Data disks must be attached to the nodes to be managed. A local disk (disk-intensive disk) or a data disk of at least 20 GiB can be attached to the node, and any data disks already attached cannot be smaller than 10 GiB.
- The node to be accepted has 2-core or higher CPU, 4 GiB or larger memory, and only one NIC.
- If an enterprise project is used, the node to be accepted and the cluster must be in the same enterprise project. Otherwise, resources cannot be identified during management. As a result, the node cannot be accepted.

- Only cloud servers with the same specifications, AZ, and data disk configuration can be added in batches.

Procedure

Step 1 Log in to the CCE console and go to the cluster where the node to be accepted resides.

Step 2 In the navigation pane, choose **Nodes**. On the displayed page, click the **Nodes** tab and then **Accept Node** in the upper right corner.

Step 3 Specify node parameters.

Configurations

Table 6-10 Node configuration parameters

Parameter	Description
Specifications	Click **Select Cloud Server** and select the servers to be accepted. You can select multiple cloud servers for batch management. However, only the cloud servers with the same specifications, AZ, and data disk configuration can be added in batches. If a cloud server contains multiple data disks, select one of them for the container runtime and kubelet.
Container Engine	The container engines supported by CCE include Docker and containerd, which may vary depending on cluster types, cluster versions, and OSs. Select a container engine based on the information displayed on the CCE console.
OS	Select an OS type. Different types of nodes support different OSs. • **Public image**: Select a public image for the node. • **Private image**: Select a private image for the node. **NOTE** 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.
Login Mode	• **Password** The default username is **root**. Enter the password for logging in to the node and confirm the password. Be sure to remember the password as you will need it when you log in to the node. • **Key Pair** Select the key pair used to log in to the node. You can select a shared key. A key pair is used for identity authentication when you remotely log in to a node. If no key pair is available, click **Create Key Pair**.

Storage Settings

Configure storage resources on a node for the containers running on it.

Table 6-11 Configuration parameters

Parameter	Description
System Disk	Directly use the system disk of the cloud server.
Data Disk	**At least one data disk is required** for the container runtime and kubelet. **The data disk cannot be deleted or uninstalled. Otherwise, the node will be unavailable.** Click **Expand** to configure **Data Disk Space Allocation**, which is used to allocate space for container engines, images, and ephemeral storage for them to run properly. For details about how to allocate data disk space, see **Data Disk Space Allocation**. For other data disks, a raw disk is created without any processing by default. You can also click **Expand** and select **Mount Disk** to mount the data disk to a specified directory.

Advanced Settings

Table 6-12 Advanced configuration parameters

Parameter	Description
Resource Tag	You can add resource tags to classify resources. You can create **predefined tags** on the TMS console. The predefined tags are available to all resources that support tags. You can use predefined tags to improve the tag creation and resource migration efficiency. CCE will automatically create the "CCE-Dynamic-Provisioning-Node=*node id*" tag.
Kubernetes Label	Click **Add Label** to set the key-value pair attached to the Kubernetes objects (such as pods). A maximum of 20 labels can be added. Labels can be used to distinguish nodes. With workload affinity settings, container pods can be scheduled to a specified node. For more information, see **Labels and Selectors**.

Parameter	Description
Taint	This parameter is left blank by default. You can add taints to configure node anti-affinity. A maximum of 20 taints are allowed for each node. Each taint contains the following parameters: • **Key**: A key must contain 1 to 63 characters, starting with a letter or digit. Only letters, digits, hyphens (-), underscores (_), and periods (.) are allowed. A DNS subdomain name can be used as the prefix of a key. • **Value**: A value must start with a letter or digit and can contain a maximum of 63 characters, including letters, digits, hyphens (-), underscores (_), and periods (.). • **Effect**: Available options are **NoSchedule**, **PreferNoSchedule**, and **NoExecute**. **NOTICE** • If taints are used, you must configure tolerations in the YAML files of pods. Otherwise, scale-up may fail or pods cannot be scheduled onto the added nodes. • After a node pool is created, you can click **Edit** to modify its configuration. The modification will be synchronized to all nodes in the node pool.
Max. Pods	Maximum number of pods that can run on the node, including the default system pods. This limit prevents the node from being overloaded with pods.
Pre-installation Command	Pre-installation script command, in which Chinese characters are not allowed. The script command will be Base64-transcoded. The script will be executed before Kubernetes software is installed. Note that if the script is incorrect, Kubernetes software may fail to be installed.
Post-installation Command	Pre-installation script command, in which Chinese characters are not allowed. The script command will be Base64-transcoded. The script will be executed after Kubernetes software is installed, which does not affect the installation.

Step 4 Click **Next: Confirm**. Click **Submit**.

----End

6.5 Logging In to a Node

Constraints

- If you use SSH to log in to a node (an ECS), ensure that the ECS already has an EIP (a public IP address).
- Only login to a running ECS is allowed.
- Only the user can log in to a Linux server.

Login Modes

You can log in to an ECS in either of the following modes:

- Management console (VNC)

  If an ECS has no EIP, log in to the ECS console and click **Remote Login** in the same row as the ECS.

- SSH

  This mode applies only to ECSs running Linux. Usually, you can use a remote login tool, such as PuTTY, Xshell, and SecureCRT, to log in to your ECS. If none of the remote login tools can be used, log in to the ECS console and click **Remote Login** in the same row as the ECS to view the connection status and running status of the ECS.

  NOTE

  - When you use the Windows OS to log in to a Linux node, set **Auto-login username** to .
  - The CCE console does not support node OS upgrade. Do not upgrade the node OS using the **yum update** command. Otherwise, the container networking components will be unavailable.

Table 6-13 Linux ECS login modes

EIP Binding	On-Premises OS	Connection Method
Yes	Windows	Use a remote login tool, such as PuTTY or Xshell.
Yes	Linux	Run commands.
Yes/No	Windows/ Linux	Remote login using the management console:

6.6 Management Nodes

6.6.1 Managing Node Labels

You can add different labels to nodes and define different attributes for labels. By using these node labels, you can quickly understand the characteristics of each node.

Node Label Usage Scenario

Node labels are mainly used in the following scenarios:

- Node management: Node labels are used to classify nodes.
- Node affinity or anti-affinity for workloads: By adding labels to nodes, you can schedule pods to specific nodes through node affinity or prevent pods from being scheduled to specific nodes through node anti-affinity. For details, see **Scheduling Policies (Affinity/Anti-affinity)**.

Inherent Label of a Node

After a node is created, some fixed labels exist and cannot be deleted. For details about these labels, see **Table 6-14**.

NOTE

Do not manually change the inherent labels that are automatically added to a node. If the manually changed value conflicts with the system value, the system value is used.

Table 6-14 Inherent labels of a node

Key	Description
New: topology.kubernetes.io/region Old: failure-domain.beta.kubernetes.io/region	Region where the node is located
New: topology.kubernetes.io/zone Old: failure-domain.beta.kubernetes.io/zone	AZ where the node is located
New: node.kubernetes.io/baremetal Old: failure-domain.beta.kubernetes.io/is-baremetal	Whether the node is a bare metal node **false** indicates that the node is not a bare metal node.
node.kubernetes.io/instance-type	Node specifications
kubernetes.io/arch	Node processor architecture
kubernetes.io/hostname	Node name
kubernetes.io/os	Node OS type
node.kubernetes.io/subnetid	ID of the subnet where the node is located.

Key	Description
os.architecture	Node processor architecture For example, **amd64** indicates a AMD64-bit processor.
os.name	Node OS name
os.version	Node OS kernel version
node.kubernetes.io/container-engine	Container engine used by the node.
accelerator/huawei-npu	NPU node labels.
accelerator	GPU node labels.
cce.cloud.com/cce-nodepool	The dedicated label of a node in a node pool.

Adding or Deleting a Node Label

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 **Nodes**. On the displayed page, click the **Nodes** tab, select the target node and click **Labels and Taints** in the upper left corner.

Step 3 In the displayed dialog box, click **Add batch operations** under **Batch Operation**, and then choose **Add/Update** or **Delete**.

Enter the key and value of the label to be added or deleted, and click **OK**.

For example, the key is **deploy_qa** and the value is **true**, indicating that the node is used to deploy the QA (test) environment.

Step 4 After the label is added, check the added label in node data.

----End

6.6.2 Managing Node Taints

Taints enable a node to repel specific pods to prevent these pods from being scheduled to the node.

Procedure for Operations Performed on the Console

On the CCE console, you can also batch manage nodes' taints.

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 **Nodes**. On the displayed page, click the **Nodes** tab, select the target node and click **Labels and Taints** in the upper left corner.

Step 3 In the displayed dialog box, click **Add Operation** under **Batch Operation**, and then choose **Add/Update** or **Delete** as well as **Taint**.

Enter the key and value of the taint to be operated, choose a taint effect, and click **OK**.

Step 4 After the taint is added, check the added taint in node data.

----End

Procedure for Operations Performed Through kubectl Commands

A taint is a key-value pair associated with an effect. The following effects are available:

- NoSchedule: No pod will be scheduled onto the node unless it has a matching toleration. Existing pods will not be evicted from the node.
- PreferNoSchedule: Kubernetes prevents pods that cannot tolerate this taint from being scheduled onto the node.
- NoExecute: If the pod has been running on a node, the pod will be evicted from the node. If the pod has not been running on a node, the pod will not be scheduled onto the node.

To add a taint to a node, run the **kubectl taint node** *nodename* command as follows:

```
$ kubectl get node
NAME            STATUS   ROLES    AGE    VERSION
192.168.10.170   Ready    <none>   73d    v1.19.8-r1-CCE21.4.1.B003
192.168.10.240   Ready    <none>   4h8m   v1.19.8-r1-CCE21.6.1.2.B001
$ kubectl taint node 192.168.10.240 key1=value1:NoSchedule
node/192.168.10.240 tainted
```

To view the taint configuration, run the **describe** and **get** commands as follows:

```
$ kubectl describe node 192.168.10.240
Name:               192.168.10.240
...
Taints:             key1=value1:NoSchedule
...
$ kubectl get node 192.168.10.240 -oyaml
apiVersion: v1
...
spec:
  providerID: 06a5ea3a-0482-11ec-8e1a-0255ac101dc2
  taints:
  - effect: NoSchedule
    key: key1
    value: value1
...
```

To remove a taint, add a hyphen (-) at the end of the command for adding a taint, as shown in the following example:

```
$ kubectl taint node 192.168.10.240 key1=value1:NoSchedule-
node/192.168.10.240 untainted
$ kubectl describe node 192.168.10.240
Name:               192.168.10.240
...
Taints:             <none>
...
```

Configuring a Node Scheduling Policy in One-Click Mode

You can configure a node to be unschedulable on the console. Then, CCE will add a taint with key **node.kubernetes.io/unschedulable** and the **NoSchedule** setting

to the node. After a node is set to be unschedulable, new pods cannot be scheduled to this node, but pods running on the node are not affected.

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 **Nodes**. On the displayed page, click the **Nodes** tab.

Step 3 In the node list, locate the target node and choose **More** > **Disable Scheduling** in the **Operation** column.

Step 4 In the dialog box that is displayed, click **Yes** to configure the node to be unschedulable.

This operation will add a taint to the node. You can use kubectl to view the content of the taint.

```
$ kubectl describe node 192.168.10.240
...
Taints:             node.kubernetes.io/unschedulable:NoSchedule
...
```

Step 5 Go back to the node list, locate the target node, and choose **More** > **Enable Scheduling**. Then, the node changes to be schedulable.

----End

System Taints

When some issues occurred on a node, Kubernetes automatically adds a taint to the node. The built-in taints are as follows:

- node.kubernetes.io/not-ready: The node is not ready. The node **Ready** value is **False**.
- node.kubernetes.io/unreachable: The node controller cannot access the node. The node **Ready** value is **Unknown**.
- node.kubernetes.io/memory-pressure: The node memory is approaching the upper limit.
- node.kubernetes.io/disk-pressure: The node disk space is approaching the upper limit.
- node.kubernetes.io/pid-pressure: The node PIDs are approaching the upper limit.
- node.kubernetes.io/network-unavailable: The node network is unavailable.
- node.kubernetes.io/unschedulable: The node cannot be scheduled.
- node.cloudprovider.kubernetes.io/uninitialized: If an external cloud platform driver is specified when kubelet is started, kubelet adds a taint to the current node and marks it as unavailable. After a controller of **cloud-controller-manager** initializes the node, kubelet will delete the taint.

Related Operations (Tolerations)

Tolerations are applied to pods, and allow (but do not require) the pods to schedule onto nodes with matching taints.

Taints and tolerations work together to ensure that pods are not scheduled onto inappropriate nodes. One or more taints are applied to a node. This marks that the node should not accept any pods that do not tolerate the taints.

Example:

```
apiVersion: v1
kind: Pod
metadata:
  name: nginx
  labels:
    env: test
spec:
  containers:
  - name: nginx
    image: nginx
    imagePullPolicy: IfNotPresent
  tolerations:
  - key: "key1"
    operator: "Equal"
    value: "value1"
    effect: "NoSchedule"
```

In the preceding example, the toleration label of the pod is key1=value1 and the taint effect is NoSchedule. Therefore, the pod can be scheduled onto the corresponding node.

You can also configure tolerations similar to the following information, which indicates that the pod can be scheduled onto a node when the node has the taint key1:

```
tolerations:
- key: "key1"
  operator: "Exists"
  effect: "NoSchedule"
```

6.6.3 Resetting a Node

Scenario

You can reset a node to modify the node configuration, such as the node OS and login mode.

Resetting a node will reinstall the node OS and the Kubernetes software on the node. If a node is unavailable because you modify the node configuration, you can reset the node to rectify the fault.

Constraints

- For CCE standard clusters to support node resetting, the version must be v1.13 or later.

Precautions

- Only worker nodes can be reset. If the node is still unavailable after the resetting, delete the node and create a new one.
- **After a node is reset, the node OS will be reinstalled. Before resetting a node, drain the node to gracefully evict the pods running on the node to other available nodes. Perform this operation during off-peak hours.**
- **After a node is reset, its system disk and data disks will be cleared. Back up important data before resetting a node.**
- **After a worker node with an extra data disk attached is reset, the attachment will be cleared. In this case, attach the disk again and data will be retained.**

- The IP addresses of the workload pods on the node will change, but the container network access is not affected.
- There is remaining EVS disk quota.
- While the node is being deleted, the backend will set the node to the unschedulable state.
- Resetting a node will clear the Kubernetes labels and taints you added (those added by editing a node pool will not be lost). As a result, node-specific resources (such as local storage and workloads scheduled to this node) may be unavailable.
- Resetting a node will cause PVC/PV data loss for the **local PV** associated with the node. These PVCs and PVs cannot be restored or used again. In this scenario, the pod that uses the local PV is evicted from the reset node. A new pod is created and stays in the pending state. This is because the PVC used by the pod has a node label, due to which the pod cannot be scheduled. After the node is reset, the pod may be scheduled to the reset node. In this case, the pod remains in the creating state because the underlying logical volume corresponding to the PVC does not exist.

Procedure

You can batch reset nodes.

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 **Nodes**. On the displayed page, click the **Nodes** tab.

Step 3 In the node list, select one or more nodes to be reset and choose **More** > **Reset Node** in the **Operation** column.

Step 4 In the displayed dialog box, click **Next**.

- For nodes in the DefaultPool node pool, the parameter setting page is displayed. Set the parameters by referring to **Step 5**.
- For a node you create in a node pool, resetting the node does not support parameter configuration. You can directly use the configuration image of the node pool to reset the node.

Step 5 Specify node parameters.

Compute Settings

Table 6-15 Configuration parameters

Parameter	Description
Specifications	Specifications cannot be modified when you reset a node.
Container Engine	The container engines supported by CCE include Docker and containerd, which may vary depending on cluster types, cluster versions, and OSs. Select a container engine based on the information displayed on the CCE console.

Parameter	Description
OS	Select an OS type. Different types of nodes support different OSs. • **Public image**: Select a public image for the node. • **Private image**: Select a private image for the node. **NOTE** 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.
Login Mode	• **Password** The default username is **root**. Enter the password for logging in to the node and confirm the password. Be sure to remember the password as you will need it when you log in to the node. • **Key Pair** Select the key pair used to log in to the node. You can select a shared key. A key pair is used for identity authentication when you remotely log in to a node. If no key pair is available, click **Create Key Pair**.

Storage Settings

Configure storage resources on a node for the containers running on it.

Table 6-16 Configuration parameters

Parameter	Description
System Disk	Directly use the system disk of the cloud server.
Data Disk	**At least one data disk is required** for the container runtime and kubelet. **The data disk cannot be deleted or uninstalled. Otherwise, the node will be unavailable.** Click **Expand** to configure **Data Disk Space Allocation**, which is used to allocate space for container engines, images, and ephemeral storage for them to run properly. For details about how to allocate data disk space, see **Data Disk Space Allocation**. For other data disks, a raw disk is created without any processing by default. You can also click **Expand** and select **Mount Disk** to mount the data disk to a specified directory.

Advanced Settings

Table 6-17 Advanced configuration parameters

Parameter	Description
Resource Tag	You can add resource tags to classify resources. You can create **predefined tags** on the TMS console. The predefined tags are available to all resources that support tags. You can use predefined tags to improve the tag creation and resource migration efficiency. CCE will automatically create the "CCE-Dynamic-Provisioning-Node=*node id*" tag.
Kubernetes Label	Click **Add Label** to set the key-value pair attached to the Kubernetes objects (such as pods). A maximum of 20 labels can be added. Labels can be used to distinguish nodes. With workload affinity settings, container pods can be scheduled to a specified node. For more information, see **Labels and Selectors**.
Taint	This parameter is left blank by default. You can add taints to configure node anti-affinity. A maximum of 20 taints are allowed for each node. Each taint contains the following parameters: • **Key**: A key must contain 1 to 63 characters, starting with a letter or digit. Only letters, digits, hyphens (-), underscores (_), and periods (.) are allowed. A DNS subdomain name can be used as the prefix of a key. • **Value**: A value must start with a letter or digit and can contain a maximum of 63 characters, including letters, digits, hyphens (-), underscores (_), and periods (.). • **Effect**: Available options are **NoSchedule**, **PreferNoSchedule**, and **NoExecute**. **NOTICE** • If taints are used, you must configure tolerations in the YAML files of pods. Otherwise, scale-up may fail or pods cannot be scheduled onto the added nodes. • After a node pool is created, you can click **Edit** to modify its configuration. The modification will be synchronized to all nodes in the node pool.
Max. Pods	Maximum number of pods that can run on the node, including the default system pods. This limit prevents the node from being overloaded with pods.
Pre-installation Command	Pre-installation script command, in which Chinese characters are not allowed. The script command will be Base64-transcoded. The script will be executed before Kubernetes software is installed. Note that if the script is incorrect, Kubernetes software may fail to be installed.

Parameter	Description
Post-installation Command	Pre-installation script command, in which Chinese characters are not allowed. The script command will be Base64-transcoded. The script will be executed after Kubernetes software is installed, which does not affect the installation.

Step 6 Click **Next: Confirm**.

Step 7 Click **Submit**.

----End

6.6.4 Removing a Node

Scenario

Removing a node from a cluster will re-install the node OS and clear CCE components on the node.

Removing a node will not delete the server corresponding to the node. You are advised to remove nodes at off-peak hours to avoid impacts on your services.

After a node is removed from the cluster, the node is still running.

Constraints

- Nodes can be removed only when the cluster is in the **Available** or **Unavailable** status.
- A CCE node can be removed only when it is in the **Active**, **Abnormal**, or **Error** status.
- A CCE node in the **Active** status can have its OS re-installed and CCE components cleared after it is removed.
- If the OS fails to be re-installed after the node is removed, manually re-install the OS. After the re-installation, log in to the node and run the clearance script to clear CCE components. For details, see **Handling Failed OS Reinstallation**.
- Removing a node will cause PVC/PV data loss for the **local PV** associated with the node. These PVCs and PVs cannot be restored or used again. In this scenario, the pod that uses the local PV is evicted from the node. A new pod is created and stays in the pending state. This is because the PVC used by the pod has a node label, due to which the pod cannot be scheduled.

Precautions

- Removing a node will lead to pod migration, which may affect services. Perform this operation during off-peak hours.
- Unexpected risks may occur during the operation. Back up data in advance.
- While the node is being deleted, the backend will set the node to the unschedulable state.

- After you remove the node and re-install the OS, the original LVM partitions will be cleared and the data managed by LVM will be cleared. Therefore, back up data in advance.

Procedure

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 **Nodes**. On the displayed page, click the **Nodes** tab.

Step 3 Locate the target node and choose **More** > **Remove** in the **Operation** column.

Step 4 In the dialog box displayed, configure the login information required for re-installing the OS and click **Yes**. Wait until the node is removed.

After the node is removed, workload pods on the node are automatically migrated to other available nodes.

----End

Handling Failed OS Reinstallation

You can perform the following steps to re-install the OS and clear the CCE components on the node if previous attempts fail:

Step 1 Log in to the management console of the server and re-install the OS.

Step 2 Log in to the server and run the following commands to clear the CCE components and LVM data:

Write the following scripts to the **clean.sh** file:

```
lsblk
vgs --noheadings | awk '{print $1}' | xargs vgremove -f
pvs --noheadings | awk '{print $1}' | xargs pvremove -f
lvs --noheadings | awk '{print $1}' | xargs -i lvremove -f --select {}
function init_data_disk() {
    all_devices=$(lsblk -o KNAME,TYPE | grep disk | grep -v nvme | awk '{print $1}' | awk '{ print "/dev/"$1}')
    for device in ${all_devices[@]}; do
        isRootDisk=$(lsblk -o KNAME,MOUNTPOINT $device 2>/dev/null| grep -E '[[:space:]]/$' | wc -l )
        if [[ ${isRootDisk} != 0 ]]; then
            continue
        fi
        dd if=/dev/urandom of=${device} bs=512 count=64
        return
    done
    exit 1
}
init_data_disk
lsblk
```

Run the following command:

bash clean.sh

----End

6.6.5 Synchronizing the Data of Cloud Servers

Scenario

Each node in a cluster is a cloud server or physical machine. After a cluster node is created, you can change the cloud server name or specifications as required.

Modifying node specifications will affect services. Perform the operation on nodes one by one.

Some information of CCE nodes is maintained independently from the ECS console. After you change the name, EIP, or specifications of an ECS on the ECS console, synchronize the ECS with the target node on the CCE console. After the synchronization, information on both consoles is consistent.

Constraints

- Data, including the VM status, ECS names, number of CPUs, size of memory, ECS specifications, and public IP addresses, can be synchronized.
- Data, such as the OS and image ID, cannot be synchronized. (Such parameters cannot be modified on the ECS console.)

Synchronizing the Data of a Cloud 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 **Nodes**. On the displayed page, click the **Nodes** tab.

Step 3 Locate the target node and choose **More** > **Sync Server Data** in the **Operation** column.

After the synchronization is complete, the **ECS data synchronization requested** message is displayed in the upper right corner.

----End

6.6.6 Draining a Node

Scenario

After you enable nodal drainage on the console, CCE configures the node to be non-schedulable and securely evicts all pods that comply with **Nodal Drainage Rules** on the node. Subsequent new pods will not be scheduled to this node.

When a node becomes faulty, nodal drainage quickly isolates the faulty node. The pods evicted from the faulty node will be scheduled by the workload controller to other nodes that are running properly.

Constraints

- Only clusters of the following versions support the nodal drainage function:
  - v1.21: v1.21.10-r0 or later
  - v1.23: v1.23.8-r0 or later
  - v1.25: v1.25.3-r0 or later
  - v1.25 or later
- To use the nodal drainage function, an IAM user must have at least one of the following permissions. For details, see **Namespace Permissions (Kubernetes RBAC-based)**.
  - cluster-admin (administrator): read and write permissions on all resources in all namespaces.

  - drainage-editor: drain a node.
  - drainage-viewer: view the nodal drainage status but cannot drain a node.
- If a **disruption budget** is not specify for the workload, the workload function may be unavailable during pod rescheduling.

Nodal Drainage Rules

The nodal drainage function securely evicts pods on a node. However, for pods that meet the following filtering criteria, the system performs the corresponding operations:

Filter Criterion	Forced Drainage Enabled	Forced Drainage Disabled
The **status.phase** field of the pod is **Succeeded** or **Failed**.	Deletion	Deletion
The pod is not managed by the workload controller.	Deletion	Drainage cancellation
The pod is managed by DaemonSet.	None	Drainage cancellation
A volume of the emptyDir type is mounted to the pod.	Eviction	Drainage cancellation
The pod is a **static pod** directly managed by kubelet	None	None

NOTE

The following operations may be performed on pods during nodal drainage:

- Deletion: The pod is deleted from the current node and will not be scheduled to other nodes.
- Eviction: The pod is deleted from the current node and rescheduled to another node.
- None: The pod will not be evicted or deleted.
- Drainage cancellation: If a pod on a node cancels drainage, the drainage process of the node is terminated and no pod is evicted or deleted.

Procedure

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 **Nodes**. On the displayed page, click the **Nodes** tab.

Step 3 Locate the target node and choose **More** > **Nodal Drainage** in the **Operation** column.

Step 4 In the **Nodal Drainage** window displayed, set parameters.

- **Timeout (s)**: The drainage task automatically fails after the preset timeout period. The value 0 indicates that the timeout period is not set.
- **Forced Drainage**: If this function is enabled, pods managed by DaemonSet will be ignored, and pods with emptyDir volumes and pods not managed by controllers will be deleted. For details, see **Nodal Drainage Rules**.

Step 5 Click **OK** and wait until the nodal drainage is complete.

----End

6.6.7 Deleting a Node

Scenario

When a node in a CCE cluster is deleted, services running on the node will also be deleted. Exercise caution when performing this operation.

Constraints

- VM nodes that are being used by CCE do not support deletion on the ECS page.
- Deleting a node will cause PVC/PV data loss for the **local PVs** associated with the node. These PVCs and PVs cannot be restored or used again. In this scenario, the pod that uses the local PV is evicted from the node. A new pod is created and stays in the pending state. This is because the PVC used by the pod has a node label, due to which the pod cannot be scheduled.

Precautions

- Deleting a node will lead to pod migration, which may affect services. Perform this operation during off-peak hours.
- Unexpected risks may occur during the operation. Back up related data in advance.
- While the node is being deleted, the backend will set the node to the unschedulable state.
- Only worker nodes can be deleted.

Procedure

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 **Nodes**. On the displayed page, click the **Nodes** tab.

Step 3 Locate the target node and choose **More** > **Delete** in the **Operation** column.

Step 4 In the **Delete Node** dialog box, enter **DELETE** and click **Yes**.

NOTE

- After the node is deleted, workload pods on the node are automatically migrated to other available nodes.
- If the disks and EIPs bound to the node are important resources, unbind them first. Otherwise, they will be deleted with the node.

----End

6.6.8 Stopping a Node

Scenario

After a node in the cluster is stopped, services on the node are also stopped. Before stopping a node, ensure that discontinuity of the services on the node will not result in adverse impacts.

Constraints

- Deleting a node will lead to pod migration, which may affect services. Therefore, delete nodes during off-peak hours.
- Unexpected risks may occur during the operation. Back up related data in advance.
- While the node is being deleted, the backend will set the node to the unschedulable state.
- Only worker nodes can be stopped.

Procedure

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 **Nodes**. On the displayed page, click the **Nodes** tab.

Step 3 Locate the target node and click its name.

Step 4 In the upper right corner of the ECS details page, click **Stop**. In the displayed dialog box, click **Yes**.

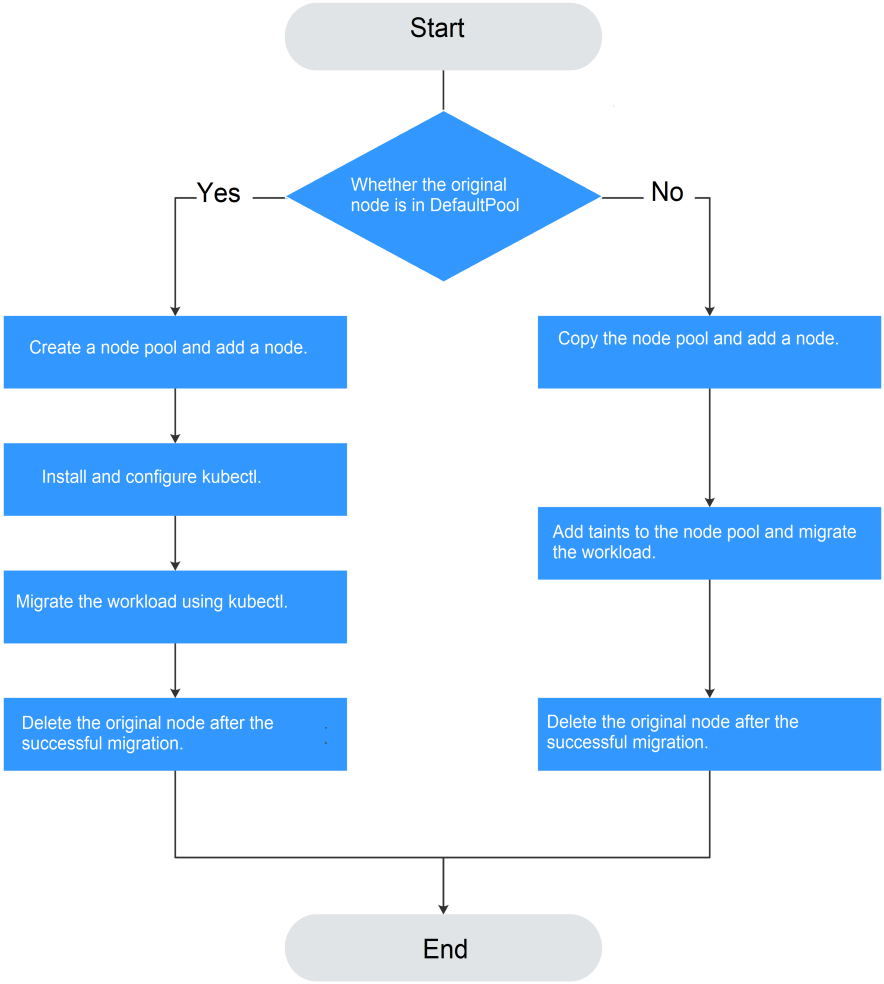
----End

6.6.9 Performing Rolling Upgrade for Nodes

Scenario

In a rolling upgrade, a new node is created, existing workloads are migrated to the new node, and then the old node is deleted. **Figure 6-1** shows the migration process.

Figure 6-1 Workload migration



Constraints

- The original node and the target node to which the workload is to be migrated must be in the same cluster.
- The cluster must be of v1.13.10 or later.
- The default node pool DefaultPool does not support this configuration.

Scenario 1: The Original Node Is in DefaultPool

Step 1 Create a node pool. For details, see **Creating a Node Pool**.

Step 2 On the node pool list page, click **View Node** in the **Operation** column of the target node pool. The IP address of the new node is displayed in the node list.

Step 3 Install and configure kubectl. For details, see **Connecting to a Cluster Using kubectl**.

Step 4 Migrate the workload.

1. Add a taint to the node where the workload needs to be migrated out.

   kubectl taint node *[node]* **key=value:***[effect]*

In the preceding command, *[node]* indicates the IP address of the node where the workload to be migrated is located. The value of *[effect]* can be **NoSchedule**, **PreferNoSchedule**, or **NoExecute**. In this example, set this parameter to **NoSchedule**.

- **NoSchedule**: Pods that do not tolerate this taint are not scheduled on the node; existing pods are not evicted from the node.
- **PreferNoSchedule**: Kubernetes tries to avoid scheduling pods that do not tolerate this taint onto the node.
- **NoExecute**: A pod is evicted from the node if it is already running on the node, and is not scheduled onto the node if it is not yet running on the node.

NOTE

To reset a taint, run the **kubectl taint node *[node]* key:*[effect]*- command** to remove the taint.

2. Safely evicts the workload on the node.

   kubectl drain *[node]*

   In the preceding command, *[node]* indicates the IP address of the node where the workload to be migrated is located.

3. In the navigation pane of the CCE console, choose **Workloads** > **Deployments**. In the workload list, the status of the workload to be migrated changes from **Running** to **Unready**. If the workload status changes to **Running** again, the migration is successful.

NOTE

During workload migration, if node affinity is configured for the workload, the workload keeps displaying a message indicating that the workload is not ready. In this case, click the workload name to go to the workload details page. On the **Scheduling Policies** tab page, delete the affinity configuration of the original node and configure the affinity and anti-affinity policies of the new node. For details, see **Scheduling Policies (Affinity/Anti-affinity)**.

After the workload is migrated, you can view that the workload is migrated to the node created in **Step 1** on the **Pods** tab page of the workload details page.

Step 5 Delete the original node.

After the workload is successfully migrated and runs properly, delete the original node.

----End

Scenario 2: The Original Node Is Not in DefaultPool

Step 1 Copy the node pool and add nodes to it. For details, see **Copying a Node Pool**.

Step 2 Click **View Node** in the **Operation** column of the node pool. The IP address of the new node is displayed in the node list.

Step 3 Migrate the workload.

1. Click **Edit** on the right of original node pool and configure **Taints**.
2. Enter the key and value of a taint. The options of **Effect** are **NoSchedule**, **PreferNoSchedule**, and **NoExecute**. Select **NoExecute** and click **Add**.

- **NoSchedule**: Pods that do not tolerate this taint are not scheduled on the node; existing pods are not evicted from the node.
- **PreferNoSchedule**: Kubernetes tries to avoid scheduling pods that do not tolerate this taint onto the node.
- **NoExecute**: A pod is evicted from the node if it is already running on the node, and is not scheduled onto the node if it is not yet running on the node.

NOTE

To reset the taint, delete the configured one.

3. Click **OK**.
4. In the navigation pane of the CCE console, choose **Workloads** > **Deployments**. In the workload list, the status of the workload to be migrated changes from **Running** to **Unready**. If the workload status changes to **Running** again, the migration is successful.

NOTE

During workload migration, if node affinity is configured for the workload, the workload keeps displaying a message indicating that the workload is not ready. In this case, click the workload name to go to the workload details page. On the **Scheduling Policies** tab page, delete the affinity configuration of the original node and configure the affinity and anti-affinity policies of the new node. For details, see **Scheduling Policies (Affinity/Anti-affinity)**.

After the workload is migrated, you can view that the workload is migrated to the node created in **Step 1** on the **Pods** tab page of the workload details page.

Step 4 Delete the original node.

After the workload is successfully migrated and runs properly, delete the original node.

----End

6.7 Node O&M

6.7.1 Node Resource Reservation Policy

Some node resources are used to run mandatory Kubernetes system components and resources to make the node as part of your cluster. Therefore, the total number of node resources and the number of allocatable node resources for your cluster are different. The larger the node specifications, the more the containers deployed on the node. Therefore, more node resources need to be reserved to run Kubernetes components.

To ensure node stability, a certain number of CCE node resources will be reserved for Kubernetes components (such as kubelet, kube-proxy, and docker) based on the node specifications.

CCE calculates the resources that can be allocated to user nodes as follows:

Allocatable resources = Total amount - Reserved amount - Eviction threshold

The memory eviction threshold is fixed at 100 MB.

NOTE

Total amount indicates the available memory of the ECS, excluding the memory used by system components. Therefore, the total amount is slightly less than the memory of the node flavor.

When the memory consumed by all pods on a node increases, the following behaviors may occur:

1. When the available memory of the node is lower than the eviction threshold, kubelet is triggered to evict the pod. For details about the eviction threshold in Kubernetes, see **Node-pressure Eviction**.
2. If a node triggers an OS memory insufficiency event (OOM) before kubelet reclaims memory, the system terminates the container. However, different from pod eviction, kubelet restarts the container based on the RestartPolicy of the pod.

Rules v1 for Reserving Node Memory

NOTE

For clusters of versions earlier than **v1.21.4-r0** and **v1.23.3-r0**, the v1 model is used for node memory reservation. For clusters of **v1.21.4-r0**, **v1.23.3-r0**, or later, the node memory reservation model is optimized to v2. For details, see **Rules for Reserving Node Memory v2**.

You can use the following formula calculate how much memory you should reserve for running containers on a node:

Total reserved amount = **Reserved memory for system components** + **Reserved memory for kubelet to manage pods**

Table 6-18 Reservation rules for system components

Total Memory (TM)	Reserved Memory for System Components
TM ≤ 8 GB	0 MB
8 GB < TM ≤ 16 GB	[(TM – 8 GB) x 1024 x 10%] MB
16 GB < TM ≤ 128 GB	[8 GB x 1024 x 10% + (TM – 16 GB) x 1024 x 6%] MB
TM > 128 GB	(8 GB x 1024 x 10% + 112 GB x 1024 x 6% + (TM – 128 GB) x 1024 x 2%) MB

Table 6-19 Reservation rules for kubelet

Total Memory (TM)	Number of Pods	Reserved Memory for kubelet
TM ≤ 2 GB	None	TM x 25%

Total Memory (TM)	Number of Pods	Reserved Memory for kubelet
TM > 2 GB	0 < Max. pods on a node ≤ 16	700 MB
	16 < Max. pods on a node ≤ 32	[700 + (Max. pods on a node – 16) x 18.75] MB
	32 < Max. pods on a node ≤ 64	[1024 + (Max. pods on a node – 32) x 6.25] MB
	64 < Max. pods on a node ≤ 128	[1230 + (Max. pods on a node – 64) x 7.80] MB
	Max. pods on a node > 128	[1740 + (Max. pods on a node – 128) x 11.20] MB

NOTICE

For a small-capacity node, adjust the maximum number of instances based on the site requirements. Alternatively, when creating a node on the CCE console, you can adjust the maximum number of instances for the node based on the node specifications.

Rules for Reserving Node Memory v2

For clusters of **v1.21.4-r0**, **v1.23.3-r0**, or later, the node memory reservation model is optimized to v2 and can be dynamically adjusted using the node pool parameters **kube-reserved-mem** and **system-reserved-mem**. For details, see **Configuring a Node Pool**.

The total reserved node memory of the v2 model is equal to the sum of that reserved for the OS and that reserved for CCE to manage pods.

Reserved memory includes basic and floating parts. For the OS, the floating memory depends on the node specifications. For CCE, the floating memory depends on the number of pods on a node.

Table 6-20 Rules for reserving node memory v2

Reserved for	Basic/Floating	Reservation	Used by
OS	Basic	400 MB (fixed)	OS service components such as sshd and systemd-journald.
	Floating (depending on the node memory)	25 MB/GB	Kernel

Reserved for	Basic/Floating	Reservation	Used by
CCE	Basic	500 MB (fixed)	Container engine components, such as kubelet and kube-proxy, when the node is unloaded
	Floating (depending on the number of pods on the node)	Docker: 20 MB/pod containerd: 5 MB/pod	Container engine components when the number of pods increases **NOTE** When the v2 model reserves memory for a node by default, the default maximum number of pods is estimated based on the memory. For details, see **Table 6-23**.

Rules for Reserving Node CPU

Table 6-21 Node CPU reservation rules

Total CPU Cores (Total)	Reserved CPU Cores
Total ≤ 1 core	Total x 6%
1 core < Total ≤ 2 cores	1 core x 6% + (Total – 1 core) x 1%
2 cores < Total ≤ 4 cores	1 core x 6% + 1 core x 1% + (Total – 2 cores) x 0.5%
Total > 4 cores	1 core x 6% + 1 core x 1% + 2 cores x 0.5% + (Total – 4 cores) x 0.25%

Rules for CCE to Reserve Data Disks on Nodes

CCE uses Logical Volume Manager (LVM) to manage disks. LVM creates a metadata area on a disk to store logical and physical volumes, occupying 4 MiB space. Therefore, the actual available disk space of a node is equal to the disk size minus 4 MiB.

6.7.2 Data Disk Space Allocation

This section describes how to allocate data disk space to nodes so that you can configure the data disk space accordingly.

Allocating Data Disk Space

When creating a node, configure data disks for the node. You can also click **Expand** and customize the data disk space allocation for the node.

- **Space Allocation for Container Engines**
  - Specified disk space: CCE divides the data disk space for two parts by default. One part is used to store the Docker/containerd working directories, container images, and image metadata. The other is reserved for kubelet and emptyDir volumes. The available container engine space affects image pulls and container startup and running.
    - Container engine and container image space (90% by default): stores the container runtime working directories, container image data, and image metadata.
    - kubelet and emptyDir space (10% by default): stores pod configuration files, secrets, and mounted storage such as emptyDir volumes.
- **Space Allocation for Pods**: indicates the basesize of a pod. You can set an upper limit for the disk space occupied by each workload pod (including the space occupied by container images). This setting prevents the pods from taking all the disk space available, which may cause 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 details, see **Mapping Between OS and Container Storage Rootfs**.
- Write Mode
  - **Linear**: A linear logical volume integrates one or more physical volumes. Data is written to the next physical volume when the previous one is used up.
  - **Striped**: available only if there are at least two data disks. A striped logical volume stripes data into blocks of the same size and stores them in multiple physical volumes in sequence. This allows data to be concurrently read and written. A storage pool consisting of striped volumes cannot be scaled-out.

Space Allocation for Container Engines

For a node using a non-shared data disk (100 GiB for example), the division of the disk space varies depending on the container storage Rootfs type **Device Mapper** or **OverlayFS**. For details about the container storage Rootfs corresponding to different OSs, see **Mapping Between OS and Container Storage Rootfs**.

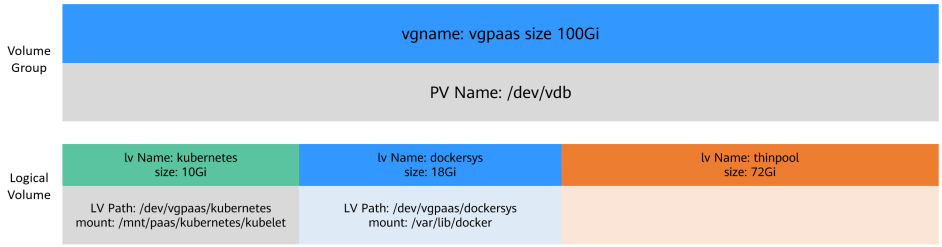
- **Rootfs (Device Mapper)**

  By default, the container engine and image space, occupying 90% of the data disk, can be divided into the following two parts:
  - The **/var/lib/docker** directory is used as the Docker working directory and occupies 20% of the container engine and container image space by default. (Space size of the **/var/lib/docker** directory = **Data disk space x 90% x 20%**)
  - The thin pool is used to store container image data, image metadata, and container data, and occupies 80% of the container engine and container

image space by default. (Thin pool space = **Data disk space x 90% x 80%**)

The thin pool is dynamically mounted. You can view it by running the **lsblk** command on a node, but not the **df -h** command.

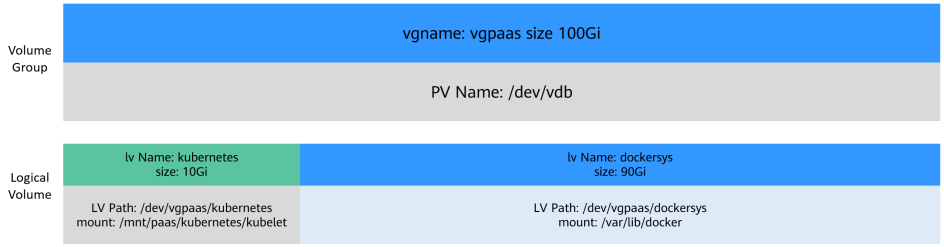
Figure 6-2 Space allocation for container engines of Device Mapper



- **Rootfs (OverlayFS)**

  No separate thin pool. The entire container engine and container image space (90% of the data disk by default) are in the **/var/lib/docker** directory.

Figure 6-3 Space allocation for container engines of OverlayFS



Space Allocation for Pods

The customized pod container space (basesize) is related to the node OS and container storage Rootfs. For details about the container storage Rootfs, see **Mapping Between OS and Container Storage Rootfs**.

- Device Mapper supports custom pod basesize. The default value is 10 GiB.
- In OverlayFS mode, the pod container space is not limited by default.

When configuring **basesize**, consider the maximum number of pods on a node. The container engine space should be greater than the total disk space used by containers. Formula: **the container engine space and container image space (90% by default)** > **Number of containers** x **basesize**. Otherwise, the container engine space allocated to the node may be insufficient and the container cannot be started.

For nodes that support **basesize**, when Device Mapper is used, although you can limit the size of the **/home** directory of a single container (to 10 GB by default), all containers on the node still share the thin pool of the node for storage. They are not completely isolated. When the sum of the thin pool space used by certain containers reaches the upper limit, other containers cannot run properly.

In addition, after a file is deleted in the **/home** directory of the container, the thin pool space occupied by the file is not released immediately. Therefore, even if **basesize** is set to 10 GB, the thin pool space occupied by files keeps increasing

until 10 GB when files are created in the container. The space released after file deletion will be reused but after a while. If **the number of containers on the node multiplied by basesize** is greater than the thin pool space size of the node, there is a possibility that the thin pool space has been used up.

Mapping Between OS and Container Storage Rootfs

Table 6-22 Node OSs and container engines in CCE clusters

OS	Container Storage Rootfs	Customized Basesize
CentOS 7.x	Clusters of v1.19.16 and earlier use Device Mapper. Clusters of v1.19.16 and later use OverlayFS.	Supported when Rootfs is set to Device Mapper and the container engine is Docker. The default value is 10 GiB. Not supported when Rootfs is set to OverlayFS.
Ubuntu 22.04	OverlayFS	Not supported.

Garbage Collection Policies for Container Images

When the container engine space is insufficient, image garbage collection is triggered.

The policy for garbage collecting images takes two factors into consideration: **HighThresholdPercent** and **LowThresholdPercent**. Disk usage exceeding the high threshold (default: 80%) will trigger garbage collection. The garbage collection will delete least recently used images until the low threshold (default: 70%) is met.

Recommended Configuration for the Container Engine Space

- The container engine space should be greater than the total disk space used by containers. Formula: **Container engine space** > **Number of containers** x **basesize**
- You are advised to create and delete files of containerized services in local storage volumes (such as emptyDir and hostPath volumes) or cloud storage directories mounted to the containers. In this way, the thin pool space is not occupied. emptyDir volumes occupy the kubelet space. Therefore, properly plan the size of the kubelet space.
- You can deploy services on nodes that use the OverlayFS (for details, see **Mapping Between OS and Container Storage Rootfs**) so that the disk space occupied by files created or deleted in containers can be released immediately.

6.7.3 Maximum Number of Pods That Can Be Created on a Node

Calculation of the Maximum Number of Pods on a Node

The maximum number of pods that can be created on a node is calculated based on the cluster type:

- For a cluster using the container tunnel network model, the value depends only on **the maximum number of pods on a node**.
- For clusters using the VPC network model, the value depends on **the maximum number of pods on a node** and **the minimum number of container IP addresses that can be allocated to a node**. It is recommended that the maximum number of pods on a node be less than or equal to the number of container IP addresses that can be allocated to the node. Otherwise, pods may fail to be scheduled.

Number of Container IP Addresses That Can Be Allocated on a Node

If you select **VPC network** for **Network Model** when creating a CCE cluster, you also need to set the number of container IP addresses that can be allocated to each node (alpha.cce/fixPoolMask). If the pod uses the host network (**hostNetwork: true**), the pod does not occupy the IP address of the allocatable container network. For details, see **Container Network vs. Host Network**.

This parameter affects the maximum number of pods that can be created on a node. Each pod occupies an IP address (when the **container network** is used). If the number of available IP addresses is insufficient, pods cannot be created. If the pod uses the host network (**hostNetwork: true**), the pod does not occupy the IP address of the allocatable container network.

By default, a node occupies three container IP addresses (network address, gateway address, and broadcast address). Therefore, the number of container IP addresses that can be allocated to a node equals the number of selected container IP addresses minus 3.

Maximum Number of Pods on a Node

When creating a node, you can configure the maximum number of pods (maxPods) that can be created on the node. This parameter is a configuration item of kubelet and determines the maximum number of pods that can be created by kubelet.

NOTICE

For nodes in the default node pool (**DefaultPool**), the maximum number of pods cannot be changed after the nodes are created.

After a node in a custom node pool is created, you can modify the **max-pods** parameter in the node pool configuration to change the maximum number of pods on the node.

Table 6-23 lists the default maximum number of pods on a node based on node specifications.

Table 6-23 Default maximum number of pods on a node

Memory	Max. Pods
4 GB	20
8 GB	40
16 GB	60
32 GB	80
64 GB or above	110

Container Network vs. Host Network

When creating a pod, you can select the container network or host network for the pod.

- Container network (default): **Each pod is assigned an IP address by the cluster networking add-ons, which occupies the IP addresses of the container network**.
- Host network: The pod uses the host network (**hostNetwork: true** needs to be configured for the pod) and occupies the host port. The pod IP address is the host IP address. The pod does not occupy the IP addresses of the container network. To use the host network, you must confirm whether the container ports conflict with the host ports. Do not use the host network unless you know exactly which host port is used by which container.

6.7.4 Migrating Nodes from Docker to containerd

Context

Kubernetes has removed dockershim from v1.24 and does not support Docker by default. CCE is going to stop the support for Docker. Change the node container engine from Docker to containerd.

Prerequisites

- At least one cluster that supports containerd nodes has been created.
- There is a Docker node or Docker node pool in your cluster.

Precautions

- Theoretically, migration during container running will interrupt services for a short period of time. Therefore, it is strongly recommended that the services to be migrated have been deployed as multi-instance. In addition, you are advised to test the migration impact in the test environment to minimize potential risks.

- containerd cannot build images. Do not use the **docker build** command to build images on containerd nodes. For other differences between Docker and containerd, see **Container Engine**.

Migrating a Node

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 **Nodes**. On the displayed page, click the **Nodes** tab.

Step 3 In the node list, select one or more nodes to be reset and choose **More** > **Reset Node** in the **Operation** column.

Step 4 Set **Container Engine** to **containerd**. You can adjust other parameters as required or retain them as set during creation.

Step 5 If the node status is **Installing**, the node is being reset.

When the node status is **Running**, you can see that the node version is switched to containerd. You can log in to the node and run containerd commands such as **crictl** to view information about the containers running on the node.

----End

Migrating a Node Pool

You can **copy a node pool**, set the container engine of the new node pool to containerd, and keep other configurations the same as those of the original Docker node pool.

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 **Nodes**. On the **Node Pools** tab page, locate the Docker node pool to be copied and choose **More** > **Copy** in the **Operation** column.

Step 3 On the **Compute Settings** area, set **Container Engine** to **containerd** and modify other parameters as required.

Step 4 Scale the number of created containerd node pools to the number of original Docker node pools and delete nodes from the Docker node pools one by one.

Rolling migration is preferred. That is, add some containerd nodes and then delete some Docker nodes until the number of nodes in the new containerd node pool is the same as that in the original Docker node pool.

NOTE

If you have set node affinity for the workloads deployed on the original Docker nodes or node pool, set affinity policies for the workloads to run on the new containerd nodes or node pool.

Step 5 After the migration, delete the original Docker node pool.

----End

6.7.5 Node Fault Detection Policy

The node fault detection function depends on the **NPD** add-on. The add-on instances run on nodes and monitor nodes. This section describes how to enable node fault detection.

Prerequisites

The **CCE Node Problem Detector** add-on has been installed in the cluster.

Enabling Node Fault Detection

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 **Nodes** and then click the **Nodes** tab. Check whether the NPD add-on has been installed in the cluster or whether the add-on has been upgraded to the latest version. After the NPD add-on has been installed, you can use the fault detection function.

Step 3 If the NPD add-on is running properly, click **Node Fault Detection Policy** to view the current fault detection items. For details about the NPD check item list, see **NPD Check Items**.

Step 4 If the check result of the current node is abnormal, a message is displayed in the node list, indicating that the metric is abnormal.

Step 5 You can click **Abnormal metrics** and rectify the fault as prompted.

----End

Customized Check Items

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 **Nodes** and then click the **Nodes** tab. Then, click **Fault Detection Policy**.

Step 3 On the displayed page, view the current check items. Click **Edit** in the **Operation** column and edit checks.

Currently, the following configurations are supported:

- **Enable/Disable**: Enable or disable a check item.
- **Target Node**: By default, check items run on all nodes. You can change the fault threshold based on special scenarios. For example, the spot price ECS interruption reclamation check runs only on the spot price ECS node.
- **Trigger Threshold**: The default thresholds match common fault scenarios. You can customize and modify the fault thresholds as required. For example, change the threshold for triggering connection tracking table exhaustion from 90% to 80%.
- **Check Period**: The default check period is 30 seconds. You can modify this parameter as required.

- **Troubleshooting Strategy**: After a fault occurs, you can select the strategies listed in the following table.

  Table 6-24 Troubleshooting strategies

Troubleshooting Strategy	Effect
Prompting Exception	Kubernetes events are reported.
Disabling scheduling	Kubernetes events are reported and the **NoSchedule** taint is added to the node.
Evict Node Load	Kubernetes events are reported and the **NoExecute** taint is added to the node. This operation will evict workloads on the node and interrupt services. Exercise caution when performing this operation.

----End

NPD Check Items

NOTE

Check items are supported only in 1.16.0 and later versions.

Check items cover events and statuses.

- Event-related

  For event-related check items, when a problem occurs, NPD reports an event to the API server. The event type can be **Normal** (normal event) or **Warning** (abnormal event).

  Table 6-25 Event-related check items

Check Item	Function	Description
OOMKilling	Listen to the kernel logs and check whether OOM events occur and are reported. Typical scenario: When the memory usage of a process in a container exceeds the limit, OOM is triggered and the process is terminated.	Warning event Listening object: **/dev/kmsg** Matching rule: "Killed process \\d+ (.+) total-vm:\\d+kB, anon-rss:\\d+kB, file-rss:\\d+kB.*"

Check Item	Function	Description
TaskHung	Listen to the kernel logs and check whether taskHung events occur and are reported. Typical scenario: Disk I/O suspension causes process suspension.	Warning event Listening object: **/dev/kmsg** Matching rule: "task \ \S+:\\w+ blocked for more than \\w+ seconds\\."
Readonly Filesystem	Check whether the **Remount root filesystem read-only** error occurs in the system kernel by listening to the kernel logs. Typical scenario: A user detaches a data disk from a node by mistake on the ECS, and applications continuously write data to the mount point of the data disk. As a result, an I/O error occurs in the kernel and the disk is remounted as a read-only disk. **NOTE** If the rootfs of node pods is of the device mapper type, an error will occur in the thin pool if a data disk is detached. This will affect NPD and NPD will not be able to detect node faults.	Warning event Listening object: **/dev/kmsg** Matching rule: **Remounting filesystem read-only**

- Status-related

  For status-related check items, when a problem occurs, NPD reports an event to the API server and changes the node status synchronously. This function can be used together with **Node-problem-controller fault isolation** to isolate nodes.

  If the check period is not specified in the following check items, the default period is 30 seconds.

  Table 6-26 Checking system components

Check Item	Function	Description
Container network component error CNIProblem	Check the status of the CNI components (container network components).	None
Container runtime component error CRIProblem	Check the status of Docker and containerd of the CRI components (container runtime components).	Check object: Docker or containerd

Check Item	Function	Description
Frequent restarts of Kubelet FrequentKubeletRestart	Periodically backtrack system logs to check whether the key component Kubelet restarts frequently.	• Default threshold: 10 restarts within 10 minutes If Kubelet restarts for 10 times within 10 minutes, it indicates that the system restarts frequently and a fault alarm is generated. • Listening object: logs in the **/run/log/journal** directory
Frequent restarts of Docker FrequentDockerRestart	Periodically backtrack system logs to check whether the container runtime Docker restarts frequently.	
Frequent restarts of containerd FrequentContainerdRestart	Periodically backtrack system logs to check whether the container runtime containerd restarts frequently.	
kubelet error KubeletProblem	Check the status of the key component Kubelet.	None
kube-proxy error KubeProxyProblem	Check the status of the key component kube-proxy.	None

Table 6-27 Checking system metrics

Check Item	Function	Description
Conntrack table full ConntrackFullProblem	Check whether the conntrack table is full.	• Default threshold: 90% • Usage: **nf_conntrack_count** • Maximum value: **nf_conntrack_max**
Insufficient disk resources DiskProblem	Check the usage of the system disk and CCE data disks (including the CRI logical disk and kubelet logical disk) on the node.	• Default threshold: 90% • Source: `df -h` Currently, additional data disks are not supported.
Insufficient file handles FDProblem	Check if the FD file handles are used up.	• Default threshold: 90% • Usage: the first value in **/proc/sys/fs/file-nr** • Maximum value: the third value in **/proc/sys/fs/file-nr**

Check Item	Function	Description
Insufficient node memory MemoryProblem	Check whether memory is used up.	• Default threshold: 80% • Usage: **MemTotal-MemAvailable** in **/proc/meminfo** • Maximum value: **MemTotal** in **/proc/meminfo**
Insufficient process resources PIDProblem	Check whether PID process resources are exhausted.	• Default threshold: 90% • Usage: **nr_threads in /proc/loadavg** • Maximum value: smaller value between **/proc/sys/kernel/pid_max** and **/proc/sys/kernel/threads-max**.

Table 6-28 Checking the storage

Check Item	Function	Description
Disk read-only DiskReadonly	Periodically perform write tests on the system disk and CCE data disks (including the CRI logical disk and Kubelet logical disk) of the node to check the availability of key disks.	Detection paths: • /mnt/paas/kubernetes/kubelet/ • /var/lib/docker/ • /var/lib/containerd/ • /var/paas/sys/log/cceaddon-npd/ The temporary file **npd-disk-write-ping** is generated in the detection path. Currently, additional data disks are not supported.

Check Item	Function	Description
emptyDir storage pool error EmptyDirVolumeGroupStatusError	Check whether the ephemeral volume group on the node is normal. Impact: Pods that depend on the storage pool cannot write data to the temporary volume. The temporary volume is remounted as a read-only file system by the kernel due to an I/O error. Typical scenario: When creating a node, a user configures two data disks as a temporary volume storage pool. Some data disks are deleted by mistake. As a result, the storage pool becomes abnormal.	• Detection period: 30s • Source: `vgs -o vg_name, vg_attr` • Principle: Check whether the VG (storage pool) is in the P state. If yes, some PVs (data disks) are lost. • Joint scheduling: The scheduler can automatically identify a PV storage pool error and prevent pods that depend on the storage pool from being scheduled to the node. • Exceptional scenario: The NPD add-on cannot detect the loss of all PVs (data disks), resulting in the loss of VGs (storage pools). In this case, kubelet automatically isolates the node, detects the loss of VGs (storage pools), and updates the corresponding resources in **nodestatus.allocatable** to **0**. This prevents pods that depend on the storage pool from being scheduled to the node. The damage of a single PV cannot be detected by this check item, but by the ReadonlyFilesystem check item.
PV storage pool error LocalPvVolumeGroupStatusError	Check the PV group on the node. Impact: Pods that depend on the storage pool cannot write data to the persistent volume. The persistent volume is remounted as a read-only file system by the kernel due to an I/O error. Typical scenario: When creating a node, a user configures two data disks as a persistent volume storage pool. Some data disks are deleted by mistake.	

Check Item	Function	Description
Mount point error MountPointProblem	Check the mount point on the node. Exceptional definition: You cannot access the mount point by running the **cd** command. Typical scenario: Network File System (NFS), for example, obsfs and s3fs is mounted to a node. When the connection is abnormal due to network or peer NFS server exceptions, all processes that access the mount point are suspended. For example, during a cluster upgrade, a kubelet is restarted, and all mount points are scanned. If the abnormal mount point is detected, the upgrade fails.	Alternatively, you can run the following command: `for dir in `df -h | grep -v "Mounted on" | awk "{print \\$NF}"`;do cd $dir; done && echo "ok"`
Suspended disk I/O DiskHung	Check whether I/O suspension occurs on all disks on the node, that is, whether I/O read and write operations are not responded. Definition of I/O suspension: The system does not respond to disk I/O requests, and some processes are in the D state. Typical scenario: Disks cannot respond due to abnormal OS hard disk drivers or severe faults on the underlying network.	• Check object: all data disks • Source: /proc/diskstat Alternatively, you can run the following command: `iostat -xmt 1` • Threshold: – Average usage: ioutil >= 0.99 – Average I/O queue length: avgqu-sz >= 1 – Average I/O transfer volume: iops (w/s) + ioth (wMB/s) <= 1 **NOTE** In some OSs, no data changes during I/O. In this case, calculate the CPU I/O time usage. The value of iowait should be greater than 0.8.

Check Item	Function	Description
Slow disk I/O DiskSlow	Check whether all disks on the node have slow I/Os, that is, whether I/Os respond slowly. Typical scenario: EVS disks have slow I/Os due to network fluctuation.	• Check object: all data disks • Source: /proc/diskstat Alternatively, you can run the following command: `iostat -xmt 1` • Default threshold: Average I/O latency: await >= 5000 ms **NOTE** If I/O requests are not responded and the **await** data is not updated, this check item is invalid.

Table 6-29 Other check items

Check Item	Function	Description
Abnormal NTP NTPProblem	Check whether the node clock synchronization service ntpd or chronyd is running properly and whether a system time drift is caused.	Default clock offset threshold: 8000 ms
Process D error ProcessD	Check whether there is a process D on the node.	Default threshold: 10 abnormal processes detected for three consecutive times Source: • /proc/{PID}/stat • Alternately, you can run the **ps aux** command. Exceptional scenario: The ProcessD check item ignores the resident D processes (heartbeat and update) on which the SDI driver on the BMS node depends.
Process Z error ProcessZ	Check whether the node has processes in Z state.	

Check Item	Function	Description
ResolvConf error ResolvConfFileProblem	Check whether the ResolvConf file is lost. Check whether the ResolvConf file is normal. Exceptional definition: No upstream domain name resolution server (nameserver) is included.	Object: **/etc/resolv.conf**
Existing scheduled event ScheduledEvent	Check whether scheduled live migration events exist on the node. A live migration plan event is usually triggered by a hardware fault and is an automatic fault rectification method at the IaaS layer. Typical scenario: The host is faulty. For example, the fan is damaged or the disk has bad sectors. As a result, live migration is triggered for VMs.	Source: • http://169.254.169.254/meta-data/latest/events/scheduled This check item is an Alpha feature and is disabled by default.

The kubelet component has the following default check items, which have bugs or defects. You can fix them by upgrading the cluster or using NPD.

Table 6-30 Default kubelet check items

Check Item	Function	Description
Insufficient PID resources PIDPressure	Check whether PIDs are sufficient.	• Interval: 10 seconds • Threshold: 90% • Defect: In community version 1.23.1 and earlier versions, this check item becomes invalid when over 65535 PIDs are used. For details, see **issue 107107**. In community version 1.24 and earlier versions, thread-max is not considered in this check item.

Check Item	Function	Description
Insufficient memory MemoryPressure	Check whether the allocable memory for the containers is sufficient.	• Interval: 10 seconds • Threshold: max. 100 MiB • Allocable = Total memory of a node – Reserved memory of a node • Defect: This check item checks only the memory consumed by containers, and does not consider that consumed by other elements on the node.
Insufficient disk resources DiskPressure	Check the disk usage and inodes usage of the kubelet and Docker disks.	• Interval: 10 seconds • Threshold: 90%

7 Node Pools

7.1 Node Pool Overview

Introduction

CCE introduces node pools to help you better manage nodes in Kubernetes clusters. A node pool contains one node or a group of nodes with identical configuration in a cluster.

You can create custom node pools on the CCE console. With node pools, you can quickly create, manage, and destroy nodes without affecting the cluster. All nodes in a custom node pool have identical parameters and node type. You cannot configure a single node in a node pool; any configuration changes affect all nodes in the node pool.

You can also use node pools for auto scaling.

- When a pod in a cluster cannot be scheduled due to insufficient resources, scale-out can be automatically triggered.
- When there is an idle node or a monitoring metric threshold is met, scale-in can be automatically triggered.

This section describes how node pools work in CCE and how to create and manage node pools.

Node Pool Architecture

Generally, all nodes in a node pool have the following same attributes:

- Node OS
- Node flavor
- Node login mode
- Node container runtime
- Startup parameters of Kubernetes components on a node
- User-defined startup script of a node

- **Kubernetes Labels** and **Taints**

CCE provides the following extended attributes for node pools:

- Node pool OS
- Maximum number of pods on each node in a node pool

Description of DefaultPool

DefaultPool is not a real node pool. It only **classifies** nodes that are not in the user-created node pools. These nodes are directly created on the console or by calling APIs. DefaultPool does not support any user-created node pool functions, including scaling and parameter configuration. DefaultPool cannot be edited, deleted, expanded, or auto scaled, and nodes in it cannot be migrated.

Applicable Scenarios

When a large-scale cluster is required, you are advised to use node pools to manage nodes.

The following table describes multiple scenarios of large-scale cluster management and the functions of node pools in each scenario.

Table 7-1 Using node pools for different management scenarios

Scenario	Function
Multiple heterogeneous nodes (with different models and configurations) in the cluster	Nodes can be grouped into different pools for management.
Frequent node scaling required in a cluster	Node pools support auto scaling to dynamically add or reduce nodes.
Complex application scheduling rules in a cluster	Node pool tags can be used to quickly specify service scheduling rules.

Functions and Precautions

Function	Description	Precaution
Creating a node pool	Add a node pool.	It is recommended that a cluster contains no more than 100 node pools.
Deleting a node pool	When a node pool is deleted, the nodes in the node pool are deleted first. Workloads on the original nodes are automatically migrated to available nodes in other node pools.	If pods in the node pool have a specific node selector and none of the other nodes in the cluster satisfies the node selector, the pods will become unschedulable.

Function	Description	Precaution
Enabling auto scaling for a node pool	After auto scaling is enabled, nodes will be automatically created or deleted in the node pool based on the cluster loads.	Do not store important data on nodes in a node pool because the nodes may be deleted after scale-in. Data on the deleted nodes cannot be restored.
Enabling auto scaling for a node pool	After auto scaling is disabled, the number of nodes in a node pool will not automatically change with the cluster loads.	None
Adjusting the size of a node pool	The number of nodes in a node pool can be directly adjusted. If the number of nodes is reduced, nodes are randomly removed from the current node pool.	After auto scaling is enabled, you are not advised to manually adjust the node pool size.
Changing node pool configurations	You can modify the node pool name, node quantity, Kubernetes labels (and their quantity), resource tags, and taints.	The deleted or added Kubernetes labels and taints (as well as their quantity) will apply to all nodes in the node pool, which may cause pod re-scheduling. Therefore, exercise caution when performing this operation.
Removing a node from a node pool	Nodes in a node pool can be migrated to the default node pool of the same cluster.	Nodes in the default node pool cannot be migrated to other node pools, and nodes in a user-created node pool cannot be migrated to other user-created node pools.
Copying a node pool	You can copy the configuration of an existing node pool to create a new node pool.	None
Setting Kubernetes parameters	You can configure core components with fine granularity.	• This function is supported only in clusters of v1.15 and later. It is not displayed for versions earlier than v1.15. • The default node pool DefaultPool does not support this type of configuration.

Deploying a Workload in a Specified Node Pool

When creating a workload, you can constrain pods to run in a specified node pool.

For example, on the CCE console, you can set the affinity between the workload and the node on the **Scheduling Policies** tab page on the workload details page to forcibly deploy the workload to a specific node pool. In this way, the workload runs only on nodes in the node pool. To better control where the workload is to be scheduled, you can use affinity or anti-affinity policies between workloads and nodes described in **Scheduling Policies (Affinity/Anti-affinity)**.

For example, you can use container's resource request as a nodeSelector so that workloads will run only on the nodes that meet the resource request.

If the workload definition file defines a container that requires four CPUs, the scheduler will not choose the nodes with two CPUs to run workloads.

Related Operations

You can log in to the CCE console and refer to the following sections to perform operations on node pools:

- **Creating a Node Pool**
- **Managing a Node Pool**
- **Creating a Deployment**
- **Scheduling Policies (Affinity/Anti-affinity)**

7.2 Creating a Node Pool

Scenario

This section describes how to create a node pool and perform operations on the node pool. For details about how a node pool works, see **Node Pool Overview**.

Constraints

- The Autoscaler add-on needs to be installed for node auto scaling. For details about the add-on installation and parameter configuration, see **CCE Cluster Autoscaler**.

Procedure

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 on the right.

Step 3 In the upper right corner of the page, click **Create Node Pool**.

Basic Settings

Table 7-2 Basic settings

Parameter	Description
Node Pool Name	Name of a node pool. By default, the name is in the format of *Cluster name*-nodepool-*Random number*. If you do not want to use the default name format, you can customize the name.
Expected Initial Nodes	Number of nodes to be created in this node pool. A maximum of 50 nodes that can be created at a time.

Configurations

You can configure the flavor and OS of a cloud server, on which your containerized applications run.

Table 7-3 Node configuration parameters

Parameter	Description
Billing Mode	The following billing modes are supported: • Pay-per-use Resources will be billed based on usage duration. You can provision or delete resources at any time.
AZ	AZ where the node is located. Nodes in a cluster can be created in different AZs for higher reliability. The value cannot be changed after the node is created. Select **Random** to deploy your node in a random AZ based on the selected node flavor. An AZ is a physical region where resources use independent power supply and networks. AZs are physically isolated but interconnected through an internal network. To enhance workload availability, create nodes in different AZs.
Node Type	Select a node type based on service requirements. Then, you can select a proper flavor from the node flavor list. CCE standard clusters support the following node types: • ECS (VM): A virtualized ECS is used as a cluster node. • ECS (physical machine): A QingTian-backed bare metal server is used as a cluster node.
Specifications	Select a node flavor based on service requirements. The available node flavors vary depending on regions or AZs. For details, see the CCE console.
Container Engine	The container engines supported by CCE include Docker and containerd, which may vary depending on cluster types, cluster versions, and OSs. Select a container engine based on the information displayed on the CCE console.

Parameter	Description
OS	Select an OS type. Different types of nodes support different OSs. • **Public image**: Select a public image for the node. • **Private image**: Select a private image for the node. **NOTE** 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.
Login Mode	• **Password** The default username is **root**. Enter the password for logging in to the node and confirm the password. Be sure to remember the password as you will need it when you log in to the node. • **Key Pair** Select the key pair used to log in to the node. You can select a shared key. A key pair is used for identity authentication when you remotely log in to a node. If no key pair is available, click **Create Key Pair**.

Storage Settings

Configure storage resources on a node for the containers running on it. Select a disk type and configure its size based on service requirements.

Table 7-4 Configuration parameters

Parameter	Description
System Disk	System disk used by the node OS. The value ranges from 40 GiB to 1024 GiB. The default value is 50 GiB.

Parameter	Description
Data Disk	**At least one data disk is required** for the container runtime and kubelet. **The data disk cannot be deleted or uninstalled. Otherwise, the node will be unavailable.** • First data disk: used for container runtime and kubelet components. The value ranges from 20 GiB to 32768 GiB. The default value is 100 GiB. • Other data disks: You can set the data disk size to a value ranging from 10 GiB to 32768 GiB. The default value is 100 GiB. **NOTE** • If the node flavor is disk-intensive or ultra-high I/O, one data disk can be a local disk. • Local disks may break down and do not ensure data reliability. Store your service data in EVS disks, which are more reliable than local disks. **Advanced Settings** Click **Expand** and configure the following parameters: • **Data Disk Space Allocation**: allocates space for container engines, images, and ephemeral storage for them to run properly. For details about how to allocate data disk space, see **Data Disk Space Allocation**. • **Encryption**: Data disk encryption safeguards your data. Snapshots generated from encrypted disks and disks created using these snapshots automatically inherit the encryption setting. **This function is available only in certain regions.** – **Encryption** is not selected by default. – After selecting **Encryption**, you can select an existing key in the displayed dialog box. If no key is available, click **View Key List** and create a key. After the key is created, click the refresh icon next to the **Encryption** text box. **Adding data disks** A maximum of four data disks can be added. By default, raw disks are created without any processing. You can also click **Expand** and select any of the following options: • **Default**: By default, a raw disk is created without any processing. • **Mount Disk**: The data disk is attached to a specified directory. • **Use as PV**: applicable when there is a high performance requirement on PVs. The **node.kubernetes.io/local-storage-persistent** label is added to the node with PV configured. The value is **linear** or **striped**. • **Use as ephemeral volume**: applicable when there is a high performance requirement on EmptyDir.

Parameter	Description
	NOTE • Local PVs are supported only when the cluster version is v1.21.2-r0 or later and the Everest add-on version is 2.1.23 or later. Version 2.1.23 or later is recommended. • Local EVs are supported only when the cluster version is v1.21.2-r0 or later and the Everest add-on version is 1.2.29 or later. **Local Persistent Volumes** and **Local EVs** support the following write modes: • **Linear**: A linear logical volume integrates one or more physical volumes. Data is written to the next physical volume when the previous one is used up. • **Striped**: A striped logical volume stripes data into blocks of the same size and stores them in multiple physical volumes in sequence, allowing data to be concurrently read and written. A storage pool consisting of striped volumes cannot be scaled-out. This option can be selected only when multiple volumes exist.

Network Settings

Configure networking resources to allow node and containerized application access.

Table 7-5 Configuration parameters

Parameter	Description
Virtual Private Cloud	The VPC to which the cluster belongs by default, which cannot be changed.
Node Subnet	The node subnet selected during cluster creation is used by default. You can choose another subnet instead. • Multiple subnets: You can select multiple subnets in the same VPC for your node pool. Newly added nodes for a scale-out will preferentially consume the IP addresses of the subnets in the top order. • Single subnet: Only one subnet is configured for your node pool. If the IP addresses of a single subnet are insufficient, configure multiple subnets. Otherwise, a node pool scale-out may fail.
Node IP Address	Random allocation is supported.

Parameter	Description
Associate Security Group	Security group used by the nodes created in the node pool. A maximum of five security groups can be selected. When a cluster is created, a node security group named **{*Cluster name*}-cce-node-{*Random ID*}** is created and used by default. Traffic needs to pass through certain ports in the node security group to ensure node communications. Ensure that you have enabled these ports if you select another security group. **NOTE** After a node pool is created, its associated security group cannot be modified.

Advanced Settings

Configure advanced node capabilities such as labels, taints, and startup command.

Table 7-6 Advanced configuration parameters

Parameter	Description
Resource Tag	You can add resource tags to classify resources. You can create **predefined tags** on the TMS console. The predefined tags are available to all resources that support tags. You can use predefined tags to improve the tag creation and resource migration efficiency. CCE will automatically create the "CCE-Dynamic-Provisioning-Node=*Node ID*" tag.
Kubernetes Label	A Kubernetes label is a key-value pair added to a Kubernetes object (such as a pod). After specifying a label, click **Add**. A maximum of 20 labels can be added. Labels can be used to distinguish nodes. With workload affinity settings, container pods can be scheduled to a specified node. For more information, see **Labels and Selectors**.

Parameter	Description
Taint	This parameter is left blank by default. You can add taints to configure anti-affinity for the node. A maximum of 20 taints are allowed for each node. Each taint contains the following parameters: • **Key**: A key must contain 1 to 63 characters, starting with a letter or digit. Only letters, digits, hyphens (-), underscores (_), and periods (.) are allowed. A DNS subdomain name can be used as the prefix of a key. • **Value**: A value must start with a letter or digit and can contain a maximum of 63 characters, including letters, digits, hyphens (-), underscores (_), and periods (.). • **Effect**: Available options are **NoSchedule**, **PreferNoSchedule**, and **NoExecute**. For details, see **Managing Node Taints**. **NOTE** For a cluster of v1.19 or earlier, the workload may have been scheduled to a node before the taint is added. To avoid such a situation, select a cluster of v1.19 or later.
Synchronization for Existing Nodes	After the options are selected, changes to Kubernetes labels/taints in the node pool will be synchronized to existing nodes.
New Node Scheduling	Default scheduling policy for the nodes newly added to a node pool. If you select **Unschedulable**, newly created nodes in the node pool will be labeled as unschedulable. In this way, you can perform some operations on the nodes before pods are scheduled to these nodes. **Scheduled Scheduling**: After scheduled scheduling is enabled, new nodes will be automatically scheduled after the custom time expires. • **Disabled**: By default, scheduled scheduling is not enabled for new nodes. To manually enable this function, go to the node list. For details, see **Configuring a Node Scheduling Policy in One-Click Mode**. • **Custom**: the default timeout for unschedulable nodes. The value ranges from 0 to 99 in the unit of minutes. **NOTE** • If auto scaling of node pools is also required, ensure the scheduled scheduling is less than 15 minutes. If a node added through Autoscaler cannot be scheduled for more than 15 minutes, Autoscaler determines that the scale-out failed and triggers another scale-out. Additionally, if the node cannot be scheduled for more than 20 minutes, the node will be scaled in by Autoscaler. • After this function is enabled, nodes will be tainted with **node.cloudprovider.kubernetes.io/uninitialized** during a node pool creation or update.

Parameter	Description
Max. Pods	Maximum number of pods that can run on the node, including the default system pods. This limit prevents the node from being overloaded with pods. This number is also decided by other factors. For details, see **Maximum Number of Pods That Can Be Created on a Node**.
ECS Group	An ECS group logically groups ECSs. The ECSs in the same ECS group comply with the same policy associated with the ECS group. Anti-affinity: ECSs in an ECS group are deployed on different physical hosts to improve service reliability. Select an existing ECS group, or click **Add ECS Group** to create one. After the ECS group is created, click the refresh icon.
Pre-installation Command	Pre-installation script command, in which Chinese characters are not allowed. The script command will be Base64-transcoded. The script will be executed before Kubernetes software is installed. Note that if the script is incorrect, Kubernetes software may fail to be installed.
Post-installation Command	Pre-installation script command, in which Chinese characters are not allowed. The script command will be Base64-transcoded. The script will be executed after Kubernetes software is installed, which does not affect the installation. **NOTE** Do not run the **reboot** command in the post-installation script to restart the system immediately. To restart the system, run the **shutdown -r 1** command to restart with a delay of one minute.
Agency	An agency is created by the account administrator on the IAM console. By creating an agency, you can share your cloud server resources with another account, or entrust a more professional person or team to manage your resources. If no agency is available, click **Create Agency** on the right to create one.

Step 4 Click **Next: Confirm**.

Step 5 Click **Submit**.

----End

7.3 Managing a Node Pool

7.3.1 Updating a Node Pool

Constraints

- The modification of resource tags of a node pool takes effect only on new nodes. To synchronize the modification onto existing nodes, manually reset the existing nodes.
- Changes to Kubernetes labels/taints in a node pool will be automatically synchronized to existing nodes after the options of **Synchronization for Existing Nodes** are selected. You do not need to reset these nodes.

Updating a Node Pool

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 on the right.

Step 3 Click **Update** next to the name of the node pool you will edit. Configure the parameters in the displayed **Update Node Pool** page.

Basic Settings

Table 7-7 Basic settings

Parameter	Description
Node Pool Name	Name of the node pool.
Expected Nodes	Change the number of nodes based on service requirements.

Configurations

Table 7-8 Node configuration parameters

Parameter	Description
Container Engine	The container engines supported by CCE include Docker and containerd, which may vary depending on cluster types, cluster versions, and OSs. Select a container engine based on the information displayed on the CCE console. **NOTE** After the container engine is modified, the modification automatically takes effect on newly added nodes. For existing nodes, manually reset the nodes for the modification to take effect.

Parameter	Description
OS	Select an OS type. Different types of nodes support different OSs. • **Public image**: Select a public image for the node. **NOTE** • 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. • After the OS is modified, the modification automatically takes effect on newly added nodes. Manually reset existing nodes for the modification to take effect.

Storage Settings

Table 7-9 Configuration parameters

Parameter	Description
System Disk	System disk used by the node OS. The disk size ranges from 40 GiB to 1024 GiB. The default value is 50 GiB. **NOTE** After the system disk configuration is modified, the modification takes effect only on newly added nodes. The configuration cannot be synchronized to existing nodes even if they are reset.

Parameter	Description
Data Disk	**At least one data disk is required** for the container runtime and kubelet. **The data disk cannot be deleted or uninstalled. Otherwise, the node will be unavailable.** • First data disk: used for container runtime and kubelet components. The disk size ranges from 20 GiB to 32768 GiB. The default value is 100 GiB. • Other data disks: You can set the data disk size to a value ranging from 10 GiB to 32768 GiB. The default value is 100 GiB. **NOTE** After the data disk configuration is modified, the modification takes effect only on newly added nodes. The configuration cannot be synchronized to existing nodes even if they are reset. **Advanced Settings** Expand the area and configure the following parameters: • **Data Disk Space Allocation**: allocates space for container engines, images, and ephemeral storage for them to run properly. For details about how to allocate data disk space, see **Data Disk Space Allocation**. **NOTE** After the data disk space allocation configuration is modified, the modification takes effect only for new nodes. The configuration cannot take effect for the existing nodes even if they are reset. • **Enabled**: Data disk encryption safeguards your data. Snapshots generated from encrypted disks and disks created using these snapshots automatically inherit the encryption setting. **This function is available only in certain regions.** – **Not encrypted** is selected by default. – After setting **Data Disk Encryption** to **Enabled**, choose an existing key. If no key is available, click **View Key List** and create a key. After the key is created, click the refresh icon next to the key text box. **NOTE** After the **Data Disk Encryption** is modified, the modification takes effect only on newly added nodes. The configuration cannot be synchronized to existing nodes even if they are reset. **Adding data disks** A maximum of four data disks can be added. By default, raw disks are created without any processing. You can also click **Expand** and select any of the following options: • **Default**: By default, a raw disk is created without any processing. • **Mount Disk**: The data disk is attached to a specified directory. • **Use as PV**: applicable when there is a high performance requirement on PVs. The **node.kubernetes.io/local-storage-**

Parameter	Description
	persistent label is added to the node with PV configured. The value is **linear** or **striped**. • **Use as ephemeral volume**: applicable when there is a high performance requirement on EmptyDir. **NOTE** • Local PVs are supported only when the cluster version is v1.21.2-r0 or later and the Everest add-on version is 2.1.23 or later. Version 2.1.23 or later is recommended. • Local EVs are supported only when the cluster version is v1.21.2-r0 or later and the Everest add-on version is 1.2.29 or later. **Local PVs** and **local EVs** can be written in the following modes: • **Linear**: A linear logical volume integrates one or more physical volumes. Data is written to the next physical volume when the previous one is used up. • **Striped**: A striped logical volume stripes data into blocks of the same size and stores them in multiple physical volumes in sequence, allowing data to be concurrently read and written. A storage pool consisting of striped volumes cannot be scaled-out. This option can be selected only when multiple volumes exist. **Local Disk Description** If the node flavor is disk-intensive or ultra-high I/O, one data disk can be a local disk. Local disks may break down and do not ensure data reliability. Store your service data in EVS disks, which are more reliable than local disks.

Advanced Settings

Table 7-10 Advanced settings

Parameter	Description
Resource Tag	You can add resource tags to classify resources. You can create **predefined tags** on the TMS console. The predefined tags are available to all resources that support tags. You can use predefined tags to improve the tag creation and resource migration efficiency. CCE will automatically create the "CCE-Dynamic-Provisioning-Node=*node id*" tag. **NOTE** Modified resource tags automatically take effect on new nodes as well as existing nodes if **Resource labels synchronized** is selected in **Synchronization for Existing Nodes**.

Parameter	Description
Kubernetes Label	A key-value pair added to a Kubernetes object (such as a pod). After specifying a label, click **Add**. A maximum of 20 labels can be added. Labels can be used to distinguish nodes. With workload affinity settings, container pods can be scheduled to a specified node. For more information, see **Labels and Selectors**. **NOTE** Modified Kubernetes labels automatically take effect on new nodes as well as existing nodes if **Kubernetes labels** is selected in **Synchronization for Existing Nodes**.
Taint	This field is left blank by default. You can add taints to configure node anti-affinity. A maximum of 20 taints are allowed for each node. Each taint contains the following parameters: • **Key**: A key must contain 1 to 63 characters, starting with a letter or digit. Only letters, digits, hyphens (-), underscores (_), and periods (.) are allowed. A DNS subdomain name can be used as the prefix of a key. • **Value**: A value must start with a letter or digit and can contain a maximum of 63 characters, including letters, digits, hyphens (-), underscores (_), and periods (.). • **Effect**: Available options are **NoSchedule**, **PreferNoSchedule**, and **NoExecute**. For details, see **Managing Node Taints**. **NOTE** Modified taints automatically take effect on new nodes as well as existing nodes if **Taints** is selected in **Synchronization for Existing Nodes**.

Parameter	Description
Synchronization for Existing Nodes	After the options are selected, changes to Kubernetes labels/taints in the node pool will be synchronized to existing nodes. **NOTE** When you update a node pool, pay attention to the following if you change the state of **Kubernetes labels** or **Taints**: • When these options are deselected, the Kubernetes labels/taints of the existing and new nodes in the node pool may be inconsistent. If service scheduling relies on node labels or taints, the scheduling may fail or the node pool may fail to scale. • When these options are selected: – If you have **modified** or **added** labels or taints in the node pool, the modifications will be automatically synchronized to existing nodes typically in 10 minutes after **Kubernetes labels** or **Taints** is selected. – If you have **deleted** a label or taint in the node pool, you must manually delete the label or taint on the node list page after **Kubernetes labels** or **Taints** is selected. – If you have **manually changed the key or effect of a taint on an existing node**, a new taint will be added to the existing node after **Kubernetes labels** or **Taints** is selected. In the new taint, its key is different from the manually changed key but its value and effect are the same as those manually changed ones, or its effect is different from the manually changed effect but its key and value are the same as those manually changed ones. This is because a Kubernetes taint natively uses a key and effect as a key-value pair. The taints with different keys or effects are considered as two taints.
New Node Scheduling	Default scheduling policy for the nodes newly added to a node pool. If you select **Unschedulable**, newly created nodes in the node pool will be labeled as unschedulable. In this way, you can perform some operations on the nodes before pods are scheduled to these nodes. **Scheduled Scheduling**: After scheduled scheduling is enabled, new nodes will be automatically scheduled after the custom time expires. • **Disabled**: By default, scheduled scheduling is not enabled for new nodes. To manually enable this function, go to the node list. For details, see **Configuring a Node Scheduling Policy in One-Click Mode**. • **Custom**: the default timeout for unschedulable nodes. The value ranges from 0 to 99 in the unit of minutes. **NOTE** • If auto scaling of node pools is also required, ensure the scheduled scheduling is less than 15 minutes. If a node added through Autoscaler cannot be scheduled for more than 15 minutes, Autoscaler determines that the scale-out failed and triggers another scale-out. Additionally, if the node cannot be scheduled for more than 20 minutes, the node will be scaled in by Autoscaler. • After this function is enabled, nodes will be tainted with **node.cloudprovider.kubernetes.io/uninitialized** during a node pool creation or update.

Parameter	Description
Edit key pair	Only node pools that use key pairs for login support key pair editing. You can select another key pair. **NOTE** The edited key pair automatically takes effect on newly added nodes. For existing nodes, manually reset the nodes for the modification to take effect.
Pre-installation Command	Pre-installation script command, in which Chinese characters are not allowed. The script command will be Base64-transcoded. The script will be executed before Kubernetes software is installed. Note that if the script is incorrect, Kubernetes software may fail to be installed. **NOTE** The modified pre-installation command automatically takes effect on newly added nodes. For existing nodes, manually reset the nodes for the modification to take effect.
Post-installation Command	Pre-installation script command, in which Chinese characters are not allowed. The script command will be Base64-transcoded. The script will be executed after Kubernetes software is installed, which does not affect the installation. **NOTE** The modified post-installation command automatically takes effect on newly added nodes. For existing nodes, manually reset the nodes for the modification to take effect.

Step 4 After the configuration, click **OK**.

After the node pool parameters are updated, go to the **Nodes** page to check whether the node to which the node pool belongs is updated. You can reset the node to synchronize the configuration updates for the node pool.

----End

7.3.2 Updating an AS Configuration

Auto Scaling (AS) enables elastic scaling of nodes in a node pool based on scaling policies. Without this function, you have to manually adjust the number of nodes in a node pool.

Constraints

To enable AS, the **CCE Cluster Autoscaler** add-on must be installed in the target cluster.

Procedure

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 **Nodes**. On the **Node Pools** tab, locate the row containing the target node pool and click **Auto Scaling**.

- If the auto scaling add-on has not been installed, configure add-on parameters based on service requirements, click **Install**, and wait until the add-on is installed. For details about add-on configurations, see **CCE Cluster Autoscaler**.
- If the auto scaling add-on has been installed, directly configure auto scaling policies.

Step 3 Configure auto scaling policies.

AS Configuration

- **Customized Rule**: Click **Add Rule**. In the dialog box displayed, configure parameters. You can add multiple node scaling policies, a maximum of one CPU usage-based rule, and one memory usage-based rule. The total number of rules cannot exceed 10.

  The following table lists custom rules.

Table 7-11 Custom rules

Rule Type	Configuration
Metric-based	– **Trigger**: Select **CPU allocation rate** or **Memory allocation rate** and enter a value. The value must be greater than the scale-in percentage configured in the auto scaling add-on. **NOTE** ▪ Resource allocation (%) = Resources requested by pods in the node pool/Resources allocatable to pods in the node pool ▪ **If multiple rules meet the conditions, the rules are executed in either of the following modes:** If rules based on the **CPU allocation rate** and **memory allocation rate** are configured and two or more rules meet the scale-out conditions, the rule that will add the most nodes will be executed. If a rule based on the **CPU allocation rate** and **a periodic rule** are configured and they both meet the scale-out conditions, one of them will be executed randomly. The rule executed first (rule A) changes the node pool to the scaling state. As a result, the other rule (rule B) cannot be executed. After rule A is executed and the node pool status becomes normal, rule B will not be executed. ▪ If rules based on the **CPU allocation rate** and **memory allocation rate** are configured, the policy detection period varies with the processing logic of each loop of the Autoscaler add-on. A scale-out is triggered once the conditions are met, but it is constrained by other factors such as the cooldown period and node pool status. ▪ When the number of nodes in the cluster reaches the upper limit, or the CPU or memory usage reaches the upper limit of the autoscaler add-on, node scale-out will not be triggered. – **Action**: Configure an action to be performed when the triggering condition is met. ▪ **Custom**: Add a specified number of nodes to a node pool. ▪ **Auto calculation**: When the trigger condition is met, nodes are automatically added and the allocation rate is restored to a value lower than the threshold. The formula is as follows: Number of nodes to be added = [Resource request of pods in the node pool/(Available resources of a single node x Target allocation rate)] – Number of current nodes + 1
Periodic	– **Trigger Time**: You can select a specific time every day, every week, every month, or every year. – **Action**: specifies an action to be carried out when the trigger time is reached. A specified number of nodes will be added to the node pool.

- **Nodes**: 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.

AS Object

Specification selection: Configure whether to enable auto scaling for node flavors in a node pool.

Step 4 Click **OK**.

----End

7.3.3 Configuring a Node Pool

Constraints

The default node pool DefaultPool does not support the following management operations.

Configuration Management

CCE allows you to highly customize Kubernetes parameter settings on core components in a cluster. For more information, see **kubelet**.

This function is supported only in clusters of **v1.15 and later**. It is not displayed for versions earlier than v1.15.

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 on the right.

Step 3 Click **Manage** in the **Operation** column of the target node pool

Step 4 On the **Manage Components** page on the right, change the values of Kubernetes parameters.

Table 7-12 kubelet

Item	Parameter	Description	Value	Modification
CPU management policy	cpu-manager-policy	CPU management policy configuration. For details, see **CPU Scheduling**. • **none**: disables pods from exclusively occupying CPUs. Select this value if you want a large pool of shareable CPU cores. • **static**: enables pods to exclusively occupy CPUs. Select this value if your workload is sensitive to latency in CPU cache and scheduling.	Default: none	None
QPS for requests to kube-apiserver	kube-api-qps	Number of queries per second for communication with the API server.	Default: 100	None
Burst for requests to kube-apiserver	kube-api-burst	Maximum number of burst requests sent to the API server per second.	Default: 100	None
Limit on the pods managed by kubelet	max-pods	Maximum number of pods that can run on a node.	• For a CCE standard cluster, the maximum number of pods is determined based on **the maximum number of pods on a node**.	None

Item	Parameter	Description	Value	Modification
Limited number of processes in a pod	pod-pids-limit	Maximum number of PIDs that can be used in each pod.	Default: -1, which indicates that the number of PIDs is not limited	None
Whether to use a local IP address as a node's ClusterDNS	with-local-dns	The default ENI IP address of the node will be automatically added to the node's kubelet configuration as the preferred DNS address.	Default: false	None
QPS limit on creating events	event-qps	Number of events that can be generated per second.	Default: 5	None
Allowed unsafe sysctls	allowed-unsafe-sysctls	Insecure system configuration allowed. Starting from **v1.17.17**, CCE enables pod security policies for kube-apiserver. Add corresponding configurations to **allowedUnsafeSysctls** of a pod security policy to make the policy take effect. (This configuration is not required for clusters earlier than v1.17.17.) For details, see **Example of Enabling Unsafe Sysctls in Pod Security Policy**.	Default: []	None

Item	Parameter	Description	Value	Modification
Node oversubscription	over-subscription-resource	Whether to enable node oversubscription. If this parameter is set to **true**, node oversubscription is enabled on nodes.	• For clusters of versions earlier than v1.23.9-r0 or v1.25.4-r0: enabled (**true**) by default • Disabled by default if the cluster version is v1.23.9-r0, v1.25.4-r0, v1.27-r0, or later	None
Hybrid deployment	colocation	Whether to enable hybrid deployment on nodes. If this parameter is set to **true**, hybrid deployment is enabled on nodes.	• For clusters of versions earlier than v1.23.9-r0 or v1.25.4-r0: enabled (**true**) by default • Disabled by default if the cluster version is v1.23.9-r0, v1.25.4-r0, v1.27-r0, or later	None

Item	Parameter	Description	Value	Modification
Topology management policy	topology-manager-policy	Set the topology management policy. Valid values are as follows: • **restricted**: kubelet accepts only pods that achieve optimal NUMA alignment on the requested resources. • **best-effort**: kubelet preferentially selects pods that implement NUMA alignment on CPU and device resources. • **none** (default): The topology management policy is disabled. • **single-numa-node**: kubelet allows only pods that are aligned to the same NUMA node in terms of CPU and device resources.	Default: none	**NOTICE** Modifying **topology-manager-policy** and **topology-manager-scope** will restart kubelet, and the resource allocation of pods will be recalculated based on the modified policy. In this case, running pods may restart or even fail to receive any resources.
Topology management scope	topology-manager-scope	Configure the resource alignment granularity of the topology management policy. Valid values are as follows: • **container** (default) • **pod**	Default: container	

Item	Parameter	Description	Value	Modification
Specified DNS configuration file	resolv-conf	DNS resolution configuration file specified by the container	Default: null	None
Timeout for all runtime requests except long-running requests	runtime-request-timeout	Timeout interval of all runtime requests except long-running requests (pull, logs, exec, and attach).	Default: 2m0s	This parameter is available only in clusters of v1.21.10-r0, v1.23.8-r0, v1.25.3-r0, or later versions.
Whether to allow kubelet to pull only one image at a time	serialize-image-pulls	Pull an image in serial mode. • **false**: recommended configuration so that an image can be pulled in parallel mode to improve pod startup. • **true**: allows images to be pulled in serial mode.	• Enabled by default if the cluster version is earlier than v1.21.12-r0, v1.23.11-r0, v1.27.3-r0 or v1.25.6-r0 • Disabled by default if the cluster version is v1.21.12-r0, v1.23.11-r0, v1.25.6-r0, v1.27.3-r0, or later	This parameter is available only in clusters of v1.21.10-r0, v1.23.8-r0, v1.25.3-r0, or later versions.
Image repository pull limit per second	registry-pull-qps	QPS upper limit of an image repository.	Default: 5 The value ranges from 1 to 50.	This parameter is available only in clusters of v1.21.10-r0, v1.23.8-r0, v1.25.3-r0, or later versions.

Item	Parameter	Description	Value	Modification
Upper limit of burst image pull	registry-burst	Maximum number of burst image pulls.	Default: 10 The value ranges from 1 to 100 and must be greater than or equal to the value of **registry-pull-qps**.	This parameter is available only in clusters of v1.21.10-r0, v1.23.8-r0, v1.25.3-r0, or later versions.
Node memory reservation	system-reserved-mem	System memory reservation reserves memory resources for OS system daemons such as sshd and udev.	Default value: automatically calculated, which varies depending on node flavors. For details, see **Node Resource Reservation Policy**.	The sum of **kube-reserved-mem** and **system-reserved-mem** must be less than 50% of the minimum memory of nodes in the node pool.
	kube-reserved-mem	Kubernetes memory reservation reserves memory resources for Kubernetes daemons such kubelet and container runtime.		

Item	Parameter	Description	Value	Modification
Hard eviction	memory.available	Available memory on a node.	The value is fixed at 100 MiB.	For details, see **Node-pressure Eviction**. **NOTICE** **Exercise caution** when modifying an eviction configuration item. Improper configuration may cause pods to be frequently evicted or fail to be evicted when the node is overloaded. kubelet can identify the following specific file system identifiers: • **nodefs**: main file system of a node. It is used for local disk volumes, emptyDir volumes that are not supported by memory, and log storage. For example, **nodefs** contains **/var/lib/kubelet/**. • **imagefs**: file system partition used by a container engine.
	nodefs.available	Percentage of the available capacity in the filesystem used by kubelet.	Default: 10% Value range: 1% to 99%	
	nodefs.inodesFree	Percentage of available inodes in the filesystem used by kubelet.	Default: 5% Value range: 1% to 99%	
	imagefs.available	Percentage of the available capacity in the filesystem used by container runtimes to store resources such as images.	Default: 10% Value range: 1% to 99%	
	imagefs.inodesFree	Percentage of available inodes in the filesystem used by container runtimes to store resources such as images.	This parameter is left blank by default. Value range: 1% to 99%	
	pid.available	Percentage of allocatable PIDs reserved for pods.	Default: 10% Value range: 1% to 99%	
Soft eviction	memory.available	Available memory on a node. The value must be greater than the hard eviction value of the same parameter, and the eviction grace period (**evictionSoftGracePeriod**) must be configured accordingly.	This parameter is left blank by default. Value range: 100 to 1000000	

Item	Parameter	Description	Value	Modification
	nodefs.available	Percentage of the available capacity in the filesystem used by kubelet. The value must be greater than the hard eviction value of the same parameter, and the eviction grace period (**evictionSoftGracePeriod**) must be configured accordingly.	This parameter is left blank by default. Value range: 1% to 99%	
	nodefs.inodesFree	Percentage of available inodes in the filesystem used by kubelet. The value must be greater than the hard eviction value of the same parameter, and the eviction grace period (**evictionSoftGracePeriod**) must be configured accordingly.	This parameter is left blank by default. Value range: 1% to 99%	

Item	Parameter	Description	Value	Modification
	imagefs.available	Percentage of the available capacity in the filesystem used by container runtimes to store resources such as images. The value must be greater than the hard eviction value of the same parameter, and the eviction grace period (**evictionSoftGracePeriod**) must be configured accordingly.	This parameter is left blank by default. Value range: 1% to 99%	
	imagefs.inodesFree	Percentage of available inodes in the filesystem used by container runtimes to store resources such as images. The value must be greater than the hard eviction value of the same parameter, and the eviction grace period (**evictionSoftGracePeriod**) must be configured accordingly.	This parameter is left blank by default. Value range: 1% to 99%	

Item	Parameter	Description	Value	Modification
	pid.available	Percentage of allocatable PIDs reserved for pods. The value must be greater than the hard eviction value of the same parameter, and the eviction grace period (**evictionSoftGrace-Period**) must be configured accordingly.	This parameter is left blank by default. Value range: 1% to 99%	

Table 7-13 kube-proxy

Item	Parameter	Description	Value	Modification
Maximum number of connection tracking entries	conntrack-min	Maximum number of connection tracking entries To obtain the value, run the following command: `sysctl -w net.nf_conntrack_max`	Default: 131072	None
Wait time of a closed TCP connection	conntrack-tcp-timeout-close-wait	Wait time of a closed TCP connection To obtain the value, run the following command: `sysctl -w net.netfilter.nf_conntrack_tcp_timeout_close_wait`	Default: 1h0m0s	None

Table 7-14 Docker (available only for node pools that use Docker)

Item	Parameter	Description	Value	Modification
Container umask	native-umask	The default value **normal** indicates that the umask value of the started container is **0022**.	Default: normal	The parameter value cannot be changed.
Available data space for a single container	docker-base-size	Maximum data space that can be used by each container.	Default: 0	The parameter value cannot be changed.
Insecure image source address	insecure-registry	Whether an insecure image source address can be used.	false	The parameter value cannot be changed.
Maximum size of a container **core** file	limitcore	Maximum size of a core file in a container. The unit is byte. If not specified, the value is **infinity**.	Default: 5368709120	None
Limit on the number of handles in a container	default-ulimit-nofile	Maximum number of handles that can be used in a container.	Default: {soft}:{hard}	The value cannot exceed the value of the kernel parameter **nr_open** and cannot be a negative number. You can run the following command to obtain the kernel parameter **nr_open**: `sysctl -a | grep nr_open`
Image pull timeout	image-pull-progress-timeout	If the image fails to be pulled before time outs, the image pull will be canceled.	Default: 1m0s	This parameter is supported in v1.25.3-r0 and later.

Table 7-15 containerd (available only for node pools that use containerd)

Item	Parameter	Description	Value	Modification
Available data space for a single container	devmapper-base-size	Maximum data space that can be used by each container.	Default: 0	The parameter value cannot be changed.
Maximum size of a container **core** file	limitcore	Maximum size of a core file in a container. The unit is byte. If not specified, the value is **infinity**.	Default: 5368709120	None
Limit on the number of handles in a container	default-ulimit-nofile	Maximum number of handles that can be used in a container.	Default: 1048576	The value cannot exceed the value of the kernel parameter **nr_open** and cannot be a negative number. You can run the following command to obtain the kernel parameter **nr_open**: `sysctl -a | grep nr_open`
Image pull timeout	image-pull-progress-timeout	If the image fails to be pulled before time outs, the image pull will be canceled.	Default: 1m0s	This parameter is supported in v1.25.3-r0 and later.
Verification on insure skips	insecure_skip_verify	Whether to skip repository certificate verification.	Default: false	The parameter value cannot be changed.

Step 5 Click **OK**.

----End

7.3.4 Copying a Node Pool

You can copy the configuration of an existing node pool on the CCE console to create new node pools.

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 on the right.

Step 3 Locate the target node pool and choose **More** > **Copy** in the **Operation** column.

Step 4 In the **Copy Resource Pool** window, the configurations of the node pool to be copied are displayed. Modify the configurations as needed. For details, see **Creating a Node Pool**. After confirming the configuration, click **Next: Confirm**.

Step 5 On the **Confirm** page, confirm the node pool configurations and click **Submit**. Then, a new node pool is created based on the modified configurations.

----End

7.3.5 Synchronizing Node Pools

After the configuration of a node pool is updated, some configurations cannot be automatically synchronized for existing nodes. You can manually synchronize configurations for these nodes.

NOTICE

- Do not delete or reset nodes during batch synchronization. Otherwise, the synchronization of node pool configuration may fail.
- This operation involves resetting nodes. **Workloads running on a node may be interrupted due to standalone deployment or insufficient schedulable resources.** Evaluate the upgrade risks and perform the upgrade during off-peak hours. Alternatively, **specify a disruption budget for your key applications** to ensure the availability of these applications during the upgrade.
- During configuration synchronization for existing nodes, the nodes will be reset, and the system disks and data disks will be cleared. Back up important data before the synchronization.
- Only some node pool parameters can be synchronized by resetting nodes. The constraints are as follows:
  - The modification of resource tags of a node pool takes effect only on new nodes. To synchronize the modification onto existing nodes, manually reset the existing nodes.
  - Changes to Kubernetes labels/taints in a node pool will be automatically synchronized to existing nodes after the options of **Synchronization for Existing Nodes** are selected. You do not need to reset these nodes.

Synchronizing a Single Node

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 **Nodes** tab on the right.

Step 3 Find **upgrade** in the **Node Pool** column of the existing nodes in the node pool.

Step 4 Click **update**. In the dialog box that is displayed, confirm whether to reset the node immediately.

----End

Batch Synchronization

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 on the right.

Step 3 Choose **More** > **Synchronize** in the **Operation** column of the target node pool.

Step 4 In the **Batch synchronization** window, configure parameters.

- **OS**: shows the image of the target version. You do not need to configure this parameter.
- **Synchronization Policy**: **Node Reset** is supported.
- **Max. Nodes for Batch Synchronize**: maximum number of nodes that will be unavailable during node synchronization. Nodes will be unavailable during synchronization by resetting the nodes. Properly configure this parameter to prevent pod scheduling failures caused by too many unavailable nodes in the cluster.
- **Node List**: Select the nodes requiring the synchronization of node pool configurations.

Step 5 Click **OK**.

----End

7.3.6 Upgrading an OS

When CCE releases a new OS image, existing nodes cannot be automatically upgraded. You can manually upgrade them in batches.

NOTICE

This section describes how to upgrade an OS by resetting the target node. **Workloads running on a node may be interrupted due to standalone deployment or insufficient schedulable resources.** Evaluate the upgrade risks and perform the upgrade during off-peak hours. Alternatively, **specify a disruption budget for your key applications** to ensure the availability of these applications during the upgrade.

Constraints

- Nodes running private images cannot be upgraded.
- Compatibility issues may occur when the node OS of an early version is upgraded. In this case, manually reset the node for the OS upgrade.

Procedure for Default Node Pools

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 on the right.

Step 3 Click **Upgrade** next to the default node pool.

Step 4 In the displayed **Operating System Upgrade** window, configure parameters.

- **Target Operating System**: shows the image of the target version. You do not need to configure this parameter.
- **Upgrade Policy**: **Node Reset** is supported.
- **Max. Nodes for Batch Upgrade**: maximum number of nodes that will be unavailable during node upgrade. Nodes will be unavailable during synchronization by resetting the nodes. Properly configure this parameter to prevent pod scheduling failures caused by too many unavailable nodes in the cluster.
- **View Node**: Select the nodes to be upgraded.
- Login Mode:
  - **Password**

    The default username is **root**. Enter the password for logging in to the node and confirm the password.

    Be sure to remember the password as you will need it when you log in to the node.
  - **Key Pair**

    Select the key pair used to log in to the node. You can select a shared key.

    A key pair is used for identity authentication when you remotely log in to a node. If no key pair is available, click **Create Key Pair**.
- Pre-installation script:

  Pre-installation script command, in which Chinese characters are not allowed. The script command will be Base64-transcoded.

  The script will be executed before Kubernetes software is installed. Note that if the script is incorrect, Kubernetes software may fail to be installed.
- Post-installation script:

  Pre-installation script command, in which Chinese characters are not allowed. The script command will be Base64-transcoded.

  The script will be executed after Kubernetes software is installed and will not affect the installation.

Step 5 Click **OK**.

----End

Procedure for Non-default Node Pools

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 on the right.

Step 3 Choose **More > Synchronize** in the **Operation** column of the target node pool.

Step 4 In the **Batch synchronization** window, configure parameters.

- **OS**: shows the image of the target version. You do not need to configure this parameter.
- **Synchronization Policy**: **Node Reset** is supported.
- **Max. Nodes for Batch Synchronize**: maximum number of nodes that will be unavailable during node synchronization. Nodes will be unavailable during synchronization by resetting the nodes. Properly configure this parameter to prevent pod scheduling failures caused by too many unavailable nodes in the cluster.
- **Node List**: Select the nodes requiring the synchronization of node pool configurations.

Step 5 Click **OK**.

----End

7.3.7 Migrating a Node

Nodes in a node pool can be migrated to the default node pool. Nodes in the default node pool or a custom node pool cannot be migrated to other custom node pools.

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 **Nodes** and click the **Node Pools** tab.

Step 3 Click **View Node** in the **Operation** column of the node pool to be migrated.

Step 4 Click **More** > **Migrate** in the **Operation** column of the target node to migrate the node.

Step 5 In the displayed **Migrate Node** dialog box, confirm the information.

NOTE

- The migration does not affect custom resource tags, Kubernetes labels, and taints of the node.
- After the migration, system labels **cce.cloud.com** and **cce-nodepool** on the node will be deleted. If an existing workload uses these labels for affinity or anti-affinity scheduling, the existing pods on the node will be stopped and rescheduled when kubelet is restarted.

----End

7.3.8 Deleting a Node Pool

Deleting a node pool will delete nodes in the pool. Pods on these nodes will be automatically migrated to available nodes in other node pools.

Precautions

- Deleting a node pool will delete all nodes in the node pool. Back up data in a timely manner to prevent data loss.
- Deleting a node will lead to pod migration, which may affect services. Perform this operation during off-peak hours. If pods in the node pool have a specific node selector and none of the other nodes in the cluster satisfies the node selector, the pods will become unschedulable.
- When deleting a node pool, the system sets all nodes in the current node pool to the unschedulable state.

Procedure

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 on the right.

Step 3 Choose **More > Delete** in the **Operation** column of the target node pool.

Step 4 Read the precautions in the **Delete Node Pool** dialog box.

Step 5 In the text box, enter **DELETE** and click **Yes** to confirm that you want to continue the deletion.

----End

8 Workloads

8.1 Overview

A workload is an application running on Kubernetes. No matter how many components are there in your workload, you can run it in a group of Kubernetes pods. A workload is an abstract model of a group of pods in Kubernetes. Workloads in Kubernetes are classified as Deployments, StatefulSets, DaemonSets, jobs, and cron jobs.

CCE provides Kubernetes-native container deployment and management and supports lifecycle management of container workloads, including creation, configuration, monitoring, auto scaling, upgrade, uninstall, service discovery, and load balancing.

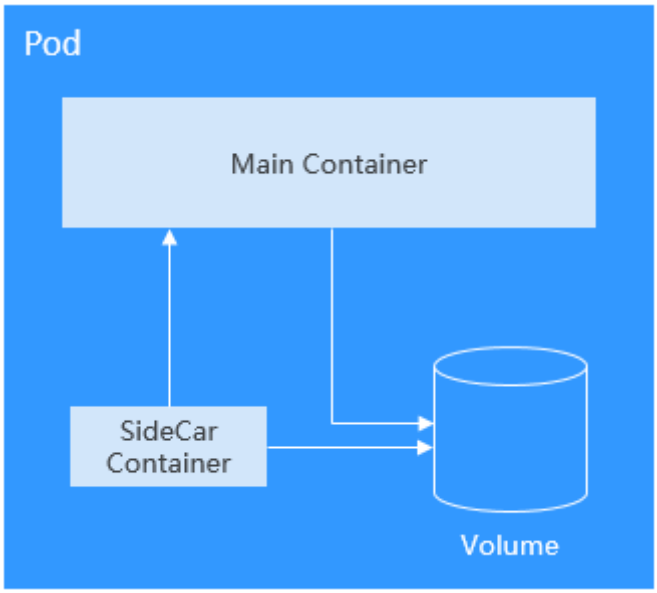
Overview of Pod

A pod is the smallest and simplest unit in the Kubernetes object model that you create or deploy. A pod is a group of one or more containers, with shared storage and network resources, and a specification for how to run the containers. Each pod has a separate IP address.

Pods can be used in either of the following ways:

- A pod runs only one container. This is the most common usage of pods in Kubernetes. You can consider a pod as a container, but Kubernetes directly manages pods instead of containers.
- A pod runs multiple containers that need to be tightly coupled. In this scenario, a pod contains a main container and several sidecar containers, as shown in **Figure 8-1**. For example, the main container is a web server that provides file services from a fixed directory, and sidecar containers periodically download files to this fixed directory.

Figure 8-1 Pod running multiple containers

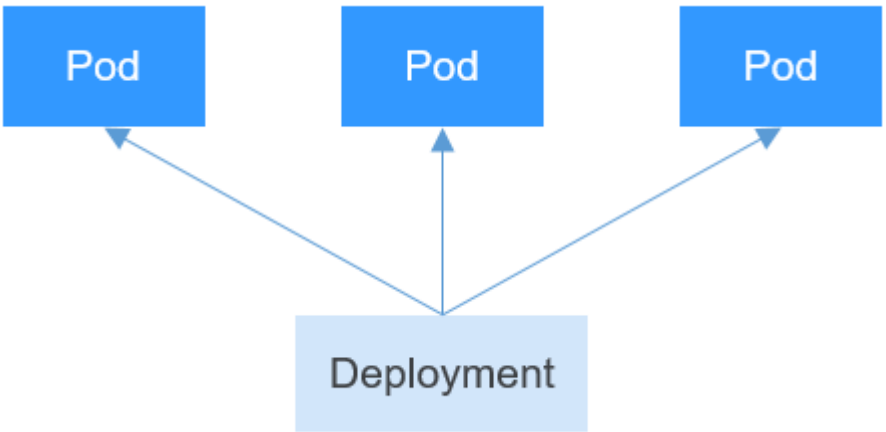


In Kubernetes, pods are rarely created directly. Instead, Kubernetes controller manages pods through pod instances such as Deployments and jobs. A controller typically uses a pod template to create pods. The controller can also manage multiple pods and provide functions such as replica management, rolling upgrade, and self-healing.

Overview of Deployment

A pod is the smallest and simplest unit that you create or deploy in Kubernetes. It is designed to be an ephemeral, one-off entity. A pod can be evicted when node resources are insufficient and disappears along with a cluster node failure. Kubernetes provides controllers to manage pods. Controllers can create and manage pods, and provide replica management, rolling upgrade, and self-healing capabilities. The most commonly used controller is Deployment.

Figure 8-2 Relationship between a Deployment and pods



A Deployment can contain one or more pods. These pods have the same role. Therefore, the system automatically distributes requests to multiple pods of a Deployment.

A Deployment integrates a lot of functions, including online deployment, rolling upgrade, replica creation, and restoration of online jobs. To some extent, Deployments can be used to realize unattended rollout, which greatly reduces difficulties and operation risks in the rollout process.

Overview of StatefulSet

All pods under a Deployment have the same characteristics except for the name and IP address. If required, a Deployment can use a pod template to create new pods. If not required, the Deployment can delete any one of the pods.

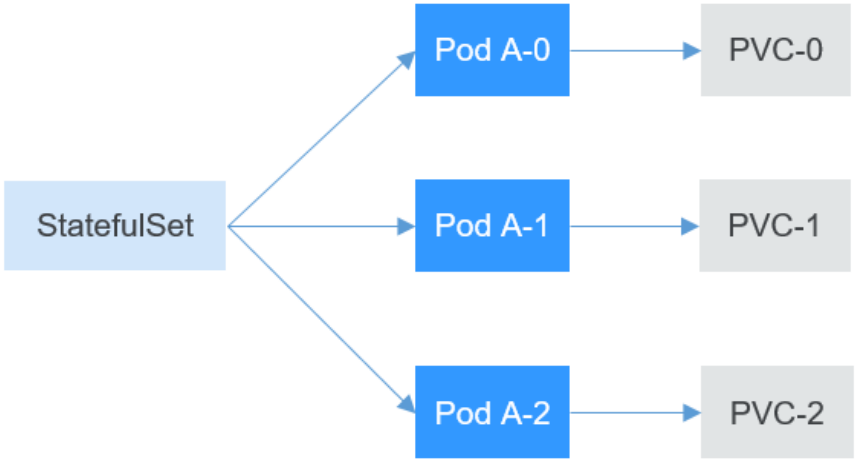
However, Deployments cannot meet the requirements in some distributed scenarios when each pod requires its own status or in a distributed database where each pod requires independent storage.

Distributed stateful applications involve different roles for different responsibilities. For example, databases work in active/standby mode, and pods depend on each other. To deploy stateful applications in Kubernetes, ensure pods meet the following requirements:

- Each pod must have a fixed identifier so that it can be recognized by other pods.
- Separate storage resources must be configured for each pod. In this way, the original data can be retrieved after a pod is deleted and restored. Otherwise, the pod status will be changed after the pod is rebuilt.

To address the preceding requirements, Kubernetes provides StatefulSets.

1. StatefulSets provide a fixed name for each pod following a fixed number ranging from 0 to N. After a pod is rescheduled, the pod name and the hostname remain unchanged.
2. StatefulSets use a headless Service to allocate a fixed domain name for each pod.
3. StatefulSets create PersistentVolumeClaims (PVCs) with fixed identifiers to ensure that pods can access the same persistent data after being rescheduled.

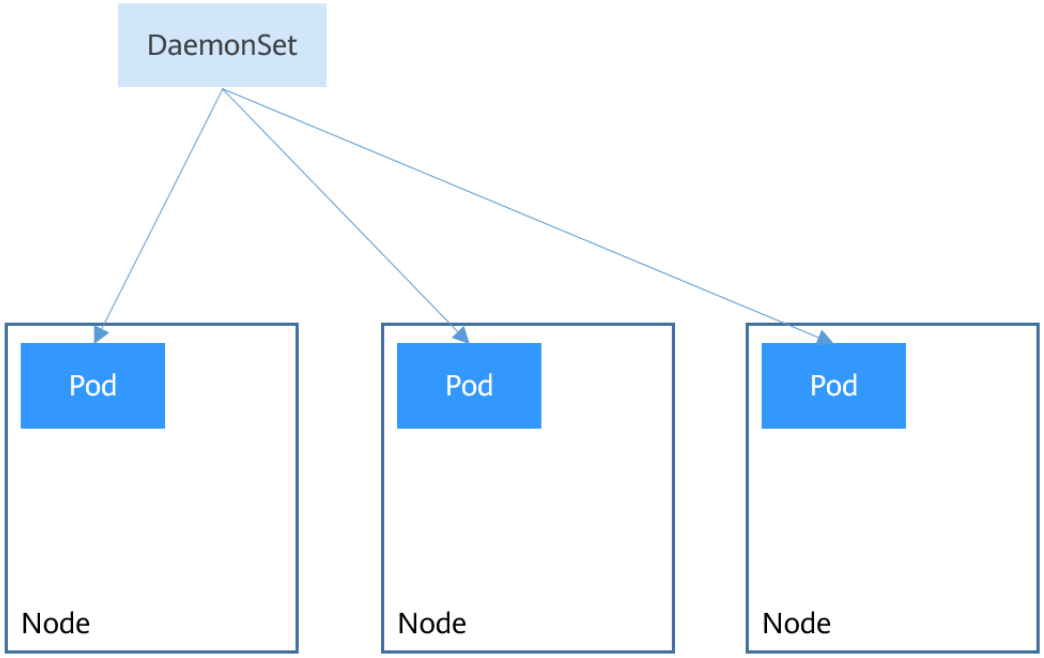


Overview of DaemonSet

A DaemonSet runs a pod on each node in a cluster and ensures that there is only one pod. This works well for certain system-level applications such as log collection and resource monitoring since they must run on each node and need only a few pods. A good example is kube-proxy.

DaemonSets are closely related to nodes. If a node becomes faulty, the DaemonSet will not create the same pods on other nodes.

Figure 8-3 DaemonSet



Overview of Job and CronJob

Jobs and cron jobs allow you to run short lived, one-off tasks in batch. They ensure the task pods run to completion.

- A job is a resource object used by Kubernetes to control batch tasks. Jobs are different from long-term servo tasks (such as Deployments and StatefulSets). The former is started and terminated at specific times, while the latter runs unceasingly unless being terminated. The pods managed by a job will be automatically removed after successfully completing tasks based on user configurations.
- A cron job runs a job periodically on a specified schedule. A cron job object is similar to a line of a crontab file in Linux.

This run-to-completion feature of jobs is especially suitable for one-off tasks, such as continuous integration (CI).

Workload Lifecycle

Table 8-1 Status description

Status	Description
Running	All pods are running or the number of pods is 0.
Unready	The container malfunctions and the pod under the workload is not working.
Processing	The workload is not running but no error is reported.
Available	For a multi-pod Deployment, some pods are abnormal but at least one pod is available.
Completed	The task is successfully executed. This status is available only for common tasks.
Stopped	The workload is stopped and the number of pods changes to 0. This status is available for workloads earlier than v1.13.
Deleting	The workload is being deleted.

8.2 Creating a Workload

8.2.1 Creating a Deployment

Scenario

Deployments are workloads (for example, Nginx) that do not store any data or status. You can create Deployments on the CCE console or by running kubectl commands.

Prerequisites

- Before creating a workload, you must have an available cluster. For details on how to create a cluster, see **Buying a CCE Standard Cluster**.
- To enable public access to a workload, ensure that an EIP or load balancer has been bound to at least one node in the cluster.

  NOTE

  If a pod has multiple containers, ensure that the ports used by the containers do not conflict with each other. Otherwise, creating the Deployment will fail.

Using the CCE Console

Step 1 Log in to the CCE console.

Step 2 Click the cluster name to go to the cluster console, choose **Workloads** in the navigation pane, and click the **Create Workload** in the upper right corner.

Step 3 Set basic information about the workload.

Basic Info

- **Workload Type**: Select **Deployment**. For details about workload types, see **Overview**.
- **Workload Name**: Enter the name of the workload. Enter 1 to 63 characters starting with a lowercase letter and ending with a lowercase letter or digit. Only lowercase letters, digits, and hyphens (-) are allowed.
- **Namespace**: Select the namespace of the workload. The default value is **default**. You can also click **Create Namespace** to create one. For details, see **Creating a Namespace**.
- **Pods**: Enter the number of pods of the workload.
- **Time Zone Synchronization**: Specify whether to enable time zone synchronization. After time zone synchronization is enabled, the container and node use the same time zone. The time zone synchronization function depends on the local disk mounted to the container. Do not modify or delete the time zone. For details, see **Configuring Time Zone Synchronization**.

Container Settings

- Container Information

  Multiple containers can be configured in a pod. You can click **Add Container** on the right to configure multiple containers for the pod.

  – **Basic Info**: Configure basic information about the container.

Parameter	Description
Container Name	Name the container.
Pull Policy	Image update or pull policy. If you select **Always**, the image is pulled from the image repository each time. If you do not select **Always**, the existing image of the node is preferentially used. If the image does not exist, the image is pulled from the image repository.
Image Name	Click **Select Image** and select the image used by the container. To use a third-party image, see **Using Third-Party Images**.
Image Tag	Select the image tag to be deployed.
CPU Quota	▪ **Request**: minimum number of CPU cores required by a container. The default value is 0.25 cores. ▪ **Limit**: maximum number of CPU cores that can be used by a container. This prevents containers from using excessive resources. If **Request** and **Limit** are not specified, the quota is not limited. For more information and suggestions about **Request** and **Limit**, see **Configuring Container Specifications**.

Parameter	Description
Memory Quota	▪ **Request**: minimum amount of memory required by a container. The default value is 512 MiB. ▪ **Limit**: maximum amount of memory available for a container. When memory usage exceeds the specified memory limit, the container will be terminated. If **Request** and **Limit** are not specified, the quota is not limited. For more information and suggestions about **Request** and **Limit**, see **Configuring Container Specifications**.
(Optional) GPU Quota	Configurable only when the cluster contains GPU nodes and the **CCE AI Suite (NVIDIA GPU)** add-on is installed. ▪ **All**: No GPU will be used. ▪ **Dedicated**: GPU resources are dedicated for the container. ▪ **Shared**: percentage of GPU resources used by the container. For example, if this parameter is set to **10%**, the container uses 10% of GPU resources. For details about how to use GPUs in the cluster, see **Default GPU Scheduling in Kubernetes**.
(Optional) NPU Quota	Number of required Ascend chips. The value must be an integer and the **CCE AI Suite (Ascend NPU)** add-on must be installed. For details about how to use NPUs in the cluster, see **NPU Scheduling**.
(Optional) Privileged Container	Programs in a privileged container have certain privileges. If **Privileged Container** is enabled, the container is assigned privileges. For example, privileged containers can manipulate network devices on the host machine and modify kernel parameters.
(Optional) Init Container	Whether to use the container as an init container. An init container does not support health check. An init container is a special container that runs before other app containers in a pod are started. Each pod can contain multiple containers. In addition, a pod can contain one or more init containers. Application containers in a pod are started and run only after the running of all init containers completes. For details, see **Init Containers**.

  - (Optional) **Lifecycle**: Configure operations to be performed in a specific phase of the container lifecycle, such as Startup Command, Post-Start, and Pre-Stop. For details, see **Configuring Container Lifecycle Parameters**.
  - (Optional) **Health Check**: Set the liveness probe, ready probe, and startup probe as required. For details, see **Configuring Container Health Check**.
  - (Optional) **Environment Variables**: Configure variables for the container running environment using key-value pairs. These variables transfer external information to containers running in pods and can be flexibly modified after application deployment. For details, see **Configuring Environment Variables**.
  - (Optional) **Data Storage**: Mount local storage or cloud storage to the container. The application scenarios and mounting modes vary with the storage type. For details, see **Storage**.

    NOTE

    If the workload contains more than one pod, EVS volumes cannot be mounted.
  - (Optional) **Security Context**: Assign container permissions to protect the system and other containers from being affected. Enter the user ID to assign container permissions and prevent systems and other containers from being affected.
  - (Optional) **Logging**: Report standard container output logs to AOM by default, without requiring manual settings. You can manually configure the log collection path. For details, see **Collecting Container Logs Using ICAgent**.

    To disable the standard output of the current workload, add the annotation **kubernetes.AOM.log.stdout: []** in **Labels and Annotations**. For details about how to use this annotation, see **Table 8-18**.

- **Image Access Credential**: Select the credential used for accessing the image repository. The default value is **default-secret**. You can use default-secret to access images in SWR. For details about **default-secret**, see **default-secret**.
- (Optional) **GPU**: **All** is selected by default. The workload instance will be scheduled to the node of the specified GPU type.

(Optional) Service Settings

A Service provides external access for pods. With a static IP address, a Service forwards access traffic to pods and automatically balances load for these pods.

You can also create a Service after creating a workload. For details about Services of different types, see **Overview**.

(Optional) Advanced Settings

- **Upgrade**: Specify the upgrade mode and parameters of the workload. **Rolling upgrade** and **Replace upgrade** are available. For details, see **Workload Upgrade Policies**.
- **Scheduling**: Configure affinity and anti-affinity policies for flexible workload scheduling. Load affinity and node affinity are provided.
  - **Load Affinity**: Common load affinity policies are offered for quick load affinity deployment.

        - **Multi-AZ deployment is preferred**: Workload pods are preferentially scheduled to nodes in different AZs through pod anti-affinity (**podAntiAffinity**). If all the nodes in the cluster are deployed in the same AZ, the pods will be scheduled to that AZ but onto different nodes for high availability. If there are fewer nodes than pods, the extra pods will fail to run.
        - **Forcible multi-AZ deployment**: Workload pods are forcibly scheduled to nodes in different AZs through pod anti-affinity (**podAntiAffinity**). If there are fewer AZs than pods, the extra pods will fail to run.
        - **Custom policies**: Affinity and anti-affinity policies can be customized as needed. For details, see **Scheduling Policies (Affinity/Anti-affinity)**.
      - **Node Affinity**: Common load affinity policies are offered for quick load affinity deployment.
        - **Node Affinity**: Workload pods can be deployed on specified nodes through node affinity (**nodeAffinity**). If no node is specified, the pods will be randomly scheduled based on the default scheduling policy of the cluster.
        - **Specified node pool scheduling**: Workload pods can be deployed in a specified node pool through node affinity (**nodeAffinity**). If no node pool is specified, the pods will be randomly scheduled based on the default scheduling policy of the cluster.
        - **Custom policies**: Affinity and anti-affinity policies can be customized as needed. For details, see **Scheduling Policies (Affinity/Anti-affinity)**.
    - **Toleration**: Using both taints and tolerations allows (not forcibly) the pod to be scheduled to a node with the matching taints, and controls the pod eviction policies after the node where the pod is located is tainted. For details, see **Taints and Tolerations**.
    - **Labels and Annotations**: Add labels or annotations for pods using key-value pairs. After entering the key and value, click **Confirm**. For details about how to use and configure labels and annotations, see **Labels and Annotations**.
    - **DNS**: Configure a separate DNS policy for the workload. For details, see **DNS Configuration**.
    - **Network Configuration**
      - Pod ingress/egress bandwidth limitation: You can set ingress/egress bandwidth limitation for pods. For details, see **Configuring QoS for a Pod**.

Step 4 Click **Create Workload** in the lower right corner.

----End

Using kubectl

The following procedure uses Nginx as an example to describe how to create a workload using kubectl.

Step 1 Use kubectl to connect to the cluster. For details, see **Connecting to a Cluster Using kubectl**.

Step 2 Create and edit the **nginx-deployment.yaml** file. **nginx-deployment.yaml** is an example file name, and you can rename it as required.

vi nginx-deployment.yaml

The following is an example YAML file. For more information about Deployments, see **Kubernetes documentation**.

```
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 you use an image in My Images, obtain the image path from SWR.
        imagePullPolicy: Always
        name: nginx
      imagePullSecrets:
      - name: default-secret
```

For details about these parameters, see **Table 8-2**.

Table 8-2 Deployment YAML parameters

Parameter	Description	Mandatory/ Optional
apiVersion	API version. **NOTE** Set this parameter based on the cluster version. • For clusters of v1.17 or later, the apiVersion format of Deployments is **apps/v1**. • For clusters of v1.15 or earlier, the apiVersion format of Deployments is **extensions/v1beta1**.	Mandatory
kind	Type of a created object.	Mandatory
metadata	Metadata of a resource object.	Mandatory
name	Name of the Deployment.	Mandatory
spec	Detailed description of the Deployment.	Mandatory

Parameter	Description	Mandatory/ Optional
replicas	Number of pods.	Mandatory
selector	Determines container pods that can be managed by the Deployment.	Mandatory
strategy	Upgrade mode. Possible values: • RollingUpdate • ReplaceUpdate By default, rolling update is used.	Optional
template	Detailed description of a created container pod.	Mandatory
metadata	Metadata.	Mandatory
labels	**metadata.labels**: Container labels.	Optional
spec: containers	• **image** (mandatory): Name of a container image. • **imagePullPolicy** (optional): Policy for obtaining an image. The options include **Always** (attempting to download images each time), **Never** (only using local images), and **IfNotPresent** (using local images if they are available; downloading images if local images are unavailable). The default value is **Always**. • **name** (mandatory): Container name.	Mandatory
imagePull Secrets	Name of the secret used during image pulling. If a private image is used, this parameter is mandatory. • To pull an image from the Software Repository for Container (SWR), set this parameter to **default-secret**. • To pull an image from a third-party image repository, set this parameter to the name of the created secret.	Optional

Step 3 Create a Deployment.

kubectl create -f nginx-deployment.yaml

If the following information is displayed, the Deployment is being created.

```
deployment "nginx" created
```

Step 4 Obtain the Deployment status.

kubectl get deployment

If the following information is displayed, the Deployment is running.

```
NAME          READY    UP-TO-DATE   AVAILABLE   AGE
nginx         1/1      1            1           4m5s
```

Parameter description

- **NAME**: Name of the application running in the pod.
- **READY**: indicates the number of available workloads. The value is displayed as "the number of available pods/the number of expected pods".
- **UP-TO-DATE**: indicates the number of replicas that have been updated.
- **AVAILABLE**: indicates the number of available pods.
- **AGE**: period the Deployment keeps running

Step 5 If the Deployment will be accessed through a ClusterIP or NodePort Service, configure the access mode. For details, see **Network**.

----End

8.2.2 Creating a StatefulSet

Scenario

StatefulSets are a type of workloads whose data or status is stored while they are running. For example, MySQL is a StatefulSet because it needs to store new data.

A container can be migrated between different hosts, but data is not stored on the hosts. To store StatefulSet data persistently, attach HA storage volumes provided by CCE to the container.

Constraints

- When you delete or scale a StatefulSet, the system does not delete the storage volumes associated with the StatefulSet to ensure data security.
- When you delete a StatefulSet, reduce the number of replicas to **0** before deleting the StatefulSet so that pods in the StatefulSet can be stopped in order.
- When you create a StatefulSet, a headless Service is required for pod access. For details, see **Headless Services**.
- When a node is unavailable, pods become **Unready**. In this case, manually delete the pods of the StatefulSet so that the pods can be migrated to a normal node.

Prerequisites

- Before creating a workload, you must have an available cluster. For details on how to create a cluster, see **Buying a CCE Standard Cluster**.
- To enable public access to a workload, ensure that an EIP or load balancer has been bound to at least one node in the cluster.

  NOTE

  If a pod has multiple containers, ensure that the ports used by the containers do not conflict with each other. Otherwise, creating the StatefulSet will fail.

Using the CCE Console

Step 1 Log in to the CCE console.

Step 2 Click the cluster name to go to the cluster console, choose **Workloads** in the navigation pane, and click the **Create Workload** in the upper right corner.

Step 3 Set basic information about the workload.

Basic Info

- **Workload Type**: Select **StatefulSet**. For details about workload types, see **Overview**.
- **Workload Name**: Enter the name of the workload. Enter 1 to 63 characters starting with a lowercase letter and ending with a lowercase letter or digit. Only lowercase letters, digits, and hyphens (-) are allowed.
- **Namespace**: Select the namespace of the workload. The default value is **default**. You can also click **Create Namespace** to create one. For details, see **Creating a Namespace**.
- **Pods**: Enter the number of pods of the workload.
- **Time Zone Synchronization**: Specify whether to enable time zone synchronization. After time zone synchronization is enabled, the container and node use the same time zone. The time zone synchronization function depends on the local disk mounted to the container. Do not modify or delete the time zone. For details, see **Configuring Time Zone Synchronization**.

Container Settings

- Container Information

  Multiple containers can be configured in a pod. You can click **Add Container** on the right to configure multiple containers for the pod.

  – **Basic Info**: Configure basic information about the container.

Parameter	Description
Container Name	Name the container.
Pull Policy	Image update or pull policy. If you select **Always**, the image is pulled from the image repository each time. If you do not select **Always**, the existing image of the node is preferentially used. If the image does not exist, the image is pulled from the image repository.
Image Name	Click **Select Image** and select the image used by the container. To use a third-party image, see **Using Third-Party Images**.
Image Tag	Select the image tag to be deployed.

Parameter	Description
CPU Quota	▪ **Request**: minimum number of CPU cores required by a container. The default value is 0.25 cores. ▪ **Limit**: maximum number of CPU cores that can be used by a container. This prevents containers from using excessive resources. If **Request** and **Limit** are not specified, the quota is not limited. For more information and suggestions about **Request** and **Limit**, see **Configuring Container Specifications**.
Memory Quota	▪ **Request**: minimum amount of memory required by a container. The default value is 512 MiB. ▪ **Limit**: maximum amount of memory available for a container. When memory usage exceeds the specified memory limit, the container will be terminated. If **Request** and **Limit** are not specified, the quota is not limited. For more information and suggestions about **Request** and **Limit**, see **Configuring Container Specifications**.
(Optional) GPU Quota	Configurable only when the cluster contains GPU nodes and the **CCE AI Suite (NVIDIA GPU)** add-on is installed. ▪ **All**: No GPU will be used. ▪ **Dedicated**: GPU resources are dedicated for the container. ▪ **Shared**: percentage of GPU resources used by the container. For example, if this parameter is set to **10%**, the container uses 10% of GPU resources. For details about how to use GPUs in the cluster, see **Default GPU Scheduling in Kubernetes**.
(Optional) NPU Quota	Number of required Ascend chips. The value must be an integer and the **CCE AI Suite (Ascend NPU)** add-on must be installed. For details about how to use NPUs in the cluster, see **NPU Scheduling**.
(Optional) Privileged Container	Programs in a privileged container have certain privileges. If **Privileged Container** is enabled, the container is assigned privileges. For example, privileged containers can manipulate network devices on the host machine and modify kernel parameters.

Parameter	Description
(Optional) Init Container	Whether to use the container as an init container. An init container does not support health check. An init container is a special container that runs before other app containers in a pod are started. Each pod can contain multiple containers. In addition, a pod can contain one or more init containers. Application containers in a pod are started and run only after the running of all init containers completes. For details, see **Init Containers**.

- (Optional) **Lifecycle**: Configure operations to be performed in a specific phase of the container lifecycle, such as Startup Command, Post-Start, and Pre-Stop. For details, see **Configuring Container Lifecycle Parameters**.
- (Optional) **Health Check**: Set the liveness probe, ready probe, and startup probe as required. For details, see **Configuring Container Health Check**.
- (Optional) **Environment Variables**: Configure variables for the container running environment using key-value pairs. These variables transfer external information to containers running in pods and can be flexibly modified after application deployment. For details, see **Configuring Environment Variables**.
- (Optional) **Data Storage**: Mount local storage or cloud storage to the container. The application scenarios and mounting modes vary with the storage type. For details, see **Storage**.

  NOTE

  - StatefulSets support dynamic attachment of EVS disks. For details, see **Dynamically Mounting an EVS Disk to a StatefulSet** and **Dynamically Mounting a Local PV to a StatefulSet**.

    Dynamic mounting is achieved by using the **volumeClaimTemplates** field and depends on the dynamic creation capability of StorageClass. A StatefulSet associates each pod with a PVC using the **volumeClaimTemplates** field, and the PVC is bound to the corresponding PV. Therefore, after the pod is rescheduled, the original data can still be mounted based on the PVC name.

  - After a workload is created, the storage that is dynamically mounted cannot be updated.
- (Optional) **Security Context**: Assign container permissions to protect the system and other containers from being affected. Enter the user ID to assign container permissions and prevent systems and other containers from being affected.
- (Optional) **Logging**: Report standard container output logs to AOM by default, without requiring manual settings. You can manually configure the log collection path. For details, see **Collecting Container Logs Using ICAgent**.

  To disable the standard output of the current workload, add the annotation **kubernetes.AOM.log.stdout: []** in **Labels and Annotations**. For details about how to use this annotation, see **Table 8-18**.

- **Image Access Credential**: Select the credential used for accessing the image repository. The default value is **default-secret**. You can use default-secret to access images in SWR. For details about **default-secret**, see **default-secret**.
- (Optional) **GPU**: **All** is selected by default. The workload instance will be scheduled to the node of the specified GPU type.

Headless Service Parameters

A headless Service is used to solve the problem of mutual access between pods in a StatefulSet. The headless Service provides a fixed access domain name for each pod. For details, see **Headless Services**.

(Optional) Service Settings

A Service provides external access for pods. With a static IP address, a Service forwards access traffic to pods and automatically balances load for these pods.

You can also create a Service after creating a workload. For details about Services of different types, see **Overview**.

(Optional) Advanced Settings

- **Upgrade**: Specify the upgrade mode and parameters of the workload. **Rolling upgrade** and **Replace upgrade** are available. For details, see **Workload Upgrade Policies**.
- **Pod Management Policies**

  For some distributed systems, the StatefulSet sequence is unnecessary and/or should not occur. These systems require only uniqueness and identifiers.

  - **OrderedReady**: The StatefulSet will deploy, delete, or scale pods in order and one by one. (The StatefulSet continues only after the previous pod is ready or deleted.) This is the default policy.
  - **Parallel**: The StatefulSet will create pods in parallel to match the desired scale without waiting, and will delete all pods at once.
- **Scheduling**: Configure affinity and anti-affinity policies for flexible workload scheduling. Load affinity and node affinity are provided.
  - **Load Affinity**: Common load affinity policies are offered for quick load affinity deployment.
    - **Multi-AZ deployment is preferred**: Workload pods are preferentially scheduled to nodes in different AZs through pod anti-affinity (**podAntiAffinity**). If all the nodes in the cluster are deployed in the same AZ, the pods will be scheduled to that AZ but onto different nodes for high availability. If there are fewer nodes than pods, the extra pods will fail to run.
    - **Forcible multi-AZ deployment**: Workload pods are forcibly scheduled to nodes in different AZs through pod anti-affinity (**podAntiAffinity**). If there are fewer AZs than pods, the extra pods will fail to run.
    - **Custom policies**: Affinity and anti-affinity policies can be customized as needed. For details, see **Scheduling Policies (Affinity/Anti-affinity)**.
  - **Node Affinity**: Common load affinity policies are offered for quick load affinity deployment.

    - **Node Affinity**: Workload pods can be deployed on specified nodes through node affinity (**nodeAffinity**). If no node is specified, the pods will be randomly scheduled based on the default scheduling policy of the cluster.
    - **Specified node pool scheduling**: Workload pods can be deployed in a specified node pool through node affinity (**nodeAffinity**). If no node pool is specified, the pods will be randomly scheduled based on the default scheduling policy of the cluster.
    - **Custom policies**: Affinity and anti-affinity policies can be customized as needed. For details, see **Scheduling Policies (Affinity/Anti-affinity)**.
- **Toleration**: Using both taints and tolerations allows (not forcibly) the pod to be scheduled to a node with the matching taints, and controls the pod eviction policies after the node where the pod is located is tainted. For details, see **Taints and Tolerations**.
- **Labels and Annotations**: Add labels or annotations for pods using key-value pairs. After entering the key and value, click **Confirm**. For details about how to use and configure labels and annotations, see **Labels and Annotations**.
- **DNS**: Configure a separate DNS policy for the workload. For details, see **DNS Configuration**.
- **Network Configuration**
  - Pod ingress/egress bandwidth limitation: You can set ingress/egress bandwidth limitation for pods. For details, see **Configuring QoS for a Pod**.

Step 4 Click **Create Workload** in the lower right corner.

----End

Using kubectl

In this example, a Nginx workload is used and the EVS volume is dynamically mounted to it using the **volumeClaimTemplates** field.

Step 1 Use kubectl to connect to the cluster. For details, see **Connecting to a Cluster Using kubectl**.

Step 2 Create and edit the **nginx-statefulset.yaml** file.

nginx-statefulset.yaml is an example file name, and you can change it as required.

vi nginx-statefulset.yaml

The following provides an example of the file contents. For more information on StatefulSet, see the **Kubernetes documentation**.

```
apiVersion: apps/v1
kind: StatefulSet
metadata:
  name: nginx
spec:
  selector:
    matchLabels:
```

```
      app: nginx
  template:
    metadata:
      labels:
        app: nginx
    spec:
      containers:
        - name: container-1
          image: nginx:latest
          imagePullPolicy: IfNotPresent
          resources:
            requests:
              cpu: 250m
              memory: 512Mi
            limits:
              cpu: 250m
              memory: 512Mi
          volumeMounts:
            - name: test
              readOnly: false
              mountPath: /usr/share/nginx/html
              subPath: ''
      imagePullSecrets:
        - name: default-secret
      dnsPolicy: ClusterFirst
      volumes: []
  serviceName: nginx-svc
  replicas: 2
  volumeClaimTemplates:  # Dynamically mounts the EVS volume to the workload.
    - apiVersion: v1
      kind: PersistentVolumeClaim
      metadata:
        name: test
        namespace: default
        annotations:
          everest.io/disk-volume-type: SAS  # SAS EVS volume type.
        labels:
          failure-domain.beta.kubernetes.io/region:   # region where the EVS volume is created.
          failure-domain.beta.kubernetes.io/zone:    # AZ where the EVS volume is created. It must be the
same as the AZ of the node.
      spec:
        accessModes:
          - ReadWriteOnce  # The value must be ReadWriteOnce for the EVS volume.
        resources:
          requests:
            storage: 10Gi
        storageClassName: csi-disk # Storage class name. The value is csi-disk for the EVS volume.
  updateStrategy:
    type: RollingUpdate
```

vi nginx-headless.yaml

```
apiVersion: v1
kind: Service
metadata:
  name: nginx-svc
  namespace: default
  labels:
    app: nginx
spec:
  selector:
    app: nginx
    version: v1
  clusterIP: None
  ports:
    - name: nginx
      targetPort: 80
      nodePort: 0
      port: 80
```

```
    protocol: TCP
  type: ClusterIP
```

Step 3 Create a workload and the corresponding headless service.

kubectl create -f nginx-statefulset.yaml

If the following information is displayed, the StatefulSet has been successfully created.

```
statefulset.apps/nginx created
```

kubectl create -f nginx-headless.yaml

If the following information is displayed, the headless service has been successfully created.

```
service/nginx-svc created
```

Step 4 If the workload will be accessed through a ClusterIP or NodePort Service, configure the access mode. For details, see **Network**.

----End

8.2.3 Creating a DaemonSet

Scenario

CCE provides deployment and management capabilities for multiple types of containers and supports features of container workloads, including creation, configuration, monitoring, scaling, upgrade, uninstall, service discovery, and load balancing.

DaemonSet ensures that only one pod runs on all or some nodes. When a node is added to a cluster, a new pod is also added for the node. When a node is removed from a cluster, the pod is also reclaimed. If a DaemonSet is deleted, all pods created by it will be deleted.

The typical application scenarios of a DaemonSet are as follows:

- Run the cluster storage daemon, such as glusterd or Ceph, on each node.
- Run the log collection daemon, such as Fluentd or Logstash, on each node.
- Run the monitoring daemon, such as Prometheus Node Exporter, collectd, Datadog agent, New Relic agent, or Ganglia (gmond), on each node.

You can deploy a DaemonSet for each type of daemons on all nodes, or deploy multiple DaemonSets for the same type of daemons. In the second case, DaemonSets have different flags and different requirements on memory and CPU for different hardware types.

Prerequisites

Before creating a DaemonSet, you must have an available cluster. For details on how to create a cluster, see **Buying a CCE Standard Cluster**.

Using the CCE Console

Step 1 Log in to the CCE console.

Step 2 Click the cluster name to go to the cluster console, choose **Workloads** in the navigation pane, and click the **Create Workload** in the upper right corner.

Step 3 Set basic information about the workload.

Basic Info

- **Workload Type**: Select **DaemonSet**. For details about workload types, see **Overview**.
- **Workload Name**: Enter the name of the workload. Enter 1 to 63 characters starting with a lowercase letter and ending with a lowercase letter or digit. Only lowercase letters, digits, and hyphens (-) are allowed.
- **Namespace**: Select the namespace of the workload. The default value is **default**. You can also click **Create Namespace** to create one. For details, see **Creating a Namespace**.
- **Time Zone Synchronization**: Specify whether to enable time zone synchronization. After time zone synchronization is enabled, the container and node use the same time zone. The time zone synchronization function depends on the local disk mounted to the container. Do not modify or delete the time zone. For details, see **Configuring Time Zone Synchronization**.

Container Settings

- Container Information

  Multiple containers can be configured in a pod. You can click **Add Container** on the right to configure multiple containers for the pod.

  – **Basic Info**: Configure basic information about the container.

Parameter	Description
Container Name	Name the container.
Pull Policy	Image update or pull policy. If you select **Always**, the image is pulled from the image repository each time. If you do not select **Always**, the existing image of the node is preferentially used. If the image does not exist, the image is pulled from the image repository.
Image Name	Click **Select Image** and select the image used by the container. To use a third-party image, see **Using Third-Party Images**.
Image Tag	Select the image tag to be deployed.

Parameter	Description
CPU Quota	▪ **Request**: minimum number of CPU cores required by a container. The default value is 0.25 cores. ▪ **Limit**: maximum number of CPU cores that can be used by a container. This prevents containers from using excessive resources. If **Request** and **Limit** are not specified, the quota is not limited. For more information and suggestions about **Request** and **Limit**, see **Configuring Container Specifications**.
Memory Quota	▪ **Request**: minimum amount of memory required by a container. The default value is 512 MiB. ▪ **Limit**: maximum amount of memory available for a container. When memory usage exceeds the specified memory limit, the container will be terminated. If **Request** and **Limit** are not specified, the quota is not limited. For more information and suggestions about **Request** and **Limit**, see **Configuring Container Specifications**.
(Optional) GPU Quota	Configurable only when the cluster contains GPU nodes and the **CCE AI Suite (NVIDIA GPU)** add-on is installed. ▪ **All**: No GPU will be used. ▪ **Dedicated**: GPU resources are dedicated for the container. ▪ **Shared**: percentage of GPU resources used by the container. For example, if this parameter is set to **10%**, the container uses 10% of GPU resources. For details about how to use GPUs in the cluster, see **Default GPU Scheduling in Kubernetes**.
(Optional) NPU Quota	Number of required Ascend chips. The value must be an integer and the **CCE AI Suite (Ascend NPU)** add-on must be installed. For details about how to use NPUs in the cluster, see **NPU Scheduling**.
(Optional) Privileged Container	Programs in a privileged container have certain privileges. If **Privileged Container** is enabled, the container is assigned privileges. For example, privileged containers can manipulate network devices on the host machine and modify kernel parameters.

Parameter	Description
(Optional) Init Container	Whether to use the container as an init container. An init container does not support health check. An init container is a special container that runs before other app containers in a pod are started. Each pod can contain multiple containers. In addition, a pod can contain one or more init containers. Application containers in a pod are started and run only after the running of all init containers completes. For details, see **Init Containers**.

  - (Optional) **Lifecycle**: Configure operations to be performed in a specific phase of the container lifecycle, such as Startup Command, Post-Start, and Pre-Stop. For details, see **Configuring Container Lifecycle Parameters**.
  - (Optional) **Health Check**: Set the liveness probe, ready probe, and startup probe as required. For details, see **Configuring Container Health Check**.
  - (Optional) **Environment Variables**: Configure variables for the container running environment using key-value pairs. These variables transfer external information to containers running in pods and can be flexibly modified after application deployment. For details, see **Configuring Environment Variables**.
  - (Optional) **Data Storage**: Mount local storage or cloud storage to the container. The application scenarios and mounting modes vary with the storage type. For details, see **Storage**.
  - (Optional) **Security Context**: Assign container permissions to protect the system and other containers from being affected. Enter the user ID to assign container permissions and prevent systems and other containers from being affected.
  - (Optional) **Logging**: Report standard container output logs to AOM by default, without requiring manual settings. You can manually configure the log collection path. For details, see **Collecting Container Logs Using ICAgent**.

    To disable the standard output of the current workload, add the annotation **kubernetes.AOM.log.stdout: []** in **Labels and Annotations**. For details about how to use this annotation, see **Table 8-18**.

- **Image Access Credential**: Select the credential used for accessing the image repository. The default value is **default-secret**. You can use default-secret to access images in SWR. For details about **default-secret**, see **default-secret**.
- (Optional) **GPU**: **All** is selected by default. The workload instance will be scheduled to the node of the specified GPU type.

(Optional) Service Settings

A Service provides external access for pods. With a static IP address, a Service forwards access traffic to pods and automatically balances load for these pods.

You can also create a Service after creating a workload. For details about Services of different types, see **Overview**.

(Optional) Advanced Settings

- **Upgrade**: Specify the upgrade mode and parameters of the workload. **Rolling upgrade** and **Replace upgrade** are available. For details, see **Workload Upgrade Policies**.
- **Scheduling**: Configure affinity and anti-affinity policies for flexible workload scheduling. Node affinity is provided.
  - **Node Affinity**: Common load affinity policies are offered for quick load affinity deployment.
    - **Specified node scheduling**: Workload pods can be deployed on specified nodes through node affinity (**nodeAffinity**). If no node is specified, the pods will be randomly scheduled based on the default scheduling policy of the cluster.
    - **Specified node pool scheduling**: Workload pods can be deployed in a specified node pool through node affinity (**nodeAffinity**). If no node pool is specified, the pods will be randomly scheduled based on the default scheduling policy of the cluster.
    - **Custom policies**: Affinity and anti-affinity policies can be customized as needed. For details, see **Scheduling Policies (Affinity/Anti-affinity)**.
- **Toleration**: Using both taints and tolerations allows (not forcibly) the pod to be scheduled to a node with the matching taints, and controls the pod eviction policies after the node where the pod is located is tainted. For details, see **Taints and Tolerations**.
- **Labels and Annotations**: Add labels or annotations for pods using key-value pairs. After entering the key and value, click **Confirm**. For details about how to use and configure labels and annotations, see **Labels and Annotations**.
- **DNS**: Configure a separate DNS policy for the workload. For details, see **DNS Configuration**.
- **Network Configuration**
  - Pod ingress/egress bandwidth limitation: You can set ingress/egress bandwidth limitation for pods. For details, see **Configuring QoS for a Pod**.

Step 4 Click **Create Workload** in the lower right corner.

----End

Using kubectl

The following procedure uses Nginx as an example to describe how to create a workload using kubectl.

Step 1 Use kubectl to connect to the cluster. For details, see **Connecting to a Cluster Using kubectl**.

Step 2 Create and edit the **nginx-daemonset.yaml** file. **nginx-daemonset.yaml** is an example file name, and you can change it as required.

vi nginx-daemonset.yaml

The content of the description file is as follows: The following provides an example. For more information on DaemonSets, see **Kubernetes documents**.

```
apiVersion: apps/v1
kind: DaemonSet
metadata:
  name: nginx-daemonset
  labels:
    app: nginx-daemonset
spec:
  selector:
    matchLabels:
      app: nginx-daemonset
  template:
    metadata:
      labels:
        app: nginx-daemonset
    spec:
      nodeSelector:                # Node selection. A pod is created on a node only when the node meets daemon=need.
        daemon: need
      containers:
      - name: nginx-daemonset
        image: nginx:alpine
        resources:
          limits:
            cpu: 250m
            memory: 512Mi
          requests:
            cpu: 250m
            memory: 512Mi
      imagePullSecrets:
      - name: default-secret
```

The **replicas** parameter used in defining a Deployment or StatefulSet does not exist in the above configuration for a DaemonSet, because each node has only one replica. It is fixed.

The nodeSelector in the preceding pod template specifies that a pod is created only on the nodes that meet **daemon=need**. If you want to create a pod on each node, delete the label.

Step 3 Create a DaemonSet.

kubectl create -f nginx-daemonset.yaml

If the following information is displayed, the DaemonSet is being created.

```
daemonset.apps/nginx-daemonset created
```

Step 4 Obtain the DaemonSet status.

kubectl get ds

```
$ kubectl get ds
NAME              DESIRED   CURRENT   READY   UP-TO-DATE   AVAILABLE   NODE SELECTOR   AGE
nginx-daemonset   1         1         0       1            0           daemon=need     116s
```

Step 5 If the workload will be accessed through a ClusterIP or NodePort Service, configure the access mode. For details, see **Network**.

----End

8.2.4 Creating a Job

Scenario

Jobs are short-lived and run for a certain time to completion. They can be executed immediately after being deployed. It is completed after it exits normally (exit 0).

A job is a resource object that is used to control batch tasks. It is different from a long-term servo workload (such as Deployment and StatefulSet).

A job is started and terminated at specific times, while a long-term servo workload runs unceasingly unless being terminated. The pods managed by a job automatically exit after successfully completing the job based on user configurations. The success flag varies according to the spec.completions policy.

- One-off jobs: A single pod runs once until successful termination.
- Jobs with a fixed success count: N pods run until successful termination.
- A queue job is considered completed based on the global success confirmed by the application.

Prerequisites

Resources have been created. For details, see **Creating a Node**. If clusters and nodes are available, you need not create them again.

Using the CCE Console

Step 1 Log in to the CCE console.

Step 2 Click the cluster name to go to the cluster console, choose **Workloads** in the navigation pane, and click the **Create Workload** in the upper right corner.

Step 3 Set basic information about the workload.

Basic Info

- **Workload Type**: Select **Job**. For details about workload types, see **Overview**.
- **Workload Name**: Enter the name of the workload. Enter 1 to 63 characters starting with a lowercase letter and ending with a lowercase letter or digit. Only lowercase letters, digits, and hyphens (-) are allowed.
- **Namespace**: Select the namespace of the workload. The default value is **default**. You can also click **Create Namespace** to create one. For details, see **Creating a Namespace**.
- **Pods**: Enter the number of pods of the workload.

Container Settings

- Container Information

  Multiple containers can be configured in a pod. You can click **Add Container** on the right to configure multiple containers for the pod.

  – **Basic Info**: Configure basic information about the container.

Parameter	Description
Container Name	Name the container.
Pull Policy	Image update or pull policy. If you select **Always**, the image is pulled from the image repository each time. If you do not select **Always**, the existing image of the node is preferentially used. If the image does not exist, the image is pulled from the image repository.
Image Name	Click **Select Image** and select the image used by the container. To use a third-party image, see **Using Third-Party Images**.
Image Tag	Select the image tag to be deployed.
CPU Quota	▪ **Request**: minimum number of CPU cores required by a container. The default value is 0.25 cores. ▪ **Limit**: maximum number of CPU cores that can be used by a container. This prevents containers from using excessive resources. If **Request** and **Limit** are not specified, the quota is not limited. For more information and suggestions about **Request** and **Limit**, see **Configuring Container Specifications**.
Memory Quota	▪ **Request**: minimum amount of memory required by a container. The default value is 512 MiB. ▪ **Limit**: maximum amount of memory available for a container. When memory usage exceeds the specified memory limit, the container will be terminated. If **Request** and **Limit** are not specified, the quota is not limited. For more information and suggestions about **Request** and **Limit**, see **Configuring Container Specifications**.

Parameter	Description
(Optional) GPU Quota	Configurable only when the cluster contains GPU nodes and the **CCE AI Suite (NVIDIA GPU)** add-on is installed. ■ **All**: No GPU will be used. ■ **Dedicated**: GPU resources are dedicated for the container. ■ **Shared**: percentage of GPU resources used by the container. For example, if this parameter is set to **10%**, the container uses 10% of GPU resources. For details about how to use GPUs in the cluster, see **Default GPU Scheduling in Kubernetes**.
(Optional) NPU Quota	Number of required Ascend chips. The value must be an integer and the **CCE AI Suite (Ascend NPU)** add-on must be installed. For details about how to use NPUs in the cluster, see **NPU Scheduling**.
(Optional) Privileged Container	Programs in a privileged container have certain privileges. If **Privileged Container** is enabled, the container is assigned privileges. For example, privileged containers can manipulate network devices on the host machine and modify kernel parameters.
(Optional) Init Container	Whether to use the container as an init container. An init container does not support health check. An init container is a special container that runs before other app containers in a pod are started. Each pod can contain multiple containers. In addition, a pod can contain one or more init containers. Application containers in a pod are started and run only after the running of all init containers completes. For details, see **Init Containers**.

- (Optional) **Lifecycle**: Configure operations to be performed in a specific phase of the container lifecycle, such as Startup Command, Post-Start, and Pre-Stop. For details, see **Configuring Container Lifecycle Parameters**.
- (Optional) **Environment Variables**: Configure variables for the container running environment using key-value pairs. These variables transfer external information to containers running in pods and can be flexibly modified after application deployment. For details, see **Configuring Environment Variables**.
- (Optional) **Data Storage**: Mount local storage or cloud storage to the container. The application scenarios and mounting modes vary with the storage type. For details, see **Storage**.

NOTE

If the workload contains more than one pod, EVS volumes cannot be mounted.

  - (Optional) **Logging**: Report standard container output logs to AOM by default, without requiring manual settings. You can manually configure the log collection path. For details, see **Collecting Container Logs Using ICAgent**.

    To disable the standard output of the current workload, add the annotation **kubernetes.AOM.log.stdout: []** in **Labels and Annotations**. For details about how to use this annotation, see **Table 8-18**.

- **Image Access Credential**: Select the credential used for accessing the image repository. The default value is **default-secret**. You can use default-secret to access images in SWR. For details about **default-secret**, see **default-secret**.
- (Optional) **GPU**: **All** is selected by default. The workload instance will be scheduled to the node of the specified GPU type.

(Optional) Advanced Settings

- **Labels and Annotations**: Add labels or annotations for pods using key-value pairs. After entering the key and value, click **Confirm**. For details about how to use and configure labels and annotations, see **Labels and Annotations**.
- **Job Settings**
  - **Parallel Pods**: Maximum number of pods that can run in parallel during job execution. The value cannot be greater than the total number of pods in the job.
  - **Timeout (s)**: Once a job reaches this time, the job status becomes failed and all pods in this job will be deleted. If you leave this parameter blank, the job will never time out.
  - Completion Mode
    - **Non-indexed**: A job is considered complete when all the pods are successfully executed. Each pod completion is homologous to each other.
    - **Indexed**: Each pod gets an associated completion index from 0 to the number of pods minus 1. The job is considered complete when every pod allocated with an index is successfully executed. For an indexed job, pods are named in the format of $(job-name)-$(index).
  - **Suspend Job**: By default, a job is executed immediately after being created. The job's execution will be suspended if you enable this option, and resumed after you disable it.
- **Network Configuration**
  - Pod ingress/egress bandwidth limitation: You can set ingress/egress bandwidth limitation for pods. For details, see **Configuring QoS for a Pod**.

Step 4 Click **Create Workload** in the lower right corner.

----End

Using kubectl

A job has the following configuration parameters:

- **.spec.completions**: indicates the number of pods that need to run successfully to end a job. The default value is **1**.
- **.spec.parallelism**: indicates the number of pods that run concurrently. The default value is **1**.
- **.spec.backoffLimit**: indicates the maximum number of retries performed if a pod fails. When the limit is reached, the pod will not try again.
- **.spec.activeDeadlineSeconds**: indicates the running time of pods. Once the time is reached, all pods of the job are terminated. The priority of .spec.activeDeadlineSeconds is higher than that of .spec.backoffLimit. That is, if a job reaches the .spec.activeDeadlineSeconds, the spec.backoffLimit is ignored.

Based on the **.spec.completions** and **.spec.parallelism** settings, jobs are classified into the following types.

Table 8-3 Job types

Job Type	Description	.spec.completions	.spec.parallelism
One-off jobs	A job creates one pod until it successfully completes.	1	1
Jobs with a fixed completion count	A job creates one pod in sequence and is complete when the number of successful pods reaches the value of **.spec.completions**.	>1	1
Parallel jobs with a fixed completion count	A job creates multiple pods in sequence and is complete when the number of successful pods reaches the value of **.spec.completions**.	>1	>1
Parallel jobs with a work queue	A job creates one or more pods. Each pod takes one task from the message queue, processes it, and repeats until the end of the queue is reached. Then the pod deletes the task and exists. For details, see **Fine Parallel Processing Using a Work Queue**.	Leave this parameter blank.	>1 or =1

The following is an example job, which calculates π till the 2000th digit and prints the output.

```
apiVersion: batch/v1
kind: Job
metadata:
  name: myjob
spec:
  completions: 50       # A total of 50 pods need to run to finish a job. In this example, π is printed for 50
```

```
times.
  parallelism: 5        # A total of 5 pods run in parallel.
  backoffLimit: 5       # A maximum of 5 retries is allowed.
  template:
    spec:
      containers:
      - name: pi
        image: perl
        command: ["perl",  "-Mbignum=bpi", "-wle", "print bpi(2000)"]
      restartPolicy: Never     # For a job, set this parameter to Never or OnFailure. For other controllers (such as Deployments), set this parameter to Always.
      imagePullSecrets:
        - name: default-secret
```

Run the job.

Step 1 Start the job.

```
[root@k8s-master k8s]# kubectl apply -f myjob.yaml
job.batch/myjob created
```

Step 2 View the job details.

kubectl get job

```
[root@k8s-master k8s]# kubectl get job
NAME    COMPLETIONS   DURATION   AGE
myjob   50/50         23s        3m45s
```

If the value of **COMPLETIONS** is **50/50**, the job is successfully executed.

Step 3 View the pod status.

kubectl get pod

```
[root@k8s-master k8s]# kubectl get pod
NAME          READY   STATUS      RESTARTS   AGE
myjob-29qlw   0/1     Completed   0          4m5s
...
```

If the status is **Completed**, the job is complete.

Step 4 View the pod logs.

kubectl logs <pod_name>

```
# kubectl logs myjob-29qlw
3.14159265358979323846264338327950288419716939937510582097494459230781640628620899862803482534211706798214808651328230664709384460955058223172535940812848111745028410270193852110555964462294895493038196442881097566593344612847564823378678316527120190914564856692346034861045432664821339360726024914127372458700660631558817488152092096282925409171536436789259036001133053054882046652138414695194151160943305727036575959195309218611738193261179310511854807446237996274956735188575272489122793818301194912983367336244065664308602139494639522473719070217986094370277053921717629317675238467481846766940513200056812714526356082778577134275778960917363717872146844090122495343014654958537105079227968925892354201995611212902196086403441815981362977477130996051870721134999999837297804995105973173281609631859502445945534690830264252230825334468503526193118817101000313783875288658753320838142061717766914730359825349042875546873115956286388235378759375195778185778053217122680661300192787661119590921642019893809525720106548586327886593615338182796823030195203530185296899577362259941389124972177528347913151557485724245415069595082953311686172785588907509838175463746493931925506040092770167113900984882401285836160356370766010471018194295559619894676783744944825537977472684710404753464620804668425906949129331367702898915210475216205696602405803815019351125338243003558764024749647326391419927260426992279678235478163600934172164121992458631503028618297455570674983850549458858692699569092721079750930295532116534498720275596023648066549911988183479775356636980742654252786255181841757467289097777279380008164706001614524919217321721477235014144197356854816136115735255213347574184946843852332390739414333454776241686251898356948556209921922218427255025425688767179049460165346680498862723279178608578438382796797668145410095388378636095068006422512520
```

```
5117392984896084128488626945604241965285022210661186306744278622039194945047123713786960
9563643719172874677646575739624138908658326459958133904780275901
```

----End

Related Operations

After a one-off job is created, you can perform operations listed in **Table 8-4**.

Table 8-4 Other operations

Operation	Description
Editing a YAML file	Click **More** > **Edit YAML** next to the job name to edit the YAML file corresponding to the current job.
Deleting a job	1. Select the target job and choose **More** > **Delete** in the **Operation** column. 2. Click **Yes**. Deleted jobs cannot be restored. Exercise caution when deleting a job.

8.2.5 Creating a Cron Job

Scenario

A cron job runs on a repeating schedule. You can perform time synchronization for all active nodes at a fixed time point.

A cron job runs periodically at the specified time. It is similar with Linux crontab. A cron job has the following characteristics:

- Runs only once at the specified time.
- Runs periodically at the specified time.

The typical usage of a cron job is as follows:

- Schedules jobs at the specified time.
- Creates jobs to run periodically, for example, database backup and email sending.

Prerequisites

Resources have been created. For details, see **Creating a Node**.

Using the CCE Console

Step 1 Log in to the CCE console.

Step 2 Click the cluster name to go to the cluster console, choose **Workloads** in the navigation pane, and click the **Create Workload** in the upper right corner.

Step 3 Set basic information about the workload.

Basic Info

- **Workload Type**: Select **Cron Job**. For details about workload types, see **Overview**.
- **Workload Name**: Enter the name of the workload. Enter 1 to 63 characters starting with a lowercase letter and ending with a lowercase letter or digit. Only lowercase letters, digits, and hyphens (-) are allowed.
- **Namespace**: Select the namespace of the workload. The default value is **default**. You can also click **Create Namespace** to create one. For details, see **Creating a Namespace**.

Container Settings

- Container Information

  Multiple containers can be configured in a pod. You can click **Add Container** on the right to configure multiple containers for the pod.

  – **Basic Info**: Configure basic information about the container.

Parameter	Description
Container Name	Name the container.
Pull Policy	Image update or pull policy. If you select **Always**, the image is pulled from the image repository each time. If you do not select **Always**, the existing image of the node is preferentially used. If the image does not exist, the image is pulled from the image repository.
Image Name	Click **Select Image** and select the image used by the container. To use a third-party image, see **Using Third-Party Images**.
Image Tag	Select the image tag to be deployed.
CPU Quota	▪ **Request**: minimum number of CPU cores required by a container. The default value is 0.25 cores. ▪ **Limit**: maximum number of CPU cores that can be used by a container. This prevents containers from using excessive resources. If **Request** and **Limit** are not specified, the quota is not limited. For more information and suggestions about **Request** and **Limit**, see **Configuring Container Specifications**.

Parameter	Description
Memory Quota	▪ **Request**: minimum amount of memory required by a container. The default value is 512 MiB. ▪ **Limit**: maximum amount of memory available for a container. When memory usage exceeds the specified memory limit, the container will be terminated. If **Request** and **Limit** are not specified, the quota is not limited. For more information and suggestions about **Request** and **Limit**, see **Configuring Container Specifications**.
(Optional) GPU Quota	Configurable only when the cluster contains GPU nodes and the **CCE AI Suite (NVIDIA GPU)** add-on is installed. ▪ **All**: No GPU will be used. ▪ **Dedicated**: GPU resources are dedicated for the container. ▪ **Shared**: percentage of GPU resources used by the container. For example, if this parameter is set to **10%**, the container uses 10% of GPU resources. For details about how to use GPUs in the cluster, see **Default GPU Scheduling in Kubernetes**.
(Optional) NPU Quota	Number of required Ascend chips. The value must be an integer and the **CCE AI Suite (Ascend NPU)** add-on must be installed. For details about how to use NPUs in the cluster, see **NPU Scheduling**.
(Optional) Privileged Container	Programs in a privileged container have certain privileges. If **Privileged Container** is enabled, the container is assigned privileges. For example, privileged containers can manipulate network devices on the host machine and modify kernel parameters.
(Optional) Init Container	Whether to use the container as an init container. An init container does not support health check. An init container is a special container that runs before other app containers in a pod are started. Each pod can contain multiple containers. In addition, a pod can contain one or more init containers. Application containers in a pod are started and run only after the running of all init containers completes. For details, see **Init Containers**.

  - (Optional) **Lifecycle**: Configure operations to be performed in a specific phase of the container lifecycle, such as Startup Command, Post-Start, and Pre-Stop. For details, see **Configuring Container Lifecycle Parameters**.
  - (Optional) **Environment Variables**: Configure variables for the container running environment using key-value pairs. These variables transfer external information to containers running in pods and can be flexibly modified after application deployment. For details, see **Configuring Environment Variables**.
- **Image Access Credential**: Select the credential used for accessing the image repository. The default value is **default-secret**. You can use default-secret to access images in SWR. For details about **default-secret**, see **default-secret**.
- (Optional) **GPU**: **All** is selected by default. The workload instance will be scheduled to the node of the specified GPU type.

Schedule

- **Concurrency Policy**: The following three modes are supported:
  - **Forbid**: A new job cannot be created before the previous job is completed.
  - **Allow**: The cron job allows concurrently running jobs, which preempt cluster resources.
  - **Replace**: A new job replaces the previous job when it is time to create a job but the previous job is not completed.
- **Policy Settings**: specifies when a new cron job is executed. Policy settings in YAML are implemented using cron expressions.
  - A cron job is executed at a fixed interval. The unit can be minute, hour, day, or month. For example, if a cron job is executed every 30 minutes and the corresponding cron expression is ***/30 * * * ***, the execution time starts from 0 in the unit range, for example, **00:00:00**, **00:30:00**, **01:00:00**, and **...**.
  - The cron job is executed at a fixed time (by month). For example, if a cron job is executed at 00:00 on the first day of each month, the cron expression is **0 0 1 */1 ***, and the execution time is ******-01-01 00:00:00**, ******-02-01 00:00:00**, and **...**.
  - The cron job is executed by week. For example, if a cron job is executed at 00:00 every Monday, the cron expression is **0 0 * * 1**, and the execution time is ******-**-01 00:00:00 on Monday**, ******-**-08 00:00:00 on Monday**, and **...**.
  - **Custom Cron Expression**: For details about how to use cron expressions, see **CronJob**.

NOTE

- If a cron job is executed at a fixed time (by month) and the number of days in a month does not exist, the cron job will not be executed in this month. For example, the execution will skip February if the date is set to 30.
- Due to the definition of cron, the fixed period is not a strict period. The time unit range is divided from 0 by period. For example, if the unit is minute, the value ranges from 0 to 59. If the value cannot be exactly divided, the last period is reset. Therefore, an accurate period can be represented only when the period can be evenly divided.

  Take a cron job that is executed by hour as an example. As **/2, /3, /4, /6, /8, and /12** can exactly divide 24 hours, an accurate period can be represented. If another period is used, the last period will be reset at the beginning of a new day. For example, if the cron expression is *** */12 * * ***, the execution time is **00:00:00** and **12:00:00** every day. If the cron expression is *** */13 * * ***, the execution time is **00:00:00** and **13:00:00** every day. At 00:00 on the next day, the execution time is updated even if the period does not reach 13 hours.

- **Job Records**: You can set the number of jobs that are successfully executed or fail to be executed. Setting a limit to **0** corresponds to keeping none of the jobs after they finish.

(Optional) Advanced Settings

- **Labels and Annotations**: Add labels or annotations for pods using key-value pairs. After entering the key and value, click **Confirm**. For details about how to use and configure labels and annotations, see **Labels and Annotations**.
- **Network Configuration**
  - Pod ingress/egress bandwidth limitation: You can set ingress/egress bandwidth limitation for pods. For details, see **Configuring QoS for a Pod**.

Step 4 Click **Create Workload** in the lower right corner.

----End

Using kubectl

A cron job has the following configuration parameters:

- **.spec.schedule**: takes a **Cron** format string, for example, **0 * * * *** or **@hourly**, as schedule time of jobs to be created and executed.
- **.spec.jobTemplate**: specifies jobs to be run, and has the same schema as when you are **Creating a Job Using kubectl**.
- **.spec.startingDeadlineSeconds**: specifies the deadline for starting a job.
- **.spec.concurrencyPolicy**: specifies how to treat concurrent executions of a job created by the Cron job. The following options are supported:
  - **Allow** (default value): allows concurrently running jobs.
  - **Forbid**: forbids concurrent runs, skipping next run if previous has not finished yet.
  - **Replace**: cancels the currently running job and replaces it with a new one.

The following is an example cron job, which is saved in the **cronjob.yaml** file.

NOTE

In clusters of v1.21 or later, CronJob apiVersion is **batch/v1**.

In clusters earlier than v1.21, CronJob apiVersion is **batch/v1beta1**.

```
apiVersion: batch/v1
kind: CronJob
metadata:
  name: hello
spec:
  schedule: "*/1 * * * *"
  jobTemplate:
    spec:
      template:
        spec:
          containers:
          - name: hello
            image: busybox
            command:
            - /bin/sh
            - -c
            - date; echo Hello from the Kubernetes cluster
          restartPolicy: OnFailure
          imagePullSecrets:
            - name: default-secret
```

Run the job.

Step 1 Create a cron job.

kubectl create -f cronjob.yaml

Information similar to the following is displayed:

```
cronjob.batch/hello created
```

Step 2 Query the running status of the cron job:

kubectl get cronjob

```
NAME      SCHEDULE      SUSPEND   ACTIVE    LAST SCHEDULE   AGE
hello     */1 * * * *   False     0         <none>          9s
```

kubectl get jobs

```
NAME               COMPLETIONS   DURATION   AGE
hello-1597387980   1/1           27s        45s
```

kubectl get pod

```
NAME                           READY     STATUS      RESTARTS   AGE
hello-1597387980-tjv8f         0/1       Completed   0          114s
hello-1597388040-lckg9         0/1       Completed   0          39s
```

kubectl logs hello-1597387980-tjv8f

```
Fri Aug 14 06:56:31 UTC 2020
Hello from the Kubernetes cluster
```

kubectl delete cronjob hello

```
cronjob.batch "hello" deleted
```

NOTICE

When a CronJob is deleted, the related jobs and pods are deleted accordingly.

----End

Related Operations

After a CronJob is created, you can perform operations listed in **Table 8-5**.

Table 8-5 Other operations

Operation	Description
Editing a YAML file	Click **More** > **Edit YAML** next to the cron job name to edit the YAML file of the current job.
Stopping a CronJob	1. Select the job to be stopped and click **Stop** in the **Operation** column. 2. Click **Yes**.
Deleting a CronJob	1. Select the CronJob to be deleted and click **More** > **Delete** in the **Operation** column. 2. Click **Yes**. Deleted jobs cannot be restored. Therefore, exercise caution when deleting a job.

8.3 Configuring a Container

8.3.1 Configuring Time Zone Synchronization

When creating a workload, you can configure containers to use the same time zone as the node. You can enable time zone synchronization when creating a workload.

The time zone synchronization function depends on the local disk (hostPath) mounted to the container. After time zone synchronization is enabled, **/etc/localtime** of the node is mounted to **/etc/localtime** of the container in HostPath mode, in this way, the node and container use the same time zone configuration file.

```
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
```

8.3.2 Configuring an Image Pull Policy

When a workload is created, the container image is pulled from the image repository to the node. The image is also pulled when the workload is restarted or upgraded.

By default, **imagePullPolicy** is set to **IfNotPresent**, indicating that if the image exists on the node, the existing image is used. If the image does not exist on the node, the image is pulled from the image repository.

The image pull policy can also be set to **Always**, indicating that the image is pulled from the image repository and overwrites the image on the node regardless of whether the image exists on the node.

```
apiVersion: v1
kind: Pod
metadata:
  name: nginx
spec:
  containers:
  - image: nginx:alpine
    name: container-0
    resources:
      limits:
        cpu: 100m
        memory: 200Mi
      requests:
        cpu: 100m
        memory: 200Mi
    imagePullPolicy: Always
  imagePullSecrets:
  - name: default-secret
```

An image pull policy can also be configured on the CCE console. When creating a workload, configure **Pull Policy**. If **Always** is selected, images are always pulled. If **Always** is not selected, images are pulled as needed.

NOTICE

Use a new tag each time you create an image. If you do not update the tag but only update the image, when **Pull Policy** is set to **IfNotPresent**, CCE considers that an image with the tag already exists on the current node and will not pull the image again.

8.3.3 Using Third-Party Images

Scenario

CCE allows you to create workloads using images pulled from third-party image repositories.

Generally, a third-party image repository can be accessed only after authentication (using your account and password). CCE uses the secret-based authentication to pull images. Therefore, create a secret for an image repository before pulling images from the repository.

Prerequisites

The node where the workload is running is accessible from public networks.

Using the Console

Step 1 Create a secret for accessing a third-party image repository.

Click the cluster name to access the cluster console. In the navigation pane, choose **ConfigMaps and Secrets**. On the **Secrets** tab page, click **Create Secret** in the upper right corner. Set **Secret Type** to **kubernetes.io/dockerconfigjson**. For details, see **Creating a Secret**.

Enter the username and password used to access the third-party image repository.

Step 2 When creating a workload, enter a private image path in the format of *domainname/namespace/imagename:tag* in **Image Name** and select the key created in **Step 1**.

Step 3 Set other parameters and click **Create Workload**.

----End

Using kubectl

Step 1 Use kubectl to connect to the cluster. For details, see **Connecting to a Cluster Using kubectl**.

Step 2 Use kubectl to create a secret of the kubernetes.io/dockerconfigjson.

```
kubectl create secret docker-registry myregistrykey  -n default --docker-server=DOCKER_REGISTRY_SERVER --docker-username=DOCKER_USER --docker-password=DOCKER_PASSWORD --docker-email=DOCKER_EMAIL
```

In the preceding command, *myregistrykey* indicates the key name, *default* indicates the namespace where the key is located, and other parameters are as follows:

- **DOCKER_REGISTRY_SERVER**: address of a third-party image repository, for example, **www.3rdregistry.com** or **10.10.10.10:443**
- **DOCKER_USER**: account used for logging in to a third-party image repository
- **DOCKER_PASSWORD**: password used for logging in to a third-party image repository
- **DOCKER_EMAIL**: email of a third-party image repository

Step 3 Use a third-party image to create a workload.

A kubernetes.io/dockerconfigjson secret is used for authentication when you obtain a private image. The following is an example of using the myregistrykey for authentication.

```
apiVersion: v1
kind: Pod
metadata:
  name: foo
  namespace: default
spec:
  containers:
    - name: foo
      image: www.3rdregistry.com/janedoe/awesomeapp:v1
  imagePullSecrets:
    - name: myregistrykey              # Use the created secret.
```

----End

8.3.4 Configuring Container Specifications

Scenario

CCE allows you to set resource requirements and limits, such as CPU and RAM, for added containers during workload creation. Kubernetes also allows using YAML to set requirements of other resource types.

Request and Limit

For **CPU** and **Memory**, the meanings of **Request** and **Limit** are as follows:

- **Request**: The system schedules a pod to the node that meets the requirements for workload deployment based on the request value.
- **Limit**: The system limits the resources used by the workload based on the limit value.

If a node has sufficient resources, the pod on this node can use more resources than requested, but no more than limited.

For example, if you set the memory request of a container to 1 GiB and the limit value to 2 GiB, a pod is scheduled to a node with 8 GiB CPUs with no other pod running. In this case, the pod can use more than 1 GiB memory when the load is heavy, but the memory usage cannot exceed 2 GiB. If a process in a container attempts to use more than 2 GiB resources, the system kernel attempts to terminate the process. As a result, an out of memory (OOM) error occurs.

NOTE

When creating a workload, you are advised to set the upper and lower limits of CPU and memory resources. If the upper and lower resource limits are not set for a workload, a resource leak of this workload will make resources unavailable for other workloads deployed on the same node. In addition, workloads that do not have upper and lower resource limits cannot be accurately monitored.

Configuration Description

In real-world scenarios, the recommended ratio of **Request** to **Limit** is about 1:1.5. For some sensitive services, the recommended ratio is 1:1. If the **Request** is too

small and the **Limit** is too large, node resources are oversubscribed. During service peaks, the memory or CPU of a node may be used up. As a result, the node is unavailable.

- CPU quota: The unit of CPU resources is core, which can be expressed by quantity or an integer suffixed with the unit (m). For example, 0.1 core in the quantity expression is equivalent to 100m in the expression. However, Kubernetes does not allow CPU resources whose precision is less than 1m.

  Table 8-6 CPU quotas

Parameter	Description
CPU request	Minimum number of CPU cores required by a container. Resources are scheduled for the container based on this value. The container can be scheduled to this node only when the total available CPU on the node is greater than or equal to the number of containerized CPU applications.
CPU limit	Maximum number of CPU cores available for a container.

  Recommended configuration

  Actual available CPU of a node ≥ Sum of CPU limits of all containers on the current node ≥ Sum of CPU requests of all containers on the current node. You can view the actual available CPUs of a node on the CCE console (**Resource Management** > **Nodes** > **Allocatable**).

- Memory quota: The default unit of memory resources is byte. You can also use an integer with the unit suffix, for example, 100 Mi. Note that the unit is case-sensitive.

  Table 8-7 Description of memory quotas

Parameter	Description
Memory request	Minimum amount of memory required by a container. Resources are scheduled for the container based on this value. The container can be scheduled to this node only when the total available memory on the node is greater than or equal to the number of containerized memory applications.
Memory Limit	Maximum amount of memory available for a container. When the memory usage exceeds the configured memory limit, the instance may be restarted, which affects the normal use of the workload.

  Recommended configuration

  Actual available memory of a node ≥ Sum of memory limits of all containers on the current node ≥ Sum of memory requests of all containers on the current node. You can view the actual available memory of a node on the CCE console (**Resource Management** > **Nodes** > **Allocatable**).

NOTE

The allocatable resources are calculated based on the resource request value (**Request**), which indicates the upper limit of resources that can be requested by pods on this node, but does not indicate the actual available resources of the node (for details, see **Example of CPU and Memory Quota Usage**). The calculation formula is as follows:

- Allocatable CPU = Total CPU – Requested CPU of all pods – Reserved CPU for other resources
- Allocatable memory = Total memory – Requested memory of all pods – Reserved memory for other resources

Example of CPU and Memory Quota Usage

Assume that a cluster contains a node with 4 CPU cores and 8 GiB memory. Two pods (pod 1 and pod 2) have been deployed on the cluster. Pod 1 oversubscribes resources (that is **Limit** > **Request**). The specifications of the two pods are as follows.

Pod	CPU Request	CPU Limit	Memory Request	Memory Limit
Pod 1	1 core	2 cores	1 GiB	4 GiB
Pod 2	2 cores	2 cores	2 GiB	2 GiB

The CPU and memory usage of the node is as follows:

- Allocatable CPUs = 4 cores – (1 core requested by pod 1 + 2 cores requested by pod 2) = 1 core
- Allocatable memory = 8 GiB – (1 GiB requested by pod 1 + 2 GiB requested by pod 2) = 5 GiB

In this case, the remaining 1 core 5 GiB can be used by the next new pod.

If pod 1 is under heavy load during peak hours, it will use more CPUs and memory within the limit. Therefore, the actual allocatable resources are fewer than 1 core 5 GiB.

Quotas of Other Resources

Typically, nodes support local ephemeral storage, which is provided by locally mounted writable devices or RAM. Ephemeral storage does not ensure long-term data availability. Pods can use local ephemeral storage to buffer data and store logs, or mount emptyDir storage volumes to containers. For details, see **Local ephemeral storage**.

Kubernetes allows you to specify the requested value and limit value of ephemeral storage in container configurations to manage the local ephemeral storage. The following attributes can be configured for each container in a pod:

- spec.containers[].resources.limits.ephemeral-storage
- spec.containers[].resources.requests.ephemeral-storage

In the following example, a pod contains two containers. The requested value of each container for local ephemeral storage is 2 GiB, and the limit value is 4 GiB.

Therefore, the requested value of the pod for local ephemeral storage is 4 GiB, the limit value is 8 GiB, and the emptyDir volume uses 500 MiB of the local ephemeral storage.

```
apiVersion: v1
kind: Pod
metadata:
  name: frontend
spec:
  containers:
  - name: container-1
    image: <example_app_image>
    resources:
      requests:
        ephemeral-storage: "2Gi"
      limits:
        ephemeral-storage: "4Gi"
    volumeMounts:
    - name: ephemeral
      mountPath: "/tmp"
  - name: container-2
    image: <example_log_aggregator_image>
    resources:
      requests:
        ephemeral-storage: "2Gi"
      limits:
        ephemeral-storage: "4Gi"
    volumeMounts:
    - name: ephemeral
      mountPath: "/tmp"
  volumes:
    - name: ephemeral
      emptyDir:
        sizeLimit: 500Mi
```

8.3.5 Configuring Container Lifecycle Parameters

Scenario

CCE provides callback functions for the lifecycle management of containerized applications. For example, if you want a container to perform a certain operation before stopping, you can register a hook function.

CCE provides the following lifecycle callback functions:

- **Startup Command**: executed to start a container. For details, see **Startup Commands**.
- **Post-Start**: executed immediately after a container is started. For details, see **Post-Start Processing**.
- **Pre-Stop**: executed before a container is stopped. The pre-stop processing function helps you ensure that the services running on the pods can be completed in advance in the case of pod upgrade or deletion. For details, see **Pre-Stop Processing**.

Startup Commands

By default, the default command during image start. To run a specific command or rewrite the default image value, you must perform specific settings:

A Docker image has metadata that stores image information. If lifecycle commands and arguments are not set, CCE runs the default commands and

arguments, that is, Docker instructions **ENTRYPOINT** and **CMD**, provided during image creation.

If the commands and arguments used to run a container are set during application creation, the default commands **ENTRYPOINT** and **CMD** are overwritten during image build. The rules are as follows:

Table 8-8 Commands and arguments used to run a container

Image ENTRYPOINT	Image CMD	Command to Run a Container	Parameters to Run a Container	Command Executed
[touch]	[/root/test]	Not set	Not set	[touch /root/test]
[touch]	[/root/test]	[mkdir]	Not set	[mkdir]
[touch]	[/root/test]	Not set	[/opt/test]	[touch /opt/test]
[touch]	[/root/test]	[mkdir]	[/opt/test]	[mkdir /opt/test]

Step 1 Log in to the CCE console. When creating a workload, configure container information and select **Lifecycle**.

Step 2 Enter a command and arguments on the **Startup Command** tab page.

Table 8-9 Container startup command

Configuration Item	Procedure
Command	Enter an executable command, for example, **/run/server**. If there are multiple executable commands, write them in different lines. **NOTE** In the case of multiple commands, you are advised to run **/bin/sh** or other **shell** commands. Other commands are used as parameters.
Args	Enter the argument that controls the container running command, for example, **--port=8080**. If there are multiple arguments, separate them in different lines.

----End

Post-Start Processing

Step 1 Log in to the CCE console. When creating a workload, configure container information and select **Lifecycle**.

Step 2 Set the post-start processing parameters on the **Post-Start** tab page.

Table 8-10 Post-start processing parameters

Parameter	Description

CLI	Set commands to be executed in the container for post-start processing. The command format is **Command Args[1] Args[2]...**. **Command** is a system command or a user-defined executable program. If no path is specified, an executable program in the default path will be selected. If multiple commands need to be executed, write the commands into a script for execution. **Commands that are executed in the background or asynchronously are not supported.**
	Example command:
	`exec:`
	`  command:`
	`  - /install.sh`
	`  - install_agent`
	Enter **/install install_agent** in the script. This command indicates that **install.sh** will be executed after the container is created successfully.

HTTP request	Send an HTTP request for post-start processing. The related parameters are described as follows: • **Path**: (optional) request URL. • **Port**: (mandatory) request port. • **Host**: (optional) requested host IP address. The default value is the IP address of the pod.

----End

Pre-Stop Processing

Step 1 Log in to the CCE console. When creating a workload, configure container information and select **Lifecycle**.

Step 2 Set the pre-start processing parameters on the **Pre-Stop** tab page.

Table 8-11 Pre-stop processing parameters

Parameter	Description

CLI	Set commands to be executed in the container for pre-stop processing. The command format is **Command Args[1] Args[2]...**. **Command** is a system command or a user-defined executable program. If no path is specified, an executable program in the default path will be selected. If multiple commands need to be executed, write the commands into a script for execution.
	Example command:
	`exec:`
	`  command:`
	`  - /uninstall.sh`
	`  - uninstall_agent`
	Enter **/uninstall uninstall_agent** in the script. This command indicates that the **uninstall.sh** script will be executed before the container completes its execution and stops running.

HTTP request	Send an HTTP request for pre-stop processing. The related parameters are described as follows: • **Path**: (optional) request URL. • **Port**: (mandatory) request port. • **Host**: (optional) requested host IP address. The default value is the IP address of the pod.

----End

Example YAML

This section uses Nginx as an example to describe how to set the container lifecycle.

In the following configuration file, the **postStart** command is defined to run the **install.sh** command in the **/bin/bash** directory. **preStop** is defined to run the **uninstall.sh** command.

```
apiVersion: apps/v1
kind: Deployment
metadata:
  name: nginx
spec:
  replicas: 1
  selector:
    matchLabels:
      app: nginx
  template:
    metadata:
      labels:
        app: nginx
    spec:
      containers:
      - image: nginx
        command:
        - sleep 3600                    # Startup command
        imagePullPolicy: Always
        lifecycle:
```

```
      postStart:
        exec:
          command:
          - /bin/bash
          - install.sh              # Post-start command
      preStop:
        exec:
          command:
          - /bin/bash
          - uninstall.sh            # Pre-stop command
    name: nginx
  imagePullSecrets:
  - name: default-secret
```

8.3.6 Configuring Container Health Check

Scenario

Health check regularly checks the health status of containers during container running. If the health check function is not configured, a pod cannot detect application exceptions or automatically restart the application to restore it. This will result in a situation where the pod status is normal but the application in the pod is abnormal.

Kubernetes provides the following health check probes:

- **Liveness probe** (livenessProbe): checks whether a container is still alive. It is similar to the **ps** command that checks whether a process exists. If the liveness check of a container fails, the cluster restarts the container. If the liveness check is successful, no operation is executed.
- **Readiness probe** (readinessProbe): checks whether a container is ready to process user requests. Upon that the container is detected unready, service traffic will not be directed to the container. It may take a long time for some applications to start up before they can provide services. This is because that they need to load disk data or rely on startup of an external module. In this case, although the application process has started, the application cannot provide services. To address this issue, this health check probe is used. If the container readiness check fails, the cluster masks all requests sent to the container. If the container readiness check is successful, the container can be accessed.
- **Startup probe** (startupProbe): checks when a containerized application has started. If such a probe is configured, it disables liveness and readiness checks until it succeeds, ensuring that those probes do not interfere with the application startup. This can be used to adopt liveness checks on slow starting containers, avoiding them getting terminated by the kubelet before they are started.

Check Method

- **HTTP request**

  This health check mode applies to containers that provide HTTP/HTTPS services. The cluster periodically initiates an HTTP/HTTPS GET request to such containers. If the return code of the HTTP/HTTPS response is within 200–399, the probe is successful. Otherwise, the probe fails. In this health check mode, you must specify a container listening port and an HTTP/HTTPS request path.

For example, for a container that provides HTTP services, the HTTP check path is **/health-check**, the port is 80, and the host address is optional (which defaults to the container IP address). Here, 172.16.0.186 is used as an example, and we can get such a request: GET http://172.16.0.186:80/health-check. The cluster periodically initiates this request to the container. You can also add one or more headers to an HTTP request. For example, set the request header name to **Custom-Header** and the corresponding value to **example**.

- **TCP port**

  For a container that provides TCP communication services, the cluster periodically establishes a TCP connection to the container. If the connection is successful, the probe is successful. Otherwise, the probe fails. In this health check mode, you must specify a container listening port.

  For example, if you have an Nginx container with service port 80, after you specify TCP port 80 for container listening, the cluster will periodically initiate a TCP connection to port 80 of the container. If the connection is successful, the probe is successful. Otherwise, the probe fails.

- **CLI**

  CLI is an efficient tool for health check. When using the CLI, you must specify an executable command in a container. The cluster periodically runs the command in the container. If the command output is 0, the health check is successful. Otherwise, the health check fails.

  The CLI mode can be used to replace the HTTP request-based and TCP port-based health check.

  - For a TCP port, you can use a program script to connect to a container port. If the connection is successful, the script returns **0**. Otherwise, the script returns **–1**.
  - For an HTTP request, you can use the script command to run the **wget** command to detect the container.

    wget http://127.0.0.1:80/health-check

    Check the return code of the response. If the return code is within 200–399, the script returns **0**. Otherwise, the script returns **–1**.

    NOTICE

    - Put the program to be executed in the container image so that the program can be executed.
    - If the command to be executed is a shell script, do not directly specify the script as the command, but add a script parser. For example, if the script is **/data/scripts/health_check.sh**, you must specify **sh/data/scripts/health_check.sh** for command execution.

- **gRPC Check**

  gRPC checks can configure startup, liveness, and readiness probes for your gRPC application without exposing any HTTP endpoint, nor do you need an executable. Kubernetes can connect to your workload via gRPC and obtain its status.

NOTICE

- The gRPC check is supported only in CCE clusters of v1.25 or later.
- To use gRPC for check, your application must support the **gRPC health checking protocol**.
- Similar to HTTP and TCP probes, if the port is incorrect or the application does not support the health checking protocol, the check fails.

Common Parameters

Table 8-12 Common parameter description

Parameter	Description
Period (periodSeconds)	Indicates the probe detection period, in seconds. For example, if this parameter is set to **30**, the detection is performed every 30 seconds.
Delay (initialDelaySeconds)	Check delay time in seconds. Set this parameter according to the normal startup time of services. For example, if this parameter is set to **30**, the health check will be started 30 seconds after the container is started. The time is reserved for containerized services to start.
Timeout (timeoutSeconds)	Number of seconds after which the probe times out. Unit: second. For example, if this parameter is set to **10**, the timeout wait time for performing a health check is 10s. If the wait time elapses, the health check is regarded as a failure. If the parameter is left blank or set to **0**, the default timeout time is 1s.
Success Threshold (successThreshold)	Minimum consecutive successes for the probe to be considered successful after having failed. For example, if this parameter is set to **1**, the workload status is normal only when the health check is successful for one consecutive time after the health check fails. The default value is **1**, which is also the minimum value. The value of this parameter is fixed to **1** in **Liveness Probe** and **Startup Probe**.
Failure Threshold (failureThreshold)	Number of retry times when the detection fails. Giving up in case of liveness probe means to restart the container. In case of readiness probe the pod will be marked Unready. The default value is **3**, and the minimum value is **1**.

YAML Example

```
apiVersion: v1
kind: Pod
metadata:
  labels:
    test: liveness
  name: liveness-http
spec:
  containers:
  - name: liveness
    image: <image_address>
    args:
    - /server
    livenessProbe:                # Liveness probe
      httpGet:                    # Checking an HTTP request is used as an example.
        path: /healthz            # The HTTP check path is /healthz.
        port: 80                  # The check port number is 80.
        httpHeaders:              # (Optional) The request header name is Custom-Header and the value is
Awesome.
        - name: Custom-Header
          value: Awesome
      initialDelaySeconds: 3
      periodSeconds: 3
    readinessProbe:               # Readiness probe
      exec:                       # Checking an execution command is used as an example.
        command:                  # Command to be executed
          - cat
          - /tmp/healthy
      initialDelaySeconds: 5
      periodSeconds: 5
    startupProbe:                 # Startup probe
      httpGet:                    # Checking an HTTP request is used as an example.
        path: /healthz            # The HTTP check path is /healthz.
        port: 80                  # The check port number is 80.
      failureThreshold: 30
      periodSeconds: 10
```

8.3.7 Configuring Environment Variables

Scenario

An environment variable is a variable whose value can affect the way a running container will behave. You can modify environment variables even after workloads are deployed, increasing flexibility in workload configuration.

The function of setting environment variables on CCE is the same as that of specifying **ENV** in a Dockerfile.

NOTICE

After a container is started, do not modify configurations in the container. If configurations in the container are modified (for example, passwords, certificates, and environment variables of a containerized application are added to the container), the configurations will be lost after the container restarts and container services will become abnormal. An example scenario of container restart is pod rescheduling due to node anomalies.

Configurations must be imported to a container as arguments. Otherwise, configurations will be lost after the container restarts.

Environment variables can be set in the following modes:

- **Custom**: Enter the environment variable name and parameter value.
- **Added from ConfigMap key**: Import all keys in a ConfigMap as environment variables.
- **Added from ConfigMap**: Import a key in a ConfigMap as the value of an environment variable.
- **Added from secret**: Import all keys in a secret as environment variables.
- **Added from secret key**: Import the value of a key in a secret as the value of an environment variable.
- **Variable value/reference**: Use the field defined by a pod as the value of the environment variable.
- **Resource Reference**: The value of **Request** or **Limit** defined by the container is used as the value of the environment variable.

Adding Environment Variables

Step 1 Log in to the CCE console.

Step 2 Click the cluster name to go to the cluster console, choose **Workloads** in the navigation pane, and click the **Create Workload** in the upper right corner.

Step 3 When creating a workload, modify the container information in **Container Settings** and click the **Environment Variables** tab.

Step 4 Configure environment variables.

----End

YAML Example

```
apiVersion: apps/v1
kind: Deployment
metadata:
  name: env-example
  namespace: default
spec:
  replicas: 1
  selector:
    matchLabels:
      app: env-example
  template:
    metadata:
      labels:
        app: env-example
    spec:
      containers:
        - name: container-1
          image: nginx:alpine
          imagePullPolicy: Always
          resources:
            requests:
              cpu: 250m
              memory: 512Mi
            limits:
              cpu: 250m
              memory: 512Mi
          env:
            - name: key                 # Custom
              value: value
            - name: key1                # Added from ConfigMap key
              valueFrom:
```

```
            configMapKeyRef:
              name: configmap-example
              key: configmap_key
          - name: key2                  # Added from secret key
            valueFrom:
              secretKeyRef:
                name: secret-example
                key: secret_key
          - name: key3                  # Variable reference, which uses the field defined by a pod as the value
of the environment variable.
            valueFrom:
              fieldRef:
                apiVersion: v1
                fieldPath: metadata.name
          - name: key4                  # Resource reference, which uses the field defined by a container as the
value of the environment variable.
            valueFrom:
              resourceFieldRef:
                containerName: container1
                resource: limits.cpu
                divisor: 1
        envFrom:
          - configMapRef:               # Added from ConfigMap
              name: configmap-example
          - secretRef:                  # Added from secret
              name: secret-example
      imagePullSecrets:
        - name: default-secret
```

Viewing Environment Variables

If the contents of **configmap-example** and **secret-example** are as follows:

```
$ kubectl get configmap configmap-example -oyaml
apiVersion: v1
data:
  configmap_key: configmap_value
kind: ConfigMap
...

$ kubectl get secret secret-example -oyaml
apiVersion: v1
data:
  secret_key: c2VjcmV0X3ZhbHVl              # c2VjcmV0X3ZhbHVl is the value of secret_value in Base64
mode.
kind: Secret
...
```

The environment variables in the pod are as follows:

```
$ kubectl get pod
NAME                           READY   STATUS    RESTARTS   AGE
env-example-695b759569-lx9jp   1/1     Running   0          17m

$ kubectl exec env-example-695b759569-lx9jp  -- printenv
/ # env
key=value                           # Custom environment variable
ey1=configmap_value                 # Added from ConfigMap key
key2=secret_value                   # Added from secret key
key3=env-example-695b759569-lx9jp     # metadata.name defined by the pod
key4=1                              # limits.cpu defined by container1. The value is rounded up, in unit of cores.
configmap_key=configmap_value         # Added from ConfigMap. The key value in the original ConfigMap
key is directly imported.
secret_key=secret_value             # Added from key. The key value in the original secret is directly imported.
```

8.3.8 Workload Upgrade Policies

In actual applications, upgrade is a common operation. A Deployment, StatefulSet, or DaemonSet can easily support application upgrade.

You can set different upgrade policies:

- **Rolling upgrade**: New pods are created gradually and then old pods are deleted. This is the default policy.
- **Replace upgrade**: The current pods are deleted and then new pods are created.

Upgrade Parameters

Parameter	Description	Constraint
Max. Surge (maxSurge)	Specifies the maximum number of pods that can exist compared with **spec.replicas**. The default value is **25%**. For example, if **spec.replicas** is set to **4**, a maximum of five pods can exist during the upgrade. That is, the upgrade is performed at a step of 1. During the actual upgrade, the value is converted into a number and rounded up. The value can also be set to an absolute number.	This parameter is supported only by Deployments and DaemonSets.
Max. Unavailable Pods (maxUnavailable)	Specifies the maximum number of pods that can be unavailable compared with **spec.replicas**. The default value is **25%**. For example, if **spec.replicas** is set to **4**, at least three pods exist during the upgrade. That is, the deletion is performed at a step of 1. The value can also be set to an absolute number.	This parameter is supported only by Deployments and DaemonSets.
Min. Ready Seconds (minReadySeconds)	A pod is considered available only when the minimum readiness time is exceeded without any of its containers crashing. The default value is **0** (the pod is considered available immediately after it is ready).	None
Revision History Limit (revisionHistory-Limit)	Specifies the number of old ReplicaSets to retain to allow rollback. These old ReplicaSets consume resources in etcd and crowd the output of **kubectl get rs**. The configuration of each Deployment revision is stored in its ReplicaSets. Therefore, once the old ReplicaSet is deleted, you lose the ability to roll back to that revision of Deployment. By default, 10 old ReplicaSets will be kept, but the ideal value depends on the frequency and stability of the new Deployments.	None

Parameter	Description	Constraint
Max. Upgrade Duration (progressDeadlineSeconds)	Specifies the number of seconds that the system waits for a Deployment to make progress before reporting a Deployment progress failure. It is surfaced as a condition with Type=Progressing, Status=False, and Reason=ProgressDeadlineExceeded in the status of the resource. The Deployment controller will keep retrying the Deployment. In the future, once automatic rollback will be implemented, the Deployment controller will roll back a Deployment as soon as it observes such a condition. If this parameter is specified, the value of this parameter must be greater than that of **.spec.minReadySeconds**.	None
Scale-In Time Window (terminationGracePeriodSeconds)	Graceful deletion time. The default value is 30 seconds. When a pod is deleted, a SIGTERM signal is sent and the system waits for the applications in the container to terminate. If the application is not terminated within the time specified by **terminationGracePeriodSeconds**, a SIGKILL signal is sent to forcibly terminate the pod.	None

Upgrade Example

The Deployment can be upgraded in a declarative mode. That is, you only need to modify the YAML definition of the Deployment. For example, you can run the **kubectl edit** command to change the Deployment image to **nginx:alpine**. After the modification, query the ReplicaSet and pod. The query result shows that a new ReplicaSet is created and the pod is re-created.

```
$ kubectl edit deploy nginx

$ kubectl get rs
NAME            DESIRED   CURRENT   READY     AGE
nginx-6f9f58dffd   2         2         2         1m
nginx-7f98958cdf   0         0         0         48m

$ kubectl get pods
NAME                   READY     STATUS    RESTARTS   AGE
nginx-6f9f58dffd-tdmqk   1/1       Running   0          1m
nginx-6f9f58dffd-tesqr   1/1       Running   0          1m
```

The Deployment can use the **maxSurge** and **maxUnavailable** parameters to control the proportion of pods to be re-created during the upgrade, which is useful in many scenarios. The configuration is as follows:

```
spec:
  strategy:
    rollingUpdate:
      maxSurge: 1
      maxUnavailable: 0
    type: RollingUpdate
```

In the preceding example, the value of **spec.replicas** is **2**. If both **maxSurge** and **maxUnavailable** are the default value 25%, **maxSurge** allows a maximum of three pods to exist (2 x 1.25 = 2.5, rounded up to 3), and **maxUnavailable** does not allow a maximum of two pods to be unavailable (2 x 0.75 = 1.5, rounded up to 2). That is, during the upgrade process, there will always be two pods running. Each time a new pod is created, an old pod is deleted, until all pods are new.

Rollback

Rollback is to roll an application back to the earlier version when a fault occurs during the upgrade. A Deployment can be easily rolled back to the earlier version.

For example, if the upgraded image is faulty, you can run the **kubectl rollout undo** command to roll back the Deployment.

```
$ kubectl rollout undo deployment nginx
deployment.apps/nginx rolled back
```

A Deployment can be easily rolled back because it uses a ReplicaSet to control a pod. After the upgrade, the previous ReplicaSet still exists. The Deployment is rolled back by using the previous ReplicaSet to re-create the pod. The number of ReplicaSets stored in a Deployment can be restricted by the **revisionHistoryLimit** parameter. The default value is **10**.

8.3.9 Scheduling Policies (Affinity/Anti-affinity)

Kubernetes supports node affinity and pod affinity/anti-affinity. You can configure custom rules to achieve affinity and anti-affinity scheduling. For example, you can deploy frontend pods and backend pods together, deploy the same type of applications on a specific node, or deploy different applications on different nodes.

Kubernetes affinity applies to nodes and pods.

- **nodeAffinity**: similar to pod nodeSelector, and they both schedule pods only to the nodes with specified labels. The difference between nodeAffinity and nodeSelector lies in that nodeAffinity features stronger expression than nodeSelector and allows you to specify preferentially selected soft constraints. The two types of node affinity are as follows:
  - requiredDuringSchedulingIgnoredDuringExecution: hard constraint that **must be met**. The scheduler can perform scheduling only when the rule is met. This function is similar to nodeSelector, but it features stronger syntax expression. For details, see **Node Affinity (nodeAffinity)**.
  - preferredDuringSchedulingIgnoredDuringExecution: soft constraint that is **met as much as possible**. The scheduler attempts to find the node that meets the rule. If no matching node is found, the scheduler still schedules the pod. For details, see **Node Preference Rules**.
- **Workload Affinity (podAffinity)**/**Workload Anti-affinity (podAntiAffinity)**: The nodes to which a pod can be scheduled are determined based on the label of the pod running on a node, but not the label of the node. Similar to node affinity, workload affinity and anti-affinity are also of requiredDuringSchedulingIgnoredDuringExecution and preferredDuringSchedulingIgnoredDuringExecution types.

NOTE

Workload affinity and anti-affinity require a certain amount of computing time, which significantly slows down scheduling in large-scale clusters. Do not enable workload affinity and anti-affinity in a cluster that contains hundreds of nodes.

You can create the preceding affinity policies on the console. For details, see **Configuring Load Affinity on the Console** and **Configuring Node Affinity on the Console**.

Configuring Load Affinity on the Console

Step 1 When creating a workload, click **Scheduling** in the **Advanced Settings** area. For details about how to create a workload, see **Creating a Workload**.

Step 2 Select a load affinity scheduling policy.

- **Not configured**: No load affinity policy is configured.
- **Multi-AZ deployment preferred**: Workload pods are **preferentially** scheduled to nodes in different AZs through pod anti-affinity.
- **Forcible multi-AZ deployment**: Workload pods are **forcibly** scheduled to different AZs and different nodes through pod anti-affinity. When this scheduling policy is used, if there are fewer nodes than pods or node resources are insufficient, the extra pods will fail to run.
- **Custom policies**: allow flexible scheduling of workload pods based on pod labels. For details about the supported scheduling policies, see **Table 8-13**.

  Select a proper policy type and click + to add a policy. For details about the parameters, see **Table 8-14**.

Table 8-13 Load affinity policies

Policy	Type	Description
Workload Affinity	Required	Hard constraint, which is used to configure the conditions that must be met and corresponds to the **requiredDuringSchedulingIgnoredDuringExecution** field in YAML. Select pods that require affinity by label. If such pods have been running on a node in the topology domain, the scheduler will **forcibly** schedule the created pods to that topology domain. **NOTE** If multiple affinity rules are configured, multiple labels will be used to filter pods that require affinity, and the newly created pods must be affinity with all pods that meet the label filtering conditions. In this way, all pods that meet the label filtering conditions locate in the same topology domain for scheduling.

Policy	Type	Description
	Preferred	Soft constraint, which is used to configure the conditions that preferentially to be met and corresponds to the **preferredDuringSchedulingIgnoredDuringExecution** field in YAML. Select pods that require affinity by label. If such pods have been running on a node in the topology domain, the scheduler will **preferentially** schedule the created pods to that topology domain. **NOTE** If multiple affinity rules are configured, multiple labels will be used to filter pods that require affinity, and the newly created pods will be preferentially to be affinity with multiple pods that meet the label filtering conditions. However, even if no pod meets the label filter conditions, a topology domain will be selected for scheduling.
Workload Anti-Affinity	Required	Hard constraint, which corresponds to **requiredDuringSchedulingIgnoredDuringExecution** in YAML for specifying the conditions that must be met. Select one or more pods that require anti-affinity by label. If such pods have been running on a node in the topology domain, the scheduler will **not** schedule the created pods to that topology domain. **NOTE** If multiple anti-affinity rules are configured, multiple labels will be used to filter pods that require anti-affinity, and the newly created pods must be anti-affinity with all pods that meet the label filtering conditions. In this way, all the topology domains where the pods that meet the label filtering conditions locate will not be scheduled.
	Preferred	Soft constraint, which corresponds to **preferredDuringSchedulingIgnoredDuringExecution** in YAML for specifying the conditions that are preferentially met. Select one or more pods that require anti-affinity by label. If such pods have been running on a node in the topology domain, the scheduler will **preferentially** schedule the created pods to other topology domains. **NOTE** If multiple anti-affinity rules are configured, multiple labels will be used to filter pods that require anti-affinity, and the newly created pods will be preferentially to be anti-affinity with multiple pods that meet the label filtering conditions. However, even if all topology domains involve the pods that require anti-affinity, a topology domain will be selected for scheduling.

Table 8-14 Parameters for configuring load affinity/anti-affinity scheduling policies

Parameter	Description
Weight	This parameter is available only in a **Preferred** scheduling policy. The weight ranges from 1 to 100. During scheduling, the scheduler adds the weight to the scores of other priority functions and schedules pods to the node with the largest total score.
Namespace	Namespace for which the scheduling policy takes effect.
Topology Key	A topology domain (**topologyKey**) determines the range of nodes to be scheduled based on node labels. For example, if the node label is **kubernetes.io/hostname**, the range of nodes is determined by node name. Nodes with different names are in different topology domains. In this case, a topology domain contains only one node. If the specified label is **kubernetes.io/os**, the range of nodes is determined by node OS. Nodes running different OSs belong to different topology domains. In this case, a topology domain may contain multiple nodes. After the node range is determined using the topology domain, configure the policy for scheduling, including the label name, operator, and label value. The minimum unit for scheduling is a topology domain. For example, if a node in a topology domain meets the load affinity policy, all nodes in the topology domain can be scheduled.
Label Key	When configuring a workload affinity or anti-affinity policy, enter the workload label to be matched. Both default labels and custom labels are supported.
Operator	The following operators are supported: – **In**: The label of the affinity or anti-affinity object is in the label value list (**values** field). – **NotIn**: The label of the affinity or anti-affinity object is not in the label value list (**values** field). – **Exists**: The affinity or anti-affinity object has a specified label name. – **DoesNotExist**: The affinity or anti-affinity object does not have the specified label name.
Label Value	When configuring a workload affinity or anti-affinity policy, enter the value of the workload label.

Step 3 After the scheduling policy is added, click **Create Workload**.

----End

Configuring Node Affinity on the Console

Step 1 When creating a workload, click **Scheduling** in the **Advanced Settings** area. For details about how to create a workload, see **Creating a Workload**.

Step 2 Select a node affinity scheduling policy.

- **Not configured**: No node affinity policy is configured.
- **Node Affinity**: Specify the nodes where workload pods are to be deployed. If no nodes are specified, the pods will be randomly scheduled based on the default cluster scheduling policy.
- **Specified Node Pool Scheduling**: Specify the node pools where workload pods are to be deployed. If no node pools are specified, the pods will be randomly scheduled based on the default cluster scheduling policy.
- **Custom policies**: allow flexible scheduling of workload pods based on node labels. For details about the supported scheduling policies, see **Table 8-15**.

  Select a proper policy type and click + to add a policy. For details about the parameters, see **Table 8-16**. You can also click **Specify Node** or **Specify AZ** to quickly select a node or AZ on the console for scheduling.

  Specifying a node or AZ is also implemented through labels. The console frees you from manually entering node labels. The **kubernetes.io/hostname** label is used when you specify a node, and the **failure-domain.beta.kubernetes.io/zone** label is used when you specify an AZ.

Table 8-15 Node affinity settings

Parameter	Description
Required	Hard constraint, which corresponds to **requiredDuringSchedulingIgnoredDuringExecution** for specifying the conditions that must be met. If multiple rules **that must be met** are added, scheduling will be performed when only one rule is met.
Preferred	Soft constraint, which corresponds to **preferredDuringSchedulingIgnoredDuringExecution** for specifying the conditions that are preferentially met. If multiple rules **that are preferentially met** are added, scheduling will be performed even if one or none of the rules is met.

Table 8-16 Parameters for configuring node affinity scheduling policies

Parameter	Description
Label	When configuring node affinity, enter the node label to be matched. Both default labels and custom labels are supported.

Parameter	Description
Operator	The following operators are supported: – **In**: The label of the affinity or anti-affinity object is in the label value list (**values** field). – **NotIn**: The label of the affinity or anti-affinity object is not in the label value list (**values** field). – **Exists**: The affinity or anti-affinity object has a specified label name. – **DoesNotExist**: The affinity or anti-affinity object does not have the specified label name. – **Gt**: (available only for node affinity) The label value of the scheduled node is greater than the list value (string comparison). – **Lt**: (available only for node affinity) The label value of the scheduled node is less than the list value (string comparison).
Label Value	When configuring node affinity, enter the value of the node label.

Step 3 After the scheduling policy is added, click **Create Workload**.

----End

Node Affinity (nodeAffinity)

Workload node affinity rules are implemented using node labels. When a node is created in a CCE cluster, certain labels are automatically added. You can run the **kubectl describe node** command to view the labels. The following is an example:

```
$ kubectl describe node 192.168.0.212
Name:               192.168.0.212
Roles:              <none>
Labels:             beta.kubernetes.io/arch=amd64
                    beta.kubernetes.io/os=linux
                    failure-domain.beta.kubernetes.io/is-baremetal=false
                    failure-domain.beta.kubernetes.io/region=******
                    failure-domain.beta.kubernetes.io/zone=******
                    kubernetes.io/arch=amd64
                    kubernetes.io/availablezone=******
                    kubernetes.io/eniquota=12
                    kubernetes.io/hostname=192.168.0.212
                    kubernetes.io/os=linux
                    node.kubernetes.io/subnetid=fd43acad-33e7-48b2-a85a-24833f362e0e
                    os.architecture=amd64
                    os.name=EulerOS_2.0_SP5
                    os.version=3.10.0-862.14.1.5.h328.eulerosv2r7.x86_64
```

In workload scheduling, common node labels are as follows:

- **failure-domain.beta.kubernetes.io/region**: region where the node is located.
- **failure-domain.beta.kubernetes.io/zone**: availability zone to which the node belongs.
- **kubernetes.io/hostname**: host name of the node.

Kubernetes provides the **nodeSelector** field. When creating a workload, you can set this field to specify that the pod can be deployed only on a node with the specific label. The following example shows how to use a nodeSelector to deploy the pod only on the node with the **gpu=true** label.

```
apiVersion: v1
kind: Pod
metadata:
  name: nginx
spec:
  nodeSelector:              # Node selection. A pod is created on a node only when the node meets gpu=true.
    gpu: true
...
```

Node affinity rules can achieve the same results. Compared with nodeSelector, node affinity rules seem more complex, but with a more expressive syntax. You can use the **spec.affinity.nodeAffinity** field to set node affinity. There are two types of node affinity:

- **requiredDuringSchedulingIgnoredDuringExecution**: Kubernetes cannot schedule the pod unless the rule is met.
- **PreferredDuringSchedulingIgnoredDuringExecution**: Kubernetes tries to find a node that meets the rule. If a matching node is not available, Kubernetes still schedules the pod.

NOTE

In these two types of node affinity, **requiredDuringScheduling** or **preferredDuringScheduling** indicates that the pod can be scheduled to a node only when all the defined rules are met (required). **IgnoredDuringExecution** indicates that if the node label changes after Kubernetes schedules the pod, the pod continues to run and will not be rescheduled. However, if kubelet on the node is restarted, kubelet will recheck the node affinity rule, and the pod will still be scheduled to another node.

The following is an example of setting node affinity:

```
apiVersion: apps/v1
kind: Deployment
metadata:
  name:  gpu
  labels:
    app:  gpu
spec:
  selector:
    matchLabels:
      app: gpu
  replicas: 3
  template:
    metadata:
      labels:
        app:  gpu
    spec:
      containers:
      - image:  nginx:alpine
        name:  gpu
        resources:
          requests:
            cpu: 100m
            memory: 200Mi
          limits:
            cpu: 100m
            memory: 200Mi
      imagePullSecrets:
      - name: default-secret
      affinity:
```

```
      nodeAffinity:
        requiredDuringSchedulingIgnoredDuringExecution:
          nodeSelectorTerms:
          - matchExpressions:
            - key: gpu
              operator: In
              values:
              - "true"
```

In this example, the scheduled node must contain a label with the key named **gpu**. The value of **operator** is to **In**, indicating that the label value must be in the **values** list. That is, the key value of the **gpu** label of the node is **true**. For details about other values of **operator**, see **Operator Values**. Note that there is no such thing as nodeAntiAffinity because operators **NotIn** and **DoesNotExist** provide the same function.

The following describes how to check whether the rule takes effect. Assume that a cluster has three nodes.

```
$ kubectl get node
NAME           STATUS   ROLES    AGE   VERSION
192.168.0.212   Ready    <none>   13m   v1.15.6-r1-20.3.0.2.B001-15.30.2
192.168.0.94    Ready    <none>   13m   v1.15.6-r1-20.3.0.2.B001-15.30.2
192.168.0.97    Ready    <none>   13m   v1.15.6-r1-20.3.0.2.B001-15.30.2
```

Add the **gpu=true** label to the **192.168.0.212** node.

```
$ kubectl label node 192.168.0.212 gpu=true
node/192.168.0.212 labeled

$ kubectl get node -L gpu
NAME           STATUS   ROLES    AGE   VERSION                         GPU
192.168.0.212   Ready    <none>   13m   v1.15.6-r1-20.3.0.2.B001-15.30.2   true
192.168.0.94    Ready    <none>   13m   v1.15.6-r1-20.3.0.2.B001-15.30.2
192.168.0.97    Ready    <none>   13m   v1.15.6-r1-20.3.0.2.B001-15.30.2
```

Create the Deployment. You can find that all pods are deployed on the **192.168.0.212** node.

```
$ kubectl create -f affinity.yaml
deployment.apps/gpu created

$ kubectl get pod -o wide
NAME                   READY   STATUS    RESTARTS   AGE   IP           NODE
gpu-6df65c44cf-42xw4     1/1     Running   0          15s   172.16.0.37   192.168.0.212
gpu-6df65c44cf-jzjvs     1/1     Running   0          15s   172.16.0.36   192.168.0.212
gpu-6df65c44cf-zv5cl     1/1     Running   0          15s   172.16.0.38   192.168.0.212
```

Node Preference Rules

The preceding **requiredDuringSchedulingIgnoredDuringExecution** rule is a hard selection rule. There is another type of selection rule, that is, **preferredDuringSchedulingIgnoredDuringExecution**. It is used to specify which nodes are preferred during scheduling.

To achieve this effect, add a node attached with SAS disks to the cluster, add the **DISK=SAS** label to the node, and add the **DISK=SSD** label to the other three nodes.

```
$ kubectl get node -L DISK,gpu
NAME           STATUS   ROLES    AGE     VERSION                         DISK     GPU
192.168.0.100   Ready    <none>   7h23m   v1.15.6-r1-20.3.0.2.B001-15.30.2   SAS
192.168.0.212   Ready    <none>   8h      v1.15.6-r1-20.3.0.2.B001-15.30.2   SSD      true
192.168.0.94    Ready    <none>   8h      v1.15.6-r1-20.3.0.2.B001-15.30.2   SSD
192.168.0.97    Ready    <none>   8h      v1.15.6-r1-20.3.0.2.B001-15.30.2   SSD
```

Define a Deployment. Use the **preferredDuringSchedulingIgnoredDuringExecution** rule to set the weight of nodes with the SSD disk installed as **80** and nodes with the **gpu=true** label as **20**. In this way, pods are preferentially deployed on the nodes with the SSD disk installed.

```
apiVersion: apps/v1
kind: Deployment
metadata:
  name:  gpu
  labels:
    app:  gpu
spec:
  selector:
    matchLabels:
      app: gpu
  replicas: 10
  template:
    metadata:
      labels:
        app:  gpu
    spec:
      containers:
      - image:  nginx:alpine
        name:  gpu
        resources:
          requests:
            cpu:  100m
            memory:  200Mi
          limits:
            cpu:  100m
            memory:  200Mi
      imagePullSecrets:
      - name: default-secret
      affinity:
        nodeAffinity:
          preferredDuringSchedulingIgnoredDuringExecution:
          - weight: 80
            preference:
              matchExpressions:
              - key: DISK
                operator: In
                values:
                - SSD
          - weight: 20
            preference:
              matchExpressions:
              - key: gpu
                operator: In
                values:
                - "true"
```

After the deployment, there are five pods deployed on the node **192.168.0.212** (label: **DISK=SSD** and **GPU=true**), three pods deployed on the node **192.168.0.97** (label: **DISK=SSD**), and two pods deployed on the node **192.168.0.100** (label: **DISK=SAS**).

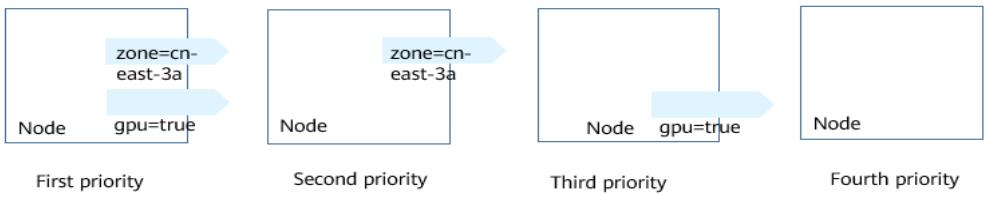
From the preceding output, you can find that no pods of the Deployment are scheduled to node **192.168.0.94** (label: **DISK=SSD**). This is because the node already has many pods on it and its resource usage is high. This also indicates that the **preferredDuringSchedulingIgnoredDuringExecution** rule defines a preference rather than a hard requirement.

```
$ kubectl create -f affinity2.yaml
deployment.apps/gpu created
```

```
$ kubectl get po -o wide
NAME                   READY   STATUS    RESTARTS   AGE     IP           NODE
gpu-585455d466-5bmcz   1/1     Running   0          2m29s   172.16.0.44   192.168.0.212
gpu-585455d466-cg2l6   1/1     Running   0          2m29s   172.16.0.63   192.168.0.97
gpu-585455d466-f2bt2   1/1     Running   0          2m29s   172.16.0.79   192.168.0.100
gpu-585455d466-hdb5n   1/1     Running   0          2m29s   172.16.0.42   192.168.0.212
gpu-585455d466-hkgvz   1/1     Running   0          2m29s   172.16.0.43   192.168.0.212
gpu-585455d466-mngvn   1/1     Running   0          2m29s   172.16.0.48   192.168.0.97
gpu-585455d466-s26qs   1/1     Running   0          2m29s   172.16.0.62   192.168.0.97
gpu-585455d466-sxtzm   1/1     Running   0          2m29s   172.16.0.45   192.168.0.212
gpu-585455d466-t56cm   1/1     Running   0          2m29s   172.16.0.64   192.168.0.100
gpu-585455d466-t5w5x   1/1     Running   0          2m29s   172.16.0.41   192.168.0.212
```

In the preceding example, the node scheduling priority is as follows. Nodes with both **SSD** and **gpu=true** labels have the highest priority. Nodes with the **SSD** label but no **gpu=true** label have the second priority (weight: 80). Nodes with the **gpu=true** label but no **SSD** label have the third priority. Nodes without any of these two labels have the lowest priority.

Figure 8-4 Scheduling priority



Workload Affinity (podAffinity)

Node affinity rules affect only the affinity between pods and nodes. Kubernetes also supports configuring inter-pod affinity rules. For example, the frontend and backend of an application can be deployed together on one node to reduce access latency. There are also two types of inter-pod affinity rules: **requiredDuringSchedulingIgnoredDuringExecution** and **preferredDuringSchedulingIgnoredDuringExecution**.

NOTE

For workload affinity, topologyKey cannot be left blank when requiredDuringSchedulingIgnoredDuringExecution and preferredDuringSchedulingIgnoredDuringExecution are used.

Assume that the backend of an application has been created and has the **app=backend** label.

```
$ kubectl get po -o wide
NAME                       READY   STATUS    RESTARTS   AGE     IP           NODE
backend-658f6cb858-dlrz8   1/1     Running   0          2m36s   172.16.0.67   192.168.0.100
```

You can configure the following pod affinity rule to deploy the frontend pods of the application to the same node as the backend pods.

```
apiVersion: apps/v1
kind: Deployment
metadata:
  name:   frontend
  labels:
    app:  frontend
spec:
```

```
selector:
  matchLabels:
    app: frontend
replicas: 3
template:
  metadata:
    labels:
      app:  frontend
  spec:
    containers:
    - image:  nginx:alpine
      name:  frontend
      resources:
        requests:
          cpu:  100m
          memory:  200Mi
        limits:
          cpu:  100m
          memory:  200Mi
    imagePullSecrets:
    - name: default-secret
    affinity:
      podAffinity:
        requiredDuringSchedulingIgnoredDuringExecution:
        - topologyKey: kubernetes.io/hostname
          labelSelector:
            matchExpressions:
            - key: app
              operator: In
              values:
              - backend
```

Deploy the frontend and you can find that the frontend is deployed on the same node as the backend.

```
$ kubectl create -f affinity3.yaml
deployment.apps/frontend created

$ kubectl get po -o wide
NAME                        READY   STATUS    RESTARTS   AGE     IP            NODE
backend-658f6cb858-dlrz8    1/1     Running   0          5m38s   172.16.0.67   192.168.0.100
frontend-67ff9b7b97-dsqzn   1/1     Running   0          6s      172.16.0.70   192.168.0.100
frontend-67ff9b7b97-hxm5t   1/1     Running   0          6s      172.16.0.71   192.168.0.100
frontend-67ff9b7b97-z8pdb   1/1     Running   0          6s      172.16.0.72   192.168.0.100
```

The **topologyKey** field is used to divide topology domains to specify the selection range. If the label keys and values of nodes are the same, the nodes are considered to be in the same topology domain. Then, the contents defined in the following rules are selected. The effect of **topologyKey** is not fully demonstrated in the preceding example because all the nodes have the **kubernetes.io/hostname** label, that is, all the nodes are within the range.

To see how **topologyKey** works, assume that the backend of the application has two pods, which are running on different nodes.

```
$ kubectl get po -o wide
NAME                        READY   STATUS    RESTARTS   AGE     IP            NODE
backend-658f6cb858-5bpd6    1/1     Running   0          23m     172.16.0.40   192.168.0.97
backend-658f6cb858-dlrz8    1/1     Running   0          2m36s   172.16.0.67   192.168.0.100
```

Add the **prefer=true** label to nodes **192.168.0.97** and **192.168.0.94**.

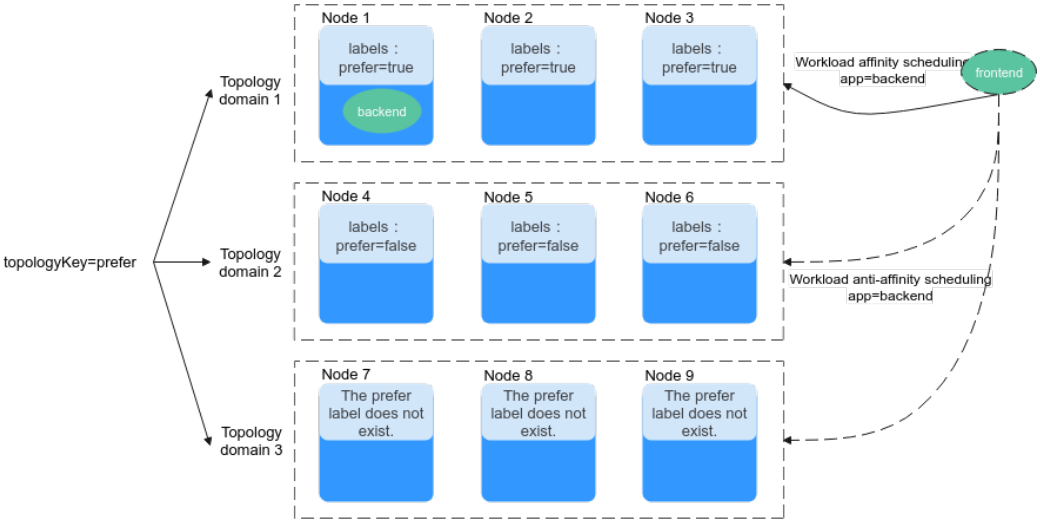
```
$ kubectl label node 192.168.0.97 prefer=true
node/192.168.0.97 labeled
$ kubectl label node 192.168.0.94 prefer=true
node/192.168.0.94 labeled

$ kubectl get node -L prefer
```

```
NAME           STATUS   ROLES    AGE   VERSION                          PREFER
192.168.0.100  Ready    <none>   44m   v1.15.6-r1-20.3.0.2.B001-15.30.2
192.168.0.212  Ready    <none>   91m   v1.15.6-r1-20.3.0.2.B001-15.30.2
192.168.0.94   Ready    <none>   91m   v1.15.6-r1-20.3.0.2.B001-15.30.2   true
192.168.0.97   Ready    <none>   91m   v1.15.6-r1-20.3.0.2.B001-15.30.2   true
```

If the **topologyKey** of **podAffinity** is set to **prefer**, the node topology domains are divided as shown in **Figure 8-5**.

```
    affinity:
      podAffinity:
        requiredDuringSchedulingIgnoredDuringExecution:
        - topologyKey: prefer
          labelSelector:
            matchExpressions:
            - key: app
              operator: In
              values:
              - backend
```

Figure 8-5 Topology domains



During scheduling, node topology domains are divided based on the **prefer** label. In this example, **192.168.0.97** and **192.168.0.94** are divided into the same topology domain. If a pod with the **app=backend** label runs in the topology domain, even if not all nodes in the topology domain run the pod with the **app=backend** label (in this example, only the **192.168.0.97** node has such a pod), **frontend** is also deployed in this topology domain (**192.168.0.97** or **192.168.0.94**).

```
$ kubectl create -f affinity3.yaml
deployment.apps/frontend created

$ kubectl get po -o wide
NAME                        READY   STATUS    RESTARTS   AGE     IP           NODE
backend-658f6cb858-5bpd6    1/1     Running   0          26m     172.16.0.40  192.168.0.97
backend-658f6cb858-dlrz8    1/1     Running   0          5m38s   172.16.0.67  192.168.0.100
frontend-67ff9b7b97-dsqzn   1/1     Running   0          6s      172.16.0.70  192.168.0.97
frontend-67ff9b7b97-hxm5t   1/1     Running   0          6s      172.16.0.71  192.168.0.97
frontend-67ff9b7b97-z8pdb   1/1     Running   0          6s      172.16.0.72  192.168.0.97
```

Workload Anti-Affinity (podAntiAffinity)

Unlike the scenarios in which pods are preferred to be scheduled onto the same node, sometimes, it could be the exact opposite. For example, if certain pods are deployed together, they will affect the performance.

NOTE

For workload anti-affinity, when requiredDuringSchedulingIgnoredDuringExecution is used, the default access controller LimitPodHardAntiAffinityTopology of Kubernetes requires that topologyKey can only be **kubernetes.io/hostname**. To use other custom topology logic, modify or disable the access controller.

The following is an example of defining an anti-affinity rule. This rule divides node topology domains by the **kubernetes.io/hostname** label. If a pod with the **app=frontend** label already exists on a node in the topology domain, pods with the same label cannot be scheduled to other nodes in the topology domain.

```
apiVersion: apps/v1
kind: Deployment
metadata:
  name:   frontend
  labels:
    app:  frontend
spec:
  selector:
    matchLabels:
      app: frontend
  replicas: 5
  template:
    metadata:
      labels:
        app:  frontend
    spec:
      containers:
      - image:  nginx:alpine
        name:  frontend
        resources:
          requests:
            cpu:  100m
            memory:  200Mi
          limits:
            cpu:  100m
            memory:  200Mi
      imagePullSecrets:
      - name: default-secret
      affinity:
        podAntiAffinity:
          requiredDuringSchedulingIgnoredDuringExecution:
          - topologyKey: kubernetes.io/hostname   # Topology domain of the node
            labelSelector:    # Pod label matching rule
              matchExpressions:
              - key: app
                operator: In
                values:
                - frontend
```

Create an anti-affinity rule and view the deployment result. In the example, node topology domains are divided by the **kubernetes.io/hostname** label. The label values of nodes with the **kubernetes.io/hostname** label are different, so there is only one node in a topology domain. If a **frontend** pod already exists in a topology domain, pods with the same label will not be scheduled to the topology domain. In this example, there are only four nodes. Therefore, there is one pod which is in the **Pending** state and cannot be scheduled.

```
$ kubectl create -f affinity4.yaml
deployment.apps/frontend created

$ kubectl get po -o wide
NAME                        READY   STATUS    RESTARTS   AGE   IP            NODE
frontend-6f686d8d87-8dlsc   1/1     Running   0          18s   172.16.0.76   192.168.0.100
frontend-6f686d8d87-d6l8p   0/1     Pending   0          18s   <none>        <none>
frontend-6f686d8d87-hgcq2   1/1     Running   0          18s   172.16.0.54   192.168.0.97
frontend-6f686d8d87-q7cfq   1/1     Running   0          18s   172.16.0.47   192.168.0.212
frontend-6f686d8d87-xl8hx   1/1     Running   0          18s   172.16.0.23   192.168.0.94
```

Operator Values

You can use the **operator** field to set the logical relationship of the usage rule. The value of **operator** can be:

- **In**: The label of the affinity or anti-affinity object is in the label value list (**values** field).
- **NotIn**: The label of the affinity or anti-affinity object is not in the label value list (**values** field).
- **Exists**: The affinity or anti-affinity object has a specified label name.
- **DoesNotExist**: The affinity or anti-affinity object does not have the specified label name.
- **Gt**: (available only for node affinity) The label value of the scheduled node is greater than the list value (string comparison).
- **Lt**: (available only for node affinity) The label value of the scheduled node is less than the list value (string comparison).

8.3.10 Taints and Tolerations

Tolerations allow the scheduler to schedule pods to nodes with target taints. Tolerances work with **node taints**. Each node allows one or more taints. If no tolerance is configured for a pod, the scheduler will schedule the pod based on node taint policies to prevent the pod from being scheduled to an inappropriate node.

The following table shows how taint policies and tolerations affect pod running.

Taint Policy	No Taint Toleration Configured	Taint Toleration Configured
NoExecute	• Pods running on the node will be evicted immediately. • Inactive pods will not scheduled to the node.	• If the tolerance time window **tolerationSeconds** is not specified, pods can run on this node all the time. • If the tolerance time window **tolerationSeconds** is specified, pods still run on the node with taints within the time window. After the time expires, the pods will be evicted.

Taint Policy	No Taint Toleration Configured	Taint Toleration Configured
PreferNoSchedule	• Pods running on the node will not be evicted. • Inactive pods will not scheduled to the node **to the best extend**.	Pods can run on this node all the time.
NoSchedule	• Pods running on the node will not be evicted. • Inactive pods will not scheduled to the node.	Pods can run on this node all the time.

Configuring Tolerance Policies on the Console

Step 1 Log in to the CCE console.

Step 2 When creating a workload, click **Toleration** in the **Advanced Settings** area.

Step 3 Add a taint tolerance policy.

Table 8-17 Parameters for configuring a taint tolerance policy

Parameter	Description
Taint key	Key of a node taint
Operator	• **Equal**: **Exact match** for the specified taint key (mandatory) and taint value. If the taint value is left blank, all taints with the key the same as the specified taint key will be matched. • **Exists**: **matches only** the nodes with the specified taint key. In this case, the taint value cannot be specified. If the taint key is left blank, all taints will be tolerated.
Taint value	Taint value specified if the operator is set to **Equal**.
Taint Policy	• **All**: All taint policies are matched. • **NoSchedule**: Only the **NoSchedule** taint is matched. • **PreferNoSchedule**: Only the **PreferNoSchedule** taint is matched. • **NoExecute**: Only the **NoExecute** taint is matched.
Toleration Time Window	**tolerationSeconds**, which is configurable only when **Taint Policy** is set to **NoExecute**. Within the tolerance time window, pods still run on the node with taints. After the time expires, the pods will be evicted.

----End

Default Tolerance Policy

Kubernetes automatically adds tolerances for the **node.kubernetes.io/not-ready** and **node.kubernetes.io/unreachable** taints to pods, and sets the tolerance time window (**tolerationSeconds**) to 300s. These default tolerance policies indicate that when either of the preceding taint is added to the node where pods are running, the pods can still run on the node for 5 minutes.

NOTE

When a DaemonSet pod is created, no tolerance time window will be specified for the tolerances automatically added for the preceding taints. When either of the preceding taints is added to the node where the DaemonSet pod is running, the DaemonSet pod will never be evicted.

```
tolerations:
  - key: node.kubernetes.io/not-ready
    operator: Exists
    effect: NoExecute
    tolerationSeconds: 300
  - key: node.kubernetes.io/unreachable
    operator: Exists
    effect: NoExecute
    tolerationSeconds: 300
```

8.3.11 Labels and Annotations

Pod Annotations

CCE allows you to add annotations to a YAML file to realize some advanced pod functions. The following table describes the annotations you can add.

Table 8-18 Pod annotations

Annotation	Description	Default Value

kubernetes.AOM.log.stdout	Standard output parameter. If not specified, the standard log output of all containers is reported to AOM. You can collect stdout logs from certain containers or ignore them at all.
	Example:
	• Collecting none of the stdout logs:
	`kubernetes.AOM.log.stdout: '[]'`
	• Collecting stdout logs of container-1 and container-2:
	`kubernetes.AOM.log.stdout: '["container-1","container-2"]'`
		None

metrics.alpha.kubernetes.io/custom-endpoints	Parameter for reporting AOM monitoring metrics that you specify. For details, see **Monitoring Custom Metrics on AOM**.	None

Annotation	Description	Default Value
prometheus.io/scrape	Parameter for reporting Prometheus metrics. If the value is **true**, the current workload reports the monitoring metrics. For details, see **Monitoring Custom Metrics Using Cloud Native Cluster Monitoring**.	None
prometheus.io/path	URL for Prometheus to collect data. For details, see **Monitoring Custom Metrics Using Cloud Native Cluster Monitoring**.	/metrics
prometheus.io/port	Endpoint port number for Prometheus to collect data. For details, see **Monitoring Custom Metrics Using Cloud Native Cluster Monitoring**.	None
prometheus.io/scheme	Protocol used by Prometheus to collect data. The value can be **http** or **https**. For details, see **Monitoring Custom Metrics Using Cloud Native Cluster Monitoring**.	None
kubernetes.io/ingress-bandwidth	Ingress bandwidth of a pod. For details, see **Configuring QoS for a Pod**.	None
kubernetes.io/egress-bandwidth	Egress bandwidth of a pod. For details, see **Configuring QoS for a Pod**.	None

Pod Labels

When you create a workload on the console, the following labels are added to the pod by default. The value of **app** is the workload name.

Example YAML:

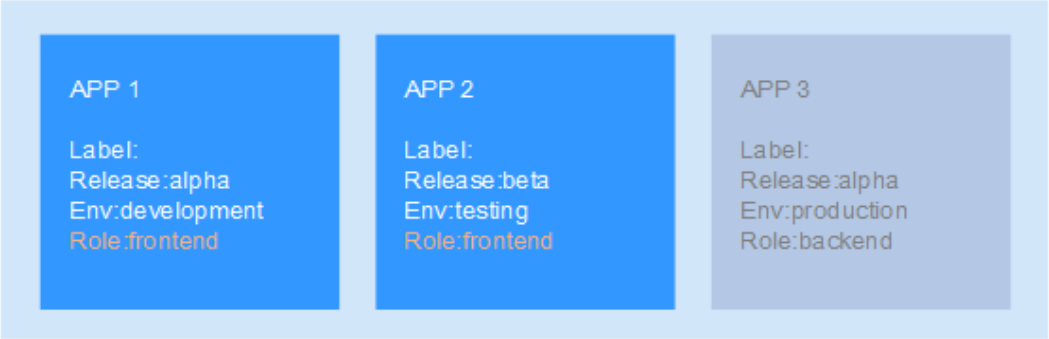
```
...
spec:
  selector:
    matchLabels:
      app: nginx
      version: v1
  template:
    metadata:
      labels:
        app: nginx
        version: v1
```

```
spec:
  ...
```

You can also add other labels to the pod for affinity and anti-affinity scheduling. In the following figure, three pod labels (release, env, and role) are defined for workload APP 1, APP 2, and APP 3. The values of these labels vary with workload.

- APP 1: [release:alpha;env:development;role:frontend]
- APP 2: [release:beta;env:testing;role:frontend]
- APP 3: [release:alpha;env:production;role:backend]

Figure 8-6 Label example



For example, if **key/value** is set to **role/backend**, APP 3 will be selected for affinity scheduling. For details, see **Workload Affinity (podAffinity)**.

8.4 Accessing a Container

Scenario

If you encounter unexpected problems when using a container, you can log in to the container to debug it.

Logging In to a Container Using kubectl

Step 1 Use kubectl to connect to the cluster. For details, see **Connecting to a Cluster Using kubectl**.

Step 2 Run the following command to view the created pod:

```
kubectl get pod
```

The example output is as follows:

```
NAME                     READY   STATUS    RESTARTS      AGE
nginx-59d89cb66f-mhljr   1/1     Running   0             11m
```

Step 3 Query the container name in the pod.

```
kubectl get po nginx-59d89cb66f-mhljr -o jsonpath='{range .spec.containers[*]}{.name}{end}{"\n"}'
```

The example output is as follows:

```
container-1
```

Step 4 Run the following command to log in to the **container-1** container in the **nginx-59d89cb66f-mhljr** pod:

```
kubectl exec -it nginx-59d89cb66f-mhljr -c container-1 -- /bin/sh
```

Step 5 To exit the container, run the **exit** command.

----End

8.5 Managing Workloads and Jobs

Scenario

After a workload is created, you can upgrade, monitor, roll back, or delete the workload, as well as edit its YAML file.

Table 8-19 Workload/Job management

Operation	Description
Monitor	You can view the CPU and memory usage of workloads and pods on the CCE console.
View Log	You can view the logs of workloads.
Upgrade	You can replace images or image tags to quickly upgrade Deployments, StatefulSets, and DaemonSets without interrupting services.
Edit YAML	You can modify and download YAML files of Deployments, StatefulSets, DaemonSets, CronJobs, and containers on the CCE console. YAML files of jobs can only be viewed, copied, and downloaded. **NOTE** If an existing CronJob is modified, the new configuration takes effect for the new pods, and the existing pod continues to run without any change.
Roll Back	Only Deployments can be rolled back.
Redeploy	You can redeploy a workload. After the workload is redeployed, all pods in the workload will be restarted.
Enabling/ Disabling the Upgrade	Only Deployments support this operation.
Manage Label	Labels are attached to workloads as key-value pairs to manage and select workloads. Jobs and Cron Jobs do not support this operation.
Delete	You can delete a workload or job that is no longer needed. Deleted workloads or jobs cannot be recovered.
View Events	You can view event names, event types, number of occurrences, Kubernetes events, first occurrence time, and last occurrence time.
Stop/Start	You can only start or stop a cron job.

Monitoring a Workload

You can view the CPU and memory usage of Deployments and pods on the CCE console to determine the resource specifications you may need. This section uses a Deployment as an example to describe how to monitor a workload.

Step 1 Log in to the CCE console, go to an existing cluster, and choose **Workloads** in the navigation pane.

Step 2 Click the **Deployments** tab and click **Monitor** of the target workload. On the page that is displayed, you can view CPU usage and memory usage of the workload.

Step 3 Click the workload name. On the **Pods** tab page, click the **Monitor** of the target pod to view its CPU and memory usage.

----End

Viewing Logs

You can view logs of Deployments, StatefulSets, DaemonSets, and jobs. This section uses a Deployment as an example to describe how to view logs.

NOTICE

Before viewing logs, ensure that the time of the browser is the same as that on the backend server.

Step 1 Log in to the CCE console, go to an existing cluster, and choose **Workloads** in the navigation pane.

Step 2 Click the **Deployments** tab and click the **View Log** of the target workload.

In the displayed **View Log** window, you can view logs.

NOTE

The displayed logs are standard output logs of containers and do not have persistence and advanced O&M capabilities. To use more comprehensive log capabilities, see **Logs**. If the function of collecting standard output is enabled for the workload (enabled by default), you can go to AOM to view more workload logs. For details, see **Collecting Container Logs Using ICAgent**.

----End

Upgrading a Workload

You quickly upgrade Deployments, StatefulSets, and DaemonSets on the CCE console.

This section uses a Deployment as an example to describe how to upgrade a workload.

Before replacing an image or image version, upload the new image to the SWR service.

Step 1 Log in to the CCE console, go to an existing cluster, and choose **Workloads** in the navigation pane.

Step 2 Click the **Deployments** tab and click **Upgrade** of the target workload.

NOTE

- Workloads cannot be upgraded in batches.
- Before performing an in-place StatefulSet upgrade, you must manually delete old pods. Otherwise, the upgrade status is always displayed as **Processing**.

Step 3 Upgrade the workload based on service requirements. The method for setting parameter is the same as that for creating a workload.

Step 4 After the update is complete, click **Upgrade Workload**, manually confirm the YAML file, and submit the upgrade.

----End

Editing a YAML file

You can modify and download YAML files of Deployments, StatefulSets, DaemonSets, CronJobs, and containers on the CCE console. YAML files of jobs can only be viewed, copied, and downloaded. This section uses a Deployment as an example to describe how to edit the YAML file.

Step 1 Log in to the CCE console, go to an existing cluster, and choose **Workloads** in the navigation pane.

Step 2 Click the **Deployments** tab and choose **More** > **Edit YAML** in the **Operation** column of the target workload. In the dialog box that is displayed, modify the YAML file.

Step 3 Click **OK**.

Step 4 (Optional) In the **Edit YAML** window, click **Download** to download the YAML file.

----End

Rolling Back a Workload (Available Only for Deployments)

CCE records the release history of all Deployments. You can roll back a Deployment to a specified version.

Step 1 Log in to the CCE console, go to an existing cluster, and choose **Workloads** in the navigation pane.

Step 2 Click the **Deployments** tab, choose **More > Roll Back** in the **Operation** column of the target workload.

Step 3 Switch to the **Change History** tab page, click **Roll Back to This Version** of the target version, manually confirm the YAML file, and click **OK**.

----End

Redeploying a Workload

After you redeploy a workload, all pods in the workload will be restarted. This section uses Deployments as an example to illustrate how to redeploy a workload.

Step 1 Log in to the CCE console, go to an existing cluster, and choose **Workloads** in the navigation pane.

Step 2 Click the **Deployments** tab and choose **More** > **Redeploy** in the **Operation** column of the target workload.

Step 3 In the dialog box that is displayed, click **Yes** to redeploy the workload.

----End

Disabling/Enabling Upgrade (Available Only for Deployments)

Only Deployments support this operation.

- After the upgrade is disabled, the upgrade command can be delivered but will not be applied to the pods.

  If you are performing a rolling upgrade, the rolling upgrade stops after the disabling upgrade command is delivered. In this case, the new and old pods co-exist.
- If a Deployment is being upgraded, it can be upgraded or rolled back. Its pods will inherit the latest updates of the Deployment. If they are inconsistent, the pods are upgraded automatically according to the latest information of the Deployment.

NOTICE

Deployments in the disable upgrade state cannot be rolled back.

Step 1 Log in to the CCE console, go to an existing cluster, and choose **Workloads** in the navigation pane.

Step 2 Click the **Deployments** tab and choose **More** > **Disable/Enable Upgrade** in the **Operation** column of the workload.

Step 3 In the dialog box that is displayed, click **Yes**.

----End

Managing Labels

Labels are key-value pairs and can be attached to workloads. You can manage and select workloads by labels. You can add labels to multiple workloads or a specified workload.

Step 1 Log in to the CCE console, go to an existing cluster, and choose **Workloads** in the navigation pane.

Step 2 Click the **Deployments** tab and choose **More** > **Manage Label** in the **Operation** column of the target workload.

Step 3 Click **Add**, enter a key and a value, and click **OK**.

NOTE

A key-value pair must contain 1 to 63 characters starting and ending with a letter or digit. Only letters, digits, hyphens (-), underscores (_), and periods (.) are allowed.

----End

Deleting a Workload/Job

You can delete a workload or job that is no longer needed. Deleted workloads or jobs cannot be recovered. Exercise caution when you perform this operation. This section uses a Deployment as an example to describe how to delete a workload.

Step 1 Log in to the CCE console, go to an existing cluster, and choose **Workloads** in the navigation pane.

Step 2 In the same row as the workload you will delete, choose **Operation** > **More** > **Delete**.

Read the system prompts carefully. A workload cannot be recovered after it is deleted. Exercise caution when performing this operation.

Step 3 Click **Yes**.

NOTE

- If the node where the pod is located is unavailable or shut down and the workload cannot be deleted, you can forcibly delete the pod from the pod list on the workload details page.
- Ensure that the storage volumes to be deleted are not used by other workloads. If these volumes are imported or have snapshots, you can only unbind them.

----End

Events

This section uses Deployments as an example to illustrate how to view events of a workload. To view the event of a job or cron jon, click **View Event** in the **Operation** column of the target workload.

Step 1 Log in to the CCE console, go to an existing cluster, and choose **Workloads** in the navigation pane.

Step 2 On the **Deployments** tab page, click the target workload. In the **Pods** tab page, click the **View Events** to view the event name, event type, number of occurrences, Kubernetes event, first occurrence time, and last occurrence time.

NOTE

Event data will be retained for one hour and then automatically deleted.

----End

8.6 Managing Custom Resources

Custom Resource Definition (CRD) is an extension of Kubernetes APIs. When default Kubernetes resources cannot meet service requirements, you can use CRDs to define new resource types. According to CRD, you can create custom resources in a cluster to meet service requirements. CRD allows you to create new resource types without adding new Kubernetes API servers. This makes cluster management more flexible.

Creating a CRD

Step 1 Log in to the CCE console.

Step 2 Click the cluster name to go to the cluster console, choose **Custom Resources** in the navigation pane, and click the **Create from YAML** in the upper right corner.

Step 3 Customize the YAML file to create a CRD based on service requirements. For details, see **Extend the Kubernetes API with CustomResourceDefinitions**.

Step 4 Click **OK**.

----End

Viewing CRDs and Their Resources

Step 1 Log in to the CCE console.

Step 2 Click the cluster name to access the cluster console. Choose **Custom Resources** in the navigation pane.

Step 3 On the **Custom Resources** page, view CRDs and their resources.

- View a CRD and its YAML.

  All CRDs in the cluster as well as their API groups, API versions, and resource application scopes are listed. Click **View YAML** in the **Operation** column of a CRD to view its YAML.

  You can enter a keyword in the search box to search for target resource types.

- View the resources of a CRD.

  Locate a CDR in the list and click **View Details** in the **Operation** column to view the resources.

----End

9 Scheduling

9.1 Overview

CCE supports different types of resource scheduling and task scheduling, improving application performance and overall cluster resource utilization. This section describes the main functions of CPU resource scheduling, GPU/NPU heterogeneous resource scheduling, and Volcano scheduling.

CPU Scheduling

CCE provides CPU policies to allocate complete physical CPU cores to applications, improving application performance and reducing application scheduling latency.

Function	Description	Documentation
CPU policy	When many CPU-intensive pods are running on a node, workloads may be migrated to different CPU cores. Many workloads are not sensitive to this migration and thus work fine without any intervention. For CPU-sensitive applications, you can use the CPU policy provided by Kubernetes to allocate dedicated cores to applications, improving application performance and reducing application scheduling latency.	CPU Policy

GPU Scheduling

CCE schedules heterogeneous GPU resources in clusters and allows GPUs to be used in containers.

Function	Description	Documentation
Default GPU scheduling in Kubernetes	This function allows you to specify the number of GPUs that a pod requests. The value can be less than 1 so that multiple pods can share a GPU.	Default GPU Scheduling in Kubernetes

NPU Scheduling

CCE schedules heterogeneous NPU resources in a cluster to quickly and efficiently perform inference and image recognition.

Function	Description	Documentation
NPU scheduling	NPU scheduling allows you to specify the number of NPUs that a pod requests to provide NPU resources for workloads.	NPU Scheduling

Volcano Scheduling

Volcano is a Kubernetes-based batch processing platform that supports machine learning, deep learning, bioinformatics, genomics, and other big data applications. It provides general-purpose, high-performance computing capabilities, such as job scheduling, heterogeneous chip management, and job running management.

Function	Description	Documentation
Scheduling workloads	Kubernetes typically uses its default scheduler to schedule workloads. To use Volcano, specify Volcano for your workloads.	Scheduling Workloads
Resource utilization-based scheduling	Scheduling policies are optimized for computing resources to effectively reduce resource fragments on each node and maximize computing resource utilization.	Resource Usage-based Scheduling
Priority-based scheduling	Scheduling policies are customized based on service importance and priorities to guarantee the resources of key services.	Priority-based Scheduling
AI performance-based scheduling	Scheduling policies are configured based on the nature and resource usage of AI tasks to increase the throughput of cluster services and improve service performance.	AI Performance-based Scheduling

Function	Description	Documentation
NUMA affinity scheduling	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 best node for NUMA topology.	NUMA Affinity Scheduling

9.2 CPU Scheduling

9.2.1 CPU Policy

Scenarios

By default, kubelet uses **CFS quotas** to enforce pod CPU limits. When the node runs many CPU-bound pods, the workload can move to different CPU cores depending on whether the pod is throttled and which CPU cores are available at scheduling time. Many workloads are not sensitive to this migration and thus work fine without any intervention. Some applications are CPU-sensitive. They are sensitive to:

- CPU throttling
- Context switching
- Processor cache misses
- Cross-socket memory access
- Hyperthreads that are expected to run on the same physical CPU card

If your workloads are sensitive to any of these items and CPU cache affinity and scheduling latency significantly affect workload performance, kubelet allows alternative CPU management policies (CPU binding) to determine some placement preferences on the node. The CPU manager preferentially allocates resources on a socket and full physical cores to avoid interference.

Constraints

The CPU management policy cannot take effect on physical cloud server nodes.

Enabling the CPU Management Policy

A **CPU management policy** is specified by the kubelet flag **--cpu-manager-policy**. By default, Kubernetes supports the following policies:

- Disabled (**none**): the default policy. The **none** policy explicitly enables the existing default CPU affinity scheme, providing no affinity beyond what the OS scheduler does automatically.

- Enabled (**static**): The **static** policy allows containers in **guaranteed** pods with integer GPU requests to be granted increased CPU affinity and exclusivity on the node.

When creating a cluster, you can configure the CPU management policy in **Advanced Settings**.

You can also configure the policy in a node pool. The configuration will change the kubelet flag **--cpu-manager-policy** on the node. Log in to the CCE console, click the cluster name, access the cluster details page, and choose **Nodes** in the navigation pane. On the page displayed, click the **Node Pools** tab. Choose **More** > **Manage** in the **Operation** column of the target node pool, and change the value of **cpu-manager-policy** to **static**.

Allowing Pods to Exclusively Use the CPU Resources

Prerequisites:

- Enable the **static** policy on the node. For details, see **Enabling the CPU Management Policy**.
- Both requests and limits must be configured in pods and their values must be the same integer.
- If an init container needs to exclusively use CPUs, set its requests to the same as that of the service container. Otherwise, the service container does not inherit the CPU allocation result of the init container, and the CPU manager reserves more CPU resources than supposed. For more information, see **App Containers can't inherit Init Containers CPUs - CPU Manager Static Policy**.

You can use **Scheduling Policies (Affinity/Anti-affinity)** to schedule the configured pods to the nodes where the **static** policy is enabled. In this way, the pods can exclusively use the CPU resources.

Example YAML:

```
kind: Deployment
apiVersion: apps/v1
metadata:
  name: test
spec:
  replicas: 1
  selector:
    matchLabels:
      app: test
  template:
    metadata:
      labels:
        app: test
    spec:
      containers:
        - name: container-1
          image: nginx:alpine
          resources:
            requests:
              cpu: 2          # The value must be an integer and must be the same as that in limits.
              memory: 2048Mi
            limits:
              cpu: 2          # The value must be an integer and must be the same as that in requests.
              memory: 2048Mi
      imagePullSecrets:
        - name: default-secret
```

9.3 GPU Scheduling

9.3.1 Default GPU Scheduling in Kubernetes

You can use GPUs in CCE containers.

Prerequisites

- A GPU node has been created. For details, see **Creating a Node**.
- The gpu-device-plugin (previously gpu-beta add-on) has been installed. During the installation, select the GPU driver on the node. For details, see **CCE AI Suite (NVIDIA GPU)**.
- gpu-device-plugin mounts the driver directory to **/usr/local/nvidia/lib64**. To use GPU resources in a container, add **/usr/local/nvidia/lib64** to the **LD_LIBRARY_PATH** environment variable.

  Generally, you can use any of the following methods to add a file:

  a. Configure the **LD_LIBRARY_PATH** environment variable in the Dockerfile used for creating an image. (Recommended)
  ```
  ENV LD_LIBRARY_PATH /usr/local/nvidia/lib64:$LD_LIBRARY_PATH
  ```

  b. Configure the **LD_LIBRARY_PATH** environment variable in the image startup command.
  ```
  /bin/bash -c "export LD_LIBRARY_PATH=/usr/local/nvidia/lib64:$LD_LIBRARY_PATH && ..."
  ```

  c. Define the **LD_LIBRARY_PATH** environment variable when creating a workload. (Ensure that this variable is not configured in the container. Otherwise, it will be overwritten.)
  ```
  ...
          env:
            - name: LD_LIBRARY_PATH
              value: /usr/local/nvidia/lib64
  ...
  ```

Using GPUs

Create a workload and request GPUs. You can specify the number of GPUs as follows:

```
apiVersion: apps/v1
kind: Deployment
metadata:
  name: gpu-test
  namespace: default
spec:
  replicas: 1
  selector:
    matchLabels:
      app: gpu-test
  template:
    metadata:
      labels:
        app: gpu-test
    spec:
      containers:
      - image: nginx:perl
        name: container-0
        resources:
```

```
        requests:
          cpu: 250m
          memory: 512Mi
          nvidia.com/gpu: 1   # Number of requested GPUs
        limits:
          cpu: 250m
          memory: 512Mi
          nvidia.com/gpu: 1   # Maximum number of GPUs that can be used
      imagePullSecrets:
      - name: default-secret
```

nvidia.com/gpu specifies the number of GPUs to be requested. The value can be smaller than **1**. For example, **nvidia.com/gpu: 0.5** indicates that multiple pods share a GPU. In this case, all the requested GPU resources come from the same GPU card.

NOTE

When you use **nvidia.com/gpu** to specify the number of GPUs, the values of requests and limits must be the same.

After **nvidia.com/gpu** is specified, workloads will not be scheduled to nodes without GPUs. If the node is GPU-starved, Kubernetes events similar to the following are reported:

- 0/2 nodes are available: 2 Insufficient nvidia.com/gpu.
- 0/4 nodes are available: 1 InsufficientResourceOnSingleGPU, 3 Insufficient nvidia.com/gpu.

To use GPU resources on the CCE console, you only need to configure the GPU quota when creating a workload.

GPU Node Labels

CCE will label GPU-enabled nodes after they are created. Different types of GPU-enabled nodes have different labels.

```
$ kubectl get node -L accelerator
NAME          STATUS   ROLES    AGE     VERSION                                 ACCELERATOR
10.100.2.179   Ready    <none>   8m43s   v1.19.10-r0-CCE21.11.1.B006-21.11.1.B006   nvidia-t4
```

When using GPUs, you can enable the affinity between pods and nodes based on labels so that the pods can be scheduled to the correct nodes.

```
apiVersion: apps/v1
kind: Deployment
metadata:
  name: gpu-test
  namespace: default
spec:
  replicas: 1
  selector:
    matchLabels:
      app: gpu-test
  template:
    metadata:
      labels:
        app: gpu-test
    spec:
      nodeSelector:
        accelerator: nvidia-t4
      containers:
      - image: nginx:perl
        name: container-0
```

```
      resources:
        requests:
          cpu: 250m
          memory: 512Mi
          nvidia.com/gpu: 1   # Number of requested GPUs
        limits:
          cpu: 250m
          memory: 512Mi
          nvidia.com/gpu: 1   # Maximum number of GPUs that can be used
    imagePullSecrets:
    - name: default-secret
```

9.4 NPU Scheduling

You can use NPUs in CCE containers.

Prerequisites

- An NPU node has been created. For details, see **Creating a Node**.
- The huawei-npu has been installed. For details, see **CCE AI Suite (Ascend NPU)**.

Using NPUs

Create a workload and request NPUs. You can specify the number of NPUs as follows:

```
kind: Deployment
apiVersion: apps/v1
metadata:
  name: npu-test
  namespace: default
spec:
  replicas: 1
  selector:
    matchLabels:
      app: npu-test
  template:
    metadata:
      labels:
        app: npu-test
    spec:
      containers:
        - name: container-0
          image: nginx:perl
          resources:
            limits:
              cpu: 250m
              huawei.com/ascend-310: '1'
              memory: 512Mi
            requests:
              cpu: 250m
              huawei.com/ascend-310: '1'
              memory: 512Mi
      imagePullSecrets:
      - name: default-secret
```

Specify the number of NPUs to be requested in **huawei.com/ascend-310**.

NOTE

When you use **huawei.com/ascend-310** to specify the number of NPUs, the values of requests and limits must be the same.

After **huawei.com/ascend-310** is specified, workloads will be scheduled only to nodes with NPUs. If NPUs are insufficient, a Kubernetes event similar to "0/2 nodes are available: 2 Insufficient huawei.com/ascend-310." will be reported.

To use NPUs on the CCE console, select the NPU quota and specify the number of NPUs to be used when creating a workload.

NPU Node Labels

CCE will label NPU-enabled nodes that are ready to use.

```
$ kubectl get node -L accelerator/huawei-npu
NAME          STATUS   ROLES    AGE     VERSION                                 HUAWEI-NPU
10.100.2.59   Ready    <none>   2m18s   v1.19.10-r0-CCE21.11.1.B006-21.11.1.B006   ascend-310
```

When using NPUs, you can enable the affinity between pods and nodes based on labels so that the pods can be scheduled to the correct nodes.

```
kind: Deployment
apiVersion: apps/v1
metadata:
  name: npu-test
  namespace: default
spec:
  replicas: 1
  selector:
    matchLabels:
      app: npu-test
  template:
    metadata:
      labels:
        app: npu-test
    spec:
      nodeSelector:
        accelerator/huawei-npu: ascend-310
      containers:
        - name: container-0
          image: nginx:perl
          resources:
            limits:
              cpu: 250m
              huawei.com/ascend-310: '1'
              memory: 512Mi
            requests:
              cpu: 250m
              huawei.com/ascend-310: '1'
              memory: 512Mi
      imagePullSecrets:
      - name: default-secret
```

9.5 Volcano Scheduling

9.5.1 Overview

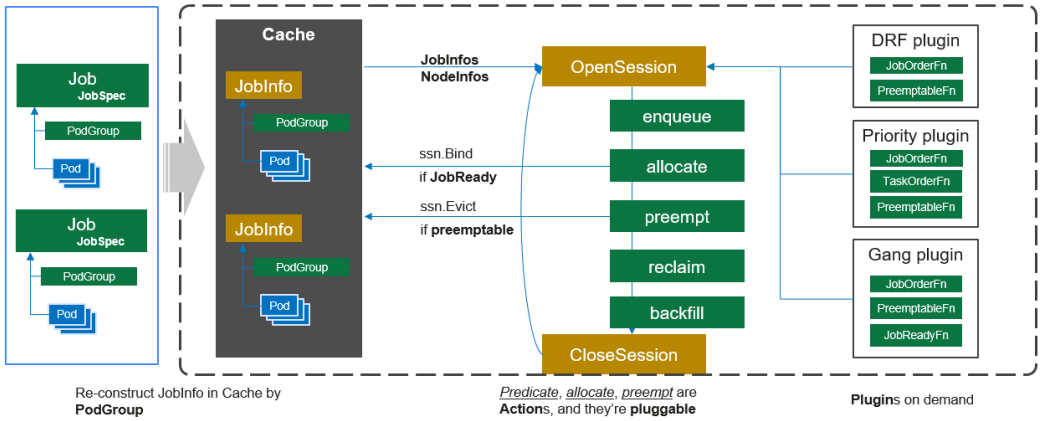
Volcano is a Kubernetes-based batch processing platform that supports machine learning, deep learning, bioinformatics, genomics, and other big data applications. It provides general-purpose, high-performance computing capabilities, such as job scheduling, heterogeneous chip management, and job running management.

Volcano Scheduler

Volcano Scheduler is a pod scheduling component, which consists of a series of actions and plugins. Actions should be executed in every step. Plugins provide the

action algorithm details in different scenarios. Volcano Scheduler features high scalability. You can specify actions and plugins as needed.

Figure 9-1 Volcano Scheduler workflow



The working process of Volcano Scheduler is as follows:

1. Identify and cache the job submitted by the client.
2. Start a periodical session. A scheduling cycle begins.
3. Send jobs that are not scheduled the to-be-scheduled queue of the session.
4. Traverse all jobs to be scheduled and perform actions such as enqueue, allocate, preempt, reclaim, and backfill in the configured sequence to find the most appropriate node for each job. Bind the job to the node. The specific algorithm logic executed in **action** depends on the implementation of each function in the registered plugin.
5. Close the session.

Custom Volcano Resources

- A pod group is a custom Volcano resource type. It is a group of pods with strong association and is mainly used in batch scheduling, for example, ps and worker tasks in TensorFlow.
- A Queue contains a group of PodGroups. It is also the basis for the PodGroups to obtain cluster resources.
- Volcano Job (vcjob for short) is a custom job resource type. Different from Kubernetes Jobs, vcjob supports specified scheduler, the minimum number of running pods, tasks, lifecycle management, specified queues, and priority-based scheduling. Volcano Job is more suitable for high-performance computing scenarios such as machine learning, big data, and scientific computing.

9.5.2 Scheduling Workloads

Volcano is a Kubernetes-based batch processing platform with high-performance general computing capabilities like task scheduling engine, heterogeneous chip management, and task running management. It provides end users with computing frameworks from multiple domains such as AI, big data, gene, and rendering. It also offers job scheduling, job management, and queue management for computing applications.

Kubernetes typically uses its default scheduler to schedule workloads. To use Volcano, specify Volcano for your workloads. For details about the Kubernetes scheduler, see **Specify schedulers for pods**.

Constraints

When a large number of workloads are scheduled, Volcano prints a large number of logs. In this case, you can use Volcano with LTS. Otherwise, the disk space of the node where Volcano resides may be used up. For details, see **Collecting Container Logs**.

Using Volcano

When using Volcano to schedule workloads, you only need to configure **schedulerName** in the **spec** field of the pod and set the parameter to **volcano**. The following is an example:

```
apiVersion: apps/v1
kind: Deployment
metadata:
  name: nginx
  labels:
    app: nginx
spec:
  replicas: 4
  selector:
    matchLabels:
      app: nginx
  template:
    metadata:
      annotations:
        # Submit the job to the q1 queue.
        scheduling.volcano.sh/queue-name: "q1"
        volcano.sh/preemptable: "true"
      labels:
        app: nginx
    spec:
      # Specify Volcano as the scheduler.
      schedulerName: volcano
      containers:
      - name: nginx
        image: nginx
        imagePullPolicy: IfNotPresent
        resources:
          limits:
            cpu: 1
            memory: 100Mi
          requests:
            cpu: 1
            memory: 100Mi
        ports:
        - containerPort: 80
```

Additionally, Volcano supports the workload queues and preemption, which can be implemented through pod annotations. The following table lists the supported annotations.

Table 9-1 Pod annotations supported by Volcano

Pod Annotations	Remarks
scheduling.volcano.sh/queue-name: "<queue-name>"	Specifies the queue to which the workload belongs. *<queue-name>* indicates the queue name.
volcano.sh/preemptable: "true"	Indicates whether a job can be preempted. If this function is enabled, the job can be preempted. Options: • **true**: Preemption is enabled. This option is enabled by default. • **false**: Preemption is disabled.

You can obtain pod details to check whether the pod is scheduled by Volcano and the allocated queue.

```
kubectl describe pod <pod_name>
```

Command output:

```
Spec:
  Min Member:  1
  Min Resources:
    Cpu:     100m
    Memory:  100Mi
  Queue:     q1
Status:
  Conditions:
    Last Transition Time:  2023-05-30T01:54:43Z
    Reason:                tasks in gang are ready to be scheduled
    Status:                True
    Transition ID:         70be1d7d-3532-41e0-8324-c7644026b38f
    Type:                  Scheduled
  Phase:                   Running
Events:
  Type    Reason     Age             From     Message
  ----    ------     ----            ----     -------
  Normal  Scheduled  0s (x3 over 2s)  volcano  pod group is ready
```

9.5.3 Resource Usage-based Scheduling

9.5.3.1 Bin Packing

Bin packing is an optimization algorithm that aims to properly allocate resources to each job and get the jobs done using the minimum amount of resources. 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.

Prerequisites

- A cluster of v1.19 or later is available. For details, see **Buying a CCE Standard Cluster**.

- The Volcano add-on has been installed. For details, see **Volcano Scheduler**.

Features

Bin packing aims to fill as many existing nodes as possible (try not to allocate blank nodes). In the concrete implementation, the bin packing algorithm scores the nodes that can be delivered, and a higher score indicates a higher resource utilization rate of nodes. Bin packing intends to centrally schedule application workloads onto some nodes in a cluster, which facilitates auto scaling of cluster nodes.

The bin packing add-on works with other scheduling add-ons of the scheduler to score nodes. You can customize the overall weight of the add-on and the weight of each resource to modify the influence in the node score. When using bin packing to calculate node scores, the scheduler considers extended resources such as CPUs, memory, and GPUs requested by pods, and calculates the scores based on the weights configured for each resource.

How It Works

A node is scored based on the overall weight of the bin packing add-on and the weight of each resource. Each type of resource requested by the to-be-scheduled pods is scored. Take CPUs as an example, the CPU score is calculated using the following formula:

CPU.weight x (Requested + Used)/Allocatable

A larger CPU weight leads to a higher score. A higher resource usage of a node leads to a higher node score. The same rule applies to memory and GPU resources. The parameters in the formula for scoring a resource are as follows:

- **CPU.weight**: customized CPU weight
- **Requested**: CPU resources requested by the pods to be scheduled
- **Used**: CPU resources that have been used on the current node
- **Allocatable**: total CPU resources available on the current node

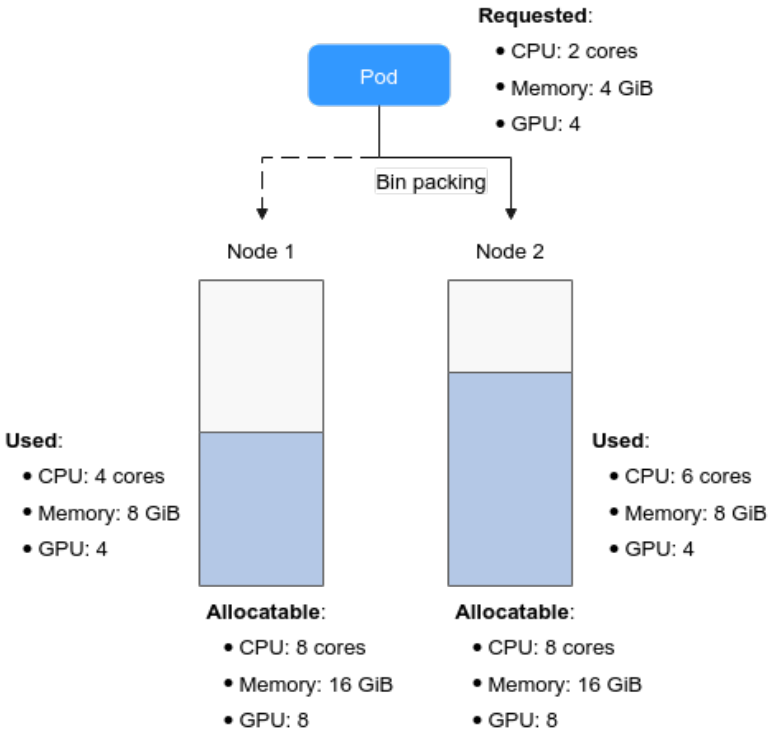
The bin packing add-on calculates the score of a node using the following formula:

Binpack.weight x (CPU.score + Memory.score + GPU.score)/(CPU.weight + Memory.weight + GPU.weight) x 100

A larger bin packing weight leads to a higher score. A larger resource weight leads to a greater influence in the node score. The parameters in the formula for scoring a node are as follows:

- **Binpack.weight**: bin packing weight
- **CPU.score**: calculated CPU score; **CPU.weight**: customized CPU weight
- **Memory.score**: calculated memory score; **Memory.weight**: customized memory weight
- **GPU.score**: calculated GPU score; **GPU.weight**: customized GPU weight

Figure 9-2 Bin packing example



As shown in the figure, there are two nodes in the cluster. When pods need to be scheduled, the bin packing policy scores the two nodes separately.

1. The scoring for node 1 is as follows:

   Each resource is scored using the following formula: CPU.weight x (Requested + Used)/Allocatable

   - CPU score: 1 x (2 + 4)/8 = 0.75
   - Memory score: 1 x (4 + 8)/16 = 0.75
   - GPU score: 2 x (4 + 4)/8 = 1

   The total score of each node is calculated using the following formula: Binpack.weight x (CPU.score + Memory.score + GPU.score)/(CPU.weight + Memory.weight + GPU.weight) x 100

   Score of node 1: 5 x (0.75 + 0.75 + 1)/(1 + 1 + 2) x 100 = 312.5

2. The scoring for node 2 is as follows:

   - CPU score: 1 x (2 + 6)/8 = 1
   - Memory score: 1 x (4 + 8)/16 = 0.75
   - GPU score: 2 x (4 + 4)/8 = 1

   Score of node 2: 5 x (1 + 0.75 + 1)/(1 + 1 + 2) x 100 = 343.75

The calculation results show that the score of node 2 is greater than that of node 1. According to the bin packing policy, new pods will be preferentially scheduled to node 2.

Configuring Bin Packing

After Volcano is installed, bin packing takes effect by default. If the default configuration cannot meet your requirements, you can customize the weight of bin packing and the weight of each resource on the **Scheduling** page. To do so, perform the following operations:

Step 1 Log in to the CCE console.

Step 2 Click the cluster name to access the cluster console. Choose **Settings** in the navigation pane and click the **Scheduling** tab.

Step 3 In the **Resource utilization optimization scheduling** area, modify the bin packing settings.

Table 9-2 Bin packing weight

Item	Description	Default Value
Binpack Scheduling Strategy Weight	A larger value indicates a higher weight of the bin packing policy in overall scheduling.	10
CPU Weight	A larger value indicates a higher cluster CPU usage.	1
Memory Weight	A larger value indicates a higher cluster memory usage.	1
Custom Resource Type	Other custom resource types requested by pods, for example, **nvidia.com/gpu**. A larger value indicates a higher usage of the specified cluster resource.	None

Step 4 Click **Confirm**.

----End

9.5.3.2 Descheduling

Scheduling in a cluster is the process of binding pending pods to nodes, and is performed by a component called kube-scheduler or Volcano Scheduler. The scheduler uses a series of algorithms to compute the optimal node for running pods. However, Kubernetes clusters are dynamic and their state changes over time. For example, if a node needs to be maintained, all pods on the node will be evicted to other nodes. After the maintenance is complete, the evicted pods will not automatically return back to the node because descheduling will not be triggered once a pod is bound to a node. Due to these changes, the load of a cluster may be unbalanced after the cluster runs for a period of time.

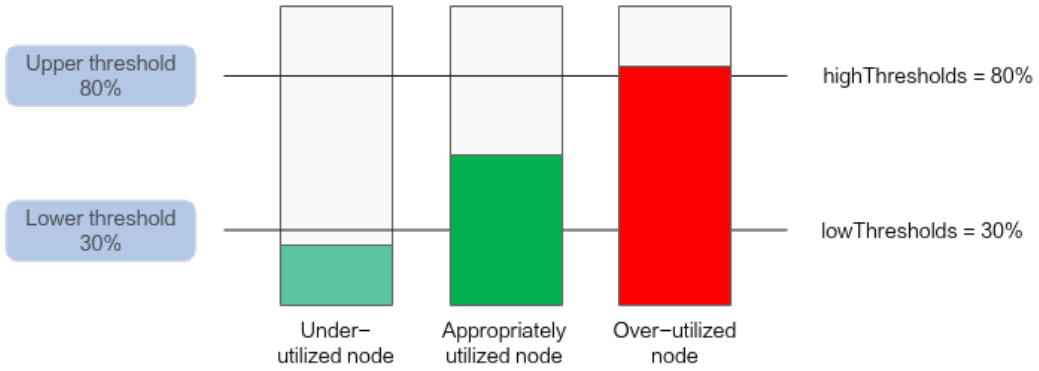
CCE has resolved this issue by using Volcano Scheduler to evict pods that do not comply with the configured policy so that pods can be rescheduled. In this way, the cluster load is balanced and resource fragmentation is minimized.

Features

Load-aware Descheduling

During Kubernetes cluster management, over-utilized nodes are due to high CPU or memory usage, which affects the stable running of pods on these nodes and increases the probability of node faults. To dynamically balance the resource usage between nodes in a cluster, a cluster resource view is required based on node monitoring metrics. During cluster management, real-time monitoring can be used to detect issues such as high resource usage on a node, node faults, and excessive number of pods on a node so that the system can take measures promptly, for example, by migrating some pods from an over-utilized node to under-utilized nodes.

Figure 9-3 Load-aware descheduling



When using this add-on, ensure the **highThresholds** value is greater than the **lowThresholds** value. Otherwise, the descheduler cannot work.

- **Appropriately utilized node**: a node whose resource usage is greater than or equal to 30% and less than or equal to 80%. The resource usage of appropriately utilized nodes is within the expected range.
- **Over-utilized node**: a node whose resource usage is higher than 80%. Some pods will be evicted from over-utilized nodes to reduce its resource usage to be less than or equal to 80%. The descheduler will schedule the evicted pods to under-utilized nodes.
- **Under-utilized node**: a node whose resource usage is lower than 30%.

HighNodeUtilization

This policy finds nodes that are under-utilized and evicts pods from the nodes in the hope that these pods will be scheduled compactly into fewer nodes. This policy must be used with the bin packing policy of Volcano Scheduler or the MostAllocated policy of the kube-scheduler scheduler. Thresholds can be configured for CPU and memory.

Prerequisites

- A cluster of v1.19.16 or later is available. For details, see **Buying a CCE Standard Cluster**.
- Volcano of v1.11.5 or later has been installed in the cluster. For details, see **Volcano Scheduler**.

Constraints

- Pods need to be rescheduled using a scheduler, and no scheduler can label pods or nodes. Therefore, an evicted pod might be rescheduled to the original node.
- Descheduling does not support anti-affinity between pods. An evicted pod is in anti-affinity relationship with other running pods. Therefore, the scheduler may still schedule the pod back to the node where the pod was evicted from.
- When configuring load-aware descheduling, you are required to enable load-aware scheduling on Volcano Scheduler. When configuring HighNodeUtilization, you are required to enable bin packing on Volcano Scheduler.

Configuring a Load-aware Descheduling Policy

When configuring a load-aware descheduling policy, do as follows to enable load-aware scheduling on Volcano Scheduler:

Step 1 Log in to the CCE console and click the cluster name to access the cluster console. In the navigation pane, choose **Settings** and click the **Scheduling** tab on the right side of the page. Then, enable load-aware scheduling.

Step 2 In the navigation pane, choose **Add-ons**. Locate **Volcano Scheduler** on the right and click **Install** or **Edit**.

Step 3 In the **Parameters** area, modify **Advanced Settings** to configure the load-aware descheduling policy. The following shows a configuration example for Volcano 1.11.21 or later:

```
{
  "colocation_enable": "",
  "default_scheduler_conf": {
    "actions": "allocate, backfill, preempt",
    "tiers": [
      {
        "plugins": [
          {
            "name": "priority"
          },
          {
            "enablePreemptable": false,
            "name": "gang"
          },
          {
            "name": "conformance"
          }
        ]
      },
      {
        "plugins": [
          {
            "enablePreemptable": false,
            "name": "drf"
          },
          {
            "name": "predicates"
          },
          {
            "name": "nodeorder"
          },
          {
            "name": "usage",
            "enablePredicate": true,
```

```
          "arguments": {
            "usage.weight": 5,
            "cpu.weight": 1,
            "memory.weight": 1,
            "thresholds": {
              "cpu": 80,
              "mem": 80
            }
          }
        }
      ]
    },
    {
      "plugins": [
        {
          "name": "cce-gpu-topology-predicate"
        },
        {
          "name": "cce-gpu-topology-priority"
        },
        {
          "name": "cce-gpu"
        }
      ]
    },
    {
      "plugins": [
        {
          "name": "nodelocalvolume"
        },
        {
          "name": "nodeemptydirvolume"
        },
        {
          "name": "nodeCSIscheduling"
        },
        {
          "name": "networkresource"
        }
      ]
    }
  ]
},
"deschedulerPolicy": {
  "profiles": [
    {
      "name": "ProfileName",
      "pluginConfig": [
        {
          "args": {
            "ignorePvcPods": true,
            "nodeFit": true,
            "priorityThreshold": {
              "value": 100
            }
          },
          "name": "DefaultEvictor"
        },
        {
          "args": {
            "evictableNamespaces": {
              "exclude": ["kube-system"]
            },
            "metrics": {
              "type": "prometheus_adaptor"
            },
            "targetThresholds": {
              "cpu": 80,
              "memory": 85
```

```
            },
            "thresholds": {
              "cpu": 30,
              "memory": 30
            }
          },
          "name": "LoadAware"
        }
      ],
      "plugins": {
        "balance": {
          "enabled": ["LoadAware"]
        }
      }
    }
  ]
 },
 "descheduler_enable": "true",
 "deschedulingInterval": "10m"
}
```

Table 9-3 Key parameters of a cluster descheduling policy

Parameter	Description
descheduler_enable	Whether to enable a cluster descheduling policy. • **true**: The cluster descheduling policy is enabled. • **false**: The cluster descheduling policy is disabled.
deschedulingInterval	Descheduling period.
deschedulerPolicy	Cluster descheduling policy. For details, see **Table 9-4**.

Table 9-4 deschedulerPolicy parameters

Parameter	Description
profiles.[].plugins.balance.enable.[]	Descheduling policy for a cluster. **LoadAware**: a load-aware descheduling policy is used.
profiles.[].pluginConfig.[].name	Configuration of a load-aware descheduling policy. Options: • **DefaultEvictor**: default eviction policy • **LoadAware**: a load-aware descheduling policy

Parameter	Description

profiles.[].pluginConfig.[].args	Descheduling policy configuration of a cluster.
	• Configurations for the **DefaultEvictor** policy:
	– **ignorePvcPods**: whether PVC pods should be ignored or evicted. Value **true** indicates that the pods are ignored, and value **false** indicates that the pods are evicted. This configuration does not differentiate PVC types (local PVs, SFS, or EVS).
	– **nodeFit**: whether to consider the existing scheduling configurations such as node affinity and taint on the node during descheduling. Value **true** indicates that the existing scheduling configurations will be considered, and value **false** indicates that those will be ignored.
	– **priorityThreshold**: priority setting. If the priority of a pod is greater than or equal to the value of this parameter, the pod will not be evicted. Example:
	`{ "value": 100 }`
	• Configurations for the **LoadAware** policy:
	– **evictableNamespaces**: namespaces where the eviction policy takes effect. The default value is the namespaces other than kube-system. Example:
	`{ "exclude": ["kube-system"] }`
	– **metrics**: how monitoring data is obtained. Either the Custom Metrics API (prometheus_adaptor) or Prometheus can be used.
	For Volcano 1.11.17 and later versions, use Custom Metrics API to obtain monitoring data. The following is an example:
	`{ "type": "prometheus_adaptor" }`
	For Volcano 1.11.5 to 1.11.16, use Prometheus to obtain monitoring data. You need to enter the IP address of the Prometheus server. The following is an example:
	`{ "address": "http://10.247.119.103:9090", "type": "prometheus" }`
	– **targetThresholds**: threshold for evicting pods from a node. When the CPU or memory usage of a node is greater than the threshold, the pods on the node will be evicted. Example:
	`{ "cpu": 60,`

Parameter	Description

	"memory": 65
	}
	– **thresholds**: threshold for a node to run pods. If the node value is less than the threshold, the node allows evicted pods to run. Example:
	{
	"cpu": 30,
	"memory": 30
	}

Step 4 Click **OK**.

----End

Configuring a HighNodeUtilization Policy

When configuring a HighNodeUtilization policy, do as follows to enable the bin packing policy on Volcano Scheduler:

Step 1 Log in to the CCE console and click the cluster name to access the cluster console. In the navigation pane, choose **Settings** and click the **Scheduling** tab on the right side of the page. Then, enable bin packing. For details, see **Bin Packing**.

Step 2 In the navigation pane, choose **Add-ons**. Locate **Volcano Scheduler** on the right and click **Install** or **Edit**.

Step 3 In the **Parameters** area, modify **Advanced Settings** to configure the HighNodeUtilization policy.

```
{
  "colocation_enable": "",
  "default_scheduler_conf": {
    "actions": "allocate, backfill, preempt",
    "tiers": [
      {
        "plugins": [
          {
            "name": "priority"
          },
          {
            "enablePreemptable": false,
            "name": "gang"
          },
          {
            "name": "conformance"
          },
          {
            "arguments": {
              "binpack.weight": 5
            },
            "name": "binpack"
          }
        ]
      },
      {
        "plugins": [
          {
            "enablePreemptable": false,
            "name": "drf"
          },
          {
```

```
        "name": "predicates"
       },
       {
        "name": "nodeorder"
       }
      ]
    },
    {
      "plugins": [
       {
        "name": "cce-gpu-topology-predicate"
       },
       {
        "name": "cce-gpu-topology-priority"
       },
       {
        "name": "cce-gpu"
       }
      ]
    },
    {
      "plugins": [
       {
        "name": "nodelocalvolume"
       },
       {
        "name": "nodeemptydirvolume"
       },
       {
        "name": "nodeCSIscheduling"
       },
       {
        "name": "networkresource"
       }
      ]
    }
  ]
},
"deschedulerPolicy": {
  "profiles": [
    {
      "name": "ProfileName",
      "pluginConfig": [
       {
        "args": {
          "ignorePvcPods": true,
          "nodeFit": true,
          "priorityThreshold": {
            "value": 100
          }
        },
        "name": "DefaultEvictor"
       },
       {
        "args": {
          "evictableNamespaces": {
            "exclude": ["kube-system"]
          },
          "thresholds": {
            "cpu": 25,
            "memory": 25
          }
        },
        "name": "HighNodeUtilization"
       }
      ],
      "plugins": {
       "balance": {
        "enabled": ["HighNodeUtilization"]
```

```
        }
      }
    }
  ]
 },
 "descheduler_enable": "true",
 "deschedulingInterval": "10m"
}
```

Table 9-5 Key parameters of a cluster descheduling policy

Parameter	Description
descheduler_enable	Whether to enable a cluster descheduling policy. • **true**: The cluster descheduling policy is enabled. • **false**: The cluster descheduling policy is disabled.
deschedulingInterval	Descheduling period.
deschedulerPolicy	Cluster descheduling policy. For details, see **Table 9-6**.

Table 9-6 deschedulerPolicy parameters

Parameter	Description
profiles.[].plugins.balance.enable.[]	Descheduling policy for a cluster. **HighNodeUtilization**: the policy for minimizing CPU and memory fragments is used.
profiles.[].pluginConfig.[].name	Configuration of a load-aware descheduling policy. Options: • **DefaultEvictor**: default eviction policy • **HighNodeUtilization**: policy for minimizing CPU and memory fragments

Parameter	Description

profiles.[].pluginConfig.[].args	Descheduling policy configuration of a cluster.
	• Configurations for the **DefaultEvictor** policy:
	– **ignorePvcPods**: whether PVC pods should be ignored or evicted. Value **true** indicates that the pods are ignored, and value **false** indicates that the pods are evicted. This configuration does not differentiate PVC types (local PVs, SFS, or EVS).
	– **nodeFit**: whether to consider the existing scheduling configurations such as node affinity and taint on the node during descheduling. Value **true** indicates that the existing scheduling configurations will be considered, and value **false** indicates that those will be ignored.
	– **priorityThreshold**: priority setting. If the priority of a pod is greater than or equal to the value of this parameter, the pod will not be evicted. Example:
	`{ "value": 100 }`
	• Configurations for the **HighNodeUtilization** policy:
	– **evictableNamespaces**: namespaces where the eviction policy takes effect. The default value is the namespaces other than kube-system. Example:
	`{ "exclude": ["kube-system"] }`
	– **thresholds**: threshold for evicting pods from a node. When the CPU or memory usage of a node is less than the threshold, the pods on the node will be evicted. Example:
	`{ "cpu": 25, "memory": 25 }`

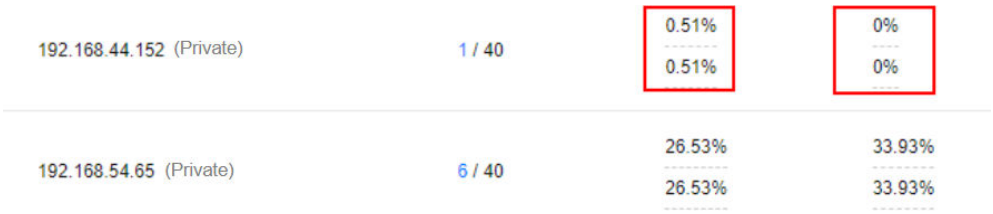
Step 4 Click **OK**.

----End

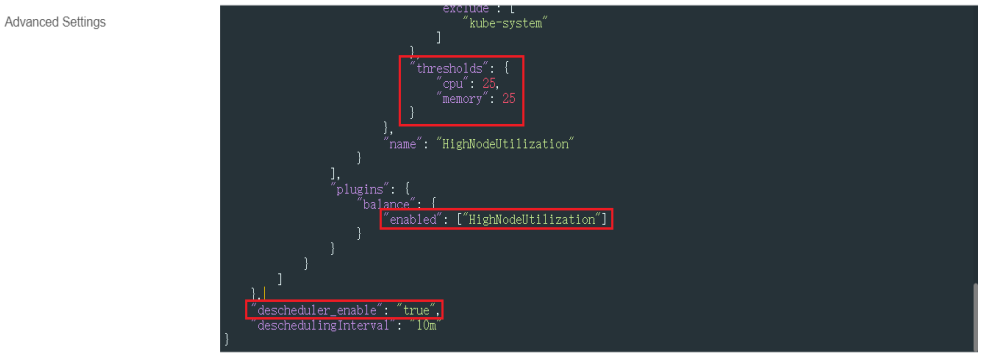
Use Cases

HighNodeUtilization

1. Check the nodes in a cluster. It is found that some nodes are under-utilized.



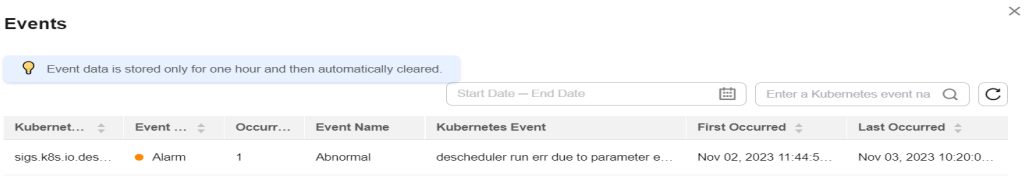
2. Edit the Volcano parameters to enable the descheduler and set the CPU and memory usage thresholds to **25**. When the CPU and memory usage of a node is less than 25%, pods on the node will be evicted.



3. After the policy takes effect, pods on the node with IP address 192.168.44.152 will be migrated to the node with IP address 192.168.54.65 for minimized resource fragments.

Common Issues

If an input parameter is incorrect, for example, the entered value is beyond the accepted value range or in an incorrect format, an event will be generated.



9.5.3.3 Node Pool Affinity

In scenarios such as node pool replacement and rolling node upgrade, an old resource pool needs to be replaced with a new one. To prevent the node pool replacement from affecting services, enable soft affinity to schedule service pods to the new node pool. Soft affinity scheduling tries to schedule newly created pods or rescheduled pods to the new node pool. If the pods cannot be scheduled to the new node pool, for example, due to insufficient resources, the pods can also be scheduled to the old node pool. Since a node pool replacement should not affect services, the node affinity configuration is not declared in service workloads. Use

soft affinity in cluster scheduling to schedule pods to new node pools when a pool replacement is triggered.

Volcano aims to soft schedule service pods to specified nodes when node soft affinity is not configured on service workloads.

Scheduling Priority

Soft affinity scheduling of a node pool is implemented based on labels in the node pool. Each node in the node pool is scored to select the optimal one for pod scheduling.

The rule is to schedule pods to nodes with specified labels as far as possible.

The formula for scoring a node is as follows:

Node score = Weight x MaxNodeScore x haveLabel

Parameters:

- **Weight**: weight of the soft affinity add-on in the node pool.
- **MaxNodeScore**: maximum score (100) of a node.
- **haveLabel**: whether the labels configured in the add-on are available on a node. If yes, the value is **1**. If no, the value is **0**.

Prerequisites

- A cluster of v1.19.16 or later is available. For details, see **Buying a CCE Standard Cluster**.
- Volcano of v1.11.5 or later has been installed in the cluster. For details, see **Volcano Scheduler**.

Configuring Soft Affinity Scheduling for Volcano Node Pools

Step 1 Configure labels for affinity scheduling in the node pool.

1. Log in to the CCE console.
2. Click the cluster name to access the cluster console. Choose **Nodes** in the navigation pane and click the **Node Pools** tab.
3. Click **Update** of the target node pool. On the page that is displayed, configure labels in the **Kubernetes Label** area.

Step 2 Choose **Add-ons** in the navigation pane, locate **Volcano Scheduler** on the right, click **Install** or **Edit**, and configure Volcano scheduler parameters in the **Parameters** area.

```
{
  "ca_cert": "",
  "default_scheduler_conf": {
    "actions": "allocate, backfill, preempt",
    "tiers": [
      {
        "plugins": [
          {
            "name": "priority"
          },
          {
            "name": "gang"
          },
```

```
            {
               "name": "conformance"
            }
         ]
      },
      {
         "plugins": [
            {
               "name": "drf"
            },
            {
               "name": "predicates"
            },
            {
               "name": "nodeorder"
            }
         ]
      },
      {
         "plugins": [
            {
               "name": "cce-gpu-topology-predicate"
            },
            {
               "name": "cce-gpu-topology-priority"
            },
            {
               "name": "cce-gpu"
            },
            {
               // Enable node pool affinity scheduling.
               "name": "nodepoolaffinity",
               // Configure the affinity scheduling weight and labels of the node pool.
               "arguments": {
                  "nodepoolaffinity.weight": 10000,
                  "nodepoolaffinity.label": "nodepool1=nodepool1"
               }
            }
         ]
      },
      {
         "plugins": [
            {
               "name": "nodelocalvolume"
            },
            {
               "name": "nodeemptydirvolume"
            },
            {
               "name": "nodeCSIscheduling"
            },
            {
               "name": "networkresource"
            }
         ]
      }
   ]
  },
  "server_cert": "",
  "server_key": ""
}
```

Step 3 Click **OK**.

----End

9.5.4 Priority-based Scheduling

9.5.4.1 Priority-based Scheduling

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.

Prerequisites

- A cluster of v1.19 or later is available. For details, see **Buying a CCE Standard Cluster**.
- The Volcano add-on has been installed. For details, see **Volcano Scheduler**.

Overview

The services running in a cluster are diversified, including core services, non-core services, online services, and offline services. You can configure priorities for different services based on service importance and SLA requirements. For example, configure a high priority for core services and online services so that such services preferentially obtain cluster resources.

Table 9-7 lists the priority-based scheduling supported by CCE clusters.

Table 9-7 Priority-based scheduling

Scheduling Type	Description	Scheduler
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.	kube-scheduler or Volcano scheduler

Configuring Priority-based Scheduling Policies

Step 1 Log in to the CCE console.

Step 2 Click the cluster name to access the cluster console. Choose **Settings** in the navigation pane and click the **Scheduling** tab.

Step 3 In the **Business priority scheduling** area, configure priority-based scheduling.

- **Scheduling based on priority**: 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.

Step 4 After the configuration, you can use **PriorityClasses** to schedule the pods of workloads or Volcano jobs based priorities.

1. Create one or more **PriorityClasses**.

```
apiVersion: scheduling.k8s.io/v1
kind: PriorityClass
metadata:
  name: high-priority
```

```
value: 1000000
globalDefault: false
description: ""
```

2. Create a workload or Volcano job and specify its PriorityClass name.
   - Workload

     ```
     apiVersion: apps/v1
     kind: Deployment
     metadata:
       name: high-test
       labels:
         app: high-test
     spec:
       replicas: 5
       selector:
         matchLabels:
           app: test
       template:
         metadata:
           labels:
             app: test
         spec:
           priorityClassName: high-priority
           schedulerName: volcano
           containers:
           - name: test
             image: busybox
             imagePullPolicy: IfNotPresent
             command: ['sh', '-c', 'echo "Hello, Kubernetes!" && sleep 3600']
             resources:
               requests:
                 cpu: 500m
               limits:
                 cpu: 500m
     ```

   - Volcano job

     ```
     apiVersion: batch.volcano.sh/v1alpha1
     kind: Job
     metadata:
       name: vcjob
     spec:
       schedulerName: volcano
       minAvailable: 4
       priorityClassName: high-priority
       tasks:
         - replicas: 4
           name: "test"
           template:
             spec:
               containers:
                 - image: alpine
                   command: ["/bin/sh", "-c", "sleep 1000"]
                   imagePullPolicy: IfNotPresent
                   name: running
                   resources:
                     requests:
                       cpu: "1"
               restartPolicy: OnFailure
     ```

----End

Example of Priority-based Scheduling

For example, there are two idle nodes and several workloads with three priorities (high-priority, medium-priority, and low-priority). Run the high-priority workload to exhaust all cluster resources, and issue the medium-priority and low-priority workloads. Then, the two types of workloads are pending due to insufficient

resources. When the high-priority workload ends, the pods of the medium-priority workload will be scheduled ahead of the pods of the low-priority workload according to the priority-based scheduling setting.

Step 1 Add three **PriorityClasses** (**high-priority**, **med-priority**, and **low-priority**) in **priority.yaml**.

Example configuration of **priority.yaml**:

```
apiVersion: scheduling.k8s.io/v1
kind: PriorityClass
metadata:
  name: high-priority
value: 100
globalDefault: false
description: "This priority class should be used for volcano job only."
---
apiVersion: scheduling.k8s.io/v1
kind: PriorityClass
metadata:
  name: med-priority
value: 50
globalDefault: false
description: "This priority class should be used for volcano job only."
---
apiVersion: scheduling.k8s.io/v1
kind: PriorityClass
metadata:
  name: low-priority
value: 10
globalDefault: false
description: "This priority class should be used for volcano job only."
```

Create PriorityClasses.

```
kubectl apply -f priority.yaml
```

Step 2 Check PriorityClasses.

```
kubectl get PriorityClass
```

Command output:

```
NAME                      VALUE       GLOBAL-DEFAULT   AGE
high-priority             100         false            97s
low-priority              10          false            97s
med-priority              50          false            97s
system-cluster-critical   2000000000  false            6d6h
system-node-critical      2000001000  false            6d6h
```

Step 3 Create a high-priority workload named **high-priority-job** to exhaust all cluster resources.

high-priority-job.yaml

```
apiVersion: batch.volcano.sh/v1alpha1
kind: Job
metadata:
  name: priority-high
spec:
  schedulerName: volcano
  minAvailable: 4
  priorityClassName: high-priority
  tasks:
    - replicas: 4
      name: "test"
      template:
        spec:
          containers:
            - image: alpine
              command: ["/bin/sh", "-c", "sleep 1000"]
```

```
            imagePullPolicy: IfNotPresent
            name: running
            resources:
              requests:
                cpu: "1"
        restartPolicy: OnFailure
```

Run the following command to issue the job:

```
kubectl apply -f high_priority_job.yaml
```

Run the **kubectl get pod** command to check pod statuses:

```
NAME                  READY   STATUS    RESTARTS   AGE
priority-high-test-0  1/1     Running   0          3s
priority-high-test-1  1/1     Running   0          3s
priority-high-test-2  1/1     Running   0          3s
priority-high-test-3  1/1     Running   0          3s
```

The command output shows that all cluster resources have been used up.

Step 4 Create a medium-priority workload **med-priority-job** and a low-priority workload **low-priority-job**.

med-priority-job.yaml

```
apiVersion: batch.volcano.sh/v1alpha1
kind: Job
metadata:
  name: priority-medium
spec:
  schedulerName: volcano
  minAvailable: 4
  priorityClassName: med-priority
  tasks:
    - replicas: 4
      name: "test"
      template:
        spec:
          containers:
            - image: alpine
              command: ["/bin/sh", "-c", "sleep 1000"]
              imagePullPolicy: IfNotPresent
              name: running
              resources:
                requests:
                  cpu: "1"
          restartPolicy: OnFailure
```

low-priority-job.yaml

```
apiVersion: batch.volcano.sh/v1alpha1
kind: Job
metadata:
  name: priority-low
spec:
  schedulerName: volcano
  minAvailable: 4
  priorityClassName: low-priority
  tasks:
    - replicas: 4
      name: "test"
      template:
        spec:
          containers:
            - image: alpine
              command: ["/bin/sh", "-c", "sleep 1000"]
              imagePullPolicy: IfNotPresent
              name: running
```

```
          resources:
            requests:
              cpu: "1"
      restartPolicy: OnFailure
```

Run the following commands to issue the jobs:

```
kubectl apply -f med_priority_job.yaml
kubectl apply -f low_priority_job.yaml
```

Run the **kubectl get pod** command to check the statuses of the pods for the newly created workloads. The command output shows that the pods are pending due to insufficient resources:

```
NAME                    READY   STATUS    RESTARTS   AGE
priority-high-test-0    1/1     Running   0          3m29s
priority-high-test-1    1/1     Running   0          3m29s
priority-high-test-2    1/1     Running   0          3m29s
priority-high-test-3    1/1     Running   0          3m29s
priority-low-test-0     0/1     Pending   0          2m26s
priority-low-test-1     0/1     Pending   0          2m26s
priority-low-test-2     0/1     Pending   0          2m26s
priority-low-test-3     0/1     Pending   0          2m26s
priority-medium-test-0  0/1     Pending   0          2m36s
priority-medium-test-1  0/1     Pending   0          2m36s
priority-medium-test-2  0/1     Pending   0          2m36s
priority-medium-test-3  0/1     Pending   0          2m36s
```

Step 5 Delete the **high_priority_job** workload to release resources and check whether the pods of the **med-priority-job** workload will be preferentially scheduled.

Run the **kubectl delete -f high_priority_job.yaml** command to release cluster resources and check pod scheduling.

```
NAME                    READY   STATUS    RESTARTS   AGE
priority-low-test-0     0/1     Pending   0          5m18s
priority-low-test-1     0/1     Pending   0          5m18s
priority-low-test-2     0/1     Pending   0          5m18s
priority-low-test-3     0/1     Pending   0          5m18s
priority-medium-test-0  1/1     Running   0          5m28s
priority-medium-test-1  1/1     Running   0          5m28s
priority-medium-test-2  1/1     Running   0          5m28s
priority-medium-test-3  1/1     Running   0          5m28s
```

----End

9.5.5 AI Performance-based Scheduling

9.5.5.1 DRF

Dominant Resource Fairness (DRF) is a scheduling algorithm based on the dominant resource of a container group. DRF scheduling can be used to enhance the service throughput of a cluster, shorten the overall service execution time, and improve service running performance. It is suitable for batch AI training and big data jobs.

Prerequisites

- A cluster of v1.19 or later is available. For details, see **Buying a CCE Standard Cluster**.
- The Volcano add-on has been installed. For details, see **Volcano Scheduler**.

How It Works

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:

1. Resources are allocated in order of increasing demand.
2. No source gets a resource share larger than its demand.
3. Sources with unsatisfied demands get an equal share of the resource.

The max-min fairness algorithm applies to the single resource scenario, where all jobs are requesting the same resources. However, in actual situations, multiple resources are involved. For example, CPU, memory, and GPU resources are requested for allocation. DRF can be used to resolve the preceding issue. DRF can be considered as a general version of the max-min fairness algorithm and supports fair allocation of multiple types of resources so that the dominant resource of each user meets the max-min fairness requirement.

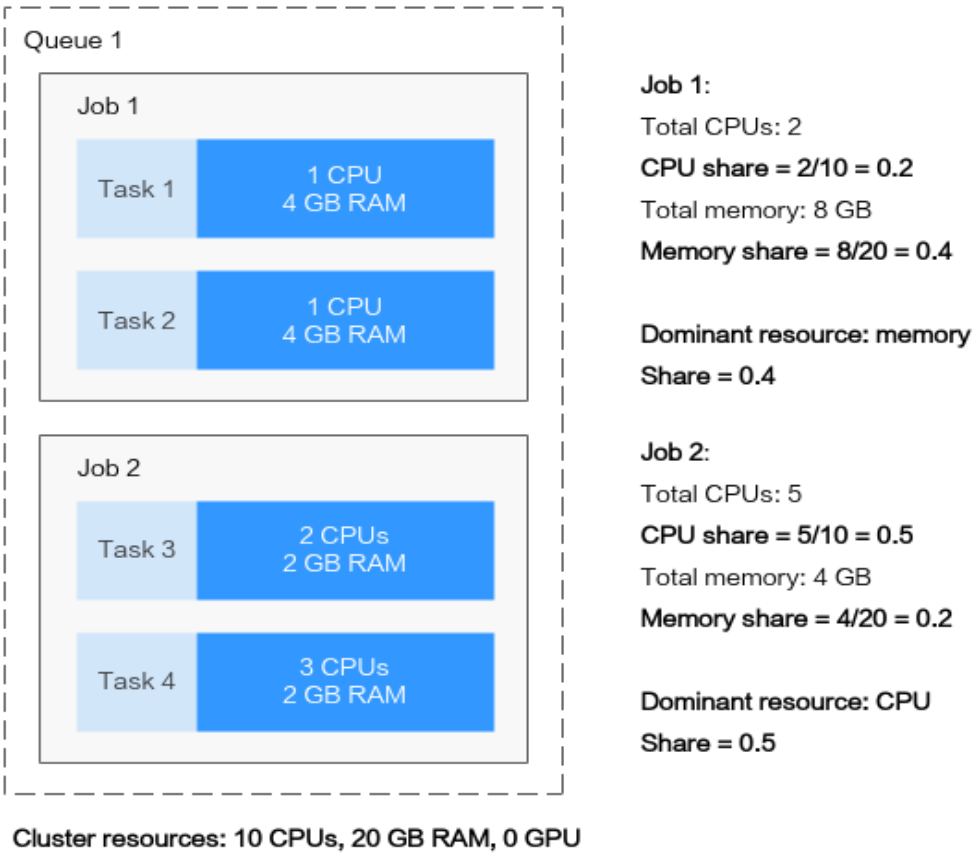
The share value of each job resource is calculated using the following formula:

Share = Total requested resources/Cluster resources

If a job involves multiple resources, the resource with the largest share value is the dominant resource. The share value of the dominant resource will be used in priority-based scheduling.

For example, there are two workloads, job 1 and job 2. The following figure shows the resources requested by the two jobs. After DRF calculation, the dominant resource of job 1 is memory, and its share value is 0.4; the dominant resource of job 2 is CPU, and its share value is 0.5. Since the dominant resource share of job 1 is less than that of job 2, job 1 takes precedence over job 2 in scheduling according to the max-min fairness policy.

Figure 9-4 DRF scheduling



Configuring DRF

After Volcano is installed, you can enable or disable DRF scheduling on the **Scheduling** page. This function is enabled by default.

Step 1 Log in to the CCE console.

Step 2 Click the cluster name to access the cluster console. Choose **Settings** in the navigation pane and click the **Scheduling** tab.

Step 3 In the **AI task performance enhanced scheduling** pane, select whether to enable DRF.

This function helps you enhance the service throughput of the cluster and improve service running performance.

Step 4 Click **Confirm**.

----End

9.5.5.2 Gang

Gang scheduling is a scheduling algorithm that schedules correlated processes or threads to run simultaneously on different processors. It 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. Gang 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 deadlocks in distributed training jobs, thereby significantly improving the utilization of cluster resources.

Prerequisites

- A cluster of v1.19 or later is available. For details, see **Buying a CCE Standard Cluster**.
- The Volcano add-on has been installed. For details, see **Volcano Scheduler**.

How It Works

The Gang scheduling policy is one of the core scheduling algorithms of Volcano. It 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. 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.

The Gang scheduling algorithm based on container groups is well suitable for 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.

Configuring Gang

After Volcano is installed, you can enable or disable Gang scheduling on the **Scheduling** page. This function is enabled by default.

Step 1 Log in to the CCE console.

Step 2 Click the cluster name to access the cluster console. Choose **Settings** in the navigation pane and click the **Scheduling** tab.

Step 3 In the **AI task performance enhanced scheduling** pane, select whether to enable Gang.

This function helps you enhance the service throughput of the cluster and improve service running performance.

Step 4 Click **Confirm**.

Step 5 After the configuration, use Gang scheduling in workloads or Volcano jobs.

- Create a workload using Gang scheduling.
  a. Create a pod group and specify **minMember** and **minResources** as follows:

```
apiVersion: scheduling.volcano.sh/v1beta1
kind: PodGroup
```

```
metadata:
  name: pg-test1
spec:
  minMember: 3
  minResources:
    cpu: 3
    memory: 3Gi
```

- **minMember**: specifies the minimum requirement on the number of pods for running a workload. When the number of pods in the current pod group meets the requirement, these pods can be centrally scheduled.
- **minResources**: specifies the minimum requirement on resources for running a workload. When the available resources in a cluster meet the requirement, the group of pods can be centrally scheduled.

b. When creating a workload, use **schedulerName** to specify Volcano Scheduler and **annotation** to specify the pod group in which Volcano Scheduler runs.

```
apiVersion: apps/v1
kind: Deployment
metadata:
  name: podgroup-test
  labels:
    app: podgroup-test
spec:
  replicas: 6
  selector:
    matchLabels:
      app: podgroup-test
  template:
    metadata:
      annotations:
        scheduling.k8s.io/group-name: pg-test1
      labels:
        app: podgroup-test
    spec:
      schedulerName: volcano
      containers:
      - name: test
        image: busybox
        imagePullPolicy: IfNotPresent
        command: ['sh', '-c', 'echo "Hello, Kubernetes!" && sleep 3600']
        resources:
          requests:
            cpu: 500m
          limits:
            cpu: 500m
```

- **schedulerName**: Set this parameter to **volcano**, indicating that Volcano will be used to schedule pods for the workload.
- **scheduling.k8s.io/group-name**: specifies the pod group created in the previous step, for example, **pg-test1**.

- Create a Volcano job using Gang scheduling.

  When creating a Volcano job, you only need to configure **minAvailable** and set **schedulerName** to **volcano**. Volcano Scheduler will automatically create a pod group and manage it. The following shows an example:

```
apiVersion: batch.volcano.sh/v1alpha1
kind: Job
metadata:
  name: vcjob
spec:
```

```
schedulerName: volcano
minAvailable: 2
tasks:
  - replicas: 4
    name: "test"
    template:
      spec:
        containers:
          - image: alpine
            command: ["/bin/sh", "-c", "sleep 1000"]
            imagePullPolicy: IfNotPresent
            name: running
            resources:
              requests:
                cpu: "1"
        restartPolicy: OnFailure
```

----End

9.5.6 NUMA Affinity Scheduling

Background

When a node runs many CPU-bound pods, the workload can move to different CPU cores depending on whether the pod is throttled and which CPU cores are available at scheduling time. Many workloads are not sensitive to this migration and work fine without any intervention. However, in workloads where CPU cache affinity and scheduling latency significantly affect workload performance, additional latency will occur when CPU cores are from different NUMA nodes. To resolve this issue, kubelet allows you to use Topology Manager to replace the CPU management policies to determine node allocation.

Both the CPU Manager and Topology Manager are kubelet components, but they have the following limitations:

- The scheduler is not topology-aware. Therefore, the workload may be scheduled on a node and then fail on the node due to the Topology Manager. This is unacceptable for TensorFlow jobs. If any worker or ps failed on node, the job will fail.
- The managers are node-level that results in an inability to match the best node for NUMA topology in the whole cluster.

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 best node for NUMA topology.

For more information, see **https://github.com/volcano-sh/volcano/blob/master/docs/design/numa-aware.md**.

Application Scope

- CPU resource topology scheduling
- Pod-level topology policies

Pod Scheduling Prediction

After a topology policy is configured for pods, Volcano predicts matched nodes based on the topology policy. The scheduling process is as follows:

1. Volcano filters nodes with the same policy based on the topology policy configured for pods. The topology policy provided by Volcano is the same as that provided by the **topology manager**.
2. Among the nodes where the same policy applies, Volcano selects the nodes whose CPU topology meets the policy requirements for scheduling.

Volcano Topology Policy	Node Scheduling	
	1. Filter nodes with the same policy.	**2. Check whether node's CPU topology meets the policy requirements.**
none	No filtering: • **none**: schedulable • **best-effort**: schedulable • **restricted**: schedulable • **single-numa-node**: schedulable	None
best-effort	Filter the nodes with the **best-effort** topology policy. • **none**: unschedulable • **best-effort**: schedulable • **restricted**: unschedulable • **single-numa-node**: unschedulable	Best-effort scheduling: Pods are preferentially scheduled to a single NUMA node. If a single NUMA node cannot meet the requested CPU cores, the pods can be scheduled to multiple NUMA nodes.
restricted	Filter the nodes with the **restricted** topology policy. • **none**: unschedulable • **best-effort**: unschedulable • **restricted**: schedulable • **single-numa-node**: unschedulable	Restricted scheduling: • If the upper CPU limit of a single NUMA node is greater than or equal to the requested CPU cores, pods can only be scheduled to a single NUMA node. If the remaining CPU cores of a single NUMA node are insufficient, the pods cannot be scheduled. • If the upper CPU limit of a single NUMA node is less than the requested CPU cores, pods can be scheduled to multiple NUMA nodes.

Volcano Topology Policy	Node Scheduling	
	1. Filter nodes with the same policy.	2. Check whether node's CPU topology meets the policy requirements.
single-numa-node	Filter the nodes with the **single-numa-node** topology policy. • **none**: unschedulable • **best-effort**: unschedulable • **restricted**: unschedulable • **single-numa-node**: schedulable	Pods can only be scheduled to a single NUMA node.

For example, two NUMA nodes provide resources, each with a total of 32 CPU cores. The following table lists resource allocation.

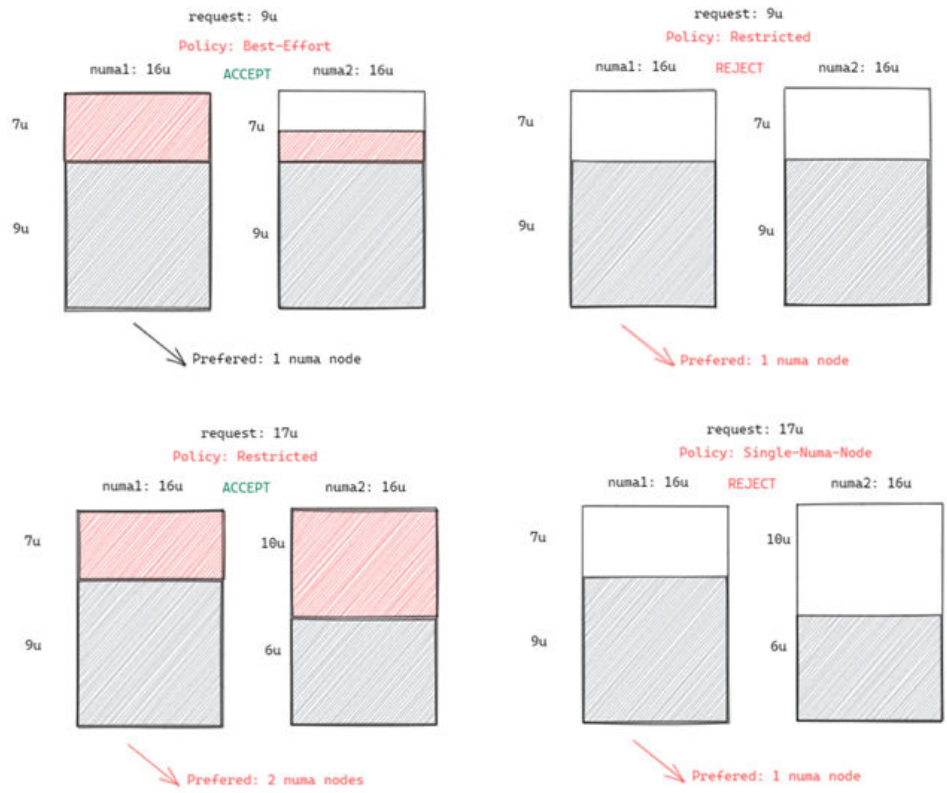
Worker Node	Node Topology Policy	Total CPU Cores on NUMA Node 1	Total CPU Cores on NUMA Node 2
Node 1	best-effort	16	16
Node 2	restricted	16	16
Node 3	restricted	16	16
Node 4	single-numa-node	16	16

Figure 9-5 shows the scheduling of a pod after a topology policy is configured.

- When 9 CPU cores are requested by a pod and the **best-effort** topology policy is used, Volcano selects node 1 whose topology policy is also **best-effort**, and this policy allows the pod to be scheduled to multiple NUMA nodes. Therefore, the requested 9 CPU cores will be allocated to two NUMA nodes, and the pod can be scheduled to node 1.
- When 9 CPU cores are requested by a pod and the **restricted** topology policy is used, Volcano selects nodes 2 and 3 whose topology policy is also **restricted**, and each node provides a total of 9 CPU cores. However, the remaining CPU cores on node 2 or 3 are less than the requested. Therefore, the pod cannot be scheduled.
- When 17 CPU cores are requested by a pod and the **restricted** topology policy is used, Volcano selects nodes 2 and 3 whose topology policy is also **restricted**, this policy allows the pod to be scheduled to multiple NUMA nodes, and the upper CPU limit of the both nodes is less than 17. Then, the pod can be scheduled to node 3.
- When 17 CPU cores are requested by a pod and the **single-numa-node** topology policy is used, Volcano selects nodes whose topology policy is also

single-numa-node. However, no node can provide a total of 17 CPU cores. Therefore, the pod cannot be scheduled.

Figure 9-5 Comparison of NUMA scheduling policies



Scheduling Priority

A topology policy aims to schedule pods to the optimal node. In this example, each node is scored to sort out the optimal node.

Principle: Schedule pods to the worker nodes that require the fewest NUMA nodes.

The scoring formula is as follows:

score = weight x (100 - 100 x numaNodeNum/maxNumaNodeNum)

Parameters:

- **weight**: the weight of NUMA Aware Plugin.
- **numaNodeNum**: the number of NUMA nodes required for running the pod on worker nodes.
- **maxNumaNodeNum**: the maximum number of NUMA nodes required for running the pod among all worker nodes.

For example, three nodes meet the CPU topology policy for a pod and the weight of NUMA Aware Plugin is set to **10**.

- Node A: One NUMA node provides the CPU resources required by the pod (numaNodeNum = 1).

- Node B: Two NUMA nodes provide the CPU resources required by the pod (numaNodeNum = 2).
- Node C: Four NUMA nodes provide the CPU resources required by the pod (numaNodeNum = 4).

According to the preceding formula, **maxNumaNodeNum** is **4**.

- score(Node A) = 10 x (100 - 100 x 1/4) = 750
- score(Node B) = 10 x (100 - 100 x 2/4) = 500
- score(Node C) = 10 x (100 - 100 x 4/4) = 0

Therefore, the optimal node is Node A.

Enabling NUMA Affinity Scheduling for Volcano

Step 1 Enable static CPU management. For details, see **Enabling the CPU Management Policy**.

Step 2 Configure a CPU topology policy.

1. Log in to the CCE console and click the cluster name to access the cluster console. In the navigation pane, choose **Nodes**. On the right of the page, click the **Node Pools** tab and choose **More** > **Manage** in the **Operation** column of the target node pool.
2. Change the kubelet **Topology Management Policy (topology-manager-policy)** value to the required CPU topology policy.

   Valid topology policies include **none**, **best-effort**, **restricted**, and **single-numa-node**. For details, see **Pod Scheduling Prediction**.

Step 3 Enable the numa-aware add-on and the **resource_exporter** function.

Volcano 1.7.1 or later

1. Log in to the CCE console and click the cluster name to access the cluster console. In the navigation pane, choose **Add-ons**. On the right of the page, locate the **Volcano** add-on and click **Edit**. In the **Parameters** area, configure Volcano scheduler parameters.

```
{
  "ca_cert": "",
  "default_scheduler_conf": {
    "actions": "allocate, backfill, preempt",
    "tiers": [
      {
        "plugins": [
          {
            "name": "priority"
          },
          {
            "name": "gang"
          },
          {
            "name": "conformance"
          }
        ]
      },
      {
        "plugins": [
          {
            "name": "drf"
          },
```

```
            {
               "name": "predicates"
            },
            {
               "name": "nodeorder"
            }
         ]
      },
      {
         "plugins": [
            {
               "name": "cce-gpu-topology-predicate"
            },
            {
               "name": "cce-gpu-topology-priority"
            },
            {
               "name": "cce-gpu"
            },
            {
               // add this also enable resource_exporter
               "name": "numa-aware",
               // the weight of the NUMA Aware Plugin
               "arguments": {
                  "weight": "10"
               }
            }
         ]
      },
      {
         "plugins": [
            {
               "name": "nodelocalvolume"
            },
            {
               "name": "nodeemptydirvolume"
            },
            {
               "name": "nodeCSIscheduling"
            },
            {
               "name": "networkresource"
            }
         ]
      }
   ]
  },
  "server_cert": "",
  "server_key": ""
}
```

Volcano earlier than 1.7.1

1. The **resource_exporter_enable** parameter is enabled for the Volcano add-on to collect node NUMA information.

```
{
  "plugins": {
    "eas_service": {
      "availability_zone_id": "",
      "driver_id": "",
      "enable": "false",
      "endpoint": "",
      "flavor_id": "",
      "network_type": "",
      "network_virtual_subnet_id": "",
      "pool_id": "",
      "project_id": "",
      "secret_name": "eas-service-secret"
    }
  },
```

```
  "resource_exporter_enable": "true"
}
```

After this function is enabled, you can view the NUMA topology information of the current node.

```
kubectl get numatopo
NAME              AGE
node-1            4h8m
node-2            4h8m
node-3            4h8m
```

2. Enable the Volcano numa-aware algorithm add-on.

   kubectl edit cm -n kube-system volcano-scheduler-configmap

```
kind: ConfigMap
apiVersion: v1
metadata:
  name: volcano-scheduler-configmap
  namespace: kube-system
data:
  default-scheduler.conf: |-
    actions: "allocate, backfill, preempt"
    tiers:
    - plugins:
      - name: priority
      - name: gang
      - name: conformance
    - plugins:
      - name: overcommit
      - name: drf
      - name: predicates
      - name: nodeorder
    - plugins:
      - name: cce-gpu-topology-predicate
      - name: cce-gpu-topology-priority
      - name: cce-gpu
    - plugins:
      - name: nodelocalvolume
      - name: nodeemptydirvolume
      - name: nodeCSIscheduling
      - name: networkresource
        arguments:
          NetworkType: vpc-router
      - name: numa-aware # add it to enable numa-aware plugin
        arguments:
          weight: 10 # the weight of the NUMA Aware Plugin
```

----End

Using Volcano to Configure NUMA Affinity Scheduling

Step 1 Refer to the following examples for configuration.

1. Example 1: Configure NUMA affinity for a Deployment.

```
kind: Deployment
apiVersion: apps/v1
metadata:
  name: numa-tset
spec:
  replicas: 1
  selector:
    matchLabels:
      app: numa-tset
  template:
    metadata:
      labels:
        app: numa-tset
      annotations:
        volcano.sh/numa-topology-policy: single-numa-node    # Configure the topology policy.
```

```
  spec:
    containers:
      - name: container-1
        image: nginx:alpine
        resources:
          requests:
            cpu: 2          # The value must be an integer and must be the same as that in limits.
            memory: 2048Mi
          limits:
            cpu: 2          # The value must be an integer and must be the same as that in requests.
            memory: 2048Mi
    imagePullSecrets:
    - name: default-secret
```

2. Example 2: Create a Volcano job and enable NUMA affinity for it.

```
apiVersion: batch.volcano.sh/v1alpha1
kind: Job
metadata:
  name: vj-test
spec:
  schedulerName: volcano
  minAvailable: 1
  tasks:
    - replicas: 1
      name: "test"
      topologyPolicy: best-effort   # set the topology policy for task
      template:
        spec:
          containers:
            - image: alpine
              command: ["/bin/sh", "-c", "sleep 1000"]
              imagePullPolicy: IfNotPresent
              name: running
              resources:
                limits:
                  cpu: 20
                  memory: "100Mi"
          restartPolicy: OnFailure
```

Step 2 Analyze NUMA scheduling.

The following table shows example NUMA nodes.

Worker Node	Topology Manager Policy	Allocatable CPU Cores on NUMA Node 0	Allocatable CPU Cores on NUMA Node 1
Node 1	single-numa-node	16	16
Node 2	best-effort	16	16
Node 3	best-effort	20	20

In the preceding examples,

- In example 1, 2 CPU cores are requested by a pod, and the **single-numa-node** topology policy is used. Therefore, the pod will be scheduled to node 1 with the same policy.
- In example 2, 20 CPU cores are requested by a pod, and the **best-effort** topology policy is used. The pod will be scheduled to node 3 because it can

allocate all the requested 20 CPU cores onto one NUMA node, while node 2 can do so on two NUMA nodes.

----End

Checking NUMA Node Usage

Run the **lscpu** command to check the CPU usage of the current node.

```
# Check the CPU usage of the current node.
lscpu
...
CPU(s):              32
NUMA node(s):        2
NUMA node0 CPU(s):   0-15
NUMA node1 CPU(s):   16-31
```

Then, check the NUMA node usage.

```
# Check the CPU allocation of the current node.
cat /var/lib/kubelet/cpu_manager_state
{"policyName":"static","defaultCpuSet":"0,10-15,25-31","entries":{"777870b5-
c64f-42f5-9296-688b9dc212ba":{"container-1":"16-24"},"fb15e10a-b6a5-4aaa-8fcd-76c1aa64e6fd":
{"container-1":"1-9"}},"checksum":318470969}
```

The preceding example shows that two containers are running on the node. One container uses CPU cores 1 to 9 of NUMA node 0, and the other container uses CPU cores 16 to 24 of NUMA node 1.

10 Network

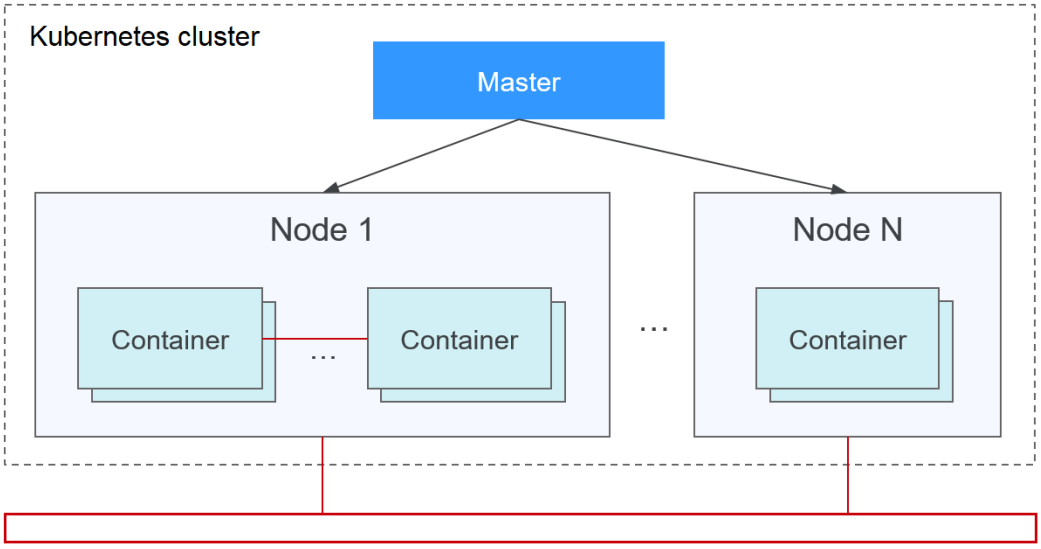
10.1 Overview

You can learn about a cluster network from the following two aspects:

- What is a cluster network like? A cluster consists of multiple nodes, and pods (or containers) are running on the nodes. Nodes and containers need to communicate with each other. For details about the cluster network types and their functions, see **Cluster Network Structure**.
- How is pod access implemented in a cluster? Accessing a pod or container is a process of accessing services of a user. Kubernetes provides **Service** and **Ingress** to address pod access issues. This section summarizes common network access scenarios. You can select the proper scenario based on site requirements. For details about the network access scenarios, see **Access Scenarios**.

Cluster Network Structure

All nodes in the cluster are located in a VPC and use the VPC network. The container network is managed by dedicated network add-ons.



- **Node Network**

  A node network assigns IP addresses to hosts (nodes in the figure above) in a cluster. Select a VPC subnet as the node network of the CCE cluster. The number of available IP addresses in a subnet determines the maximum number of nodes (including master nodes and worker nodes) that can be created in a cluster. This quantity is also affected by the container network. For details, see the container network model.

- **Container Network**

  A container network assigns IP addresses to containers in a cluster. CCE inherits the IP-Per-Pod-Per-Network network model of Kubernetes. That is, each pod has an independent IP address on a network plane and all containers in a pod share the same network namespace. All pods in a cluster exist in a directly connected flat network. They can access each other through their IP addresses without using NAT. Kubernetes only provides a network mechanism for pods, but does not directly configure pod networks. The configuration of pod networks is implemented by specific container network add-ons. The container network add-ons are responsible for configuring networks for pods and managing container IP addresses.

  Currently, CCE supports the following container network models:

  – Container tunnel network: The container tunnel network is constructed on but independent of the node network through tunnel encapsulation. This network model uses VXLAN to encapsulate Ethernet packets into UDP packets and transmits them in tunnels. Open vSwitch serves as the backend virtual switch.

  – VPC network: The VPC network uses VPC routing to integrate with the underlying network. This network model applies 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. This networking model is free from tunnel encapsulation overhead and outperforms the container tunnel network model. In addition, as VPC routing includes routes to node IP addresses and the container CIDR block, container pods in a cluster can be directly accessed from outside the cluster.

  The performance, networking scale, and application scenarios of a container network vary according to the container network model. For details about the functions and features of different container network models, see **Overview**.

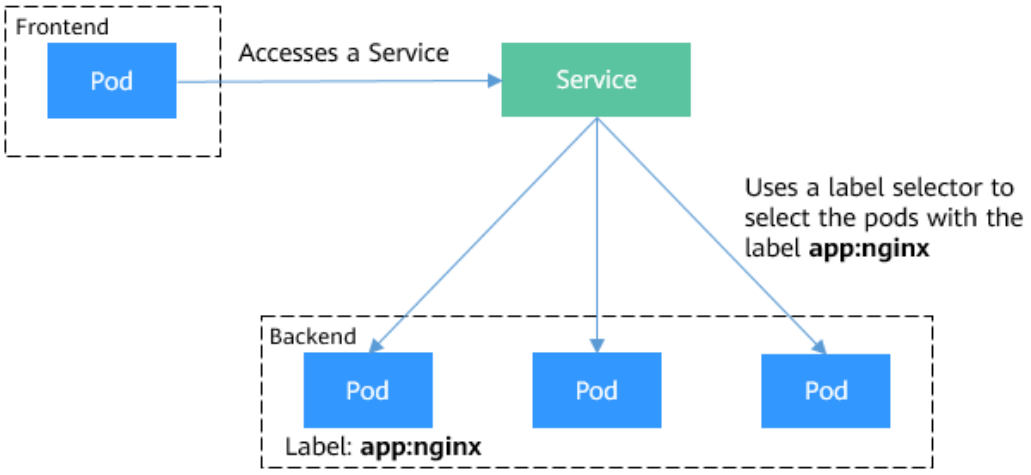
- **Service Network**

  Service is also a Kubernetes object. Each Service has a static IP address. When creating a cluster on CCE, you can specify the Service CIDR block. The Service CIDR block cannot overlap with the node or container CIDR block. The Service CIDR block can be used only within a cluster.

Service

A Service is used for pod access. With a static IP address, a Service forwards access traffic to pods and performs load balancing for these pods.

Figure 10-1 Accessing pods through a Service



You can configure the following types of Services:

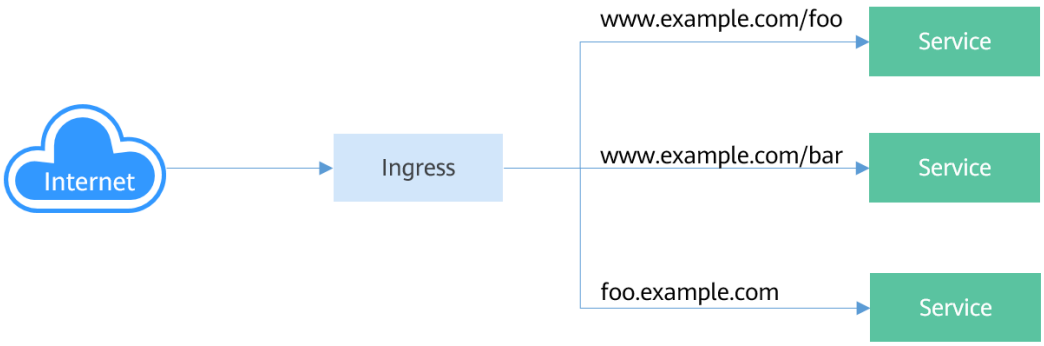
- ClusterIP: used to make the Service only reachable from within a cluster.
- NodePort: used for access from outside a cluster. A NodePort Service is accessed through the port on the node.
- LoadBalancer: used for access from outside a cluster. It is an extension of NodePort, to which a load balancer routes, and external systems only need to access the load balancer.
- DNAT: used for access from outside a cluster. It translates addresses for cluster nodes and allows multiple cluster nodes to share an EIP.

For details about the Service, see **Overview**.

Ingress

Services forward requests using layer-4 TCP and UDP protocols. Ingresses forward requests using layer-7 HTTP and HTTPS protocols. Domain names and paths can be used to achieve finer granularities.

Figure 10-2 Ingress and Service



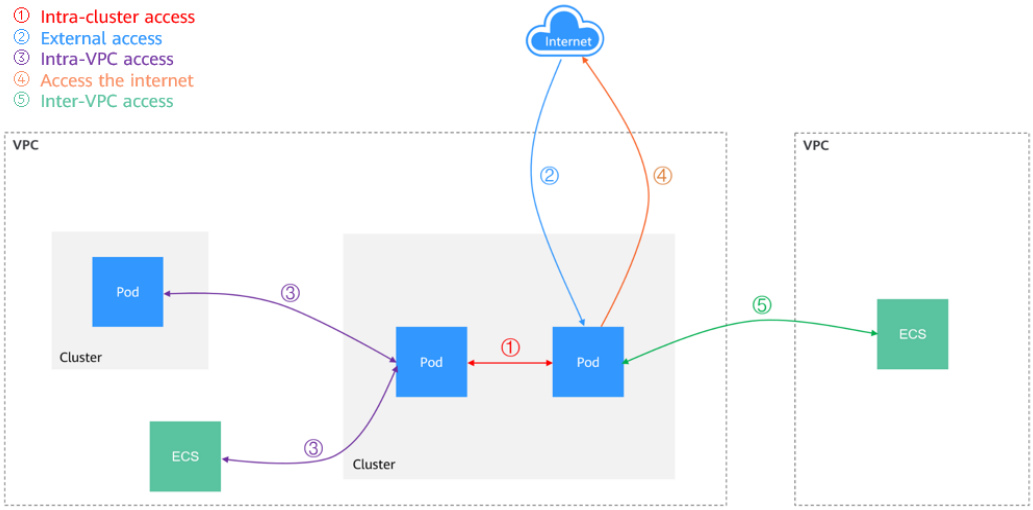
For details about the ingress, see **Overview**.

Access Scenarios

Workload access scenarios can be categorized as follows:

- Intra-cluster access: A ClusterIP Service is used for workloads in the same cluster to access each other.
- Access from outside a cluster: A Service (NodePort or LoadBalancer type) or an ingress is recommended for a workload outside a cluster to access workloads in the cluster.
  - Access through the public network: An EIP should be bound to the node or load balancer.
  - Access through the private network: The workload can be accessed through the internal IP address of the node or load balancer. If workloads are located in different VPCs, a peering connection is required to enable communication between different VPCs.
- The workload can access the external network as follows:
  - Accessing an intranet: The workload accesses the intranet address, but the implementation method varies depending on container network models. Ensure that the peer security group allows the access requests from the container CIDR block.
  - Accessing a public network: Assign an EIP to the node where the workload runs, or configure SNAT rules through the NAT gateway. For details, see **Accessing the Internet from a Container**.

Figure 10-3 Network access diagram



10.2 Container Network Models

10.2.1 Overview

The container network assigns IP addresses to pods in a cluster and provides networking services. In CCE, you can select the following network models for your cluster:

- Tunnel network
- VPC network

Network Model Comparison

Table 10-1 describes the differences of network models supported by CCE.

CAUTION

After a cluster is created, the network model cannot be changed.

Table 10-1 Network model comparison

Dimension	Tunnel Network	VPC Network
Application scenarios	• Common container service scenarios • Scenarios that do not have high requirements on network latency and bandwidth	• Scenarios that have high requirements on network latency and bandwidth • Containers can communicate with VMs using a microservice registration framework, such as Dubbo and CSE.
Core technology	OVS	IPvlan and VPC route
Applicable clusters	CCE standard cluster	CCE standard cluster
Network isolation	Kubernetes native NetworkPolicy for pods	No
Passthrough networking	No	No
IP address management	• The container CIDR block is allocated separately. • CIDR blocks are divided by node and can be dynamically allocated (CIDR blocks can be dynamically added after being allocated.)	• The container CIDR block is allocated separately. • CIDR blocks are divided by node and statically allocated (the CIDR block cannot be changed after a node is created).
Network performance	Performance loss due to VXLAN encapsulation	No tunnel encapsulation. Cross-node packets are forwarded through VPC routers, delivering performance equivalent to that of the host network.

Dimension	Tunnel Network	VPC Network
Networking scale	A maximum of 2000 nodes are supported.	Suitable for small- and medium-scale networks due to the limitation on VPC routing 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 routing tables. Therefore, the cluster scale is limited by the VPC routing tables.

NOTICE

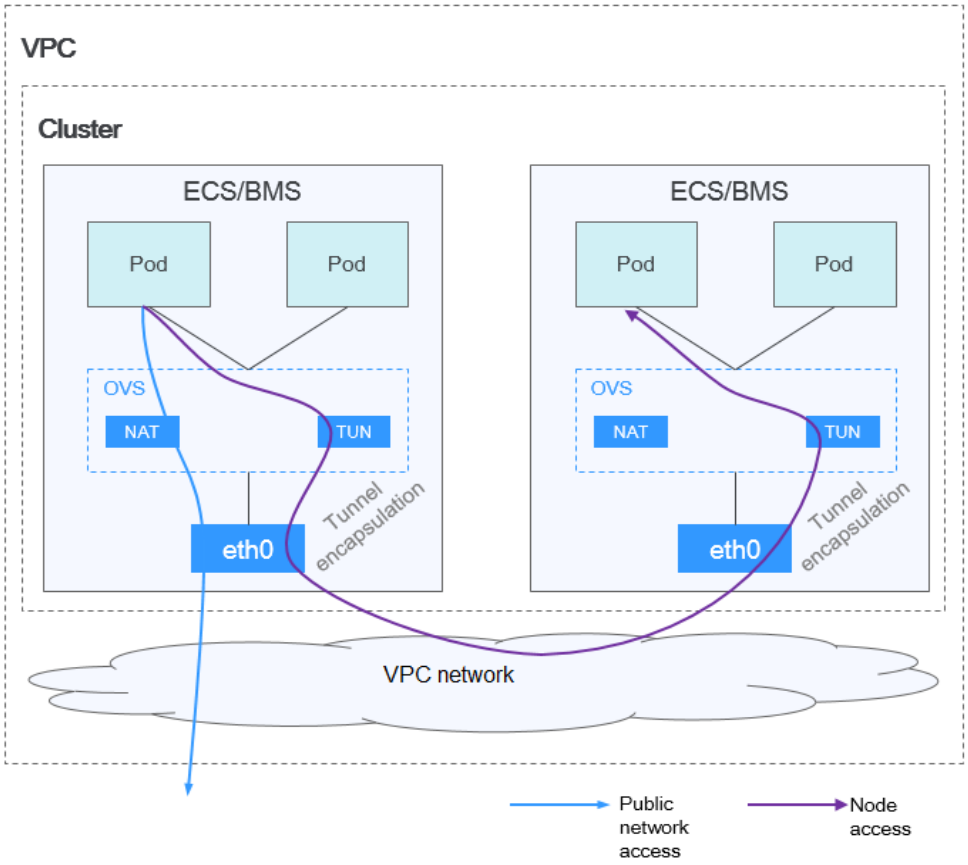
1. The scale of a cluster that uses the VPC network model is limited by the custom routes of the VPC. Therefore, estimate the number of required nodes before creating a cluster.
2. By default, VPC routing network supports direct communication between containers and hosts in the same VPC. If a peering 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.
3. Do not change the mask of the primary CIDR block on the VPC after a cluster is created. Otherwise, the network will be abnormal.

10.2.2 Container Tunnel Network

Container Tunnel Network Model

The container tunnel network is constructed on but independent of the node network through tunnel encapsulation. This network model uses VXLAN to encapsulate Ethernet packets into UDP packets and transmits them in tunnels. Open vSwitch serves as the backend virtual switch. Though at some costs of performance, packet encapsulation and tunnel transmission enable higher interoperability and compatibility with advanced features (such as network policy-based isolation) for most common scenarios.

Figure 10-4 Container tunnel network



Pod-to-pod communication

- On the same node: Packets are directly forwarded via the OVS bridge on the node.
- Across nodes: Packets are encapsulated in the OVS bridge and then forwarded to the peer node.

Advantages and Disadvantages

Advantages

- The container network is decoupled from the node network and is not limited by the VPC quotas and response speed (such as the number of VPC routes, number of elastic ENIs, and creation speed).
- Network isolation is supported. For details, see **Network Policies**.
- Bandwidth limits are supported.
- Large-scale networking is supported.

Disadvantages

- High encapsulation overhead, complex networking, and low performance
- Pods cannot directly use functionalities such as EIPs and security groups.
- External networks cannot be directly connected to container IP addresses.

Applicable Scenarios

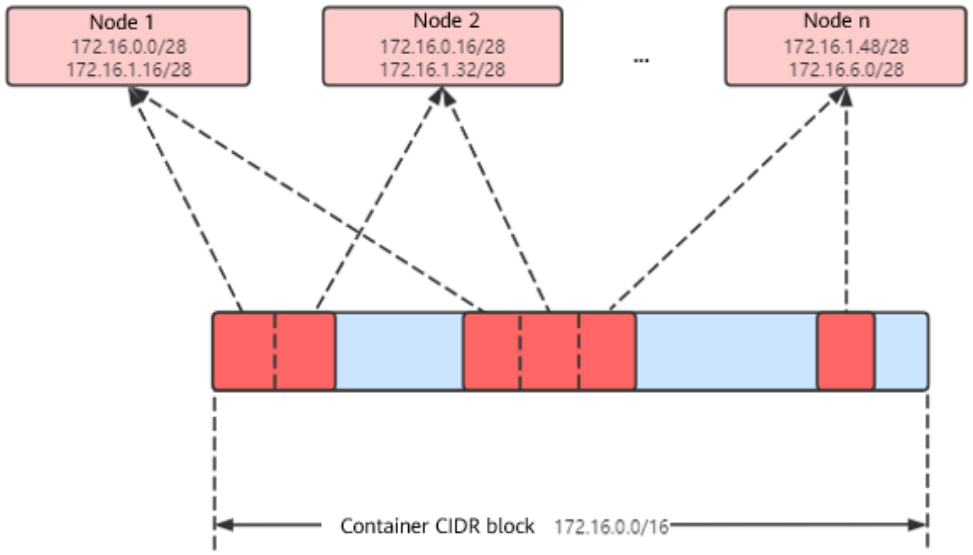
- Low requirements on performance: As the container tunnel network requires additional VXLAN tunnel encapsulation, it has about 5% to 15% of performance loss when compared with the other two container network models. Therefore, the container tunnel network applies to the scenarios that do not have high 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 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.

Container IP Address Management

The container tunnel network allocates container IP addresses according to the following rules:

- The container CIDR block is allocated separately, which is irrelevant to the node CIDR block.
- IP addresses are allocated by node. One or more CIDR blocks with a fixed size (16 by default) are allocated to each node in a cluster from the container CIDR block.
- When the IP addresses on a node are used up, you can apply for a new CIDR block.
- The container CIDR block cyclically allocates CIDR blocks to new nodes or existing nodes in sequence.
- Pods scheduled to a node are cyclically allocated IP addresses from one or more CIDR blocks allocated to the node.

Figure 10-5 IP address allocation of the container tunnel network



Maximum number of nodes that can be created in the cluster using the container tunnel network = Number of IP addresses in the container CIDR block / Size of the IP CIDR block allocated to the node by the container CIDR block at a time (16 by default)

For example, if the container CIDR block is 172.16.0.0/16, the number of IP addresses is 65536. If 16 IP addresses are allocated to a node at a time, a maximum of 4096 (65536/16) nodes can be created in the cluster. This is an extreme case. If 4096 nodes are created, a maximum of 16 pods can be created for each node because only 16 IP CIDR block\s are allocated to each node. In addition, the number of nodes that can be created in a cluster also depends on the node network and cluster scale.

Recommendation for CIDR Block Planning

As described in **Cluster Network Structure**, network addresses in a cluster can be divided into three parts: node network, container network, and service network. When planning network addresses, consider the following aspects:

- The three CIDR blocks cannot overlap. Otherwise, a conflict occurs.
- Ensure that each CIDR block has sufficient IP addresses.
  - The IP addresses in the node CIDR block must match the cluster scale. Otherwise, nodes cannot be created due to insufficient IP addresses.
  - The IP addresses in the container CIDR block must match the service scale. Otherwise, pods cannot be created due to insufficient IP addresses. The number of pods that can be created on each node also depends on other parameter settings.

Example of Container Tunnel Network Access

Create a cluster that uses the container tunnel network model. Create a Deployment in the cluster.

```
kind: Deployment
apiVersion: apps/v1
metadata:
  name: example
  namespace: default
spec:
  replicas: 4
  selector:
    matchLabels:
      app: example
  template:
    metadata:
      labels:
        app: example
    spec:
      containers:
        - name: container-0
          image: 'nginx:perl'
          resources:
            limits:
              cpu: 250m
              memory: 512Mi
            requests:
              cpu: 250m
              memory: 512Mi
      imagePullSecrets:
        - name: default-secret
```

View the created pod.

```
$ kubectl get pod -owide
NAME                       READY   STATUS    RESTARTS   AGE     IP          NODE          NOMINATED NODE
READINESS GATES
example-5bdc5699b7-5rvq4   1/1     Running   0          3m28s   10.0.0.20   192.168.0.42   <none>
<none>
example-5bdc5699b7-984j9   1/1     Running   0          3m28s   10.0.0.21   192.168.0.42   <none>
<none>
example-5bdc5699b7-lfxkm   1/1     Running   0          3m28s   10.0.0.22   192.168.0.42   <none>
<none>
example-5bdc5699b7-wjcmg   1/1     Running   0          3m28s   10.0.0.52   192.168.0.64   <none>
<none>
```

In this case, the IP address of the pod cannot be directly accessed outside the cluster in the same VPC. This is a feature of the container tunnel network.

However, the pod can be accessed from a node in the cluster or in the pod. As shown in the following figure, the pod can be accessed directly from the container.

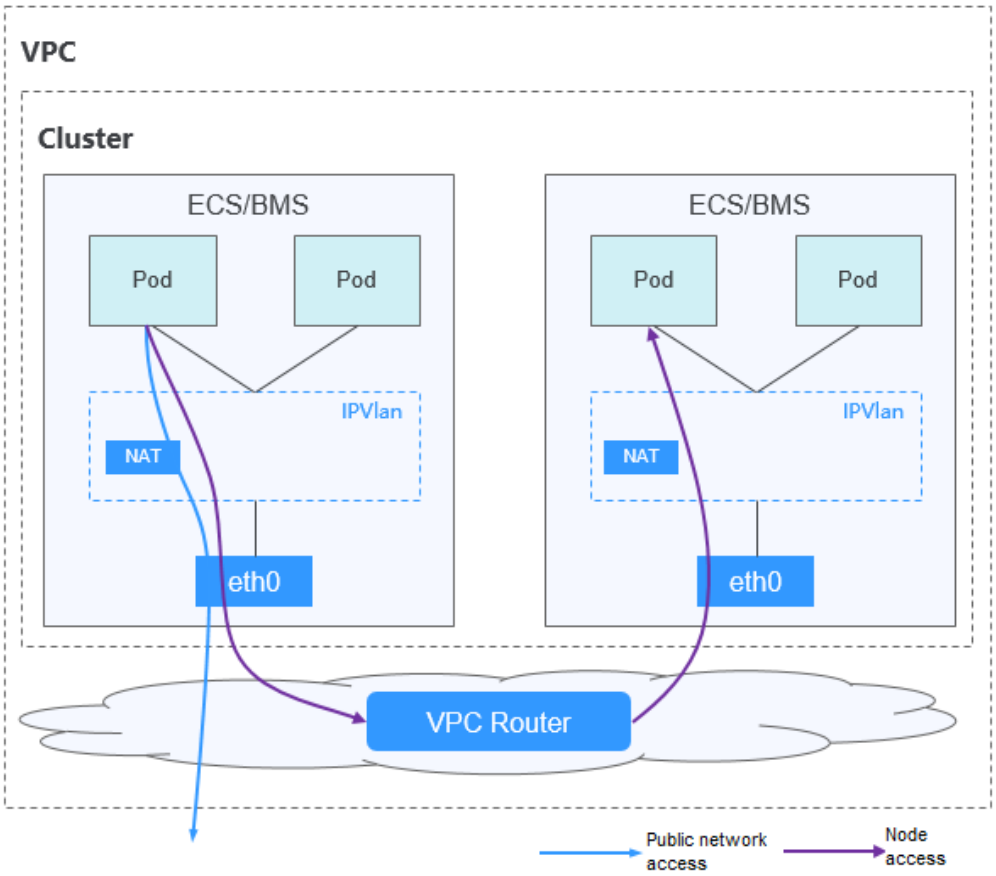
```
$ kubectl exec -it example-5bdc5699b7-5rvq4 -- curl 10.0.0.21
<!DOCTYPE html>
<html>
<head>
<title>Welcome to nginx!</title>
<style>
    body {
        width: 35em;
        margin: 0 auto;
        font-family: Tahoma, Verdana, Arial, sans-serif;
    }
</style>
</head>
<body>
<h1>Welcome to nginx!</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>
```

10.2.3 VPC Network

Model Definition

The VPC network uses VPC routing to integrate with the underlying network. This network model is suitable for performance-intensive scenarios. The maximum number of nodes allowed in a cluster depends on the VPC route quota. Each node is assigned a CIDR block of a fixed size. This networking model is free from tunnel encapsulation overhead and outperforms the container tunnel network model. In addition, as VPC routing includes routes to node IP addresses and the container CIDR block, container pods in a cluster can be directly accessed from ECSs in the same VPC outside the cluster.

Figure 10-6 VPC network model



Pod-to-pod communication

- On the same node: Packets are directly forwarded through IPvlan.
- Across nodes: Packets are forwarded to the default gateway through default routes, and then to the peer node via the VPC routes.

Advantages and Disadvantages

Advantages

- No tunnel encapsulation is required, so network problems are easy to locate and the performance is high.
- In the same VPC, the external network of the cluster can be directly connected to the container IP address.

Disadvantages

- The number of nodes is limited by the VPC route quota.
- Each node is assigned a CIDR block of a fixed size, which leads to a waste of IP addresses in the container CIDR block.
- Pods cannot directly use functionalities such as EIPs and security groups.

Applicable Scenarios

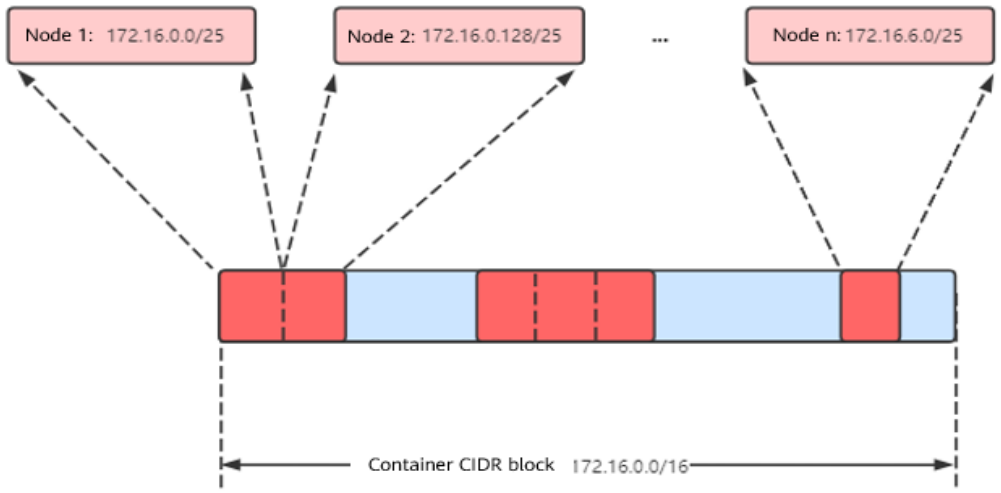
- High performance requirements: As no tunnel encapsulation is required, the VPC network model delivers the performance close to that of a VPC network when compared with the container tunnel network model. Therefore, the VPC network model applies to scenarios that have high requirements on performance, such as AI computing and big data computing.
- Small- and medium-scale networks: Due to the limitation on VPC routing tables, it is recommended that the number of nodes in a cluster be less than or equal to 1000.

Container IP Address Management

The VPC network allocates container IP addresses according to the following rules:

- The container CIDR block is allocated separately.
- IP addresses are allocated by node. One CIDR block with a fixed size (which is configurable) is allocated to each node in a cluster from the container CIDR block.
- The container CIDR block cyclically allocates CIDR blocks to new nodes in sequence.
- Pods scheduled to a node are cyclically allocated IP addresses from CIDR blocks allocated to the node.

Figure 10-7 IP address management of the VPC network



Maximum number of nodes that can be created in the cluster using the VPC network = Number of IP addresses in the container CIDR block /Number of IP addresses in the CIDR block allocated to the node by the container CIDR block

For example, if the container CIDR block is 172.16.0.0/16, the number of IP addresses is 65536. The mask of the container CIDR block allocated to the node is 25. That is, the number of container IP addresses on each node is 128. Therefore, a maximum of 512 (65536/128) nodes can be created. In addition, the number of nodes that can be created in a cluster also depends on the node network and cluster scale.

Recommendation for CIDR Block Planning

As described in **Cluster Network Structure**, network addresses in a cluster can be divided into three parts: node network, container network, and service network. When planning network addresses, consider the following aspects:

- The three CIDR blocks cannot overlap. Otherwise, a conflict occurs.
- Ensure that each CIDR block has sufficient IP addresses.
  - The IP addresses in the node CIDR block must match the cluster scale. Otherwise, nodes cannot be created due to insufficient IP addresses.
  - The IP addresses in the container CIDR block must match the service scale. Otherwise, pods cannot be created due to insufficient IP addresses. The number of pods that can be created on each node also depends on other parameter settings.

Assume that a cluster contains 200 nodes and the network model is VPC network.

In this case, the number of available IP addresses in the selected node subnet must be greater than 200. Otherwise, nodes cannot be created due to insufficient IP addresses.

The container CIDR block is 10.0.0.0/16, and the number of available IP addresses is 65536. As described in **Container IP Address Management**, the VPC network is allocated a CIDR block with the fixed size (using the mask to determine the maximum number of container IP addresses allocated to each node). For example, if the upper limit is 128, the cluster supports a maximum of 512 (65536/128) nodes, including the three master nodes.

Example of VPC Network Access

Create a cluster using the VPC network model. The cluster contains one node.

```
$ kubectl get node
NAME          STATUS   ROLES    AGE   VERSION
192.168.0.99   Ready    <none>   9d    v1.17.17-r0-CCE21.6.1.B004-17.37.5
```

Check the VPC routing table. The destination address 172.16.0.0/25 is the container CIDR block allocated to the node, and the next hop is the corresponding node. When the container IP address is accessed, the VPC route forwards the access request to the next-hop node. This indicates that the VPC network model uses VPC routes.

Create a Deployment in the cluster.

```
kind: Deployment
apiVersion: apps/v1
metadata:
  name: example
  namespace: default
spec:
  replicas: 4
  selector:
    matchLabels:
      app: example
  template:
    metadata:
      labels:
        app: example
    spec:
      containers:
```

```
      - name: container-0
        image: 'nginx:perl'
    imagePullSecrets:
      - name: default-secret
```

Check the pod.

```
$ kubectl get pod -owide
NAME                       READY   STATUS    RESTARTS   AGE   IP           NODE           NOMINATED NODE
READINESS GATES
example-86b9779494-l8qrw   1/1     Running   0          14s   172.16.0.6   192.168.0.99   <none>
<none>
example-86b9779494-svs8t   1/1     Running   0          14s   172.16.0.7   192.168.0.99   <none>
<none>
example-86b9779494-x8kl5   1/1     Running   0          14s   172.16.0.5   192.168.0.99   <none>
<none>
example-86b9779494-zt627   1/1     Running   0          14s   172.16.0.8   192.168.0.99   <none>
<none>
```

In this case, if you access the IP address of the pod from an ECS (outside the cluster) in the same VPC, the access is successful. This is a feature of VPC networking. Pods can be directly accessed from any node locating outside of the cluster and in the same VPC as that of the pods using the pods' IP addresses.

Pods can be accessed from nodes or pods in the same cluster. In the following example, you can directly access the pods in the container.

```
$ kubectl exec -it example-86b9779494-l8qrw -- curl 172.16.0.7
<!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>
```

10.3 Service

10.3.1 Overview

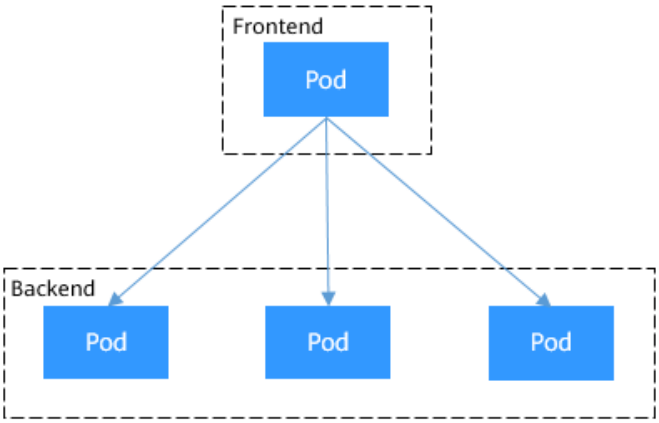
Direct Access to a Pod

After a pod is created, the following problems may occur if you directly access the pod:

- The pod can be deleted and recreated at any time by a controller such as a Deployment, and the result of accessing the pod becomes unpredictable.
- The IP address of the pod is allocated only after the pod is started. Before the pod is started, the IP address of the pod is unknown.
- An application is usually composed of multiple pods that run the same image. Accessing pods one by one is not efficient.

For example, an application uses Deployments to create the frontend and backend. The frontend calls the backend for computing, as shown in **Figure 10-8**. Three pods are running in the backend, which are independent and replaceable. When a backend pod is re-created, the new pod is assigned with a new IP address, of which the frontend pod is unaware.

Figure 10-8 Inter-pod access

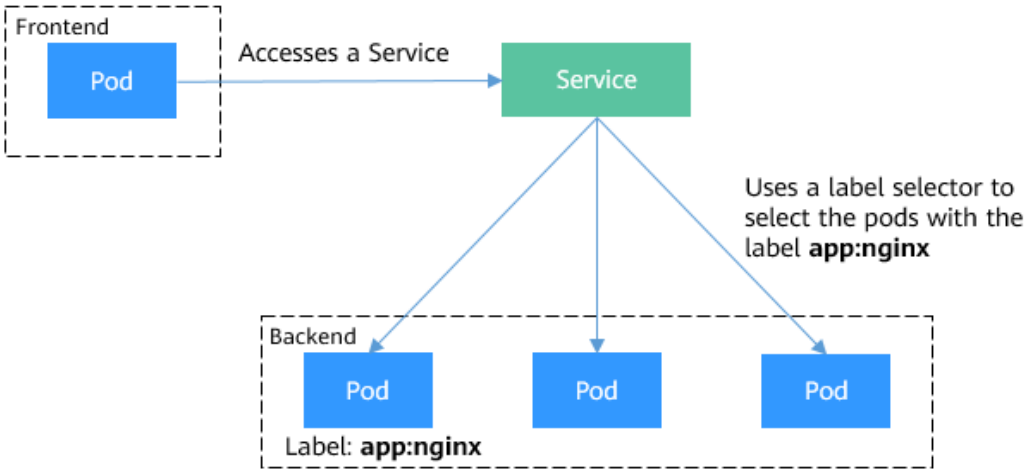


Using Services for Pod Access

Kubernetes Services are used to solve the preceding pod access problems. A Service has a fixed IP address. (When a CCE cluster is created, a Service CIDR block is set, which is used to allocate IP addresses to Services.) A Service forwards requests accessing the Service to pods based on labels, and at the same time, perform load balancing for these pods.

In the preceding example, a Service is added for the frontend pod to access the backend pods. In this way, the frontend pod does not need to be aware of the changes on backend pods, as shown in **Figure 10-9**.

Figure 10-9 Accessing pods through a Service



Service Types

Kubernetes allows you to specify a Service of a required type. The values and actions of different types of Services are as follows:

- **ClusterIP**

  ClusterIP Services allow workloads in the same cluster to use their cluster-internal domain names to access each other.

- **NodePort**

  A Service is exposed on each node's IP address at a static port (NodePort). A ClusterIP Service, to which the NodePort Service will route, is automatically created. By requesting <NodeIP>:<NodePort>, you can access a NodePort Service from outside the cluster.

- **LoadBalancer**

  LoadBalancer Services can access workloads from the public network through a load balancer, which is more reliable than EIP-based access. LoadBalancer Services are recommended for accessing workloads from outside the cluster.

- **DNAT**

  A DNAT gateway translates addresses for cluster nodes and allows multiple cluster nodes to share an EIP. DNAT Services provide higher reliability than EIP-based NodePort Services. You do not need to bind an EIP to a single node and requests can still be distributed to the workload even any of the nodes insides is down.

externalTrafficPolicy (Service Affinity)

For a NodePort and LoadBalancer Service, requests are first sent to the node port, then the Service, and finally the pod backing the Service. The backing pod may be not located in the node receiving the requests. By default, the backend workload can be accessed from any node IP address and service port. If the pod is not on the node that receives the request, the request will be redirected to the node where the pod is located, which may cause performance loss.

The **externalTrafficPolicy** parameter in a Service is used to determine whether the external traffic can be routed to the local nodes or cluster-wide endpoints. The following is an example:

```
apiVersion: v1
kind: Service
metadata:
  name: nginx-nodeport
spec:
  externalTrafficPolicy: Local
  ports:
  - name: service
    nodePort: 30000
    port: 80
    protocol: TCP
    targetPort: 80
  selector:
    app: nginx
  type: NodePort
```

If the value of **externalTrafficPolicy** is **Local**, requests sent from *Node IP address:Service port* will be forwarded only to the pod on the local node. If the node does not have a pod, the requests are suspended.

If the value of **externalTrafficPolicy** is **Cluster**, requests are forwarded within the cluster and the backend workload can be accessed from any node IP address and service port.

If **externalTrafficPolicy** is not set, the default value **Cluster** will be used.

When creating a NodePort on the CCE console, you can configure this parameter using the **Service Affinity** option.

The following table compares the two options of **externalTrafficPolicy**.

Table 10-2 Comparison of the two types of service affinity

Dimension	externalTrafficPolicy (Service Affinity)	
	Cluster-level (Cluster)	Node-level (Local)
Application scenario	This mode applies to scenarios where high performance is not required and the source IP address of the client does not need to be retained. This mode brings more balanced load to each node in the cluster.	This mode applies to scenarios where high performance is required and the source IP address of the client need to be retained. However, traffic is forwarded only to the node where the container resides, and source IP address translation is not performed.
Access mode	The IP addresses and access ports of all nodes in a cluster can access the workload associated with the Service.	Only the IP address and access port of the node where the workload is located can access the workload associated with the Service.
Obtaining client source IP address	The source IP address of the client cannot be obtained.	The source IP address of the client can be obtained.

Dimension	externalTrafficPolicy (Service Affinity)	
	Cluster-level (Cluster)	Node-level (Local)
Access performance	Service access will cause performance loss due to route redirection, and the next hop for a data packet may be another node.	Service access will not cause performance loss due to route redirection.
Load balancing	Traffic propagation has good overall load balancing.	There is a potential risk of unbalanced traffic propagation.
Other special case	None	In different container network models and service forwarding modes, accessing Services from within the cluster may fail. For details, see **Why a Service Fail to Be Accessed from Within the Cluster**.

Why a Service Fail to Be Accessed from Within the Cluster

If the service affinity of a Service is set to the node level, that is, the value of **externalTrafficPolicy** is **Local**, the Service may fail to be accessed from within the cluster (specifically, nodes or containers). Information similar to the following is displayed:

```
upstream connect error or disconnect/reset before headers. reset reason: connection failure
Or
curl: (7) Failed to connect to 192.168.10.36 port 900: Connection refused
```

It is common that a load balancer in a cluster cannot be accessed. The reason is as follows: When Kubernetes creates a Service, kube-proxy adds the access address of the load balancer as an external IP address (External-IP, as shown in the following command output) to iptables or IPVS. If a client inside the cluster initiates a request to access the load balancer, the address is considered as the external IP address of the Service, and the request is directly forwarded by kube-proxy without passing through the load balancer outside the cluster.

```
# kubectl get svc nginx
NAME    TYPE          CLUSTER-IP      EXTERNAL-IP                PORT(S)       AGE
nginx   LoadBalancer  10.247.76.156   123.**.**.**,192.168.0.133  80:32146/TCP  37s
```

When the value of **externalTrafficPolicy** is **Local**, the access failures in different container network models and service forwarding modes are as follows:

NOTE

- For a multi-pod workload, ensure that all pods are accessible. Otherwise, there is a possibility that the access to the workload fails.
- The table lists only the scenarios where the access may fail. Other scenarios that are not listed in the table indicate that the access is normal.

Service Type Released on the Server	Access Type	Request Initiation Location on the Client	Tunnel Network Cluster (IPVS)	VPC Network Cluster (IPVS)	Tunnel Network Cluster (iptables)	VPC Network Cluster (iptables)
NodePort Service	Public/ Private network	Same node as the service pod	Access the IP address and NodePort on the node where the server is located: The access is successful. Access the IP address and NodePort on a node other than the node where the server is located: The access failed.	Access the IP address and NodePort on the node where the server is located: The access is successful. Access the IP address and NodePort on a node other than the node where the server is located: The access failed.	Access the IP address and NodePort on the node where the server is located: The access is successful. Access the IP address and NodePort on a node other than the node where the server is located: The access failed.	Access the IP address and NodePort on the node where the server is located: The access is successful. Access the IP address and NodePort on a node other than the node where the server is located: The access failed.

Service Type Released on the Server	Access Type	Request Initiation Location on the Client	Tunnel Network Cluster (IPVS)	VPC Network Cluster (IPVS)	Tunnel Network Cluster (iptables)	VPC Network Cluster (iptables)
		Different nodes from the service pod	Access the IP address and NodePort on the node where the server is located: The access is successful. Access the IP address and NodePort on a node other than the node where the server is located: The access failed.	Access the IP address and NodePort on the node where the server is located: The access is successful. Access the IP address and NodePort on a node other than the node where the server is located: The access failed.	The access is successful.	The access is successful.

Service Type Released on the Server	Access Type	Request Initiation Location on the Client	Tunnel Network Cluster (IPVS)	VPC Network Cluster (IPVS)	Tunnel Network Cluster (iptables)	VPC Network Cluster (iptables)
		Other containers on the same node as the service pod	Access the IP address and NodePort on the node where the server is located: The access is successful. Access the IP address and NodePort on a node other than the node where the server is located: The access failed.	The access failed.	Access the IP address and NodePort on the node where the server is located: The access is successful. Access the IP address and NodePort on a node other than the node where the server is located: The access failed.	The access failed.

Service Type Released on the Server	Access Type	Request Initiation Location on the Client	Tunnel Network Cluster (IPVS)	VPC Network Cluster (IPVS)	Tunnel Network Cluster (iptables)	VPC Network Cluster (iptables)
		Other containers on different nodes from the service pod	Access the IP address and NodePort on the node where the server is located: The access is successful. Access the IP address and NodePort on a node other than the node where the server is located: The access failed.	Access the IP address and NodePort on the node where the server is located: The access is successful. Access the IP address and NodePort on a node other than the node where the server is located: The access failed.	Access the IP address and NodePort on the node where the server is located: The access is successful. Access the IP address and NodePort on a node other than the node where the server is located: The access failed.	Access the IP address and NodePort on the node where the server is located: The access is successful. Access the IP address and NodePort on a node other than the node where the server is located: The access failed.
LoadBalancer Service using a dedicated load balancer	Private network	Same node as the service pod	The access failed.	The access failed.	The access failed.	The access failed.

Service Type Released on the Server	Access Type	Request Initiation Location on the Client	Tunnel Network Cluster (IPVS)	VPC Network Cluster (IPVS)	Tunnel Network Cluster (iptables)	VPC Network Cluster (iptables)
		Other containers on the same node as the service pod	The access failed.	The access failed.	The access failed.	The access failed.
DNAT gateway Service	Public network	Same node as the service pod	The access failed.	The access failed.	The access failed.	The access failed.
		Different nodes from the service pod	The access failed.	The access failed.	The access failed.	The access failed.
		Other containers on the same node as the service pod	The access failed.	The access failed.	The access failed.	The access failed.
		Other containers on different nodes from the service pod	The access failed.	The access failed.	The access failed.	The access failed.

Service Type Released on the Server	Access Type	Request Initiation Location on the Client	Tunnel Network Cluster (IPVS)	VPC Network Cluster (IPVS)	Tunnel Network Cluster (iptables)	VPC Network Cluster (iptables)
nginx-ingress add-on connected with a dedicated load balancer (**Local**)	Private network	Same node as cceaddon-nginx-ingress-controller pod	The access failed.	The access failed.	The access failed.	The access failed.
		Other containers on the same node as the cceaddon-nginx-ingress-controller pod	The access failed.	The access failed.	The access failed.	The access failed.

The following methods can be used to solve this problem:

- (**Recommended**) In the cluster, use the ClusterIP Service or service domain name for access.
- Set **externalTrafficPolicy** of the Service to **Cluster**, which means cluster-level service affinity. Note that this affects source address persistence.

```
apiVersion: v1
kind: Service
metadata:
  annotations:
    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_type":"5_bgp","name":"james"}'
  labels:
    app: nginx
  name: nginx
spec:
  externalTrafficPolicy: Cluster
  ports:
  - name: service0
    port: 80
    protocol: TCP
    targetPort: 80
  selector:
    app: nginx
  type: LoadBalancer
```

- Leveraging the pass-through feature of the Service, kube-proxy is bypassed when the ELB address is used for access. The ELB load balancer is accessed

first, and then the workload. For details, see **Enabling Passthrough Networking for LoadBalancer Services**.

NOTE

- After passthrough networking is configured for a dedicated load balancer, in a CCE standard cluster, pods that run on the same node as the workload and pods that run on the same node cannot be accessed through the LoadBalancer Service.
- Passthrough networking is not supported for clusters of v1.15 or earlier.
- In IPVS network mode, the pass-through settings of Service connected to the same ELB 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.

```
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_type":"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
```

10.3.2 ClusterIP

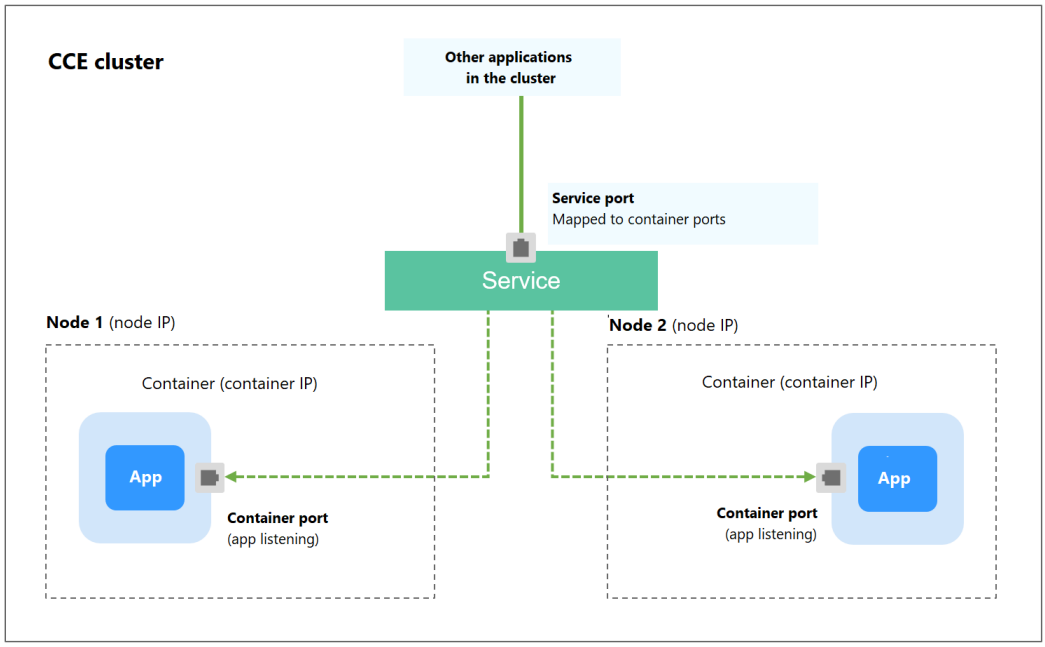
Scenario

ClusterIP Services allow workloads in the same cluster to use their cluster-internal domain names to access each other.

The cluster-internal domain name format is *<Service name>.<Namespace of the workload>***.svc.cluster.local:***<Port>*, for example, **nginx.default.svc.cluster.local:80**.

Figure 10-10 shows the mapping relationships between access channels, container ports, and access ports.

Figure 10-10 Intra-cluster access (ClusterIP)



Creating a ClusterIP Service

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 **Services & Ingresses**. In the upper right corner, click **Create Service**.

Step 3 Configure intra-cluster access parameters.

- **Service Name**: Specify a Service name, which can be the same as the workload name.
- **Service Type**: Select **ClusterIP**.
- **Namespace**: Namespace to which the workload belongs.
- **Selector**: Add a label and click **Confirm**. A Service selects a pod based on the added label. You can also click **Reference Workload Label** to use the label of an existing workload. In the dialog box that is displayed, select a workload and click **OK**.
- **Port Settings**
  - **Protocol**: protocol used by the Service.
  - **Service Port**: port used by the Service. The port number ranges from 1 to 65535.
  - **Container Port**: port on which the workload listens. For example, Nginx uses port 80 by default.

Step 4 Click **OK**.

----End

Setting the Access Type Using kubectl

You can run kubectl commands to set the access type (Service). This section uses an Nginx workload as an example to describe how to implement intra-cluster access using kubectl.

Step 1 Use kubectl to connect to the cluster. For details, see **Connecting to a Cluster Using kubectl**.

Step 2 Create and edit the **nginx-deployment.yaml** and **nginx-clusterip-svc.yaml** files.

The file names are user-defined. **nginx-deployment.yaml** and **nginx-clusterip-svc.yaml** are merely example file names.

vi nginx-deployment.yaml

```
apiVersion: apps/v1
kind: Deployment
metadata:
  name: nginx
spec:
  replicas: 1
  selector:
    matchLabels:
      app: nginx
  template:
    metadata:
      labels:
        app: nginx
    spec:
      containers:
      - image: nginx:latest
        name: nginx
      imagePullSecrets:
      - name: default-secret
```

vi nginx-clusterip-svc.yaml

```
apiVersion: v1
kind: Service
metadata:
  labels:
    app: nginx
  name: nginx-clusterip
spec:
  ports:
  - name: service0
    port: 8080              # 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 a Service to access the target container. This port is closely related to the applications running in a 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. In this example, select the pod with the app:nginx label.
    app: nginx
  type: ClusterIP           # Type of a Service. ClusterIP indicates that a Service is only reachable from within the cluster.
```

Step 3 Create a workload.

kubectl create -f nginx-deployment.yaml

If information similar to the following is displayed, the workload has been created.

```
deployment "nginx" created
```

kubectl get po

If information similar to the following is displayed, the workload is running.

```
NAME                     READY     STATUS            RESTARTS   AGE
nginx-2601814895-znhbr   1/1       Running           0          15s
```

Step 4 Create a Service.

kubectl create -f nginx-clusterip-svc.yaml

If information similar to the following is displayed, the Service is being created.

```
service "nginx-clusterip" created
```

kubectl get svc

If information similar to the following is displayed, the Service has been created, and a cluster-internal IP address has been assigned to the Service.

```
# kubectl get svc
NAME              TYPE        CLUSTER-IP     EXTERNAL-IP   PORT(S)    AGE
kubernetes        ClusterIP   10.247.0.1     <none>        443/TCP    4d6h
nginx-clusterip   ClusterIP   10.247.74.52   <none>        8080/TCP   14m
```

Step 5 Access a Service.

A Service can be accessed from containers or nodes in a cluster.

Create a pod, access the pod, and run the **curl** command to access *IP address:Port* or the domain name of the Service, as shown in the following figure.

The domain name suffix can be omitted. In the same namespace, you can directly use **nginx-clusterip:8080** for access. In other namespaces, you can use **nginx-clusterip.default:8080** for access.

```
# kubectl run -i --tty --image nginx:alpine test --rm /bin/sh
If you do not see a command prompt, try pressing Enter.
/ # curl 10.247.74.52:8080
<!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>
/ # curl nginx-clusterip.default.svc.cluster.local:8080
...
<h1>Welcome to nginx!</h1>
...
/ # curl nginx-clusterip.default:8080
...
<h1>Welcome to nginx!</h1>
...
```

```
/ # curl nginx-clusterip:8080
...
<h1>Welcome to nginx!</h1>
...
```

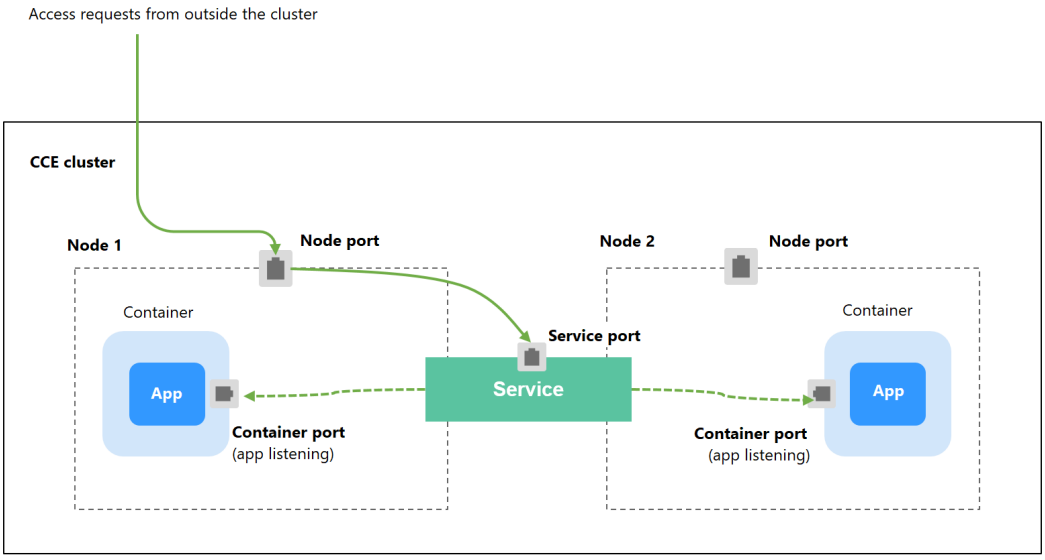
----End

10.3.3 NodePort

Scenario

A Service is exposed on each node's IP address at a static port (NodePort). When you create a NodePort Service, Kubernetes automatically allocates an internal IP address (ClusterIP) of the cluster. When clients outside the cluster access <NodeIP>:<NodePort>, the traffic will be forwarded to the target pod through the ClusterIP of the NodePort Service.

Figure 10-11 NodePort access



Constraints

- By default, a NodePort Service is accessed within a VPC. To use an EIP to access a NodePort Service through public networks, bind an EIP to the node in the cluster in advance.
- After a Service is created, if the affinity setting is switched from the cluster level to the node level, the connection tracing table will not be cleared. Do not modify the Service affinity setting after the Service is created. To modify it, create a Service again.
- In VPC network mode, when container A is published through a NodePort service and the service affinity is set to the node level (that is, **externalTrafficPolicy** is set to **local**), container B deployed on the same node cannot access container A through the node IP address and NodePort service.
- When a NodePort service is created in a cluster of v1.21.7 or later, the port on the node is not displayed using **netstat** by default. If the cluster forwarding mode is **iptables**, run the **iptables -t nat -L** command to view the port. If the

cluster forwarding mode is **IPVS**, run the **ipvsadm -Ln** command to view the port.

Creating a NodePort Service

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 **Services & Ingresses**. In the upper right corner, click **Create Service**.

Step 3 Configure intra-cluster access parameters.

- **Service Name**: Specify a Service name, which can be the same as the workload name.
- **Service Type**: Select **NodePort**.
- **Namespace**: Namespace to which the workload belongs.
- **Service Affinity**: For details, see **externalTrafficPolicy (Service Affinity)**.
  - **Cluster level**: The IP addresses and access ports of all nodes in a cluster can 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 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.
- **Selector**: Add a label and click **Confirm**. A Service selects a pod based on the added label. You can also click **Reference Workload Label** to use the label of an existing workload. In the dialog box that is displayed, select a workload and click **OK**.
- **Port Settings**
  - **Protocol**: protocol used by the Service.
  - **Service Port**: port used by the Service. The port number ranges from 1 to 65535.
  - **Container Port**: port on which the workload listens. For example, Nginx uses port 80 by default.
  - **Node Port**: You are advised to select **Auto**. You can also specify a port. The default port ranges from 30000 to 32767.

Step 4 Click **OK**.

----End

Using kubectl

You can run kubectl commands to set the access type. This section uses an Nginx workload as an example to describe how to set a NodePort Service using kubectl.

Step 1 Use kubectl to connect to the cluster. For details, see **Connecting to a Cluster Using kubectl**.

Step 2 Create and edit the **nginx-deployment.yaml** and **nginx-nodeport-svc.yaml** files.

The file names are user-defined. **nginx-deployment.yaml** and **nginx-nodeport-svc.yaml** are merely example file names.

vi nginx-deployment.yaml

```
apiVersion: apps/v1
kind: Deployment
metadata:
  name: nginx
spec:
  replicas: 1
  selector:
    matchLabels:
      app: nginx
  template:
    metadata:
      labels:
        app: nginx
    spec:
      containers:
      - image: nginx:latest
        name: nginx
      imagePullSecrets:
      - name: default-secret
```

vi nginx-nodeport-svc.yaml

```
apiVersion: v1
kind: Service
metadata:
  labels:
    app: nginx
  name: nginx-nodeport
spec:
  ports:
  - name: service
    nodePort: 30000     # Node port. The value ranges from 30000 to 32767.
    port: 8080          # 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 a Service to access the target container. This port is closely related to the applications running in a 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. In this example, select the pod with the app:nginx label.
    app: nginx
  type: NodePort        # Service type. NodePort indicates that the Service is accessed through a node port.
```

Step 3 Create a workload.

kubectl create -f nginx-deployment.yaml

If information similar to the following is displayed, the workload has been created.

```
deployment "nginx" created
```

kubectl get po

If information similar to the following is displayed, the workload is running.

```
NAME                     READY     STATUS            RESTARTS   AGE
nginx-2601814895-qhxqv   1/1       Running           0          9s
```

Step 4 Create a Service.

kubectl create -f nginx-nodeport-svc.yaml

If information similar to the following is displayed, the Service is being created.

```
service "nginx-nodeport" created
```

kubectl get svc

If information similar to the following is displayed, the Service has been created.

```
# kubectl get svc
NAME            TYPE        CLUSTER-IP     EXTERNAL-IP   PORT(S)          AGE
kubernetes      ClusterIP   10.247.0.1     <none>        443/TCP          4d8h
nginx-nodeport  NodePort    10.247.30.40   <none>        8080:30000/TCP   18s
```

Step 5 Access the Service.

By default, a NodePort Service can be accessed by using *Any node IP address:Node port*.

The Service can be accessed from a node in another cluster in the same VPC or in another pod in the cluster. If a public IP address is bound to the node, you can also use the public IP address to access the Service. Create a container in the cluster and access the container by using *Node IP address:Node port*.

```
# kubectl get node -owide
NAME          STATUS   ROLES    AGE    INTERNAL-IP    EXTERNAL-IP   OS-IMAGE               KERNEL-
VERSION               CONTAINER-RUNTIME
10.100.0.136   Ready    <none>   152m   10.100.0.136   <none>        CentOS Linux 7 (Core)
3.10.0-1160.25.1.el7.x86_64   docker://18.9.0
10.100.0.5     Ready    <none>   152m   10.100.0.5     <none>        CentOS Linux 7 (Core)
3.10.0-1160.25.1.el7.x86_64   docker://18.9.0
# kubectl run -i --tty --image nginx:alpine test --rm /bin/sh
If you do not see a command prompt, try pressing Enter.
/ # curl 10.100.0.136:30000
<!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>
/ #
```

----End

10.3.4 LoadBalancer

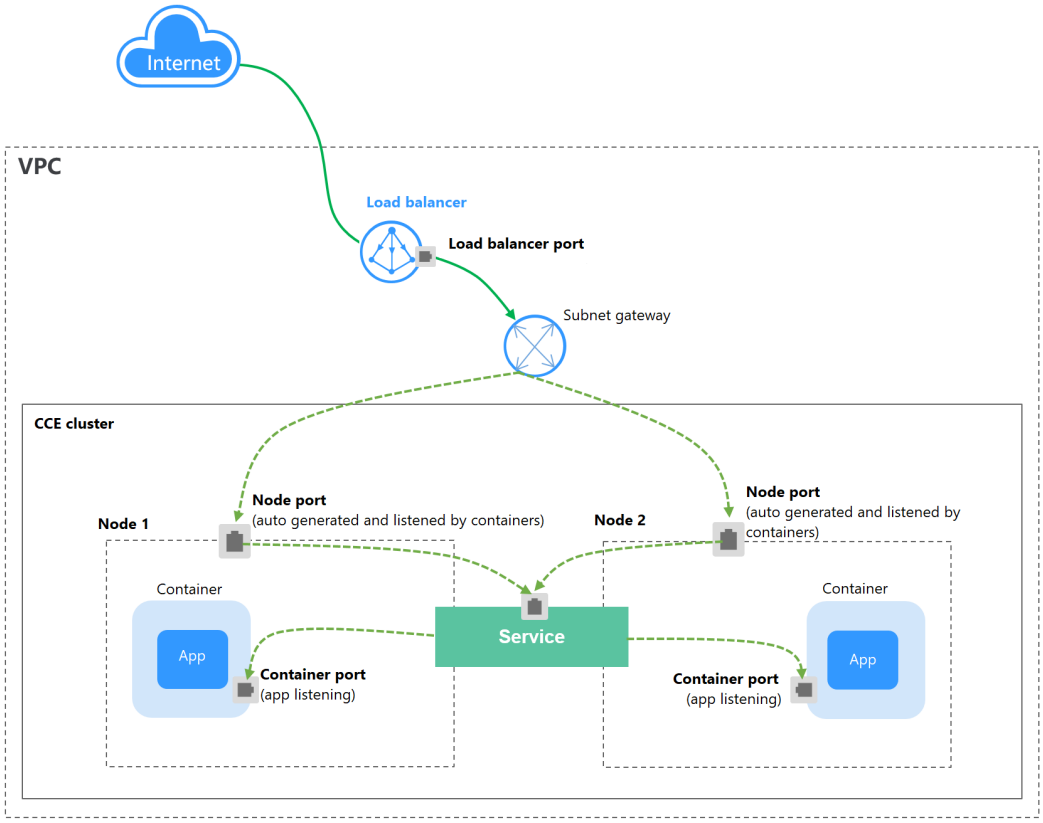
10.3.4.1 Creating a LoadBalancer Service

Scenario

LoadBalancer Services can access workloads from the public network through ELB, which is more reliable than EIP-based access. The LoadBalancer access address is in the format of *IP address of public network load balancer:Access port*, for example, **10.117.117.117:80**.

In this access mode, requests are transmitted through an ELB load balancer to a node and then forwarded to the destination pod through the Service.

Figure 10-12 LoadBalancer



Constraints

- LoadBalancer Services allow workloads to be accessed from public networks through ELB. This access mode has the following restrictions:
  - Automatically created load balancers should not be used by other resources. Otherwise, these load balancers cannot be completely deleted.
  - Do not change the listener name for the load balancer in clusters of v1.15 and earlier. Otherwise, the load balancer cannot be accessed.
- After a Service is created, if the affinity setting is switched from the cluster level to the node level, the connection tracing table will not be cleared. You are advised not to modify the Service affinity setting after the Service is created. To modify it, create a Service again.

- If the service affinity is set to the node level (that is, **externalTrafficPolicy** is set to **Local**), the cluster may fail to access the Service by using the ELB address. For details, see **Why a Service Fail to Be Accessed from Within the Cluster**.
- Dedicated ELB load balancers can be used only in clusters of v1.17 and later.
- Dedicated load balancers must be of the network type (TCP/UDP) supporting private networks (with a private IP). If the Service needs to support HTTP, the dedicated load balancers must be of the network (TCP/UDP) or application load balancing (HTTP/HTTPS) type.
- In a CCE cluster, if the cluster-level affinity is configured for a LoadBalancer Service, requests are distributed to the node ports of each node using SNAT when entering the cluster. The number of node ports cannot exceed the number of available node ports on the node. If the service affinity is at the node level (Local), there is no such constraint.
- When the cluster service forwarding (proxy) mode is IPVS, the node IP cannot be configured as the external IP of the Service. Otherwise, the node is unavailable.
- In a cluster using the IPVS proxy mode, if the ingress and Service use the same ELB load balancer, the ingress cannot be accessed from the nodes and containers in the cluster because kube-proxy mounts the LoadBalancer Service address to the ipvs-0 bridge. This bridge intercepts the traffic of the load balancer connected to the ingress. Use different load balancers for the ingress and Service.

Creating a LoadBalancer Service

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 **Services & Ingresses**. In the upper right corner, click **Create Service**.

Step 3 Configure parameters.

- **Service Name**: Specify a Service name, which can be the same as the workload name.
- **Service Type**: Select **LoadBalancer**.
- **Namespace**: Namespace to which the workload belongs.
- **Service Affinity**: For details, see **externalTrafficPolicy (Service Affinity)**.
  - **Cluster level**: The IP addresses and access ports of all nodes in a cluster can 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 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.
- **Selector**: Add a label and click **Confirm**. A Service selects a pod based on the added label. You can also click **Reference Workload Label** to use the label of an existing workload. In the dialog box that is displayed, select a workload and click **OK**.

- **Load Balancer**: Select a load balancer type and creation mode.

  A load balancer can be dedicated or shared. A dedicated load balancer supports **Network (TCP/UDP)**, **Application (HTTP/HTTPS)**, or **Network (TCP/UDP) & Application (HTTP/HTTPS)**.

  You can select **Use existing** or **Auto create** to obtain a load balancer. For details about the configuration of different creation modes, see **Table 10-3**.

  Table 10-3 Load balancer configurations

How to Create	Configuration
Use existing	Only the load balancers in the same VPC as the cluster can be selected. If no load balancer is available, click **Create Load Balancer** to create one on the ELB console.
Auto create	– **Instance Name**: Enter a load balancer name. – **Enterprise Project**: This parameter is available only for enterprise users who have enabled an enterprise project. Enterprise projects facilitate project-level management and grouping of cloud resources and users. – **AZ**: available only to dedicated load balancers. You can create load balancers in multiple AZs to improve service availability. You can deploy a load balancer in multiple AZs for high availability. – **Frontend Subnet**: available only to dedicated load balancers. It is used to allocate IP addresses for load balancers to provide services externally. – **Backend Subnet**: available only to dedicated load balancers. It is used to allocate IP addresses for load balancers to access the backend service. – **Network/Application-oriented Specifications** (available only to dedicated load balancers) ▪ **Fixed**: applies to stable traffic, billed based on specifications. – **EIP**: If you select **Auto create**, you can configure the billing mode and size of the public network bandwidth.

  You can click  in the **Set ELB** area and configure load balancer parameters in the **Set ELB** dialog box.

  – **Algorithm**: Three algorithms are available: weighted round robin, weighted least connections algorithm, or source IP hash.

NOTE

- **Weighted round robin**: Requests are forwarded to different servers based on their weights, which indicate server processing performance. Backend servers with higher weights receive proportionately more requests, whereas equal-weighted servers receive the same number of requests. This algorithm is often used for short connections, such as HTTP services.
- **Weighted least connections**: In addition to the weight assigned to each server, the number of connections processed by each backend server is considered. Requests are forwarded to the server with the lowest connections-to-weight ratio. Building on **least connections**, the **weighted least connections** algorithm assigns a weight to each server based on their processing capability. This algorithm is often used for persistent connections, such as database connections.
- **Source IP hash**: The source IP address of each request is calculated using the hash algorithm to obtain a unique hash key, and all backend servers are numbered. The generated key allocates the client to a particular server. This enables requests from different clients to be distributed in load balancing mode and ensures that requests from the same client are forwarded to the same server. This algorithm applies to TCP connections without cookies.

  - **Type**: This function is disabled by default. You can select **Source IP address**. Source IP address-based sticky session means that access requests from the same IP address are forwarded to the same backend server.

    NOTE

    When the **distribution policy** uses the source IP hash, sticky session cannot be set.

- **Health Check**: Configure health check for the load balancer.
  - **Global health check**: applies only to ports using the same protocol. You are advised to select **Custom health check**.
  - **Custom health check**: applies to **ports** using different protocols. For details about the YAML definition for custom health check, see **Configuring Health Check on Multiple Service Ports**.

Table 10-4 Health check parameters

Parameter	Description
Protocol	When the protocol of **Port** is set to TCP, the TCP and HTTP are supported. When the protocol of **Port** is set to UDP, the UDP is supported. – **Check Path** (supported only by HTTP for health check): specifies the health check URL. The check path must start with a slash (/) and contain 1 to 80 characters.

Parameter	Description
Port	By default, the service port (NodePort or container port of the Service) is used for health check. You can also specify another port for health check. After the port is specified, a service port named **cce-healthz** will be added for the Service. – **Node Port**: If a shared load balancer is used or no ENI instance is associated, the node port is used as the health check port. If this parameter is not specified, a random port is used. The value ranges from 30000 to 32767. – **Container Port**: When a dedicated load balancer is associated with an ENI instance, the container port is used for health check. The value ranges from 1 to 65535.
Check Period (s)	Specifies the maximum interval between health checks. The value ranges from 1 to 50.
Timeout (s)	Specifies the maximum timeout duration for each health check. The value ranges from 1 to 50.
Max. Retries	Specifies the maximum number of health check retries. The value ranges from 1 to 10.

- **Ports**
  - **Protocol**: protocol used by the Service.
  - **Service Port**: port used by the Service. The port number ranges from 1 to 65535.
  - **Container Port**: port on which the workload listens. For example, Nginx uses port 80 by default.
  - **Frontend Protocol**: the frontend protocol of the load balancer listener for establishing a traffic distribution connection with the client. When a dedicated load balancer is selected, HTTP/HTTPS can be configured only when **Application (HTTP/HTTPS)** is selected.
  - **Health Check**: If **Health Check** is set to **Custom health check**, you can configure health check for ports using different protocols. For details, see **Table 10-4**.

  NOTE

  When a LoadBalancer Service is created, a random node port number (NodePort) is automatically generated.
- **Annotation**: The LoadBalancer Service has some advanced CCE functions, which are implemented by annotations. For details, see **Using Annotations to Balance Load**.

Step 4 Click **OK**.

----End

Using kubectl to Create a Service (Using an Existing Load Balancer)

You can set the Service when creating a workload using kubectl. This section uses an Nginx workload as an example to describe how to add a LoadBalancer Service using kubectl.

Step 1 Use kubectl to connect to the cluster. For details, see **Connecting to a Cluster Using kubectl**.

Step 2 Create the files named **nginx-deployment.yaml** and **nginx-elb-svc.yaml** and edit them.

The file names are user-defined. **nginx-deployment.yaml** and **nginx-elb-svc.yaml** are merely example file names.

vi nginx-deployment.yaml

```
apiVersion: apps/v1
kind: Deployment
metadata:
  name: nginx
spec:
  replicas: 1
  selector:
    matchLabels:
      app: nginx
  template:
    metadata:
      labels:
        app: nginx
    spec:
      containers:
      - image: nginx
        name: nginx
      imagePullSecrets:
      - name: default-secret
```

vi nginx-elb-svc.yaml

NOTE

Before enabling sticky session, ensure that the following conditions are met:

- The workload protocol is TCP.
- Anti-affinity has been configured between pods of the workload. That is, all pods of the workload are deployed on different nodes. For details, see **Scheduling Policies (Affinity/Anti-affinity)**.

```
apiVersion: v1
kind: Service
metadata:
  name: nginx
  annotations:
    kubernetes.io/elb.id: <your_elb_id>                    # ELB ID. Replace it with the actual value.
    kubernetes.io/elb.class: performance                   # Load balancer type
    kubernetes.io/elb.lb-algorithm: ROUND_ROBIN            # Load balancer algorithm
    kubernetes.io/elb.session-affinity-mode: SOURCE_IP     # The sticky session type is source IP address.
    kubernetes.io/elb.session-affinity-option: '{"persistence_timeout": "30"}'    # Stickiness duration (min)
    kubernetes.io/elb.health-check-flag: 'on'              # Enable the ELB health check function.
    kubernetes.io/elb.health-check-option: '{
      "protocol":"TCP",
      "delay":"5",
      "timeout":"10",
      "max_retries":"3"
    }'
spec:
```

```
  selector:
    app: nginx
  ports:
  - name: service0
    port: 80     # Port for accessing the Service, which is also the listener port on the load balancer.
    protocol: TCP
    targetPort: 80  # Port used by a Service to access the target container. This port is closely related to the applications running in a container.
    nodePort: 31128  # Port number of the node. If this parameter is not specified, a random port number ranging from 30000 to 32767 is generated.
  type: LoadBalancer
```

The preceding example uses annotations to implement some advanced functions of load balancing, such as sticky session and health check. For details, see **Table 10-5**.

For more annotations and examples related to advanced functions, see **Using Annotations to Balance Load**.

Table 10-5 annotations parameters

Parameter	Mandatory	Type	Description
kubernetes.io/elb.id	Yes	String	ID of an enhanced load balancer. Mandatory when an existing load balancer is to be associated. **How to obtain**: On the management console, click **Service List**, and choose **Networking** > **Elastic Load Balance**. Click the name of the target load balancer. On the **Summary** tab page, find and copy the ID. **NOTE** The system preferentially connects to the load balancer based on the **kubernetes.io/elb.id** field. If this field is not specified, the **spec.loadBalancerIP** field is used (optional and available only in 1.23 and earlier versions). Do not use the **spec.loadBalancerIP** field to connect to the load balancer. This field will be discarded by Kubernetes. For details, see **Deprecation**.
kubernetes.io/elb.class	Yes	String	Select a proper load balancer type. The value can be: • **performance**: dedicated load balancer, which can be used only in clusters of v1.17 and later. **NOTE** If a LoadBalancer Service accesses an existing dedicated load balancer, the dedicated load balancer must support TCP/UDP networking.

Parameter	Mandatory	Type	Description
kubernetes.io/elb.lb-algorithm	No	String	Specifies the load balancing algorithm of the backend server group. The default value is **ROUND_ROBIN**. Options: • **ROUND_ROBIN**: weighted round robin algorithm • **LEAST_CONNECTIONS**: weighted least connections algorithm • **SOURCE_IP**: source IP hash algorithm **NOTE** If this parameter is set to **SOURCE_IP**, the weight setting (**weight** field) of backend servers bound to the backend server group is invalid, and sticky session cannot be enabled.
kubernetes.io/elb.session-affinity-mode	No	String	Source IP address-based sticky session is supported. That is, access requests from the same IP address are forwarded to the same backend server. • Disabling sticky session: Do not configure this parameter. • Enabling sticky session: Set this parameter to **SOURCE_IP**, indicating that the sticky session is based on the source IP address. **NOTE** When **kubernetes.io/elb.lb-algorithm** is set to **SOURCE_IP** (source IP hash), sticky session cannot be enabled.
kubernetes.io/elb.session-affinity-option	No	**Table 10-6** object	Sticky session timeout.
kubernetes.io/elb.health-check-flag	No	String	Whether to enable the ELB health check. • Enabling health check: Leave blank this parameter or set it to **on**. • Disabling health check: Set this parameter to **off**. If this parameter is enabled, the **kubernetes.io/elb.health-check-option** field must also be specified at the same time.

Parameter	Mandatory	Type	Description
kubernetes.io/elb.health-check-option	No	Table 10-7 object	ELB health check configuration items.

Table 10-6 elb.session-affinity-option data structure

Parameter	Mandatory	Type	Description
persistence_timeout	Yes	String	Sticky session timeout, in minutes. This parameter is valid only when **elb.session-affinity-mode** is set to **SOURCE_IP**. Value range: 1 to 60. Default value: **60**

Table 10-7 elb.health-check-option data structure

Parameter	Mandatory	Type	Description
delay	No	String	Health check interval (s) Value range: 1 to 50. Default value: **5**
timeout	No	String	Health check timeout, in seconds. Value range: 1 to 50. Default value: **10**
max_retries	No	String	Maximum number of health check retries. Value range: 1 to 10. Default value: **3**
protocol	No	String	Health check protocol. Value options: TCP or HTTP
path	No	String	Health check URL. This parameter needs to be configured when the protocol is **HTTP**. Default value: **/** Value range: 1-80 characters

Step 3 Create a workload.

kubectl create -f nginx-deployment.yaml

If information similar to the following is displayed, the workload has been created.

```
deployment/nginx created
```

kubectl get pod

If information similar to the following is displayed, the workload is running.

```
NAME                     READY   STATUS    RESTARTS   AGE
nginx-2601814895-c1xhw   1/1     Running   0          6s
```

Step 4 Create a Service.

kubectl create -f nginx-elb-svc.yaml

If information similar to the following is displayed, the Service has been created.

```
service/nginx created
```

kubectl get svc

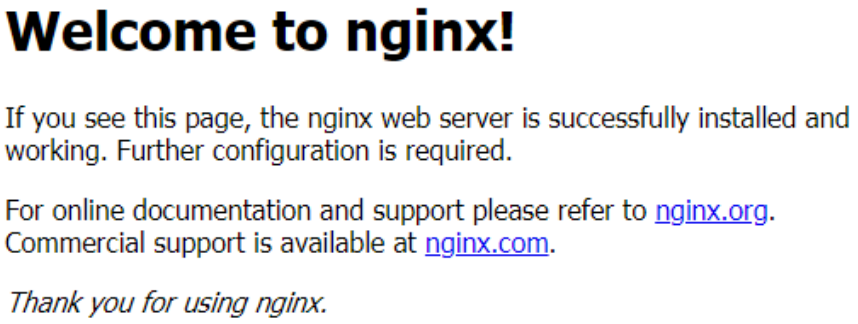
If information similar to the following is displayed, the access type has been set, and the workload is accessible.

```
NAME         TYPE           CLUSTER-IP      EXTERNAL-IP    PORT(S)        AGE
kubernetes   ClusterIP      10.247.0.1      <none>         443/TCP        3d
nginx        LoadBalancer   10.247.130.196  10.78.42.242   80:31540/TCP   51s
```

Step 5 Enter the URL in the address box of the browser, for example, **10.78.42.242:80**. **10.78.42.242** indicates the IP address of the load balancer, and **80** indicates the access port displayed on the CCE console.

The Nginx is accessible.

Figure 10-13 Accessing Nginx through the LoadBalancer Service



----End

Using kubectl to Create a Service (Automatically Creating a Load Balancer)

You can set the Service when creating a workload using kubectl. This section uses an Nginx workload as an example to describe how to add a LoadBalancer Service using kubectl.

Step 1 Use kubectl to connect to the cluster. For details, see **Connecting to a Cluster Using kubectl**.

Step 2 Create the files named **nginx-deployment.yaml** and **nginx-elb-svc.yaml** and edit them.

The file names are user-defined. **nginx-deployment.yaml** and **nginx-elb-svc.yaml** are merely example file names.

vi nginx-deployment.yaml

```
apiVersion: apps/v1
kind: Deployment
metadata:
  name: nginx
spec:
  replicas: 1
  selector:
    matchLabels:
      app: nginx
  template:
    metadata:
      labels:
        app: nginx
    spec:
      containers:
      - image: nginx
        name: nginx
      imagePullSecrets:
      - name: default-secret
```

vi nginx-elb-svc.yaml

NOTE

Before enabling sticky session, ensure that the following conditions are met:

- The workload protocol is TCP.
- Anti-affinity has been configured between pods of the workload. That is, all pods of the workload are deployed on different nodes. For details, see **Scheduling Policies (Affinity/Anti-affinity)**.

Example Service using a public network dedicated load balancer (only for clusters of v1.17 and later):

```
apiVersion: v1
kind: Service
metadata:
  name: nginx
  labels:
    app: nginx
  namespace: default
  annotations:
    kubernetes.io/elb.class: performance
    kubernetes.io/elb.autocreate: '{
      "type": "public",
      "bandwidth_name": "cce-bandwidth-1626694478577",
      "bandwidth_chargemode": "bandwidth",
      "bandwidth_size": 5,
      "bandwidth_sharetype": "PER",
      "eip_type": "5_bgp",
      "vip_subnet_cidr_id": "******",
      "vip_address": "**.**.**.**",


      "available_zone": [
        ""
      ],
      "l4_flavor_name": "L4_flavor.elb.s1.small"
    }'
    kubernetes.io/elb.enterpriseID: '0'      # ID of the enterprise project to which the load balancer belongs
    kubernetes.io/elb.lb-algorithm: ROUND_ROBIN                # Load balancer algorithm
    kubernetes.io/elb.session-affinity-mode: SOURCE_IP         # The sticky session type is source IP address.
    kubernetes.io/elb.session-affinity-option: '{"persistence_timeout": "30"}'     # Stickiness duration (min)
    kubernetes.io/elb.health-check-flag: 'on'                  # Enable the ELB health check function.
    kubernetes.io/elb.health-check-option: '{
      "protocol":"TCP",
      "delay":"5",
      "timeout":"10",
      "max_retries":"3"
```

```
  }'
spec:
  selector:
    app: nginx
  ports:
  - name: cce-service-0
    targetPort: 80
    nodePort: 0
    port: 80
    protocol: TCP
  type: LoadBalancer
```

The preceding example uses annotations to implement some advanced functions of load balancing, such as sticky session and health check. For details, see **Table 10-8**.

For more annotations and examples related to advanced functions, see **Using Annotations to Balance Load**.

Table 10-8 annotations parameters

Parameter	Mandatory	Type	Description
kubernetes.io/elb.class	Yes	String	Select a proper load balancer type. The value can be: • **performance**: dedicated load balancer, which can be used only in clusters of v1.17 and later.
kubernetes.io/elb.autocreate	Yes	**elb.autocreate** object	Whether to automatically create a load balancer associated with the Service. **Example** • If a public network load balancer will be automatically created, set this parameter to the following value: '{"type":"public","bandwidth_name":"cce-bandwidth-1551163379627","bandwidth_chargemode":"bandwidth","bandwidth_size":5,"bandwidth_sharetype":"PER","eip_type":"5_bgp","name":"james"}' • If a private network load balancer will be automatically created, set this parameter to the following value: {"type":"inner","name":"A-location-d-test"}
kubernetes.io/elb.subnet-id	None	String	ID of the subnet where the cluster is located. The value can contain 1 to 100 characters. • Mandatory when a cluster of v1.11.7-r0 or earlier is to be automatically created. • Optional for clusters later than v1.11.7-r0.

Parameter	Mandatory	Type	Description
kubernetes.io/elb.enterpriseID	No	String	**Clusters of v1.15 and later versions support this field. In clusters earlier than v1.15, load balancers are created in the default project by default.** This parameter indicates the ID of the enterprise project in which the ELB load balancer will be created. If this parameter is not specified or is set to **0**, resources will be bound to the default enterprise project. **How to obtain**: Log in to the management console and choose **Enterprise** > **Project Management** on the top menu bar. In the list displayed, click the name of the target enterprise project, and copy the ID on the enterprise project details page.
kubernetes.io/elb.lb-algorithm	No	String	Specifies the load balancing algorithm of the backend server group. The default value is **ROUND_ROBIN**. Options: ● **ROUND_ROBIN**: weighted round robin algorithm ● **LEAST_CONNECTIONS**: weighted least connections algorithm ● **SOURCE_IP**: source IP hash algorithm **NOTE** If this parameter is set to **SOURCE_IP**, the weight setting (**weight** field) of backend servers bound to the backend server group is invalid, and sticky session cannot be enabled.
kubernetes.io/elb.session-affinity-mode	No	String	Source IP address-based sticky session is supported. That is, access requests from the same IP address are forwarded to the same backend server. ● Disabling sticky session: Do not configure this parameter. ● Enabling sticky session: Set this parameter to **SOURCE_IP**, indicating that the sticky session is based on the source IP address. **NOTE** When **kubernetes.io/elb.lb-algorithm** is set to **SOURCE_IP** (source IP hash), sticky session cannot be enabled.

Parameter	Mandatory	Type	Description
kubernetes.io/elb.session-affinity-option	No	Table 10-6 object	Sticky session timeout.
kubernetes.io/elb.health-check-flag	No	String	Whether to enable the ELB health check. • Enabling health check: Leave blank this parameter or set it to **on**. • Disabling health check: Set this parameter to **off**. If this parameter is enabled, the **kubernetes.io/elb.health-check-option** field must also be specified at the same time.
kubernetes.io/elb.health-check-option	No	Table 10-7 object	ELB health check configuration items.

Table 10-9 elb.autocreate data structure

Parameter	Mandatory	Type	Description
name	No	String	Name of the automatically created load balancer. The value can contain 1 to 64 characters. Only letters, digits, underscores (_), hyphens (-), and periods (.) are allowed. Default: **cce-lb+service.UID**
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.

Parameter	Mandatory	Type	Description
bandwidth_chargemode	No	String	Bandwidth 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. ● The minimum increment is 1 Mbit/s if the allowed bandwidth does not exceed 300 Mbit/s. ● The minimum increment is 50 Mbit/s if the allowed bandwidth ranges from 300 Mbit/s to 1000 Mbit/s. ● The minimum increment is 500 Mbit/s if the allowed bandwidth exceeds 1000 Mbit/s.
bandwidth_sharetype	Yes for public network load balancers	String	Bandwidth sharing mode. ● **PER**: dedicated bandwidth
eip_type	Yes for public network load balancers	String	EIP type. ● **5_bgp**: dynamic BGP The specific type varies with regions. For details, see the EIP console.
vip_subnet_cidr_id	No	String	Subnet where a load balancer is located. The subnet must belong to the VPC where the cluster resides. If this parameter is not specified, the ELB load balancer and the cluster are in the same subnet. This field can be specified only for clusters of v1.21 or later.

Parameter	Mandatory	Type	Description
vip_address	No	String	Private IP address of the load balancer. Only IPv4 addresses are supported. The IP address must be in the ELB CIDR block. If this parameter is not specified, an IP address will be automatically assigned from the ELB CIDR block. This parameter is available only in clusters of v1.23.11-r0, v1.25.6-r0, v1.27.3-r0, or later versions.
available_zone	Yes	Array of strings	AZ where the load balancer is located. This parameter is available only for dedicated load balancers.
l4_flavor_name	Yes	String	Flavor name of the layer-4 load balancer. This parameter is available only for dedicated load balancers.
l7_flavor_name	No	String	Flavor name of the layer-7 load balancer. This parameter is available only for dedicated load balancers. The value of this parameter must be the same as that of **l4_flavor_name**, that is, both are elastic specifications or fixed specifications.
elb_virsubnet_ids	No	Array of strings	Subnet where the backend server of the load balancer is located. If this parameter is left blank, the default cluster subnet is used. Load balancers occupy different number of subnet IP addresses based on their specifications. Do not use the subnet CIDR blocks of other resources (such as clusters and nodes) as the load balancer CIDR block. This parameter is available only for dedicated load balancers. Example: `"elb_virsubnet_ids": [ "14567f27-8ae4-42b8-ae47-9f847a4690dd" ]`

Step 3 Create a workload.

kubectl create -f nginx-deployment.yaml

If information similar to the following is displayed, the workload is being created.

```
deployment/nginx created
```

kubectl get pod

If information similar to the following is displayed, the workload is running.

```
NAME                READY   STATUS    RESTARTS   AGE
nginx-2601814895-c1xhw   1/1     Running   0          6s
```

Step 4 Create a Service.

kubectl create -f nginx-elb-svc.yaml

If information similar to the following is displayed, the Service has been created.

```
service/nginx created
```

kubectl get svc

If information similar to the following is displayed, the access type has been set, and the workload is accessible.

```
NAME         TYPE           CLUSTER-IP      EXTERNAL-IP    PORT(S)        AGE
kubernetes   ClusterIP      10.247.0.1      <none>         443/TCP        3d
nginx        LoadBalancer   10.247.130.196  10.78.42.242   80:31540/TCP   51s
```

Step 5 Enter the URL in the address box of the browser, for example, **10.78.42.242:80**. **10.78.42.242** indicates the IP address of the load balancer, and **80** indicates the access port displayed on the CCE console.

The Nginx is accessible.

Figure 10-14 Accessing Nginx through the LoadBalancer Service

----End

10.3.4.2 Using Annotations to Balance Load

You can add annotations to a YAML file to use some CCE advanced functions. This section describes the available annotations when a LoadBalancer service is created.

- **Interconnection with ELB**
- **Sticky Session**
- **Health Check**
- **HTTP or HTTPS**
- **Dynamic Adjustment of the Weight of the Backend ECS**
- **Passthrough Capability**
- **Host Network**
- **Timeout**

Interconnection with ELB

Table 10-10 Annotations for interconnecting with ELB

Parameter	Type	Description	Supported Cluster Version
kubernetes.io/elb.class	String	Select a proper load balancer type. The value can be: • **performance**: dedicated load balancer, which can be used only in clusters of v1.17 and later.	v1.9 or later
kubernetes.io/elb.id	String	Mandatory **when an existing load balancer is to be associated**. ID of a load balancer. **How to obtain**: On the management console, click **Service List**, and choose **Networking** > **Elastic Load Balance**. Click the name of the target load balancer. On the **Summary** tab page, find and copy the ID. **NOTE** The system preferentially connects to the load balancer based on the **kubernetes.io/elb.id** field. If this field is not specified, the **spec.loadBalancerIP** field is used (optional and available only in 1.23 and earlier versions). Do not use the **spec.loadBalancerIP** field to connect to the load balancer. This field will be discarded by Kubernetes. For details, see **Deprecation**.	v1.9 or later
kubernetes.io/elb.autocreate	**Table 10-18**	Mandatory **when load balancers are automatically created**. **Example:** • If a public network load balancer will be automatically created, set this parameter to the following value: '{"type":"public","bandwidth_name":"cce-bandwidth-1551163379627","bandwidth_chargemode":"bandwidth","bandwidth_size":5,"bandwidth_sharetype":"PER","eip_type":"5_bgp","name":"james"}' • If a private network load balancer will be automatically created, set this parameter to the following value: {"type":"inner","name":"A-location-d-test"}	v1.9 or later

Parameter	Type	Description	Supported Cluster Version
kubernetes.io/elb.enterpriseID	String	Optional **when load balancers are automatically created**. **Clusters of v1.15 and later versions support this field. In clusters earlier than v1.15, load balancers are created in the default project by default.** This parameter indicates the ID of the enterprise project in which the ELB load balancer will be created. If this parameter is not specified or is set to **0**, resources will be bound to the default enterprise project. **How to obtain**: Log in to the management console and choose **Enterprise** > **Project Management** on the top menu bar. In the list displayed, click the name of the target enterprise project, and copy the ID on the enterprise project details page.	v1.15 or later
kubernetes.io/elb.subnet-id	String	Optional **when load balancers are automatically created**. ID of the subnet where the cluster is located. The value can contain 1 to 100 characters. ● Mandatory when a cluster of v1.11.7-r0 or earlier is to be automatically created. ● Optional for clusters later than v1.11.7-r0.	Mandatory for clusters earlier than v1.11.7-r0 Discarded in clusters later than v1.11.7-r0
kubernetes.io/elb.lb-algorithm	String	Specifies the load balancing algorithm of the backend server group. The default value is **ROUND_ROBIN**. Options: ● **ROUND_ROBIN**: weighted round robin algorithm ● **LEAST_CONNECTIONS**: weighted least connections algorithm ● **SOURCE_IP**: source IP hash algorithm **NOTE** If this parameter is set to **SOURCE_IP**, the weight setting (**weight** field) of backend servers bound to the backend server group is invalid, and sticky session cannot be enabled.	v1.9 or later

The following shows how to use the preceding annotations:

- Associate an existing load balancer. For details, see **Using kubectl to Create a Service (Using an Existing Load Balancer)**.

```
apiVersion: v1
kind: Service
metadata:
  name: nginx
  annotations:
    kubernetes.io/elb.id: <your_elb_id>                    # ELB ID. Replace it with the actual value.
    kubernetes.io/elb.class: performance                   # Load balancer type
    kubernetes.io/elb.lb-algorithm: ROUND_ROBIN            # Load balancer algorithm
spec:
  selector:
    app: nginx
  ports:
  - name: service0
    port: 80
    protocol: TCP
    targetPort: 80
  type: LoadBalancer
```

- Automatically create a load balancer. For details, see **Using kubectl to Create a Service (Automatically Creating a Load Balancer)**.

  Dedicated load balancer:

```
apiVersion: v1
kind: Service
metadata:
  name: nginx
  labels:
    app: nginx
  namespace: default
  annotations:
    kubernetes.io/elb.class: performance
    kubernetes.io/elb.autocreate: '{
      "type": "public",
      "bandwidth_name": "cce-bandwidth-1626694478577",
      "bandwidth_chargemode": "bandwidth",
      "bandwidth_size": 5,
      "bandwidth_sharetype": "PER",
      "eip_type": "5_bgp",
      "available_zone": [
        ""
      ],
      "l4_flavor_name": "L4_flavor.elb.s1.small"
    }'
    kubernetes.io/elb.enterpriseID: '0'                    # ID of the enterprise project to which the load balancer belongs
    kubernetes.io/elb.lb-algorithm: ROUND_ROBIN            # Load balancer algorithm
spec:
  selector:
    app: nginx
  ports:
  - name: cce-service-0
    targetPort: 80
    nodePort: 0
    port: 80
    protocol: TCP
  type: LoadBalancer
```

Sticky Session

Table 10-11 Annotations for sticky session

Parameter	Type	Description	Supported Cluster Version
kubernetes.io/elb.session-affinity-mode	String	Source IP address-based sticky session is supported. That is, access requests from the same IP address are forwarded to the same backend server. • Disabling sticky session: Do not configure this parameter. • Enabling sticky session: Set this parameter to **SOURCE_IP**, indicating that the sticky session is based on the source IP address. **NOTE** When **kubernetes.io/elb.lb-algorithm** is set to **SOURCE_IP** (source IP hash), sticky session cannot be enabled.	v1.9 or later
kubernetes.io/elb.session-affinity-option	Table 10-21	Sticky session timeout.	v1.9 or later

The following shows how to use the preceding annotations:

```
apiVersion: v1
kind: Service
metadata:
  name: nginx
  annotations:
    kubernetes.io/elb.id: <your_elb_id>                    # ELB ID. Replace it with the actual value.
    kubernetes.io/elb.class: performance                   # Load balancer type
    kubernetes.io/elb.session-affinity-mode: SOURCE_IP     # The sticky session type is source IP address.
    kubernetes.io/elb.session-affinity-option: '{"persistence_timeout": "30"}'     # Stickiness duration (min)
spec:
  selector:
    app: nginx
  ports:
  - name: service0
    port: 80
    protocol: TCP
    targetPort: 80
  type: LoadBalancer
```

Health Check

Table 10-12 Annotations for health check

Parameter	Type	Description	Supported Cluster Version
kubernetes.io/elb.health-check-flag	String	Whether to enable the ELB health check. • Enabling health check: Leave blank this parameter or set it to **on**. • Disabling health check: Set this parameter to **off**. If this parameter is enabled, the **kubernetes.io/elb.health-check-option** field must also be specified at the same time.	v1.9 or later
kubernetes.io/elb.health-check-option	**Table 10-19**	ELB health check configuration items.	v1.9 or later
kubernetes.io/elb.health-check-options	**Table 10-20**	ELB health check configuration item. Each Service port can be configured separately, and you can configure only some ports. **NOTE** **kubernetes.io/elb.health-check-option** and **kubernetes.io/elb.health-check-options** cannot be configured at the same time.	v1.19.16-r5 or later v1.21.8-r0 or later v1.23.6-r0 or later v1.25.2-r0 or later

- The following shows how to use **kubernetes.io/elb.health-check-option**:

```
apiVersion: v1
kind: Service
metadata:
  name: nginx
  annotations:
    kubernetes.io/elb.id: <your_elb_id>                    # ELB ID. Replace it with the actual value.
    kubernetes.io/elb.class: performance                 # Load balancer type
    kubernetes.io/elb.health-check-flag: 'on'              # Enable the ELB health check function.
    kubernetes.io/elb.health-check-option: '{
      "protocol":"TCP",
      "delay":"5",
      "timeout":"10",
      "max_retries":"3"
    }'
spec:
  selector:
    app: nginx
  ports:
  - name: service0
    port: 80
```

```
    protocol: TCP
    targetPort: 80
  type: LoadBalancer
```

- For details about how to use **kubernetes.io/elb.health-check-options**, see **Configuring Health Check on Multiple Service Ports**.

HTTP or HTTPS

Table 10-13 Annotations for using HTTP or HTTPS

Parameter	Type	Description	Supported Cluster Version
kubernetes.io/elb.protocol-port	String	If a Service is HTTP/HTTPS-compliant, configure the protocol and port number in the format of "protocol:port", where, • **protocol**: specifies the protocol used by the listener port. The value can be **http** or **https**. • **ports**: service ports specified by **spec.ports[].port**.	v1.19.16 or later
kubernetes.io/elb.cert-id	String	ID of an ELB certificate, which is used as the HTTPS server certificate. To obtain the certificate, log in to the CCE console, choose **Service List** > **Networking** > **Elastic Load Balance**, and click **Certificates** in the navigation pane. In the load balancer list, copy the ID under the target certificate name.	v1.19.16 or later

For details, see **Configuring an HTTP or HTTPS Service**.

Dynamic Adjustment of the Weight of the Backend ECS

Table 10-14 Annotations for dynamically adjusting the weight of the backend ECS

Parameter	Type	Description	Supported Cluster Version
kubernetes.io/elb.adaptive-weight	String	Dynamically adjust the weight of the ELB backend ECS based on the number pods on the node. The requests received by each pod are more balanced. • **true**: enabled • **false**: disabled This parameter applies only to clusters of v1.21 or later and is invalid in passthrough networking.	v1.21 or later

The following shows how to use the preceding annotations:

```
apiVersion: v1
kind: Service
metadata:
  name: nginx
  annotations:
    kubernetes.io/elb.id: <your_elb_id>                  # ELB ID. Replace it with the actual value.
    kubernetes.io/elb.class: performance                 # Load balancer type
    kubernetes.io/elb.adaptive-weight: 'true'            # Enable dynamic adjustment of the weight of
the backend ECS.
spec:
  selector:
    app: nginx
  ports:
  - name: service0
    port: 80
    protocol: TCP
    targetPort: 80
  type: LoadBalancer
```

Passthrough Capability

Table 10-15 Annotations for passthrough capability

Parameter	Type	Description	Supported Cluster Version
kubernetes.io/elb.pass-through	String	Whether the access requests from within the cluster to the Service pass through the ELB load balancer.	v1.19 or later

For details, see **Enabling Passthrough Networking for LoadBalancer Services**.

Host Network

Table 10-16 Annotations for host network

Parameter	Type	Description	Supported Cluster Version
kubernetes.io/hws-hostNetwork	String	If the pod uses **hostNetwork**, the ELB forwards the request to the host network after this annotation is used. Options: • **true**: enabled • **false** (default): disabled	v1.9 or later

The following shows how to use the preceding annotations:

```
apiVersion: v1
kind: Service
metadata:
  name: nginx
  annotations:
    kubernetes.io/elb.id: <your_elb_id>                 # ELB ID. Replace it with the actual value.
    kubernetes.io/elb.class: performance                # Load balancer type
    kubernetes.io/hws-hostNetwork: 'true'               # The load balancer forwards the request to the
host network.
spec:
  selector:
    app: nginx
  ports:
  - name: service0
    port: 80
    protocol: TCP
    targetPort: 80
  type: LoadBalancer
```

Timeout

Table 10-17 Annotation for configuring timeout

Parameter	Type	Description	Supported Cluster Version
kubernetes.io/elb.keepalive_timeout	String	Timeout for client connections. If there are no requests reaching the load balancer during the timeout duration, the load balancer will disconnect the connection from the client and establish a new connection when there is a new request. Value: • For TCP listeners, the value ranges from **10** to **4000** (in seconds). The default value is **300**. • For HTTP, HTTPS, and TERMINATED_HTTPS listeners, the value ranges from **0** to **4000** (in seconds). The default value is **60**. • For UDP listeners, this parameter does not take effect.	Dedicated load balancers: v1.19.16-r30, v1.21.10-r10, v1.23.8-r10, v1.25.3-r10, or later Shared load balancers: v1.23.13-r0, v1.25.8-r0, v1.27.5-r0, v1.28.3-r0, or later

For details, see **Configuring Timeout for a Service**.

Parameters for Automatically Creating a Load Balancer

Table 10-18 elb.autocreate data structure

Parameter	Mandatory	Type	Description
name	No	String	Name of the automatically created load balancer. The value can contain 1 to 64 characters. Only letters, digits, underscores (_), hyphens (-), and periods (.) are allowed. Default: **cce-lb+service.UID**
type	No	String	Network type of the load balancer. • **public**: public network load balancer • **inner**: private network load balancer Default: **inner**

Parameter	Mandatory	Type	Description
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 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. ● The minimum increment is 1 Mbit/s if the allowed bandwidth does not exceed 300 Mbit/s. ● The minimum increment is 50 Mbit/s if the allowed bandwidth ranges from 300 Mbit/s to 1000 Mbit/s. ● The minimum increment is 500 Mbit/s if the allowed bandwidth exceeds 1000 Mbit/s.
bandwidth_sharetype	Yes for public network load balancers	String	Bandwidth sharing mode. ● **PER**: dedicated bandwidth
eip_type	Yes for public network load balancers	String	EIP type. ● **5_bgp**: dynamic BGP The specific type varies with regions. For details, see the EIP console.

Parameter	Mandatory	Type	Description
vip_subnet_cidr_id	No	String	Subnet where a load balancer is located. The subnet must belong to the VPC where the cluster resides. If this parameter is not specified, the ELB load balancer and the cluster are in the same subnet. This field can be specified only for clusters of v1.21 or later.
vip_address	No	String	Private IP address of the load balancer. Only IPv4 addresses are supported. The IP address must be in the ELB CIDR block. If this parameter is not specified, an IP address will be automatically assigned from the ELB CIDR block. This parameter is available only in clusters of v1.23.11-r0, v1.25.6-r0, v1.27.3-r0, or later versions.
available_zone	Yes	Array of strings	AZ where the load balancer is located. This parameter is available only for dedicated load balancers.
l4_flavor_name	Yes	String	Flavor name of the layer-4 load balancer. This parameter is available only for dedicated load balancers.
l7_flavor_name	No	String	Flavor name of the layer-7 load balancer. This parameter is available only for dedicated load balancers. The value of this parameter must be the same as that of **l4_flavor_name**, that is, both are elastic specifications or fixed specifications.
elb_virsubnet_ids	No	Array of strings	Subnet where the backend server of the load balancer is located. If this parameter is left blank, the default cluster subnet is used. Load balancers occupy different number of subnet IP addresses based on their specifications. Do not use the subnet CIDR blocks of other resources (such as clusters and nodes) as the load balancer CIDR block. This parameter is available only for dedicated load balancers. Example: `"elb_virsubnet_ids": [ "14567f27-8ae4-42b8-ae47-9f847a4690dd" ]`

Table 10-19 elb.health-check-option data structure

Parameter	Mandatory	Type	Description
delay	No	String	Health check interval (s) Value range: 1 to 50. Default value: **5**
timeout	No	String	Health check timeout, in seconds. Value range: 1 to 50. Default value: **10**
max_retries	No	String	Maximum number of health check retries. Value range: 1 to 10. Default value: **3**
protocol	No	String	Health check protocol. Value options: TCP or HTTP
path	No	String	Health check URL. This parameter needs to be configured when the protocol is **HTTP**. Default value: **/** Value range: 1-80 characters

Table 10-20 elb.health-check-options

Parameter	Mandatory	Type	Description
target_service_port	Yes	String	Port for health check specified by spec.ports. The value consists of the protocol and port number, for example, TCP:80.
monitor_port	No	String	Re-specified port for health check. If this parameter is not specified, the service port is used by default. **NOTE** Ensure that the port is in the listening state on the node where the pod is located. Otherwise, the health check result will be affected.
delay	No	String	Health check interval (s) Value range: 1 to 50. Default value: **5**
timeout	No	String	Health check timeout, in seconds. Value range: 1 to 50. Default value: **10**
max_retries	No	String	Maximum number of health check retries. Value range: 1 to 10. Default value: **3**

Parameter	Mandatory	Type	Description
protocol	No	String	Health check protocol. Default value: protocol of the associated Service Value options: TCP, UDP, or HTTP
path	No	String	Health check URL. This parameter needs to be configured when the protocol is **HTTP**. Default value: **/** Value range: 1-80 characters

Table 10-21 elb.session-affinity-option data structure

Parameter	Mandatory	Type	Description
persistence_timeout	Yes	String	Sticky session timeout, in minutes. This parameter is valid only when **elb.session-affinity-mode** is set to **SOURCE_IP**. Value range: 1 to 60. Default value: **60**

10.3.4.3 Configuring an HTTP or HTTPS Service

Constraints

- Only clusters of v1.19.16 or later support HTTP or HTTPS.

Table 10-22 Scenarios where a load balancer supports HTTP or HTTPS

ELB Type	Application scenario	Whether to Support HTTP or HTTPS	Description
Dedicated load balancer	Interconnecting with an existing load balancer	Yes (A YAML file is required.)	• For versions earlier than v1.19.16-r50, v1.21.11-r10, v1.23.9-r10, v1.25.4-r10 and v1.27.1-r10, the load balancer flavor must **support both the layer-4 and layer-7 routing**. • For v1.19.16-r50, v1.21.11-r10, v1.23.9-r10, v1.25.4-r10, v1.27.1-r10, and later versions, the load balancer flavor **must support layer-7 routing**.
	Automatically creating a load balancer	Yes (A YAML file is required.)	• For versions earlier than v1.19.16-r50, v1.21.11-r10, v1.23.9-r10, v1.25.4-r10 and v1.27.1-r10, the load balancer flavor must **support both the layer-4 and layer-7 routing**. • For v1.19.16-r50, v1.21.11-r10, v1.23.9-r10, v1.25.4-r10, v1.27.1-r10, and later versions, the load balancer flavor **must support layer-7 routing**.

- Do not connect an ingress and a Service that uses HTTP or HTTPS to the same listener of the same load balancer. Otherwise, a port conflict occurs.

Using kubectl

If a Service is HTTP/HTTPS-compliant, add the following annotations:

- **kubernetes.io/elb.protocol-port**: "https:443,http:80"

  The value of **protocol-port** must be the same as the port in the **spec.ports** field of the Service. The format is *Protocol:Port*. The port matches the one in the **service.spec.ports** field and is released as the corresponding protocol.
- **kubernetes.io/elb.cert-id**: "17e3b4f4bc40471c86741dc3aa211379"

  cert-id indicates the certificate ID in ELB certificate management. When **https** is configured for **protocol-port**, the certificate of the ELB listener will be set to the server certificate. When multiple HTTPS Services are released, they will use the same certificate.

The following is a configuration example for automatically creating a dedicated load balancer, in which key configurations are marked in red:

- Different ELB types and cluster versions have different requirements on flavors. For details, see **Table 10-22**.

- The two ports in **spec.ports** must correspond to those in **kubernetes.io/elb.protocol-port**. In this example, ports 443 and 80 are enabled with HTTPS and HTTP, respectively.

```
apiVersion: v1
kind: Service
metadata:
  annotations:
# Specify the Layer 4 and Layer 7 flavors in the parameters for automatically creating a load balancer.
    kubernetes.io/elb.autocreate: '
      {
          "type": "public",
          "bandwidth_name": "cce-bandwidth-1634816602057",
          "bandwidth_chargemode": "bandwidth",
          "bandwidth_size": 5,
          "bandwidth_sharetype": "PER",
          "eip_type": "5_bgp",
          "available_zone": [
              ""
          ],
          "l7_flavor_name": "L7_flavor.elb.s2.small",
          "l4_flavor_name": "L4_flavor.elb.s1.medium"
      }'
    kubernetes.io/elb.class: performance  # Dedicated load balancer
    kubernetes.io/elb.protocol-port: "https:443,http:80"  # HTTP/HTTPS and port number, which must be the same as the port numbers in spec.ports
    kubernetes.io/elb.cert-id: "17e3b4f4bc40471c86741dc3aa211379"  # Certificate ID of the LoadBalancer Service
  labels:
    app: nginx
    name: test
  name: test
  namespace: default
spec:
  ports:
  - name: cce-service-0
    port: 443
    protocol: TCP
    targetPort: 80
  - name: cce-service-1
    port: 80
    protocol: TCP
    targetPort: 80
  selector:
    app: nginx
    version: v1
  sessionAffinity: None
  type: LoadBalancer
```

Use the preceding example configurations to create a Service. In the new ELB load balancer, you can see that the listeners on ports 443 and 80 are created.

10.3.4.4 Configuring Timeout for a Service

LoadBalancer Services allow you to configure timeout, which is the maximum duration for keeping a connection if no request is received from the client. If no request is received during this period, the load balancer closes the connection and establishes a new one with the client when the next request arrives.

Constraints

- The following table lists the scenarios where timeout can be configured for a Service.

Timeout Type	Load Balancer Type	Restrictions	Cluster Version
Idle timeout	Dedicated	None	• v1.19: v1.19.16-r30 or later • v1.21: v1.21.10-r10 or later • v1.23: v1.23.8-r10 or later • v1.25: v1.25.3-r10 or later • Other clusters of later versions

- If you delete the timeout configuration during a Service update, the timeout configuration on the existing listeners will be retained.

Using kubectl

Use annotations to configure timeout. The following shows an example:

```
apiVersion: v1
kind: Service
metadata:
  annotations:
    kubernetes.io/elb.id: <your_elb_id>    # In this example, an existing dedicated load balancer is used. Replace its ID with the ID of your dedicated load balancer.
    kubernetes.io/elb.class: performance  # Load balancer type
    kubernetes.io/elb.keepalive_timeout: '300'  # Timeout setting for client connections
  name: nginx
spec:
  ports:
  - name: service0
    port: 80
    protocol: TCP
    targetPort: 80
  selector:
    app: nginx
  type: LoadBalancer
```

Table 10-23 Key annotation parameters

Parameter	Mandatory	Type	Description
kubernetes.io/elb.keepalive_timeout	No	String	Timeout for client connections. If there are no requests reaching the load balancer during the timeout duration, the load balancer will disconnect the connection from the client and establish a new connection when there is a new request. Value: • For TCP listeners, the value ranges from **10** to **4000** (in seconds). The default value is **300**. • For HTTP, HTTPS, and TERMINATED_HTTPS listeners, the value ranges from **10** to **4000** (in seconds). The default value is **60**. • For UDP listeners, the value ranges from **10** to **4000** (in seconds). The default value is **300**.

10.3.4.5 Configuring Health Check on Multiple Service Ports

The annotation field related to the health check of the LoadBalancer Service is upgraded from **Kubernetes.io/elb.health-check-option** to **Kubernetes.io/elb.health-check-options**. Each Service port can be configured separately, and you can configure only some ports. If the port protocol does not need to be configured separately, the original annotation field is still available and does not need to be modified.

Constraints

- This feature is available in the following versions:
  - v1.19: v1.19.16-r5 or later
  - v1.21: v1.21.8-r0 or later
  - v1.23: v1.23.6-r0 or later
  - v1.25: v1.25.2-r0 or later
  - Versions later than v1.25
- **kubernetes.io/elb.health-check-option** and **kubernetes.io/elb.health-check-options** cannot be configured at the same time.
- The **target_service_port** field is mandatory and must be unique.
- For a TCP port, the health check protocol can only be TCP or HTTP. For a UDP port, the health check protocol must be UDP.

Procedure

The following is an example of using the **kubernetes.io/elb.health-check-options** annotation:

```
apiVersion: v1
kind: Service
metadata:
  name: nginx
  namespace: default
  labels:
    app: nginx
    version: v1
  annotations:
    kubernetes.io/elb.class: union          # Load balancer type
    kubernetes.io/elb.id: <your_elb_id>    # ELB ID. Replace it with the actual value.
    kubernetes.io/elb.lb-algorithm: ROUND_ROBIN  # Load balancer algorithm
    kubernetes.io/elb.health-check-flag: 'on'    # Enable ELB health check.
    kubernetes.io/elb.health-check-options: '[
    {
        "protocol": "TCP",
        "delay": "5",
        "timeout": "10",
        "max_retries": "3",
        "target_service_port": "TCP:1",
        "monitor_port": "22"
    },
    {
        "protocol": "HTTP",
        "delay": "5",
        "timeout": "10",
        "max_retries": "3",
        "path": "/",
        "target_service_port": "TCP:2",
        "monitor_port": "22",
              "expected_codes": "200-399,401,404"
    }
    ]'
spec:
  selector:
    app: nginx
    version: v1
  externalTrafficPolicy: Cluster
  ports:
    - name: cce-service-0
      targetPort: 1
      nodePort: 0
      port: 1
      protocol: TCP
    - name: cce-service-1
      targetPort: 2
      nodePort: 0
      port: 2
      protocol: TCP
  type: LoadBalancer
  loadBalancerIP: **.**.**.**
```

Table 10-24 elb.health-check-options

Parameter	Mandatory	Type	Description
target_service_port	Yes	String	Port for health check specified by spec.ports. The value consists of the protocol and port number, for example, TCP:80.

Parameter	Mandatory	Type	Description
monitor_port	No	String	Re-specified port for health check. If this parameter is not specified, the service port is used by default. **NOTE** Ensure that the port is in the listening state on the node where the pod is located. Otherwise, the health check result will be affected.
delay	No	String	Health check interval (s) Value range: 1 to 50. Default value: **5**
timeout	No	String	Health check timeout, in seconds. Value range: 1 to 50. Default value: **10**
max_retries	No	String	Maximum number of health check retries. Value range: 1 to 10. Default value: **3**
protocol	No	String	Health check protocol. Default value: protocol of the associated Service Value options: TCP, UDP, or HTTP
path	No	String	Health check URL. This parameter needs to be configured when the protocol is **HTTP**. Default value: **/** Value range: 1-80 characters

10.3.4.6 Enabling Passthrough Networking for LoadBalancer Services

Background

A Kubernetes cluster can publish applications running on a group of pods as Services, which provide unified layer-4 access entries. For a Loadbalancer Service, kube-proxy configures the LoadbalanceIP in **status** of the Service to the local forwarding rule of the node by default. When a pod accesses the load balancer from within the cluster, the traffic is forwarded within the cluster instead of being forwarded by the load balancer.

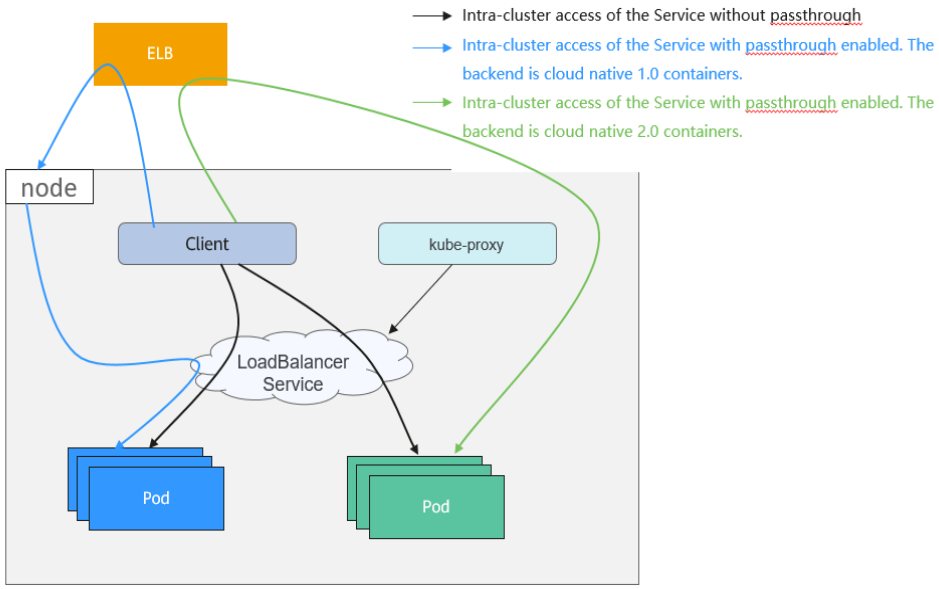
kube-proxy is responsible for intra-cluster forwarding. kube-proxy has two forwarding modes: iptables and IPVS. iptables is a simple polling forwarding mode. IPVS has multiple forwarding modes but it requires modifying the startup parameters of kube-proxy. Compared with iptables and IPVS, load balancers provide more flexible forwarding policies as well as health check capabilities.

Solution

CCE supports passthrough networking. You can configure the **annotation** of **kubernetes.io/elb.pass-through** for the Loadbalancer Service. Intra-cluster access

to the Service load balancer address is then forwarded to backend pods by the load balancer.

Figure 10-15 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.

Constraints

- After passthrough networking is configured for a dedicated load balancer, in a CCE standard cluster, pods that run on the same node as the workload and pods that run on the same node cannot be accessed through the LoadBalancer Service.
- Passthrough networking is not supported for clusters of v1.15 or earlier.
- In IPVS network mode, the pass-through settings of Service connected to the same ELB 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 Nginx image to create a Deployment.

```
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
```

Step 2 For a LoadBalance Service type, set **kubernetes.io/elb.pass-through** to **true**. 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
```

----End

Verification

Check the ELB load balancer corresponding to the created Service. The load balancer name is **james**. The number of ELB connections is **0**.

Use kubectl to connect to the cluster, go to an Nginx container, and access the ELB address. The access is successful.

```
# kubectl get pod
NAME                     READY   STATUS    RESTARTS   AGE
nginx-7c4c5cc6b5-vpncx   1/1     Running   0          9m47s
nginx-7c4c5cc6b5-xj5wl   1/1     Running   0          9m47s
# kubectl exec -it nginx-7c4c5cc6b5-vpncx -- /bin/sh
# curl 120.46.141.192
<!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>
```

Wait for a period of time and view the ELB monitoring data. A new access connection is created for the ELB, indicating that the access passes through the ELB load balancer as expected.

10.3.4.7 Enabling ICMP Security Group Rules

Application Scenarios

If a workload uses UDP for both load balancing and health check, enable ICMP security group rules for the backend servers.

Procedure

Step 1 Log in to the CCE console, choose **Service List** > **Networking** > **Virtual Private Cloud**, and choose **Access Control** > **Security Groups** in the navigation pane.

Step 2 In the security group list, locate the security group of the cluster. Click the **Inbound Rules** tab page and then **Add Rule**. In the **Add Inbound Rule** dialog box, configure inbound parameters.

Cluster Type	ELB Type	Security Group	Protocol & Port	Allowed Source CIDR Block
CCE Standard	Shared	Node security group, which is named in the format of "{Cluster name}-cce-node-{Random ID}". If a custom node security group is bound to the cluster, select the target security group.	All ICMP ports	100.125.0.0/16 for the shared load balancer

Cluster Type	ELB Type	Security Group	Protocol & Port	Allowed Source CIDR Block
	Dedicated	Node security group, which is named in the format of "{Cluster name}-cce-node-{Random ID}". If a custom node security group is bound to the cluster, select the target security group.	All ICMP ports	Backend subnet of the load balancer

Step 3 Click **OK**.

----End

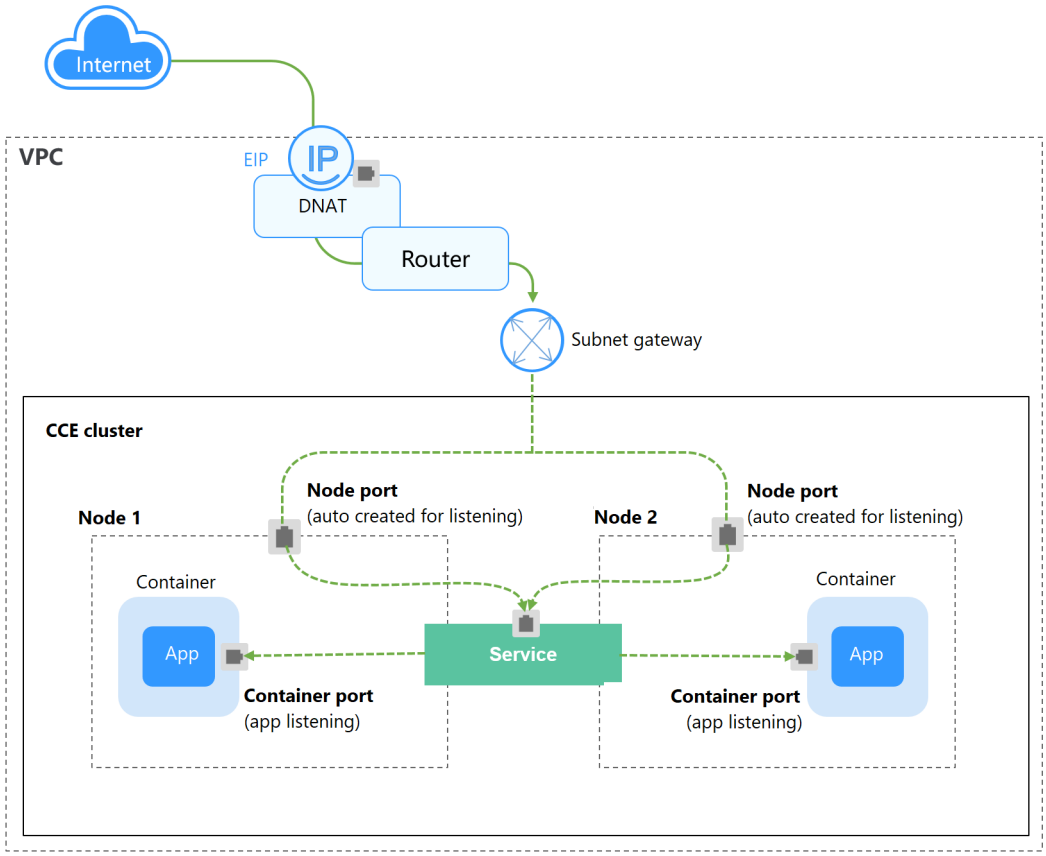
10.3.5 DNAT

Scenario

A **destination network address translation (DNAT) gateway** is situated between cluster nodes and public networks and assigned an EIP. After receiving inbound requests from public networks, the NAT gateway translates the EIP (destination address in the inbound requests) into a cluster-internal address. It appears to workload users as if all nodes running the workload share the same EIP.

DNAT provides higher reliability than EIP-based NodePort in which the EIP is bound to a single node and once the node is down, all inbound requests to the workload will not be distributed. The access address is in the format of <EIP>:<access port>, for example, 10.117.117.117:80.

Figure 10-16 DNAT

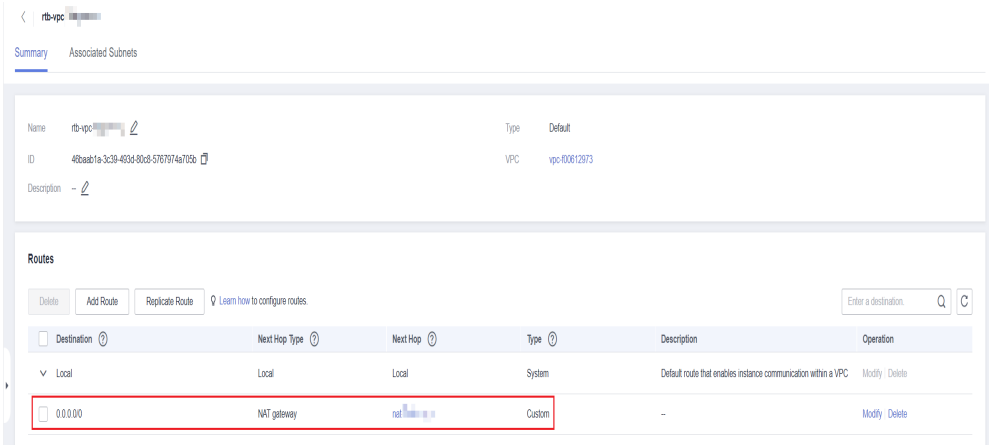


Constraints

Observe the following constraints when using the NAT Gateway service:

- DNAT rules do not support enterprise project authorization.
- Containers in the cluster cannot access the DNAT Service whose **externalTrafficPolicy** is **Local**.
- Multiple rules for one NAT gateway can use the same EIP, but the rules for different NAT gateways must use different EIPs.
- Each VPC can have only one NAT gateway.
- Users cannot manually add the default route in a VPC.
- Only one SNAT rule can be added to a subnet in a VPC.
- SNAT and DNAT rules are designed for different functions. If SNAT and DNAT rules use the same EIP, resource preemption will occur. An SNAT rule cannot share an EIP with a DNAT rule with **Port Type** set to **All ports**.
- DNAT rules do not support binding an EIP to a virtual IP address.
- When both the EIP and NAT Gateway services are configured for a server, data will be forwarded through the EIP.
- The custom CIDR block must be a subset of the VPC subnet CIDR blocks.
- The custom CIDR block must be a CIDR block of Direct Connect and cannot conflicts with VPC's existing subnet CIDR blocks.

- When you perform operations on underlying resources of an ECS, for example, changing its specifications, the configured NAT gateway rules become invalid. Delete the rules and reconfigure them.
- After a Service is created, if the affinity setting is switched from the cluster level to the node level, the connection tracing table will not be cleared. You are advised not to modify the Service affinity setting after the Service is created. To modify it, create a Service again.
- If the node subnet is associated with a custom route table, add the NAT route to the custom route table when using the DNAT Service.



Creating a NAT Gateway and an Elastic IP Address

You have created a NAT gateway and an elastic IP address. The specific procedure is as follows:

Step 1 Log in to the management console, choose **Networking** > **NAT Gateway** from the service list, and click **Buy Public NAT Gateway** in the upper right corner.

NOTE

When buying a NAT gateway, ensure that the NAT gateway belongs to the same VPC and subnet as the CCE cluster where the workload is running.

Step 2 Log in to the management console, choose **Networking** > **Elastic IP** from the service list, and click **Buy EIP** in the upper right corner.

----End

Creating a DNAT Gateway Service

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 **Services & Ingresses**. In the upper right corner, click **Create Service**.

Step 3 Set related parameters.

- **Service Name**: Specify a Service name, which can be the same as the workload name.
- **Service Type**: Select **DNAT**.
- **Namespace**: Namespace to which the workload belongs.

- **Service Affinity**: For details, see **externalTrafficPolicy (Service Affinity)**.
  - **Cluster level**: The IP addresses and access ports of all nodes in a cluster can 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 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.
- **Selector**: Add a label and click **Confirm**. A Service selects a pod based on the added label. You can also click **Reference Workload Label** to use the label of an existing workload. In the dialog box that is displayed, select a workload and click **OK**.
- **DNAT**: Select the DNAT gateway and EIP created in **Creating a NAT Gateway and an Elastic IP Address**.
- **Port**
  - **Protocol**: protocol used by the Service.
  - **Container Port**: port on which the workload listens. The Nginx workload listens on port 80.
  - **Service Port**: a port mapped to the container port at the cluster-internal IP address. The workload can be accessed at <cluster-internal IP address>:<access port>. The port number range is 1–65535.

Step 4 Click **OK**.

----End

Setting the Access Type Using kubectl

You can set the Service when creating a workload using kubectl. This section uses an Nginx workload as an example to describe how to implement intra-cluster access using kubectl.

Step 1 Use kubectl to connect to the cluster. For details, see **Connecting to a Cluster Using kubectl**.

Step 2 Create and edit the **nginx-deployment.yaml** and **nginx-nat-svc.yaml** files.

The file names are user-defined. **nginx-deployment.yaml** and **nginx-nat-svc.yaml** are merely example file names.

vi nginx-deployment.yaml

```
apiVersion: apps/v1
kind: Deployment
metadata:
  name: nginx
spec:
  replicas: 1
  selector:
    matchLabels:
      app: nginx
  template:
    metadata:
      labels:
        app: nginx
```

```
  spec:
    containers:
    - image: nginx:latest
      name: nginx
    imagePullSecrets:
    - name: default-secret
```

For descriptions of the preceding fields, see **Table 8-2**.

vi nginx-nat-svc.yaml

```
apiVersion: v1
kind: Service
metadata:
  name: nginx
  annotations:
    kubernetes.io/elb.class: dnat
    kubernetes.io/natgateway.id: e4a1cfcf-29df-4ab8-a4ea-c05dc860f554
spec:
  loadBalancerIP: 10.78.42.242
  ports:
  - name: service0
    port: 80
    protocol: TCP
    targetPort: 80
  selector:
    app: nginx
  type: LoadBalancer
```

Table 10-25 Key parameters

Parameter	Mandatory	Type	Description
kubernetes.io/elb.class	Yes	String	This parameter is set to **dnat** so CCE can work with a NAT gateway and DNAT rules can be added.
kubernetes.io/natgateway.id	Yes	String	ID of a NAT gateway.
loadBalancerIP	Yes	String	EIP ID.
port	Yes	Integer	Access port set on the console. The value ranges from 1 to 65535.
targetPort	Yes	String	Container port set on the console. The value ranges from 1 to 65535.
type	Yes	String	NAT gateway service type must be set to **LoadBalancer**.

Step 3 Create a workload.

kubectl create -f nginx-deployment.yaml

If information similar to the following is displayed, the workload is being created.

```
deployment "nginx" created
```

kubectl get po

If information similar to the following is displayed, the workload is running.

```
NAME                     READY     STATUS            RESTARTS   AGE
nginx-2601814895-sf71t   1/1       Running           0          8s
```

Step 4 Create a Service.

kubectl create -f nginx-nat-svc.yaml

If information similar to the following is displayed, the Service has been created.

```
service "nginx-eip" created
```

kubectl get svc

If the following information is displayed, the Service has been set successfully, and the workload is accessible.

```
NAME         TYPE        CLUSTER-IP      EXTERNAL-IP    PORT(S)        AGE
kubernetes   ClusterIP   10.247.0.1      <none>         443/TCP        3d
nginx-nat    LoadBalancer 10.247.226.2  10.154.74.98   80:30589/TCP   5s
```

Step 5 In the address bar of your browser, enter **10.154.74.98:80** and press **Enter**.

In this example, **10.154.74.98** is the elastic IP address and **80** is the port number obtained in the previous step.

----End

10.3.6 Headless Services

Services allow internal and external pod access, but not the following scenarios:

- Accessing all pods at the same time
- Pods in a Service accessing each other

This is where headless Service come into service. A headless Service does not create a cluster IP address, and the DNS records of all pods are returned during query. In this way, the IP addresses of all pods can be queried. **StatefulSets** use headless Services to support mutual access between pods.

```
apiVersion: v1
kind: Service       # Object type (Service)
metadata:
  name: nginx-headless
  labels:
    app: nginx
spec:
  ports:
    - name: nginx      #     - 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 that a headless Service is to be created.
```

Run the following command to create a headless Service:

```
# kubectl create -f headless.yaml
service/nginx-headless created
```

After the Service is created, you can query the Service.

```
# kubectl get svc
NAME             TYPE        CLUSTER-IP   EXTERNAL-IP   PORT(S)   AGE
nginx-headless   ClusterIP   None         <none>        80/TCP    5s
```

Create a pod to query the DNS. You can view the records of all pods. In this way, all pods can be accessed.

```
$ kubectl run -i --tty --image tutum/dnsutils dnsutils --restart=Never --rm /bin/sh
If you do not see a command prompt, try pressing Enter.
/ # nslookup nginx-0.nginx
Server:         10.247.3.10
Address:        10.247.3.10#53
Name:   nginx-0.nginx.default.svc.cluster.local
Address: 172.16.0.31

/ # nslookup nginx-1.nginx
Server:         10.247.3.10
Address:        10.247.3.10#53
Name:   nginx-1.nginx.default.svc.cluster.local
Address: 172.16.0.18

/ # nslookup nginx-2.nginx
Server:         10.247.3.10
Address:        10.247.3.10#53
Name:   nginx-2.nginx.default.svc.cluster.local
Address: 172.16.0.19
```

10.4 Ingresses

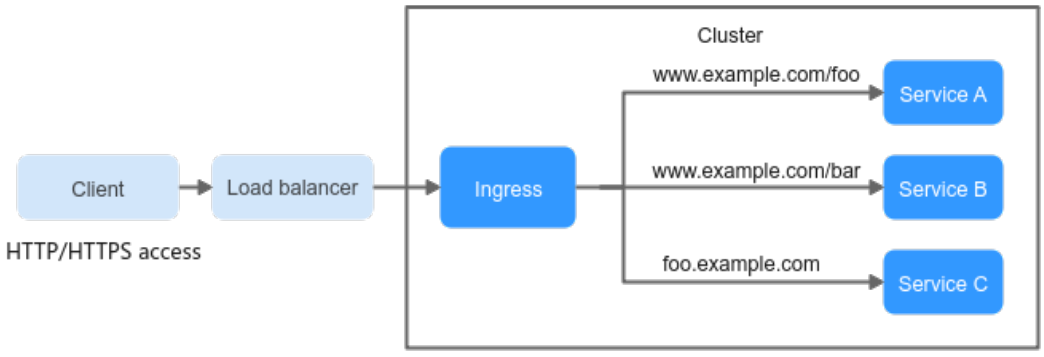
10.4.1 Overview

Why We Need Ingresses

A Service is generally used to forward access requests based on TCP and UDP and provide layer-4 load balancing for clusters. However, in actual scenarios, if there is a large number of HTTP/HTTPS access requests on the application layer, the Service cannot meet the forwarding requirements. Therefore, the Kubernetes cluster provides an HTTP-based access mode, ingress.

An ingress is an independent resource in the Kubernetes cluster and defines rules for forwarding external access traffic. As shown in **Figure 10-17**, you can customize forwarding rules based on domain names and URLs to implement fine-grained distribution of access traffic.

Figure 10-17 Ingress diagram



The following describes the ingress-related definitions:

- Ingress object: a set of access rules that forward requests to specified Services based on domain names or URLs. It can be added, deleted, modified, and queried by calling APIs.

- Ingress Controller: an executor for request forwarding. It monitors the changes of resource objects such as ingresses, Services, endpoints, secrets (mainly TLS certificates and keys), nodes, and ConfigMaps in real time, parses rules defined by ingresses, and forwards requests to the target backend Services.

Ingress Controllers provided by different vendors are implemented in different ways. Based on the types of load balancers, Ingress Controllers are classified into LoadBalancer Ingress Controller and Nginx Ingress Controller. Both of them are supported in CCE. LoadBalancer Ingress Controller forwards traffic through ELB. Nginx Ingress Controller uses the templates and images maintained by the Kubernetes community to forward traffic through the Nginx component.

Ingress Feature Comparison

Table 10-26 Comparison between ingress features

Feature	ELB Ingress Controller	Nginx Ingress Controller
O&M	O&M-free	Self-installation, upgrade, and maintenance
Performance	One ingress supports only one load balancer.	Multiple ingresses support one load balancer.
	Enterprise-grade load balancers are used to provide high performance and high availability. Service forwarding is not affected in upgrade and failure scenarios.	Performance varies depending on the resource configuration of pods.
	Dynamic loading is supported.	• Processes must be reloaded for non-backend endpoint changes, which cause loss to persistent connections. • Lua supports hot updates of endpoint changes. • Processes must be reloaded for a Lua modification.
Component deployment	Deployed on the master node	Deployed on worker nodes, and operations costs required for the Nginx component
Route redirection	Not supported	Supported
SSL configuration	Supported	Supported

Feature	ELB Ingress Controller	Nginx Ingress Controller
Using ingress as a proxy for backend services	Supported	Supported, which can be implemented through backend-protocol: HTTPS annotations.

The LoadBalancer ingress is essentially different from the open source Nginx ingress. Therefore, their supported Service types are different. For details, see **Services Supported by Ingresses**.

LoadBalancer Ingress Controller is deployed on a master node. All policies and forwarding behaviors are configured on the ELB side. Load balancers outside the cluster can connect to nodes in the cluster only through the IP address of the VPC. Therefore, LoadBalancer ingresses support only NodePort Services.

Nginx Ingress Controller runs in a cluster and is exposed as a Service through NodePort. Traffic is forwarded to other Services in the cluster through Nginx-ingress. The traffic forwarding behavior and forwarding object are in the cluster. Therefore, both ClusterIP and NodePort Services are supported.

In conclusion, LoadBalancer ingresses use enterprise-grade load balancers to forward traffic and delivers high performance and stability. Nginx Ingress Controller is deployed on cluster nodes, which consumes cluster resources but has better configurability.

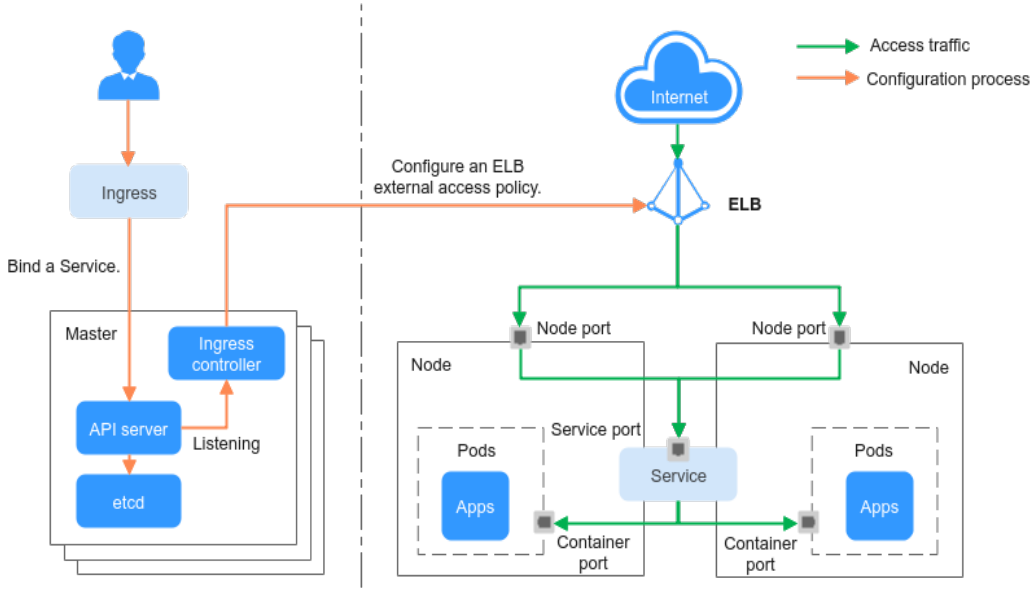
Working Rules of LoadBalancer Ingress Controller

LoadBalancer Ingress Controller developed by CCE implements layer-7 network access for the internet and intranet (in the same VPC) based on ELB and distributes access traffic to the corresponding Services using different URLs.

LoadBalancer Ingress Controller is deployed on the master node and bound to the load balancer in the VPC where the cluster resides. Different domain names, ports, and forwarding policies can be configured for the same load balancer (with the same IP address). **Figure 10-18** shows the working rules of LoadBalancer Ingress Controller.

1. A user creates an ingress object and configures a traffic access rule in the ingress, including the load balancer, URL, SSL, and backend service port.
2. When Ingress Controller detects that the ingress object changes, it reconfigures the listener and backend server route on the ELB side according to the traffic access rule.
3. When a user accesses a workload, the traffic is forwarded to the corresponding backend service port based on the forwarding policy configured on ELB, and then forwarded to each associated workload through the Service.

Figure 10-18 Working rules of shared LoadBalancer ingresses in CCE standard clusters



Working Rules of Nginx Ingress Controller

An Nginx ingress uses ELB as the traffic ingress. The **nginx-ingress** add-on is deployed in a cluster to balance traffic and control access.

NOTE

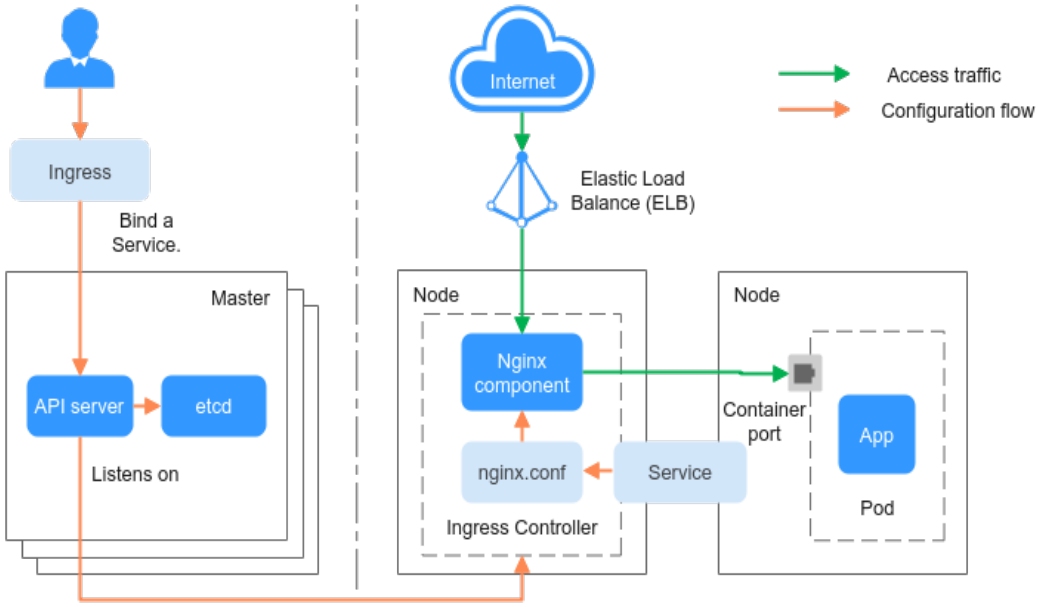
nginx-ingress uses the templates and images provided by the open-source community, and issues may occur during usage. CCE periodically synchronizes the community version to fix known vulnerabilities. Check whether your service requirements can be met.

You can visit the **open source community** for more information.

Nginx Ingress Controller is deployed on worker nodes through pods, which will result in O&M costs and Nginx component running overheads. **Figure 10-19** shows the working rules of Nginx Ingress Controller.

1. After you update ingress resources, Nginx Ingress Controller writes a forwarding rule defined in the ingress resources into the **nginx.conf** configuration file of Nginx.
2. The built-in Nginx component reloads the updated configuration file to modify and update the Nginx forwarding rule.
3. When traffic accesses a cluster, the traffic is first forwarded by the created load balancer to the Nginx component in the cluster. Then, the Nginx component forwards the traffic to each workload based on the forwarding rule.

Figure 10-19 Working rules of Nginx Ingress Controller



Services Supported by Ingresses

Table 10-27 lists the services supported by LoadBalancer ingresses.

Table 10-27 Services supported by LoadBalancer ingresses

Cluster Type	ELB Type	ClusterIP	NodePort
CCE standard cluster	Shared load balancer	Not supported	Supported
	Dedicated load balancer	Not supported (Failed to access the dedicated load balancers because no ENI is bound to the associated pod of the ClusterIP Service.)	Supported

Table 10-28 lists the services supported by Nginx ingresses.

Table 10-28 Services supported by Nginx ingresses

Cluster Type	ELB Type	ClusterIP	NodePort
CCE standard cluster	Shared load balancer	Supported	Supported
	Dedicated load balancer	Supported	Supported

10.4.2 LoadBalancer Ingresses

10.4.2.1 Creating a LoadBalancer Ingress on the Console

Prerequisites

- An ingress provides network access for backend workloads. Ensure that a workload is available in a cluster. If no workload is available, deploy a workload by referring to **Creating a Deployment**, **Creating a StatefulSet**, or **Creating a DaemonSet**.
- **Services Supported by Ingresses** lists the Service types supported by LoadBalancer ingresses.

Constraints

- It is recommended that other resources not use the load balancer automatically created by an ingress. Otherwise, the load balancer will be occupied when the ingress is deleted, resulting in residual resources.
- After an ingress is created, upgrade and maintain the configuration of the selected load balancers on the CCE console. Do not modify the configuration on the ELB console. Otherwise, the ingress service may be abnormal.
- The URL registered in an ingress forwarding policy must be the same as the URL used to access the backend Service. Otherwise, a 404 error will be returned.
- In a cluster using the IPVS proxy mode, if the ingress and Service use the same ELB load balancer, the ingress cannot be accessed from the nodes and containers in the cluster because kube-proxy mounts the LoadBalancer Service address to the ipvs-0 bridge. This bridge intercepts the traffic of the load balancer connected to the ingress. Use different load balancers for the ingress and Service.
- A dedicated load balancer must be of the application type (HTTP/HTTPS) type and support private networks (with a private IP).
- If multiple ingresses access the same ELB port in a cluster, the listener configuration items (such as the certificate associated with the listener and the HTTP2 attribute of the listener) are subject to the configuration of the first ingress.

Adding a LoadBalancer Ingress

This section uses an Nginx workload as an example to describe how to add a LoadBalancer ingress.

Step 1 Log in to the CCE console and click the cluster name to access the cluster console.

Step 2 Choose **Services & Ingresses** in the navigation pane, click the **Ingresses** tab, and click **Create Ingress** in the upper right corner.

Step 3 Configure ingress parameters.

- **Name**: specifies a name of an ingress, for example, **ingress-demo**.
- **Interconnect with Nginx**: This option is displayed only after the **Nginx Ingress Controller** add-on is installed. If this option is available, the nginx-

ingress add-on has been installed. Enabling this option will create an Nginx ingress. Disable it if you want to create a LoadBalancer ingress. For details, see **Creating Nginx Ingresses on the Console**.

- **Load Balancer**: Select a load balancer type and creation mode.

  A load balancer can be dedicated or shared. A dedicated load balancer must be of the application (HTTP/HTTPS) type and support private networks.

  You can select **Use existing** or **Auto create** to obtain a load balancer. For details about the configuration of different creation modes, see **Table 10-29**.

  Table 10-29 Load balancer configurations

How to Create	Configuration
Use existing	Only the load balancers in the same VPC as the cluster can be selected. If no load balancer is available, click **Create Load Balancer** to create one on the ELB console.
Auto create	– **Instance Name**: Enter a load balancer name. – **Enterprise Project**: This parameter is available only for enterprise users who have enabled an enterprise project. Enterprise projects facilitate project-level management and grouping of cloud resources and users. – **AZ**: available only to dedicated load balancers. You can create load balancers in multiple AZs to improve service availability. You can deploy a load balancer in multiple AZs for high availability. – **Frontend Subnet**: available only to dedicated load balancers. It is used to allocate IP addresses for load balancers to provide services externally. – **Backend Subnet**: available only to dedicated load balancers. It is used to allocate IP addresses for load balancers to access the backend service. – **Network/Application-oriented Specifications** (available only to dedicated load balancers) ▪ **Fixed**: applies to stable traffic, billed based on specifications. – **EIP**: If you select **Auto create**, you can configure the billing mode and size of the public network bandwidth.

- **Listener**: An ingress configures a listener for the load balancer, which listens to requests from the load balancer and distributes traffic. After the configuration is complete, a listener is created on the load balancer. The default listener name is *k8s_<Protocol type>_<Port number>*, for example, *k8s_HTTP_80*.
  - **External Protocol**: **HTTP** or **HTTPS**
  - **External Port**: port number that is open to the ELB service address. The port number can be specified randomly.

  - **Certificate Source**: TLS secret and ELB server certificate are supported.
  - **Server Certificate**: When an HTTPS listener is created for a load balancer, bind a certificate to the load balancer to support encrypted authentication for HTTPS data transmission.
    - **TLS secret**: For details about how to create a secret certificate, see **Creating a Secret**.
    - **ELB server certificate**: Use the certificate created in the ELB service.

      NOTE

      If there is already an HTTPS ingress for the chosen port on the load balancer, the certificate of the new HTTPS ingress must be the same as the certificate of the existing ingress. This means that a listener has only one certificate. If two certificates, each with a different ingress, are added to the same listener of the same load balancer, only the certificate added earliest takes effect on the load balancer.
  - **SNI**: Server Name Indication (SNI) is an extended protocol of TLS. It allows multiple TLS-based access domain names to be provided for external systems using the same IP address and port. Different domain names can use different security certificates. After SNI is enabled, the client is allowed to submit the requested domain name when initiating a TLS handshake request. After receiving the TLS request, the load balancer searches for the certificate based on the domain name in the request. If the certificate corresponding to the domain name is found, the load balancer returns the certificate for authorization. Otherwise, the default certificate (server certificate) is returned for authorization.

    NOTE

    - The **SNI** option is available only when **HTTPS** is used.
    - This function is supported only in clusters of v1.15.11 and later.
    - Only one domain name can be specified for each SNI certificate. Wildcard-domain certificates are supported.
    - For ingresses connected to the same ELB port, do not configure SNIs with the same domain name but different certificates. Otherwise, the SNIs will be overwritten.
  - **Security Policy**: combinations of different TLS versions and supported cipher suites available to HTTPS listeners.

    For details about security policies, see ELB User Guide.

    NOTE

    - **Security Policy** is available only when **HTTPS** is selected.
    - This function is supported only in clusters of v1.17.9 and later.
  - **Backend Protocol**:

    When the **listener** is HTTP-compliant, only **HTTP** can be selected.

    If it is an **HTTPS listener**, this parameter can be set to **HTTP** or **HTTPS**.

- **Forwarding Policy**: When the access address of a request matches the forwarding policy (a forwarding policy consists of a domain name and URL,

for example, 10.117.117.117:80/helloworld), the request is forwarded to the corresponding target Service for processing. You can click + to add multiple forwarding policies.

- **Domain Name**: actual domain name. Ensure that the domain name has been registered and archived. Once a domain name rule is configured, you must use the domain name for access.
- **URL Matching Rule**
  - **Prefix match**: If the URL is set to **/healthz**, the URL that meets the prefix can be accessed, for example, **/healthz/v1** and **/healthz/v2**.
  - **Exact match**: The URL can be accessed only when it is fully matched. For example, if the URL is set to **/healthz**, only /healthz can be accessed.
  - **RegEX match**: The URL is matched based on the regular expression. For example, if the regular expression is **/[A-Za-z0-9_.-]+/test**, all URLs that comply with this rule can be accessed, for example, **/abcA9/test** and **/v1-Ab/test**. Two regular expression standards are supported: POSIX and Perl.
- **URL**: access path to be registered, for example, **/healthz**.

  NOTE

  The access path added here must exist in the backend application. Otherwise, the forwarding fails.

  For example, the default access URL of the Nginx application is **/usr/share/nginx/html**. When adding **/test** to the ingress forwarding policy, ensure the access URL of your Nginx application contains **/usr/share/nginx/html/test**. Otherwise, error 404 will be returned.
- **Destination Service**: Select an existing Service or create a Service. Services that do not meet search criteria are automatically filtered out.
- **Destination Service Port**: Select the access port of the destination Service.
- **Set ELB**:
  - **Algorithm**: Three algorithms are available: weighted round robin, weighted least connections algorithm, or source IP hash.

NOTE

- **Weighted round robin**: Requests are forwarded to different servers based on their weights, which indicate server processing performance. Backend servers with higher weights receive proportionately more requests, whereas equal-weighted servers receive the same number of requests. This algorithm is often used for short connections, such as HTTP services.
- **Weighted least connections**: In addition to the weight assigned to each server, the number of connections processed by each backend server is considered. Requests are forwarded to the server with the lowest connections-to-weight ratio. Building on **least connections**, the **weighted least connections** algorithm assigns a weight to each server based on their processing capability. This algorithm is often used for persistent connections, such as database connections.
- **Source IP hash**: The source IP address of each request is calculated using the hash algorithm to obtain a unique hash key, and all backend servers are numbered. The generated key allocates the client to a particular server. This enables requests from different clients to be distributed in load balancing mode and ensures that requests from the same client are forwarded to the same server. This algorithm applies to TCP connections without cookies.

- **Sticky Session**: This function is disabled by default. Options are as follows:
  - **Load balancer cookie**: Enter the **Stickiness Duration** , which ranges from 1 to 1,440 minutes.

  NOTE

  - When the **distribution policy** uses the source IP hash, sticky session cannot be set.
  - Dedicated load balancers in the clusters of a version earlier than v1.21 do not support sticky sessions. If sticky sessions are required, use shared load balancers.

- **Health Check**: Set the health check configuration of the load balancer. If this function is enabled, the following configurations are supported:

Parameter	Description
Protocol	When the protocol of the target Service port is TCP, more protocols including HTTP are supported. ○ **Check Path** (supported only by HTTP for health check): specifies the health check URL. The check path must start with a slash (/) and contain 1 to 80 characters.

Parameter	Description
Port	By default, the service port (NodePort or container port of the Service) is used for health check. You can also specify another port for health check. After the port is specified, a service port named **cce-healthz** will be added for the Service. ○ **Node Port**: If a shared load balancer is used or no ENI instance is associated, the node port is used as the health check port. If this parameter is not specified, a random port is used. The value ranges from 30000 to 32767. ○ **Container Port**: When a dedicated load balancer is associated with an ENI instance, the container port is used for health check. The value ranges from 1 to 65535.
Check Period (s)	Specifies the maximum interval between health checks. The value ranges from 1 to 50.
Timeout (s)	Specifies the maximum timeout duration for each health check. The value ranges from 1 to 50.
Max. Retries	Specifies the maximum number of health check retries. The value ranges from 1 to 10.

  - **Operation**: Click **Delete** to delete the configuration.
- **Annotation**: Ingresses provide some advanced CCE functions, which are implemented by annotations. When you use kubectl to create a container, annotations will be used. For details, see **Creating an Ingress - Automatically Creating a Load Balancer** or **Creating an Ingress - Interconnecting with an Existing Load Balancer**.

Step 4 After the configuration is complete, click **OK**. After the ingress is created, it is displayed in the ingress list.

On the ELB console, you can view the ELB automatically created through CCE. The default name is **cce-lb-ingress.UID**. Click the ELB name to access its details page. On the **Listeners** tab page, view the route settings of the ingress, including the URL, listener port, and backend server group port.

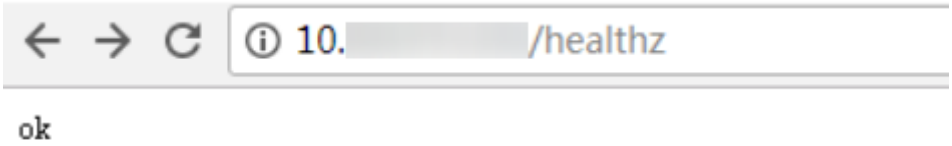
NOTICE

After an ingress is created, upgrade and maintain the selected load balancer on the CCE console. Do not modify the configuration on the ELB console. Otherwise, the ingress service may be abnormal.

Step 5 Access the /healthz interface of the workload, for example, workload **defaultbackend**.

1. Obtain the access address of the **/healthz** interface of the workload. The access address consists of the load balancer IP address, external port, and mapping URL, for example, 10.**.**.**:80/healthz.
2. Enter the URL of the /healthz interface, for example, http://10.**.**.**:80/healthz, in the address box of the browser to access the workload, as shown in **Figure 10-20**.

   Figure 10-20 Accessing the /healthz interface of defaultbackend

----End

10.4.2.2 Using kubectl to Create a LoadBalancer Ingress

Scenario

This section uses an **Nginx workload** as an example to describe how to create a LoadBalancer ingress using kubectl.

- If no load balancer is available in the same VPC, CCE can automatically create a load balancer when creating an ingress. For details, see **Creating an Ingress - Automatically Creating a Load Balancer**.
- If a load balancer is available in the same VPC, perform the operation by referring to **Creating an Ingress - Interconnecting with an Existing Load Balancer**.

Prerequisites

- An ingress provides network access for backend workloads. Ensure that a workload is available in a cluster. If no workload is available, deploy a sample Nginx workload by referring to **Creating a Deployment**, **Creating a StatefulSet**, or **Creating a DaemonSet**.
- **Services Supported by Ingresses** lists the Service types supported by LoadBalancer ingresses.
- Dedicated load balancers must be the application type (HTTP/HTTPS) supporting private networks (with a private IP).

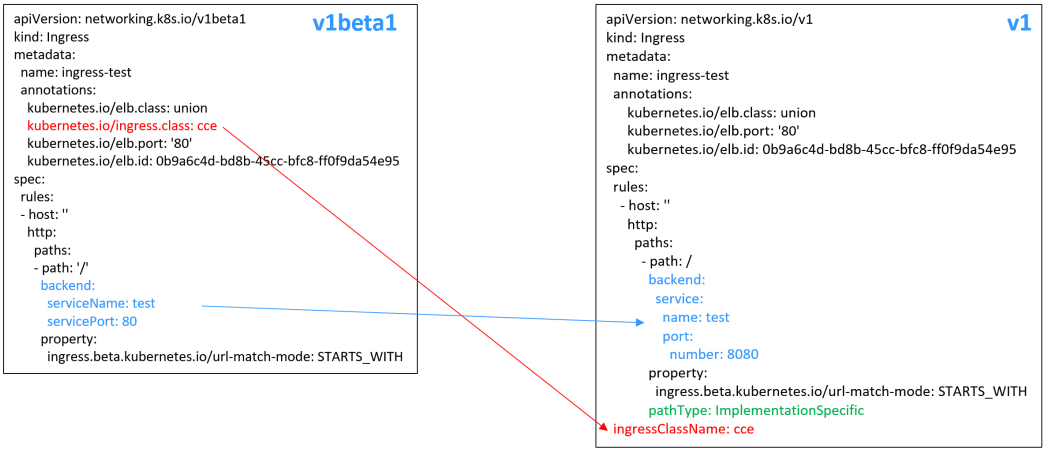
Ingress Description of networking.k8s.io/v1

In CCE clusters of v1.23 or later, the ingress version is switched to **networking.k8s.io/v1**.

Compared with v1beta1, v1 has the following differences in parameters:

- The ingress type is changed from **kubernetes.io/ingress.class** in **annotations** to **spec.ingressClassName**.

- The format of **backend** is changed.
- The **pathType** parameter must be specified for each path. The options are as follows:
  - **ImplementationSpecific**: The matching method depends on Ingress Controller. The matching method defined by **ingress.beta.kubernetes.io/url-match-mode** is used in CCE, which is the same as v1beta1.
  - **Exact**: exact matching of the URL, which is case-sensitive.
  - **Prefix**: matching based on the URL prefix separated by a slash (/). The match is case-sensitive, and elements in the path are matched one by one. A path element refers to a list of labels in the path separated by a slash (/).



Creating an Ingress - Automatically Creating a Load Balancer

The following describes how to run the kubectl command to automatically create a load balancer when creating an ingress.

Step 1 Use kubectl to connect to the cluster. For details, see **Connecting to a Cluster Using kubectl**.

Step 2 Create a YAML file named **ingress-test.yaml**. The file name can be customized.

vi ingress-test.yaml

NOTE

Starting from cluster v1.23, the ingress version is switched from **networking.k8s.io/v1beta1** to **networking.k8s.io/v1**. For details about the differences between v1 and v1beta1, see **Ingress Description of networking.k8s.io/v1**.

Example of a dedicated load balancer (public network access) for clusters of v1.23 or later:

```
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.autocreate:
      '{
```

```
        "type": "public",
        "bandwidth_name": "cce-bandwidth-******",
        "bandwidth_chargemode": "bandwidth",
        "bandwidth_size": 5,
        "bandwidth_sharetype": "PER",
        "eip_type": "5_bgp",
        "vip_subnet_cidr_id": "******",
        "vip_address": "**.**.**.**",
        "elb_virsubnet_ids":["******"],
        "available_zone": [
            ""
        ],
        "l7_flavor_name": "L7_flavor.elb.s1.small"
    }'
spec:
  rules:
  - host: ''
    http:
      paths:
      - path: '/'
        backend:
          service:
            name: <your_service_name>  # Replace it with the name of your target Service.
            port:
              number: <your_service_port>  # Replace it with the port number of your target Service.
        property:
          ingress.beta.kubernetes.io/url-match-mode: STARTS_WITH
        pathType: ImplementationSpecific
  ingressClassName: cce
```

Example of a dedicated load balancer (public network access) for clusters of version 1.21 or earlier:

```
apiVersion: networking.k8s.io/v1beta1
kind: Ingress
metadata:
  name: ingress-test
  namespace: default
  annotations:
    kubernetes.io/elb.class: performance
    kubernetes.io/ingress.class: cce
    kubernetes.io/elb.port: '80'
    kubernetes.io/elb.autocreate:
      '{
        "type": "public",
        "bandwidth_name": "cce-bandwidth-******",
        "bandwidth_chargemode": "bandwidth",
        "bandwidth_size": 5,
        "bandwidth_sharetype": "PER",
        "eip_type": "5_bgp",
        "elb_virsubnet_ids":["******"],
        "available_zone": [
            ""
        ],
        "l7_flavor_name": "L7_flavor.elb.s1.small"
    }'
spec:
  rules:
  - host: ''
    http:
      paths:
      - path: '/'
        backend:
          serviceName: <your_service_name>  # Replace it with the name of your target Service.
          servicePort: <your_service_port>  # Replace it with the port number of your target Service.
        property:
          ingress.beta.kubernetes.io/url-match-mode: STARTS_WITH
```

Table 10-30 Key parameters

Parameter	Mandatory	Type	Description
kubernetes.io/elb.class	Yes	String	Select a proper load balancer type. • **performance**: dedicated load balancer
kubernetes.io/ingress.class	Yes (only for clusters of v1.21 or earlier)	String	**cce**: A proprietary LoadBalancer ingress is used. This parameter is mandatory when an ingress is created by calling the API.
ingressClassName	Yes (only for clusters of v1.23 or later)	String	**cce**: A proprietary LoadBalancer ingress is used. This parameter is mandatory when an ingress is created by calling the API.
kubernetes.io/elb.port	Yes	String	This parameter indicates the external port registered with the address of the LoadBalancer Service. Supported range: 1 to 65535 **NOTE** Some ports are high-risk ports and are blocked by default, for example, port 21.
kubernetes.io/elb.subnet-id	None	String	ID of the subnet where the cluster is located. The value can contain 1 to 100 characters. • Mandatory when a cluster of v1.11.7-r0 or earlier is to be automatically created. • Optional for clusters later than v1.11.7-r0. It is left blank by default.
kubernetes.io/elb.enterpriseID	No	String	**Kubernetes clusters of v1.15 and later versions support this field. In Kubernetes clusters earlier than v1.15, load balancers are created in the default project by default.** ID of the enterprise project in which the load balancer will be created. The value contains 1 to 100 characters. **How to obtain**: Log in to the management console and choose **Enterprise** > **Project Management** on the top menu bar. In the list displayed, click the name of the target enterprise project, and copy the ID on the enterprise project details page.

Parameter	Mandatory	Type	Description
kubernetes.io/elb.autocreate	Yes	elb.autocreate object	Whether to automatically create a load balancer associated with an ingress. For details about the field description, see **Table 10-31**. **Example** • If a public network load balancer will be automatically created, set this parameter to the following value: '{"type":"public","bandwidth_name":"cce-bandwidth-******","bandwidth_chargemode":"bandwidth","bandwidth_size":5,"bandwidth_sharetype":"PER","eip_type":"5_bgp","name":"james"}' • If a private network load balancer will be automatically created, set this parameter to the following value: {"type":"inner","name":"A-location-d-test"}
host	No	String	Domain name for accessing the Service. By default, this parameter is left blank, and the domain name needs to be fully matched. Ensure that the domain name has been registered and archived. Once a domain name rule is configured, you must use the domain name for access.
path	Yes	String	User-defined route path. All external access requests must match **host** and **path**. **NOTE** The access path added here must exist in the backend application. Otherwise, the forwarding fails. For example, the default access URL of the Nginx application is **/usr/share/nginx/html**. When adding **/test** to the ingress forwarding policy, ensure the access URL of your Nginx application contains **/usr/share/nginx/html/test**. Otherwise, error 404 will be returned.
ingress.beta.kubernetes.io/url-match-mode	No	String	Route matching policy. Default: **STARTS_WITH** (prefix match) Options: • **EQUAL_TO**: exact match • **STARTS_WITH**: prefix match • **REGEX**: regular expression match

Parameter	Mandatory	Type	Description
pathType	Yes	String	Path type. This field is supported only by clusters of v1.23 or later. • **ImplementationSpecific**: The matching method depends on Ingress Controller. The matching method defined by **ingress.beta.kubernetes.io/url-match-mode** is used in CCE. • **Exact**: exact matching of the URL, which is case-sensitive. • **Prefix**: prefix matching, which is case-sensitive. With this method, the URL path is separated into multiple elements by slashes (/) and the elements are matched one by one. If each element in the URL matches the path, the subpaths of the URL can be routed normally. **NOTE** – During prefix matching, each element must be exactly matched. If the last element of the URL is the substring of the last element in the request path, no matching is performed. For example, **/foo/bar** matches **/foo/bar/baz** but does not match **/foo/barbaz**. – When elements are separated by slashes (/), if the URL or request path ends with a slash (/), the slash (/) at the end is ignored. For example, **/foo/bar** matches **/foo/bar/**. See **examples** of ingress path matching.

Table 10-31 elb.autocreate data structure

Parameter	Mandatory	Type	Description
name	No	String	Name of the automatically created load balancer. The value can contain 1 to 64 characters. Only letters, digits, underscores (_), hyphens (-), and periods (.) are allowed. Default: **cce-lb+service.UID**

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 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. ● The minimum increment is 1 Mbit/s if the allowed bandwidth does not exceed 300 Mbit/s. ● The minimum increment is 50 Mbit/s if the allowed bandwidth ranges from 300 Mbit/s to 1000 Mbit/s. ● The minimum increment is 500 Mbit/s if the allowed bandwidth exceeds 1000 Mbit/s.
bandwidth_sharetype	Yes for public network load balancers	String	Bandwidth sharing mode. ● **PER**: dedicated bandwidth
eip_type	Yes for public network load balancers	String	EIP type. ● **5_bgp**: dynamic BGP The specific type varies with regions. For details, see the EIP console.

Parameter	Mandatory	Type	Description
vip_subnet_cidr_id	No	String	Subnet where a load balancer is located. The subnet must belong to the VPC where the cluster resides. If this parameter is not specified, the ELB load balancer and the cluster are in the same subnet. This field can be specified only for clusters of v1.21 or later.
vip_address	No	String	Private IP address of the load balancer. Only IPv4 addresses are supported. The IP address must be in the ELB CIDR block. If this parameter is not specified, an IP address will be automatically assigned from the ELB CIDR block. This parameter is available only in clusters of v1.23.11-r0, v1.25.6-r0, v1.27.3-r0, or later versions.
available_zone	Yes	Array of strings	AZ where the load balancer is located. This parameter is available only for dedicated load balancers.
l4_flavor_name	Yes	String	Flavor name of the layer-4 load balancer. This parameter is available only for dedicated load balancers.
l7_flavor_name	No	String	Flavor name of the layer-7 load balancer. This parameter is available only for dedicated load balancers. The value of this parameter must be the same as that of **l4_flavor_name**, that is, both are elastic specifications or fixed specifications.
elb_virsubnet_ids	No	Array of strings	Subnet where the backend server of the load balancer is located. If this parameter is left blank, the default cluster subnet is used. Load balancers occupy different number of subnet IP addresses based on their specifications. Do not use the subnet CIDR blocks of other resources (such as clusters and nodes) as the load balancer CIDR block. This parameter is available only for dedicated load balancers. Example: `"elb_virsubnet_ids": [ "14567f27-8ae4-42b8-ae47-9f847a4690dd" ]`

Step 3 Create an ingress.

kubectl create -f ingress-test.yaml

If information similar to the following is displayed, the ingress has been created.

```
ingress/ingress-test created
```

kubectl get ingress

If information similar to the following is displayed, the ingress has been created and the workload is accessible.

```
NAME           HOSTS     ADDRESS         PORTS   AGE
ingress-test   *         121.**.**.**    80      10s
```

Step 4 Enter **http://*121.**.**.***:80** in the address box of the browser to access the workload (for example, **Nginx workload**).

121.**.**.** indicates the IP address of the unified load balancer.

----End

Creating an Ingress - Interconnecting with an Existing Load Balancer

CCE allows you to connect to an existing load balancer when creating an ingress.

NOTE

- Existing dedicated load balancers must be the application type (HTTP/HTTPS) supporting private networks (with a private IP).

If the cluster version is 1.23 or later, the YAML file configuration is as follows:

```
apiVersion: networking.k8s.io/v1
kind: Ingress
metadata:
  name: ingress-test
  annotations:
    kubernetes.io/elb.id: <your_elb_id>  # Replace it with the ID of your existing load balancer.
    kubernetes.io/elb.ip: <your_elb_ip>  # Replace it with the IP of your existing load balancer.
    kubernetes.io/elb.class: performance  # Load balancer type
    kubernetes.io/elb.port: '80'
spec:
  rules:
  - host: ''
    http:
      paths:
      - path: '/'
        backend:
          service:
            name: <your_service_name>  # Replace it with the name of your target Service.
            port:
              number: 8080             # Replace 8080 with the port number of your target Service.
        property:
          ingress.beta.kubernetes.io/url-match-mode: STARTS_WITH
        pathType: ImplementationSpecific
  ingressClassName: cce
```

If the cluster version is 1.21 or earlier, the YAML file configuration is as follows:

```
apiVersion: networking.k8s.io/v1beta1
kind: Ingress
metadata:
  name: ingress-test
  annotations:
```

```
    kubernetes.io/elb.id: <your_elb_id>  # Replace it with the ID of your existing load balancer.
    kubernetes.io/elb.ip: <your_elb_ip>  # Replace it with the IP of your existing load balancer.
    kubernetes.io/elb.class: performance  # Load balancer type
    kubernetes.io/elb.port: '80
    kubernetes.io/ingress.class: cce
spec:
  rules:
  - host: ''
    http:
      paths:
      - path: '/'
        backend:
          serviceName: <your_service_name>  # Replace it with the name of your target Service.
          servicePort: 80
        property:
          ingress.beta.kubernetes.io/url-match-mode: STARTS_WITH
```

Table 10-32 Key parameters

Parameter	Mandatory	Type	Description
kubernetes.io/elb.id	Yes	String	ID of a load balancer. The value can contain 1 to 100 characters. **How to obtain**: On the management console, click **Service List**, and choose **Networking** > **Elastic Load Balance**. Click the name of the target load balancer. On the **Summary** tab page, find and copy the ID.
kubernetes.io/elb.ip	No	String	Service address of a load balancer. The value can be the public IP address of a public network load balancer or the private IP address of a private network load balancer.
kubernetes.io/elb.class	Yes	String	Load balancer type. • **performance**: dedicated load balancer, which can be used only in clusters of v1.17 and later. **NOTE** If a LoadBalancer ingress accesses an existing dedicated load balancer, the dedicated load balancer must be of the application load balancing (HTTP/HTTPS) type.

10.4.2.3 Configuring a LoadBalancer Ingress Using Annotations

By adding annotations to a YAML file, you can implement more advanced ingress functions. This section describes the annotations that can be used when you create a LoadBalancer ingress.

- **Interconnection with ELB**
- **Using HTTP/2**
- **Configuring ELB Certificates**

- **Interconnecting with HTTPS Backend Services**
- **Configuring Timeout for an Ingress**

Interconnection with ELB

Table 10-33 Annotations for interconnecting with ELB

Parameter	Type	Description	Supported Cluster Version
kubernetes.io/elb.class	String	Select a proper load balancer type. • **performance**: dedicated load balancer, which can be used only in clusters of v1.17 and later.	v1.9 or later
kubernetes.io/ingress.class	String	• **cce**: A proprietary LoadBalancer ingress is used. • **nginx**: Nginx ingress is used. This parameter is mandatory when an ingress is created by calling the API. For clusters of v1.23 or later, use the parameter **ingressClassName**. For details, see **Using kubectl to Create a LoadBalancer Ingress**.	Only clusters of v1.21 or earlier
kubernetes.io/elb.port	String	This parameter indicates the external port registered with the address of the LoadBalancer Service. The value ranges from 1 to 65535. **NOTE** Some ports are high-risk ports and are blocked by default, for example, port 21.	v1.9 or later
kubernetes.io/elb.id	String	Mandatory **when an existing load balancer is to be interconnected**. ID of a load balancer. **How to obtain**: On the management console, click **Service List**, and choose **Networking** > **Elastic Load Balance**. Click the name of the target load balancer. On the **Summary** tab page, find and copy the ID.	v1.9 or later
kubernetes.io/elb.ip	String	Mandatory **when an existing load balancer is to be interconnected**. Service address of a load balancer. The value can be the public IP address of a public network load balancer or the private IP address of a private network load balancer.	v1.9 or later

Parameter	Type	Description	Supported Cluster Version
kubernetes.io/elb.autocreate	Table 10-38 Object	Mandatory **when load balancers are automatically created**. **Example** • If a public network load balancer will be automatically created, set this parameter to the following value: '{"type":"public","bandwidth_name":"cce-bandwidth-1551163379627","bandwidth_chargemode":"bandwidth","bandwidth_size":5,"bandwidth_sharetype":"PER","eip_type":"5_bgp","name":"james"}' • If a private network load balancer will be automatically created, set this parameter to the following value: {"type":"inner","name":"A-location-d-test"}	v1.9 or later
kubernetes.io/elb.enterpriseID	String	Optional **when load balancers are automatically created**. **Clusters of v1.15 and later versions support this field. In clusters earlier than v1.15, load balancers are created in the default project by default.** This parameter indicates the ID of the enterprise project in which the ELB load balancer will be created. If this parameter is not specified or is set to **0**, resources will be bound to the default enterprise project. **How to obtain**: Log in to the management console and choose **Enterprise** > **Project Management** on the top menu bar. In the list displayed, click the name of the target enterprise project, and copy the ID on the enterprise project details page.	v1.15 or later

Parameter	Type	Description	Supported Cluster Version
kubernetes.io/elb.subnet-id	String	Optional **when load balancers are automatically created**. ID of the subnet where the cluster is located. The value can contain 1 to 100 characters. • Mandatory when a cluster of v1.11.7-r0 or earlier is to be automatically created. • Optional for clusters later than v1.11.7-r0.	Mandatory for clusters earlier than v1.11.7-r0 Discarded in clusters later than v1.11.7-r0

The following shows how to use the preceding annotations:

- Associate an existing load balancer. For details, see **Creating an Ingress - Interconnecting with an Existing Load Balancer**.
- Automatically create a load balancer. For details, see **Creating an Ingress - Automatically Creating a Load Balancer**.

Using HTTP/2

Table 10-34 Annotations of using HTTP/2

Parameter	Type	Description	Supported Cluster Version
kubernetes.io/elb.http2-enable	String	Whether HTTP/2 is enabled. Request forwarding using HTTP/2 improves the access performance between your application and the load balancer. However, the load balancer still uses HTTP/1.x to forward requests to the backend server. Options: • **true**: enabled • **false**: disabled (default value) Note: **HTTP/2 can be enabled or disabled only when the listener uses HTTPS.** This parameter is invalid and defaults to **false** when the listener protocol is HTTP.	v1.23.13-r0, v1.25.8-r0, v1.27.5-r0, v1.28.3-r0, or later

For details, see **Configuring HTTP/2 for a LoadBalancer Ingress**.

Configuring ELB Certificates

Table 10-35 ELB certificate annotations

Parameter	Type	Description	Supported Cluster Version
kubernetes.io/elb.tls-certificate-ids	String	ELB certificate IDs, which are separated by comma (,). The list length is greater than or equal to 1. The first ID in the list is the server certificate, and the other IDs are SNI certificates in which a domain name must be contained. To obtain the certificate, log in to the CCE console, choose **Service List** > **Networking** > **Elastic Load Balance**, and click **Certificates** in the navigation pane. In the load balancer list, copy the ID under the target certificate name.	v1.19.16-r2, v1.21.5-r0, v1.23.3-r0, or later

For details, see **Using the ELB Certificate**.

Interconnecting with HTTPS Backend Services

Table 10-36 Annotations for interconnecting with HTTPS backend services

Parameter	Type	Description	Supported Cluster Version
kubernetes.io/elb.pool-protocol	String	To interconnect with HTTPS backend services, set this parameter to **https**.	v1.23.8, v1.25.3, or later

For details, see **Interconnecting LoadBalancer Ingresses with HTTPS Backend Services**.

Configuring Timeout for an Ingress

Table 10-37 Annotations of configuring ingress redirection rules

Parameter	Type	Description	Supported Cluster Version
kubernetes.io/elb.keepalive_timeout	String	Timeout for client connections. If there are no requests reaching the load balancer during the timeout duration, the load balancer will disconnect the connection from the client and establish a new connection when there is a new request. Value: ● For TCP listeners, the value ranges from **10** to **4000** (in seconds). The default value is **300**. ● For HTTP or HTTPS listeners, the value ranges from **0** to **4000** (in seconds). The default value is **60**. For UDP listeners, this parameter does not take effect.	Dedicated load balancers: v1.19.16-r30, v1.21.10-r10, v1.23.8-r10, v1.25.3-r10, or later Shared load balancers: v1.23.13-r0, v1.25.8-r0, v1.27.5-r0, v1.28.3-r0, or later

Parameter	Type	Description	Supported Cluster Version
kubernetes.io/elb.client_timeout	String	Timeout for waiting for a request from a client. There are two cases: • If the client fails to send a request header to the load balancer during the timeout duration, the request will be interrupted. • If the interval between two consecutive request bodies reaching the load balancer is greater than the timeout duration, the connection will be disconnected. The value ranges from **1** to **300** (in seconds). The default value is **60**. This parameter is available only for HTTP and HTTPS listeners. Minimum value: **1** Maximum value: **300** Default value: **60**	Dedicated load balancers: v1.19.16-r30, v1.21.10-r10, v1.23.8-r10, v1.25.3-r10, or later Shared load balancers: v1.23.13-r0, v1.25.8-r0, v1.27.5-r0, v1.28.3-r0, or later

Parameter	Type	Description	Supported Cluster Version
kubernetes.io/elb.member_timeout	String	Timeout for waiting for a response from a backend server. After a request is forwarded to the backend server, if the backend server does not respond within the duration specified by **member_timeout**, the load balancer will stop waiting and return HTTP 504 Gateway Timeout. The value ranges from **1** to **300** (in seconds). The default value is **60**. This parameter is available only for HTTP and HTTPS listeners. Minimum value: **1** Maximum value: **300** Default value: **60**	Dedicated load balancers: v1.19.16-r30, v1.21.10-r10, v1.23.8-r10, v1.25.3-r10, or later Shared load balancers: v1.23.13-r0, v1.25.8-r0, v1.27.5-r0, v1.28.3-r0, or later

For details, see **Configuring Timeout for a LoadBalancer Ingress**.

Parameters for Automatically Creating a Load Balancer

Table 10-38 elb.autocreate data structure

Parameter	Mandatory	Type	Description
name	No	String	Name of the automatically created load balancer. The value can contain 1 to 64 characters. Only letters, digits, underscores (_), hyphens (-), and periods (.) are allowed. Default: **cce-lb+service.UID**

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 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. ● The minimum increment is 1 Mbit/s if the allowed bandwidth does not exceed 300 Mbit/s. ● The minimum increment is 50 Mbit/s if the allowed bandwidth ranges from 300 Mbit/s to 1000 Mbit/s. ● The minimum increment is 500 Mbit/s if the allowed bandwidth exceeds 1000 Mbit/s.
bandwidth_sharetype	Yes for public network load balancers	String	Bandwidth sharing mode. ● **PER**: dedicated bandwidth
eip_type	Yes for public network load balancers	String	EIP type. ● **5_bgp**: dynamic BGP The specific type varies with regions. For details, see the EIP console.

Parameter	Mandatory	Type	Description
vip_subnet_cidr_id	No	String	Subnet where a load balancer is located. The subnet must belong to the VPC where the cluster resides. If this parameter is not specified, the ELB load balancer and the cluster are in the same subnet. This field can be specified only for clusters of v1.21 or later.
vip_address	No	String	Private IP address of the load balancer. Only IPv4 addresses are supported. The IP address must be in the ELB CIDR block. If this parameter is not specified, an IP address will be automatically assigned from the ELB CIDR block. This parameter is available only in clusters of v1.23.11-r0, v1.25.6-r0, v1.27.3-r0, or later versions.
available_zone	Yes	Array of strings	AZ where the load balancer is located. This parameter is available only for dedicated load balancers.
l4_flavor_name	Yes	String	Flavor name of the layer-4 load balancer. This parameter is available only for dedicated load balancers.
l7_flavor_name	No	String	Flavor name of the layer-7 load balancer. This parameter is available only for dedicated load balancers. The value of this parameter must be the same as that of **l4_flavor_name**, that is, both are elastic specifications or fixed specifications.
elb_virsubnet_ids	No	Array of strings	Subnet where the backend server of the load balancer is located. If this parameter is left blank, the default cluster subnet is used. Load balancers occupy different number of subnet IP addresses based on their specifications. Do not use the subnet CIDR blocks of other resources (such as clusters and nodes) as the load balancer CIDR block. This parameter is available only for dedicated load balancers. Example: `"elb_virsubnet_ids": [ "14567f27-8ae4-42b8-ae47-9f847a4690dd" ]`

10.4.2.4 Configuring an HTTPS Certificate for a LoadBalancer Ingress

Ingresses support TLS certificates and secure your Services with HTTPS.

You can use a TLS secret certificate configured in the cluster and the ELB certificate.

NOTE

If HTTPS is enabled for the same port of the same load balancer of multiple ingresses, you must select the same certificate.

Using a TLS Secret Certificate

Step 1 Use kubectl to connect to the cluster. For details, see **Connecting to a Cluster Using kubectl**.

Step 2 Ingress supports two TLS secret types: kubernetes.io/tls and IngressTLS. IngressTLS is used as an example. For details, see **Creating a Secret**. For details about examples of the kubernetes.io/tls secret and its description, see **TLS secrets**.

Create a YAML file named **ingress-test-secret.yaml**. The file name can be customized.

vi ingress-test-secret.yaml

The YAML file is configured as follows:

```
apiVersion: v1
data:
  tls.crt: LS0******tLS0tCg==
  tls.key: LS0tL******0tLS0K
kind: Secret
metadata:
  annotations:
    description: test for ingressTLS secrets
  name: ingress-test-secret
  namespace: default
type: IngressTLS
```

NOTE

In the preceding information, **tls.crt** and **tls.key** are only examples. Replace them with the actual files. The values of **tls.crt** and **tls.key** are Base64-encoded.

Step 3 Create a secret.

kubectl create -f ingress-test-secret.yaml

If information similar to the following is displayed, the secret has been created:

```
secret/ingress-test-secret created
```

View the created secret.

kubectl get secrets

If information similar to the following is displayed, the secret has been created:

```
NAME                  TYPE                                  DATA   AGE
ingress-test-secret   IngressTLS                            2      13s
```

Step 4 Create a YAML file named **ingress-test.yaml**. The file name can be customized.

vi ingress-test.yaml

NOTE

Default security policy (kubernetes.io/elb.tls-ciphers-policy) is supported only in clusters of v1.17.17 or later.

The following uses the automatically created load balancer as an example. The YAML file is configured as follows:

For clusters of v1.21 or earlier:

```
apiVersion: networking.k8s.io/v1beta1
kind: Ingress
metadata:
  name: ingress-test
  annotations:
    kubernetes.io/elb.class: performance
    kubernetes.io/ingress.class: cce
    kubernetes.io/elb.port: '443'
    kubernetes.io/elb.autocreate:
      '{
          "type": "public",
          "bandwidth_name": "cce-bandwidth-******",
          "bandwidth_chargemode": "bandwidth",
          "bandwidth_size": 5,
          "bandwidth_sharetype": "PER",
          "eip_type": "5_bgp",
          "available_zone": [
              ""
          ],
          "elb_virsubnet_ids":["b4bf8152-6c36-4c3b-9f74-2229f8e640c9"],
          "l7_flavor_name": "L7_flavor.elb.s1.small"
      }'
    kubernetes.io/elb.tls-ciphers-policy: tls-1-2
spec:
  tls:
  - secretName: ingress-test-secret
  rules:
  - host: foo.bar.com
    http:
      paths:
      - path: '/'
        backend:
          serviceName: <your_service_name>  # Replace it with the name of your target Service.
          servicePort: 80
        property:
          ingress.beta.kubernetes.io/url-match-mode: STARTS_WITH
```

For clusters of v1.23 or later:

```
apiVersion: networking.k8s.io/v1
kind: Ingress
metadata:
  name: ingress-test
  annotations:
    kubernetes.io/elb.class: performance
    kubernetes.io/elb.port: '443'
    kubernetes.io/elb.autocreate:
      '{
          "type": "public",
          "bandwidth_name": "cce-bandwidth-******",
          "bandwidth_chargemode": "bandwidth",
          "bandwidth_size": 5,
          "bandwidth_sharetype": "PER",
          "eip_type": "5_bgp",
          "available_zone": [
              ""
          ],
          "elb_virsubnet_ids":["b4bf8152-6c36-4c3b-9f74-2229f8e640c9"],
          "l7_flavor_name": "L7_flavor.elb.s1.small"
```

```
    }'
  kubernetes.io/elb.tls-ciphers-policy: tls-1-2
spec:
  tls:
  - secretName: ingress-test-secret
  rules:
  - host: foo.bar.com
    http:
      paths:
      - path: '/'
        backend:
          service:
            name: <your_service_name>  # Replace it with the name of your target Service.
            port:
              number: 8080             # Replace 8080 with the port number of your target Service.
        property:
          ingress.beta.kubernetes.io/url-match-mode: STARTS_WITH
        pathType: ImplementationSpecific
  ingressClassName: cce
```

Table 10-39 Key parameters

Parameter	Mandatory	Type	Description
kubernetes.io/elb.tls-ciphers-policy	No	String	The default value is **tls-1-2**, which is the default security policy used by the listener and takes effect only when HTTPS is used. Options: • tls-1-0 • tls-1-1 • tls-1-2 • tls-1-2-strict For details of cipher suites for each security policy, see **Table 10-40**.
tls	No	Array of strings	When HTTPS is used, this parameter must be added to specify the secret certificate. Multiple independent domain names and certificates can be added. For details, see **Configuring SNI for a LoadBalancer Ingress**.
secretName	No	String	This parameter is mandatory if HTTPS is used. Set this parameter to the name of the created secret.

Table 10-40 tls_ciphers_policy parameter description

Security Policy	TLS Version	Cipher Suite
tls-1-0	TLS 1.2 TLS 1.1 TLS 1.0	ECDHE-RSA-AES256-GCM-SHA384:ECDHE-RSA-AES128-GCM-SHA256:ECDHE-ECDSA-AES256-GCM-SHA384:ECDHE-ECDSA-AES128-GCM-SHA256:AES128-GCM-SHA256:AES256-GCM-SHA384:ECDHE-ECDSA-AES128-SHA256:ECDHE-RSA-AES128-SHA256:AES128-SHA256:AES256-SHA256:ECDHE-ECDSA-AES256-SHA384:ECDHE-RSA-AES256-SHA384:ECDHE-ECDSA-AES128-SHA:ECDHE-RSA-AES128-SHA:ECDHE-RSA-AES256-SHA:ECDHE-ECDSA-AES256-SHA:AES128-SHA:AES256-SHA
tls-1-1	TLS 1.2 TLS 1.1	
tls-1-2	TLS 1.2	
tls-1-2-strict	TLS 1.2	ECDHE-RSA-AES256-GCM-SHA384:ECDHE-RSA-AES128-GCM-SHA256:ECDHE-ECDSA-AES256-GCM-SHA384:ECDHE-ECDSA-AES128-GCM-SHA256:AES128-GCM-SHA256:AES256-GCM-SHA384:ECDHE-ECDSA-AES128-SHA256:ECDHE-RSA-AES128-SHA256:AES128-SHA256:AES256-SHA256:ECDHE-ECDSA-AES256-SHA384:ECDHE-RSA-AES256-SHA384

Step 5 Create an ingress.

kubectl create -f ingress-test.yaml

If information similar to the following is displayed, the ingress has been created.

```
ingress/ingress-test created
```

View the created ingress.

kubectl get ingress

If information similar to the following is displayed, the ingress has been created and the workload is accessible.

```
NAME           HOSTS     ADDRESS         PORTS   AGE
ingress-test   *         121.**.**.**    80      10s
```

Step 6 Enter **https://*121.**.**.***:443** in the address box of the browser to access the workload (for example, **Nginx workload**).

121.**.**.** indicates the IP address of the unified load balancer.

----End

Using the ELB Certificate

To use the ELB certificate, you can specify the annotations **kubernetes.io/elb.tls-certificate-ids**.

NOTE

1. If you specify both the IngressTLS certificate and the ELB certificate, the latter is used.
2. CCE does not check whether the ELB certificate is valid. It only checks whether the certificate exists.
3. Only clusters of v1.19.16-r2, v1.21.5-r0, v1.23.3-r0, or later support the ELB certificate.

For clusters of v1.21 or earlier:

```
apiVersion: networking.k8s.io/v1beta1
kind: Ingress
metadata:
  name: ingress-test
  annotations:
    kubernetes.io/ingress.class: cce
    kubernetes.io/elb.port: '443'
    kubernetes.io/elb.id: 0b9a6c4d-bd8b-45cc-bfc8-ff0f9da54e95
    kubernetes.io/elb.class: union
    kubernetes.io/elb.tls-certificate-ids:
058cc023690d48a3867ad69dbe9cd6e5,b98382b1f01c473286653afd1ed9ab63
spec:
  rules:
  - host: ''
    http:
      paths:
      - path: '/'
        backend:
          serviceName: <your_service_name>  # Replace it with the name of your target Service.
          servicePort: 80
        property:
          ingress.beta.kubernetes.io/url-match-mode: STARTS_WITH
```

For clusters of v1.23 or later:

```
apiVersion: networking.k8s.io/v1
kind: Ingress
metadata:
  name: ingress-test
  namespace: default
  annotations:
    kubernetes.io/elb.port: '443'
    kubernetes.io/elb.id: 0b9a6c4d-bd8b-45cc-bfc8-ff0f9da54e95
    kubernetes.io/elb.class: union
    kubernetes.io/elb.tls-certificate-ids:
058cc023690d48a3867ad69dbe9cd6e5,b98382b1f01c473286653afd1ed9ab63
spec:
  rules:
    - host: ''
      http:
        paths:
          - path: '/'
            backend:
              service:
                name: <your_service_name>  # Replace it with the name of your target Service.
                port:
                  number: 8080             # Replace 8080 with the port number of your target Service.
            property:
              ingress.beta.kubernetes.io/url-match-mode: STARTS_WITH
            pathType: ImplementationSpecific
  ingressClassName: cce
```

Table 10-41 Key parameters

Parameter	Type	Description
kubernetes.io/elb.tls-certificate-ids	String	ELB certificate IDs, which are separated by comma (,). The list length is greater than or equal to 1. The first ID in the list is the server certificate, and the other IDs are SNI certificates in which a domain name must be contained. If an SNI certificate cannot be found based on the domain name requested by the client, the server certificate will be returned by default. To obtain the certificate, log in to the CCE console, choose **Service List** > **Networking** > **Elastic Load Balance**, and click **Certificates** in the navigation pane. In the load balancer list, copy the ID under the target certificate name.

10.4.2.5 Configuring SNI for a LoadBalancer Ingress

An SNI certificate is an extended server certificate that allows the same IP address and port number to provide multiple access domain names for external systems. Different security certificates can be used based on the domain names requested by clients to ensure HTTPS communication security.

When configuring SNI, you need to add a certificate associated with a domain name. The client submits the requested domain name information when initiating an SSL handshake request. After receiving the SSL request, the load balancer searches for the certificate based on the domain name. If the certificate is found, the load balancer will return it to the client. If the certificate is not found, the load balancer will return the default server certificate.

NOTE

- This function is supported only in clusters of v1.15.11 and later.
- The **SNI** option is available only when HTTPS is used.
- Only one domain name can be specified for each SNI certificate. Wildcard-domain certificates are supported.
- Security policy (kubernetes.io/elb.tls-ciphers-policy) is supported only in clusters of v1.17.11 or later.

You can enable SNI when the preceding conditions are met. The following uses the automatic creation of a load balancer as an example. In this example, **sni-test-secret-1** and **sni-test-secret-2** are SNI certificates. The domain names specified by the certificates must be the same as those in the certificates.

For clusters of v1.21 or earlier:

```
apiVersion: networking.k8s.io/v1beta1
kind: Ingress
metadata:
  name: ingress-test
```

```
  annotations:
    kubernetes.io/elb.class: performance
    kubernetes.io/ingress.class: cce
    kubernetes.io/elb.port: '443'
    kubernetes.io/elb.autocreate:
      '{
          "type": "public",
          "bandwidth_name": "cce-bandwidth-******",
          "bandwidth_chargemode": "bandwidth",
          "bandwidth_size": 5,
          "bandwidth_sharetype": "PER",
          "eip_type": "5_bgp",
          "available_zone": [
              ""
          ],
          "elb_virsubnet_ids":["b4bf8152-6c36-4c3b-9f74-2229f8e640c9"],
          "l7_flavor_name": "L7_flavor.elb.s1.small"
      }'
    kubernetes.io/elb.tls-ciphers-policy: tls-1-2
spec:
  tls:
  - secretName: ingress-test-secret
  - hosts:
      - example.top  # Domain name specified when a certificate is issued
    secretName: sni-test-secret-1
  - hosts:
      - example.com  # Domain name specified when a certificate is issued
    secretName: sni-test-secret-2
  rules:
  - host: example.com
    http:
      paths:
      - path: '/'
        backend:
          serviceName: <your_service_name>  # Replace it with the name of your target Service.
          servicePort: 80
        property:
          ingress.beta.kubernetes.io/url-match-mode: STARTS_WITH
```

For clusters of v1.23 or later:

```
apiVersion: networking.k8s.io/v1
kind: Ingress
metadata:
  name: ingress-test
  annotations:
    kubernetes.io/elb.class: performance
    kubernetes.io/elb.port: '443'
    kubernetes.io/elb.autocreate:
      '{
          "type": "public",
          "bandwidth_name": "cce-bandwidth-******",
          "bandwidth_chargemode": "bandwidth",
          "bandwidth_size": 5,
          "bandwidth_sharetype": "PER",
          "eip_type": "5_bgp",
          "available_zone": [
              ""
          ],
          "elb_virsubnet_ids":["b4bf8152-6c36-4c3b-9f74-2229f8e640c9"],
          "l7_flavor_name": "L7_flavor.elb.s1.small"
      }'
    kubernetes.io/elb.tls-ciphers-policy: tls-1-2
spec:
  tls:
  - secretName: ingress-test-secret
  - hosts:
      - example.top  # Domain name specified when a certificate is issued
    secretName: sni-test-secret-1
  - hosts:
      - example.com  # Domain name specified when a certificate is issued
```

```
  secretName: sni-test-secret-2
rules:
- host: example.com
  http:
    paths:
    - path: '/'
      backend:
        service:
          name: <your_service_name>  # Replace it with the name of your target Service.
          port:
            number: 8080             # Replace 8080 with the port number of your target Service.
      property:
        ingress.beta.kubernetes.io/url-match-mode: STARTS_WITH
      pathType: ImplementationSpecific
ingressClassName: cce
```

10.4.2.6 LoadBalancer Ingresses to Multiple Services

Ingresses can route to multiple backend Services based on different matching policies. The **spec** field in the YAML file is set as below. You can access **www.example.com/foo**, **www.example.com/bar**, and **foo.example.com/** to route to three different backend Services.

NOTICE

The URL registered in an ingress forwarding policy must be the same as the URL used to access the backend Service. Otherwise, a 404 error will be returned.

For example, the default access URL of the Nginx application is **/usr/share/nginx/html**. When adding **/test** to the ingress forwarding policy, ensure the access URL of your Nginx application contains **/usr/share/nginx/html/test**. Otherwise, error 404 will be returned.

```
...
spec:
  rules:
  - host: 'www.example.com'
    http:
      paths:
      - path: '/foo'
        backend:
          serviceName: <your_service_name>  # Replace it with the name of your target Service.
          servicePort: 80
        property:
          ingress.beta.kubernetes.io/url-match-mode: STARTS_WITH
      - path: '/bar'
        backend:
          serviceName: <your_service_name>  # Replace it with the name of your target Service.
          servicePort: 80
        property:
          ingress.beta.kubernetes.io/url-match-mode: STARTS_WITH
  - host: 'foo.example.com'
    http:
      paths:
      - path: '/'
        backend:
          serviceName: <your_service_name>  # Replace it with the name of your target Service.
          servicePort: 80
        property:
          ingress.beta.kubernetes.io/url-match-mode: STARTS_WITH
```

10.4.2.7 Configuring HTTP/2 for a LoadBalancer Ingress

Ingresses can use HTTP/2 to expose Services. Connections from the load balancer to your application use HTTP/1.X by default. If your application is capable of receiving HTTP2 requests, you can add the following field to the ingress annotation to enable the use of HTTP/2:

```
kubernetes.io/elb.http2-enable: 'true'
```

NOTE

- An HTTPS-compliant load balancer supports HTTP/2.
- This function is available in clusters of version v1.23.13-r0, v1.25.8-r0, v1.27.5-r0, or v1.28.3-r0.
- If the advanced configuration for enabling HTTP/2 or the target annotation is deleted, the ELB configuration will not be modified.

The following shows an example YAML file where an existing load balancer is associated:

```
apiVersion: networking.k8s.io/v1
kind: Ingress
metadata:
  name: ingress-test
  annotations:
    kubernetes.io/elb.id: <your_elb_id>  # Replace it with the ID of your existing load balancer.
    kubernetes.io/elb.ip: <your_elb_ip>  # Replace it with the IP of your existing load balancer.
    kubernetes.io/elb.port: '443'
    kubernetes.io/elb.http2-enable: 'true' # Enable HTTP/2.
spec:
  tls:
  - secretName: ingress-test-secret
  rules:
  - host: ''
    http:
      paths:
      - path: '/'
        backend:
          service:
            name: <your_service_name>  # Replace it with the name of your target Service.
            port:
              number: 8080             # Replace 8080 with the port number of your target Service.
        property:
          ingress.beta.kubernetes.io/url-match-mode: STARTS_WITH
        pathType: ImplementationSpecific
  ingressClassName: cce
```

Table 10-42 HTTP/2 parameters

Parameter	Mandatory	Type	Description
kubernetes.io/elb.http2-enable	No	String	Whether HTTP/2 is enabled. Request forwarding using HTTP/2 improves the access performance between your application and the load balancer. However, the load balancer still uses HTTP/1.x to forward requests to the backend server. Options: ● **true**: enabled ● **false**: disabled (default value) Note: **HTTP/2 can be enabled or disabled only when the listener uses HTTPS.** This parameter is invalid when the listener protocol is HTTP, and defaults to **false**.

10.4.2.8 Interconnecting LoadBalancer Ingresses with HTTPS Backend Services

Ingresses can interconnect with backend services of different protocols. By default, the backend proxy channel of an ingress is HTTP-compliant. To create an HTTPS channel, add the following configuration to the **annotations** field:

```
kubernetes.io/elb.pool-protocol: https
```

Constraints

- This function is available only in clusters of v1.23.8, v1.25.3, or later.
- Ingresses can interconnect with HTTPS backend services only when dedicated load balancers are used.
- When an ingress interconnects with an HTTPS backend service, the ingress protocol must be HTTPS.

Configuration Example

An ingress configuration example is as follows:

```
apiVersion: networking.k8s.io/v1
kind: Ingress
metadata:
  name: ingress-test
  namespace: default
  annotations:
    kubernetes.io/elb.port: '443'
    kubernetes.io/elb.id: <your_elb_id>    # In this example, an existing dedicated load balancer is used.
Replace its ID with the ID of your dedicated load balancer.
    kubernetes.io/elb.class: performance
    kubernetes.io/elb.pool-protocol: https  # Interconnected HTTPS backend service
    kubernetes.io/elb.tls-ciphers-policy: tls-1-2
spec:
```

```
tls:
  - secretName: ingress-test-secret
rules:
  - host: ''
    http:
      paths:
        - path: '/'
          backend:
            service:
              name: <your_service_name>  # Replace it with the name of your target Service.
              port:
                number: 80
          property:
            ingress.beta.kubernetes.io/url-match-mode: STARTS_WITH
          pathType: ImplementationSpecific
ingressClassName: cce
```

10.4.2.9 Configuring Timeout for a LoadBalancer Ingress

LoadBalancer ingresses support the following timeout settings:

- Idle timeout setting for client connections: Maximum duration for keeping a connection when no client request is received. If no request is received during this period, the load balancer closes the connection and establishes a new one with the client when the next request arrives.
- Timeout for waiting for a request from a client: If the client fails to send a request header to the load balancer during the timeout duration or the interval for sending body data exceeds a specified period, the load balancer will release the connection.
- Timeout setting for waiting for a response from a backend server: If the backend server fails to respond during the timeout duration, the load balancer will stop waiting and return HTTP 504 Gateway Timeout to the client.

Constraints

- The following table lists the scenarios where timeout can be configured for a Service.

Timeout Type	Load Balancer Type	Supported Cluster Version
Idle Timeout	Dedicated	• v1.19: v1.19.16-r30 or later • v1.21: v1.21.10-r10 or later • v1.23: v1.23.8-r10 or later • v1.25: v1.25.3-r10 or later • Other clusters of later versions
Request Timeout	Dedicated	
Response Timeout	Dedicated	

- If you delete the timeout configuration during an ingress update, the timeout configuration on the existing listeners will be retained.

Using kubectl

An ingress configuration example is as follows:

```
apiVersion: networking.k8s.io/v1
kind: Ingress
```

```
metadata:
  name: test
  namespace: default
  annotations:
    kubernetes.io/elb.port: '80'
    kubernetes.io/elb.id: <your_elb_id>    # In this example, an existing dedicated load balancer is used.
Replace its ID with the ID of your dedicated load balancer.
    kubernetes.io/elb.class: performance
    kubernetes.io/elb.keepalive_timeout: '300'  # Timeout setting for client connections
    kubernetes.io/elb.client_timeout: '60'      # Timeout duration for waiting for a request from a client
    kubernetes.io/elb.member_timeout: '60'      # Timeout duration for waiting for a response from a
backend server
spec:
  rules:
    - host: ''
      http:
        paths:
          - path: /
            backend:
              service:
                name: test
                port:
                  number: 80
            property:
              ingress.beta.kubernetes.io/url-match-mode: STARTS_WITH
            pathType: ImplementationSpecific
  ingressClassName: cce
```

Table 10-43 Key annotation parameters

Parameter	Mandatory	Type	Description
kubernetes.io/elb.keepalive_timeout	No	String	Timeout for client connections. If there are no requests reaching the load balancer during the timeout duration, the load balancer will disconnect the connection from the client and establish a new connection when there is a new request. The value ranges from **0** to **4000** (in seconds). The default value is **60**.
kubernetes.io/elb.client_timeout	No	String	Timeout for waiting for a request from a client. There are two situations: ● If the client fails to send a request header to the load balancer during the timeout duration, the request will be interrupted. ● If the interval between two consecutive request bodies reaching the load balancer is greater than the timeout duration, the connection will be disconnected. The value ranges from **1** to **300** (in seconds). The default value is **60**.

Parameter	Mandatory	Type	Description
kubernetes.io/elb.member_timeout	No	String	Timeout duration for waiting for a response from a backend server. After a request is forwarded to the backend server, if the backend server does not respond within the duration specified by **member_timeout**, the load balancer will stop waiting and return HTTP 504 Gateway Timeout. The value ranges from **1** to **300** (in seconds). The default value is **60**.

10.4.3 Nginx Ingresses

10.4.3.1 Creating Nginx Ingresses on the Console

Prerequisites

- An ingress provides network access for backend workloads. Ensure that a workload is available in a cluster. If no workload is available, deploy a workload by referring to **Creating a Deployment**, **Creating a StatefulSet**, or **Creating a DaemonSet**.
- A ClusterIP or NodePort Service has been configured for the workload. For details about how to configure the Service, see **ClusterIP** or **NodePort**.
- To add an Nginx ingress, ensure that the NGINX Ingress Controller add-on has been installed in the cluster. For details, see **Installing the Add-on**.

Constraints

- **It is not recommended modifying any configuration of a load balancer on the ELB console. Otherwise, the Service will be abnormal.** If you have modified the configuration, uninstall the nginx-ingress add-on and reinstall it.
- The URL registered in an ingress forwarding policy must be the same as the URL used to access the backend Service. Otherwise, a 404 error will be returned.
- The selected or created load balancer must be in the same VPC as the current cluster, and it must match the load balancer type (private or public network).
- The load balancer has at least two listeners, and ports 80 and 443 are not occupied by listeners.

Creating an Nginx Ingress

This section uses an Nginx workload as an example to describe how to create an Nginx ingress.

Step 1 Log in to the CCE console and click the cluster name to access the cluster console.

Step 2 Choose **Services & Ingresses** in the navigation pane, click the **Ingresses** tab, and click **Create Ingress** in the upper right corner.

Step 3 Configure ingress parameters.

- **Name**: Specify a name of an ingress, for example, **nginx-ingress-demo**.
- **Namespace**: Select the namespace to which the ingress is to be added.
- **nginx-ingress**: This option is displayed only after the **Nginx Ingress Controller** add-on is installed in the cluster.

  After you switch on  , nginx-ingress is interconnected to provide layer-7 access. You can configure the following parameters:

  TLS: nginx-ingress supports HTTP and HTTPS. The default listening port reserved during nginx-ingress installation is **80** for HTTP requests and **443** for HTTPS requests. To use HTTPS, configure a certificate.

  - **Server Certificate**: When creating an HTTPS listener, bind a TLS certificate to support encrypted authentication for HTTPS data transmission. For details on how to create a secret, see **Creating a Secret**.
  - **SNI**: stands for Server Name Indication (SNI), which is an extended protocol of TLS. SNI allows multiple TLS-compliant domain names for external access using the same IP address and port number, and different domain names can use different security certificates. After SNI is enabled, the client is allowed to submit the requested domain name when initiating a TLS handshake request. After receiving the TLS request, the load balancer searches for the certificate based on the domain name in the request. If the certificate corresponding to the domain name is found, the load balancer returns the certificate for authorization. Otherwise, the default certificate (server certificate) is returned for authorization.
- **Forwarding Policy**: When the access address of a request matches the forwarding policy (a forwarding policy consists of a domain name and URL), the request is forwarded to the corresponding target Service for processing. Click **Add Forwarding Policies** to add multiple forwarding policies.
  - **Domain Name**: actual domain name. Ensure that the entered domain name has been registered and archived. After the ingress is created, bind the domain name to the IP address of the automatically created load balancer (IP address of the ingress access address). If a domain name rule is configured, the domain name must always be used for access.
  - **URL Matching Rule**
    - **Default**: Prefix match is used by default.
    - **Prefix match**: If the URL is set to **/healthz**, the URL that meets the prefix can be accessed, for example, **/healthz/v1** and **/healthz/v2**.
    - **Exact match**: The URL can be accessed only when it is fully matched. For example, if the URL is set to **/healthz**, only **/healthz** can be accessed.
  - **URL**: access path to be registered, for example, **/healthz**.

NOTE

- The access path matching rule of Nginx ingress is based on the path prefix separated by the slash (/) and is case-sensitive. If the subpath separated by a slash (/) matches the prefix, the access is normal. However, if the prefix is only a part of the character string in the subpath, the access is not matched. For example, if the URL is set to /healthz, /healthz/v1 is matched, but /healthzv1 is not matched.
- The access path added here must exist in the backend application. Otherwise, the forwarding fails.

  For example, the default access URL of the Nginx application is **/usr/share/nginx/html**. When adding **/test** to the ingress forwarding policy, ensure the access URL of your Nginx application contains **/usr/share/nginx/html/test**. Otherwise, error 404 will be returned.

  - **Destination Service**: Select an existing Service or create a Service. Services that do not meet search criteria are automatically filtered out.
  - **Destination Service Port**: Select the access port of the destination Service.
  - **Operation**: Click **Delete** to delete the configuration.

- **Annotation**: The value is in the format of key:value. You can use **annotations** to query the configurations supported by nginx-ingress.

Step 4 After the configuration is complete, click **OK**.

After the ingress is created, it is displayed in the ingress list.

----End

10.4.3.2 Using kubectl to Create an Nginx Ingress

Scenario

This section uses an **Nginx workload** as an example to describe how to create an Nginx ingress using kubectl.

Prerequisites

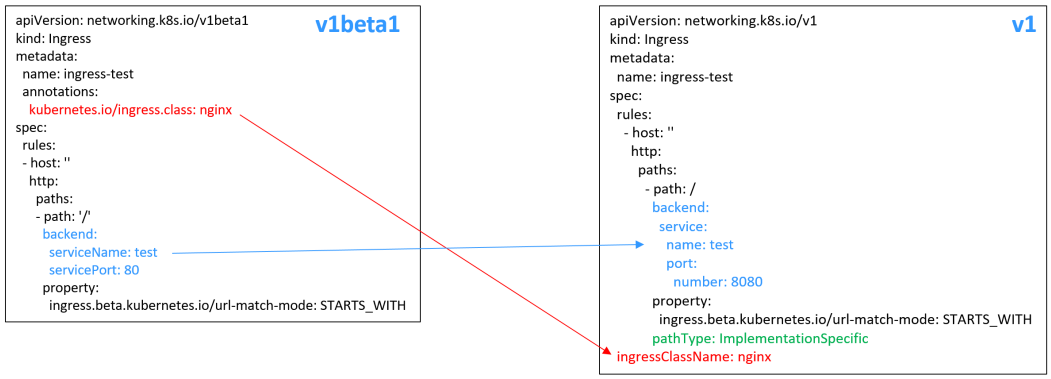
- The NGINX Ingress Controller add-on has been installed in a cluster. For details, see **Installing the Add-on**.
- An ingress provides network access for backend workloads. Ensure that a workload is available in a cluster. If no workload is available, deploy a workload by referring to **Creating a Deployment**, **Creating a StatefulSet**, or **Creating a DaemonSet**.
- A ClusterIP or NodePort Service has been configured for the workload. For details about how to configure the Service, see **ClusterIP** or **NodePort**.

Ingress Description of networking.k8s.io/v1

In CCE clusters of v1.23 or later, the ingress version is switched to **networking.k8s.io/v1**.

Compared with v1beta1, v1 has the following differences in parameters:

- The ingress type is changed from **kubernetes.io/ingress.class** in **annotations** to **spec.ingressClassName**.
- The format of **backend** is changed.
- The **pathType** parameter must be specified for each path. The options are as follows:
  - **ImplementationSpecific**: The matching method depends on Ingress Controller. The matching method defined by **ingress.beta.kubernetes.io/url-match-mode** is used in CCE, which is the same as v1beta1.
  - **Exact**: exact matching of the URL, which is case-sensitive.
  - **Prefix**: matching based on the URL prefix separated by a slash (/). The match is case-sensitive, and elements in the path are matched one by one. A path element refers to a list of labels in the path separated by a slash (/).



Creating an Nginx Ingress

Step 1 Use kubectl to connect to the cluster. For details, see **Connecting to a Cluster Using kubectl**.

Step 2 Create a YAML file named **ingress-test.yaml**. The file name can be customized.

vi ingress-test.yaml

NOTE

Starting from cluster v1.23, the ingress version is switched from **networking.k8s.io/v1beta1** to **networking.k8s.io/v1**. For details about the differences between v1 and v1beta1, see **Ingress Description of networking.k8s.io/v1**.

The following uses HTTP as an example to describe how to configure the YAML file:

For clusters of v1.23 or later:

```
apiVersion: networking.k8s.io/v1
kind: Ingress
metadata:
  name: ingress-test
spec:
  rules:
    - host: ''
      http:
        paths:
          - path: /
            backend:
```

```
          service:
            name: <your_service_name>  # Replace it with the name of your target Service.
            port:
              number: <your_service_port>  # Replace it with the port number of your target Service.
        property:
          ingress.beta.kubernetes.io/url-match-mode: STARTS_WITH
        pathType: ImplementationSpecific
ingressClassName: nginx  # Nginx ingress is used.
```

For clusters of v1.21 or earlier:

```
apiVersion: networking.k8s.io/v1beta1
kind: Ingress
metadata:
  name: ingress-test
  namespace: default
  annotations:
    kubernetes.io/ingress.class: nginx  # Nginx ingress is used.
spec:
  rules:
    - host: ''
      http:
        paths:
          - path: '/'
            backend:
              serviceName: <your_service_name>  # Replace it with the name of your target Service.
              servicePort: <your_service_port>  # Replace it with the port number of your target Service.
```

Table 10-44 Key parameters

Parameter	Mandatory	Type	Description
kubernetes.io/ingress.class	Yes (only for clusters of v1.21 or earlier)	String	**nginx**: indicates that Nginx ingress is used. This option cannot be used if the nginx-ingress add-on is not installed. This parameter is mandatory when an ingress is created by calling the API.
ingressClassName	Yes (only for clusters of v1.23 or later)	String	**nginx**: indicates that Nginx ingress is used. This option cannot be used if the nginx-ingress add-on is not installed. This parameter is mandatory when an ingress is created by calling the API.
host	No	String	Domain name for accessing the Service. By default, this parameter is left blank, and the domain name needs to be fully matched. Ensure that the domain name has been registered and archived. Once a domain name rule is configured, you must use the domain name for access.

Parameter	Mandatory	Type	Description
path	Yes	String	User-defined route path. All external access requests must match **host** and **path**. **NOTE** • The access path matching rule of Nginx ingress is based on the path prefix separated by the slash (/) and is case-sensitive. If the subpath separated by a slash (/) matches the prefix, the access is normal. However, if the prefix is only a part of the character string in the subpath, the access is not matched. For example, if the URL is set to /healthz, /healthz/v1 is matched, but /healthzv1 is not matched. • The access path added here must exist in the backend application. Otherwise, the forwarding fails. For example, the default access URL of the Nginx application is **/usr/share/nginx/html**. When adding **/test** to the ingress forwarding policy, ensure the access URL of your Nginx application contains **/usr/share/nginx/html/test**. Otherwise, error 404 will be returned.
ingress.beta.kubernetes.io/url-match-mode	No	String	Route matching policy. Default: **STARTS_WITH** (prefix match) Options: • **EQUAL_TO**: exact match • **STARTS_WITH**: prefix match

Parameter	Mandatory	Type	Description
pathType	Yes	String	Path type. This field is supported only by clusters of v1.23 or later. • **ImplementationSpecific**: The matching method depends on Ingress Controller. The matching method defined by **ingress.beta.kubernetes.io/url-match-mode** is used in CCE. • **Exact**: exact matching of the URL, which is case-sensitive. • **Prefix**: prefix matching, which is case-sensitive. With this method, the URL path is separated into multiple elements by slashes (/) and the elements are matched one by one. If each element in the URL matches the path, the subpaths of the URL can be routed normally. **NOTE** – During prefix matching, each element must be exactly matched. If the last element of the URL is the substring of the last element in the request path, no matching is performed. For example, **/foo/bar** matches **/foo/bar/baz** but does not match **/foo/barbaz**. – When elements are separated by slashes (/), if the URL or request path ends with a slash (/), the slash (/) at the end is ignored. For example, **/foo/bar** matches **/foo/bar/**. See **examples** of ingress path matching.

Step 3 Create an ingress.

kubectl create -f ingress-test.yaml

If information similar to the following is displayed, the ingress has been created.

```
ingress/ingress-test created
```

View the created ingress.

kubectl get ingress

If information similar to the following is displayed, the ingress has been created successfully and the workload is accessible.

```
NAME           HOSTS     ADDRESS         PORTS   AGE
ingress-test   *         121.**.**.**    80      10s
```

Step 4 Enter **http://*121.**.**.***:80** in the address box of the browser to access the workload (for example, **Nginx workload**).

121.**.**.** indicates the IP address of the unified load balancer.

----End

10.4.3.3 Configuring Nginx Ingresses Using Annotations

The nginx-ingress add-on in CCE uses the community chart and image. If the default add-on parameters cannot meet your demands, you can add annotations to define what you need, such as the default backend, timeout, and size of a request body.

This section describes common annotations used for creating an ingress of the Nginx type.

NOTE

- The key value of an annotation can only be a string. Other types (such as Boolean values or numeric values) must be enclosed in quotation marks (""), for example, "true", "false", and "100".
- Nginx ingresses support native annotations of the community. For details, see **Annotations**.

- **Ingress Type**
- **Configuring a Redirection Rule**
- **Configuring a URL Rewriting Rule**
- **Interconnecting with HTTPS Backend Services**
- **Creating a Consistent Hashing Rule for Load Balancing**
- **Customized Timeout Interval**
- **Customizing Body Size**
- **Documentation**

Ingress Type

Table 10-45 Ingress type annotations

Parameter	Type	Description	Supported Cluster Version
kubernetes.io/ingress.class	String	• **nginx**: Nginx ingress is used. • **cce**: A proprietary LoadBalancer ingress is used. This parameter is mandatory when an ingress is created by calling the API. For clusters of v1.23 or later, use the parameter **ingressClassName**. For details, see **Using kubectl to Create an Nginx Ingress**.	Only clusters of v1.21 or earlier

For details about how to use the preceding annotations, see **Using kubectl to Create an Nginx Ingress**.

Configuring a Redirection Rule

Table 10-46 Redirection rule annotations

Parameter	Type	Description
nginx.ingress.kubernetes.io/permanent-redirect	String	Permanently redirects an access request to a target website (status code 301).
nginx.ingress.kubernetes.io/permanent-redirect-code	String	Changes the returned status code of a permanent redirection rule to a specified value.
nginx.ingress.kubernetes.io/temporal-redirect	String	Temporarily redirects an access request to a target website (status code 302).
nginx.ingress.kubernetes.io/ssl-redirect	String	Specifies whether an HTTP request can be redirected to HTTPS only through SSL. The default value is **true** when the ingress contains an SSL certificate.
nginx.ingress.kubernetes.io/force-ssl-redirect	String	Indicates whether to forcibly redirect a request to HTTPS even if TLS is not enabled for the ingress. When HTTP is used for access, the request is forcibly redirected (status code 308) to HTTPS.

For details, see **Configuring Redirection Rules for an Nginx Ingress**.

Configuring a URL Rewriting Rule

Table 10-47 URL rewriting rule annotations

Parameter	Type	Description
nginx.ingress.kubernetes.io/rewrite-target	String	Target URI where the traffic must be redirected.

For details, see **Configuring URL Rewriting Rules for Nginx Ingresses**.

Interconnecting with HTTPS Backend Services

Table 10-48 Annotations for interconnecting with HTTPS backend services

Parameter	Type	Description
nginx.ingress.kubernetes.io/backend-protocol	String	If this parameter is set to **HTTPS**, HTTPS is used to forward requests to the backend service container.

For details, see **Interconnecting Nginx Ingresses with HTTPS Backend Services**.

Creating a Consistent Hashing Rule for Load Balancing

Table 10-49 Annotation of consistent hashing for load balancing

Parameter	Type	Description
nginx.ingress.kubernetes.io/upstream-hash-by	String	Enable consistent hashing for load balancing for backend servers. The parameter value can be an Nginx parameter, a text value, or any combination. For example: • **nginx.ingress.kubernetes.io/upstream-hash-by: "$request_uri"** indicates that requests are hashed based on the request URI. • **nginx.ingress.kubernetes.io/upstream-hash-by: "$request_uri$host"** indicates that requests are hashed based on the request URI and domain name. • **nginx.ingress.kubernetes.io/upstream-hash-by: "${request_uri}-text-value"** indicates that requests are hashed based on the request URI and text value.

For details, see **Nginx Ingresses Using Consistent Hashing for Load Balancing**.

Customized Timeout Interval

Table 10-50 Customized timeout interval annotations

Parameter	Type	Description
nginx.ingress.kubernetes.io/proxy-connect-timeout	String	Customized connection timeout interval. You do not need to set the unit when setting the timeout interval. The default unit is second. Example: `nginx.ingress.kubernetes.io/proxy-connect-timeout: '120'`

Customizing Body Size

Table 10-51 Annotations of customizing body size

Parameter	Type	Description
nginx.ingress.kubernetes.io/proxy-body-size	String	When the body size in a request exceeds the upper limit, error 413 is returned to the client. You can use this parameter to adjust the upper limit of the body size. Example: nginx.ingress.kubernetes.io/proxy-body-size: 8m

Documentation

For details about annotation parameters supported by Nginx ingresses, see **Annotations**.

10.4.3.4 Configuring HTTPS Certificates for Nginx Ingresses

HTTPS certificates can be configured for ingress to provide security services.

Step 1 Use kubectl to connect to the cluster. For details, see **Connecting to a Cluster Using kubectl**.

Step 2 Ingress supports two TLS key types: kubernetes.io/tls and IngressTLS. IngressTLS is used as an example. For details, see **Creating a Secret**. For details about examples of the kubernetes.io/tls secret and its description, see **TLS Secret**.

Run the following command to create a YAML file named **ingress-test-secret.yaml** (the file name can be customized):

vi ingress-test-secret.yaml

The YAML file is configured as follows:

```
apiVersion: v1
data:
  tls.crt: LS0******tLS0tCg==
  tls.key: LS0tL******0tLS0K
kind: Secret
metadata:
  annotations:
    description: test for ingressTLS secrets
  name: ingress-test-secret
  namespace: default
type: IngressTLS
```

NOTE

In the preceding information, **tls.crt** and **tls.key** are only examples. Replace them with the actual files. The values of **tls.crt** and **tls.key** are Base64-encoded.

Step 3 Create a secret.

kubectl create -f ingress-test-secret.yaml

If information similar to the following is displayed, the secret is being created:

```
secret/ingress-test-secret created
```

View the created secret.

kubectl get secrets

If information similar to the following is displayed, the secret has been created:

```
NAME                  TYPE                DATA   AGE
ingress-test-secret   IngressTLS          2      13s
```

Step 4 Create a YAML file named **ingress-test.yaml**. The file name can be customized.

vi ingress-test.yaml

For clusters of v1.23 or later:

```
apiVersion: networking.k8s.io/v1
kind: Ingress
metadata:
  name: ingress-test
  namespace: default
spec:
  tls:
  - hosts:
    - foo.bar.com
    secretName: ingress-test-secret  # Replace it with your TLS key certificate.
  rules:
    - host: foo.bar.com
      http:
        paths:
          - path: /
            backend:
              service:
                name: <your_service_name>  # Replace it with the name of your target Service.
                port:
                  number: <your_service_port>  # Replace it with the port number of your target Service.
            property:
              ingress.beta.kubernetes.io/url-match-mode: STARTS_WITH
            pathType: ImplementationSpecific
  ingressClassName: nginx
```

For clusters of v1.21 or earlier:

```
apiVersion: networking.k8s.io/v1beta1
kind: Ingress
metadata:
  name: ingress-test
  annotations:
    kubernetes.io/ingress.class: nginx
spec:
  tls:
  - hosts:
    - foo.bar.com
    secretName: ingress-test-secret   # Replace it with your TLS key certificate.
  rules:
  - host: foo.bar.com
    http:
      paths:
      - path: '/'
        backend:
          serviceName: <your_service_name>  # Replace it with the name of your target Service.
          servicePort: <your_service_port>  # Replace 8080 with the port number of your target Service.
  ingressClassName: nginx
```

Step 5 Create an ingress.

kubectl create -f ingress-test.yaml

If information similar to the following is displayed, the ingress has been created.

```
ingress/ingress-test created
```

View the created ingress.

kubectl get ingress

If information similar to the following is displayed, the ingress has been created and the workload is accessible.

```
NAME           HOSTS     ADDRESS         PORTS   AGE
ingress-test   *         121.**.**.**    80      10s
```

Step 6 Enter **https://*121.**.**.***:443** in the address box of the browser to access the workload (for example, **Nginx workload**).

121.**.**.** indicates the IP address of the unified load balancer.

----End

10.4.3.5 Configuring Redirection Rules for an Nginx Ingress

Configuring a Permanent Redirection Rule

To permanently redirect an access request to a target website (status code 301), use the **nginx.ingress.kubernetes.io/permanent-redirect** annotation. For example, to permanently redirect all access requests to **www.example.com**, run the following command:

```
nginx.ingress.kubernetes.io/permanent-redirect: https://www.example.com
```

The configuration in an Nginx ingress is as follows:

For clusters of v1.23 or later:

```
apiVersion: networking.k8s.io/v1
kind: Ingress
metadata:
  name: ingress-test
  namespace: default
  annotations:
    nginx.ingress.kubernetes.io/permanent-redirect: https://www.example.com
spec:
  rules:
    - host: ''
      http:
        paths:
          - path: /
            backend:
              service:
                name: <your_service_name>  # Replace it with the name of your target Service.
                port:
                  number: <your_service_port>  # Replace it with the port number of your target Service.
            property:
              ingress.beta.kubernetes.io/url-match-mode: STARTS_WITH
            pathType: ImplementationSpecific
  ingressClassName: nginx
```

For clusters of v1.21 or earlier:

```
apiVersion: networking.k8s.io/v1beta1
kind: Ingress
metadata:
  name: ingress-test
  namespace: default
  annotations:
    kubernetes.io/ingress.class: nginx
    nginx.ingress.kubernetes.io/permanent-redirect: https://www.example.com
```

```
spec:
  rules:
    - host: ''
      http:
        paths:
          - path: /
            backend:
              serviceName: <your_service_name>  # Replace it with the name of your target Service.
              servicePort: <your_service_port>  # Replace it with the port number of your target Service.
```

Configuring the Returned Status Code for the Permanent Redirection Rule

When configuring a permanent redirection rule, you can use the **nginx.ingress.kubernetes.io/permanent-redirect-code** annotation to modify its returned status code. For example, to set the status code for the permanent redirection to 308, run the following command:

```
nginx.ingress.kubernetes.io/permanent-redirect-code: '308'
```

The configuration in an Nginx ingress is as follows:

For clusters of v1.23 or later:

```
apiVersion: networking.k8s.io/v1
kind: Ingress
metadata:
  name: ingress-test
  namespace: default
  annotations:
    nginx.ingress.kubernetes.io/permanent-redirect: https://www.example.com
    nginx.ingress.kubernetes.io/permanent-redirect-code: '308'
spec:
  rules:
    - host: ''
      http:
        paths:
          - path: /
            backend:
              service:
                name: <your_service_name>  # Replace it with the name of your target Service.
                port:
                  number: <your_service_port>  # Replace it with the port number of your target Service.
            property:
              ingress.beta.kubernetes.io/url-match-mode: STARTS_WITH
            pathType: ImplementationSpecific
  ingressClassName: nginx
```

For clusters of v1.21 or earlier:

```
apiVersion: networking.k8s.io/v1beta1
kind: Ingress
metadata:
  name: ingress-test
  namespace: default
  annotations:
    kubernetes.io/ingress.class: nginx
    nginx.ingress.kubernetes.io/permanent-redirect: https://www.example.com
    nginx.ingress.kubernetes.io/permanent-redirect-code: '308'
spec:
  rules:
    - host: ''
      http:
        paths:
          - path: /
            backend:
              serviceName: <your_service_name>  # Replace it with the name of your target Service.
              servicePort: <your_service_port>  # Replace it with the port number of your target Service.
```

Configuring a Temporary Redirection Rule

To temporarily redirect an access request to a target website (status code 302), use the **nginx.ingress.kubernetes.io/temporal-redirect** annotation. For example, to temporarily redirect all access requests to **www.example.com**, run the following command:

```
nginx.ingress.kubernetes.io/temporal-redirect: https://www.example.com
```

The configuration in an Nginx ingress is as follows:

For clusters of v1.23 or later:

```
apiVersion: networking.k8s.io/v1
kind: Ingress
metadata:
  name: ingress-test
  namespace: default
  annotations:
    nginx.ingress.kubernetes.io/temporal-redirect: https://www.example.com
spec:
  rules:
    - host: ''
      http:
        paths:
          - path: /
            backend:
              service:
                name: <your_service_name>  # Replace it with the name of your target Service.
                port:
                  number: <your_service_port>  # Replace it with the port number of your target Service.
            property:
              ingress.beta.kubernetes.io/url-match-mode: STARTS_WITH
            pathType: ImplementationSpecific
  ingressClassName: nginx
```

For clusters of v1.21 or earlier:

```
apiVersion: networking.k8s.io/v1beta1
kind: Ingress
metadata:
  name: ingress-test
  namespace: default
  annotations:
    kubernetes.io/ingress.class: nginx
    nginx.ingress.kubernetes.io/temporal-redirect: https://www.example.com
spec:
  rules:
    - host: ''
      http:
        paths:
          - path: /
            backend:
              serviceName: <your_service_name>  # Replace it with the name of your target Service.
              servicePort: <your_service_port>  # Replace it with the port number of your target Service.
```

Redirecting HTTP to HTTPS

By default, if an ingress uses TLS, requests will be redirected (status code 308) to HTTPS when HTTP is used for access. You can configure the redirection by using the **nginx.ingress.kubernetes.io/ssl-redirect** annotation.

- If the value of this annotation is set to **true**, an HTTP access is redirected to HTTPS (status code 308) when the TLS certificate is used.
- If the value of this annotation is set to **false**, an HTTP access cannot be redirected to HTTPS when the TLS certificate is used.

If you need to forcibly redirect an HTTP access to HTTPS without a TLS, you can configure the redirecion by setting the value of **nginx.ingress.kubernetes.io/force-ssl-redirect** to **true**.

For clusters of v1.23 or later:

```
apiVersion: networking.k8s.io/v1
kind: Ingress
metadata:
  name: ingress-test
  namespace: default
  annotations:
    nginx.ingress.kubernetes.io/ssl-redirect: 'true'
spec:
  rules:
    - host: ''
      http:
        paths:
          - path: /
            backend:
              service:
                name: <your_service_name>  # Replace it with the name of your target Service.
                port:
                  number: <your_service_port>  # Replace it with the port number of your target Service.
            property:
              ingress.beta.kubernetes.io/url-match-mode: STARTS_WITH
            pathType: ImplementationSpecific
  ingressClassName: nginx
```

For clusters of v1.21 or earlier:

```
apiVersion: networking.k8s.io/v1beta1
kind: Ingress
metadata:
  name: ingress-test
  namespace: default
  annotations:
    kubernetes.io/ingress.class: nginx
    nginx.ingress.kubernetes.io/ssl-redirect: 'true'
spec:
  rules:
    - host: ''
      http:
        paths:
          - path: /
            backend:
              serviceName: <your_service_name>  # Replace it with the name of your target Service.
              servicePort: <your_service_port>  # Replace it with the port number of your target Service.
```

10.4.3.6 Configuring URL Rewriting Rules for Nginx Ingresses

In some application scenarios, the access URL provided by the backend service is different from the path specified in the ingress rule. The ingress directly forwards the access path to the same backend path. If URL rewriting is not configured, 404 is returned for all access requests. For example, if the access path in the ingress rule is set to **/app/demo** and the access path provided by the backend service is **/demo**, access requests are directly forwarded to the **/app/demo** path of the backend service, which does not match the actual access path (**/demo**) provided by the backend service. As a result, 404 is returned.

In this case, you can use the Rewrite method to implement URL rewriting. That is, you can use the **nginx.ingress.kubernetes.io/rewrite-target** annotation to implement rewriting rules for different paths.

Configuring Rewriting Rules

For clusters of v1.23 or later:

```
apiVersion: networking.k8s.io/v1
kind: Ingress
metadata:
  name: ingress-test
  namespace: default
  annotations:
    nginx.ingress.kubernetes.io/rewrite-target: /$2
spec:
  rules:
    - host: 'rewrite.bar.com'
      http:
        paths:
          - path: '/something(/|$)(.*)'
            backend:
              service:
                name: <your_service_name>  # Replace it with the name of your target Service.
                port:
                  number: <your_service_port>  # Replace 8080 with the port number of your target Service.
            property:
              ingress.beta.kubernetes.io/url-match-mode: STARTS_WITH
            pathType: ImplementationSpecific
  ingressClassName: nginx
```

For clusters of v1.21 or earlier:

```
apiVersion: networking.k8s.io/v1beta1
kind: Ingress
metadata:
  name: ingress-test
  namespace: default
  annotations:
    kubernetes.io/ingress.class: nginx
    nginx.ingress.kubernetes.io/rewrite-target: /$2
spec:
  rules:
    - host: 'rewrite.bar.com'
      http:
        paths:
          - path: '/something(/|$)(.*)'
            backend:
              serviceName: <your_service_name>  # Replace it with the name of your target Service.
              servicePort: <your_service_port>  # Replace 8080 with the port number of your target Service.
```

NOTE

As long as **rewrite-target** is specified for one ingress, all paths under the same host in all ingress definitions are case-sensitive, including the ingresses that do not have **rewrite-target** specified.

In the preceding example, the placeholder $2 indicates that all characters matched by the second parenthesis (.*) are filled in the **nginx.ingress.kubernetes.io/rewrite-target** annotation.

For example, the preceding ingress definition will result in the following rewrites:

- rewrite.bar.com/something rewrites to rewrite.bar.com/.
- rewrite.bar.com/something/ rewrites to rewrite.bar.com/.
- rewrite.bar.com/something/new rewrites to rewrite.bar.com/new.

In the nginx-ingress-controller container, you can view all ingress configurations in the **nginx.conf** file in the **/etc/nginx** directory. The rewriting rule in the preceding example generates a Rewrite command and writes it to the **location** field in the **nginx.conf** file.

```
## start server rewrite.bar.com
    server {
        server_name rewrite.bar.com ;
        ...
        location ~* "^/something(/|$)(.*)" {
            set $namespace      "default";
            set $ingress_name   "ingress-test";
            set $service_name   "<your_service_name>";
            set $service_port   "80";
            ...
            rewrite "(?i)/something(/|$)(.*)" /$2 break;
            ...
        }
    }
    ## end server rewrite.bar.com
```

The basic syntax of the Rewrite command is as follows:

```
rewrite regex replacement [flag];
```

- **regex**: regular expression for matching URIs. In the preceding example, **(?i)/something(/|$)(.*)** is the regular expression for matching URIs, where **(?i)** indicates case-insensitive.
- **replacement**: content to rewrite. In the preceding example, **/$2** indicates that the path is rewritten to all the characters matched by the second parenthesis **(.*)**.
- **flag**: rewrite format.
  - **last**: continues to match the next rule after the current rule is matched.
  - **break**: stops matching after the current rule is matched.
  - **redirect**: returns a temporary redirect with the 302 code.
  - **permanent**: returns a permanent redirect with the 301 code.

Advanced Rewrite Configuration

Some complex, advanced Rewrite requirements can be implemented by modifying the Nginx configuration file **nginx.conf**. However, the **nginx.ingress.kubernetes.io/rewrite-target** annotation function can be customized to meet more complex Rewrite requirements.

- nginx.ingress.kubernetes.io/server-snippet: Add custom settings to the **server** field in the **nginx.conf** file.
- nginx.ingress.kubernetes.io/configuration-snippet: Add custom settings to the **location** field in the **nginx.conf** file.

You can use the preceding two annotations to insert a Rewrite command into the **server** or **location** field in the **nginx.conf** file to rewrite the URL. The following is an example:

```
annotations:
    kubernetes.io/ingress.class: "nginx"
    nginx.ingress.kubernetes.io/configuration-snippet: |
      rewrite ^/stylesheets/(.*)$ /something/stylesheets/$1 redirect;  # Add the /something prefix.
      rewrite ^/images/(.*)$ /something/images/$1 redirect;  # Add the /something prefix.
```

In the preceding two rules, the **/something** path is added to the access URL.

- When a user accesses **rewrite.bar.com/stylesheets/new.css**, it rewrites to **rewrite.bar.com/something/stylesheets/new.css**.
- When a user accesses **rewrite.bar.com/images/new.jpg**, it rewrites to **rewrite.bar.com/something/images/new.jpg**.

10.4.3.7 Interconnecting Nginx Ingresses with HTTPS Backend Services

Ingress can function as a proxy for backend services using different protocols. By default, the backend proxy channel of an ingress is an HTTP channel. To create an HTTPS channel, add the following configuration to the **annotations** field:

```
nginx.ingress.kubernetes.io/backend-protocol: "HTTPS"
```

An ingress configuration example:

For clusters of v1.23 or later:

```
apiVersion: networking.k8s.io/v1
kind: Ingress
metadata:
  name: ingress-test
  namespace: default
  annotations:
    nginx.ingress.kubernetes.io/backend-protocol: "HTTPS"
spec:
  tls:
    - secretName: ingress-test-secret  # Replace it with your TLS key certificate.
  rules:
    - host: ''
      http:
        paths:
          - path: '/'
            backend:
              service:
                name: <your_service_name>  # Replace it with the name of your target Service.
                port:
                  number: <your_service_port>  # Replace 8080 with the port number of your target Service.
            property:
              ingress.beta.kubernetes.io/url-match-mode: STARTS_WITH
            pathType: ImplementationSpecific
  ingressClassName: nginx
```

For clusters of v1.21 or earlier:

```
apiVersion: networking.k8s.io/v1beta1
kind: Ingress
metadata:
  name: ingress-test
  namespace: default
  annotations:
    kubernetes.io/ingress.class: nginx
    nginx.ingress.kubernetes.io/backend-protocol: "HTTPS"
spec:
  tls:
    - secretName: ingress-test-secret  # Replace it with your TLS key certificate.
  rules:
    - host: ''
      http:
        paths:
          - path: '/'
            backend:
              serviceName: <your_service_name>  # Replace it with the name of your target Service.
              servicePort: <your_service_port>  # Replace 8080 with the port number of your target Service.
```

10.4.3.8 Nginx Ingresses Using Consistent Hashing for Load Balancing

The native Nginx supports multiple load balancing rules, including weighted round robin and IP hash. An Nginx ingress supports load balancing by using consistent hashing based on the native Nginx capabilities.

By default, the IP hash method supported by Nginx uses the linear hash space. The backend server is selected based on the hash value of the IP address. However, when this method is used to add or delete a node, all IP addresses need

to be hashed again and then routed again. As a result, a large number of sessions are lost or the cache becomes invalid. Therefore, consistent hashing is introduced to the Nginx ingress to solve this problem.

Consistent hashing is a special hash algorithm, which constructs a ring hash space to replace the common linear hash space. When a node is added or deleted, only the target route is migrated clockwise, and other routes do not need to be changed. In this way, rerouting can be reduced as much as possible, resolving the load balancing issue caused by dynamic node addition and deletion.

If a consistent hashing rule is configured, the newly added server will share the load of all other servers. Similarly, when a server is removed, all other servers can share the load of the removed server. This balances the load among nodes in the cluster and prevents the avalanche effect caused by the breakdown of a node.

Configuring a Consistent Hashing Rule

An Nginx ingress can use the **nginx.ingress.kubernetes.io/upstream-hash-by** annotation to configure consistent hashing rules. The following is an example:

For clusters of v1.23 or later:

```
apiVersion: networking.k8s.io/v1
kind: Ingress
metadata:
  name: ingress-test
  namespace: default
  annotations:
    nginx.ingress.kubernetes.io/upstream-hash-by: "$request_uri"  # Perform hashing based on the
request URI.
spec:
  rules:
    - host: ''
      http:
        paths:
          - path: '/'
            backend:
              service:
                name: <your_service_name>  # Replace it with the name of your target Service.
                port:
                  number: <your_service_port>  # Replace 8080 with the port number of your target Service.
            property:
              ingress.beta.kubernetes.io/url-match-mode: STARTS_WITH
            pathType: ImplementationSpecific
  ingressClassName: nginx
```

For clusters of v1.21 or earlier:

```
apiVersion: networking.k8s.io/v1beta1
kind: Ingress
metadata:
  name: ingress-test
  namespace: default
  annotations:
    kubernetes.io/ingress.class: nginx
    nginx.ingress.kubernetes.io/upstream-hash-by: "$request_uri"  # Perform hashing based on the
request URI.
spec:
  rules:
    - host: ''
      http:
        paths:
          - path: '/'
            backend:
              serviceName: <your_service_name>  # Replace it with the name of your target Service.
              servicePort: <your_service_port>  # Replace 8080 with the port number of your target Service.
```

The value of **nginx.ingress.kubernetes.io/upstream-hash-by** can be an nginx variable, a text value, or any combination:

- **nginx.ingress.kubernetes.io/upstream-hash-by: "$request_uri"** indicates that requests are hashed based on the request URI.
- **nginx.ingress.kubernetes.io/upstream-hash-by: "$request_uri$host"** indicates that requests are hashed based on the request URI and domain name.
- **nginx.ingress.kubernetes.io/upstream-hash-by: "${request_uri}-text-value"** indicates that requests are hashed based on the request URI and text value.

Documentation

Custom NGINX upstream hashing

10.5 DNS

10.5.1 Overview

Introduction to CoreDNS

When you create a cluster, the **CoreDNS add-on** is installed to resolve domain names in the cluster.

You can view the pod of the CoreDNS add-on in the kube-system namespace.

```
$ kubectl get po --namespace=kube-system
NAME                       READY   STATUS    RESTARTS   AGE
coredns-7689f8bdf-295rk    1/1     Running   0          9m11s
coredns-7689f8bdf-h7n68    1/1     Running   0          11m
```

After CoreDNS is installed, it becomes a DNS. After the Service is created, CoreDNS records the Service name and IP address. In this way, the pod can obtain the Service IP address by querying the Service name from CoreDNS.

nginx.<namespace>.svc.cluster.local is used to access the Service. **nginx** is the Service name, **<namespace>** is the namespace, and **svc.cluster.local** is the domain name suffix. In actual use, you can omit **<namespace>.svc.cluster.local** in the same namespace and use the ServiceName.

An advantage of using ServiceName is that you can write ServiceName into the program when developing the application. In this way, you do not need to know the IP address of a specific Service.

After CoreDNS is installed, there is also a Service in the kube-system namespace, as shown below.

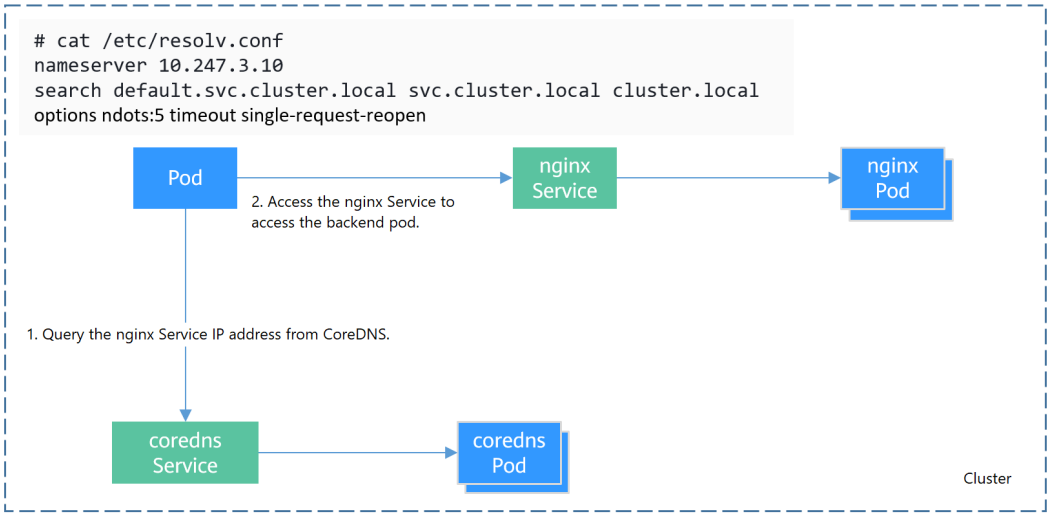
```
$ kubectl get svc -n kube-system
NAME          TYPE        CLUSTER-IP     EXTERNAL-IP   PORT(S)                  AGE
coredns       ClusterIP   10.247.3.10    <none>        53/UDP,53/TCP,8080/TCP   13d
```

By default, after other pods are created, the address of the CoreDNS Service is written as the address of the domain name resolution server in the **/etc/resolv.conf** file of the pod. Create a pod and view the **/etc/resolv.conf** file as follows:

```
$ kubectl exec test01-6cbbf97b78-krj6h -it -- /bin/sh
/ # cat /etc/resolv.conf
nameserver 10.247.3.10
search default.svc.cluster.local svc.cluster.local cluster.local
options ndots:5 timeout single-request-reopen
```

When a user accesses the *Service name:Port* of the Nginx pod, the IP address of the Nginx Service is resolved from CoreDNS, and then the IP address of the Nginx Service is accessed. In this way, the user can access the backend Nginx pod.

Figure 10-21 Example of domain name resolution in a cluster



How Does Domain Name Resolution Work in Kubernetes?

DNS policies can be configured for each pod. Kubernetes supports DNS policies **Default**, **ClusterFirst**, **ClusterFirstWithHostNet**, and **None**. For details, see **DNS for Services and Pods**. These policies are specified in the **dnsPolicy** field in the pod-specific.

- **Default**: Pods inherit the name resolution configuration from the node that the pods run on. The custom upstream DNS server and the stub domain cannot be used together with this policy.
- **ClusterFirst**: Any DNS query that does not match the configured cluster domain suffix, such as **www.kubernetes.io**, is forwarded to the upstream name server inherited from the node. Cluster administrators may have extra stub domains and upstream DNS servers configured.
- **ClusterFirstWithHostNet**: For pods running with hostNetwork, set its DNS policy **ClusterFirstWithHostNet**.
- **None**: It allows a pod to ignore DNS settings from the Kubernetes environment. All DNS settings are supposed to be provided using the **dnsPolicy** field in the pod-specific.

NOTE

- Clusters of Kubernetes v1.10 and later support **Default**, **ClusterFirst**, **ClusterFirstWithHostNet**, and **None**. Clusters earlier than Kubernetes v1.10 support only **Default**, **ClusterFirst**, and **ClusterFirstWithHostNet**.
- **Default** is not the default DNS policy. If **dnsPolicy** is not explicitly specified, **ClusterFirst** is used.

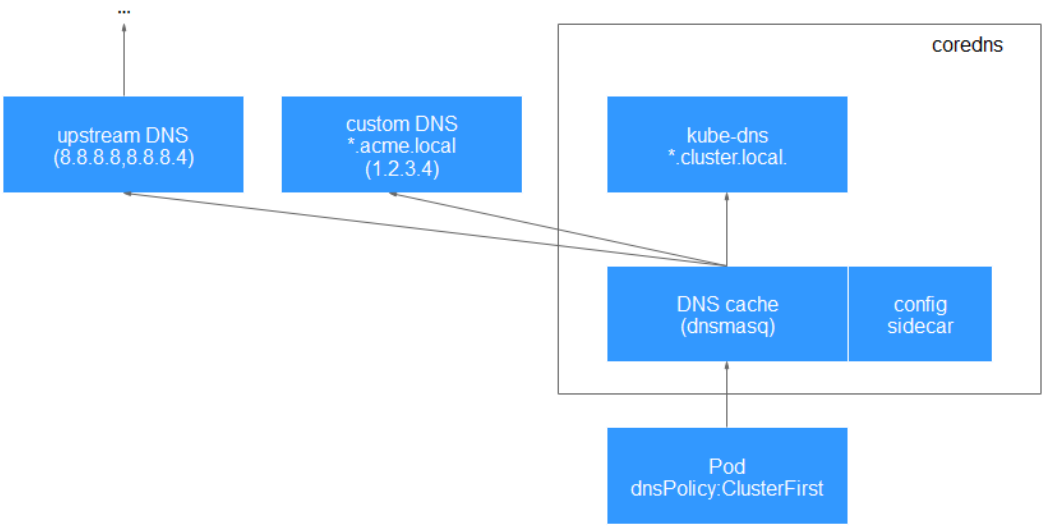
Routing

Without stub domain configurations: Any query that does not match the configured cluster domain suffix, such as **www.kubernetes.io**, is forwarded to the upstream DNS server inherited from the node.

With stub domain configurations: If stub domains and upstream DNS servers are configured, DNS queries are routed according to the following flow:

1. The query is first sent to the DNS caching layer in CoreDNS.
2. From the caching layer, the suffix of the request is examined and then the request is forwarded to the corresponding DNS:
   - Names with the cluster suffix, for example, **.cluster.local**: The request is sent to CoreDNS.
   - Names with the stub domain suffix, for example, **.acme.local**: The request is sent to the configured custom DNS resolver that listens, for example, on 1.2.3.4.
   - Names that do not match the suffix (for example, **widget.com**): The request is forwarded to the upstream DNS.

Figure 10-22 Routing



Related Operations

You can also configure DNS in a workload. For details, see **DNS Configuration**.

You can also use CoreDNS to implement user-defined domain name resolution. For details, see **Using CoreDNS for Custom Domain Name Resolution**.

You can also use DNSCache to improve the DNS resolution performance. For details, see **Using NodeLocal DNSCache to Improve DNS Performance**.

10.5.2 DNS Configuration

Every Kubernetes cluster has a built-in DNS add-on (Kube-DNS or CoreDNS) to provide domain name resolution for workloads in the cluster. When handling a high concurrency of DNS queries, Kube-DNS/CoreDNS may encounter a

performance bottleneck, that is, it may fail occasionally to fulfill DNS queries. There are cases when Kubernetes workloads initiate unnecessary DNS queries. This makes DNS overloaded if there are many concurrent DNS queries. Tuning DNS configuration for workloads will reduce the risks of DNS query failures to some extent.

For more information about DNS, see **CoreDNS**.

DNS Configuration Items

Run the **cat /etc/resolv.conf** command on a Linux node or container to view the DNS resolver configuration file. The following is an example DNS resolver configuration of a container in a Kubernetes cluster:

```
nameserver 10.247.x.x
search default.svc.cluster.local svc.cluster.local cluster.local
options ndots:5
```

Configuration Options

- **nameserver**: an IP address list of a name server that the resolver will query. If this parameter is set to 10.247.x.x, the resolver will query the kube-dns/CoreDNS. If this parameter is set to another IP address, the resolver will query a cloud or on-premises DNS server.
- **search**: a search list for host-name lookup. When a domain name cannot be resolved, DNS queries will be attempted combining the domain name with each domain in the search list in turn until a match is found or all domains in the search list are tried. For CCE clusters, the search list is currently limited to three domains per container. When a nonexistent domain name is being resolved, eight DNS queries will be initiated because each domain name (including those in the search list) will be queried twice, one for IPv4 and the other for IPv6.
- **options**: options that allow certain internal resolver variables to be modified. Common options include timeout and ndots.

  The value **ndots:5** means that if a domain name has fewer than 5 dots (.), DNS queries will be attempted by combining the domain name with each domain in the search list in turn. If no match is found after all the domains in the search list are tried, the domain name is then used for DNS query. If the domain name has 5 or more than 5 dots, it will be tried first for DNS query. In case that the domain name cannot be resolved, DNS queries will be attempted by combining the domain name with each domain in the search list in turn.

  For example, the domain name **www.***.com** has only two dots (smaller than the value of **ndots**), and therefore the sequence of DNS queries is as follows: **www.***.com.default.svc.cluster.local**, **www.***.com.svc.cluster.local**, **www.***.com.cluster.local**, and **www.***.com**. This means that at least seven DNS queries will be initiated before the domain name is resolved into an IP address. It is clear that when many unnecessary DNS queries will be initiated to access an external domain name. There is room for improvement in workload's DNS configuration.

NOTE

For more information about configuration options in the resolver configuration file used by Linux operating systems, visit **http://man7.org/linux/man-pages/man5/resolv.conf.5.html**.

Configuring DNS for a Workload Using the Console

Kubernetes provides DNS-related configuration options for applications. The use of application's DNS configuration can effectively reduce unnecessary DNS queries in certain scenarios and improve service concurrency. The following procedure uses an Nginx application as an example to describe how to add DNS configurations for a workload on the console.

Step 1 Log in to the CCE console, access the cluster console, select **Workloads** in the navigation pane, and click **Create Workload** in the upper right corner.

Step 2 Configure basic information about the workload. For details, see **Creating a Workload**.

Step 3 In the **Advanced Settings** area, click the **DNS** tab and set the following parameters as required:

- **DNS Policy**: The DNS policies provided on the console correspond to the **dnsPolicy** field in the YAML file. For details, see **Table 10-52**.
  - **Supplement defaults**: corresponds to **dnsPolicy=ClusterFirst**. Containers can resolve both the cluster-internal domain names registered by a Service and the external domain names exposed to public networks.
  - **Replace defaults**: corresponds to **dnsPolicy=None**. You must configure **IP Address** and **Search Domain**. Containers only use the user-defined IP address and search domain configurations for domain name resolution.
  - **Inherit defaults**: corresponds to **dnsPolicy=Default**. Containers use the domain name resolution configuration from the node that pods run on and cannot resolve the cluster-internal domain names.
- **Optional Objects**: The options parameters in the **dnsConfig field**. Each object may have a name property (required) and a value property (optional). After setting the properties, click **confirm to add**.
  - **timeout**: Timeout interval, in seconds.
  - **ndots**: Number of dots (.) that must be present in a domain name. If a domain name has dots fewer than this value, the operating system will look up the name in the search domain. If not, the name is a fully qualified domain name (FQDN) and will be tried first as an absolute name.
- **IP Address**: **nameservers** in the **dnsConfig**. You can configure the domain name server for the custom domain name. The value is one or a group of DNS IP addresses.
- **Search Domain**: **searches** in the **dnsConfig**. 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 search domain names generated from the chosen DNS policy in **dnsPolicy**. Duplicate domain names are removed.

Step 4 Click **Create Workload**.

----End

Configuring DNS Using the Workload YAML

When creating a workload using a YAML file, you can configure the DNS settings in the YAML. The following is an example for an Nginx application:

```
apiVersion: apps/v1
kind: Deployment
metadata:
  name: nginx
  namespace: default
spec:
  replicas: 1
  selector:
    matchLabels:
      app: nginx
  template:
    metadata:
      labels:
        app: nginx
    spec:
      containers:
        - name: container-1
          image: nginx:latest
          imagePullPolicy: IfNotPresent
      imagePullSecrets:
        - name: default-secret
      dnsPolicy: None
      dnsConfig:
        options:
          - name: ndots
            value: '5'
          - name: timeout
            value: '3'
        nameservers:
          - 10.2.3.4
        searches:
          - my.dns.search.suffix
```

- **dnsPolicy**

  The **dnsPolicy** field is used to configure a DNS policy for an application. The default value is **ClusterFirst**. The following table lists **dnsPolicy** configurations.

  Table 10-52 dnsPolicy

Parameter	Description
ClusterFirst (default value)	Custom DNS configuration added to the default DNS configuration. By default, the application connects to CoreDNS (CoreDNS of the CCE cluster connects to the DNS on the cloud by default). The custom dnsConfig will be added to the default DNS parameters. Containers can resolve both the cluster-internal domain names registered by a Service and the external domain names exposed to public networks. The search list (**search** option) and **ndots: 5** are present in the DNS configuration file. Therefore, when accessing an external domain name and a long cluster-internal domain name (for example, kubernetes.default.svc.cluster.local), the search list will usually be traversed first, resulting in at least six invalid DNS queries. The issue of invalid DNS queries disappears only when a short cluster-internal domain name (for example, kubernetes) is being accessed.

Parameter	Description
ClusterFirstWithHostNet	By default, the applications configured with the **host network** are interconnected with the DNS configuration of the node where the pod is located. The DNS configuration is specified in the DNS file that the kubelet **--resolv-conf** parameter points to. In this case, the CCE cluster uses the DNS on the cloud. If workloads need to use Kube-DNS/CoreDNS of the cluster, set **dnsPolicy** to **ClusterFirstWithHostNet** and container's DNS configuration file is the same as ClusterFirst, in which invalid DNS queries still exist. ... spec: containers: - image: nginx:latest imagePullPolicy: IfNotPresent name: container-1 restartPolicy: Always **hostNetwork: true** dnsPolicy: **ClusterFirstWithHostNet**
Default	The DNS configuration of the node where the pod is located is inherited, and the custom DNS configuration is added to the inherited configuration. Container's DNS configuration file is the DNS configuration file that the kubelet's **--resolv-conf** flag points to. In this case, a cloud DNS is used for CCE clusters. Both **search** and **options** fields are left unspecified. This configuration can only resolve the external domain names registered with the Internet, and not cluster-internal domain names. This configuration is free from the issue of invalid DNS queries.
None	The default DNS configuration is replaced by the custom DNS configuration, and only the custom DNS configuration is used. If **dnsPolicy** is set to **None**, the **dnsConfig** field must be specified because all DNS settings are supposed to be provided using the **dnsConfig** field.

NOTE

If the **dnsPolicy** field is not specified, the default value is **ClusterFirst** instead of **Default**.

- **dnsConfig**

  The **dnsConfig** field is used to configure DNS parameters for workloads. The configured parameters are merged to the DNS configuration file generated according to **dnsPolicy**. If **dnsPolicy** is set to **None**, the workload's DNS configuration file is specified by the **dnsConfig** field. If **dnsPolicy** is not set to **None**, the DNS parameters configured in **dnsConfig** are added to the DNS configuration file generated according to **dnsPolicy**.

Table 10-53 dnsConfig

Parameter	Description
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 in **dnsPolicy**. Duplicate entries are removed.
nameservers	A list of IP addresses that will be used as DNS servers. If workload'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 nameservers generated from the specified DNS policy in **dnsPolicy** 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 search domain names generated from the chosen DNS policy in **dnsPolicy**. Duplicate domain names are removed. Kubernetes allows for at most 6 search domains.

Configuration Examples

The following example describes how to configure DNS for workloads.

- **Use Case 1: Using Kube-DNS/CoreDNS Built in Kubernetes Clusters**

  Scenario

  Kubernetes in-cluster Kube-DNS/CoreDNS applies to resolving only cluster-internal domain names or cluster-internal domain names + external domain names. This is the default DNS for workloads.

  Example:

```
apiVersion: v1
kind: Pod
metadata:
  namespace: default
  name: dns-example
spec:
  containers:
  - name: test
    image: nginx:alpine
  dnsPolicy: ClusterFirst
  imagePullSecrets:
    - name: default-secret
```

  Container's DNS configuration file:

```
nameserver 10.247.3.10
search default.svc.cluster.local svc.cluster.local cluster.local
options ndots:5
```

- **Use Case 2: Using a Cloud DNS**

  Scenario

A DNS cannot resolve cluster-internal domain names and therefore applies to the scenario where workloads access only external domain names registered with the Internet.

Example:

```
apiVersion: v1
kind: Pod
metadata:
  namespace: default
  name: dns-example
spec:
  containers:
  - name: test
    image: nginx:alpine
  dnsPolicy: Default  # The DNS configuration file that the kubelet --resolv-conf parameter points to is used. In this case, the CCE cluster uses the DNS on the cloud.
  imagePullSecrets:
    - name: default-secret
```

Container's DNS configuration file:

```
nameserver 100.125.x.x
```

- **Use Case 3: Using Kube-DNS/CoreDNS for Workloads Running with hostNetwork**

  Scenario

  By default, a DNS is used for workloads running with hostNetwork. If workloads need to use Kube-DNS/CoreDNS, set **dnsPolicy** to **ClusterFirstWithHostNet**.

  Example:

  ```
  apiVersion: v1
  kind: Pod
  metadata:
    name: nginx
  spec:
    hostNetwork: true
    dnsPolicy: ClusterFirstWithHostNet
    containers:
    - name: nginx
      image: nginx:alpine
      ports:
      - containerPort: 80
    imagePullSecrets:
      - name: default-secret
  ```

  Container's DNS configuration file:

  ```
  nameserver 10.247.3.10
  search default.svc.cluster.local svc.cluster.local cluster.local
  options ndots:5
  ```

- **Use Case 4: Customizing Application's DNS Configuration**

  Scenario

  You can flexibly customize the DNS configuration file for applications. Using **dnsPolicy** and **dnsConfig** together can address almost all scenarios, including the scenarios in which an on-premises DNS will be used, multiple DNSs will be cascaded, and DNS configuration options will be modified.

  Example 1: Using Your On-Premises DNS

  *Set **dnsPolicy** to **None** so application's DNS configuration file is generated based on **dnsConfig**.*

  ```
  apiVersion: v1
  kind: Pod
  metadata:
  ```

```
  namespace: default
  name: dns-example
spec:
  containers:
  - name: test
    image: nginx:alpine
  dnsPolicy: "None"
  dnsConfig:
    nameservers:
    - 10.2.3.4  # IP address of your on-premises DNS
    searches:
    - ns1.svc.cluster.local
    - my.dns.search.suffix
    options:
    - name: ndots
      value: "2"
    - name: timeout
      value: "3"
  imagePullSecrets:
    - name: default-secret
```

Container's DNS configuration file:

```
nameserver 10.2.3.4
search ns1.svc.cluster.local my.dns.search.suffix
options timeout:3 ndots:2
```

Example 2: Modifying the ndots Option in the DNS Configuration File to Reduce Invalid DNS Queries

Set **dnsPolicy** to a value other than **None** so the DNS parameters configured in **dnsConfig** are added to the DNS configuration file generated based on **dnsPolicy**.

```
apiVersion: v1
kind: Pod
metadata:
  namespace: default
  name: dns-example
spec:
  containers:
  - name: test
    image: nginx:alpine
  dnsPolicy: "ClusterFirst"
  dnsConfig:
    options:
    - name: ndots
      value: "2" # The ndots:5 option in the DNS configuration file generated based on the ClusterFirst policy is changed to ndots:2.
  imagePullSecrets:
    - name: default-secret
```

Container's DNS configuration file:

```
nameserver 10.247.3.10
search default.svc.cluster.local svc.cluster.local cluster.local
options ndots:2
```

Example 3: Using Multiple DNSs in Serial Sequence

```
apiVersion: v1
kind: Pod
metadata:
  namespace: default
  name: dns-example
spec:
  containers:
  - name: test
    image: nginx:alpine
  dnsPolicy: ClusterFirst  # Added DNS configuration. The cluster connects to CoreDNS by default.
  dnsConfig:
    nameservers:
    - 10.2.3.4 # IP address of your on-premises DNS
```

```
imagePullSecrets:
  - name: default-secret
```

Container's DNS configuration file:

```
nameserver 10.247.3.10 10.2.3.4
search default.svc.cluster.local svc.cluster.local cluster.local
options ndots:5
```

10.5.3 Using CoreDNS for Custom Domain Name Resolution

Challenges

When using CCE, you may need to resolve custom internal domain names in the following scenarios:

- In the legacy code, a fixed domain name is configured for calling other internal services. If the system decides to use Kubernetes Services, the code refactoring workload could be heavy.
- A service is created outside the cluster. Data in the cluster needs to be sent to the service through a fixed domain name.

Solution

There are several CoreDNS-based solutions for custom domain name resolution:

- **Configuring the Stub Domain for CoreDNS**: You can add it on the console, which is easy to operate.
- **Using the CoreDNS Hosts plug-in to configure resolution for any domain name**: You can add any record set, which is similar to adding a record set in the local **/etc/hosts** file.
- **Using the CoreDNS Rewrite plug-in to point a domain name to a service in the cluster**: A nickname is assigned to the Kubernetes Service. You do not need to know the IP address of the resolution record in advance.
- **Using the CoreDNS Forward plug-in to set the self-built DNS as the upstream DNS**: The self-built DNS can manage a large number of resolution records. You do not need to modify the CoreDNS configuration when adding or deleting records.

Precautions

Improper modification on CoreDNS configuration may cause domain name resolution failures in the cluster. Perform tests before and after the modification.

Configuring the Stub Domain for CoreDNS

Cluster administrators can modify the ConfigMap for the CoreDNS Corefile to change how service discovery works.

Assume that a cluster administrator has a Consul DNS server located at 10.150.0.1 and all Consul domain names have the suffix **.consul.local**.

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**.

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.

The corresponding Corefile content is as follows:

```
.: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
}
consul.local:5353 {
    bind {$POD_IP}
    errors
    cache 30
    forward . 10.150.0.1
}
```

----End

Modifying the CoreDNS Hosts Configuration File

After modifying the hosts file in CoreDNS, you do not need to configure the hosts file in each pod to add resolution records.

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 the advanced configuration under **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 CoreDNS plug-in. 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/**.

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.

The corresponding Corefile content is as follows:

```
.: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
}
```

----End

Adding the CoreDNS Rewrite Configuration to Point the Domain Name to Services in the Cluster

Use the Rewrite plug-in of CoreDNS to resolve a specified domain name to the domain name of a Service. For example, the request for accessing the example.com domain name is redirected to the example.default.svc.cluster.local domain name, that is, the example service in the default namespace.

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 the advanced configuration under **Parameters** and add the following content to the **plugins** field:

```
{
  "name": "rewrite",
  "parameters": "name example.com example.default.svc.cluster.local"
}
```

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.

The corresponding Corefile content is as follows:

```
.:5353 {
    bind {$POD_IP}
    rewrite name example.com example.default.svc.cluster.local
    cache 30
    errors
    health {$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
}
```

----End

Using CoreDNS to Cascade Self-Built DNS

By default, CoreDNS uses the **/etc/resolv.conf** file of the node for resolution. You can also change the resolution address to that of the external 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 the advanced configuration under **Parameters** and modify the following content in the **plugins** field:

```
{
    "configBlock": "policy random",
    "name": "forward",
    "parameters": ". 192.168.1.1"
}
```

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.

The corresponding Corefile content is as follows:

```
.: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 . 192.168.1.1 {
        policy random
    }
    reload
    ready {$POD_IP}:8081
}
```

----End

10.5.4 Using NodeLocal DNSCache to Improve DNS Performance

Challenges

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

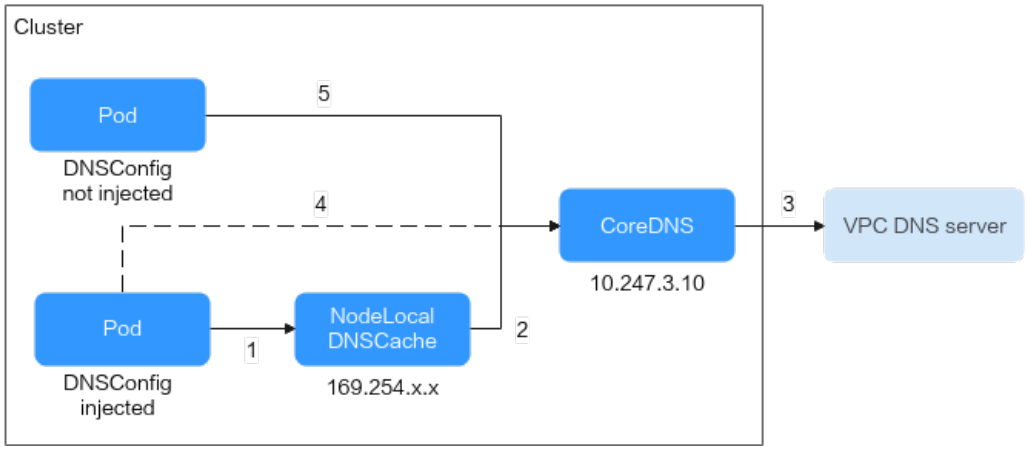
- Increased delay: CoreDNS needs to process more requests, which may slow down the DNS query and affect service performance.
- Increased resource usage: To ensure DNS performance, CoreDNS requires higher specifications.

Solution

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.

After NodeLocal DNSCache is enabled, a DNS query goes through the path as shown below.

Figure 10-23 NodeLocal DNSCache query path



The resolution rules are as follows:

- 1. By default, the pods with DNSConfig injected use NodeLocal DNSCache to resolve requested domain names.
- 2. If NodeLocal DNSCache cannot resolve domain names, it will ask CoreDNS for resolution.

- 3. CoreDNS uses the DNS server in the VPC to resolve the domain names out of the cluster.
- 4. If a pod with DNSConfig injected cannot access NodeLocal DNSCache, CoreDNS will resolve the domain name.
- 5. By default, CoreDNS resolves domain names for the pods without DNSConfig injected.

Constraints

- Only clusters of version 1.19 or later support the **NodeLocal DNSCache** add-on.
- The **node-local-dns-injection** label is the system label used by NodeLocal DNSCache. Use this label only to **prevent an automatic DNSConfig injection**.

Installing the Add-on

CCE provides add-on **NodeLocal DNSCache** for you to install NodeLocal DNSCache.

NOTE

NodeLocal DNSCache serves as a transparent caching proxy for CoreDNS and does not provide plug-ins such as hosts or rewrite. If you want to enable these plug-ins, modify the CoreDNS configurations.

Step 1 (Optional) Modify the CoreDNS configuration so that the CoreDNS preferentially uses UDP to communicate with the upstream DNS server.

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. 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.

Perform the following operations. In the forward add-on, specify **prefer_udp** as the protocol used by requests. After the modification, CoreDNS preferentially uses UDP to communicate with the upstream system.

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 the following content to the **plugins** field:

```
{
    "configBlock": "prefer_udp",
    "name": "forward",
    "parameters": ". /etc/resolv.conf"
}
```

Step 2 Log in to the CCE console and click the cluster name to access the cluster console. Choose **Add-ons** in the navigation pane, locate **NodeLocal DNSCache** on the right, and click **Install**.

Step 3 On the **Install Add-on** page, select the add-on specifications and set related parameters.

- **enable_dnsconfig_admission**: After this function is enabled, a DNSConfig dynamic injection controller will be created. The controller intercepts pod creation requests in the namespace labeled with **node-localdns-injection=enabled** based on Admission Webhook, and automatically configures **Pod dnsConfig** that uses the DNS cache. If this function is disabled or the pod belongs to a non-target namespace, you must manually configure DNSConfig for the pod.
- **Target Namespace**: This parameter is available after **DNSConfig Automatic Injection** is enabled. Only NodeLocal DNSCache of v1.3.0 or later supports this function.
  - **All Enabled**: CCE adds the **node-local-dns-injection=enabled** label to all created namespaces excluding built-in ones (such as **kube-system**), identifies namespace creation requests, and automatically adds the label to newly created namespaces.
  - **Manual configuration**: You must manually add the **node-local-dns-injection=enabled** label to the namespaces requiring the injection of DNSConfig. For details, see **Managing Namespace Labels**.

Step 4 Click **Install**.

----End

Using NodeLocal DNSCache

By default, application requests are sent through the CoreDNS proxy. To use node-local-dns as the DNS cache proxy, use any of the following methods:

- Auto injection: Automatically configure the **dnsConfig** field of the pod when creating the pod. (Pods cannot be automatically injected into system namespaces such as kube-system.)
- Manual configuration: Manually configure the **dnsConfig** field of the pod.

Auto injection

The following conditions must be met:

- **Automatic DNSConfig injection** has been enabled during the add-on installation.
- The **node-local-dns-injection=enabled** label has been added to the namespace. For example, run the following command to add the label to the **default** namespace:

  kubectl label namespace *default* **node-local-dns-injection=enabled**
- The new pod does not run in system namespaces such as kube-system and kube-public namespace.
- The **node-local-dns-injection=disabled** label for disabling DNS injection is not added to the new pod.
- The new pod's **DNSPolicy** is **ClusterFirstWithHostNet**. Alternatively, the pod does not use the host network and **DNSPolicy** is **ClusterFirst**.

After auto injection is enabled, the following **dnsConfig** settings are automatically added to the created pod. In addition to the NodeLocal DNSCache address

169.254.20.10, the CoreDNS address 10.247.3.10 is added to **nameservers**, ensuring high availability of the service DNS server.

```
...
  dnsConfig:
    nameservers:
      - 169.254.20.10
      - 10.247.3.10
    searches:
      - default.svc.cluster.local
      - svc.cluster.local
      - cluster.local
    options:
      - name: timeout
        value: ''
      - name: ndots
        value: '5'
      - name: single-request-reopen
...
```

Manual configuration

Manually add the **dnsConfig** settings to the pod.

Create a pod and add the NodeLocal DNSCache IP address 169.254.20.10 to the DNSConfig nameservers configuration.

```
apiVersion: v1
kind: Pod
metadata:
  name: nginx
spec:
  containers:
  - image: nginx:alpine
    name: container-0
  dnsConfig:
    nameservers:
    - 169.254.20.10
    - 10.247.3.10
    searches:
    - default.svc.cluster.local
    - svc.cluster.local
    - cluster.local
    options:
    - name: ndots
      value: '2'
  imagePullSecrets:
  - name: default-secret
```

Common Issues

- How Do I Avoid an Automatic DNSConfig Injection?

  Solution:

  To prevent automatic DNSConfig injection for a workload, add **node-local-dns-injection: disabled** to the **labels** field in the pod template. Example:

  ```
  apiVersion: apps/v1
  kind: Deployment
  metadata:
    name: test
    namespace: default
  spec:
    replicas: 2
    selector:
      matchLabels:
        app: test
    template:
  ```

```
metadata:
  labels:
    app: test
    node-local-dns-injection: disabled   # Prevent automatic DNSConfig injection.
spec:
  containers:
    - name: container-1
      image: nginx:latest
      imagePullPolicy: IfNotPresent
  imagePullSecrets:
    - name: default-secret
```

10.6 Container Network Settings

10.6.1 Host Network

Scenario

Kubernetes allows pods to directly use the host/node network. When a pod is configured with **hostNetwork: true**, applications running in the pod can directly view the network interface of the host where the pod is located.

Configuration

Add **hostNetwork: true** to the pod definition.

```
apiVersion: apps/v1
kind: Deployment
metadata:
  name: nginx
spec:
  replicas: 1
  selector:
    matchLabels:
      app: nginx
  template:
    metadata:
      labels:
        app: nginx
    spec:
      hostNetwork: true
      containers:
      - image: nginx:alpine
        name: nginx
      imagePullSecrets:
      - name: default-secret
```

The configuration succeeds if the pod IP is the same as the node IP.

```
$ kubectl get pod -owide
NAME                READY   STATUS    RESTARTS   AGE     IP          NODE        NOMINATED NODE
READINESS GATES
nginx-6fdf99c8b-6wwft   1/1     Running   0          3m41s   10.1.0.55   10.1.0.55   <none>          <none>
```

Precautions

If a pod uses the host network, it occupies a host port. The pod IP is the host IP. To use the host network, you must confirm pods do not conflict with each other in terms of the host ports they occupy. Do not use the host network unless you know exactly which host port is used by which pod.

When using the host network, you access a pod on a node through a node port. Therefore, **allow access from the security group port of the node**. Otherwise, the access fails.

In addition, using the host network requires you to reserve host ports for the pods. When using a Deployment to deploy pods of the hostNetwork type, ensure that **the number of pods does not exceed the number of nodes**. Otherwise, multiple pods will be scheduled onto the node, and they will fail to start due to port conflicts. For example, in the preceding example nginx YAML, if two pods (setting **replicas** to **2**) are deployed in a cluster with only one node, one pod cannot be created. The pod logs will show that the Nginx cannot be started because the port is occupied.

CAUTION

Do not schedule multiple pods that use the host network on the same node. Otherwise, when a ClusterIP Service is created to access a pod, the cluster IP address cannot be accessed.

```
$ kubectl get deploy
NAME    READY   UP-TO-DATE   AVAILABLE   AGE
nginx   1/2     2            1           67m
$ kubectl get pod
NAME                     READY   STATUS             RESTARTS   AGE
nginx-6fdf99c8b-6wwft    1/1     Running            0          67m
nginx-6fdf99c8b-rglm7    0/1     CrashLoopBackOff   13         44m
$ kubectl logs nginx-6fdf99c8b-rglm7
/docker-entrypoint.sh: /docker-entrypoint.d/ is not empty, will attempt to perform configuration
/docker-entrypoint.sh: Looking for shell scripts in /docker-entrypoint.d/
/docker-entrypoint.sh: Launching /docker-entrypoint.d/10-listen-on-ipv6-by-default.sh
10-listen-on-ipv6-by-default.sh: info: Getting the checksum of /etc/nginx/conf.d/default.conf
10-listen-on-ipv6-by-default.sh: info: Enabled listen on IPv6 in /etc/nginx/conf.d/default.conf
/docker-entrypoint.sh: Launching /docker-entrypoint.d/20-envsubst-on-templates.sh
/docker-entrypoint.sh: Launching /docker-entrypoint.d/30-tune-worker-processes.sh
/docker-entrypoint.sh: Configuration complete; ready for start up
2022/05/11 07:18:11 [emerg] 1#1: bind() to 0.0.0.0:80 failed (98: Address in use)
nginx: [emerg] bind() to 0.0.0.0:80 failed (98: Address in use)
2022/05/11 07:18:11 [emerg] 1#1: bind() to [::]:80 failed (98: Address in use)
nginx: [emerg] bind() to [::]:80 failed (98: Address in use)
2022/05/11 07:18:11 [emerg] 1#1: bind() to 0.0.0.0:80 failed (98: Address in use)
nginx: [emerg] bind() to 0.0.0.0:80 failed (98: Address in use)
2022/05/11 07:18:11 [emerg] 1#1: bind() to [::]:80 failed (98: Address in use)
nginx: [emerg] bind() to [::]:80 failed (98: Address in use)
2022/05/11 07:18:11 [emerg] 1#1: bind() to 0.0.0.0:80 failed (98: Address in use)
nginx: [emerg] bind() to 0.0.0.0:80 failed (98: Address in use)
2022/05/11 07:18:11 [emerg] 1#1: bind() to [::]:80 failed (98: Address in use)
nginx: [emerg] bind() to [::]:80 failed (98: Address in use)
2022/05/11 07:18:11 [emerg] 1#1: bind() to 0.0.0.0:80 failed (98: Address in use)
nginx: [emerg] bind() to 0.0.0.0:80 failed (98: Address in use)
2022/05/11 07:18:11 [emerg] 1#1: bind() to [::]:80 failed (98: Address in use)
nginx: [emerg] bind() to [::]:80 failed (98: Address in use)
2022/05/11 07:18:11 [emerg] 1#1: bind() to 0.0.0.0:80 failed (98: Address in use)
nginx: [emerg] bind() to 0.0.0.0:80 failed (98: Address in use)
2022/05/11 07:18:11 [emerg] 1#1: bind() to [::]:80 failed (98: Address in use)
nginx: [emerg] bind() to [::]:80 failed (98: Address in use)
2022/05/11 07:18:11 [emerg] 1#1: still could not bind()
nginx: [emerg] still could not bind()
```

10.6.2 Configuring QoS for a Pod

Scenario

Bandwidth preemption occurs between different containers deployed on the same node, which may cause service jitter. You can configure QoS rate limiting for inter-pod access to prevent this problem.

Constraints

The following shows constraints on setting the rate limiting for inter-pod access:

Constraint Type	Tunnel network model	VPC Network Model
Supported versions	All versions	Clusters of v1.19.10 and later
Supported runtime types	Only common containers	
Supported pod types	Only non-HostNetwork pods	
Supported scenarios	Inter-pod access, pods accessing nodes, and pods accessing services	
Constraints	None	None
Value range of rate limit	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.	

Using the CCE Console

When creating a workload on the console, you can set pod ingress and egress bandwidth limits by clicking **Network Configuration** in the **Advanced Settings** area.

Using kubectl

You can add annotations to a workload to specify its egress and ingress bandwidth.

```
apiVersion: apps/v1
kind: Deployment
metadata:
  name: test
  namespace: default
```

```
  labels:
    app: test
spec:
  replicas: 2
  selector:
    matchLabels:
      app: test
  template:
    metadata:
      labels:
        app: test
      annotations:
        kubernetes.io/ingress-bandwidth: 100M
        kubernetes.io/egress-bandwidth: 100M
    spec:
      containers:
        - name: container-1
          image: nginx:alpine
          imagePullPolicy: IfNotPresent
      imagePullSecrets:
        - name: default-secret
```

- **kubernetes.io/ingress-bandwidth**: ingress bandwidth of the pod
- **kubernetes.io/egress-bandwidth**: egress bandwidth of the pod

If these two parameters are not specified, the bandwidth is not limited.

NOTE

After modifying the ingress or egress bandwidth limit of a pod, restart the container for the modification to take effect. After annotations are modified in a pod not managed by workloads, the container will not be restarted, so the bandwidth limits do not take effect. You can create a pod again or manually restart the container.

10.6.3 Container Tunnel Network Settings

10.6.3.1 Network Policies

Network policies are designed by Kubernetes to restrict pod access. It is equivalent to a firewall at the application layer to enhance network security. The capabilities supported by network policies depend on the capabilities of the network add-ons of the cluster.

By default, if a namespace does not have any policy, pods in the namespace accept traffic from any source and send traffic to any destination.

Network policies are classified into the following types:

- **namespaceSelector**: selects particular namespaces for which all pods should be allowed as ingress sources or egress destinations.
- **podSelector**: selects particular pods in the same namespace as the network policy which should be allowed as ingress sources or egress destinations.
- **ipBlock**: selects particular IP blocks to allow as ingress sources or egress destinations.

Constraints

- Only clusters that use the tunnel network model support network policies. Network policies are classified into the following types:

  - Ingress: All versions support this type.
  - Egress: This rule type cannot be set currently.
- Network isolation is not supported for IPv6 addresses.

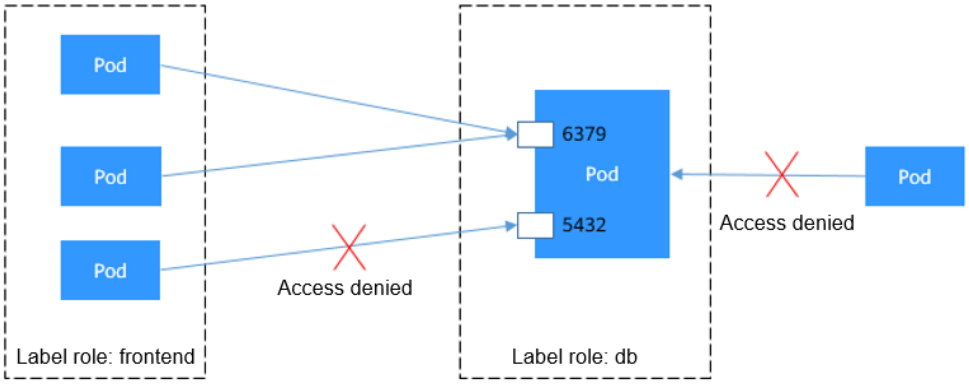
Using Ingress Rules

- **Using podSelector to specify the access scope**

```
apiVersion: networking.k8s.io/v1
kind: NetworkPolicy
metadata:
  name: test-network-policy
  namespace: default
spec:
  podSelector:                # The rule takes effect for pods with the role=db label.
    matchLabels:
      role: db
  ingress:                    # This is an ingress rule.
  - from:
    - podSelector:            # Only traffic from the pods with the "role=frontend" label is allowed.
        matchLabels:
          role: frontend
    ports:                    # Only TCP can be used to access port 6379.
    - protocol: TCP
      port: 6379
```

The following figure shows how podSelector works.

Figure 10-24 podSelector

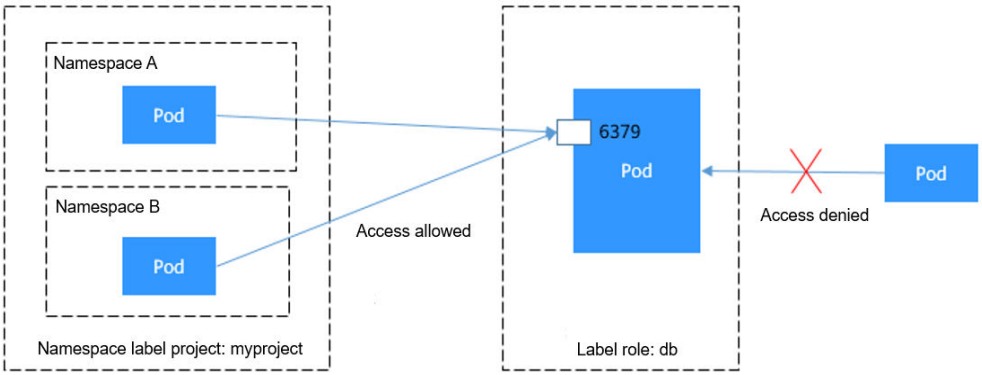


- **Using namespaceSelector to specify the access scope**

```
apiVersion: networking.k8s.io/v1
kind: NetworkPolicy
metadata:
  name: test-network-policy
spec:
  podSelector:                # The rule takes effect for pods with the role=db label.
    matchLabels:
      role: db
  ingress:                    # This is an ingress rule.
  - from:
    - namespaceSelector:      # Only traffic from the pods in the namespace with the
"project=myproject" label is allowed.
        matchLabels:
          project: myproject
    ports:                    # Only TCP can be used to access port 6379.
    - protocol: TCP
      port: 6379
```

The following figure shows how namespaceSelector works.

Figure 10-25 namespaceSelector



Creating a Network Policy on the Console

Step 1 Log in to the CCE console and click the cluster name to access the cluster console.

Step 2 Choose **Policies** in the navigation pane, click the **Network Policies** tab, and click **Create Network Policy** in the upper right corner.

- **Policy Name**: Specify a network policy name.
- **Namespace**: Select a namespace in which the network policy is applied.
- **Selector**: Enter a label, select the pod to be associated, and click **Add**. You can also click **Reference Workload Label** to use the label of an existing workload.
- **Inbound Rule**: Click + to add an inbound rule. For details about parameter settings, see **Table 10-54**.

Table 10-54 Adding an inbound rule

Parameter	Description
Protocol & Port	Select the protocol type and port. Currently, TCP and UDP are supported.
Source Namespace	Select a namespace whose objects can be accessed. If this parameter is not specified, the object belongs to the same namespace as the current policy.
Source Pod Label	Allow accessing the pods with this label. If this parameter is not specified, all pods in the namespace can be accessed.

Step 3 After the configuration is complete, click **OK**.

----End

10.7 Cluster Network Settings

10.7.1 Switching a Node Subnet

Scenario

This section describes how to switch subnets for nodes in a cluster.

Constraints

- Only subnets in the same VPC as the cluster can be switched. The security group of the node cannot be switched.

Procedure

Step 1 Log in to the ECS console.

Step 2 Click **More > Manage Network > Change VPC** in the **Operation** column of the target ECS.

Step 3 Set parameters for changing the VPC.

- **VPC**: Select the same VPC as that of the cluster.
- **Subnet**: Select the target subnet to be switched.
- **Private IP Address**: Select **Assign new** or **Use existing** as required.
- **Security Group**: Select the security group of the cluster node. Otherwise, the node is unavailable.

Step 4 Click **OK**.

Step 5 Go to the CCE console and reset the node. You can use the default parameter settings. For details, see **Resetting a Node**.

----End

10.7.2 Adding a Container CIDR Block for a Cluster

Scenario

If the container CIDR block set during CCE cluster creation is insufficient, you can add a container CIDR block for the cluster.

Constraints

- This function applies to CCE standard clusters of v1.19 or later, but not to clusters using container tunnel networking.
- The container CIDR block or container subnet cannot be deleted after being added. Exercise caution when performing this operation.

Adding a Container CIDR Block for a CCE Standard Cluster

Step 1 Log in to the CCE console and click the cluster name to access the cluster console.

Step 2 On the **Overview** page, locate the **Networking Configuration** area and click **Add**.

Step 3 Configure the container CIDR block to be added. You can click + to add multiple container CIDR blocks at a time.

NOTE

New container CIDR blocks cannot conflict with service CIDR blocks, VPC CIDR blocks, and existing container CIDR blocks.

Step 4 Click **OK**.

----End

10.8 Configuring Intra-VPC Access

This section describes how to access an intranet from a container (outside the cluster in a VPC), including intra-VPC access and cross-VPC access.

Intra-VPC Access

The performance of accessing an intranet from a container varies depending on the container network models of a cluster.

- **Container tunnel network**

  The container tunnel network encapsulates network data packets through tunnels based on the node network. A container can access other resources in the same VPC as long as the node can access the resources. If the access fails, check whether the security group of the peer resource allows access from the node where the container is located.

- **VPC network**

  The VPC network model uses VPC routes to forward container traffic. The container CIDR block and the node VPC are not in the same CIDR block. When a container accesses other resources in the same VPC, **the security group of the peer resource must allow access of the container CIDR block**.

  For example, the CIDR block where the cluster node resides is 192.168.10.0/24, and the container CIDR block is 172.16.0.0/16.

  There is an ECS whose IP address is 192.168.10.52 in the VPC (outside the cluster). The security group of the ECS allows access of only the CIDR block of the cluster node.

  In this case, if you ping 192.168.10.52 from the container, the ping operation fails.

  ```
  kubectl exec test01-6cbbf97b78-krj6h  -it -- /bin/sh
  / # ping 192.168.10.25
  PING 192.168.10.25 (192.168.10.25): 56 data bytes
  ^C
  --- 192.168.10.25 ping statistics ---
  104 packets transmitted, 0 packets received, 100% packet loss
  ```

  Configure the security group to allow access from the container CIDR block 172.16.0.0/16.

  In this case, 192.168.10.52 can be pinged from the container.

  ```
  $ kubectl exec test01-6cbbf97b78-krj6h  -it -- /bin/sh
  / # ping 192.168.10.25
  PING 192.168.10.25 (192.168.10.25): 56 data bytes
  ```

```
64 bytes from 192.168.10.25: seq=0 ttl=64 time=1.412 ms
64 bytes from 192.168.10.25: seq=1 ttl=64 time=1.400 ms
64 bytes from 192.168.10.25: seq=2 ttl=64 time=1.299 ms
64 bytes from 192.168.10.25: seq=3 ttl=64 time=1.283 ms
^C
--- 192.168.10.25 ping statistics ---
4 packets transmitted, 4 packets received, 0% packet loss
```

Cross-VPC Access

Cross-VPC access is implemented by establishing a peering connection between VPCs.

- In the container tunnel network model, a container can access the peer VPC only when the communication is enabled between the node network and the peer VPC.
- Each VPC network has an independent container CIDR block. In addition to the VPC CIDR block, the container CIDR block also needs to be connected.

  Assume that there are two VPCs.

  - vpc-demo: Its CIDR block is 192.168.0.0/16, the cluster is in vpc-demo, and the container CIDR block is 10.0.0.0/16.
  - vpc-demo2: Its CIDR block is 10.1.0.0/16.

  Create a peering connection named **peering-demo** (the local VPC is vpc-demo and the peer VPC is vpc-demo2). Add the container CIDR block to the route of the peer VPC.

  After this configuration, you can access the container CIDR block 10.0.0.0/16 in vpc-demo2. During the access, pay attention to the security group configuration and enable the port configuration.

Accessing Other Cloud Services

Common services that communicate with CCE through an intranet include RDS, DCS, Kafka, RabbitMQ, and ModelArts.

In addition to the network configurations described in **Intra-VPC Access** and **Cross-VPC Access**, you also need to check **whether these cloud services allow external access**. For example, the DCS Redis instance can be accessed only by the IP addresses in its whitelist. Generally, these cloud services can be accessed by IP addresses in the same VPC. However, the container CIDR block in the VPC network model is different from the CIDR block of the VPC. Therefore, you must add the container CIDR block to the whitelist.

What If a Container Fails to Access an Intranet?

If an intranet cannot be accessed from a container, perform the following operations:

1. View the security group rule of the peer server to check whether the container is allowed to access the peer server.
   - The container tunnel network model needs to allow the IP address of the node where the container is located.
   - The VPC network model needs to allow the container CIDR block.

2. Check whether a whitelist is configured for the peer server. For example, the DCS Redis instance can be accessed only by the IP addresses in its whitelist. Add the container and node CIDR blocks to the whitelist.
3. Check whether the container engine is installed on the peer server and whether it conflicts with the container CIDR block in CCE. If a network conflict occurs, the access fails.

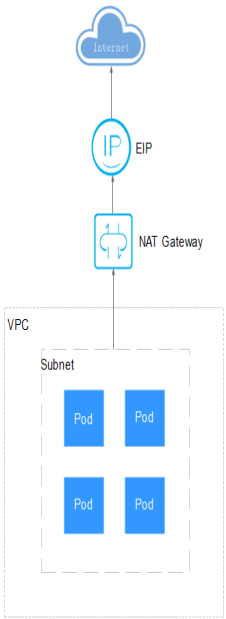
10.9 Accessing the Internet from a Container

Containers can access the Internet in either of the following ways:

- Bind an EIP to the node where the container is located.
- Configure SNAT rules through NAT Gateway.

You can use NAT Gateway to enable container pods in a VPC to access the Internet. NAT Gateway provides source network address translation (SNAT), which translates private IP addresses to a public IP address by binding an elastic IP address (EIP) to the gateway, providing secure and efficient access to the Internet. **Figure 10-26** shows the SNAT architecture. The SNAT function allows the container pods in a VPC to access the Internet without being bound to an EIP. SNAT supports a large number of concurrent connections, which makes it suitable for applications involving a large number of requests and connections.

Figure 10-26 SNAT



To enable a container pod to access the Internet, perform the following steps:

Step 1 Assign an EIP.

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. Click in the upper left corner and choose **Networking** > **Elastic IP** in the expanded list.
4. On the **EIPs** page, click **Assign EIP**.
5. Configure parameters as required.

   NOTE

   Set **Region** to the region where container pods are located.

Step 2 Create a NAT gateway.

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. Click in the upper left corner and choose **Networking** > **NAT Gateway** in the expanded list.
4. On the **Public Network Gateways** page, click **Create Public NAT Gateway** in the upper right corner.
5. Configure parameters as required.

   NOTE

   Select the same VPC.

Step 3 Configure an SNAT rule and bind the EIP to the subnet.

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. Click in the upper left corner and choose **Networking** > **NAT Gateway** in the expanded list.
4. On the page displayed, click the name of the NAT gateway for which you want to add the SNAT rule.
5. On the **SNAT Rules** tab page, click **Add SNAT Rule**.
6. Set parameters as required.

   NOTE

   SNAT rules take effect by CIDR block. As different container network models use different communication modes, the subnet needs to be selected according to the following rules:

   - Tunnel network and VPC network: Select the subnet where the node is located, that is, the subnet selected during node creation.

   If there are multiple CIDR blocks, you can create multiple SNAT rules or customize a CIDR block as long as the CIDR block contains the node subnet.

After the SNAT rule is configured, workloads can access the Internet from the container. The Internet can be pinged from the container.

----End

11 Storage

11.1 Overview

Container Storage

CCE container storage is implemented based on Kubernetes container storage APIs (**CSI**). CCE integrates multiple types of cloud storage and covers different application scenarios. CCE is fully compatible with Kubernetes native storage services, such as emptyDir, hostPath, secret, and ConfigMap.

CCE allows workload pods to use multiple types of storage:

- In terms of implementation, storage supports Container Storage Interface (CSI) and Kubernetes native storage.

Type	Description
CSI	An **out-of-tree** volume add-on, which specifies the standard container storage API and allows storage vendors to use standard custom storage plugins that are mounted using PVCs and PVs without the need to add their plugin source code to the Kubernetes repository for unified build, compilation, and release. CSI is a recommended in Kubernetes 1.13 and later versions.
Kubernetes native storage	An "in-tree" volume add-on that is built, compiled, and released with the Kubernetes repository.

- In terms of storage media, storage can be classified as cloud storage, local storage, and Kubernetes resource objects.

Type	Description	Application Scenario
Cloud storage	The storage media is provided by storage vendors. Storage volumes of this type are mounted using PVCs and PVs.	Data requires high availability or needs to be shared, for example, logs and media resources. Select a proper cloud storage type based on the application scenario. For details, see **Cloud Storage Comparison**.
Local storage	The storage media is the local data disk or memory of the node. The local persistent volume is a customized storage type provided by CCE and mounted using PVCs and PVs through the CSI. Other storage types are Kubernetes native storage.	Non-HA data requires high I/O and low latency. Select a proper local storage type based on the application scenario. For details, see **Local Storage Comparison**.
Kubernetes resource objects	ConfigMaps and secrets are resources created in clusters. They are special storage types and are provided by tmpfs (RAM-based file system) on the Kubernetes API server.	ConfigMaps are used to inject configuration data to pods. Secrets are used to transmit sensitive information such as passwords to pods.

Cloud Storage Comparison

Item	EVS	SFS Turbo	OBS
Definition	EVS offers scalable block storage for cloud servers. With high reliability, high performance, and rich specifications, EVS disks can be used for distributed file systems, dev/test environments, data warehouses, and high-performance computing (HPC) applications.	Expandable to 320 TB, SFS Turbo provides fully hosted shared file storage, which is highly available and stable, to support small files and applications requiring low latency and high IOPS. You can use SFS Turbo in high-traffic websites, log storage, compression/ decompression, DevOps, enterprise OA, and containerized applications.	Object Storage Service (OBS) provides massive, secure, and cost-effective data storage for you to store data of any type and size. You can use it in enterprise backup/ archiving, video on demand (VoD), video surveillance, and many other scenarios.
Data storage logic	Stores binary data and cannot directly store files. To store files, format the file system first.	Stores files and sorts and displays data in the hierarchy of files and folders.	Stores objects. Files directly stored automatically generate the system metadata, which can also be customized by users.
Access mode	Accessible only after being mounted to ECSs or BMSs and initialized.	Supports the Network File System (NFS) protocol (NFSv3 only). You can seamlessly integrate existing applications and tools with SFS Turbo.	Accessible through the Internet or Direct Connect (DC). Specify the bucket address and use transmission protocols such as HTTP or HTTPS.
Static storage volumes	Supported. For details, see **Using an Existing EVS Disk Through a Static PV**.	Supported. For details, see **Using an Existing SFS Turbo File System Through a Static PV**.	Supported. For details, see **Using an Existing OBS Bucket Through a Static PV**.
Dynamic storage volumes	Supported. For details, see **Using an EVS Disk Through a Dynamic PV**.	Not supported	Supported. For details, see **Using an OBS Bucket Through a Dynamic PV**.

Item	EVS	SFS Turbo	OBS
Features	Non-shared storage. Each volume can be mounted to only one node.	Shared storage featuring high performance and bandwidth	Shared, user-mode file system
Application scenarios	HPC, enterprise core cluster applications, enterprise application systems, and dev/test **NOTE** HPC apps here require high-speed and high-IOPS storage, such as industrial design and energy exploration.	High-traffic websites, log storage, DevOps, and enterprise OA	Big data analytics, static website hosting, online video on demand (VoD), gene sequencing, intelligent video surveillance, backup and archiving, and enterprise cloud boxes (web disks)
Capacity	TB	General-purpose: TB	EB
Latency	1–2 ms	General-purpose: 1–5 ms	10 ms
Max. IOPS	2200–256000, depending on flavors	General-purpose: up to 100,000	Tens of millions
Bandwidth	MB/s	General-purpose: up to GB/s	TB/s

Local Storage Comparison

Item	Local PV	Local Ephemeral Volume	emptyDir	hostPath
Definition	Node's local disks form a storage pool (VolumeGroup) through LVM. LVM divides them into logical volumes (LVs) and mounts them to pods.	Kubernetes native emptyDir, where node's local disks form a storage pool (VolumeGroup) through LVM. LVs are created as the storage media of emptyDir and mounted to pods. LVs deliver better performance than the default storage medium of emptyDir.	Kubernetes native emptyDir. Its lifecycle is the same as that of a pod. Memory can be specified as the storage media. When the pod is deleted, the emptyDir volume is deleted and its data is lost.	Used to mount a file directory of the host where a pod is located to a specified mount point of the pod.
Features	Low-latency, high-I/O, and non-HA persistent volume. Storage volumes are non-shared storage and bound to nodes through labels. Therefore, storage volumes can be mounted only to a single pod.	Local temporary volume. The storage space is from local LVs.	Local temporary volume. The storage space comes from the local kubelet root directory or memory.	Used to mount files or directories of the host file system. Host directories can be automatically created. Pods can be migrated (not bound to nodes).
Storage volume mounting	Static storage volumes are not supported. **Using a Local PV Through a Dynamic PV** is supported.	For details, see **Using a Local EV**.	For details, see **Using a Temporary Path**.	For details, see **hostPath**.

Item	Local PV	Local Ephemeral Volume	emptyDir	hostPath
Application scenarios	High I/O requirements and built-in HA solutions of applications, for example, deploying MySQL in HA mode.	• Scratch space, such as for a disk-based merge sort • Checkpointing a long computation for recovery from crashes • Saving the files obtained by the content manager container when web server container data is used	• Scratch space, such as for a disk-based merge sort • Checkpointing a long computation for recovery from crashes • Saving the files obtained by the content manager container when web server container data is used	Requiring a node file, for example, if Docker is used, you can use hostPath to mount the **/var/lib/docker** path of the node. **NOTICE** Avoid using hostPath volumes as much as possible, as they are prone to security risks. If hostPath volumes must be used, they can only be applied to files or directories and mounted in read-only mode.

Enterprise Project Support

NOTE

To use this function, the Everest add-on must be upgraded to v1.2.33 or later.

- Automatically creating storage:

  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 no enterprise project is specified, the enterprise project specified in StorageClass will be used by default for creating storage resources.

  - For a custom StorageClass, you can specify an enterprise project in StorageClass. For details, see **Specifying an Enterprise Project for Storage Classes**. If no enterprise project is specified in StorageClass, the default enterprise project is used.
  - For the csi-disk and csi-obs storage classes provided by CCE, the created storage resources belong to the default enterprise project.

- Use existing storage:

  When you create a PVC using a PV, ensure that **everest.io/enterprise-project-id** specified in the PVC and PV are the same because an enterprise

project has been specified during storage resource creation. Otherwise, the PVC and PV cannot be bound.

Documentation

- **Storage Basics**
- **Elastic Volume Service**
- **SFS Turbo**
- **Object Storage Service**

11.2 Storage Basics

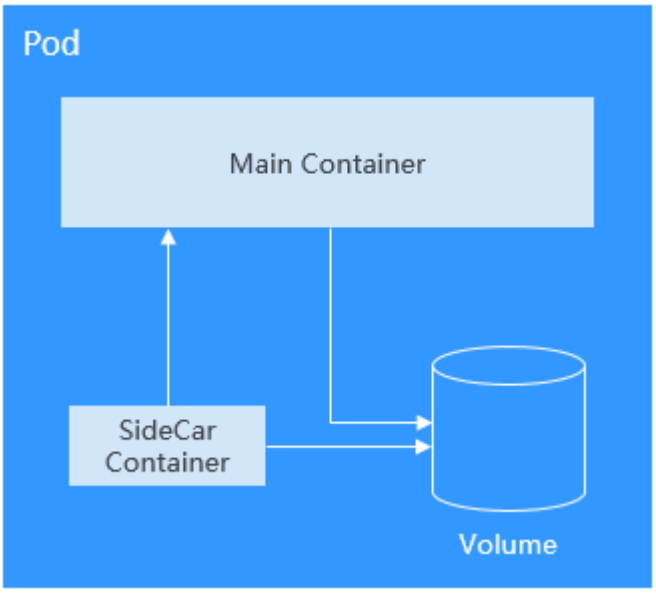
Volumes

On-disk files in a container are ephemeral, which presents the following problems to important applications running in the container:

1. When a container is rebuilt, files in the container will be lost.
2. When multiple containers run in a pod at the same time, files need to be shared among the containers.

Kubernetes volumes resolve both of these problems. Volumes, as part of a pod, cannot be created independently and can only be defined in pods. All containers in a pod can access its volumes, but the volumes must have been mounted to any directory in a container.

The following figure shows how a storage volume is used between containers in a pod.



The basic principles for using volumes are as follows:

- Multiple volumes can be mounted to a pod. However, do not mount too many volumes to a pod.

- Multiple types of volumes can be mounted to a pod.
- Each volume mounted to a pod can be shared among containers in the pod.
- You are advised to use PVCs and PVs to mount volumes for Kubernetes.

NOTE

The lifecycle of a volume is the same as that of the pod to which the volume is mounted. When the pod is deleted, the volume is also deleted. However, files in the volume may outlive the volume, depending on the volume type.

Kubernetes provides various volume types, which can be classified as in-tree and out-of-tree.

Volume Classification	Description
In-tree	Maintained through the Kubernetes code repository and built, edited, and released with Kubernetes binary files. Kubernetes does not accept this volume type anymore. Kubernetes-native volumes such as HostPath, EmptyDir, Secret, and ConfigMap are all the in-tree type. PVCs are a special in-tree volume. Kubernetes uses this type of volume to convert from in-tree to out-of-tree. PVCs allow you to request for PVs created using the underlying storage resources provided by different storage vendors.
Out-of-tree	Out-of-tree volumes include container storage interfaces (CSIs) and FlexVolumes (deprecated). Storage vendors only need to comply with certain specifications to create custom storage add-ons and PVs that can be used by Kubernetes, without adding add-on source code to the Kubernetes code repository. Cloud storage such as SFS and OBS is used by installing storage drivers in a cluster. You need to create PVs in the cluster and mount the PVs to pods using PVCs.

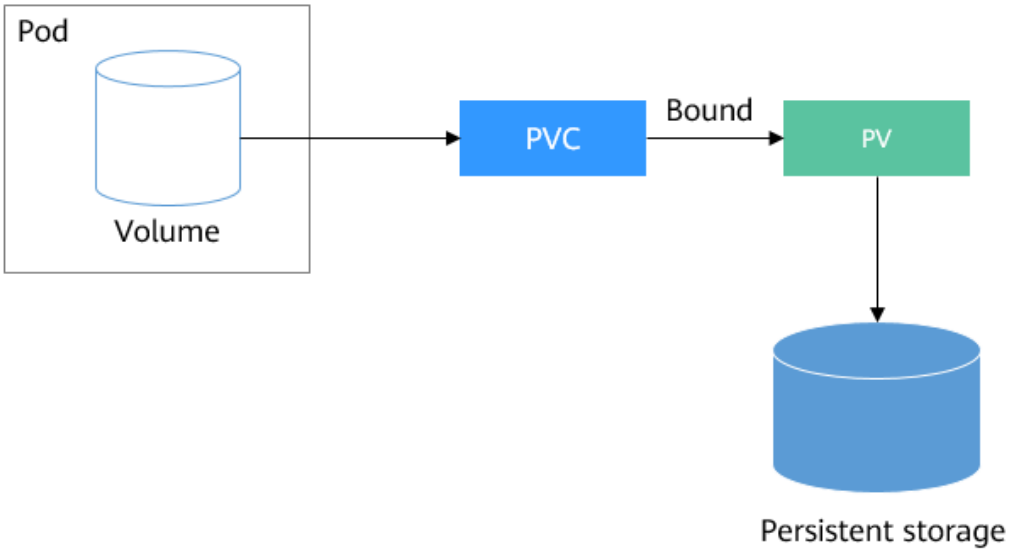
PV and PVC

Kubernetes provides PersistentVolumes (PVs) and PersistentVolumeClaims (PVCs) to abstract details of how storage is provided from how it is consumed. You can request specific size of storage when needed, just like pods can request specific levels of resources (CPU and memory).

- PV: describes a persistent storage volume in a cluster. A PV is a cluster-level resource just like a node. It applies to the entire Kubernetes cluster. A PV has a lifecycle independent of any individual Pod that uses the PV.
- PVC: describes a request for storage by a user. When configuring storage for an application, claim a storage request (that is, PVC). Kubernetes selects a PV that best meets the request and binds the PV to the PVC. A PVC to PV binding is a one-to-one mapping. When creating a PVC, describe the attributes of the requested persistent storage, such as the storage size and read/write permission.

You can bind PVCs to PVs in a pod so that the pod can use storage resources. The following figure shows the relationship between PVs and PVCs.

Figure 11-1 PVC-to-PV binding



CSI

CSI is a standard for container storage interfaces and a storage plugin implementation solution recommended by the Kubernetes community. **Everest** is a storage add-on developed based on CSI. It provides different types of persistent storage for containers.

Volume Access Modes

Storage volumes can be mounted to the host system only in the mode supported by underlying storage resources. For example, a file storage system can be read and written by multiple nodes, but an EVS disk can be read and written by only one node.

- **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.

Table 11-1 Access modes supported by storage volumes

Storage Type	ReadWriteOnce	ReadWriteMany
EVS	√	x
OBS	x	√
SFS Turbo	x	√
Local PV	√	x

Mounting a Storage Volume

You can mount volumes in the following ways:

Use PVs to describe existing storage resources, and then create PVCs to use the storage resources in pods. You can also use the dynamic creation mode. That is, specify the **StorageClass** when creating a PVC and use the provisioner in the StorageClass to automatically create a PV and bind the PV to the PVC.

Table 11-2 Modes of mounting volumes

Mounting Mode	Description	Supported Volume Type	Other Constraints
Statically creating storage volume (using existing storage)	Use existing storage (such as EVS disks and SFS file systems) to create PVs and mount the PVs to the workload through PVCs. Kubernetes binds PVCs to the matching PVs so that workloads can access storage services.	All volumes	None
Dynamically creating storage volumes (automatically creating storage)	Specify a **StorageClass** for a PVC. The storage provisioner creates underlying storage media as required to automatically create PVs and directly bind the PV to the PVC.	EVS, OBS, SFS, and local PV	None
Dynamic mounting (VolumeClaimTemplate)	Achieved by using the **volumeClaimTemplates** field and depends on the dynamic PV creation capability of StorageClass. In this mode, each pod is associated with a unique PVC and PV. After a pod is rescheduled, the original data can still be mounted to it based on the PVC name.	EVS and local PV	Supported only by StatefulSets

PV Reclaim Policy

A PV reclaim policy is used to delete or reclaim underlying volumes when a PVC is deleted. The value can be **Delete** or **Retain**.

- **Delete**: Deleting a PVC will remove the PV from Kubernetes, so the associated underlying storage assets from the external infrastructure.
- **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 resources are in the **Released** state and cannot be directly bound to the PVC.

You can manually delete and reclaim volumes by performing the following operations:

a. Delete the PV.

b. Clear data on the associated underlying storage resources as required.

c. Delete the associated underlying storage resources.

To reuse the underlying storage resources, create a PV.

CCE also allows you to delete a PVC without deleting underlying storage resources. This function can be achieved only by using a YAML file: Set the PV reclaim policy to **Delete** and add **everest.io/reclaim-policy: retain-volume-only** to **annotations**. In this way, when the PVC is deleted, the PV is deleted, but the underlying storage resources are retained.

The following YAML file takes EVS as an example:

```
apiVersion: v1
kind: PersistentVolumeClaim
metadata:
  name: test
  namespace: default
  annotations:
    volume.beta.kubernetes.io/storage-provisioner: everest-csi-provisioner
    everest.io/disk-volume-type: SAS
  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
  volumeName: pv-evs-test

---
apiVersion: v1
kind: PersistentVolume
metadata:
  annotations:
    pv.kubernetes.io/provisioned-by: everest-csi-provisioner
    everest.io/reclaim-policy: retain-volume-only
  name: pv-evs-test
  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
  capacity:
    storage: 10Gi
  csi:
    driver: disk.csi.everest.io
    fsType: ext4
    volumeHandle: 2af98016-6082-4ad6-bedc-1a9c673aef20
    volumeAttributes:
      storage.kubernetes.io/csiProvisionerIdentity: everest-csi-provisioner
      everest.io/disk-mode: SCSI
      everest.io/disk-volume-type: SAS
  persistentVolumeReclaimPolicy: Delete
  storageClassName: csi-disk
```

Documentation

- For more information about Kubernetes storage, see **Storage**.
- For more information about CCE container storage, see **Overview**.

11.3 Elastic Volume Service

11.3.1 Overview

To achieve persistent storage, CCE allows you to mount the storage volumes created from Elastic Volume Service (EVS) disks to a path of a container. When the container is migrated within an AZ, the mounted EVS volumes are also migrated. By using EVS volumes, you can mount the remote file directory of a storage system to a container so that data in the data volume is permanently preserved. Even if the container is deleted, the data in the data volume is still stored in the storage system.

EVS Disk Performance Specifications

EVS performance metrics include:

- IOPS: number of read/write operations performed by an EVS disk per second
- Throughput: amount of data read from and written into an EVS disk per second
- Read/write I/O latency: minimum interval between two consecutive read/write operations on an EVS disk

Table 11-3 EVS disk performance specifications

Parameter	Ultra-high I/O	High I/O
Max. capacity (GiB)	• System disk: 1,024 • Data disk: 32,768	• System disk: 1,024 • Data disk: 32,768
Max. IOPS	50,000	5000
Max. throughput (MiB/s)	350	150
Burst IOPS limit	16,000	5000
Disk IOPS	Min. (50,000, 1800 + 50 x Capacity)	Min. (5000, 1800 + 8 x Capacity)
Disk throughput (MiB/s)	Min. (350, 120 + 0.5 × Capacity)	Min. (150, 100 + 0.15 × Capacity)
Single-queue access latency (ms)	1	1–3
API name	SSD	SAS

Application Scenarios

EVS disks can be mounted in the following modes based on application scenarios:

- **Using an Existing EVS Disk Through a Static PV**: static creation mode, where you use an existing EVS disk to create a PV and then mount storage to the workload through a PVC. This mode applies to scenarios where the underlying storage is available.
- **Using an EVS Disk Through a Dynamic PV**: dynamic creation mode, where you do not need to create EVS volumes in advance. Instead, specify a StorageClass during PVC creation and an EVS disk and a PV will be automatically created. This mode applies to scenarios where no underlying storage is available.
- **Dynamically Mounting an EVS Disk to a StatefulSet**: Only StatefulSets support this mode. Each pod is associated with a unique PVC and PV. After a pod is rescheduled, the original data can still be mounted to it based on the PVC name. This mode applies to StatefulSets with multiple pods.

11.3.2 Using an Existing EVS Disk Through a Static PV

CCE allows you to create a PV using an existing EVS disk. After the PV is created, you can create a PVC and bind it to the PV. This mode applies if the underlying storage is available.

Prerequisites

- You have created a cluster and installed the **CCE Container Storage (Everest)** add-on in the cluster.
- You have created an EVS disk that meets the following requirements:
  - The existing EVS disk cannot be a system disk, DSS disk, or shared disk.
  - The EVS disk must be of the **SCSI** type (the default disk type is **VBD** when you purchase an EVS disk).
  - The EVS disk must be available and not used by other resources.
  - The AZ of the EVS disk must be the same as that of the cluster node. Otherwise, the EVS disk cannot be mounted and the pod cannot start.
  - If the EVS disk is encrypted, the key must be available.
  - Only the EVS disks in the enterprise project to which the cluster belongs and the default enterprise project are supported.
  - EVS disks that have been partitioned are not supported.
  - Only ext4 EVS disks are supported.
- Before creating a cluster using commands, ensure kubectl is used to access the cluster. For details, see **Connecting to a Cluster Using kubectl**.

Constraints

- EVS disks cannot be attached across AZs and cannot be used by multiple workloads, multiple pods of the same workload, or multiple tasks. Data sharing of a shared disk is not supported between nodes in a CCE cluster. If an EVS disk is attacked to multiple nodes, I/O conflicts and data cache conflicts may occur. Therefore, create only one pod when creating a Deployment that uses EVS disks.

- For clusters earlier than v1.19.10, if an HPA policy is used to scale out a workload with EVS volumes mounted, the existing pods cannot be read or written when a new pod is scheduled to another node.

  For clusters of v1.19.10 and later, if an HPA policy is used to scale out a workload with EVS volumes mounted, a new pod cannot be started because EVS disks cannot be attached.

Using an Existing EVS Disk on the Console

Step 1 Log in to the CCE console and click the cluster name to access the cluster console.

Step 2 Statically create a PVC and PV.

1. Choose **Storage** in the navigation pane and click the **PVCs** tab. Click **Create PVC** in the upper right corner. In the dialog box displayed, configure the PVC parameters.

Parameter	Description
PVC Type	In this example, select **EVS**.
PVC Name	Enter the PVC name, which must be unique in the same namespace.
Creation Method	– If underlying storage is available, create a storage volume or use an existing storage volume to statically create a PVC based on whether a PV has been created. – If no underlying storage is available, select **Dynamically provision**. For details, see **Using an EVS Disk Through a Dynamic PV**. In this example, select **Create new** to create a PV and PVC at the same time on the console.
PV[a]	Select an existing PV volume in the cluster. Create a PV in advance. For details, see "Creating a storage volume" in **Related Operations**. You do not need to specify this parameter in this example.
EVS[b]	Click **Select EVS**. On the displayed page, select the EVS disk that meets your requirements and click **OK**.
PV Name[b]	Enter the PV name, which must be unique in the same cluster.
Access Mode[b]	EVS disks support only **ReadWriteOnce**, indicating that a storage volume can be mounted to one node in read/write mode. For details, see **Volume Access Modes**.
Reclaim Policy[b]	You can select **Delete** or **Retain** to specify the reclaim policy of the underlying storage when the PVC is deleted. For details, see **PV Reclaim Policy**.

NOTE

a: The parameter is available when **Creation Method** is set to **Use existing**.

b: The parameter is available when **Creation Method** is set to **Create new**.

2. Click **Create** to create a PVC and a PV.

   You can choose **Storage** in the navigation pane and view the created PVC and PV on the **PVCs** and **PVs** tab pages, respectively.

Step 3 Create an application.

1. In the navigation pane on the left, click **Workloads**. In the right pane, click the **StatefulSets** tab.
2. Click **Create Workload** in the upper right corner. On the displayed page, click **Data Storage** in the **Container Settings** area and click **Add Volume** to select **PVC**.

   Mount and use storage volumes, as shown in **Table 11-4**. For details about other parameters, see **Workloads**.

Table 11-4 Mounting a storage volume

Parameter	Description
PVC	Select an existing EVS volume. An EVS volume cannot be repeatedly mounted to multiple workloads.
Mount Path	Enter a mount path, for example, **/tmp**. This parameter indicates the container path to which a data volume will be mounted. Do not mount the volume to a system directory such as **/** or **/var/run**. Otherwise, containers will be malfunctional. Mount the volume to an empty directory. If the directory is not empty, ensure that there are no files that affect container startup. Otherwise, the files will be replaced, causing container startup failures or workload creation failures. **NOTICE** If a volume is mounted to a high-risk directory, use an account with minimum permissions to start the container. Otherwise, high-risk files on the host machine may be damaged.
Subpath	Enter the subpath of the storage volume and mount a path in the storage volume to the container. In this way, different folders of the same storage volume can be used in a single pod. **tmp**, for example, indicates that data in the mount path of the container is stored in the **tmp** folder of the storage volume. If this parameter is left blank, the root path is used by default.

Parameter	Description
Permission	– **Read-only**: You can only read the data in the mounted volumes. – **Read/Write**: You can modify the data volumes mounted to the path. Newly written data will not be migrated if the container is migrated, which may cause data loss.

In this example, the disk is mounted to the **/data** path of the container. The container data generated in this path is stored in the EVS disk.

NOTE

A non-shared EVS disk cannot be attached to multiple pods in a workload. Otherwise, the pods cannot start properly. Ensure that the number of workload pods is 1 when you attach an EVS disk.

3. After the configuration, click **Create Workload**.

   After the workload is created, the data in the container mount directory will be persistently stored. Verify the storage by referring to **Verifying Data Persistence**.

----End

(kubectl) Using an Existing EVS Disk

Step 1 Use kubectl to access the cluster.

Step 2 Create a PV. If a PV has been created in your cluster, skip this step.

1. Create the **pv-evs.yaml** file.

```
apiVersion: v1
kind: PersistentVolume
metadata:
  annotations:
    pv.kubernetes.io/provisioned-by: everest-csi-provisioner
    everest.io/reclaim-policy: retain-volume-only         # (Optional) The PV is deleted while the underlying volume is retained.
  name: pv-evs    # PV name.
  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     # Access mode. The value must be ReadWriteOnce for EVS disks.
  capacity:
    storage: 10Gi       # EVS disk capacity, in the unit of GiB. The value ranges from 1 to 32768.
  csi:
    driver: disk.csi.everest.io     # Dependent storage driver for the mounting.
    fsType: ext4     # Must be the same as that of the original file system of the disk.
    volumeHandle: <your_volume_id>   # Volume ID of the EVS disk.
    volumeAttributes:
      everest.io/disk-mode: SCSI           # Device type of the EVS disk. Only SCSI is supported.
      everest.io/disk-volume-type: SAS     # EVS disk type.
      storage.kubernetes.io/csiProvisionerIdentity: everest-csi-provisioner
      everest.io/crypt-key-id: <your_key_id>    # (Optional) Encryption key ID. Mandatory for an encrypted disk.
```

```
    everest.io/enterprise-project-id: <your_project_id>  # (Optional) Enterprise project ID. If an enterprise project is specified, use the same enterprise project when creating a PVC. Otherwise, the PVC cannot be bound to a PV.
  persistentVolumeReclaimPolicy: Delete    # Reclaim policy.
  storageClassName: csi-disk               # Storage class name. The value must be csi-disk for EVS disks.
```

Table 11-5 Key parameters

Parameter	Mandatory	Description
everest.io/reclaim-policy: retain-volume-only	No	Optional. Currently, only **retain-volume-only** is supported. This field is valid only when the Everest version is 1.2.9 or later and the reclaim policy is **Delete**. If the reclaim policy is **Delete** and the current value is **retain-volume-only**, the associated PV is deleted while the underlying storage volume is retained, when a PVC is deleted.
failure-domain.beta.kubernetes.io/region	Yes	Region where the cluster is located.
failure-domain.beta.kubernetes.io/zone	Yes	AZ where the EVS volume is created. It must be the same as the AZ planned for the workload.
fsType	Yes	Configure the file system type. The value defaults to **ext4**.
volumeHandle	Yes	Volume ID of the EVS disk. To obtain the volume ID, log in to the **Cloud Server Console**. In the navigation pane, choose **Elastic Volume Service** > **Disks**. Click the name of the target EVS disk to go to its details page. On the **Summary** tab page, click the copy button after **ID**.
everest.io/disk-volume-type	Yes	EVS disk type. All letters are in uppercase. – **SAS**: high I/O – **SSD**: ultra-high I/O

Parameter	Mandatory	Description
everest.io/crypt-key-id	No	Mandatory when the EVS disk is encrypted. Enter the encryption key ID selected during EVS disk creation. To obtain the encryption key ID, log in to the **Cloud Server Console**. In the navigation pane, choose **Elastic Volume Service** > **Disks**. Click the name of the target EVS disk to go to its details page. On the **Summary** tab page, copy the value of **KMS Key ID** in the **Configuration Information** area.
everest.io/enterprise-project-id	No	Optional. Enterprise project ID of the EVS disk. If an enterprise project is specified, use the same enterprise project when creating a PVC. Otherwise, the PVC cannot be bound to a PV. To obtain the enterprise project ID, log in to the **Cloud Server Console**. In the navigation pane, choose **Elastic Volume Service** > **Disks**. Click the name of the target EVS disk to go to its details page. On the **Summary** tab page, click the enterprise project in **Management Information** to access the enterprise project console. Copy the corresponding ID to obtain the ID of the enterprise project to which the EVS disk belongs.

Parameter	Mandatory	Description
persistentVolumeReclaimPolicy	Yes	A reclaim policy is supported when the cluster version is or later than 1.19.10 and the Everest version is or later than 1.2.9. The **Delete** and **Retain** reclaim policies are supported. For details, see **PV Reclaim Policy**. If high data security is required, select **Retain** to prevent data from being deleted by mistake. **Delete**: – If **everest.io/reclaim-policy** is not specified, both the PV and EVS volume are deleted when a PVC is deleted. – If **everest.io/reclaim-policy** is set to **retain-volume-only**, when a PVC is deleted, the PV is deleted but the EVS resources are retained. **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 is in the **Released** status and cannot be bound to the PVC again.
storageClassName	Yes	The storage class for EVS disks is **csi-disk**.

2. Run the following command to create a PV:

```
kubectl apply -f pv-evs.yaml
```

Step 3 Create a PVC.

1. Create the **pvc-evs.yaml** file.

```
apiVersion: v1
kind: PersistentVolumeClaim
metadata:
  name: pvc-evs
  namespace: default
  annotations:
    everest.io/disk-volume-type: SAS    # EVS disk type.
    everest.io/crypt-key-id: <your_key_id>    # (Optional) Encryption key ID. Mandatory for an encrypted disk.
    everest.io/enterprise-project-id: <your_project_id>  # (Optional) Enterprise project ID. If an enterprise project is specified, use the same enterprise project when creating a PVC. Otherwise, the PVC cannot be bound to a PV.
  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              # The value must be ReadWriteOnce for EVS disks.
  resources:
    requests:
      storage: 10Gi            # EVS disk capacity, ranging from 1 to 32768. The value must be the same as the storage size of the existing PV.
```

```
storageClassName: csi-disk    # The storage class is EVS.
volumeName: pv-evs            # PV name.
```

Table 11-6 Key parameters

Parameter	Mandatory	Description
failure-domain.beta.kubernetes.io/region	Yes	Region where the cluster is located.
failure-domain.beta.kubernetes.io/zone	Yes	AZ where the EVS volume is created. It must be the same as the AZ planned for the workload.
storage	Yes	Requested capacity in the PVC, in Gi. The value must be the same as the storage size of the existing PV.
volumeName	Yes	PV name, which must be the same as the PV name in **1**.
storageClassName	Yes	Storage class name, which must be the same as the storage class of the PV in **1**. The storage class for EVS disks is **csi-disk**.

2. Run the following command to create a PVC:

```
kubectl apply -f pvc-evs.yaml
```

Step 4 Create an application.

1. Create a file named **web-evs.yaml**. In this example, the EVS volume is mounted to the **/data** path.

```
apiVersion: apps/v1
kind: StatefulSet
metadata:
  name: web-evs
  namespace: default
spec:
 replicas: 1            # The number of workload replicas that use the EVS volume must be 1.
  selector:
    matchLabels:
      app: web-evs
  serviceName: web-evs   # Headless Service name.
  template:
    metadata:
      labels:
        app: web-evs
    spec:
      containers:
      - name: container-1
        image: nginx:latest
        volumeMounts:
        - name: pvc-disk     # Volume name, which must be the same as the volume name in the volumes field.
          mountPath: /data  # Location where the storage volume is mounted.
      imagePullSecrets:
        - name: default-secret
      volumes:
```

```
      - name: pvc-disk    # Volume name, which can be customized.
        persistentVolumeClaim:
          claimName: pvc-evs    # Name of the created PVC.
---
apiVersion: v1
kind: Service
metadata:
  name: web-evs   # Headless Service name.
  namespace: default
  labels:
    app: web-evs
spec:
  selector:
    app: web-evs
  clusterIP: None
  ports:
    - name: web-evs
      targetPort: 80
      nodePort: 0
      port: 80
      protocol: TCP
  type: ClusterIP
```

2. Run the following command to create a workload to which the EVS volume is mounted:

```
kubectl apply -f web-evs.yaml
```

After the workload is created, the data in the container mount directory will be persistently stored. Verify the storage by referring to **Verifying Data Persistence**.

----End

Verifying Data Persistence

Step 1 View the deployed application and EVS volume files.

1. Run the following command to view the created pod:

```
kubectl get pod | grep web-evs
```

Expected output:

```
web-evs-0               1/1     Running   0             38s
```

2. Run the following command to check whether the EVS volume has been mounted to the **/data** path:

```
kubectl exec web-evs-0 -- df | grep data
```

Expected output:

```
/dev/sdc        10255636     36888  10202364   0% /data
```

3. Run the following command to view the files in the **/data** path:

```
kubectl exec web-evs-0 -- ls /data
```

Expected output:

```
lost+found
```

Step 2 Run the following command to create a file named **static** in the **/data** path:

```
kubectl exec web-evs-0 --  touch /data/static
```

Step 3 Run the following command to view the files in the **/data** path:

```
kubectl exec web-evs-0 -- ls /data
```

Expected output:

```
lost+found
static
```

Step 4 Run the following command to delete the pod named **web-evs-0**:

```
kubectl delete pod web-evs-0
```

Expected output:

```
pod "web-evs-0" deleted
```

Step 5 After the deletion, the StatefulSet controller automatically creates a replica with the same name. Run the following command to check whether the files in the **/data** path have been modified:

```
kubectl exec web-evs-0 -- ls /data
```

Expected output:

```
lost+found
static
```

If the **static** file still exists, the data in the EVS volume can be stored persistently.

----End

Related Operations

You can also perform the operations listed in **Table 11-7**.

Table 11-7 Related operations

Operation	Description	Procedure
Creating a storage volume (PV)	Create a PV on the CCE console.	1. Choose **Storage** in the navigation pane and click the **PVs** tab. Click **Create PersistentVolume** in the upper right corner. In the dialog box displayed, configure parameters. • **Volume Type**: Select **EVS**. • **EVS**: Click **Select EVS**. On the displayed page, select the EVS disk that meets your requirements and click **OK**. • **PV Name**: Enter the PV name, which must be unique in the same cluster. • **Access Mode**: EVS disks support only **ReadWriteOnce**, indicating that a storage volume can be mounted to one node in read/write mode. For details, see **Volume Access Modes**. • **Reclaim Policy**: **Delete** or **Retain** is supported. For details, see **PV Reclaim Policy**. 2. Click **Create**.

Operation	Description	Procedure
Expanding the capacity of an EVS disk	Quickly expand the capacity of a mounted EVS disk on the CCE console.	1. Choose **Storage** in the navigation pane and click the **PVCs** tab. Click **More** in the **Operation** column of the target PVC and select **Scale-out**. 2. Enter the capacity to be added and click **OK**.
Viewing events	You can view event names, event types, number of occurrences, Kubernetes events, first occurrence time, and last occurrence time of the PVC or PV.	1. Choose **Storage** in the navigation pane and click the **PVCs** or **PVs** tab. 2. Click **View Events** in the **Operation** column of the target PVC or PV to view events generated within one hour (event data is retained for one hour).
Viewing a YAML file	You can view, copy, and download the YAML files of a PVC or PV.	1. Choose **Storage** in the navigation pane and click the **PVCs** or **PVs** tab. 2. Click **View YAML** in the **Operation** column of the target PVC or PV to view or download the YAML.

11.3.3 Using an EVS Disk Through a Dynamic PV

CCE allows you to specify a StorageClass to automatically create an EVS disk and the corresponding PV. This function is applicable when no underlying storage volume is available.

Prerequisites

- You have created a cluster and installed the **CCE Container Storage (Everest)** add-on in the cluster.
- Before creating a cluster using commands, ensure kubectl is used to access the cluster. For details, see **Connecting to a Cluster Using kubectl**.

Constraints

- EVS disks cannot be attached across AZs and cannot be used by multiple workloads, multiple pods of the same workload, or multiple tasks. Data sharing of a shared disk is not supported between nodes in a CCE cluster. If an EVS disk is attacked to multiple nodes, I/O conflicts and data cache conflicts may occur. Therefore, create only one pod when creating a Deployment that uses EVS disks.
- For clusters earlier than v1.19.10, if an HPA policy is used to scale out a workload with EVS volumes mounted, the existing pods cannot be read or written when a new pod is scheduled to another node.

For clusters of v1.19.10 and later, if an HPA policy is used to scale out a workload with EVS volumes mounted, a new pod cannot be started because EVS disks cannot be attached.

- Resource tags can be added to dynamically created EVS disks. After the EVS disks are created, the resource tags cannot be updated on CCE. To update them, go to the EVS console. If you use an existing EVS disk to create a PV, you also need to add or update resource tags on the EVS console.

(Console) Automatically Creating an EVS Disk

Step 1 Log in to the CCE console and click the cluster name to access the cluster console.

Step 2 Dynamically create a PVC and PV.

1. Choose **Storage** in the navigation pane and click the **PVCs** tab. Click **Create PVC** in the upper right corner. In the dialog box displayed, configure the PVC parameters.

Parameter	Description
PVC Type	In this example, select **EVS**.
PVC Name	Enter the PVC name, which must be unique in the same namespace.
Creation Method	– If no underlying storage is available, select **Dynamically provision** to create a PVC, PV, and underlying storage on the console in cascading mode. – If underlying storage is available, create a storage volume or use an existing storage volume to statically create a PVC based on whether a PV is available. For details, see **Using an Existing EVS Disk Through a Static PV**. In this example, select **Dynamically provision**.
Storage Classes	The storage class for EVS disks is **csi-disk**.
AZ	Select the AZ of the EVS disk. The AZ must be the same as that of the cluster node. **NOTE** An EVS disk can only be mounted to a node in the same AZ. After an EVS disk is created, its AZ cannot be changed.
Disk Type	Select an EVS disk type. EVS disk types vary depending on regions. Obtain the available EVS types on the console.
Access Mode	EVS disks support only **ReadWriteOnce**, indicating that a storage volume can be mounted to one node in read/write mode. For details, see **Volume Access Modes**.
Capacity (GiB)	Capacity of the requested storage volume.

Parameter	Description
Encryption	Configure whether to encrypt underlying storage. If you select **Enabled (key)**, an encryption key must be configured. Before using encryption, check whether the region where the EVS disk is located supports disk encryption.
Enterprise Project	Supported enterprise projects: default, the one to which the cluster belongs, or the one specified by the storage class.
Resource Tag	You can add resource tags to classify resources, which is supported only when the Everest version in the cluster is 2.1.39 or later. You can create predefined tags on the TMS console. The predefined tags are available to all resources that support tags. You can use predefined tags to improve the tag creation and resource migration efficiency. CCE automatically creates system tags **CCE-Cluster-ID=***{Cluster ID}*, **CCE-Cluster-Name=***{Cluster name}*, and **CCE-Namespace=***{Namespace name}*. These tags cannot be modified. **NOTE** After a dynamic PV of the EVS type is created, the resource tags cannot be updated on the CCE console. To update these resource tags, go to the EVS console.

2. Click **Create**.

   You can choose **Storage** in the navigation pane and view the created PVC and PV on the **PVCs** and **PVs** tab pages, respectively.

Step 3 Create an application.

1. In the navigation pane on the left, click **Workloads**. In the right pane, click the **StatefulSets** tab.
2. Click **Create Workload** in the upper right corner. On the displayed page, click **Data Storage** in the **Container Settings** area and click **Add Volume** to select **PVC**.

   Mount and use storage volumes, as shown in **Table 11-8**. For details about other parameters, see **Workloads**.

   Table 11-8 Mounting a storage volume

Parameter	Description
PVC	Select an existing EVS volume. An EVS volume cannot be repeatedly mounted to multiple workloads.

Parameter	Description
Mount Path	Enter a mount path, for example, **/tmp**. This parameter indicates the container path to which a data volume will be mounted. Do not mount the volume to a system directory such as **/** or **/var/run**. Otherwise, containers will be malfunctional. Mount the volume to an empty directory. If the directory is not empty, ensure that there are no files that affect container startup. Otherwise, the files will be replaced, causing container startup failures or workload creation failures. **NOTICE** If a volume is mounted to a high-risk directory, use an account with minimum permissions to start the container. Otherwise, high-risk files on the host machine may be damaged.
Subpath	Enter the subpath of the storage volume and mount a path in the storage volume to the container. In this way, different folders of the same storage volume can be used in a single pod. **tmp**, for example, indicates that data in the mount path of the container is stored in the **tmp** folder of the storage volume. If this parameter is left blank, the root path is used by default.
Permission	– **Read-only**: You can only read the data in the mounted volumes. – **Read/Write**: You can modify the data volumes mounted to the path. Newly written data will not be migrated if the container is migrated, which may cause data loss.

In this example, the disk is mounted to the **/data** path of the container. The container data generated in this path is stored in the EVS disk.

NOTE

A non-shared EVS disk cannot be attached to multiple pods in a workload. Otherwise, the pods cannot start properly. Ensure that the number of workload pods is 1 when you attach an EVS disk.

3. After the configuration, click **Create Workload**.

   After the workload is created, the data in the container mount directory will be persistently stored. Verify the storage by referring to **Verifying Data Persistence**.

----End

(kubectl) Automatically Creating an EVS Disk

Step 1 Use kubectl to access the cluster.

Step 2 Use **StorageClass** to dynamically create a PVC and PV.

1. Create the **pvc-evs-auto.yaml** file.

```
apiVersion: v1
kind: PersistentVolumeClaim
metadata:
  name: pvc-evs-auto
  namespace: default
  annotations:
    everest.io/disk-volume-type: SAS    # EVS disk type.
    everest.io/crypt-key-id: <your_key_id>    # (Optional) Encryption key ID. Mandatory for an encrypted disk.
    everest.io/enterprise-project-id: <your_project_id>  # (Optional) Enterprise project ID. If an enterprise project is specified, use the same enterprise project when creating a PVC. Otherwise, the PVC cannot be bound to a PV.
    everest.io/disk-volume-tags: '{"key1":"value1","key2":"value2"}' # (Optional) Custom resource tags

  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              # The value must be ReadWriteOnce for EVS disks.
  resources:
    requests:
      storage: 10Gi            # EVS disk capacity, ranging from 1 to 32768.
  storageClassName: csi-disk    # The storage class is EVS.
```

Table 11-9 Key parameters

Parameter	Mandatory	Description
failure-domain.beta.kubernetes.io/region	Yes	Region where the cluster is located.
failure-domain.beta.kubernetes.io/zone	Yes	AZ where the EVS volume is created. It must be the same as the AZ planned for the workload.
everest.io/disk-volume-type	Yes	EVS disk type. All letters are in uppercase. – **SAS**: high I/O – **SSD**: ultra-high I/O
everest.io/crypt-key-id	No	This parameter is mandatory when an EVS disk is encrypted. Enter the encryption key ID selected during EVS disk creation. You can use a custom key or the default key named **evs/default**. To obtain a key ID, log in to the DEW console, locate the key to be encrypted, and copy the key ID.

Parameter	Mandatory	Description
everest.io/enterprise-project-id	No	Optional. Enterprise project ID of the EVS disk. If an enterprise project is specified, use the same enterprise project when creating a PVC. Otherwise, the PVC cannot be bound to a PV. To obtain an enterprise project ID, log in to the EPS console, click the name of the target enterprise project, and copy the enterprise project ID.
everest.io/disk-volume-tags	No	This field is optional. It is supported when the Everest version in the cluster is 2.1.39 or later. You can add resource tags to classify resources. You can create **predefined tags** on the TMS console. The predefined tags are available to all resources that support tags. You can use predefined tags to improve the tag creation and resource migration efficiency. CCE automatically creates system tags **CCE-Cluster-ID=***{Cluster ID}*, **CCE-Cluster-Name=***{Cluster name}*, and **CCE-Namespace=***{Namespace name}*. These tags cannot be modified.
storage	Yes	Requested PVC capacity, in Gi. The value ranges from **1** to **32768**.
storageClassName	Yes	The storage class for EVS disks is **csi-disk**.

2. Run the following command to create a PVC:
```
kubectl apply -f pvc-evs-auto.yaml
```

Step 3 Create an application.

1. Create a file named **web-evs-auto.yaml**. In this example, the EVS volume is mounted to the **/data** path.
```
apiVersion: apps/v1
kind: StatefulSet
metadata:
  name: web-evs-auto
  namespace: default
spec:
  replicas: 1
  selector:
    matchLabels:
      app: web-evs-auto
  serviceName: web-evs-auto   # Headless Service name.
  template:
    metadata:
```

```
      labels:
        app: web-evs-auto
    spec:
      containers:
      - name: container-1
        image: nginx:latest
        volumeMounts:
        - name: pvc-disk    # Volume name, which must be the same as the volume name in the volumes field.
          mountPath: /data  # Location where the storage volume is mounted.
      imagePullSecrets:
        - name: default-secret
      volumes:
        - name: pvc-disk    # Volume name, which can be customized.
          persistentVolumeClaim:
            claimName: pvc-evs-auto    # Name of the created PVC.
---
apiVersion: v1
kind: Service
metadata:
  name: web-evs-auto   # Headless Service name.
  namespace: default
  labels:
    app: web-evs-auto
spec:
  selector:
    app: web-evs-auto
  clusterIP: None
  ports:
    - name: web-evs-auto
      targetPort: 80
      nodePort: 0
      port: 80
      protocol: TCP
  type: ClusterIP
```

2. Run the following command to create a workload to which the EVS volume is mounted:

```
kubectl apply -f web-evs-auto.yaml
```

After the workload is created, the data in the container mount directory will be persistently stored. Verify the storage by referring to **Verifying Data Persistence**.

----End

Verifying Data Persistence

Step 1 View the deployed application and EVS volume files.

1. Run the following command to view the created pod:

```
kubectl get pod | grep web-evs-auto
```

Expected output:

```
web-evs-auto-0                1/1     Running   0             38s
```

2. Run the following command to check whether the EVS volume has been mounted to the **/data** path:

```
kubectl exec web-evs-auto-0 -- df | grep data
```

Expected output:

```
/dev/sdc            10255636     36888  10202364   0% /data
```

3. Run the following command to view the files in the **/data** path:

```
kubectl exec web-evs-auto-0 -- ls /data
```

Expected output:

```
lost+found
```

Step 2 Run the following command to create a file named **static** in the **/data** path:

```
kubectl exec web-evs-auto-0 --  touch /data/static
```

Step 3 Run the following command to view the files in the **/data** path:

```
kubectl exec web-evs-auto-0 -- ls /data
```

Expected output:

```
lost+found
static
```

Step 4 Run the following command to delete the pod named **web-evs-auto-0**:

```
kubectl delete pod web-evs-auto-0
```

Expected output:

```
pod "web-evs-auto-0" deleted
```

Step 5 After the deletion, the StatefulSet controller automatically creates a replica with the same name. Run the following command to check whether the files in the **/data** path have been modified:

```
kubectl exec web-evs-auto-0 -- ls /data
```

Expected output:

```
lost+found
static
```

If the **static** file still exists, the data in the EVS volume can be stored persistently.

----End

Related Operations

You can also perform the operations listed in **Table 11-10**.

Table 11-10 Related operations

Operation	Description	Procedure
Expanding the capacity of an EVS disk	Quickly expand the capacity of a mounted EVS disk on the CCE console.	1. Choose **Storage** in the navigation pane and click the **PVCs** tab. Click **More** in the **Operation** column of the target PVC and select **Scale-out**. 2. Enter the capacity to be added and click **OK**.
Viewing events	You can view event names, event types, number of occurrences, Kubernetes events, first occurrence time, and last occurrence time of the PVC or PV.	1. Choose **Storage** in the navigation pane and click the **PVCs** or **PVs** tab. 2. Click **View Events** in the **Operation** column of the target PVC or PV to view events generated within one hour (event data is retained for one hour).

Operation	Description	Procedure
Viewing a YAML file	You can view, copy, and download the YAML files of a PVC or PV.	1. Choose **Storage** in the navigation pane and click the **PVCs** or **PVs** tab. 2. Click **View YAML** in the **Operation** column of the target PVC or PV to view or download the YAML.

11.3.4 Dynamically Mounting an EVS Disk to a StatefulSet

Application Scenarios

Dynamic mounting is available only for creating a **StatefulSet**. It is implemented through a volume claim template (**volumeClaimTemplates** field) and depends on the storage class to dynamically provision PVs. In this mode, each pod in a multi-pod StatefulSet is associated with a unique PVC and PV. After a pod is rescheduled, the original data can still be mounted to it based on the PVC name. In the common mounting mode for a Deployment, if ReadWriteMany is supported, multiple pods of the Deployment will be mounted to the same underlying storage.

Prerequisites

- You have created a cluster and installed the **CCE Container Storage (Everest)** add-on in the cluster.
- Before creating a cluster using commands, ensure kubectl is used to access the cluster. For details, see **Connecting to a Cluster Using kubectl**.

(Console) Dynamically Mounting an EVS Disk

Step 1 Log in to the CCE console and click the cluster name to access the cluster console.

Step 2 In the navigation pane on the left, click **Workloads**. In the right pane, click the **StatefulSets** tab.

Step 3 Click **Create Workload** in the upper right corner. On the displayed page, click **Data Storage** in the **Container Settings** area and click **Add Volume** to select **VolumeClaimTemplate (VTC)**.

Step 4 Click **Create PVC**. In the dialog box displayed, configure the PVC parameters.

Click **Create**.

Parameter	Description
PVC Type	In this example, select **EVS**.
PVC Name	Enter the name of the PVC. After a PVC is created, a suffix is automatically added based on the number of pods. The format is <*Custom PVC name*>-<*Serial number*>, for example, example-0.

Parameter	Description
Creation Method	You can select **Dynamically provision** to create a PVC, PV, and underlying storage on the console in cascading mode.
Storage Classes	The storage class for EVS disks is **csi-disk**.
AZ	Select the AZ of the EVS disk. The AZ must be the same as that of the cluster node. **NOTE** An EVS disk can only be mounted to a node in the same AZ. After an EVS disk is created, its AZ cannot be changed.
Disk Type	Select an EVS disk type. EVS disk types vary depending on regions. Obtain the available EVS types on the console.
Access Mode	EVS disks support only **ReadWriteOnce**, indicating that a storage volume can be mounted to one node in read/write mode. For details, see **Volume Access Modes**.
Capacity (GiB)	Capacity of the requested storage volume.
Encryption	Configure whether to encrypt underlying storage. If you select **Enabled (key)**, an encryption key must be configured. Before using encryption, check whether the region where the EVS disk is located supports disk encryption.
Enterprise Project	Supported enterprise projects: default, the one to which the cluster belongs, or the one specified by the storage class.
Resource Tag	You can add resource tags to classify resources, which is supported only when the Everest version in the cluster is 2.1.39 or later. You can create **predefined tags** on the TMS console. The predefined tags are available to all resources that support tags. You can use predefined tags to improve the tag creation and resource migration efficiency. CCE automatically creates system tags **CCE-Cluster-ID=***{Cluster ID}*, **CCE-Cluster-Name=***{Cluster name}*, and **CCE-Namespace=***{Namespace name}*. These tags cannot be modified. **NOTE** After a dynamic PV of the EVS type is created, the resource tags cannot be updated on the CCE console. To update these resource tags, go to the EVS console.

Step 5 Enter the path to which the volume is mounted.

Table 11-11 Mounting a storage volume

Parameter	Description
Mount Path	Enter a mount path, for example, **/tmp**. This parameter indicates the container path to which a data volume will be mounted. Do not mount the volume to a system directory such as **/** or **/var/run**. Otherwise, containers will be malfunctional. Mount the volume to an empty directory. If the directory is not empty, ensure that there are no files that affect container startup. Otherwise, the files will be replaced, causing container startup failures or workload creation failures. **NOTICE** If a volume is mounted to a high-risk directory, use an account with minimum permissions to start the container. Otherwise, high-risk files on the host machine may be damaged.
Subpath	Enter the subpath of the storage volume and mount a path in the storage volume to the container. In this way, different folders of the same storage volume can be used in a single pod. **tmp**, for example, indicates that data in the mount path of the container is stored in the **tmp** folder of the storage volume. If this parameter is left blank, the root path is used by default.
Permission	• **Read-only**: You can only read the data in the mounted volumes. • **Read/Write**: You can modify the data volumes mounted to the path. Newly written data will not be migrated if the container is migrated, which may cause data loss.

In this example, the disk is mounted to the **/data** path of the container. The container data generated in this path is stored in the EVS disk.

Step 6 Dynamically mount and use storage volumes. For details about other parameters, see **Creating a StatefulSet**. After the configuration, click **Create Workload**.

After the workload is created, the data in the container mount directory will be persistently stored. Verify the storage by referring to **Verifying Data Persistence**.

----End

Dynamically Mounting an EVS Volume Using kubectl

Step 1 Use kubectl to access the cluster.

Step 2 Create a file named **statefulset-evs.yaml**. In this example, the EVS volume is mounted to the **/data** path.

```
apiVersion: apps/v1
kind: StatefulSet
metadata:
  name: statefulset-evs
  namespace: default
```

```
spec:
  selector:
    matchLabels:
      app: statefulset-evs
  template:
    metadata:
      labels:
        app: statefulset-evs
    spec:
      containers:
        - name: container-1
          image: nginx:latest
          volumeMounts:
            - name: pvc-disk          # The value must be the same as that in the volumeClaimTemplates field.
              mountPath: /data        # Location where the storage volume is mounted.
      imagePullSecrets:
        - name: default-secret
  serviceName: statefulset-evs        # Headless Service name.
  replicas: 2
  volumeClaimTemplates:
    - apiVersion: v1
      kind: PersistentVolumeClaim
      metadata:
        name: pvc-disk
        namespace: default
        annotations:
          everest.io/disk-volume-type: SAS    # EVS disk type.
          everest.io/crypt-key-id: <your_key_id>    # (Optional) Encryption key ID. Mandatory for an encrypted disk.
          everest.io/enterprise-project-id: <your_project_id> # (Optional) Enterprise project ID. If an enterprise project is specified, use the same enterprise project when creating a PVC. Otherwise, the PVC cannot be bound to a PV.
          everest.io/disk-volume-tags: '{"key1":"value1","key2":"value2"}' # (Optional) Custom resource tags

        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             # The value must be ReadWriteOnce for EVS disks.
        resources:
          requests:
            storage: 10Gi             # EVS disk capacity, ranging from 1 to 32768.
        storageClassName: csi-disk    # The storage class is EVS.
---
apiVersion: v1
kind: Service
metadata:
  name: statefulset-evs   # Headless Service name.
  namespace: default
  labels:
    app: statefulset-evs
spec:
  selector:
    app: statefulset-evs
  clusterIP: None
  ports:
    - name: statefulset-evs
      targetPort: 80
      nodePort: 0
      port: 80
      protocol: TCP
  type: ClusterIP
```

Table 11-12 Key parameters

Parameter	Mandatory	Description
failure-domain.beta.kubernetes.io/region	Yes	Region where the cluster is located.
failure-domain.beta.kubernetes.io/zone	Yes	AZ where the EVS volume is created. It must be the same as the AZ planned for the workload.
everest.io/disk-volume-type	Yes	EVS disk type. All letters are in uppercase. • **SAS**: high I/O • **SSD**: ultra-high I/O
everest.io/crypt-key-id	No	Mandatory when the EVS disk is encrypted. Enter the encryption key ID selected during EVS disk creation. To obtain the encryption key ID, log in to the **Cloud Server Console**. In the navigation pane, choose **Elastic Volume Service** > **Disks**. Click the name of the target EVS disk to go to its details page. On the **Summary** tab page, copy the value of **KMS Key ID** in the **Configuration Information** area.
everest.io/enterprise-project-id	No	Optional. Enterprise project ID of the EVS disk. If an enterprise project is specified, use the same enterprise project when creating a PVC. Otherwise, the PVC cannot be bound to a PV. To obtain the enterprise project ID, log in to the **Cloud Server Console**. In the navigation pane, choose **Elastic Volume Service** > **Disks**. Click the name of the target EVS disk to go to its details page. On the **Summary** tab page, click the enterprise project in **Management Information** to access the enterprise project console. Copy the corresponding ID to obtain the ID of the enterprise project to which the EVS disk belongs.

Parameter	Mandatory	Description
everest.io/disk-volume-tags	No	This field is optional. It is supported when the Everest version in the cluster is 2.1.39 or later. You can add resource tags to classify resources. You can create **predefined tags** on the TMS console. The predefined tags are available to all resources that support tags. You can use predefined tags to improve the tag creation and resource migration efficiency. CCE automatically creates system tags **CCE-Cluster-ID=***{Cluster ID}*, **CCE-Cluster-Name=***{Cluster name}*, and **CCE-Namespace=***{Namespace name}*. These tags cannot be modified.
storage	Yes	Requested PVC capacity, in Gi. The value ranges from **1** to **32768**.
storageClassName	Yes	The storage class for EVS disks is **csi-disk**.

Step 3 Run the following command to create a workload to which the EVS volume is mounted:

```
kubectl apply -f statefulset-evs.yaml
```

After the workload is created, the data in the container mount directory will be persistently stored. Verify the storage by referring to **Verifying Data Persistence**.

----End

Verifying Data Persistence

Step 1 View the deployed application and EVS volume files.

1. Run the following command to view the created pod:

   ```
   kubectl get pod | grep statefulset-evs
   ```

   Expected output:

   ```
   statefulset-evs-0       1/1     Running   0          45s
   statefulset-evs-1       1/1     Running   0          28s
   ```

2. Run the following command to check whether the EVS volume has been mounted to the **/data** path:

   ```
   kubectl exec statefulset-evs-0 -- df | grep data
   ```

   Expected output:

   ```
   /dev/sdd        10255636     36888  10202364   0% /data
   ```

3. Run the following command to view the files in the **/data** path:

   ```
   kubectl exec statefulset-evs-0 -- ls /data
   ```

   Expected output:

   ```
   lost+found
   ```

Step 2 Run the following command to create a file named **static** in the **/data** path:

```
kubectl exec statefulset-evs-0 --  touch /data/static
```

Step 3 Run the following command to view the files in the **/data** path:

```
kubectl exec statefulset-evs-0 -- ls /data
```

Expected output:

```
lost+found
static
```

Step 4 Run the following command to delete the pod named **web-evs-auto-0**:

```
kubectl delete pod statefulset-evs-0
```

Expected output:

```
pod "statefulset-evs-0" deleted
```

Step 5 After the deletion, the StatefulSet controller automatically creates a replica with the same name. Run the following command to check whether the files in the **/data** path have been modified:

```
kubectl exec statefulset-evs-0 -- ls /data
```

Expected output:

```
lost+found
static
```

If the **static** file still exists, the data in the EVS volume can be stored persistently.

----End

Related Operations

You can also perform the operations listed in **Table 11-13**.

Table 11-13 Related operations

Operation	Description	Procedure
Expanding the capacity of an EVS disk	Quickly expand the capacity of a mounted EVS disk on the CCE console.	1. Choose **Storage** in the navigation pane and click the **PVCs** tab. Click **More** in the **Operation** column of the target PVC and select **Scale-out**. 2. Enter the capacity to be added and click **OK**.
Viewing events	You can view event names, event types, number of occurrences, Kubernetes events, first occurrence time, and last occurrence time of the PVC or PV.	1. Choose **Storage** in the navigation pane and click the **PVCs** or **PVs** tab. 2. Click **View Events** in the **Operation** column of the target PVC or PV to view events generated within one hour (event data is retained for one hour).

Operation	Description	Procedure
Viewing a YAML file	You can view, copy, and download the YAML files of a PVC or PV.	1. Choose **Storage** in the navigation pane and click the **PVCs** or **PVs** tab. 2. Click **View YAML** in the **Operation** column of the target PVC or PV to view or download the YAML.

11.3.5 Snapshots and Backups

CCE works with EVS to support snapshots. A snapshot is a complete copy or image of EVS disk data at a certain point of time, which can be used for data DR.

You can create snapshots to rapidly save the disk data at a certain point of time. In addition, you can use snapshots to create disks so that the created disks will contain the snapshot data in the beginning.

Precautions

- The snapshot function is available **only for clusters of v1.15 or later** and requires the CSI-based Everest add-on.
- The subtype (common I/O, high I/O, or ultra-high I/O), disk mode (SCSI or VBD), data encryption, sharing status, and capacity of an EVS disk created from a snapshot must be the same as those of the disk associated with the snapshot. These attributes cannot be modified after being queried or set.
- Snapshots can be created only for EVS disks that are available or in use, and a maximum of seven snapshots can be created for a single EVS disk.
- Snapshots can be created only for PVCs created using the storage class (whose name starts with csi) provided by the Everest add-on. Snapshots cannot be created for PVCs created using the Flexvolume storage class whose name is ssd, sas, or sata.
- Snapshot data of encrypted disks is stored encrypted, and that of non-encrypted disks is stored non-encrypted.

Application Scenarios

The snapshot feature helps address your following needs:

- **Routine data backup**

  You can create snapshots for EVS disks regularly and use snapshots to recover your data in case that data loss or data inconsistency occurred due to misoperations, viruses, or attacks.

- **Rapid data restoration**

  You can create a snapshot or multiple snapshots before an OS change, application software upgrade, or a service data migration. If an exception occurs during the upgrade or migration, service data can be rapidly restored to the time point when the snapshot was created.

  For example, a fault occurred on system disk A of ECS A, and therefore ECS A cannot be started. Because system disk A is already faulty, the data on system

disk A cannot be restored by rolling back snapshots. In this case, you can use an existing snapshot of system disk A to create EVS disk B and attach it to ECS B that is running properly. Then, ECS B can read data from system disk A using EVS disk B.

NOTE

The snapshot capability provided by CCE is the same as the CSI snapshot function provided by the Kubernetes community. EVS disks can be created only based on snapshots, and snapshots cannot be rolled back to source EVS disks.

- **Rapid deployment of multiple services**

  You can use a snapshot to create multiple EVS disks containing the same initial data, and these disks can be used as data resources for various services, for example, data mining, report query, and development and testing. This method protects the initial data and creates disks rapidly, meeting the diversified service data requirements.

Creating a Snapshot

Using the CCE console

Step 1 Log in to the CCE console.

Step 2 Click the cluster name to go to the cluster console. Choose **Storage** in the navigation pane and click the **Snapshots and Backups** tab.

Step 3 Click **Create Snapshot** in the upper right corner. In the dialog box displayed, set related parameters.

- **Snapshot Name**: Enter a snapshot name.
- **Storage**: Select an EVS PVC.

Step 4 Click **Create**.

----End

Using YAML

```
kind: VolumeSnapshot
apiVersion: snapshot.storage.k8s.io/v1beta1
metadata:
  finalizers:
    - snapshot.storage.kubernetes.io/volumesnapshot-as-source-protection
    - snapshot.storage.kubernetes.io/volumesnapshot-bound-protection
  name: cce-disksnap-test   # Snapshot name
  namespace: default
spec:
  source:
    persistentVolumeClaimName: pvc-evs-test     # PVC name. Only an EVS PVC can be selected.
  volumeSnapshotClassName: csi-disk-snapclass
```

Using a Snapshot to Create a PVC

The disk type, encryption setting, and disk mode of the created EVS PVC are consistent with those of the snapshot's source EVS disk.

Using the CCE console

Step 1 Log in to the CCE console.

Step 2 Click the cluster name to go to the cluster console. Choose **Storage** in the navigation pane and click the **Snapshots and Backups** tab.

Step 3 Locate the snapshot that you want to use for creating a PVC, click **Create PVC**, and configure PVC parameters in the displayed dialog box.

- **PVC Name**: Enter a PVC name.

Step 4 Click **Create**.

----End

Using YAML

```
apiVersion: v1
kind: PersistentVolumeClaim
metadata:
  name: pvc-test
  namespace: default
  annotations:
    everest.io/disk-volume-type: SSD    # EVS disk type, which must be the same as that of the snapshot's source EVS disk.


  labels:
    failure-domain.beta.kubernetes.io/region: <your_region>   # Replace the region with the one where the EVS disk is located.
    failure-domain.beta.kubernetes.io/zone: <your_zone>       # Replace the AZ with the one where the EVS disk is located.
spec:
  accessModes:
  - ReadWriteOnce
  resources:
    requests:
      storage: 10Gi
  storageClassName: csi-disk
  dataSource:
    name: cce-disksnap-test            # Snapshot name
    kind: VolumeSnapshot
    apiGroup: snapshot.storage.k8s.io
```

11.4 SFS Turbo

11.4.1 Overview

Introduction

CCE allows you to mount storage volumes created by SFS Turbo file systems to a path of a container to meet data persistence requirements. SFS Turbo file systems are fast, on-demand, and scalable, which are suitable for scenarios with a massive number of small files, such as DevOps, containerized microservices, and enterprise office applications.

Expandable to 320 TB, SFS Turbo provides a fully hosted shared file storage, which is highly available and stable, to support small files and applications requiring low latency and high IOPS.

- **Standard file protocols**: You can mount file systems as volumes to servers, the same as using local directories.
- **Data sharing**: The same file system can be mounted to multiple servers, so that data can be shared.

- **Private network**: Users can access data only in private networks of data centers.
- **Data isolation**: The on-cloud storage service provides exclusive cloud file storage, which delivers data isolation and ensures IOPS performance.
- **Use cases**: Deployments/StatefulSets in the ReadWriteMany mode, DaemonSets, and jobs created for high-traffic websites, log storage, DevOps, and enterprise OA applications

Application Scenarios

SFS Turbo supports the following mounting modes:

- **Using an Existing SFS Turbo File System Through a Static PV**: static creation mode, where you use an existing SFS volume to create a PV and then mount storage to the workload through a PVC.
- **Using StorageClass to Dynamically Create a Subdirectory in an SFS Turbo File System**: SFS Turbo allows you to dynamically create subdirectories and mount them to containers so that SFS Turbo can be shared and the SFS Turbo storage capacity can be used more economically and properly.

11.4.2 Using an Existing SFS Turbo File System Through a Static PV

SFS Turbo is a shared file system with high availability and durability. It is suitable for applications that contain massive small files and require low latency, and high IOPS. This section describes how to use an existing SFS Turbo file system to statically create PVs and PVCs for data persistence and sharing in workloads.

Prerequisites

- You have created a cluster and installed the **CCE Container Storage (Everest)** add-on in the cluster.
- Before creating a cluster using commands, ensure kubectl is used to access the cluster. For details, see **Connecting to a Cluster Using kubectl**.
- You have created an available SFS Turbo file system, and the SFS Turbo file system and the cluster are in the same VPC.

Constraints

- Multiple PVs can use the same SFS or SFS Turbo file system with the following restrictions:
  - Do not mount all PVCs/PVs that use the same underlying SFS or SFS Turbo file system to a pod. This leads to a pod startup failure because not all PVCs can be mounted to the pod due to the same **volumeHandle** values of these PVs.
  - The **persistentVolumeReclaimPolicy** parameter in the PVs is suggested to be set to **Retain**. Otherwise, when a PV is deleted, the associated underlying volume may be deleted. In this case, other PVs associated with the underlying volume malfunction.
  - When the underlying volume is repeatedly used, enable isolation and protection for ReadWriteMany at the application layer to prevent data overwriting and loss.

Using an Existing SFS Turbo File System on the Console

Step 1 Log in to the CCE console and click the cluster name to access the cluster console.

Step 2 Statically create a PVC and PV.

1. Choose **Storage** in the navigation pane and click the **PVCs** tab. Click **Create PVC** in the upper right corner. In the dialog box displayed, configure the PVC parameters.

Parameter	Description
PVC Type	In this example, select **SFS Turbo**.
PVC Name	Enter the PVC name, which must be unique in the same namespace.
Creation Method	You can create a storage volume or use an existing storage volume to statically create a PVC based on whether a PV has been created. In this example, select **Create new** to create a PV and PVC at the same time on the console.
PV[a]	Select an existing PV volume in the cluster. Create a PV in advance. For details, see "Creating a storage volume" in **Related Operations**. You do not need to specify this parameter in this example.
SFS Turbo[b]	Click **Select SFS Turbo**. On the displayed page, select the SFS Turbo file system that meets your requirements and click **OK**.
PV Name[b]	Enter the PV name, which must be unique in the same cluster.
Access Mode[b]	SFS Turbo volumes support only **ReadWriteMany**, indicating that a storage volume can be mounted to multiple nodes in read/write mode. For details, see **Volume Access Modes**.
Reclaim Policy[b]	Only **Retain** is available. This indicates that the PV is not deleted when the PVC is deleted. For details, see **PV Reclaim Policy**.
Mount Options[b]	Enter the mounting parameter key-value pairs. For details, see **Configuring SFS Turbo Mount Options**.

NOTE

a: The parameter is available when **Creation Method** is set to **Use existing**.

b: The parameter is available when **Creation Method** is set to **Create new**.

2. Click **Create** to create a PVC and a PV.

You can choose **Storage** in the navigation pane and view the created PVC and PV on the **PVCs** and **PVs** tab pages, respectively.

Step 3 Create an application.

1. In the navigation pane on the left, click **Workloads**. In the right pane, click the **Deployments** tab.
2. Click **Create Workload** in the upper right corner. On the displayed page, click **Data Storage** in the **Container Settings** area and click **Add Volume** to select **PVC**.

   Mount and use storage volumes, as shown in **Table 11-14**. For details about other parameters, see **Workloads**.

   Table 11-14 Mounting a storage volume

Parameter	Description
PVC	Select an existing SFS Turbo volume.
Mount Path	Enter a mount path, for example, **/tmp**. This parameter indicates the container path to which a data volume will be mounted. Do not mount the volume to a system directory such as **/** or **/var/run**. Otherwise, containers will be malfunctional. Mount the volume to an empty directory. If the directory is not empty, ensure that there are no files that affect container startup. Otherwise, the files will be replaced, causing container startup failures or workload creation failures. **NOTICE** If a volume is mounted to a high-risk directory, use an account with minimum permissions to start the container. Otherwise, high-risk files on the host machine may be damaged.
Subpath	Enter the subpath of the storage volume and mount a path in the storage volume to the container. In this way, different folders of the same storage volume can be used in a single pod. **tmp**, for example, indicates that data in the mount path of the container is stored in the **tmp** folder of the storage volume. If this parameter is left blank, the root path is used by default.
Permission	– **Read-only**: You can only read the data in the mounted volumes. – **Read/Write**: You can modify the data volumes mounted to the path. Newly written data will not be migrated if the container is migrated, which may cause data loss.

   In this example, the disk is mounted to the **/data** path of the container. The container data generated in this path is stored in the SFS Turbo file system.

3. After the configuration, click **Create Workload**.

After the workload is created, the data in the container mount directory will be persistently stored. Verify the storage by referring to **Verifying Data Persistence and Sharing**.

----End

(kubectl) Using an Existing SFS File System

Step 1 Use kubectl to access the cluster.

Step 2 Create a PV.

1. Create the **pv-sfsturbo.yaml** file.

```
apiVersion: v1
kind: PersistentVolume
metadata:
  annotations:
    pv.kubernetes.io/provisioned-by: everest-csi-provisioner
  name: pv-sfsturbo    # PV name.
spec:
  accessModes:
  - ReadWriteMany      # Access mode. The value must be ReadWriteMany for SFS Turbo.
  capacity:
    storage: 500Gi     # SFS Turbo volume capacity.
  csi:
    driver: sfsturbo.csi.everest.io    # Dependent storage driver for the mounting.
    fsType: nfs
    volumeHandle: <your_volume_id>  # SFS Turbo volume ID.
    volumeAttributes:
      everest.io/share-export-location: <your_location>  # Shared path of the SFS Turbo volume.
      everest.io/enterprise-project-id: <your_project_id>  # Project ID of the SFS Turbo volume.

      storage.kubernetes.io/csiProvisionerIdentity: everest-csi-provisioner
  persistentVolumeReclaimPolicy: Retain    # Reclaim policy.
  storageClassName: csi-sfsturbo         # Storage class name of the SFS Turbo file system.
  mountOptions: []                       # Mount options.
```

Table 11-15 Key parameters

Parameter	Mandatory	Description
volumeHandle	Yes	SFS Turbo volume ID. How to obtain: Log in to the CCE console, choose **Service List** > **Storage** > **Scalable File Service**, and select **SFS Turbo**. In the list, click the name of the target SFS Turbo volume. On the details page, copy the content following **ID**.
everest.io/share-export-location	Yes	Shared path of the SFS Turbo volume. Log in to the CCE console, choose **Service List** > **Storage** > **Scalable File Service**, and select **SFS Turbo**. You can obtain the shared path of the file system from the **Mount Address** column.

Parameter	Mandatory	Description
everest.io/enterprise-project-id	No	Project ID of the SFS Turbo volume. How to obtain: On the SFS console, click **SFS Turbo** in the left navigation pane. Click the name of the SFS Turbo file system to interconnect. On the **Basic Info** tab, find and click the enterprise project to go to the console, and copy the ID.
mountOptions	No	Mount options. If not specified, the following configurations are used by default. For details, see **Configuring SFS Turbo Mount Options**. mountOptions: - vers=3 - timeo=600 - nolock - hard
persistentVolumeReclaimPolicy	Yes	A reclaim policy is supported when the cluster version is or later than 1.19.10 and the Everest version is or later than 1.2.9. Only the **Retain** reclaim policy is supported. For details, see **PV Reclaim Policy**. **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 is in the **Released** status and cannot be bound to the PVC again.
storage	Yes	Requested capacity in the PVC, in Gi.
storageClassName	Yes	The storage class name of SFS Turbo volumes is **csi-sfsturbo**.

2. Run the following command to create a PV:
```
kubectl apply -f pv-sfsturbo.yaml
```

Step 3 Create a PVC.

1. Create the **pvc-sfsturbo.yaml** file.
```
apiVersion: v1
kind: PersistentVolumeClaim
metadata:
  name: pvc-sfsturbo
  namespace: default
  annotations:
    volume.beta.kubernetes.io/storage-provisioner: everest-csi-provisioner
    everest.io/enterprise-project-id: <your_project_id>  # Project ID of the SFS Turbo volume.

spec:
  accessModes:
  - ReadWriteMany               # The value must be ReadWriteMany for SFS Turbo.
  resources:
    requests:
```

```
    storage: 500Gi              # SFS Turbo volume capacity.
  storageClassName: csi-sfsturbo      # Storage class of the SFS Turbo volume, which must be the same as that of the PV.
  volumeName: pv-sfsturbo    # PV name.
```

Table 11-16 Key parameters

Parameter	Mandatory	Description
everest.io/enterprise-project-id	No	Project ID of the SFS Turbo volume. How to obtain: On the SFS console, click **SFS Turbo** in the left navigation pane. Click the name of the SFS Turbo file system to interconnect. On the **Basic Info** tab, find and click the enterprise project to go to the console, and copy the ID.
storage	Yes	Requested capacity in the PVC, in Gi. The value must be the same as the storage size of the existing PV.
storageClassName	Yes	Storage class name, which must be the same as the storage class of the PV in **1**. The storage class name of SFS Turbo volumes is **csi-sfsturbo**.
volumeName	Yes	PV name, which must be the same as the PV name in **1**.

2. Run the following command to create a PVC:
```
kubectl apply -f pvc-sfsturbo.yaml
```

Step 4 Create an application.

1. Create a file named **web-demo.yaml**. In this example, the SFS Turbo volume is mounted to the **/data** path.
```
apiVersion: apps/v1
kind: Deployment
metadata:
  name: web-demo
  namespace: default
spec:
  replicas: 2
  selector:
    matchLabels:
      app: web-demo
  template:
    metadata:
      labels:
        app: web-demo
    spec:
      containers:
      - name: container-1
        image: nginx:latest
        volumeMounts:
        - name: pvc-sfsturbo-volume    #Volume name, which must be the same as the volume name in the volumes field.
          mountPath: /data  # Location where the storage volume is mounted.
      imagePullSecrets:
```

```
    - name: default-secret
  volumes:
    - name: pvc-sfsturbo-volume    # Volume name, which can be customized.
      persistentVolumeClaim:
        claimName: pvc-sfsturbo    # Name of the created PVC.
```

2. Run the following command to create a workload to which the SFS Turbo volume is mounted:

```
kubectl apply -f web-demo.yaml
```

After the workload is created, you can try **Verifying Data Persistence and Sharing**.

----End

Verifying Data Persistence and Sharing

Step 1 View the deployed application and files.

1. Run the following command to view the created pod:

```
kubectl get pod | grep web-demo
```

Expected output:

```
web-demo-846b489584-mjhm9   1/1     Running   0          46s
web-demo-846b489584-wvv5s   1/1     Running   0          46s
```

2. Run the following commands in sequence to view the files in the **/data** path of the pods:

```
kubectl exec web-demo-846b489584-mjhm9 -- ls /data
kubectl exec web-demo-846b489584-wvv5s -- ls /data
```

If no result is returned for both pods, no file exists in the **/data** path.

Step 2 Run the following command to create a file named **static** in the **/data** path:

```
kubectl exec web-demo-846b489584-mjhm9 --  touch /data/static
```

Step 3 Run the following command to view the files in the **/data** path:

```
kubectl exec web-demo-846b489584-mjhm9 -- ls /data
```

Expected output:

```
static
```

Step 4 **Verify data persistence.**

1. Run the following command to delete the pod named **web-demo-846b489584-mjhm9**:

```
kubectl delete pod web-demo-846b489584-mjhm9
```

Expected output:

```
pod "web-demo-846b489584-mjhm9" deleted
```

After the deletion, the Deployment controller automatically creates a replica.

2. Run the following command to view the created pod:

```
kubectl get pod | grep web-demo
```

The expected output is as follows, in which **web-demo-846b489584-d4d4j** is the newly created pod:

```
web-demo-846b489584-d4d4j   1/1     Running   0          110s
web-demo-846b489584-wvv5s   1/1     Running   0          7m50s
```

3. Run the following command to check whether the files in the **/data** path of the new pod have been modified:

```
kubectl exec web-demo-846b489584-d4d4j -- ls /data
```

Expected output:

```
static
```

If the **static** file still exists, the data can be stored persistently.

Step 5 Verify data sharing.

1. Run the following command to view the created pod:
   ```
   kubectl get pod | grep web-demo
   ```
   Expected output:
   ```
   web-demo-846b489584-d4d4j   1/1     Running   0          7m
   web-demo-846b489584-wvv5s   1/1     Running   0          13m
   ```
2. Run the following command to create a file named **share** in the **/data** path of either pod: In this example, select the pod named **web-demo-846b489584-d4d4j**.
   ```
   kubectl exec web-demo-846b489584-d4d4j --  touch /data/share
   ```
   Check the files in the **/data** path of the pod.
   ```
   kubectl exec web-demo-846b489584-d4d4j -- ls /data
   ```
   Expected output:
   ```
   share
   static
   ```
3. Check whether the **share** file exists in the **/data** path of another pod (**web-demo-846b489584-wvv5s**) as well to verify data sharing.
   ```
   kubectl exec web-demo-846b489584-wvv5s -- ls /data
   ```
   Expected output:
   ```
   share
   static
   ```
   After you create a file in the **/data** path of a pod, if the file is also created in the **/data** path of the other pod, the two pods share the same volume.

----End

Related Operations

You can also perform the operations listed in **Table 11-17**.

Table 11-17 Related operations

Operation	Description	Procedure
Creating a storage volume (PV)	Create a PV on the CCE console.	1. Choose **Storage** in the navigation pane and click the **PVs** tab. Click **Create PersistentVolume** in the upper right corner. In the dialog box displayed, configure parameters. • **Volume Type**: Select **SFS Turbo**. • **SFS Turbo**: Click **Select SFS Turbo**. On the page displayed, select the SFS Turbo volume that meets the requirements and click **OK**. • **PV Name**: Enter the PV name, which must be unique in the same cluster. • **Access Mode**: SFS volumes support only **ReadWriteMany**, indicating that a storage volume can be mounted to multiple nodes in read/write mode. For details, see **Volume Access Modes**. • **Reclaim Policy**: Only **Retain** is supported. For details, see **PV Reclaim Policy**. • **Mount Options**: Enter the mounting parameter key-value pairs. For details, see **Configuring SFS Turbo Mount Options**. 2. Click **Create**.
Expanding the capacity of an SFS Turbo volume	Quickly expand the capacity of a mounted SFS Turbo volume on the CCE console.	1. Choose **Storage** in the navigation pane and click the **PVCs** tab. Click **More** in the **Operation** column of the target PVC and select **Scale-out**. 2. Enter the capacity to be added and click **OK**.
Viewing events	You can view event names, event types, number of occurrences, Kubernetes events, first occurrence time, and last occurrence time of the PVC or PV.	1. Choose **Storage** in the navigation pane and click the **PVCs** or **PVs** tab. 2. Click **View Events** in the **Operation** column of the target PVC or PV to view events generated within one hour (event data is retained for one hour).

Operation	Description	Procedure
Viewing a YAML file	You can view, copy, and download the YAML files of a PVC or PV.	1. Choose **Storage** in the navigation pane and click the **PVCs** or **PVs** tab. 2. Click **View YAML** in the **Operation** column of the target PVC or PV to view or download the YAML.

11.4.3 Configuring SFS Turbo Mount Options

This section describes how to configure SFS Turbo mount options. For SFS Turbo, you can only set mount options in a PV and bind the PV by creating a PVC.

Prerequisites

The **CCE Container Storage (Everest)** add-on version must be **1.2.8 or later**. This add-on identifies the mount options and transfers them to the underlying storage resources. The parameter settings take effect only if the underlying storage resources support the specified options.

Constraints

- Due to the restrictions of the NFS protocol, if an SFS volume is mounted to a node for multiple times, link-related mounting parameters (such as **timeo**) take effect only when the SFS volume is mounted for the first time by default. For example, if the same SFS file system is mounted to multiple pods running on a node, the mounting parameter set later does not overwrite the existing parameter value. If you want to configure different mounting parameters in the preceding scenario, additionally configure the **nosharecache** parameter.

SFS Turbo Mount Options

The Everest add-on in CCE presets the options described in **Table 11-18** for mounting SFS Turbo volumes.

Table 11-18 SFS Turbo mount options

Parameter	Value	Description
vers	3	File system version. Currently, only NFSv3 is supported. Value: **3**
nolock	Blank	Whether to lock files on the server using the NLM protocol. If **nolock** is selected, the lock is valid for applications on one host. For applications on another host, the lock is invalid.
timeo	600	Waiting time before the NFS client retransmits a request. The unit is 0.1 seconds. Recommended value: **600**

Parameter	Value	Description
hard/soft	Blank	Mount mode. • **hard**: If the NFS request times out, the client keeps resending the request until the request is successful. • **soft**: If the NFS request times out, the client returns an error to the invoking program. The default value is **hard**.
sharecache/ nosharecache	Blank	How the data cache and attribute cache are shared when one file system is concurrently mounted to different clients. If this parameter is set to **sharecache**, the caches are shared. If this parameter is set to **nosharecache**, the caches are not shared, and one cache is configured for each client mounting. The default value is **sharecache**. **NOTE** The **nosharecache** setting will affect the performance. The mounting information must be obtained for each mounting, which increases the communication overhead with the NFS server and the memory consumption of the NFS clients. In addition, the **nosharecache** setting on the NFS clients may lead to inconsistent caches. Determine whether to use **nosharecache** based on site requirements.

Configuring Mount Options in a PV

You can use the **mountOptions** field to configure mount options in a PV. The options you can configure in **mountOptions** are listed in **SFS Turbo Mount Options**.

Step 1 Use kubectl to connect to the cluster. For details, see **Connecting to a Cluster Using kubectl**.

Step 2 Configure mount options in a PV. Example:

```
apiVersion: v1
kind: PersistentVolume
metadata:
  annotations:
    pv.kubernetes.io/provisioned-by: everest-csi-provisioner
  name: pv-sfsturbo    # PV name.
spec:
  accessModes:
  - ReadWriteMany      # Access mode. The value must be ReadWriteMany for SFS Turbo.
  capacity:
    storage: 500Gi       # SFS Turbo volume capacity.
  csi:
    driver: sfsturbo.csi.everest.io    # Dependent storage driver for the mounting.
    fsType: nfs
    volumeHandle: {your_volume_id}   # SFS Turbo volume ID
    volumeAttributes:
      everest.io/share-export-location: {your_location}   # Shared path of the SFS Turbo volume.
      everest.io/enterprise-project-id: {your_project_id} # Project ID of the SFS Turbo volume.
```

```
    storage.kubernetes.io/csiProvisionerIdentity: everest-csi-provisioner
persistentVolumeReclaimPolicy: Retain     # Reclaim policy.
storageClassName: csi-sfsturbo            # SFS Turbo storage class name.
mountOptions:                             # Mount options.
- vers=3
- nolock
- timeo=600
- hard
```

Step 3 After a PV is created, you can create a PVC and bind it to the PV, and then mount the PV to the container in the workload. For details, see **Using an Existing SFS Turbo File System Through a Static PV**.

Step 4 Check whether the mount options take effect.

In this example, the PVC is mounted to the workload that uses the **nginx:latest** image. You can run the **mount -l** command to check whether the mount options take effect.

1. View the pod to which the SFS Turbo volume has been mounted. In this example, the workload name is **web-sfsturbo**.
   ```
   kubectl get pod | grep web-sfsturbo
   ```
   Command output:
   ```
   web-sfsturbo-***  1/1     Running   0          23m
   ```
2. Run the following command to check the mount options (**web-sfsturbo-****** is an example pod):
   ```
   kubectl exec -it web-sfsturbo-*** -- mount -l | grep nfs
   ```
   If the mounting information in the command output is consistent with the configured mount options, the mount options have been configured.
   ```
   <Your mount path> on /data type nfs
   (rw,relatime,vers=3,rsize=1048576,wsize=1048576,namlen=255,hard,nolock,noresvport,proto=tcp,
   timeo=600,retrans=2,sec=sys,mountaddr=**.**.**.**,mountvers=3,mountport=20048,mountproto=tc
   p,local_lock=all,addr=**.**.**.**)
   ```

----End

11.4.4 Using StorageClass to Dynamically Create a Subdirectory in an SFS Turbo File System

Background

The minimum capacity of an SFS Turbo file system is 500 GiB. 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.

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.
- 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
mountOptions:
- 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/
  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
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. **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
  namespace: default
spec:
  accessModes:
  - ReadWriteMany
  resources:
    requests:
      storage: 50Gi
  storageClassName: sfsturbo-subpath-sc
  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
  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
        name: container-0
        volumeMounts:
        - mountPath: /tmp
          name: pvc-sfs-turbo-example
      restartPolicy: Always
      imagePullSecrets:
      - name: default-secret
      volumes:
      - name: pvc-sfs-turbo-example
        persistentVolumeClaim:
          claimName: sfs-turbo-test
```

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
  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'
          resources: {}
          volumeMounts:
            - name: sfs-turbo-160024548582479676
              mountPath: /tmp
          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:
          - ReadWriteOnce
        resources:
          requests:
            storage: 10Gi
        storageClassName: sfsturbo-subpath-sc
  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

11.5 Object Storage Service

11.5.1 Overview

Introduction

Object Storage Service (OBS) provides massive, secure, and cost-effective data storage capabilities for you to store data of any type and size. You can use it in enterprise backup/archiving, video on demand (VoD), video surveillance, and many other scenarios.

- **Standard APIs**: With HTTP RESTful APIs, OBS allows you to use client tools or third-party tools to access object storage.
- **Data sharing**: Servers, embedded devices, and IoT devices can use the same path to access shared object data in OBS.
- **Public/Private networks**: OBS allows data to be accessed from public networks to meet Internet application requirements.
- **Capacity and performance**: No capacity limit; high performance (read/write I/O latency within 10 ms).
- **Use cases**: Deployments/StatefulSets in the **ReadOnlyMany** mode and jobs created for big data analysis, static website hosting, online VOD, gene sequencing, intelligent video surveillance, backup and archiving, and enterprise cloud boxes (web disks). You can create object storage by using the OBS console, tools, and SDKs.

OBS Specifications

OBS provides multiple storage classes to meet customers' requirements on storage performance and costs.

- Parallel File System (PFS, **recommended**): It is an optimized high-performance file system provided by OBS. It provides millisecond-level access latency, TB/s-level bandwidth, and million-level IOPS, and can quickly process HPC workloads. PFS outperforms OBS buckets.
- Object bucket (**not recommended**):
  - Standard: features low latency and high throughput. It is therefore good for storing frequently (multiple times per month) accessed files or small

files (less than 1 MB). Its application scenarios include big data analytics, mobile apps, hot videos, and social apps.

- OBS Infrequent Access: applicable to storing semi-frequently accessed (less than 12 times a year) data requiring quick response. Its application scenarios include file synchronization or sharing, and enterprise-level backup. This storage class has the same durability, low latency, and high throughput as the Standard storage class, with a lower cost, but its availability is slightly lower than the Standard storage class.

Application Scenarios

OBS supports the following mounting modes based on application scenarios:

- **Using an Existing OBS Bucket Through a Static PV**: static creation mode, where you use an existing OBS volume to create a PV and then mount storage to the workload through a PVC. This mode applies to scenarios where the underlying storage is available.
- **Using an OBS Bucket Through a Dynamic PV**: dynamic creation mode, where you do not need to create OBS volumes in advance. Instead, specify a StorageClass during PVC creation and an OBS volume and a PV will be automatically created. This mode applies to scenarios where no underlying storage is available.

11.5.2 Using an Existing OBS Bucket Through a Static PV

This section describes how to use an existing Object Storage Service (OBS) bucket to statically create PVs and PVCs and implement data persistence and sharing in workloads.

Prerequisites

- You have created a cluster and installed the **CCE Container Storage (Everest)** add-on in the cluster.
- Before creating a cluster using commands, ensure kubectl is used to access the cluster. For details, see **Connecting to a Cluster Using kubectl**.

Constraints

- If OBS volumes are used, the owner group and permission of the mount point cannot be modified.
- CCE allows parallel file systems to be mounted using OBS SDKs or PVCs. If PVC mounting is used, the obsfs tool provided by OBS must be used. An obsfs resident process is generated each time an object storage volume generated from the parallel file system is mounted to a node, as shown in the following figure.

  Figure 11-2 obsfs resident process

  Reserve 1 GiB of memory for each obsfs process. For example, for a node with 4 vCPUs and 8 GiB of memory, an obsfs parallel file system should be mounted to **no more than** eight pods.

NOTE

- An obsfs resident process runs on a node. If the consumed memory exceeds the upper limit of the node, the node malfunctions. On a node with 4 vCPUs and 8 GiB of memory, if more than 100 pods are mounted to a parallel file system, the node will be unavailable. Control the number of pods mounted to a parallel file system on a single node.

- Multiple PVs can use the same OBS storage volume with the following restrictions:
  - Do not mount all PVCs/PVs that use the same underlying object storage volume to a pod. This leads to a pod startup failure because not all PVCs can be mounted to the pod due to the same **volumeHandle** values of these PVs.
  - The **persistentVolumeReclaimPolicy** parameter in the PVs must be set to **Retain**. Otherwise, when a PV is deleted, the associated underlying volume may be deleted. In this case, other PVs associated with the underlying volume malfunction.
  - If underlying storage is repeatedly used, you are required to maintain data consistency. Enable isolation and protection for ReadWriteMany at the application layer and prevent multiple clients from writing the same file to prevent data overwriting and loss.

Using an Existing OBS Bucket on the Console

Step 1 Log in to the CCE console and click the cluster name to access the cluster console.

Step 2 Statically create a PVC and PV.

1. Choose **Storage** in the navigation pane and click the **PVCs** tab. Click **Create PVC** in the upper right corner. In the dialog box displayed, configure the PVC parameters.

Parameter	Description
PVC Type	In this example, select **OBS**.
PVC Name	Enter the PVC name, which must be unique in the same namespace.
Creation Method	– If underlying storage is available, create a storage volume or use an existing storage volume to statically create a PVC based on whether a PV is available. – If no underlying storage is available, select **Dynamically provision**. For details, see **Using an OBS Bucket Through a Dynamic PV**. In this example, select **Create new** to create a PV and PVC at the same time on the console.
PV[a]	Select an existing PV volume in the cluster. Create a PV in advance. For details, see "Creating a storage volume" in **Related Operations**. You do not need to specify this parameter in this example.

Parameter	Description
OBS[b]	Click **Select OBS**. On the displayed page, select the OBS storage that meets your requirements and click **OK**.
PV Name[b]	Enter the PV name, which must be unique in the same cluster.
Access Mode[b]	OBS volumes support only **ReadWriteMany**, indicating that a storage volume can be mounted to multiple nodes in read/write mode. For details, see **Volume Access Modes**.
Reclaim Policy[b]	You can select **Delete** or **Retain** to specify the reclaim policy of the underlying storage when the PVC is deleted. For details, see **PV Reclaim Policy**. **NOTE** If multiple PVs use the same OBS volume, use **Retain** to avoid cascading deletion of underlying volumes.
Access Key (AK/SK)[b]	**Custom**: Customize a secret if you want to assign different user permissions to different OBS storage devices. For details, see **Using a Custom Access Key (AK/SK) to Mount an OBS Volume**. Only secrets with the **secret.kubernetes.io/used-by = csi** label can be selected. The secret type is cfe/secure-opaque. If no secret is available, click **Create Secret** to create one. – **Name**: Enter a secret name. – **Namespace**: Select the namespace where the secret is. – **Access Key (AK/SK)**: Upload a key file in .csv format. For details, see **Obtaining an Access Key**.
Mount Options[b]	Enter the mounting parameter key-value pairs. For details, see **Configuring OBS Mount Options**.

NOTE

a: The parameter is available when **Creation Method** is set to **Use existing**.

b: The parameter is available when **Creation Method** is set to **Create new**.

2. Click **Create** to create a PVC and a PV.

   You can choose **Storage** in the navigation pane and view the created PVC and PV on the **PVCs** and **PVs** tab pages, respectively.

Step 3 Create an application.

1. In the navigation pane on the left, click **Workloads**. In the right pane, click the **Deployments** tab.
2. Click **Create Workload** in the upper right corner. On the displayed page, click **Data Storage** in the **Container Settings** area and click **Add Volume** to select **PVC**.

   Mount and use storage volumes, as shown in **Table 11-19**. For details about other parameters, see **Workloads**.

Table 11-19 Mounting a storage volume

Parameter	Description
PVC	Select an existing object storage volume.
Mount Path	Enter a mount path, for example, **/tmp**. This parameter indicates the container path to which a data volume will be mounted. Do not mount the volume to a system directory such as **/** or **/var/run**. Otherwise, containers will be malfunctional. Mount the volume to an empty directory. If the directory is not empty, ensure that there are no files that affect container startup. Otherwise, the files will be replaced, causing container startup failures or workload creation failures. **NOTICE** If a volume is mounted to a high-risk directory, use an account with minimum permissions to start the container. Otherwise, high-risk files on the host machine may be damaged.
Subpath	Enter the subpath of the storage volume and mount a path in the storage volume to the container. In this way, different folders of the same storage volume can be used in a single pod. **tmp**, for example, indicates that data in the mount path of the container is stored in the **tmp** folder of the storage volume. If this parameter is left blank, the root path is used by default.
Permission	– **Read-only**: You can only read the data in the mounted volumes. – **Read/Write**: You can modify the data volumes mounted to the path. Newly written data will not be migrated if the container is migrated, which may cause data loss.

In this example, the disk is mounted to the **/data** path of the container. The container data generated in this path is stored in the OBS volume.

3. After the configuration, click **Create Workload**.

   After the workload is created, the data in the container mount directory will be persistently stored. Verify the storage by referring to **Verifying Data Persistence and Sharing**.

----End

(kubectl) Using an Existing OBS Bucket

Step 1 Use kubectl to access the cluster.

Step 2 Create a PV.

1. Create the **pv-obs.yaml** file.

```
apiVersion: v1
kind: PersistentVolume
metadata:
```

```
  annotations:
    pv.kubernetes.io/provisioned-by: everest-csi-provisioner
    everest.io/reclaim-policy: retain-volume-only      # (Optional) The PV is deleted while the
underlying volume is retained.
  name: pv-obs       # PV name.
spec:
  accessModes:
  - ReadWriteMany    # Access mode. The value must be ReadWriteMany for OBS.
  capacity:
    storage: 1Gi     # OBS volume capacity.
  csi:
    driver: obs.csi.everest.io        # Dependent storage driver for the mounting.
    fsType: obsfs                     # Instance type.
    volumeHandle: <your_volume_id>    # Name of the OBS volume.
    volumeAttributes:
      storage.kubernetes.io/csiProvisionerIdentity: everest-csi-provisioner
      everest.io/obs-volume-type: STANDARD
      everest.io/region: <your_region>                    # Region where the OBS volume is.
      everest.io/enterprise-project-id: <your_project_id>     # (Optional) Enterprise project ID. If an
enterprise project is specified, use the same enterprise project when creating a PVC. Otherwise, the
PVC cannot be bound to a PV.

    nodePublishSecretRef:             # Custom secret of the OBS volume.
      name: <your_secret_name>        # Custom secret name.
      namespace: <your_namespace>     # Namespace of the custom secret.
  persistentVolumeReclaimPolicy: Retain     # Reclaim policy.
  storageClassName: csi-obs               # Storage class name.
  mountOptions: []                        # Mount options.
```

Table 11-20 Key parameters

Parameter	Mandatory	Description
everest.io/reclaim-policy: retain-volume-only	No	Optional. Currently, only **retain-volume-only** is supported. This field is valid only when the Everest version is 1.2.9 or later and the reclaim policy is **Delete**. If the reclaim policy is **Delete** and the current value is **retain-volume-only**, the associated PV is deleted while the underlying storage volume is retained, when a PVC is deleted.
fsType	Yes	Instance type. The value can be **obsfs** or **s3fs**. – **obsfs**: Parallel file system, which is mounted using obsfs (recommended). – **s3fs**: Object bucket, which is mounted using s3fs.
volumeHandle	Yes	OBS volume name.

Parameter	Mandatory	Description
everest.io/obs-volume-type	Yes	OBS storage class. – 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**.
everest.io/region	Yes	Region where the OBS bucket is deployed.
everest.io/enterprise-project-id	No	Optional. Enterprise project ID of OBS. If an enterprise project is specified, use the same enterprise project when creating a PVC. Otherwise, the PVC cannot be bound to a PV. **How to obtain**: On the OBS console, choose **Buckets** or **Parallel File Systems** in the navigation pane on the left. Click the name of the OBS bucket to access its details page. In the **Basic Information** area, locate the enterprise project and click it to access the enterprise project console. Copy the corresponding ID to obtain the ID of the enterprise project to which the object storage belongs.

nodePublishSecretRef	No	Access key (AK/SK) used for mounting the object storage volume. You can use the AK/SK to create a secret and mount it to the PV. For details, see **Using a Custom Access Key (AK/SK) to Mount an OBS Volume**.
		An example is as follows:
		`nodePublishSecretRef:`
		`  name: secret-demo`
		`  namespace: default`

mountOptions	No	Mount options. For details, see **Configuring OBS Mount Options**.

Parameter	Mandatory	Description
persistentVolumeReclaimPolicy	Yes	A reclaim policy is supported when the cluster version is or later than 1.19.10 and the Everest version is or later than 1.2.9. The **Delete** and **Retain** reclaim policies are supported. For details, see **PV Reclaim Policy**. If multiple PVs use the same OBS volume, use **Retain** to avoid cascading deletion of underlying volumes. **Delete**: – If **everest.io/reclaim-policy** is not specified, both the PV and storage resources are deleted when a PVC is deleted. – If **everest.io/reclaim-policy** is set to **retain-volume-only**, when a PVC is deleted, the PV is deleted but the storage resources are retained. **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 is in the **Released** status and cannot be bound to the PVC again.
storage	Yes	Storage capacity, in Gi. For OBS, this field is used only for verification (cannot be empty or 0). Its value is fixed at **1**, and any value you set does not take effect for OBS.
storageClassName	Yes	The storage class name of OBS volumes is **csi-obs**.

2. Run the following command to create a PV:

```
kubectl apply -f pv-obs.yaml
```

Step 3 Create a PVC.

1. Create the **pvc-obs.yaml** file.

```
apiVersion: v1
kind: PersistentVolumeClaim
metadata:
  name: pvc-obs
  namespace: default
  annotations:
    volume.beta.kubernetes.io/storage-provisioner: everest-csi-provisioner
    everest.io/obs-volume-type: STANDARD
    csi.storage.k8s.io/fstype: obsfs
    csi.storage.k8s.io/node-publish-secret-name: <your_secret_name>  # Custom secret name.
    csi.storage.k8s.io/node-publish-secret-namespace: <your_namespace>       # Namespace of the
custom secret.
    everest.io/enterprise-project-id: <your_project_id>     # (Optional) Enterprise project ID. If an
```

```
enterprise project is specified, use the same enterprise project when creating a PVC. Otherwise, the
PVC cannot be bound to a PV.

spec:
  accessModes:
  - ReadWriteMany               # The value must be ReadWriteMany for OBS.
  resources:
    requests:
      storage: 1Gi
  storageClassName: csi-obs      # Storage class name, which must be the same as that of the PV.
  volumeName: pv-obs    # PV name.
```

Table 11-21 Key parameters

Parameter	Mandatory	Description
csi.storage.k8s.io/node-publish-secret-name	No	Name of the custom secret specified in the PV.
csi.storage.k8s.io/node-publish-secret-namespace	No	Namespace of the custom secret specified in the PV.
everest.io/enterprise-project-id	No	Project ID of OBS. **How to obtain**: On the OBS console, choose **Buckets** or **Parallel File Systems** in the navigation pane on the left. Click the name of the OBS bucket to access its details page. In the **Basic Information** area, locate the enterprise project and click it to access the enterprise project console. Copy the corresponding ID to obtain the ID of the enterprise project to which the object storage belongs.
storage	Yes	Requested capacity in the PVC, in Gi. For OBS, this field is used only for verification (cannot be empty or 0). Its value is fixed at **1**, and any value you set does not take effect for OBS.
storageClassName	Yes	Storage class name, which must be the same as the storage class of the PV in **1**. The storage class name of OBS volumes is **csi-obs**.
volumeName	Yes	PV name, which must be the same as the PV name in **1**.

2. Run the following command to create a PVC:
   ```
   kubectl apply -f pvc-obs.yaml
   ```

Step 4 Create an application.

1. Create a file named **web-demo.yaml**. In this example, the OBS volume is mounted to the **/data** path.

```
apiVersion: apps/v1
kind: Deployment
metadata:
  name: web-demo
  namespace: default
spec:
  replicas: 2
  selector:
    matchLabels:
      app: web-demo
  template:
    metadata:
      labels:
        app: web-demo
    spec:
      containers:
      - name: container-1
        image: nginx:latest
        volumeMounts:
        - name: pvc-obs-volume    #Volume name, which must be the same as the volume name in the volumes field.
          mountPath: /data  # Location where the storage volume is mounted.
      imagePullSecrets:
        - name: default-secret
      volumes:
        - name: pvc-obs-volume    # Volume name, which can be customized.
          persistentVolumeClaim:
            claimName: pvc-obs    # Name of the created PVC.
```

2. Run the following command to create a workload to which the OBS volume is mounted:

```
kubectl apply -f web-demo.yaml
```

After the workload is created, you can try **Verifying Data Persistence and Sharing**.

----End

Verifying Data Persistence and Sharing

Step 1 View the deployed application and files.

1. Run the following command to view the created pod:

```
kubectl get pod | grep web-demo
```

Expected output:

```
web-demo-846b489584-mjhm9   1/1     Running   0          46s
web-demo-846b489584-wvv5s   1/1     Running   0          46s
```

2. Run the following commands in sequence to view the files in the **/data** path of the pods:

```
kubectl exec web-demo-846b489584-mjhm9 -- ls /data
kubectl exec web-demo-846b489584-wvv5s -- ls /data
```

If no result is returned for both pods, no file exists in the **/data** path.

Step 2 Run the following command to create a file named **static** in the **/data** path:

```
kubectl exec web-demo-846b489584-mjhm9 --  touch /data/static
```

Step 3 Run the following command to view the files in the **/data** path:

```
kubectl exec web-demo-846b489584-mjhm9 -- ls /data
```

Expected output:

```
static
```

Step 4 Verify data persistence.

1. Run the following command to delete the pod named **web-demo-846b489584-mjhm9**:
   ```
   kubectl delete pod web-demo-846b489584-mjhm9
   ```
   Expected output:
   ```
   pod "web-demo-846b489584-mjhm9" deleted
   ```
   After the deletion, the Deployment controller automatically creates a replica.
2. Run the following command to view the created pod:
   ```
   kubectl get pod | grep web-demo
   ```
   The expected output is as follows, in which **web-demo-846b489584-d4d4j** is the newly created pod:
   ```
   web-demo-846b489584-d4d4j  1/1   Running  0          110s
   web-demo-846b489584-wvv5s  1/1   Running  0          7m50s
   ```
3. Run the following command to check whether the files in the **/data** path of the new pod have been modified:
   ```
   kubectl exec web-demo-846b489584-d4d4j -- ls /data
   ```
   Expected output:
   ```
   static
   ```
   If the **static** file still exists, the data can be stored persistently.

Step 5 Verify data sharing.

1. Run the following command to view the created pod:
   ```
   kubectl get pod | grep web-demo
   ```
   Expected output:
   ```
   web-demo-846b489584-d4d4j  1/1   Running  0          7m
   web-demo-846b489584-wvv5s  1/1   Running  0          13m
   ```
2. Run the following command to create a file named **share** in the **/data** path of either pod: In this example, select the pod named **web-demo-846b489584-d4d4j**.
   ```
   kubectl exec web-demo-846b489584-d4d4j --  touch /data/share
   ```
   Check the files in the **/data** path of the pod.
   ```
   kubectl exec web-demo-846b489584-d4d4j -- ls /data
   ```
   Expected output:
   ```
   share
   static
   ```
3. Check whether the **share** file exists in the **/data** path of another pod (**web-demo-846b489584-wvv5s**) as well to verify data sharing.
   ```
   kubectl exec web-demo-846b489584-wvv5s -- ls /data
   ```
   Expected output:
   ```
   share
   static
   ```
   After you create a file in the **/data** path of a pod, if the file is also created in the **/data** path of the other pod, the two pods share the same volume.

----End

Related Operations

You can also perform the operations listed in **Table 11-22**.

Table 11-22 Related operations

Operation	Description	Procedure
Creating a storage volume (PV)	Create a PV on the CCE console.	1. Choose **Storage** in the navigation pane and click the **PVs** tab. Click **Create PersistentVolume** in the upper right corner. In the dialog box displayed, configure parameters. • **Volume Type**: Select **OBS**. • **OBS**: Click **Select OBS**. On the displayed page, select the OBS storage that meets your requirements and click **OK**. • **PV Name**: Enter the PV name, which must be unique in the same cluster. • **Access Mode**: SFS volumes support only **ReadWriteMany**, indicating that a storage volume can be mounted to multiple nodes in read/write mode. For details, see **Volume Access Modes**. • **Reclaim Policy**: **Delete** or **Retain** is supported. For details, see **PV Reclaim Policy**. **NOTE** If multiple PVs use the same underlying storage volume, use **Retain** to avoid cascading deletion of underlying volumes. • **Access Key (AK/SK)**: Customize a secret if you want to assign different user permissions to different OBS storage devices. For details, see **Using a Custom Access Key (AK/SK) to Mount an OBS Volume**. Only secrets with the **secret.kubernetes.io/used-by = csi** label can be selected. The secret type is cfe/secure-opaque. If no secret is available, click **Create Secret** to create one. • **Mount Options**: Enter the mounting parameter key-value pairs. For details, see **Configuring OBS Mount Options**. 2. Click **Create**.

Operation	Description	Procedure
Updating an access key	Update the access key of object storage on the CCE console.	1. Choose **Storage** in the navigation pane and click the **PVCs** tab. Click **More** in the **Operation** column of the target PVC and select **Update Access Key**. 2. Upload a key file in .csv format. For details, see **Obtaining an Access Key**. Click **OK**. **NOTE** After a global access key is updated, all pods mounted with the object storage that uses this access key can be accessed only after being restarted.
Viewing events	You can view event names, event types, number of occurrences, Kubernetes events, first occurrence time, and last occurrence time of the PVC or PV.	1. Choose **Storage** in the navigation pane and click the **PVCs** or **PVs** tab. 2. Click **View Events** in the **Operation** column of the target PVC or PV to view events generated within one hour (event data is retained for one hour).
Viewing a YAML file	You can view, copy, and download the YAML files of a PVC or PV.	1. Choose **Storage** in the navigation pane and click the **PVCs** or **PVs** tab. 2. Click **View YAML** in the **Operation** column of the target PVC or PV to view or download the YAML.

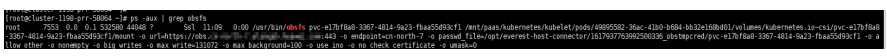
11.5.3 Using an OBS Bucket Through a Dynamic PV

This section describes how to automatically create an OBS bucket. It is applicable when no underlying storage volume is available.

Constraints

- If OBS volumes are used, the owner group and permission of the mount point cannot be modified.
- CCE allows parallel file systems to be mounted using OBS SDKs or PVCs. If PVC mounting is used, the obsfs tool provided by OBS must be used. An obsfs resident process is generated each time an object storage volume generated from the parallel file system is mounted to a node, as shown in the following figure.

Figure 11-3 obsfs resident process



Reserve 1 GiB of memory for each obsfs process. For example, for a node with 4 vCPUs and 8 GiB of memory, an obsfs parallel file system should be mounted to **no more than** eight pods.

NOTE

- An obsfs resident process runs on a node. If the consumed memory exceeds the upper limit of the node, the node malfunctions. On a node with 4 vCPUs and 8 GiB of memory, if more than 100 pods are mounted to a parallel file system, the node will be unavailable. Control the number of pods mounted to a parallel file system on a single node.

- OBS allows a single user to create a maximum of 100 buckets. If a large number of dynamic PVCs are created, the number of buckets may exceed the upper limit, and no more OBS buckets can be created. In this case, use OBS by calling its API or SDK and do not mount OBS buckets to workloads.

Automatically Creating an OBS Volume on the Console

Step 1 Log in to the CCE console and click the cluster name to access the cluster console.

Step 2 Dynamically create a PVC and PV.

1. Choose **Storage** in the navigation pane and click the **PVCs** tab. Click **Create PVC** in the upper right corner. In the dialog box displayed, configure the PVC parameters.

Parameter	Description
PVC Type	In this example, select **OBS**.
PVC Name	Enter the PVC name, which must be unique in the same namespace.
Creation Method	– If no underlying storage is available, select **Dynamically provision** to create a PVC, PV, and underlying storage on the console in cascading mode. – If underlying storage is available, create a storage volume or use an existing storage volume to statically create a PVC based on whether a PV has been created. For details, see **Using an Existing OBS Bucket Through a Static PV**. In this example, select **Dynamically provision**.
Storage Classes	The storage class of OBS volumes is **csi-obs**.
Instance Type	– **Parallel file system**: a high-performance file system provided by OBS. It provides millisecond-level access latency, TB/s-level bandwidth, and million-level IOPS. **Parallel file systems are recommended.** – **Object bucket**: a container that stores objects in OBS. All objects in a bucket are at the same logical level.

Parameter	Description
OBS Class	You can select the following object bucket types: – **Standard**: Applicable when a large number of hotspot files or small-sized files need to be accessed frequently (multiple times per month on average) and require fast access response. – **Infrequent access**: Applicable when data is not frequently accessed (fewer than 12 times per year on average) but requires fast access response.
Access Mode	OBS volumes support only **ReadWriteMany**, indicating that a storage volume can be mounted to multiple nodes in read/write mode. For details, see **Volume Access Modes**.
Access Key (AK/SK)	**Custom**: Customize a secret if you want to assign different user permissions to different OBS storage devices. For details, see **Using a Custom Access Key (AK/SK) to Mount an OBS Volume**. Only secrets with the **secret.kubernetes.io/used-by = csi** label can be selected. The secret type is cfe/secure-opaque. If no secret is available, click **Create Secret** to create one. – **Name**: Enter a secret name. – **Namespace**: Select the namespace where the secret is. – **Access Key (AK/SK)**: Upload a key file in .csv format. For details, see **Obtaining an Access Key**.
Enterprise Project	Supported enterprise projects: default, the one to which the cluster belongs, or the one specified by the storage class.

2. Click **Create** to create a PVC and a PV.

   You can choose **Storage** in the navigation pane and view the created PVC and PV on the **PVCs** and **PVs** tab pages, respectively.

Step 3 Create an application.

1. In the navigation pane on the left, click **Workloads**. In the right pane, click the **Deployments** tab.
2. Click **Create Workload** in the upper right corner. On the displayed page, click **Data Storage** in the **Container Settings** area and click **Add Volume** to select **PVC**.

   Mount and use storage volumes, as shown in **Table 11-23**. For details about other parameters, see **Workloads**.

Table 11-23 Mounting a storage volume

Parameter	Description
PVC	Select an existing object storage volume.
Mount Path	Enter a mount path, for example, **/tmp**. This parameter indicates the container path to which a data volume will be mounted. Do not mount the volume to a system directory such as **/** or **/var/run**. Otherwise, containers will be malfunctional. Mount the volume to an empty directory. If the directory is not empty, ensure that there are no files that affect container startup. Otherwise, the files will be replaced, causing container startup failures or workload creation failures. **NOTICE** If a volume is mounted to a high-risk directory, use an account with minimum permissions to start the container. Otherwise, high-risk files on the host machine may be damaged.
Subpath	Enter the subpath of the storage volume and mount a path in the storage volume to the container. In this way, different folders of the same storage volume can be used in a single pod. **tmp**, for example, indicates that data in the mount path of the container is stored in the **tmp** folder of the storage volume. If this parameter is left blank, the root path is used by default.
Permission	– **Read-only**: You can only read the data in the mounted volumes. – **Read/Write**: You can modify the data volumes mounted to the path. Newly written data will not be migrated if the container is migrated, which may cause data loss.

In this example, the disk is mounted to the **/data** path of the container. The container data generated in this path is stored in the OBS volume.

3. After the configuration, click **Create Workload**.

   After the workload is created, the data in the container mount directory will be persistently stored. Verify the storage by referring to **Verifying Data Persistence and Sharing**.

----End

(kubectl) Automatically Creating an OBS Volume

Step 1 Use kubectl to connect to the cluster.

Step 2 Use **StorageClass** to dynamically create a PVC and PV.

1. Create the **pvc-obs-auto.yaml** file.

```
apiVersion: v1
kind: PersistentVolumeClaim
metadata:
```

```
  name: pvc-obs-auto
  namespace: default
  annotations:
    everest.io/obs-volume-type: STANDARD    # Object storage type.
    csi.storage.k8s.io/fstype: obsfs        # Instance type.
    csi.storage.k8s.io/node-publish-secret-name: <your_secret_name>       # Custom secret name.
    csi.storage.k8s.io/node-publish-secret-namespace: <your_namespace>    # Namespace of the
custom secret.
    everest.io/enterprise-project-id: <your_project_id>     # (Optional) Enterprise project ID. If an
enterprise project is specified, use the same enterprise project when creating a PVC. Otherwise, the
PVC cannot be bound to a PV.

spec:
  accessModes:
    - ReadWriteMany             # The value must be ReadWriteMany for object storage.
  resources:
    requests:
      storage: 1Gi              # OBS volume capacity.
  storageClassName: csi-obs     # The storage class type is OBS.
```

Table 11-24 Key parameters

Parameter	Mandatory	Description
everest.io/obs-volume-type	Yes	OBS storage class. – 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**.
csi.storage.k8s.io/fstype	Yes	Instance type. The value can be **obsfs** or **s3fs**. – **obsfs**: Parallel file system, which is mounted using obsfs (recommended). – **s3fs**: Object bucket, which is mounted using s3fs.
csi.storage.k8s.io/node-publish-secret-name	No	Custom secret name. (Recommended) Select this option if you want to assign different user permissions to different OBS storage devices. For details, see **Using a Custom Access Key (AK/SK) to Mount an OBS Volume**.
csi.storage.k8s.io/node-publish-secret-namespace	No	Namespace of a custom secret.
everest.io/enterprise-project-id	No	Project ID of OBS. To obtain an enterprise project ID, log in to the EPS console, click the name of the target enterprise project, and copy the enterprise project ID.

Parameter	Mandatory	Description
storage	Yes	Requested capacity in the PVC, in Gi. For OBS, this field is used only for verification (cannot be empty or 0). Its value is fixed at **1**, and any value you set does not take effect for OBS.
storageClassName	Yes	Storage class name. The storage class name of OBS volumes is **csi-obs**.

2. Run the following command to create a PVC:
```
kubectl apply -f pvc-obs-auto.yaml
```

Step 3 Create an application.

1. Create a file named **web-demo.yaml**. In this example, the OBS volume is mounted to the **/data** path.
```
apiVersion: apps/v1
kind: Deployment
metadata:
  name: web-demo
  namespace: default
spec:
  replicas: 2
  selector:
    matchLabels:
      app: web-demo
  template:
    metadata:
      labels:
        app: web-demo
    spec:
      containers:
      - name: container-1
        image: nginx:latest
        volumeMounts:
        - name: pvc-obs-volume    #Volume name, which must be the same as the volume name in the volumes field.
          mountPath: /data  # Location where the storage volume is mounted.
      imagePullSecrets:
        - name: default-secret
      volumes:
        - name: pvc-obs-volume    # Volume name, which can be customized.
          persistentVolumeClaim:
            claimName: pvc-obs-auto    # Name of the created PVC.
```

2. Run the following command to create a workload to which the OBS volume is mounted:
```
kubectl apply -f web-demo.yaml
```

After the workload is created, you can try **Verifying Data Persistence and Sharing**.

----End

Verifying Data Persistence and Sharing

Step 1 View the deployed application and files.

1. Run the following command to view the created pod:

```
kubectl get pod | grep web-demo
```

Expected output:

```
web-demo-846b489584-mjhm9   1/1     Running   0          46s
web-demo-846b489584-wvv5s   1/1     Running   0          46s
```

2. Run the following commands in sequence to view the files in the **/data** path of the pods:

```
kubectl exec web-demo-846b489584-mjhm9 -- ls /data
kubectl exec web-demo-846b489584-wvv5s -- ls /data
```

If no result is returned for both pods, no file exists in the **/data** path.

Step 2 Run the following command to create a file named **static** in the **/data** path:

```
kubectl exec web-demo-846b489584-mjhm9 --  touch /data/static
```

Step 3 Run the following command to view the files in the **/data** path:

```
kubectl exec web-demo-846b489584-mjhm9 -- ls /data
```

Expected output:

```
static
```

Step 4 Verify data persistence.

1. Run the following command to delete the pod named **web-demo-846b489584-mjhm9**:

```
kubectl delete pod web-demo-846b489584-mjhm9
```

Expected output:

```
pod "web-demo-846b489584-mjhm9" deleted
```

After the deletion, the Deployment controller automatically creates a replica.

2. Run the following command to view the created pod:

```
kubectl get pod | grep web-demo
```

The expected output is as follows, in which **web-demo-846b489584-d4d4j** is the newly created pod:

```
web-demo-846b489584-d4d4j   1/1     Running   0          110s
web-demo-846b489584-wvv5s   1/1     Running   0          7m50s
```

3. Run the following command to check whether the files in the **/data** path of the new pod have been modified:

```
kubectl exec web-demo-846b489584-d4d4j -- ls /data
```

Expected output:

```
static
```

If the **static** file still exists, the data can be stored persistently.

Step 5 Verify data sharing.

1. Run the following command to view the created pod:

```
kubectl get pod | grep web-demo
```

Expected output:

```
web-demo-846b489584-d4d4j   1/1     Running   0          7m
web-demo-846b489584-wvv5s   1/1     Running   0          13m
```

2. Run the following command to create a file named **share** in the **/data** path of either pod: In this example, select the pod named **web-demo-846b489584-d4d4j**.

```
kubectl exec web-demo-846b489584-d4d4j --  touch /data/share
```

Check the files in the **/data** path of the pod.

```
kubectl exec web-demo-846b489584-d4d4j -- ls /data
```

Expected output:

```
share
static
```

3. Check whether the **share** file exists in the **/data** path of another pod (**web-demo-846b489584-wvv5s**) as well to verify data sharing.

```
kubectl exec web-demo-846b489584-wvv5s -- ls /data
```

Expected output:

```
share
static
```

After you create a file in the **/data** path of a pod, if the file is also created in the **/data** path of the other pod, the two pods share the same volume.

----End

Related Operations

You can also perform the operations listed in **Table 11-25**.

Table 11-25 Related operations

Operation	Description	Procedure
Updating an access key	Update the access key of object storage on the CCE console.	1. Choose **Storage** in the navigation pane and click the **PVCs** tab. Click **More** in the **Operation** column of the target PVC and select **Update Access Key**. 2. Upload a key file in .csv format. For details, see **Obtaining an Access Key**. Click **OK**. **NOTE** After a global access key is updated, all pods mounted with the object storage that uses this access key can be accessed only after being restarted.
Viewing events	You can view event names, event types, number of occurrences, Kubernetes events, first occurrence time, and last occurrence time of the PVC or PV.	1. Choose **Storage** in the navigation pane and click the **PVCs** or **PVs** tab. 2. Click **View Events** in the **Operation** column of the target PVC or PV to view events generated within one hour (event data is retained for one hour).
Viewing a YAML file	You can view, copy, and download the YAML files of a PVC or PV.	1. Choose **Storage** in the navigation pane and click the **PVCs** or **PVs** tab. 2. Click **View YAML** in the **Operation** column of the target PVC or PV to view or download the YAML.

11.5.4 Configuring OBS Mount Options

This section describes how to configure OBS volume mount options. You can configure mount options in a PV and bind the PV to a PVC. Alternatively, configure mount options in a StorageClass and use the StorageClass to create a PVC. In this way, PVs can be dynamically created and inherit mount options configured in the StorageClass by default.

Prerequisites

The **CCE Container Storage (Everest)** add-on version must be **1.2.8 or later**. This add-on identifies the mount options and transfers them to the underlying storage resources. The parameter settings take effect only if the underlying storage resources support the specified options.

OBS Mount Options

When mounting an OBS volume, the Everest add-on presets the options described in **Table 11-26** and **Table 11-27** by default. The options in **Table 11-26** are mandatory.

Table 11-26 Mandatory mount options configured by default

Parameter	Value	Description
use_ino	Blank	If enabled, obsfs allocates the **inode** number. Enabled by default in read/write mode.
big_writes	Blank	If configured, the maximum size of the cache can be modified.
nonempty	Blank	Allows non-empty mount paths.
allow_other	Blank	Allows other users to access the parallel file system.
no_check_certificate	Blank	Disables server certificate verification.
enable_noobj_cache	Blank	Enables cache entries for objects that do not exist, which can improve performance. Enabled by default in object bucket read/write mode. **This option is no longer configured by default since Everest 1.2.40.**
sigv2	Blank	Specifies the signature version. Used by default in object buckets.
public_bucket	1	If this parameter is set to **1**, public buckets are mounted anonymously. Enabled by default in object bucket read-only mode.

Table 11-27 Optional mount options configured by default

Parameter	Value	Description
max_write	131072	This parameter is valid only when **big_writes** is configured. The recommended value is **128 KB**.
ssl_verify_hostname	0	Disables SSL certificate verification based on the host name.
max_background	100	Allows setting the maximum number of waiting requests in the background. Used by default in parallel file systems.
umask	A three-digit octal number	Mask of the configuration file permission. For example, if the umask value is **022**, the directory permission (the maximum permission is **777**) is **755** (777 - 022 = 755, rwxr-xr-x).

Configuring Mount Options in a PV

You can use the **mountOptions** field to configure mount options in a PV. The options you can configure in **mountOptions** are listed in **OBS Mount Options**.

Step 1 Use kubectl to connect to the cluster. For details, see **Connecting to a Cluster Using kubectl**.

Step 2 Configure mount options in a PV. Example:

```
apiVersion: v1
kind: PersistentVolume
metadata:
  annotations:
    pv.kubernetes.io/provisioned-by: everest-csi-provisioner
    everest.io/reclaim-policy: retain-volume-only      # (Optional) The PV is deleted while the underlying volume is retained.
  name: pv-obs       # PV name.
spec:
  accessModes:
  - ReadWriteMany    # Access mode. The value must be ReadWriteMany for OBS.
  capacity:
    storage: 1Gi     # OBS volume capacity.
  csi:
    driver: obs.csi.everest.io        # Dependent storage driver for the mounting.
    fsType: obsfs                     # Instance type.
    volumeHandle: <your_volume_id>    # Name of the OBS volume.
    volumeAttributes:
      storage.kubernetes.io/csiProvisionerIdentity: everest-csi-provisioner
      everest.io/obs-volume-type: STANDARD
      everest.io/region: <your_region>                    # Region where the OBS volume is.
      everest.io/enterprise-project-id: <your_project_id>     # (Optional) Enterprise project ID. If an enterprise project is specified, use the same enterprise project when creating a PVC. Otherwise, the PVC cannot be bound to a PV.

    nodePublishSecretRef:           # Custom secret of the OBS volume.
      name: <your_secret_name>       # Custom secret name.
      namespace: <your_namespace>    # Namespace of the custom secret.
  persistentVolumeReclaimPolicy: Retain    # Reclaim policy.
  storageClassName: csi-obs              # Storage class name.
  mountOptions:                          # Mount options.
  - umask=027
```

Step 3 After a PV is created, you can create a PVC and bind it to the PV, and then mount the PV to the container in the workload. For details, see **Using an Existing OBS Bucket Through a Static PV**.

Step 4 Check whether the mount options take effect.

In this example, the PVC is mounted to the workload that uses the **nginx:latest** image. You can log in to the node where the pod to which the OBS volume is mounted resides and view the progress details.

Run the following command:

- Object bucket: **ps -ef | grep s3fs**

```
root     22142     1  0 Jun03 ?        00:00:00 /usr/bin/s3fs {your_obs_name} /mnt/paas/kubernetes/kubelet/pods/{pod_uid}/volumes/kubernetes.io~csi/{your_pv_name}/mount -o url=https://{endpoint}:443 -o endpoint={region} -o passwd_file=/opt/everest-host-connector/***_obstmpcred/{your_obs_name} -o nonempty -o big_writes -o sigv2 -o allow_other -o no_check_certificate -o ssl_verify_hostname=0 -o umask=027 -o max_write=131072 -o multipart_size=20
```

- Parallel file system: **ps -ef | grep obsfs**

```
root      1355     1  0 Jun03 ?        00:03:16 /usr/bin/obsfs {your_obs_name} /mnt/paas/kubernetes/kubelet/pods/{pod_uid}/volumes/kubernetes.io~csi/{your_pv_name}/mount -o url=https://{endpoint}:443 -o endpoint={region} -o passwd_file=/opt/everest-host-connector/***_obstmpcred/{your_obs_name} -o allow_other -o nonempty -o big_writes -o use_ino -o no_check_certificate -o ssl_verify_hostname=0 -o max_background=100 -o umask=027 -o max_write=131072
```

----End

Configuring Mount Options in a StorageClass

You can use the **mountOptions** field to configure mount options in a StorageClass. The options you can configure in **mountOptions** are listed in **OBS Mount Options**.

Step 1 Use kubectl to connect to the cluster. For details, see **Connecting to a Cluster Using kubectl**.

Step 2 Create a customized StorageClass. Example:

```
kind: StorageClass
apiVersion: storage.k8s.io/v1
metadata:
  name: csi-obs-mount-option
provisioner: everest-csi-provisioner
parameters:
  csi.storage.k8s.io/csi-driver-name: obs.csi.everest.io
  csi.storage.k8s.io/fstype: s3fs
  everest.io/obs-volume-type: STANDARD
reclaimPolicy: Delete
volumeBindingMode: Immediate
mountOptions:                   # Mount options.
- umask=0027
```

Step 3 After the StorageClass is configured, you can use it to create a PVC. By default, the dynamically created PVs inherit the mount options configured in the StorageClass. For details, see **Using an OBS Bucket Through a Dynamic PV**.

Step 4 Check whether the mount options take effect.

In this example, the PVC is mounted to the workload that uses the **nginx:latest** image. You can log in to the node where the pod to which the OBS volume is mounted resides and view the progress details.

Run the following command:

- Object bucket: **ps -ef | grep s3fs**

```
root     22142     1  0 Jun03 ?        00:00:00 /usr/bin/s3fs {your_obs_name} /mnt/paas/kubernetes/kubelet/pods/{pod_uid}/volumes/kubernetes.io~csi/{your_pv_name}/mount -o url=https://{endpoint}:443 -o endpoint={region} -o passwd_file=/opt/everest-host-connector/***_obstmpcred/{your_obs_name} -o nonempty -o big_writes -o sigv2 -o allow_other -o no_check_certificate -o ssl_verify_hostname=0 -o umask=027 -o max_write=131072 -o multipart_size=20
```

- Parallel file system: **ps -ef | grep obsfs**

```
root     1355     1  0 Jun03 ?        00:03:16 /usr/bin/obsfs {your_obs_name} /mnt/paas/kubernetes/kubelet/pods/{pod_uid}/volumes/kubernetes.io~csi/{your_pv_name}/mount -o url=https://{endpoint}:443 -o endpoint={region} -o passwd_file=/opt/everest-host-connector/***_obstmpcred/{your_obs_name} -o allow_other -o nonempty -o big_writes -o use_ino -o no_check_certificate -o ssl_verify_hostname=0 -o max_background=100 -o umask=027 -o max_write=131072
```

----End

11.5.5 Using a Custom Access Key (AK/SK) to Mount an OBS Volume

Scenario

CCE Container Storage (Everest) of version 1.2.8 or later supports custom access keys. In this way, IAM users can use their own custom access keys to mount an OBS volume.

Prerequisites

- The **CCE Container Storage (Everest)** add-on version must be 1.2.8 or later.
- The cluster version must be 1.15.11 or later.

Constraints

- When an OBS volume is mounted using a custom access key (AK/SK), the access key cannot be deleted or disabled. Otherwise, the service container cannot access the mounted OBS volume.

Disabling Auto Key Mounting

The key you uploaded is used by default when mounting an OBS volume. That is, all IAM users under your account will use the same key to mount OBS buckets, and they have the same permissions on buckets. This setting does not allow you to configure differentiated permissions for different IAM users.

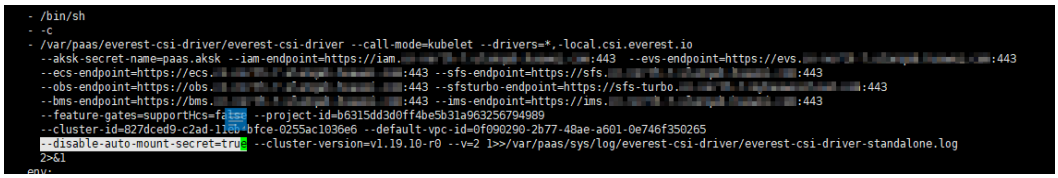
If you have uploaded the AK/SK, disable the automatic mounting of access keys by enabling the **disable_auto_mount_secret** parameter in the Everest add-on to prevent IAM users from performing unauthorized operations. In this way, the access keys uploaded on the console will not be used when creating OBS volumes.

NOTE

- When enabling **disable-auto-mount-secret**, ensure that no OBS volume exists in the cluster. A workload mounted with an OBS volume, when scaled or restarted, will fail to remount the OBS volume because it needs to specify the access key but is prohibited by **disable-auto-mount-secret**.
- If **disable-auto-mount-secret** is set to **true**, an access key must be specified when a PV or PVC is created. Otherwise, the OBS volume fails to be mounted.

kubectl edit ds everest-csi-driver -nkube-system

Search for **disable-auto-mount-secret** and set it to **true**.



Run **:wq** to save the settings and exit. Wait until the pod is restarted.

Obtaining an Access Key

Step 1 Log in to the console.

Step 2 Hover the cursor over the username in the upper right corner and choose **My Credentials** from the drop-down list.

Step 3 In the navigation pane, choose **Access Keys**.

Step 4 Click **Create Access Key**. The **Create Access Key** dialog box is displayed.

Step 5 Click **OK** to download the access key.

----End

Creating a Secret Using an Access Key

Step 1 Obtain an access key.

Step 2 Encode the keys using Base64. (Assume that the AK is xxx and the SK is yyy.)

echo -n xxx|base64

echo -n yyy|base64

Record the encoded AK and SK.

Step 3 Create a YAML file for the secret, for example, **test-user.yaml**.

```
apiVersion: v1
data:
  access.key: WE5WWVhVNU*****
  secret.key: Nnk4emJyZ0*****
kind: Secret
metadata:
  name: test-user
  namespace: default
  labels:
    secret.kubernetes.io/used-by: csi
type: cfe/secure-opaque
```

Specifically:

Parameter	Description
access.key	Base64-encoded AK.
secret.key	Base64-encoded SK.
name	Secret name.

Parameter	Description
namespace	Namespace of the secret.
secret.kubernetes.io/used-by: csi	Add this label in the YAML file if you want to make it available on the CCE console when you create an OBS PV/PVC.
type	Secret type. The value must be **cfe/secure-opaque**. When this type is used, the data entered by users is automatically encrypted.

Step 4 Create the secret.

kubectl create -f test-user.yaml

----End

Mounting a Secret When Statically Creating an OBS Volume

After a secret is created using the AK/SK, you can associate the secret with the PV to be created and then use the AK/SK in the secret to mount an OBS volume.

Step 1 Log in to the OBS console, create an OBS bucket, and record the bucket name and storage class. The parallel file system is used as an example.

Step 2 Create a YAML file for the PV, for example, **pv-example.yaml**.

```
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:
    nodePublishSecretRef:
      name: test-user
      namespace: default
    driver: obs.csi.everest.io
    fsType: obsfs
    volumeAttributes:
      everest.io/obs-volume-type: STANDARD
      everest.io/region:
      storage.kubernetes.io/csiProvisionerIdentity: everest-csi-provisioner
    volumeHandle: obs-normal-static-pv
  persistentVolumeReclaimPolicy: Delete
  storageClassName: csi-obs
```

Parameter	Description
nodePublishSecretRef	Secret specified during the mounting. • **name**: name of the secret • **namespace**: namespace of the secret

Parameter	Description
fsType	File type. The value can be **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. You are advised to set this field to **obsfs**.
volumeHandle	OBS bucket name.

Step 3 Create a PV.

kubectl create -f pv-example.yaml

After a PV is created, you can create a PVC and associate it with the PV.

Step 4 Create a YAML file for the PVC, for example, **pvc-example.yaml**.

Example YAML file for the PVC:

```
apiVersion: v1
kind: PersistentVolumeClaim
metadata:
  annotations:
    csi.storage.k8s.io/node-publish-secret-name: test-user
    csi.storage.k8s.io/node-publish-secret-namespace: default
    volume.beta.kubernetes.io/storage-provisioner: everest-csi-provisioner
    everest.io/obs-volume-type: STANDARD
    csi.storage.k8s.io/fstype: obsfs
  name: obs-secret
  namespace: default
spec:
  accessModes:
  - ReadWriteMany
  resources:
    requests:
      storage: 1Gi
  storageClassName: csi-obs
  volumeName: pv-obs-example
```

Parameter	Description
csi.storage.k8s.io/node-publish-secret-name	Name of the secret
csi.storage.k8s.io/node-publish-secret-namespace	Namespace of the secret

Step 5 Create a PVC.

kubectl create -f pvc-example.yaml

After the PVC is created, you can create a workload and associate it with the PVC to create volumes.

----End

Mounting a Secret When Dynamically Creating an OBS Volume

When dynamically creating an OBS volume, you can use the following method to specify a secret:

Step 1 Create a YAML file for the PVC, for example, **pvc-example.yaml**.

```
apiVersion: v1
kind: PersistentVolumeClaim
metadata:
  annotations:
    csi.storage.k8s.io/node-publish-secret-name: test-user
    csi.storage.k8s.io/node-publish-secret-namespace: default
    everest.io/obs-volume-type: STANDARD
    csi.storage.k8s.io/fstype: obsfs
  name: obs-secret
  namespace: default
spec:
  accessModes:
  - ReadWriteMany
  resources:
    requests:
      storage: 1Gi
  storageClassName: csi-obs
```

Parameter	Description
csi.storage.k8s.io/node-publish-secret-name	Name of the secret
csi.storage.k8s.io/node-publish-secret-namespace	Namespace of the secret

Step 2 Create a PVC.

kubectl create -f pvc-example.yaml

After the PVC is created, you can create a workload and associate it with the PVC to create volumes.

----End

Verification

You can use a secret of an IAM user to mount an OBS volume. Assume that a workload named **obs-secret** is created, the mount path in the container is **/temp**, and the IAM user has the CCE **ReadOnlyAccess** and **Tenant Guest** permissions.

1. Query the name of the workload pod.

   kubectl get po | grep obs-secret

   Expected outputs:

   ```
   obs-secret-5cd558f76f-vxslv         1/1     Running   0          3m22s
   ```

2. Query the objects in the mount path. In this example, the query is successful.

   kubectl exec obs-secret-5cd558f76f-vxslv -- ls -l /temp/

3. Write data into the mount path. In this example, the write operation failed.

   kubectl exec obs-secret-5cd558f76f-vxslv -- touch /temp/test

   Expected outputs:

```
touch: setting times of '/temp/test': No such file or directory
command terminated with exit code 1
```

4. Set the read/write permissions for the IAM user who mounted the OBS volume by referring to the bucket policy configuration.
5. Write data into the mount path again. In this example, the write operation succeeded.

   kubectl exec obs-secret-5cd558f76f-vxslv -- touch /temp/test
6. Check the mount path in the container to see whether the data is successfully written.

   kubectl exec obs-secret-5cd558f76f-vxslv -- ls -l /temp/

   Expected outputs:

```
-rwxrwxrwx 1 root root 0 Jun  7 01:52 test
```

11.6 Local Persistent Volumes

11.6.1 Overview

Introduction

CCE allows you to use LVM to combine data volumes on nodes into a storage pool (VolumeGroup) and create LVs for containers to mount. A PV that uses a local persistent volume as the medium is considered local PV.

Compared with the HostPath volume, the local PV can be used in a persistent and portable manner. In addition, the PV of the local PV has the node affinity configuration. The pod mounted to the local PV is automatically scheduled based on the affinity configuration. You do not need to manually schedule the pod to a specific node.

Mounting Modes

Local PVs can be mounted only in the following modes:

- **Using a Local PV Through a Dynamic PV**: dynamic creation mode, where you specify a StorageClass during PVC creation and an OBS volume and a PV will be automatically created.
- **Dynamically Mounting a Local PV to a StatefulSet**: Only StatefulSets support this mode. Each pod is associated with a unique PVC and PV. After a pod is rescheduled, the original data can still be mounted to it based on the PVC name. This mode applies to StatefulSets with multiple pods.

NOTE

Local PVs cannot be used through static PVs. That is, local PVs cannot be manually created and then mounted to workloads through PVCs.

Constraints

- Local PVs are supported only when the cluster version is v1.21.2-r0 or later and the Everest add-on version is 2.1.23 or later. Version 2.1.23 or later is recommended.

- Deleting, removing, resetting, or scaling in a node will cause the PVC/PV data of the local PV associated with the node to be lost, which cannot be restored or used again. For details, see **Removing a Node**, **Deleting a Node**, **Resetting a Node**, and **Scaling a Node**. In these scenarios, the pod that uses the local PV is evicted from the node. A new pod will be created and stay in the pending state. This is because the PVC used by the pod has a node label, due to which the pod cannot be scheduled. After the node is reset, the pod may be scheduled to the reset node. In this case, the pod remains in the creating state because the underlying logical volume corresponding to the PVC does not exist.
- Do not manually delete the corresponding storage pool or detach data disks from the node. Otherwise, exceptions such as data loss may occur.
- Local PVs are in non-shared mode and cannot be mounted to multiple workloads or tasks concurrently. Additionally, local PVs cannot be mounted to multiple pods of a workload concurrently.

11.6.2 Importing a PV to a Storage Pool

CCE allows you to use LVM to combine data volumes on nodes into a storage pool (VolumeGroup) and create LVs for containers to mount. Before creating a local PV, import the data disk of the node to the storage pool.

Constraints

- Local PVs are supported only when the cluster version is v1.21.2-r0 or later and the Everest add-on version is 2.1.23 or later. Version 2.1.23 or later is recommended.
- The first data disk (used by container runtime and the kubelet component) on a node cannot be imported as a storage pool.
- Storage pools in striped mode do not support scale-out. After scale-out, fragmented space may be generated and the storage pool cannot be used.
- Storage pools cannot be scaled in or deleted.
- If disks in a storage pool on a node are deleted, the storage pool will malfunction.

Importing a Storage Pool

Imported during node creation

When creating a node, you can add a data disk to the node in **Storage Settings** and import the data disk to the storage pool as a PV. For details, see **Creating a Node**.

Imported manually

If no PV is imported during node creation, or the capacity of the current storage volume is insufficient, you can manually import a storage pool.

Step 1 Go to the ECS console and add a SCSI disk to the node.

Step 2 Log in to the CCE console and click the cluster name to access the cluster console.

Step 3 Choose **Storage** in the navigation pane and click the **Storage Pool** tab.

Step 4 View the node to which the disk has been added and select **Import as PV**. You can select a write mode during the import.

NOTE

If the manually attached disk is not displayed in the storage pool, wait for 1 minute and refresh the list.

- **Linear**: A linear logical volume integrates one or more physical volumes. Data is written to the next physical volume when the previous one is used up.
- **Striped**: A striped logical volume stripes data into blocks of the same size and stores them in multiple physical volumes in sequence, allowing data to be concurrently read and written. Select this option only when there are multiple volumes.

----End

11.6.3 Using a Local PV Through a Dynamic PV

Prerequisites

- You have created a cluster and installed the CSI add-on (**Everest**) in the cluster.
- Before creating a cluster using commands, ensure kubectl is used to access the cluster. For details, see **Connecting to a Cluster Using kubectl**.
- You have imported a data disk of a node to the local PV storage pool. For details, see **Importing a PV to a Storage Pool**.

Constraints

- Local PVs are supported only when the cluster version is v1.21.2-r0 or later and the Everest add-on version is 2.1.23 or later. Version 2.1.23 or later is recommended.
- Deleting, removing, resetting, or scaling in a node will cause the PVC/PV data of the local PV associated with the node to be lost, which cannot be restored or used again. For details, see **Removing a Node**, **Deleting a Node**, **Resetting a Node**, and **Scaling a Node**. In these scenarios, the pod that uses the local PV is evicted from the node. A new pod will be created and stay in the pending state. This is because the PVC used by the pod has a node label, due to which the pod cannot be scheduled. After the node is reset, the pod may be scheduled to the reset node. In this case, the pod remains in the creating state because the underlying logical volume corresponding to the PVC does not exist.
- Do not manually delete the corresponding storage pool or detach data disks from the node. Otherwise, exceptions such as data loss may occur.
- Local PVs are in non-shared mode and cannot be mounted to multiple workloads or tasks concurrently. Additionally, local PVs cannot be mounted to multiple pods of a workload concurrently.

Automatically Creating a Local PV on the Console

Step 1 Log in to the CCE console and click the cluster name to access the cluster console.

Step 2 Dynamically create a PVC and PV.

1. Choose **Storage** in the navigation pane and click the **PVCs** tab. Click **Create PVC** in the upper right corner. In the dialog box displayed, configure the PVC parameters.

Parameter	Description
PVC Type	In this section, select **Local PV**.
PVC Name	Enter the PVC name, which must be unique in the same namespace.
Creation Method	You can only select **Dynamically provision** to create a PVC, PV, and underlying storage on the console in cascading mode.
Storage Classes	The storage class of local PVs is **csi-local-topology**.
Access Mode	Local PVs support only **ReadWriteOnce**, indicating that a storage volume can be mounted to one node in read/write mode. For details, see **Volume Access Modes**.
Storage Pool	View the imported storage pool. For details about how to import a new data volume to the storage pool, see **Importing a PV to a Storage Pool**.
Capacity (GiB)	Capacity of the requested storage volume.

2. Click **Create** to create a PVC and a PV.

   You can choose **Storage** in the navigation pane and view the created PVC and PV on the **PVCs** and **PVs** tab pages, respectively.

   NOTE

   The volume binding mode of the local storage class (named **csi-local-topology**) is late binding (that is, the value of **volumeBindingMode** is **WaitForFirstConsumer**). In this mode, PV creation and binding are delayed. The corresponding PV is created and bound only when the PVC is used during workload creation.

Step 3 Create an application.

1. In the navigation pane on the left, click **Workloads**. In the right pane, click the **Deployments** tab.
2. Click **Create Workload** in the upper right corner. On the displayed page, click **Data Storage** in the **Container Settings** area and click **Add Volume** to select **PVC**.

   Mount and use storage volumes, as shown in **Table 11-28**. For details about other parameters, see **Workloads**.

Table 11-28 Mounting a storage volume

Parameter	Description
PVC	Select an existing local PV. A local PV cannot be repeatedly mounted to multiple workloads.
Mount Path	Enter a mount path, for example, **/tmp**. This parameter indicates the container path to which a data volume will be mounted. Do not mount the volume to a system directory such as **/** or **/var/run**. Otherwise, containers will be malfunctional. Mount the volume to an empty directory. If the directory is not empty, ensure that there are no files that affect container startup. Otherwise, the files will be replaced, causing container startup failures or workload creation failures. **NOTICE** If the container is mounted to a high-risk directory, use an account with minimum permissions to start the container. Otherwise, high-risk files on the host may be damaged.
Subpath	Enter the subpath of the storage volume and mount a path in the storage volume to the container. In this way, different folders of the same storage volume can be used in a single pod. **tmp**, for example, indicates that data in the mount path of the container is stored in the **tmp** folder of the storage volume. If this parameter is left blank, the root path is used by default.
Permission	– **Read-only**: You can only read the data in the mounted volumes. – **Read/Write**: You can modify the data volumes mounted to the path. Newly written data will not be migrated if the container is migrated, which may cause data loss.

In this example, the disk is mounted to the **/data** path of the container. The container data generated in this path is stored in the local PV.

3. After the configuration, click **Create Workload**.

   After the workload is created, the data in the container mount directory will be persistently stored. Verify the storage by referring to **Verifying Data Persistence**.

----End

(kubectl) Automatically Creating a Local PV

Step 1 Use kubectl to access the cluster.

Step 2 Use **StorageClass** to dynamically create a PVC and PV.

1. Create the **pvc-local.yaml** file.

```
apiVersion: v1
kind: PersistentVolumeClaim
metadata:
  name: pvc-local
  namespace: default
spec:
  accessModes:
    - ReadWriteOnce            # The value must be ReadWriteOnce for local PVs.
  resources:
    requests:
      storage: 10Gi            # Size of the local PV.
  storageClassName: csi-local-topology    # StorageClass is local PV.
```

Table 11-29 Key parameters

Parameter	Mandatory	Description
storage	Yes	Requested capacity in the PVC, in Gi.
storageClassName	Yes	Storage class name. The storage class name of local PV is **csi-local-topology**.

2. Run the following command to create a PVC:

```
kubectl apply -f pvc-local.yaml
```

Step 3 Create an application.

1. Create a file named **web-demo.yaml**. In this example, the local PV is mounted to the **/data** path.

```
apiVersion: apps/v1
kind: StatefulSet
metadata:
  name: web-local
  namespace: default
spec:
  replicas: 1
  selector:
    matchLabels:
      app: web-local
  serviceName: web-local   # Headless Service name.
  template:
    metadata:
      labels:
        app: web-local
    spec:
      containers:
      - name: container-1
        image: nginx:latest
        volumeMounts:
        - name: pvc-disk    #Volume name, which must be the same as the volume name in the volumes field.
          mountPath: /data  #Location where the storage volume is mounted.
      imagePullSecrets:
        - name: default-secret
      volumes:
        - name: pvc-disk    #Volume name, which can be customized.
          persistentVolumeClaim:
            claimName: pvc-local    #Name of the created PVC.
---
apiVersion: v1
kind: Service
metadata:
```

```
  name: web-local   # Headless Service name.
  namespace: default
  labels:
    app: web-local
spec:
  selector:
    app: web-local
  clusterIP: None
  ports:
    - name: web-local
      targetPort: 80
      nodePort: 0
      port: 80
      protocol: TCP
  type: ClusterIP
```

2. Run the following command to create a workload to which the local PV is mounted:

```
kubectl apply -f web-local.yaml
```

After the workload is created, the data in the container mount directory will be persistently stored. Verify the storage by referring to **Verifying Data Persistence**.

----End

Verifying Data Persistence

Step 1 View the deployed application and local files.

1. Run the following command to view the created pod:

```
kubectl get pod | grep web-local
```

Expected output:

```
web-local-0                1/1     Running   0             38s
```

2. Run the following command to check whether the local PV has been mounted to the **/data** path:

```
kubectl exec web-local-0 -- df | grep data
```

Expected output:

```
/dev/mapper/vg--everest--localvolume--persistent-pvc-local          10255636     36888  10202364   0% /data
```

3. Run the following command to view the files in the **/data** path:

```
kubectl exec web-local-0 -- ls /data
```

Expected output:

```
lost+found
```

Step 2 Run the following command to create a file named **static** in the **/data** path:

```
kubectl exec web-local-0 --  touch /data/static
```

Step 3 Run the following command to view the files in the **/data** path:

```
kubectl exec web-local-0 -- ls /data
```

Expected output:

```
lost+found
static
```

Step 4 Run the following command to delete the pod named **web-local-0**:

```
kubectl delete pod web-local-0
```

Expected output:

```
pod "web-local-0" deleted
```

Step 5 After the deletion, the StatefulSet controller automatically creates a replica with the same name. Run the following command to check whether the files in the **/data** path have been modified:

```
kubectl exec web-local-0 -- ls /data
```

Expected output:

```
lost+found
static
```

If the **static** file still exists, the data in the local PV can be stored persistently.

----End

Related Operations

You can also perform the operations listed in **Table 11-30**.

Table 11-30 Related operations

Operation	Description	Procedure
Viewing events	You can view event names, event types, number of occurrences, Kubernetes events, first occurrence time, and last occurrence time of the PVC or PV.	1. Choose **Storage** in the navigation pane and click the **PVCs** or **PVs** tab. 2. Click **View Events** in the **Operation** column of the target PVC or PV to view events generated within one hour (event data is retained for one hour).
Viewing a YAML file	You can view, copy, and download the YAML files of a PVC or PV.	1. Choose **Storage** in the navigation pane and click the **PVCs** or **PVs** tab. 2. Click **View YAML** in the **Operation** column of the target PVC or PV to view or download the YAML.

11.6.4 Dynamically Mounting a Local PV to a StatefulSet

Application Scenarios

Dynamic mounting is available only for creating a **StatefulSet**. It is implemented through a volume claim template (**volumeClaimTemplates** field) and depends on the storage class to dynamically provision PVs. In this mode, each pod in a multi-pod StatefulSet is associated with a unique PVC and PV. After a pod is rescheduled, the original data can still be mounted to it based on the PVC name. In the common mounting mode for a Deployment, if ReadWriteMany is supported, multiple pods of the Deployment will be mounted to the same underlying storage.

Prerequisites

- You have created a cluster and installed the CSI add-on (**Everest**) in the cluster.
- Before creating a cluster using commands, ensure kubectl is used to access the cluster. For details, see **Connecting to a Cluster Using kubectl**.
- You have imported a data disk of a node to the local PV storage pool. For details, see **Importing a PV to a Storage Pool**.

Dynamically Mounting a Local PV on the Console

Step 1 Log in to the CCE console and click the cluster name to access the cluster console.

Step 2 In the navigation pane on the left, click **Workloads**. In the right pane, click the **StatefulSets** tab.

Step 3 Click **Create Workload** in the upper right corner. On the displayed page, click **Data Storage** in the **Container Settings** area and click **Add Volume** to select **VolumeClaimTemplate**.

Step 4 Click **Create PVC**. In the dialog box displayed, configure the volume claim template parameters.

Click **Create**.

Parameter	Description
PVC Type	In this section, select **Local PV**.
PVC Name	Enter the name of the PVC. After a PVC is created, a suffix is automatically added based on the number of pods. The format is <*Custom PVC name*>-<*Serial number*>, for example, example-0.
Creation Method	You can only select **Dynamically provision** to create a PVC, PV, and underlying storage on the console in cascading mode.
Storage Classes	The storage class of local PVs is **csi-local-topology**.
Access Mode	Local PVs support only **ReadWriteOnce**, indicating that a storage volume can be mounted to one node in read/write mode. For details, see **Volume Access Modes**.
Storage Pool	View the imported storage pool. For details about how to import a new data volume to the storage pool, see **Importing a PV to a Storage Pool**.
Capacity (GiB)	Capacity of the requested storage volume.

Step 5 Enter the path to which the volume is mounted.

Table 11-31 Mounting a storage volume

Parameter	Description
Mount Path	Enter a mount path, for example, **/tmp**. This parameter indicates the container path to which a data volume will be mounted. Do not mount the volume to a system directory such as **/** or **/var/run**. Otherwise, containers will be malfunctional. Mount the volume to an empty directory. If the directory is not empty, ensure that there are no files that affect container startup. Otherwise, the files will be replaced, causing container startup failures or workload creation failures. **NOTICE** If a volume is mounted to a high-risk directory, use an account with minimum permissions to start the container. Otherwise, high-risk files on the host machine may be damaged.
Subpath	Enter the subpath of the storage volume and mount a path in the storage volume to the container. In this way, different folders of the same storage volume can be used in a single pod. **tmp**, for example, indicates that data in the mount path of the container is stored in the **tmp** folder of the storage volume. If this parameter is left blank, the root path is used by default.
Permission	• **Read-only**: You can only read the data in the mounted volumes. • **Read/Write**: You can modify the data volumes mounted to the path. Newly written data will not be migrated if the container is migrated, which may cause data loss.

In this example, the disk is mounted to the **/data** path of the container. The container data generated in this path is stored in the local PV.

Step 6 Dynamically mount and use storage volumes. For details about other parameters, see **Creating a StatefulSet**. After the configuration, click **Create Workload**.

After the workload is created, the data in the container mount directory will be persistently stored. Verify the storage by referring to **Verifying Data Persistence**.

----End

Dynamically Mounting a Local PV Using kubectl

Step 1 Use kubectl to access the cluster.

Step 2 Create a file named **statefulset-local.yaml**. In this example, the local PV is mounted to the **/data** path.

```
apiVersion: apps/v1
kind: StatefulSet
metadata:
  name: statefulset-local
  namespace: default
```

```
spec:
  selector:
    matchLabels:
      app: statefulset-local
  template:
    metadata:
      labels:
        app: statefulset-local
    spec:
      containers:
        - name: container-1
          image: nginx:latest
          volumeMounts:
            - name: pvc-local          # The value must be the same as that in the volumeClaimTemplates field.
              mountPath: /data         # Location where the storage volume is mounted.
      imagePullSecrets:
        - name: default-secret
  serviceName: statefulset-local       # Headless Service name.
  replicas: 2
  volumeClaimTemplates:
    - apiVersion: v1
      kind: PersistentVolumeClaim
      metadata:
        name: pvc-local
        namespace: default
      spec:
        accessModes:
          - ReadWriteOnce              # The value must be ReadWriteOnce for local PVs.
        resources:
          requests:
            storage: 10Gi              # Storage volume capacity.
        storageClassName: csi-local-topology      # StorageClass is local PV.
---
apiVersion: v1
kind: Service
metadata:
  name: statefulset-local   # Headless Service name.
  namespace: default
  labels:
    app: statefulset-local
spec:
  selector:
    app: statefulset-local
  clusterIP: None
  ports:
    - name: statefulset-local
      targetPort: 80
      nodePort: 0
      port: 80
      protocol: TCP
  type: ClusterIP
```

Table 11-32 Key parameters

Parameter	Mandatory	Description
storage	Yes	Requested capacity in the PVC, in Gi.
storageClassName	Yes	The storage class of local PVs is **csi-local-topology**.

Step 3 Run the following command to create a workload to which the local PV is mounted:

```
kubectl apply -f statefulset-local.yaml
```

After the workload is created, you can try **Verifying Data Persistence**.

----End

Verifying Data Persistence

Step 1 View the deployed application and files.

1. Run the following command to view the created pod:
   ```
   kubectl get pod | grep statefulset-local
   ```
   Expected output:
   ```
   statefulset-local-0         1/1     Running   0          45s
   statefulset-local-1         1/1     Running   0          28s
   ```
2. Run the following command to check whether the local PV has been mounted to the **/data** path:
   ```
   kubectl exec statefulset-local-0 -- df | grep data
   ```
   Expected output:
   ```
   /dev/mapper/vg--everest--localvolume--persistent-pvc-local      10255636     36888  10202364   0% /data
   ```
3. Run the following command to view the files in the **/data** path:
   ```
   kubectl exec statefulset-local-0 -- ls /data
   ```
   Expected output:
   ```
   lost+found
   ```

Step 2 Run the following command to create a file named **static** in the **/data** path:

```
kubectl exec statefulset-local-0 --  touch /data/static
```

Step 3 Run the following command to view the files in the **/data** path:

```
kubectl exec statefulset-local-0 -- ls /data
```

Expected output:

```
lost+found
static
```

Step 4 Run the following command to delete the pod named **web-local-auto-0**:

```
kubectl delete pod statefulset-local-0
```

Expected output:

```
pod "statefulset-local-0" deleted
```

Step 5 After the deletion, the StatefulSet controller automatically creates a replica with the same name. Run the following command to check whether the files in the **/data** path have been modified:

```
kubectl exec statefulset-local-0 -- ls /data
```

Expected output:

```
lost+found
static
```

If the **static** file still exists, the data in the local PV can be stored persistently.

----End

Related Operations

You can also perform the operations listed in **Table 11-33**.

Table 11-33 Related operations

Operation	Description	Procedure
Viewing events	You can view event names, event types, number of occurrences, Kubernetes events, first occurrence time, and last occurrence time of the PVC or PV.	1. Choose **Storage** in the navigation pane and click the **PVCs** or **PVs** tab. 2. Click **View Events** in the **Operation** column of the target PVC or PV to view events generated within one hour (event data is retained for one hour).
Viewing a YAML file	You can view, copy, and download the YAML files of a PVC or PV.	1. Choose **Storage** in the navigation pane and click the **PVCs** or **PVs** tab. 2. Click **View YAML** in the **Operation** column of the target PVC or PV to view or download the YAML.

11.7 Ephemeral Volumes

11.7.1 Overview

Introduction

Some applications require additional storage, but whether the data is still available after a restart is not important. For example, although cache services are limited by memory size, cache services can move infrequently used data to storage slower than memory. As a result, overall performance is not impacted significantly. Other applications require read-only data injected as files, such as configuration data or secrets.

Ephemeral volumes (EVs) in Kubernetes are designed for the above scenario. EVs are created and deleted together with pods following the pod lifecycle.

Common EVs in Kubernetes:

- **emptyDir**: empty at pod startup, with storage coming locally from the kubelet base directory (usually the root disk) or memory. emptyDir is allocated from the **EV of the node**. If data from other sources (such as log files or image tiering data) occupies the ephemeral storage, the storage capacity may be insufficient.
- **ConfigMap**: Kubernetes data of the ConfigMap type is mounted to pods as data volumes.

- **Secret**: Kubernetes data of the Secret type is mounted to pods as data volumes.

emptyDir Types

CCE provides the following emptyDir types:

- **Using a Temporary Path**: Kubernetes-native emptyDir type. Its lifecycle is the same as that of a pod. Memory can be specified as the storage medium. When the pod is deleted, the emptyDir volume is deleted and its data is lost.
- **Using a Local EV**: Local data disks in a node form a **storage pool** (VolumeGroup) through LVM. LVs are created as the storage medium of emptyDir and mounted to containers. LVs deliver better performance than the default storage medium of emptyDir.

Constraints

- Local EVs are supported only when the cluster version is v1.21.2-r0 or later and the Everest add-on version is 1.2.29 or later.
- Do not manually delete the corresponding storage pool or detach data disks from the node. Otherwise, exceptions such as data loss may occur.
- Ensure that the **/var/lib/kubelet/pods/** directory is not mounted to the pod on the node. Otherwise, the pod, mounted with such volumes, may fail to be deleted.

11.7.2 Importing an EV to a Storage Pool

CCE allows you to use LVM to combine data volumes on nodes into a storage pool (VolumeGroup) and create LVs for containers to mount. Before creating a local EV, import the data disk of the node to the storage pool.

Constraints

- Local EVs are supported only when the cluster version is v1.21.2-r0 or later and the Everest add-on version is 1.2.29 or later.
- The first data disk (used by container runtime and the kubelet component) on a node cannot be imported as a storage pool.
- Storage pools in striped mode do not support scale-out. After scale-out, fragmented space may be generated and the storage pool cannot be used.
- Storage pools cannot be scaled in or deleted.
- If disks in a storage pool on a node are deleted, the storage pool will malfunction.

Importing a Storage Pool

Imported during node creation

When creating a node, you can add a data disk to the node in **Storage Settings** and import the data disk to the storage pool as an EV. For details, see **Creating a Node**.

Imported manually

If no EV is imported during node creation, or the capacity of the current storage volume is insufficient, you can manually import a storage pool.

Step 1 Go to the ECS console and add a SCSI disk to the node.

Step 2 Log in to the CCE console and click the cluster name to access the cluster console.

Step 3 Choose **Storage** in the navigation pane and click the **Storage Pool** tab.

Step 4 View the node to which the disk has been added and select **Import as EV**. You can select a write mode during the import.

NOTE

If the manually attached disk is not displayed in the storage pool, wait for 1 minute and refresh the list.

- **Linear**: A linear logical volume integrates one or more physical volumes. Data is written to the next physical volume when the previous one is used up.
- **Striped**: A striped logical volume stripes data into blocks of the same size and stores them in multiple physical volumes in sequence, allowing data to be concurrently read and written. Select this option only when there are multiple volumes.

----End

11.7.3 Using a Local EV

Local Ephemeral Volumes (EVs) are stored in EV **storage pools**. Local EVs deliver better performance than the default storage medium of native emptyDir and support scale-out.

Prerequisites

- You have created a cluster and installed the CSI add-on (**Everest**) in the cluster.
- If you want to create a cluster using commands, use kubectl to connect to the cluster. For details, see **Connecting to a Cluster Using kubectl**.
- To use a local EV, import a data disk of a node to the local EV storage pool. For details, see **Importing an EV to a Storage Pool**.

Constraints

- Local EVs are supported only when the cluster version is v1.21.2-r0 or later and the Everest add-on version is 1.2.29 or later.
- Do not manually delete the corresponding storage pool or detach data disks from the node. Otherwise, exceptions such as data loss may occur.
- Ensure that the **/var/lib/kubelet/pods/** directory is not mounted to the pod on the node. Otherwise, the pod, mounted with such volumes, may fail to be deleted.

Using the Console to Mount a Local EV

Step 1 Log in to the CCE console and click the cluster name to access the cluster console.

Step 2 In the navigation pane on the left, click **Workloads**. In the right pane, click the **Deployments** tab.

Step 3 Click **Create Workload** in the upper right corner of the page. In the **Container Settings** area, click the **Data Storage** tab and click **Add Volume** > **Local Ephemeral Volume (emptyDir)**.

Step 4 Mount and use storage volumes, as shown in **Table 11-34**. For details about other parameters, see **Workloads**.

Table 11-34 Mounting a local EV

Parameter	Description
Capacity	Capacity of the requested storage volume.
Mount Path	Enter a mount path, for example, **/tmp**. This parameter indicates the container path to which a data volume will be mounted. Do not mount the volume to a system directory such as **/** or **/var/run**. Otherwise, containers will be malfunctional. Mount the volume to an empty directory. If the directory is not empty, ensure that there are no files that affect container startup. Otherwise, the files will be replaced, causing container startup failures or workload creation failures. **NOTICE** If the container is mounted to a high-risk directory, use an account with minimum permissions to start the container. Otherwise, high-risk files on the host may be damaged.
Subpath	Enter the subpath of the storage volume and mount a path in the storage volume to the container. In this way, different folders of the same storage volume can be used in a single pod. tmp, for example, indicates that data in the mount path of the container is stored in the **tmp** folder of the storage volume. If this parameter is left blank, the root path is used by default.
Permission	• **Read-only**: You can only read the data in the mounted volumes. • **Read/Write**: You can modify the data volumes mounted to the path. Newly written data will not be migrated if the container is migrated, which may cause data loss.

Step 5 After the configuration, click **Create Workload**.

----End

Using kubectl to Mount a Local EV

Step 1 Use kubectl to connect to the cluster. For details, see **Connecting to a Cluster Using kubectl**.

Step 2 Create a file named **nginx-emptydir.yaml** and edit it.

vi nginx-emptydir.yaml

Content of the YAML file:

```
apiVersion: apps/v1
kind: Deployment
metadata:
  name: nginx-emptydir
  namespace: default
spec:
  replicas: 2
  selector:
    matchLabels:
      app: nginx-emptydir
  template:
    metadata:
      labels:
        app: nginx-emptydir
    spec:
      containers:
        - name: container-1
          image: nginx:latest
          volumeMounts:
            - name: vol-emptydir        # Volume name, which must be the same as the volume name in the volumes field.
              mountPath: /tmp           # Path to which an EV is mounted.
      imagePullSecrets:
        - name: default-secret
      volumes:
        - name: vol-emptydir            # Volume name, which can be customized.
          emptyDir:
            medium: LocalVolume         # If the disk medium of emptyDir is set to LocalVolume, the local EV is used.
            sizeLimit: 1Gi              # Volume capacity.
```

Step 3 Create a workload.

kubectl apply -f nginx-emptydir.yaml

----End

11.7.4 Using a Temporary Path

A temporary path is of the Kubernetes-native emptyDir type. Its lifecycle is the same as that of a pod. Memory can be specified as the storage medium. When the pod is deleted, the emptyDir volume is deleted and its data is lost.

Using the Console to Use a Temporary Path

Step 1 Log in to the CCE console and click the cluster name to access the cluster console.

Step 2 In the navigation pane on the left, click **Workloads**. In the right pane, click the **Deployments** tab.

Step 3 Click **Create Workload** in the upper right corner of the page. In the **Container Settings** area, click the **Data Storage** tab and click **Add Volume** > **EmptyDir**.

Step 4 Mount and use storage volumes, as shown in **Table 11-35**. For details about other parameters, see **Workloads**.

Table 11-35 Mounting an EV

Parameter	Description
Storage Medium	**Memory**: • You can select this option to improve the running speed, but the storage capacity is subject to the memory size. This mode is applicable when data volume is small and efficient read and write is required. • If this function is disabled, data is stored in hard disks, which applies to a large amount of data with low requirements on reading and writing efficiency. **NOTE** • If **Memory** is selected, pay attention to the memory size. If the storage capacity exceeds the memory size, an OOM event occurs. • If **Memory** is selected, the size of an EV is the same as pod specifications. • If **Memory** is not selected, EVs will not occupy the system memory.
Mount Path	Enter a mount path, for example, **/tmp**. This parameter indicates the container path to which a data volume will be mounted. Do not mount the volume to a system directory such as **/** or **/var/run**. Otherwise, containers will be malfunctional. Mount the volume to an empty directory. If the directory is not empty, ensure that there are no files that affect container startup. Otherwise, the files will be replaced, causing container startup failures or workload creation failures. **NOTICE** If the container is mounted to a high-risk directory, use an account with minimum permissions to start the container. Otherwise, high-risk files on the host may be damaged.
Subpath	Enter the subpath of the storage volume and mount a path in the storage volume to the container. In this way, different folders of the same storage volume can be used in a single pod. tmp, for example, indicates that data in the mount path of the container is stored in the **tmp** folder of the storage volume. If this parameter is left blank, the root path is used by default.
Permission	• **Read-only**: You can only read the data in the mounted volumes. • **Read/Write**: You can modify the data volumes mounted to the path. Newly written data will not be migrated if the container is migrated, which may cause data loss.

Step 5 After the configuration, click **Create Workload**.

----End

Using kubectl to Use a Temporary Path

Step 1 Use kubectl to connect to the cluster. For details, see **Connecting to a Cluster Using kubectl**.

Step 2 Create a file named **nginx-emptydir.yaml** and edit it.

vi nginx-emptydir.yaml

Content of the YAML file:

```
apiVersion: apps/v1
kind: Deployment
metadata:
  name: nginx-emptydir
  namespace: default
spec:
  replicas: 2
  selector:
    matchLabels:
      app: nginx-emptydir
  template:
    metadata:
      labels:
        app: nginx-emptydir
    spec:
      containers:
        - name: container-1
          image: nginx:latest
          volumeMounts:
            - name: vol-emptydir     # Volume name, which must be the same as the volume name in the volumes field.
              mountPath: /tmp        # Path to which an EV is mounted.
      imagePullSecrets:
        - name: default-secret
      volumes:
        - name: vol-emptydir         # Volume name, which can be customized.
          emptyDir:
            medium: Memory           # EV disk medium: If this parameter is set to Memory, the memory is enabled. If this parameter is left blank, the native default storage medium is used.
            sizeLimit: 1Gi           # Volume capacity.
```

Step 3 Create a workload.

kubectl apply -f nginx-emptydir.yaml

----End

11.8 hostPath

hostPath is used for mounting the file directory of the host where the container is located to the specified mount point of the container. If the container needs to access **/etc/hosts**, use hostPath to map **/etc/hosts**.

NOTICE

- Avoid using hostPath volumes as much as possible, as they are prone to security risks. If hostPath volumes must be used, they can only be applied to files or paths and mounted in read-only mode.
- After the pod to which a hostPath volume is mounted is deleted, the data in the hostPath volume is retained.

Mounting a hostPath Volume on the Console

You can mount a path on the host to a specified container path. A hostPath volume is usually used to **store workload logs permanently** or used by workloads that need to **access internal data structure of the Docker engine on the host**.

Step 1 Log in to the CCE console.

Step 2 When creating a workload, click **Data Storage** in **Container Settings**. Click **Add Volume** and choose **hostPath** from the drop-down list.

Step 3 Set parameters for adding a local volume, as listed in **Table 11-36**.

Table 11-36 Setting parameters for mounting a hostPath volume

Parameter	Description
Volume Type	Select **HostPath**.
HostPath	Path of the host to which the local volume is to be mounted, for example, **/etc/hosts**. **NOTE** **HostPath** cannot be set to the root directory **/**. Otherwise, the mounting fails. Mount paths can be as follows: • **/opt/*xxxx*** (excluding **/opt/cloud**) • **/mnt/*xxxx*** (excluding **/mnt/paas**) • **/tmp/*xxx*** • **/var/*xxx*** (excluding key directories such as **/var/lib**, **/var/script**, and **/var/paas**) • **/*xxxx*** (It cannot conflict with the system directory, such as **bin**, **lib**, **home**, **root**, **boot**, **dev**, **etc**, **lost+found**, **mnt**, **proc**, **sbin**, **srv**, **tmp**, **var**, **media**, **opt**, **selinux**, **sys**, and **usr**.) Do not set this parameter to **/home/paas**, **/var/paas**, **/var/lib**, **/var/script**, **/mnt/paas**, or **/opt/cloud**. Otherwise, the system or node installation will fail.
Mount Path	Enter a mount path, for example, **/tmp**. This parameter indicates the container path to which a data volume will be mounted. Do not mount the volume to a system directory such as **/** or **/var/run**. Otherwise, containers will be malfunctional. Mount the volume to an empty directory. If the directory is not empty, ensure that there are no files that affect container startup. Otherwise, the files will be replaced, causing container startup failures or workload creation failures. **NOTICE** If the container is mounted to a high-risk directory, use an account with minimum permissions to start the container. Otherwise, high-risk files on the host may be damaged.

Parameter	Description
Subpath	Enter the subpath of the storage volume and mount a path in the storage volume to the container. In this way, different folders of the same storage volume can be used in a single pod. tmp, for example, indicates that data in the mount path of the container is stored in the **tmp** folder of the storage volume. If this parameter is left blank, the root path is used by default.
Permission	• **Read-only**: You can only read the data in the mounted volumes. • **Read/Write**: You can modify the data volumes mounted to the path. Newly written data will not be migrated if the container is migrated, which may cause data loss.

Step 4 After the configuration, click **Create Workload**.

----End

Mounting a hostPath Volume Using kubectl

Step 1 Use kubectl to connect to the cluster.

Step 2 Create a file named **nginx-hostpath.yaml** and edit it.

vi nginx-hostpath.yaml

The content of the YAML file is as follows. Mount the **/data** directory on the node to the **/data** directory in the container.

```
apiVersion: apps/v1
kind: Deployment
metadata:
  name: nginx-hostpath
  namespace: default
spec:
  replicas: 2
  selector:
    matchLabels:
      app: nginx-hostpath
  template:
    metadata:
      labels:
        app: nginx-hostpath
    spec:
      containers:
        - name: container-1
          image: nginx:latest
          volumeMounts:
            - name: vol-hostpath        # Volume name, which must be the same as the volume name in the volumes field.
              mountPath: /data          # Mount path in the container.
      imagePullSecrets:
        - name: default-secret
      volumes:
        - name: vol-hostpath            # Volume name, which can be customized.
          hostPath:
            path: /data                 # Directory location on the host node.
```

Step 3 Create a workload.

kubectl apply -f nginx-hostpath.yaml

----End

11.9 StorageClass

Introduction

StorageClass describes the classification of storage types in a cluster and can be represented as a configuration template for creating PVs. When creating a PVC or PV, specify StorageClass.

As a user, you only need to specify **storageClassName** when defining a PVC to automatically create a PV and underlying storage, significantly reducing the workload of creating and maintaining a PV.

In addition to the **default storage classes** provided by CCE, you can also customize storage classes.

- **Application Scenarios of Custom Storage**
- **Custom Storage Class**
- **Specifying a Default Storage Class**
- **Specifying an Enterprise Project for Storage Classes**

CCE Default Storage Classes

As of now, CCE provides storage classes 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 storage classes that CCE supports. Use the CSI add-on provided by CCE to create a storage class.

```
# 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 delayed
csi-nas           everest-csi-provisioner      17d       # SFS 1.0
csi-obs           everest-csi-provisioner      17d       # OBS
csi-sfsturbo      everest-csi-provisioner      17d       # SFS Turbo
```

Each storage class contains the default parameters used for dynamically creating a PV. The following is an example of storage class 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 11-37 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 11-38**.
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 created PV will be automatically destroyed. • **Retain**: indicates that a dynamically created PV will not be automatically destroyed.
allowVolumeExpansion	Specifies whether the PV of this storage class 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**: PV binding and dynamic creation are completed when a PVC is created. • **WaitForFirstConsumer**: PV binding and creation are delayed. The PV creation and binding processes are executed only when the PVC is used in the workload.
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 11-38 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**.

Volume Type	Parameter	Mandatory	Description
	everest.io/disk-volume-type	Yes	EVS disk type. All letters are in uppercase. • **SAS**: high I/O • **SSD**: ultra-high I/O
	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.
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 storage class. 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**: Parallel file system, which is mounted using obsfs (recommended). • **s3fs**: Object bucket, which is mounted using s3fs.

Volume Type	Parameter	Mandatory	Description
	everest.io/obs-volume-type	Yes	OBS storage class. • 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**.

Application Scenarios of Custom Storage

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 a 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 on CCE, use the **everest.io/disk-volume-type** field. SAS indicates the EVS disk type.

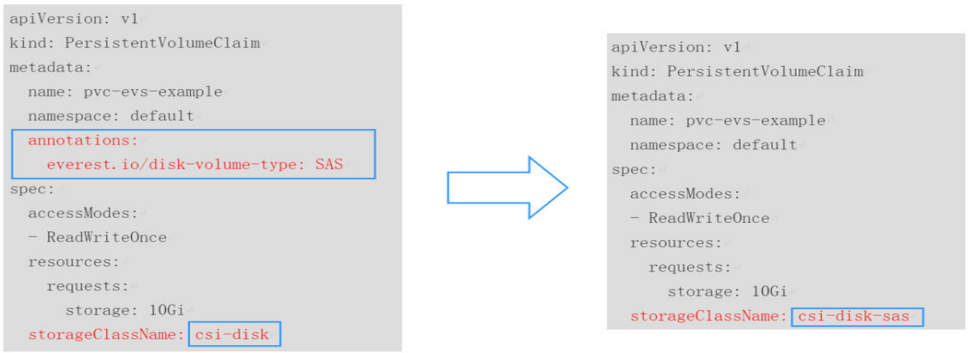
The preceding is a basic method of using StorageClass. In real-world scenarios, you can use StorageClass to perform other operations.

Application Scenario	Solution	Procedure
When **annotations** is used to specify storage configuration, the configuration is complex. For example, the **everest.io/disk-volume-type** field is used to specify the EVS disk type.	Define PVC annotations in the **parameters** field of StorageClass. When compiling a YAML file, you only need to specify **storageClassName**. For example, you can define SAS EVS disk and SSD EVS disk as a storage class, respectively. If a storage class named **csi-disk-sas** is defined, it is used to create SAS storage.	Custom Storage Class

Application Scenario	Solution	Procedure
When a user migrates services from a self-built Kubernetes cluster or other Kubernetes services to CCE, the storage class used in the original application YAML file is different from that used in CCE. As a result, a large number of YAML files or Helm chart packages need to be modified when the storage is used, which is complex and error-prone.	Create a storage class with the same name as that in the original application YAML file in the CCE centralization. After the migration, you do not need to modify the **storageClassName** in the application YAML file. For example, the EVS disk storage class used before the migration is **disk-standard**. After migrating services to a CCE cluster, you can copy the YAML file of the **csi-disk** storage class in the CCE cluster, change its name to **disk-standard**, and create another storage class.	
storageClassName must be specified in the YAML file to use the storage. If not, the storage cannot be created.	If you set the default StorageClass in the cluster, you can create storage without specifying the **storageClassName** in the YAML file.	**Specifying a Default Storage Class**

Custom Storage Class

This section uses the custom storage class of EVS disks as an example to describe how to define SAS EVS disk and SSD EVS disk as a storage class, respectively. For example, if you define a storage class named **csi-disk-sas**, which is used to create SAS storage, the differences are shown in the following figure. When compiling a YAML file, you only need to specify **storageClassName**.



StorageClass not customized

StorageClass customized

- 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 reclaim 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 is in the **Released** status and cannot be bound to the PVC again.

If high data security is required, 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 **StorageClass** again. The command output is as follows:

```
# 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
```

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
```

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
```

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.

12 Observability

12.1 Logging

12.1.1 Overview

Kubernetes logs allow you to locate and rectify faults. This section describes how you can manage Kubernetes logs:

- Connect CCE to AOM. For details, see **Collecting Container Logs Using ICAgent**.

12.1.2 Collecting Container Logs

12.1.2.1 Collecting Container Logs Using ICAgent

CCE works with AOM to collect workload logs. When a node is created, ICAgent (a DaemonSet named **icagent** in the **kube-system** namespace of a cluster) of AOM is installed by default. ICAgent collects workload logs and reports them to AOM. You can view workload logs on the CCE or AOM console.

Constraints

ICAgent only collects text logs in .log, .trace, and .out formats.

Using ICAgent to Collect Logs

Step 1 When **creating a workload**, set logging for the container.

Step 2 Click + to add a log policy.

Step 3 Set **Volume Type** to **hostPath** or **EmptyDir**.

Table 12-1 Configuring log policies

Parameter	Description
Volume Type	• **hostPath**: A host path is mounted to the specified container path (mount path). In the node host path, you can view the container logs output into the mount path. • **emptyDir**: A temporary path of the node is mounted to the specified path (mount path). Log data that exists in the temporary path but is not reported by the collector to AOM will disappear after the pod is deleted.
hostPath	Enter a host path, for example, **/var/paas/sys/log/nginx**.
Mount Path	Container path (for example, **/tmp**) to which the storage resources will be mounted. **NOTICE** • Do not mount storage to a system directory such as **/** or **/var/run**; this action may cause a container error to occur. You are advised to mount the container to an empty directory. If the directory is not empty, ensure that there are no files affecting container startup in the directory. Otherwise, such files will be replaced, resulting in failures to start the container and create the workload. • If the container is mounted to a high-risk directory, you are advised to use an account with minimum permissions to start the container; otherwise, high-risk files on the host may be damaged. • AOM collects only the first 20 logs that have been modified recently. It collects logs from 2 levels of subdirectories by default. • AOM only collects **.log**, **.trace**, and **.out** text logs in mounting paths. • For details about how to set permissions for mount points in a container, see **Configure a Security Context for a Pod or Container**.
Extended Host Path	This parameter is mandatory only if **Volume Type** is set to **HostPath**. Extended host paths contain pod IDs or container names to distinguish different containers into which the host path is mounted. A level-3 directory is added to the original volume directory/subdirectory. You can easily obtain the files output by a single Pod. • **None**: No extended path is configured. • **PodUID**: ID of a pod. • **PodName**: name of a pod. • **PodUID/ContainerName**: ID of a pod or name of a container. • **PodName/ContainerName**: name of a pod or container.

Parameter	Description
Collection Path	A collection path narrows down the scope of collection to specified logs. ● If no collection path is specified, log files in **.log**, **.trace**, and **.out** formats will be collected from the specified path. ● **/Path/**/** indicates that all log files in **.log**, **.trace**, and **.out** formats will be recursively collected from the specified path and all subdirectories at 5 levels deep. ● * in log file names indicates a fuzzy match. Example: The collection path **/tmp/**/test*.log** indicates that all **.log** files prefixed with **test** will be collected from **/tmp** and subdirectories at 5 levels deep. **CAUTION** Ensure that ICAgent is of v5.12.22 or later.
Log Dump	Log dump refers to rotating log files on a local host. ● **Enabled**: AOM scans log files every minute. When a log file exceeds 50 MB, it is dumped. A new **.zip** file is generated in the directory where the log file locates. For a log file, AOM stores only the latest 20 **.zip** files. When the number of **.zip** files exceeds 20, earlier **.zip** files will be deleted. ● **Disabled**: AOM does not dump log files. **NOTE** ● AOM rotates log files using copytruncate. Before enabling log dumping, ensure that log files are written in the append mode. Otherwise, file holes may occur. ● Currently, mainstream log components such as Log4j and Logback support log file rotation. If you have already set rotation for log files, skip the configuration. Otherwise, conflicts may occur. ● You are advised to configure log file rotation for your own services to flexibly control the size and number of rolled files.

Step 4 Click **OK**.

----End

YAML Example

You can set the container log storage path by defining a YAML file.

As shown in the following figure, an emptyDir volume is mounted a temporary path to **/var/log/nginx**. In this way, the ICAgent collects logs in **/var/log/nginx**. The **policy** field is customized by CCE and allows the ICAgent to identify and collect logs.

```
apiVersion: apps/v1
kind: Deployment
metadata:
  name: testlog
  namespace: default
spec:
```

```
selector:
  matchLabels:
    app: testlog
template:
  replicas: 1
  metadata:
    labels:
      app: testlog
  spec:
    containers:
      - image: 'nginx:alpine'
        name: container-0
        resources:
          requests:
            cpu: 250m
            memory: 512Mi
          limits:
            cpu: 250m
            memory: 512Mi
        volumeMounts:
          - name: vol-log
            mountPath: /var/log/nginx
            policy:
              logs:
                rotate: ''
    volumes:
      - emptyDir: {}
        name: vol-log
    imagePullSecrets:
      - name: default-secret
```

The following shows how to use a hostPath volume. Compared with emptyDir, the type of **volumes** is changed to **hostPath**, and the path on the host needs to be configured for this hostPath volume. In the following example, **/tmp/log** on the host is mounted to **/var/log/nginx**. In this way, the ICAgent can collects logs in **/var/log/nginx**, without deleting the logs from **/tmp/log**.

```
apiVersion: apps/v1
kind: Deployment
metadata:
  name: testlog
  namespace: default
spec:
  replicas: 1
  selector:
    matchLabels:
      app: testlog
  template:
    metadata:
      labels:
        app: testlog
    spec:
      containers:
        - image: 'nginx:alpine'
          name: container-0
          resources:
            requests:
              cpu: 250m
              memory: 512Mi
            limits:
              cpu: 250m
              memory: 512Mi
          volumeMounts:
            - name: vol-log
              mountPath: /var/log/nginx
              readOnly: false
              extendPathMode: PodUID
              policy:
                logs:
```

```
            rotate: Hourly
            annotations:
              pathPattern: '**'

  volumes:
    - hostPath:
        path: /tmp/log
      name: vol-log
  imagePullSecrets:
    - name: default-secret
```

Table 12-2 Parameter description

Parameter	Description	Description
extendPathMode	Extended host path	Extended host paths contain pod IDs or container names to distinguish different containers into which the host path is mounted. A level-3 directory is added to the original volume directory/subdirectory. You can easily obtain the files output by a single Pod. ● **None**: No extended path is configured. ● **PodUID**: ID of a pod. ● **PodName**: name of a pod. ● **PodUID/ContainerName**: ID of a pod or name of a container. ● **PodName/ContainerName**: name of a pod or container.
policy.logs.rotate	Log dump	Log dump refers to rotating log files on a local host. ● **Enabled**: AOM scans log files every minute. When a log file exceeds 50 MB, it is dumped immediately. A new **.zip** file is generated in the directory where the log file locates. For a log file, AOM stores only the latest 20 **.zip** files. When the number of **.zip** files exceeds 20, earlier **.zip** files will be deleted. After the dump is complete, the log file in AOM will be cleared. ● **Disabled**: AOM does not dump log files. **NOTE** ● AOM rotates log files using copytruncate. Before enabling log dumping, ensure that log files are written in the append mode. Otherwise, file holes may occur. ● Currently, mainstream log components such as Log4j and Logback support log file rotation. If you have already set rotation for log files, skip the configuration. Otherwise, conflicts may occur. ● You are advised to configure log file rotation for your own services to flexibly control the size and number of rolled files.

Parameter	Description	Description
policy.logs.annotations.pathPattern	Collection path	A collection path narrows down the scope of collection to specified logs. • If no collection path is specified, log files in **.log**, **.trace**, and **.out** formats will be collected from the specified path. • **/Path/**/** indicates that all log files in **.log**, **.trace**, and **.out** formats will be recursively collected from the specified path and all subdirectories at 5 levels deep. • * in log file names indicates a fuzzy match. Example: The collection path **/tmp/**/test*.log** indicates that all **.log** files prefixed with **test** will be collected from **/tmp** and subdirectories at 5 levels deep. **CAUTION** Ensure that ICAgent is of v5.12.22 or later.

Viewing Logs

After a log collection path is configured and the workload is created, the ICAgent collects log files from the configured path. The collection takes about 1 minute.

After the log collection is complete, go to the workload details page and click **Logs** in the upper right corner to view logs.

You can also view logs on the AOM console.

You can also run the **kubectl logs** command to view the standard output of a container.

```
# View logs of a specified pod.
kubectl logs <pod_name>
kubectl logs -f <pod_name> # Similar to tail -f

# View logs of a specified container in a specified pod.
kubectl logs <pod_name> -c <container_name>

kubectl logs pod_name -c container_name -n namespace (one-off query)
kubectl logs -f <pod_name> -n namespace (real-time query in tail -f mode)
```

12.2 Best Practices

12.2.1 Monitoring Custom Metrics Using Cloud Native Cluster Monitoring

CCE provides a cloud native cluster monitoring add-on to monitor custom metrics using Prometheus.

The following procedure uses an Nginx application as an example to describe how to use Prometheus to monitor custom metrics:

1. **Installing the Cloud Native Cluster Monitoring Add-on**

   CCE provides an add-on that integrates Prometheus functions. You can install it with several clicks.

2. **Preparing an Application**

   Prepare an application image. The application must provide a metric monitoring API for Prometheus to collect data, and the monitoring data must **comply with the Prometheus specifications**.

3. Monitoring Custom Metrics

   Use the application image to deploy a workload in a cluster. Custom metrics will be automatically reported to Prometheus.

   You can customize monitoring metrics by these ways:

   - **Method 1: Configuring Custom Metrics for Pod Annotations**
   - **Method 2: Configuring Custom Metrics for Service Annotations**
   - **Method 3: Configuring Custom Metrics for PodMonitor**
   - **Method 4: Configuring Custom Metrics for ServiceMonitor**

Constraints

- To use Prometheus to monitor custom metrics, the application needs to provide a metric monitoring API. For details, see **Prometheus Monitoring Data Collection**.
- Currently, metrics in the **kube-system** and **monitoring** namespaces cannot be collected when pod and service annotations are used. To collect metrics in the two namespaces, use PodMonitor and ServiceMonitor.
- The nginx/nginx-prometheus-exporter:0.9.0 image is pulled for the Nginx application. You need to add an EIP for the node where the application is deployed or upload the image to SWR to prevent application deployment failures.

Prometheus Monitoring Data Collection

Prometheus periodically calls the metric monitoring API (**/metrics** by default) of an application to obtain monitoring data. The application needs to provide the metric monitoring API for Prometheus to call, and the monitoring data must meet the following specifications of Prometheus:

```
# TYPE nginx_connections_active gauge
nginx_connections_active 2
# TYPE nginx_connections_reading gauge
nginx_connections_reading 0
```

Prometheus provides clients in various languages. For details about the clients, see **Prometheus CLIENT LIBRARIES**. For details about how to develop an exporter, see **WRITING EXPORTERS**. The Prometheus community provides various third-party exporters that can be directly used. For details, see **EXPORTERS AND INTEGRATIONS**.

Installing the Cloud Native Cluster Monitoring Add-on

Cloud Native Cluster Monitoring is available only in clusters v1.17 or later.

- For 3.8.0 and later versions, ensure that custom metric collection is enabled.

- For versions earlier than 3.8.0, you do not need to enable custom metric collection.

Preparing an Application

User-developed applications must provide a metric monitoring API, and the monitoring data must comply with the Prometheus specifications. For details, see **Prometheus Monitoring Data Collection**.

This section uses Nginx as an example to describe how to collect monitoring data. There is a module named **ngx_http_stub_status_module** in Nginx, which provides basic monitoring functions. You can configure the **nginx.conf** file to provide an interface for external systems to access Nginx monitoring data.

Step 1 Log in to a Linux VM that can access to the Internet and run Docker commands.

Step 2 Create an **nginx.conf** file. Add the server configuration under **http** to enable Nginx to provide an interface for the external systems to access the monitoring data.

```
user  nginx;
worker_processes  auto;

error_log  /var/log/nginx/error.log warn;
pid        /var/run/nginx.pid;

events {
    worker_connections  1024;
}

http {
    include       /etc/nginx/mime.types;
    default_type  application/octet-stream;
    log_format  main  '$remote_addr - $remote_user [$time_local] "$request" '
                      '$status $body_bytes_sent "$http_referer" '
                      '"$http_user_agent" "$http_x_forwarded_for"';

    access_log  /var/log/nginx/access.log  main;
    sendfile        on;
    #tcp_nopush     on;
    keepalive_timeout  65;
    #gzip  on;
    include /etc/nginx/conf.d/*.conf;

    server {
      listen 8080;
      server_name  localhost;
      location /stub_status {
         stub_status on;
         access_log off;
      }
    }
}
```

Step 3 Use this configuration to create an image and a Dockerfile file.

```
vi Dockerfile
```

The content of Dockerfile is as follows:

```
FROM nginx:1.21.5-alpine
ADD nginx.conf /etc/nginx/nginx.conf
EXPOSE 80
CMD ["nginx", "-g", "daemon off;"]
```

Step 4 Use this Dockerfile to build an image and upload it to SWR. The image name is **nginx:exporter**.

1. In the navigation pane, choose **My Images**. In the upper right corner, click **Upload Through Client**. On the displayed dialog box, click **Generate a temporary login command** and click  to copy the command.
2. Run the login command copied in the previous step on the node. If the login is successful, the message "Login Succeeded" is displayed.
3. Run the following command to build an image named nginx. The image version is exporter.
   ```
   docker build -t nginx:exporter .
   ```
4. Tag the image and upload it to the image repository. Change the image repository address and organization name based on your requirements.
   ```
   docker tag nginx:exporter {swr-address}/{group}/nginx:exporter
   docker push {swr-address}/{group}/nginx:exporter
   ```

Step 5 View application metrics.

1. Use **nginx:exporter** to create a workload.
2. **Access the container** and use http://<ip_address>:8080/stub_status to obtain nginx monitoring data. **<ip_address>** indicates the IP address of the container. Information similar to the following is displayed.
   ```
   # curl http://127.0.0.1:8080/stub_status
   Active connections: 3
   server accepts handled requests
    146269 146269 212
   Reading: 0 Writing: 1 Waiting: 2
   ```

----End

Method 1: Configuring Custom Metrics for Pod Annotations

When the annotation settings of pods comply with the Prometheus data collection rules, Prometheus automatically collects the metrics exposed by the pods.

The format of the monitoring data provided by **nginx:exporter** does not meet the requirements of Prometheus. Convert the data format to the format required by Prometheus. To convert the format of Nginx metrics, use **nginx-prometheus-exporter**. Deploy **nginx:exporter** and **nginx-prometheus-exporter** in the same pod and add the following annotations during deployment. Then Prometheus can automatically collect metrics.

```
kind: Deployment
apiVersion: apps/v1
metadata:
  name: nginx-exporter
  namespace: default
spec:
  replicas: 1
  selector:
    matchLabels:
      app: nginx-exporter
  template:
    metadata:
      labels:
        app: nginx-exporter
      annotations:
        prometheus.io/scrape: "true"
        prometheus.io/port: "9113"
        prometheus.io/path: "/metrics"
        prometheus.io/scheme: "http"
    spec:
      containers:
```

```
    - name: container-0
      image: 'nginx:exporter'      # Replace it with the address of the image you uploaded to SWR.
      resources:
        limits:
          cpu: 250m
          memory: 512Mi
        requests:
          cpu: 250m
          memory: 512Mi
    - name: container-1
      image: 'nginx/nginx-prometheus-exporter:0.9.0'
      command:
        - nginx-prometheus-exporter
      args:
        - '-nginx.scrape-uri=http://127.0.0.1:8080/stub_status'
  imagePullSecrets:
    - name: default-secret
```

Where,

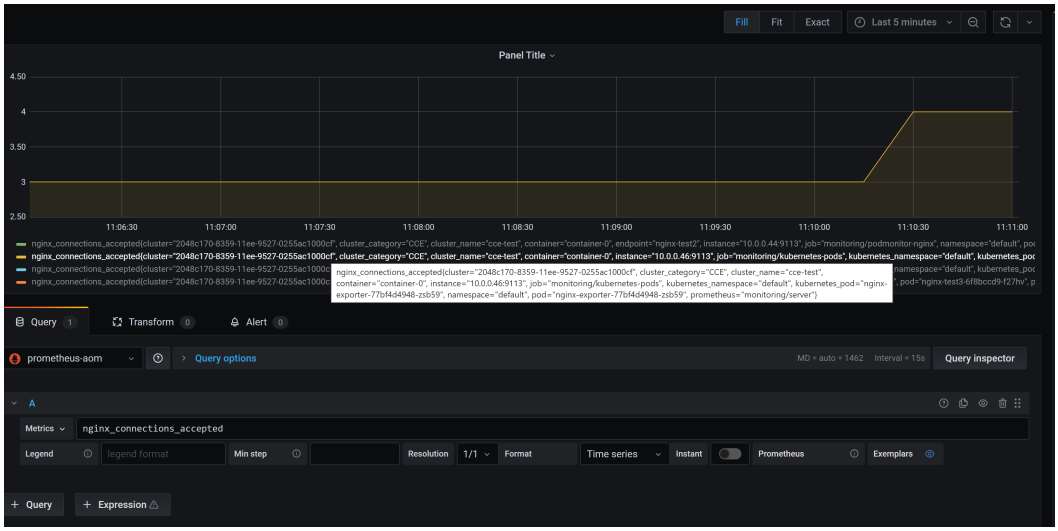
- **prometheus.io/scrape** indicates whether to enable Prometheus to collect pod monitoring data. The value is **true**.
- **prometheus.io/port** indicates the port for collecting monitoring data, which varies depending on the application. In this example, the port is 9113.
- **prometheus.io/path** indicates the URL of the API for collecting monitoring data. If this parameter is not set, the default value **/metrics** is used.
- **prometheus.io/scheme**: protocol used for data collection. The value can be **http** or **https**.

After the application is successfully deployed, access the cloud native cluster monitoring add-on to query custom monitoring metrics.

The custom monitoring metrics related to Nginx can be queried. You can use the job name to determine whether the metrics are reported based on the pod settings.

```
nginx_connections_accepted{cluster="2048c170-8359-11ee-9527-0255ac1000cf", cluster_category="CCE", cluster_name="cce-test", container="container-0", instance="10.0.0.46:9113", job="monitoring/kubernetes-pods", kubernetes_namespace="default", kubernetes_pod="nginx-exporter-77bf4d4948-zsb59", namespace="default", pod="nginx-exporter-77bf4d4948-zsb59", prometheus="monitoring/server"}
```

Figure 12-1 Viewing monitoring metrics



Method 2: Configuring Custom Metrics for Service Annotations

When the annotation settings of services comply with the Prometheus data collection rules, Prometheus automatically collects the metrics exposed by the services.

You can use service annotations in the same way as pod annotations. However, their application scenarios are different. Pod annotations focus on pod resource usage metrics while service annotations focus on metrics such as requests for a service.

The following is an example configuration:

```
kind: Deployment
apiVersion: apps/v1
metadata:
  name: nginx-test
  namespace: default
spec:
  replicas: 1
  selector:
    matchLabels:
      app: nginx-test
  template:
    metadata:
      labels:
        app: nginx-test
    spec:
      containers:
        - name: container-0
          image: 'nginx:exporter'      # Replace it with the address of the image you uploaded to SWR.
          resources:
            limits:
              cpu: 250m
              memory: 512Mi
            requests:
              cpu: 250m
              memory: 512Mi
        - name: container-1
          image: 'nginx/nginx-prometheus-exporter:0.9.0'
          command:
            - nginx-prometheus-exporter
          args:
            - '-nginx.scrape-uri=http://127.0.0.1:8080/stub_status'
      imagePullSecrets:
        - name: default-secret
```

The following is an example service configuration:

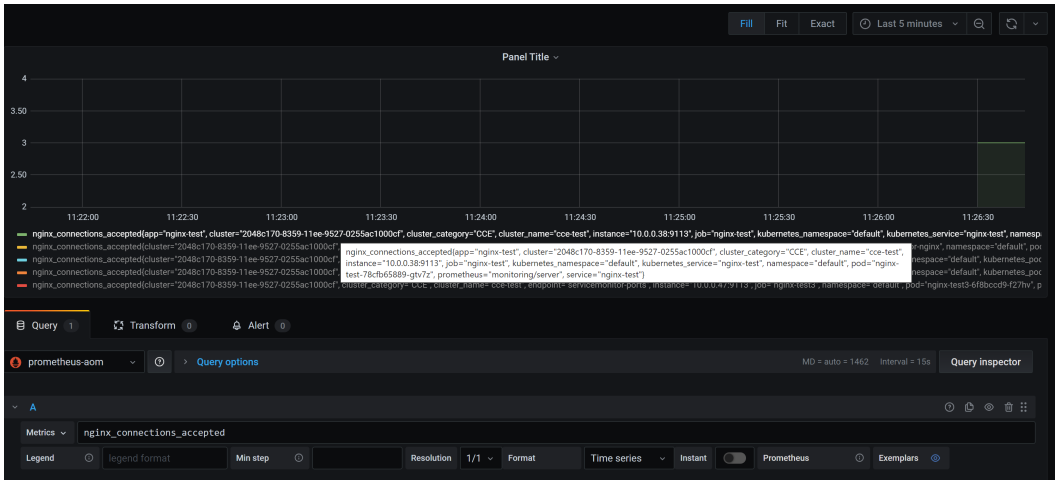
```
apiVersion: v1
kind: Service
metadata:
  name: nginx-test
  labels:
    app: nginx-test
  namespace: default
  annotations:
    prometheus.io/scrape: "true"  # Value true indicates that service discovery is enabled.
    prometheus.io/port: "9113"  # Set it to the port on which metrics are exposed.
    prometheus.io/path: "/metrics" # Enter the URI path under which metrics are exposed. Generally, the value is /metrics.
spec:
  selector:
    app: nginx-test
  externalTrafficPolicy: Cluster
  ports:
    - name: cce-service-0
      targetPort: 80
```

```
    nodePort: 0
    port: 8080
    protocol: TCP
  - name: cce-service-1
    protocol: TCP
    port: 9113
    targetPort: 9113
type: NodePort
```

View the metric. You can use the service name to determine whether the metric is reported based on the service configuration.

```
nginx_connections_accepted{app="nginx-test", cluster="2048c170-8359-11ee-9527-0255ac1000cf", cluster_category="CCE", cluster_name="cce-test", instance="10.0.0.38:9113", job="nginx-test", kubernetes_namespace="default", kubernetes_service="nginx-test", namespace="default", pod="nginx-test-78cfb65889-gtv7z", prometheus="monitoring/server", service="nginx-test"}
```

Figure 12-2 Viewing monitoring metrics



Method 3: Configuring Custom Metrics for PodMonitor

The cloud native cluster monitoring add-on allows you to configure metric collection tasks based on PodMonitor and ServiceMonitor. Prometheus Operator watches PodMonitor. The reload mechanism of Prometheus is used to trigger a hot update of the Prometheus collection tasks to the Prometheus instance.

To use CRDs defined by Prometheus Operator on GitHub, visit **https://github.com/prometheus-community/helm-charts/tree/main/charts/kube-prometheus-stack/charts/crds/crds**.

The following is an example configuration:

```
apiVersion: apps/v1
kind: Deployment
metadata:
  name: nginx-test2
  namespace: default
spec:
  replicas: 1
  selector:
    matchLabels:
      app: nginx-test2
  template:
    metadata:
      labels:
        app: nginx-test2
```

```
  spec:
    containers:
    - image: nginx:exporter     # Replace it with the address of the image you uploaded to SWR.
      name: container-0
      ports:
      - containerPort: 9113     # Port on which metrics are exposed.
        name: nginx-test2       # Application name used when PodMonitor is configured.
        protocol: TCP
      resources:
        limits:
          cpu: 250m
          memory: 300Mi
        requests:
          cpu: 100m
          memory: 100Mi
    - name: container-1
      image: 'nginx/nginx-prometheus-exporter:0.9.0'
      command:
        - nginx-prometheus-exporter
      args:
        - '-nginx.scrape-uri=http://127.0.0.1:8080/stub_status'
    imagePullSecrets:
      - name: default-secret
```

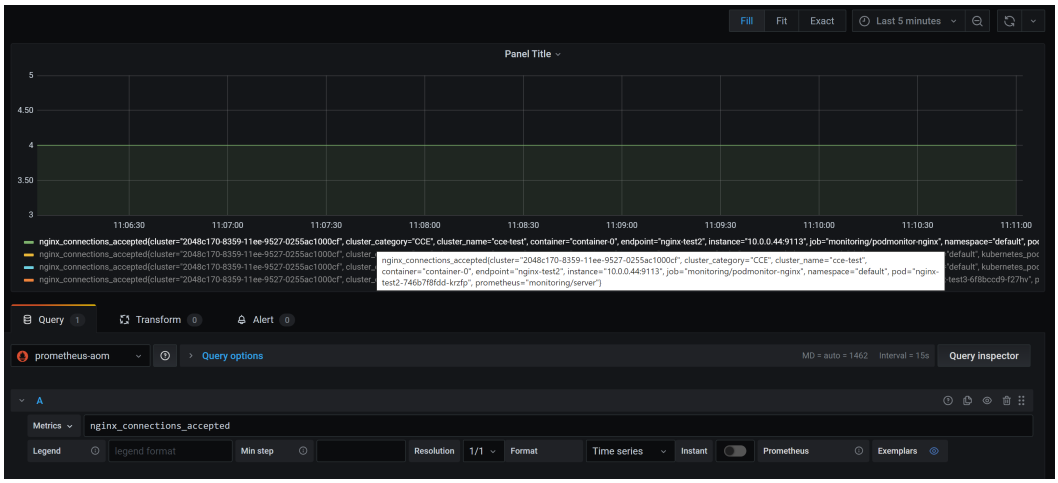
The following is an example PodMonitor configuration:

```
apiVersion: monitoring.coreos.com/v1
kind: PodMonitor
metadata:
  name: podmonitor-nginx   # PodMonitor name
  namespace: monitoring    # Namespace that PodMonitor belongs to. monitoring is recommended.
spec:
  namespaceSelector:       # An selector matching the namespace where the workload is located
    matchNames:
    - default              # Namespace that the workload belongs to
  jobLabel: podmonitor-nginx
  podMetricsEndpoints:
  - interval: 15s
    path: /metrics           # Path under which metrics are exposed by the workload
    port: nginx-test2        # Port on which metrics are exposed by the workload
    tlsConfig:
      insecureSkipVerify: true
  selector:
    matchLabels:
      app: nginx-test2   # Label carried by the pod, which can be selected by the selector
```

View the metric. You can use the job name to determine whether the metric is reported based on the PodMonitor settings.

```
nginx_connections_accepted{cluster="2048c170-8359-11ee-9527-0255ac1000cf", cluster_category="CCE",
cluster_name="cce-test", container="container-0", endpoint="nginx-test2", instance="10.0.0.44:9113",
job="monitoring/podmonitor-nginx", namespace="default", pod="nginx-test2-746b7f8fdd-krzfp",
prometheus="monitoring/server"}
```

Figure 12-3 Viewing monitoring metrics



Method 4: Configuring Custom Metrics for ServiceMonitor

The cloud native cluster monitoring add-on allows you to configure metric collection tasks based on PodMonitor and ServiceMonitor. Prometheus Operator watches ServiceMonitor. The reload mechanism of Prometheus is used to trigger a hot update of the Prometheus collection tasks to the Prometheus instance.

To use CRDs defined by Prometheus Operator on GitHub, visit **https://github.com/prometheus-community/helm-charts/tree/main/charts/kube-prometheus-stack/charts/crds/crds**.

The following is an example configuration:

```
apiVersion: apps/v1
kind: Deployment
metadata:
  name: nginx-test3
  namespace: default
spec:
  replicas: 1
  selector:
    matchLabels:
      app: nginx-test3
  template:
    metadata:
      labels:
        app: nginx-test3
    spec:
      containers:
      - image: nginx:exporter       # Replace it with the address of the image you uploaded to SWR.
        name: container-0
        resources:
          limits:
            cpu: 250m
            memory: 300Mi
          requests:
            cpu: 100m
            memory: 100Mi
      - name: container-1
        image: 'nginx/nginx-prometheus-exporter:0.9.0'
        command:
          - nginx-prometheus-exporter
        args:
          - '-nginx.scrape-uri=http://127.0.0.1:8080/stub_status'
      imagePullSecrets:
        - name: default-secret
```

The following is an example service configuration:

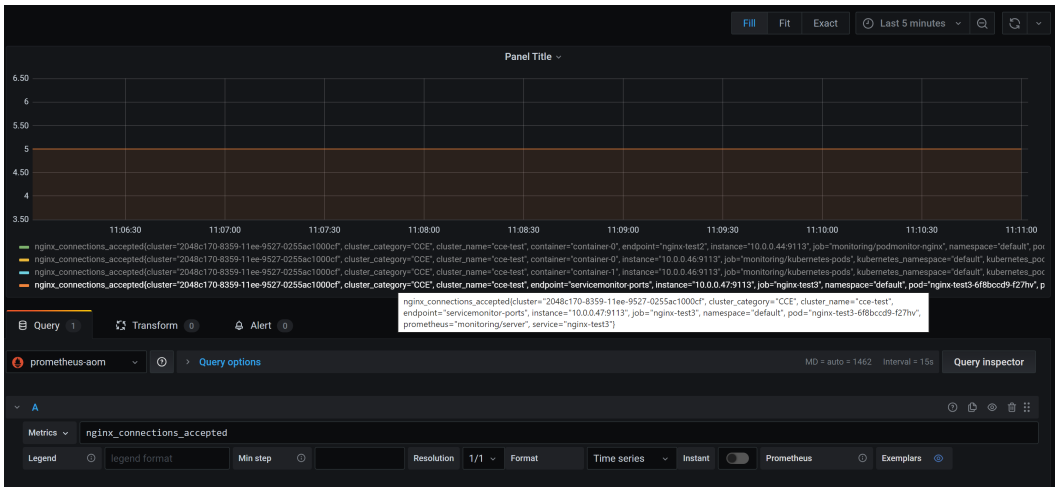
```
apiVersion: v1
kind: Service
metadata:
  name: nginx-test3
  labels:
    app: nginx-test3
  namespace: default
spec:
  selector:
    app: nginx-test3
  externalTrafficPolicy: Cluster
  ports:
    - name: cce-service-0
      targetPort: 80
      nodePort: 0
      port: 8080
      protocol: TCP
    - name: servicemonitor-ports
      protocol: TCP
      port: 9113
      targetPort: 9113
  type: NodePort
```

The following is an example ServiceMonitor configuration:

```
apiVersion: monitoring.coreos.com/v1
kind: ServiceMonitor
metadata:
  name: servicemonitor-nginx
  namespace: monitoring
spec:
  # Configure the name of the port on which metrics are exposed.
  endpoints:
  - path: /metrics
    port: servicemonitor-ports
  jobLabel: servicemonitor-nginx
  # Application scope of a collection task. If this parameter is not set, the default value default is used.
  namespaceSelector:
    matchNames:
    - default
  selector:
    matchLabels:
      app: nginx-test3
```

View the metric. You can use the endpoint name to determine whether the metric is reported based on the ServiceMonitor settings.

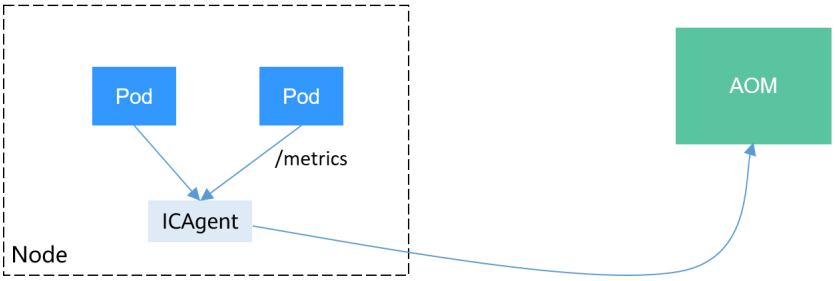
```
nginx_connections_accepted{cluster="2048c170-8359-11ee-9527-0255ac1000cf", cluster_category="CCE", cluster_name="cce-test", endpoint="servicemonitor-ports", instance="10.0.0.47:9113", job="nginx-test3", namespace="default", pod="nginx-test3-6f8bccd9-f27hv", prometheus="monitoring/server", service="nginx-test3"}
```



12.2.2 Monitoring Custom Metrics on AOM

CCE allows you to upload custom metrics to AOM. ICAgent on a node periodically calls the metric monitoring API configured on a workload to read monitoring data and then uploads the data to AOM.

Figure 12-4 Using ICAgent to collect monitoring metrics



The custom metric API of a workload can be configured when the workload is created. The following procedure uses an Nginx application as an example to describe how to report custom metrics to AOM.

1. **Preparing an Application**

   Prepare an application image. The application must provide a metric monitoring API for ICAgent to collect data, and the monitoring data must **comply with the Prometheus specifications**.

2. **Deploying Applications and Converting Nginx Metrics**

   Use the application image to deploy a workload in a cluster. Custom metrics are automatically reported.

3. **Verification**

   Go to AOM to check whether the custom metrics are successfully collected.

Constraints

- The ICAgent is compatible with the monitoring data specifications of **Prometheus**. The custom metrics provided by pods can be collected by the ICAgent only when they meet the monitoring data specifications of Prometheus. For details, see **Prometheus Monitoring Data Collection**.

- The ICAgent supports only **Gauge** metrics.
- The interval for the ICAgent to call the custom metric API is 1 minute, which cannot be changed.

Prometheus Monitoring Data Collection

Prometheus periodically calls the metric monitoring API (**/metrics** by default) of an application to obtain monitoring data. The application needs to provide the metric monitoring API for Prometheus to call, and the monitoring data must meet the following specifications of Prometheus:

```
# TYPE nginx_connections_active gauge
nginx_connections_active 2
# TYPE nginx_connections_reading gauge
nginx_connections_reading 0
```

Prometheus provides clients in various languages. For details about the clients, see **Prometheus CLIENT LIBRARIES**. For details about how to develop an exporter, see **WRITING EXPORTERS**. The Prometheus community provides various third-party exporters that can be directly used. For details, see **EXPORTERS AND INTEGRATIONS**.

Preparing an Application

User-developed applications must provide a metric monitoring API, and the monitoring data must comply with the Prometheus specifications. For details, see **Prometheus Monitoring Data Collection**.

This section uses Nginx as an example to describe how to collect monitoring data. There is a module named **ngx_http_stub_status_module** in Nginx, which provides basic monitoring functions. You can configure the **nginx.conf** file to provide an interface for external systems to access Nginx monitoring data.

Step 1 Log in to a Linux VM that can access to the Internet and run Docker commands.

Step 2 Create an **nginx.conf** file. Add the server configuration under **http** to enable Nginx to provide an interface for the external systems to access the monitoring data.

```
user  nginx;
worker_processes  auto;

error_log  /var/log/nginx/error.log warn;
pid        /var/run/nginx.pid;

events {
    worker_connections  1024;
}

http {
    include       /etc/nginx/mime.types;
    default_type  application/octet-stream;
    log_format  main  '$remote_addr - $remote_user [$time_local] "$request" '
                      '$status $body_bytes_sent "$http_referer" '
                      '"$http_user_agent" "$http_x_forwarded_for"';

    access_log  /var/log/nginx/access.log  main;
    sendfile        on;
    #tcp_nopush     on;
    keepalive_timeout  65;
    #gzip  on;
    include /etc/nginx/conf.d/*.conf;
```

```
  server {
    listen 8080;
    server_name  localhost;
    location /stub_status {
       stub_status on;
       access_log off;
    }
  }
}
```

Step 3 Use this configuration to create an image and a Dockerfile file.

```
vi Dockerfile
```

The content of Dockerfile is as follows:

```
FROM nginx:1.21.5-alpine
ADD nginx.conf /etc/nginx/nginx.conf
EXPOSE 80
CMD ["nginx", "-g", "daemon off;"]
```

Step 4 Use this Dockerfile to build an image and upload it to SWR. The image name is **nginx:exporter**.

1. In the navigation pane, choose **My Images**. In the upper right corner, click **Upload Through Client**. On the displayed dialog box, click **Generate a temporary login command** and click  to copy the command.
2. Run the login command copied in the previous step on the node. If the login is successful, the message "Login Succeeded" is displayed.
3. Run the following command to build an image named nginx. The image version is exporter.

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

4. Tag the image and upload it to the image repository. Change the image repository address and organization name based on your requirements.

   ```
   docker tag nginx:exporter {swr-address}/{group}/nginx:exporter
   docker push {swr-address}/{group}/nginx:exporter
   ```

Step 5 View application metrics.

1. Use **nginx:exporter** to create a workload.
2. **Access the container** and use http://<ip_address>:8080/stub_status to obtain nginx monitoring data. **<ip_address>** indicates the IP address of the container. Information similar to the following is displayed.

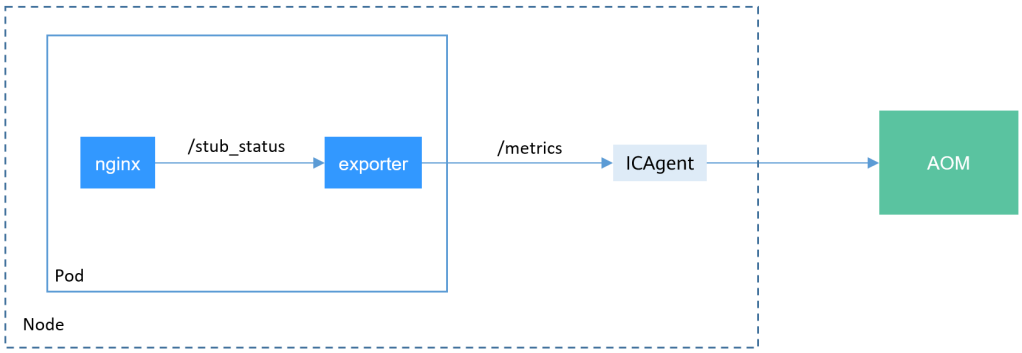
   ```
   # curl http://127.0.0.1:8080/stub_status
   Active connections: 3
   server accepts handled requests
    146269 146269 212
   Reading: 0 Writing: 1 Waiting: 2
   ```

----End

Deploying Applications and Converting Nginx Metrics

The format of the monitoring data provided by **nginx:exporter** does not meet the requirements of Prometheus. Convert the data format to the format required by Prometheus. To convert the format of Nginx metrics, use **nginx-prometheus-exporter**, as shown in the following figure.

Figure 12-5 Using exporter to convert the data format



Deploy **nginx:exporter** and **nginx-prometheus-exporter** in the same pod.

```
kind: Deployment
apiVersion: apps/v1
metadata:
  name: nginx-exporter
  namespace: default
spec:
  replicas: 1
  selector:
    matchLabels:
      app: nginx-exporter
  template:
    metadata:
      labels:
        app: nginx-exporter
      annotations:
        metrics.alpha.kubernetes.io/custom-endpoints: '[{"api":"prometheus","path":"/
metrics","port":"9113","names":""}]'
    spec:
      containers:
        - name: container-0
          image: 'nginx:exporter'  # Replace it with the address of the image you uploaded to SWR.
          resources:
            limits:
              cpu: 250m
              memory: 512Mi
            requests:
              cpu: 250m
              memory: 512Mi
        - name: container-1
          image: 'nginx/nginx-prometheus-exporter:0.9.0'
          command:
            - nginx-prometheus-exporter
          args:
            - '-nginx.scrape-uri=http://127.0.0.1:8080/stub_status'
      imagePullSecrets:
        - name: default-secret
```

NOTE

The **nginx/nginx-prometheus-exporter:0.9.0** image needs to be pulled from the public network. Therefore, a public IP address needs to be bound to each node in the cluster.

nginx-prometheus-exporter requires a startup command. **nginx-prometheus-exporter -nginx.scrape-uri=http://127.0.0.1:8080/stub_status** is used to obtain Nginx monitoring data.

In addition, add an annotation **metrics.alpha.kubernetes.io/custom-endpoints: '[{"api":"prometheus","path":"/metrics","port":"9113","names":""}]'** to the pod.

Verification

After an application is deployed, you can access Nginx to construct some access data and check whether the corresponding monitoring data can be obtained in AOM.

Step 1 Obtain the pod name of Nginx.

```
$ kubectl get pod
NAME                          READY   STATUS    RESTARTS   AGE
nginx-exporter-78859765db-6j8sw   2/2     Running   0          4m
```

Step 2 Log in to the container and run commands to access Nginx.

```
$ kubectl exec -it nginx-exporter-78859765db-6j8sw -- /bin/sh
Defaulting container name to container-0.
Use 'kubectl describe pod/nginx-exporter-78859765db-6j8sw -n default' to see all of the containers in this pod.
/ # curl http://localhost
<!DOCTYPE html>
<html>
<head>
<title>Welcome to nginx!</title>
<style>
html { color-scheme: light dark; }
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>
/ #
```

Step 3 Log in to AOM. In the navigation pane, choose **Monitoring** > **Metric Monitoring** to view Nginx-related metrics, for example, **nginx_connections_active**.

----End

12.2.3 Monitoring Metrics of Master Node Components Using Prometheus

This section describes how to use Prometheus to monitor the kube-apiserver, kube-controller, kube-scheduler and etcd-server components on the master node.

Collecting Metrics of Master Node Components Using Prometheus

This section describes how to collect metrics of master node components using Prometheus.

NOTICE

- The cluster version must be 1.19 or later.
- You need to install Prometheus using Helm by referring to **Prometheus**. You need to use prometheus-operator to manage installed Prometheus. For details, see **Prometheus Operator**.

  The Prometheus (**Prometheus**) add-on is end of maintenance and does not support this function. Therefore, do not use this add-on.

Step 1 Use **kubectl** to connect to the cluster.

Step 2 Modify the ClusterRole of Prometheus.

```
kubectl edit ClusterRole prometheus -n {namespace}
```

Add the following content under the **rules** field:

```
rules:
...
- apiGroups:
  - proxy.exporter.k8s.io
  resources:
  - "*"
  verbs: ["get", "list", "watch"]
```

Step 3 Create a file named **kube-apiserver.yaml** and edit it.

```
vi kube-apiserver.yaml
```

Example file content:

```
apiVersion: monitoring.coreos.com/v1
kind: ServiceMonitor
metadata:
  labels:
    app.kubernetes.io/name: apiserver
  name: kube-apiserver
  namespace: monitoring    # Change it to the namespace where Prometheus will be installed.
spec:
  endpoints:
  - bearerTokenFile: /var/run/secrets/kubernetes.io/serviceaccount/token
    interval: 30s
    metricRelabelings:
    - action: keep
      regex: (aggregator_unavailable_apiservice|
apiserver_admission_controller_admission_duration_seconds_bucket|
apiserver_admission_webhook_admission_duration_seconds_bucket|
apiserver_admission_webhook_admission_duration_seconds_count|
apiserver_client_certificate_expiration_seconds_bucket|apiserver_client_certificate_expiration_seconds_count|
apiserver_current_inflight_requests|apiserver_request_duration_seconds_bucket|apiserver_request_total|
go_goroutines|kubernetes_build_info|process_cpu_seconds_total|process_resident_memory_bytes|
rest_client_requests_total|workqueue_adds_total|workqueue_depth|
workqueue_queue_duration_seconds_bucket|aggregator_unavailable_apiservice_total|
rest_client_request_duration_seconds_bucket)
      sourceLabels:
      - __name__
    - action: drop
      regex: apiserver_request_duration_seconds_bucket;(0.15|0.25|0.3|0.35|0.4|0.45|0.6|0.7|0.8|0.9|1.25|1.5|1.75|
2.5|3|3.5|4.5|6|7|8|9|15|25|30|50)
      sourceLabels:
      - __name__
      - le
    port: https
    scheme: https
    tlsConfig:
      caFile: /var/run/secrets/kubernetes.io/serviceaccount/ca.crt
      serverName: kubernetes
  jobLabel: component
```

```
  namespaceSelector:
    matchNames:
    - default
  selector:
    matchLabels:
      component: apiserver
      provider: kubernetes
```

Create a ServiceMonitor:

```
kubectl apply -f kube-apiserver.yaml
```

Step 4 Create a file named **kube-controller.yaml** and edit it.

```
vi kube-controller.yaml
```

Example file content:

```
apiVersion: monitoring.coreos.com/v1
kind: ServiceMonitor
metadata:
  labels:
    app.kubernetes.io/name: kube-controller
  name: kube-controller-manager
  namespace: monitoring    # Change it to the namespace where Prometheus will be installed.
spec:
  endpoints:
    - bearerTokenFile: /var/run/secrets/kubernetes.io/serviceaccount/token
      interval: 15s
      honorLabels: true
      port: https
      relabelings:
        - regex: (.+)
          replacement: /apis/proxy.exporter.k8s.io/v1beta1/kube-controller-proxy/${1}/metrics
          sourceLabels:
            - __address__
          targetLabel: __metrics_path__
        - regex: (.+)
          replacement: ${1}
          sourceLabels:
            - __address__
          targetLabel: instance
        - replacement: kubernetes.default.svc.cluster.local:443
          targetLabel: __address__
      scheme: https
      tlsConfig:
        caFile: /var/run/secrets/kubernetes.io/serviceaccount/ca.crt
  jobLabel: app
  namespaceSelector:
    matchNames:
      - kube-system
  selector:
    matchLabels:
      app: kube-controller-proxy
      version: v1
```

Create a ServiceMonitor:

```
kubectl apply -f kube-controller.yaml
```

Step 5 Create a file named **kube-scheduler.yaml** and edit it.

```
vi kube-scheduler.yaml
```

Example file content:

```
apiVersion: monitoring.coreos.com/v1
kind: ServiceMonitor
metadata:
  labels:
    app.kubernetes.io/name: kube-scheduler
  name: kube-scheduler
  namespace: monitoring    # Change it to the namespace where Prometheus will be installed.
```

```
spec:
  endpoints:
    - bearerTokenFile: /var/run/secrets/kubernetes.io/serviceaccount/token
      interval: 15s
      honorLabels: true
      port: https
      relabelings:
        - regex: (.+)
          replacement: /apis/proxy.exporter.k8s.io/v1beta1/kube-scheduler-proxy/${1}/metrics
          sourceLabels:
            - __address__
          targetLabel: __metrics_path__
        - regex: (.+)
          replacement: ${1}
          sourceLabels:
            - __address__
          targetLabel: instance
        - replacement: kubernetes.default.svc.cluster.local:443
          targetLabel: __address__
      scheme: https
      tlsConfig:
        caFile: /var/run/secrets/kubernetes.io/serviceaccount/ca.crt
  jobLabel: app
  namespaceSelector:
    matchNames:
      - kube-system
  selector:
    matchLabels:
      app: kube-scheduler-proxy
      version: v1
```

Create a ServiceMonitor:

```
kubectl apply -f kube-scheduler.yaml
```

Step 6 Create a file named **etcd-server.yaml** and edit it.

```
vi etcd-server.yaml
```

Example file content:

```
apiVersion: monitoring.coreos.com/v1
kind: ServiceMonitor
metadata:
  labels:
    app.kubernetes.io/name: etcd-server
  name: etcd-server
  namespace: monitoring    # Change it to the namespace where Prometheus will be installed.
spec:
  endpoints:
    - bearerTokenFile: /var/run/secrets/kubernetes.io/serviceaccount/token
      interval: 15s
      honorLabels: true
      port: https
      relabelings:
        - regex: (.+)
          replacement: /apis/proxy.exporter.k8s.io/v1beta1/etcd-server-proxy/${1}/metrics
          sourceLabels:
            - __address__
          targetLabel: __metrics_path__
        - regex: (.+)
          replacement: ${1}
          sourceLabels:
            - __address__
          targetLabel: instance
        - replacement: kubernetes.default.svc.cluster.local:443
          targetLabel: __address__
      scheme: https
      tlsConfig:
        caFile: /var/run/secrets/kubernetes.io/serviceaccount/ca.crt
  jobLabel: app
```

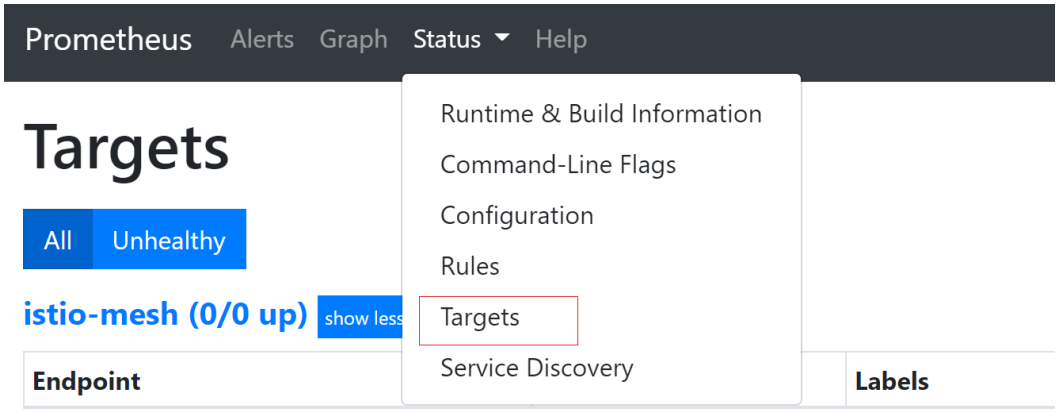
```
namespaceSelector:
  matchNames:
    - kube-system
selector:
  matchLabels:
    app: etcd-server-proxy
    version: v1
```

Create a ServiceMonitor:

```
kubectl apply -f etcd-server.yaml
```

Step 7 Access Prometheus and choose **Status** > **Targets**.

The preceding master node components are displayed.



----End

12.3 Cloud Trace Service

12.3.1 CCE Operations Supported by Cloud Trace Service

Cloud Trace Service (CTS) records operations on cloud service resources, allowing users to query, audit, and backtrack the resource operation requests initiated from the management console or open APIs as well as responses to the requests.

Table 12-3 CCE Operations Supported by CTS

Operation	Resource Type	Event Name
Creating an agency	Cluster	createUserAgencies
Creating a cluster	Cluster	createCluster
Updating the description of a cluster	Cluster	updateCluster
Upgrading a cluster	Cluster	clusterUpgrade
Deleting a cluster	Cluster	claimCluster/deleteCluster

Operation	Resource Type	Event Name
Downloading a cluster certificate	Cluster	getClusterCertByUID
Binding and unbinding an EIP	Cluster	operateMasterEIP
Waking up a cluster and resetting node management (V2)	Cluster	operateCluster
Hibernating a cluster (V3)	Cluster	hibernateCluster
Waking up a cluster (V3)	Cluster	awakeCluster
Changing the specifications of a cluster	Cluster	resizeCluster
Modifying configurations of a cluster	Cluster	updateConfiguration
Creating a node pool	Node pool	createNodePool
Updating a node pool	Node pool	updateNodePool
Deleting a node pool	Node pool	claimNodePool
Migrating a node pool	Node pool	migrateNodepool
Modifying node pool configurations	Node pool	updateConfiguration
Creating a node	Node	createNode
Deleting all the nodes from a specified cluster	Node	deleteAllHosts
Deleting a single node	Node	deleteOneHost/claimOneHost
Updating the description of a node	Node	updateNode
Creating an add-on instance	Add-on instance	createAddonInstance
Deleting an add-on instance	Add-on instance	deleteAddonInstance
Uploading a chart	Chart	uploadChart

Operation	Resource Type	Event Name
Updating a chart	Chart	updateChart
Deleting a chart	Chart	deleteChart
Creating a release	Release	createRelease
Upgrading a release	Release	updateRelease
Deleting a release	Release	deleteRelease
Creating a ConfigMap	Kubernetes resource	createConfigmaps
Creating a DaemonSet	Kubernetes resource	createDaemonsets
Creating a Deployment	Kubernetes resource	createDeployments
Creating an event	Kubernetes resource	createEvents
Creating an Ingress	Kubernetes resource	createIngresses
Creating a job	Kubernetes resource	createJobs
Creating a namespace	Kubernetes resource	createNamespaces
Creating a node	Kubernetes resource	createNodes
Creating a PersistentVolume-Claim	Kubernetes resource	createPersistentvolumeclaims
Creating a pod	Kubernetes resource	createPods
Creating a replica set	Kubernetes resource	createReplicasets
Creating a resource quota	Kubernetes resource	createResourcequotas
Creating a secret	Kubernetes resource	createSecrets
Creating a service	Kubernetes resource	createServices
Creating a StatefulSet	Kubernetes resource	createStatefulsets

Operation	Resource Type	Event Name
Creating a volume	Kubernetes resource	createVolumes
Deleting a ConfigMap	Kubernetes resource	deleteConfigmaps
Deleting a DaemonSet	Kubernetes resource	deleteDaemonsets
Deleting a Deployment	Kubernetes resource	deleteDeployments
Deleting an event	Kubernetes resource	deleteEvents
Deleting an Ingress	Kubernetes resource	deleteIngresses
Deleting a job	Kubernetes resource	deleteJobs
Deleting a namespace	Kubernetes resource	deleteNamespaces
Deleting a node	Kubernetes resource	deleteNodes
Deleting a Pod	Kubernetes resource	deletePods
Deleting a replica set	Kubernetes resource	deleteReplicasets
Deleting a resource quota	Kubernetes resource	deleteResourcequotas
Deleting a secret	Kubernetes resource	deleteSecrets
Deleting a service	Kubernetes resource	deleteServices
Deleting a StatefulSet	Kubernetes resource	deleteStatefulsets
Deleting volumes	Kubernetes resource	deleteVolumes
Replacing a specified ConfigMap	Kubernetes resource	updateConfigmaps
Replacing a specified DaemonSet	Kubernetes resource	updateDaemonsets
Replacing a specified Deployment	Kubernetes resource	updateDeployments

Operation	Resource Type	Event Name
Replacing a specified event	Kubernetes resource	updateEvents
Replacing a specified ingress	Kubernetes resource	updateIngresses
Replacing a specified job	Kubernetes resource	updateJobs
Replacing a specified namespace	Kubernetes resource	updateNamespaces
Replacing a specified node	Kubernetes resource	updateNodes
Replacing a specified PersistentVolume-Claim	Kubernetes resource	updatePersistentvolumeclaims
Replacing a specified pod	Kubernetes resource	updatePods
Replacing a specified replica set	Kubernetes resource	updateReplicasets
Replacing a specified resource quota	Kubernetes resource	updateResourcequotas
Replacing a specified secret	Kubernetes resource	updateSecrets
Replacing a specified service	Kubernetes resource	updateServices
Replacing a specified StatefulSet	Kubernetes resource	updateStatefulsets
Replacing the specified status	Kubernetes resource	updateStatus
Uploading a chart	Kubernetes resource	uploadChart
Updating a component template	Kubernetes resource	updateChart
Deleting a chart	Kubernetes resource	deleteChart
Creating a template application	Kubernetes resource	createRelease
Updating a template application	Kubernetes resource	updateRelease

Operation	Resource Type	Event Name
Deleting a template application	Kubernetes resource	deleteRelease

12.3.2 Querying Real-Time Traces

Scenarios

After you enable CTS and the management tracker is created, CTS starts recording operations on cloud resources. After a data tracker is created, the system starts recording operations on data in OBS buckets. CTS stores operation records generated in the last seven days.

This section describes how to query and export operation records of the last seven days on the CTS console.

- **Viewing Real-Time Traces in the Trace List of the New Edition**
- **Viewing Real-Time Traces in the Trace List of the Old Edition**

Viewing Real-Time Traces in the Trace List of the New Edition

1. Log in to the management console.
2. Click  in the upper left corner and choose Management & Deployment > **Cloud Trace Service**. The CTS console is displayed.
3. Choose **Trace List** in the navigation pane on the left.
4. On the **Trace List** page, use advanced search to query traces. You can combine one or more filters.
   - **Trace Name**: Enter a trace name.
   - **Trace ID**: Enter a trace ID.
   - **Resource Name**: Enter a resource name. If the cloud resource involved in the trace does not have a resource name or the corresponding API operation does not involve the resource name parameter, leave this field empty.
   - **Resource ID**: Enter a resource ID. Leave this field empty if the resource has no resource ID or if resource creation failed.
   - **Trace Source**: Select a cloud service name from the drop-down list.
   - **Resource Type**: Select a resource type from the drop-down list.
   - **Operator**: Select one or more operators from the drop-down list.
   - **Trace Status**: Select **normal**, **warning**, or **incident**.
     - **normal**: The operation succeeded.
     - **warning**: The operation failed.
     - **incident**: The operation caused a fault that is more serious than the operation failure, for example, causing other faults.

- Time range: Select **Last 1 hour**, **Last 1 day**, or **Last 1 week**, or specify a custom time range.

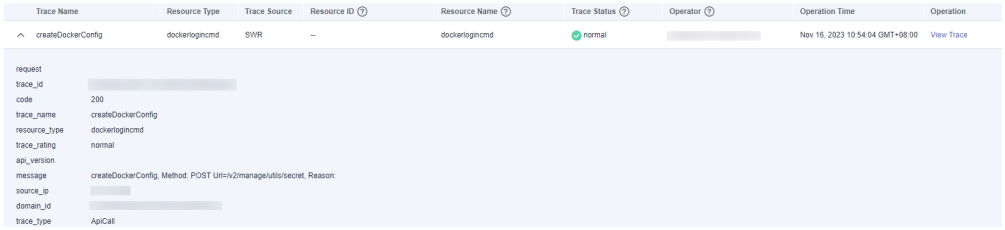
5. On the **Trace List** page, you can also export and refresh the trace list, and customize the list display settings.
   - Enter any keyword in the search box and press Enter to filter desired traces.
   - Click **Export** to export all traces in the query result as an .xlsx file. The file can contain up to 5000 records.
   - Click  to view the latest information about traces.
   - Click  to customize the information to be displayed in the trace list. If **Auto wrapping** is enabled (), excess text will move down to the next line; otherwise, the text will be truncated. By default, this function is disabled.
6. For details about key fields in the trace structure, see section "Trace References" > "Trace Structure" and section "Trace References" > "Example Traces".
7. (Optional) On the **Trace List** page of the new edition, click **Go to Old Edition** in the upper right corner to switch to the **Trace List** page of the old edition.

Viewing Real-Time Traces in the Trace List of the Old Edition

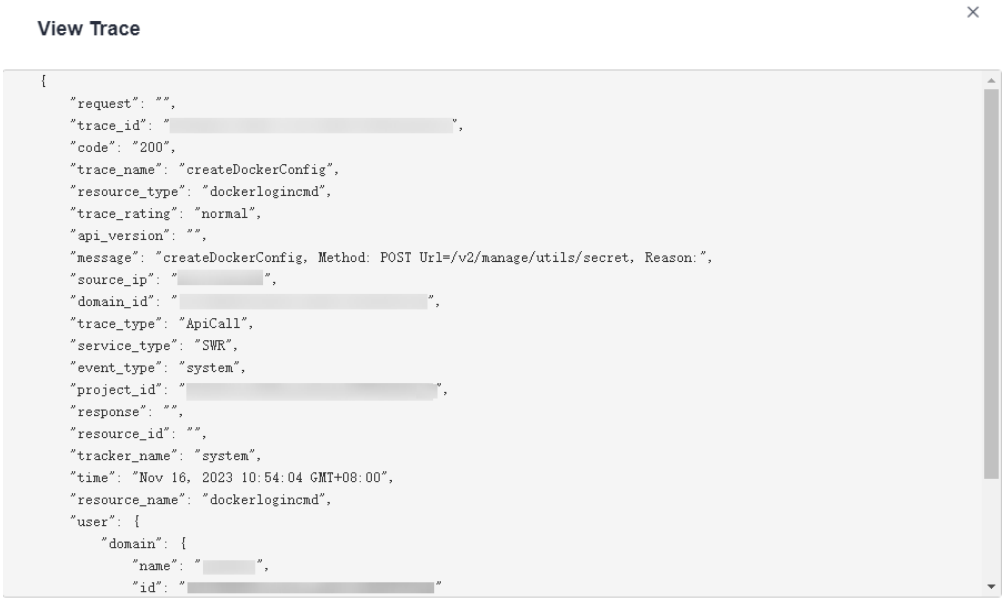
1. Log in to the management console.
2. Click  in the upper left corner and choose **Management & Deployment** > **Cloud Trace Service**. The CTS console is displayed.
3. Choose **Trace List** in the navigation pane on the left.
4. Each time you log in to the CTS console, the new edition is displayed by default. Click **Go to Old Edition** in the upper right corner to switch to the trace list of the old edition.
5. Set filters to search for your desired traces. The following filters are available:
   - **Trace Type**, **Trace Source**, **Resource Type**, and **Search By**: Select a filter from the drop-down list.
     - If you select **Resource ID** for **Search By**, specify a resource ID.
     - If you select **Trace name** for **Search By**, specify a trace name.
     - If you select **Resource name** for **Search By**, specify a resource name.
   - **Operator**: Select a user.
   - **Trace Status**: Select **All trace statuses**, **Normal**, **Warning**, or **Incident**.
   - Time range: You can query traces generated during any time range in the last seven days.
   - Click **Export** to export all traces in the query result as a CSV file. The file can contain up to 5000 records.
6. Click **Query**.
7. On the **Trace List** page, you can also export and refresh the trace list.

- Click **Export** to export all traces in the query result as a CSV file. The file can contain up to 5000 records.
- Click to view the latest information about traces.

8. Click on the left of a trace to expand its details.



9. Click **View Trace** in the **Operation** column. The trace details are displayed.



10. For details about key fields in the trace structure, see section "Trace References" > "Trace Structure" and section "Trace References" > "Example Traces" in the *CTS User Guide*.
11. (Optional) On the **Trace List** page of the old edition, click **New Edition** in the upper right corner to switch to the **Trace List** page of the new edition.

13 Namespaces

13.1 Creating a Namespace

Scenario

A namespace is a collection of resources and objects. Multiple namespaces can be created inside a cluster and isolated from each other. This enables namespaces to share the same cluster Services without affecting each other.

For example, you can deploy workloads in a development environment into one namespace, and deploy workloads in a testing environment into another namespace.

Prerequisites

At least one cluster has been created.

Constraints

A maximum of 6000 Services can be created in each namespace. The Services mentioned here indicate the Kubernetes Service resources added for workloads.

Namespace Types

Namespaces can be created in either of the following ways:

- Created automatically: When a cluster is up, the **default**, **kube-public**, **kube-system**, and **kube-node-lease** namespaces are created by default.
  - **default**: All objects for which no namespace is specified are allocated to this namespace.
  - **kube-public**: Resources in this namespace can be accessed by all users (including unauthenticated users), such as public add-ons and container charts.
  - **kube-system**: All resources created by Kubernetes are in this namespace.
  - **kube-node-lease**: Each node has an associated Lease object in this namespace. The object is periodically updated by the node. Both

NodeStatus and NodeLease are considered as heartbeats from a node. In versions earlier than v1.13, only NodeStatus is available. The NodeLease feature is introduced in v1.13. NodeLease is more lightweight than NodeStatus. This feature significantly improves the cluster scalability and performance.

- Created manually: You can create namespaces to serve separate purposes. For example, you can create three namespaces, one for a development environment, one for joint debugging environment, and one for test environment. You can also create one namespace for login services and one for game services.

Creating a Namespace

Step 1 Log in to the CCE console and click the cluster name to access the cluster console.

Step 2 Choose **Namespaces** in the navigation pane and click **Create Namespace** in the upper right corner.

Step 3 Set namespace parameters based on **Table 13-1**.

Table 13-1 Parameters for creating a namespace

Parameter	Description
Name	Unique name of the created namespace.
Description	Description about the namespace.
Quota Management	Resource quotas can limit the amount of resources available in namespaces, achieving resource allocation by namespace. **NOTICE** **You are advised to set resource quotas in the namespace as required to prevent cluster or node exceptions caused by resource overload.** For example, the default number of pods that can be created on each node in a cluster is 110. If you create a cluster with 50 nodes, you can create a maximum of 5,500 pods. Therefore, you can set a resource quota to ensure that the total number of pods in all namespaces does not exceed 5,500. Enter an integer. If the quota of a resource is not specified, no limit is posed on the resource. If you want to limit the CPU or memory quota, you must specify the CPU or memory request value when creating a workload.

Step 4 After the configuration is complete, click **OK**.

----End

Using kubectl to Create a Namespace

Define a namespace.

```
apiVersion: v1
kind: Namespace
metadata:
  name: custom-namespace
```

Run the **kubectl** command to create it.

```
$ kubectl create -f custom-namespace.yaml
namespace/custom-namespace created
```

You can also run the **kubectl create namespace** command to create a namespace.

```
$ kubectl create namespace custom-namespace
namespace/custom-namespace created
```

13.2 Managing Namespaces

Using Namespaces

- When creating a workload, you can select a namespace to isolate resources or users.
- When querying workloads, you can select a namespace to view all workloads in the namespace.

Isolating Namespaces

- **Isolating namespaces by environment**

  An application generally goes through the development, joint debugging, and testing stages before it is launched. In this process, the workloads deployed in each environment (stage) are the same, but are logically defined. There are two ways to define them:

  - Group them in different clusters for different environments.

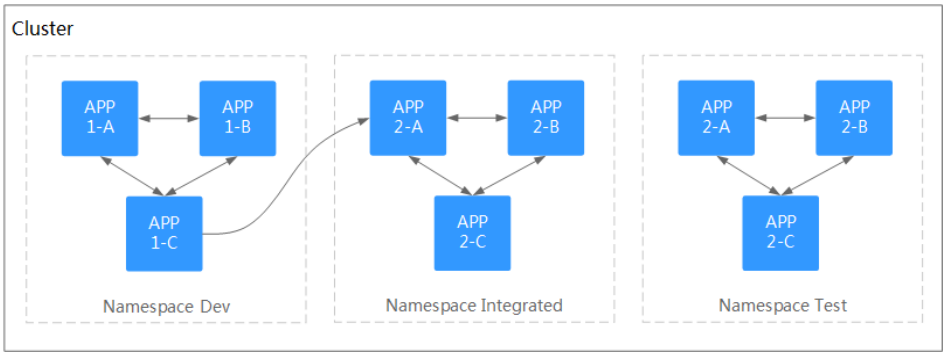
    Resources cannot be shared among different clusters. In addition, services in different environments can access each other only through load balancing.

  - Group them in different namespaces for different environments.

    Workloads in the same namespace can be mutually accessed by using the Service name. Cross-namespace access can be implemented by using the Service name or namespace name.

    The following figure shows namespaces created for the development, joint debugging, and testing environments, respectively.

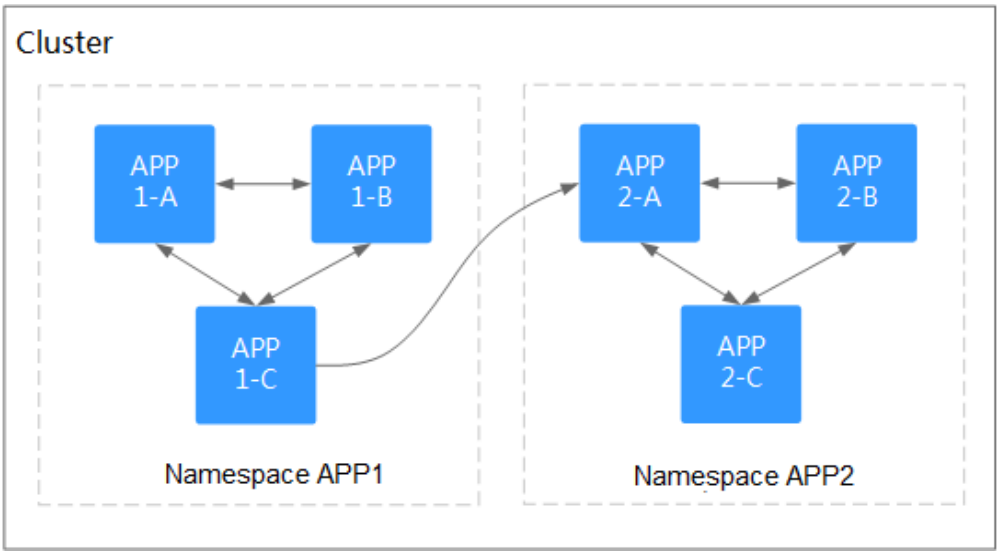
    Figure 13-1 One namespace for one environment

- **Isolating namespaces by application**

  You are advised to use this method if a large number of workloads are deployed in the same environment. For example, in the following figure, different namespaces (APP1 and APP2) are created to logically manage workloads as different groups. Workloads in the same namespace access each other using the Service name, and workloads in different namespaces access each other using the Service name or namespace name.

  Figure 13-2 Grouping workloads into different namespaces

Managing Namespace Labels

Step 1 Log in to the CCE console and click the cluster name to access the cluster console. In the navigation pane, choose **Namespaces**.

Step 2 Locate the row containing the target namespace and choose **More** > **Manage Label** in the **Operation** column.

Step 3 In the dialog box that is displayed, the existing labels of the namespace are displayed. Modify the labels as needed.

- Adding a label: Click the add icon, enter the key and value of the label to be added, and click **OK**.

  For example, the key is **project** and the value is **cicd**, indicating that the namespace is used to deploy CICD.

- Deleting a label: Click ⊖ next the label to be deleted and then **OK**.

Step 4 Switch to the **Manage Label** dialog box again and check the modified labels.

----End

Enabling Node Affinity in a Namespace

After node affinity is enabled in a namespace, the workloads newly created in the namespace can be scheduled only to nodes with specific labels. For details, see **PodNodeSelector**.

Step 1 Log in to the CCE console and click the cluster name to access the cluster console. In the navigation pane, choose **Namespaces**.

Step 2 Locate the target namespace and click  in the **Node Affinity** column.

Step 3 In the displayed dialog box, select **Enable** and click **OK**.

After node affinity is enabled, new workloads in the current namespace will be scheduled only to nodes with specified labels. For example, in namespace **test**, the workloads in the namespace can be scheduled only to the node whose label key is **kubelet.kubernetes.io/namespace** and label value is **test**.

Step 4 You can add specified labels to a node in **Labels and Taints** on the **Nodes** page. For details, see **Managing Node Labels**.

----End

Deleting a Namespace

If a namespace is deleted, all resources (such as workloads, jobs, and ConfigMaps) in this namespace will also be deleted. Exercise caution when deleting a namespace.

Step 1 Log in to the CCE console and click the cluster name to access the cluster console.

Step 2 Choose **Namespaces** in the navigation pane. On the displayed page, click **More** in the row of the target namespace and choose **Delete**.

Follow the prompts to delete the namespace. The default namespaces cannot be deleted.

----End

13.3 Configuring Resource Quotas

Namespace-level resource quotas limit the amount of resources available to teams or users when these teams or users use the same cluster. The quotas include the total number of a type of objects and the total amount of compute resources (CPU and memory) consumed by the objects.

Usage

By default, running pods can use the CPUs and memory of a node without restrictions. This means the pods in a namespace may exhaust all resources of the cluster.

Kubernetes provides namespaces for you to group workloads in a cluster. By setting resource quotas for each namespace, you can prevent resource exhaustion and ensure cluster reliability.

You can configure quotas for resources such as CPU, memory, and the number of pods in a namespace. For more information, see **Resource Quotas**.

The following table recommends how many pods you can configure for your clusters of different sizes.

Cluster Scale	Recommended Number of Pods
50 nodes	2,500 pods
200 nodes	10,000 pods
1000 nodes	30,000 pods
2000 nodes	50,000 pods

In clusters of v1.21 and later, the default resource quotas will be created when a namespace is created if you have enabled **enable-resource-quota** in **Cluster Configuration Management**. **Table 13-2** lists the resource quotas based on cluster specifications. You can modify them according to your service requirements.

Table 13-2 Default resource quotas

Cluster Scale	Pod	Deployment	Secret	ConfigMap	Service
50 nodes	2000	1000	1000	1000	1000
200 nodes	2000	1000	1000	1000	1000
1000 nodes	5000	2000	2000	2000	2000
2000 nodes	5000	2000	2000	2000	2000

Constraints

Kubernetes provides optimistic concurrency control (OCC), also known as optimistic locking, for frequent data updates. You can use optimistic locking by defining the **resourceVersion** field. This field is in the object metadata. This field identifies the internal version number of the object. When the object is modified, this field is modified accordingly. You can use kube-apiserver to check whether an object has been modified. When the API server receives an update request containing the **resourceVersion** field, the server compares the requested data with the resource version number of the server. If they are different, the object on the server has been modified when the update is submitted. In this case, the API server returns a conflict error (409). Obtain the server data, modify the data, and submit the data to the server again. The resource quota limits the total resource consumption of each namespace and records the resource information in the cluster. Therefore, after the **enable-resource-quota** option is enabled, the probability of resource creation conflicts increases in large-scale concurrency scenarios, affecting the performance of batch resource creation.

Procedure

Step 1 Log in to the CCE console and click the cluster name to access the cluster console.

Step 2 In the navigation pane, click **Namespaces**.

Step 3 Click **Quota Management** next to the target namespace.

This operation cannot be performed on system namespaces **kube-system** and **kube-public**.

Step 4 Set the resource quotas and click **OK**.

NOTICE

- After setting CPU and memory quotas for a namespace, you must specify the request and limit values of CPU and memory resources when creating a workload. Otherwise, the workload cannot be created. If the quota of a resource is set to **0**, the resource usage is not limited.
- Accumulated quota usage includes the resources used by CCE to create default components, such as the Kubernetes Services (which can be viewed using kubectl) created under the **default** namespace. Therefore, you are advised to set a resource quota greater than expected to reserve resource for creating default components.

----End

14 ConfigMaps and Secrets

14.1 Creating a ConfigMap

Scenario

A ConfigMap is a type of resource that stores configuration information required by a workload. Its content is user-defined. After creating ConfigMaps, you can use them as files or environment variables in a containerized workload.

ConfigMaps allow you to decouple configuration files from container images to enhance the portability of workloads.

Benefits of ConfigMaps:

- Manage configurations of different environments and services.
- Deploy workloads in different environments. Multiple versions are supported for configuration files so that you can update and roll back workloads easily.
- Quickly import configurations in the form of files to containers.

Constraints

- The size of a ConfigMap resource file cannot exceed 1 MB.
- ConfigMaps cannot be used in **static pods**.

Procedure

Step 1 Log in to the CCE console and click the cluster name to access the cluster console.

Step 2 Choose **ConfigMaps and Secrets** in the navigation pane and click **Create ConfigMap** in the upper right corner.

Step 3 Configure parameters.

Table 14-1 Parameters for creating a ConfigMap

Parameter	Description
Name	Name of the ConfigMap you create, which must be unique in a namespace.
Namespace	Namespace to which the ConfigMap belongs. If you do not specify this parameter, the value **default** is used by default.
Description	Description of the ConfigMap.
Data	Data of a ConfigMap, in the key-value pair format. Click + to add data. The value can be in string, JSON, or YAML format.
Label	Label of the ConfigMap. Enter a key-value pair and click **Confirm**.

Step 4 Click **OK**.

The new ConfigMap is displayed in the ConfigMap list.

----End

Creating a ConfigMap Using kubectl

Step 1 Use kubectl to connect to the cluster. For details, see **Connecting to a Cluster Using kubectl**.

Step 2 Create a file named **cce-configmap.yaml** and edit it.

vi cce-configmap.yaml

```
apiVersion: v1
kind: ConfigMap
metadata:
  name: cce-configmap
data:
  SPECIAL_LEVEL: Hello
  SPECIAL_TYPE: CCE
```

Table 14-2 Key parameters

Parameter	Description
apiVersion	The value is fixed at **v1**.
kind	The value is fixed at **ConfigMap**.
metadata.name	ConfigMap name, which can be customized.
data	ConfigMap data. The value must be key-value pairs.

Step 3 Run the following commands to create a ConfigMap.

kubectl create -f cce-configmap.yaml

Run the following commands to view the created ConfigMap:

kubectl get cm

```
NAME            DATA      AGE
cce-configmap   3         7m
```

----End

Related Operations

After creating a ConfigMap, you can update or delete it as described in **Table 14-3**.

Table 14-3 Related operations

Operation	Description
Editing a YAML file	Click **Edit YAML** in the row where the target ConfigMap resides to edit its YAML file.
Updating a ConfigMap	1. Select the name of the ConfigMap to be updated and click **Update**. 2. Modify the secret data. For more information, see **Table 14-1**. 3. Click **OK**.
Deleting a ConfigMap	Select the configuration you want to delete and click **Delete**. Follow the prompts to delete the ConfigMap.

14.2 Using a ConfigMap

After a ConfigMap is created, it can be used in three workload scenarios: environment variables, command line parameters, and data volumes.

- **Configuring Environment Variables of a Workload**
- **Configuring Command Line Parameters**
- **Mounting a ConfigMap to the Workload Data Volume**

The following example shows how to use a ConfigMap.

```
apiVersion: v1
kind: ConfigMap
metadata:
  name: cce-configmap
data:
  SPECIAL_LEVEL: Hello
  SPECIAL_TYPE: CCE
```

NOTICE

- When a ConfigMap is used in a workload, the workload and ConfigMap must be in the same cluster and namespace.
- When a ConfigMap is mounted as a data volume and the ConfigMap is updated, Kubernetes updates the data in the data volume at the same time.

  For a ConfigMap data volume mounted in **subPath** mode, Kubernetes cannot automatically update data in the data volume when the ConfigMap is updated.
- When a ConfigMap is used as an environment variable, data is not automatically updated when the ConfigMap is updated. To update the data, restart the pod.

Configuring Environment Variables of a Workload

Using the CCE console

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 **Workloads**. In the dialog box displayed, click **Create Workload** in the upper right corner.

When creating a workload, click **Environment Variables** in the **Container Settings** area, and click **Add Variable**.

- **Added from ConfigMap**: Select a ConfigMap to import all of its keys as environment variables.
- **Added from ConfigMap key**: Import a key in a ConfigMap as the value of an environment variable.
  - **Variable Name**: name of an environment variable in the workload. The name can be customized and is set to the key name selected in the ConfigMap by default.
  - **Variable Value/Reference**: Select a ConfigMap and the key to be imported. The corresponding value is imported as a workload environment variable.

  For example, after you import the value **Hello** of **SPECIAL_LEVEL** in ConfigMap **cce-configmap** as the value of workload environment variable **SPECIAL_LEVEL**, an environment variable named **SPECIAL_LEVEL** with its value **Hello** exists in the container.

Step 3 Configure other workload parameters and click **Create Workload**.

After the workload runs properly, **log in to the container** and run the following statement to check whether the ConfigMap has been set as an environment variable of the workload:

```
printenv SPECIAL_LEVEL
```

The example output is as follows:

```
Hello
```

----End

Using kubectl

Step 1 Use kubectl to connect to the cluster. For details, see **Connecting to a Cluster Using kubectl**.

Step 2 Create a file named **nginx-configmap.yaml** and edit it.

vi nginx-configmap.yaml

Content of the YAML file:

- **Added from ConfigMap**: To add all data in a ConfigMap to environment variables, use the **envFrom** parameter. The keys in the ConfigMap will become names of environment variables in the workload.

```
apiVersion: apps/v1
kind: Deployment
metadata:
  name: nginx-configmap
spec:
  replicas: 1
  selector:
    matchLabels:
      app: nginx-configmap
  template:
    metadata:
      labels:
        app: nginx-configmap
    spec:
      containers:
      - name: container-1
        image: nginx:latest
        envFrom:                    # Use envFrom to specify a ConfigMap to be referenced by environment variables.
        - configMapRef:
            name: cce-configmap     # Name of the referenced ConfigMap.
      imagePullSecrets:
      - name: default-secret
```

- **Added from ConfigMap key**: When creating a workload, you can use a ConfigMap to set environment variables and use the **valueFrom** parameter to reference the key-value pair in the ConfigMap separately.

```
apiVersion: apps/v1
kind: Deployment
metadata:
  name: nginx-configmap
spec:
  replicas: 1
  selector:
    matchLabels:
      app: nginx-configmap
  template:
    metadata:
      labels:
        app: nginx-configmap
    spec:
      containers:
      - name: container-1
        image: nginx:latest
        env:                        # Set the environment variable in the workload.
        - name: SPECIAL_LEVEL       # Name of the environment variable in the workload.
          valueFrom:                # Specify a ConfigMap to be referenced by the environment variable.
            configMapKeyRef:
              name: cce-configmap   # Name of the referenced ConfigMap.
              key: SPECIAL_LEVEL    # Key in the referenced ConfigMap.
        - name: SPECIAL_TYPE        # Add multiple environment variables to import them at the same time.
          valueFrom:
            configMapKeyRef:
              name: cce-configmap
              key: SPECIAL_TYPE
```

```
    imagePullSecrets:
    - name: default-secret
```

Step 3 Create a workload.

kubectl apply -f nginx-configmap.yaml

Step 4 View the environment variables in the pod.

1. Run the following command to view the created pod:
   ```
   kubectl get pod | grep nginx-configmap
   ```
   Expected output:
   ```
   nginx-configmap-***   1/1     Running   0          2m18s
   ```
2. Run the following command to view the environment variables in the pod:
   ```
   kubectl exec nginx-configmap-*** -- printenv SPECIAL_LEVEL SPECIAL_TYPE
   ```
   Expected output:
   ```
   Hello
   CCE
   ```
   The ConfigMap has been set as environment variables of the workload.

----End

Configuring Command Line Parameters

You can use a ConfigMap as an environment variable to set commands or parameter values for a container by using the environment variable substitution syntax $(VAR_NAME).

Using the CCE console

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 **Workloads**. In the dialog box displayed, click **Create Workload** in the upper right corner.

When creating a workload, click **Environment Variables** in the **Container Settings** area, and click **Add Variable**. In this example, select **Added from ConfigMap**.

- **Added from ConfigMap**: Select a ConfigMap to import all of its keys as environment variables.

Step 3 Click **Lifecycle** in the **Container Settings** area, click the **Post-Start** tab on the right, and set the following parameters:

- **Processing Method**: **CLI**
- **Command**: Enter the following three command lines. *SPECIAL_LEVEL* and *SPECIAL_TYPE* are the environment variable names in the workload, that is, the key names in the **cce-configmap** ConfigMap.
  ```
  /bin/bash
  -c
  echo $SPECIAL_LEVEL $SPECIAL_TYPE > /usr/share/nginx/html/index.html
  ```

Step 4 Set other workload parameters and click **Create Workload**.

After the workload runs properly, **log in to the container** and run the following statement to check whether the ConfigMap has been set as an environment variable of the workload:

```
cat /usr/share/nginx/html/index.html
```

The example output is as follows:

```
Hello CCE
```

----End

Using kubectl

Step 1 Use kubectl to connect to the cluster. For details, see **Connecting to a Cluster Using kubectl**.

Step 2 Create a file named **nginx-configmap.yaml** and edit it.

vi nginx-configmap.yaml

As shown in the following example, the **cce-configmap** ConfigMap is imported to the workload. *SPECIAL_LEVEL* and *SPECIAL_TYPE* are the environment variable names in the workload, that is, the key names in the **cce-configmap** ConfigMap.

```
apiVersion: apps/v1
kind: Deployment
metadata:
  name: nginx-configmap
spec:
  replicas: 1
  selector:
    matchLabels:
      app: nginx-configmap
  template:
    metadata:
      labels:
        app: nginx-configmap
    spec:
      containers:
      - name: container-1
        image: nginx:latest
        lifecycle:
          postStart:
            exec:
              command: [ "/bin/sh", "-c", "echo $SPECIAL_LEVEL $SPECIAL_TYPE > /usr/share/nginx/html/
index.html" ]
        envFrom:                    # Use envFrom to specify a ConfigMap to be referenced by environment
variables.
        - configMapRef:
            name: cce-configmap     # Name of the referenced ConfigMap.
      imagePullSecrets:
        - name: default-secret
```

Step 3 Create a workload.

kubectl apply -f nginx-configmap.yaml

Step 4 After the workload runs properly, the following content is entered into the **/usr/share/nginx/html/index.html** file in the container:

1. Run the following command to view the created pod:

   ```
   kubectl get pod | grep nginx-configmap
   ```

   Expected output:

   ```
   nginx-configmap-***   1/1     Running   0          2m18s
   ```

2. Run the following command to view the environment variables in the pod:

   ```
   kubectl exec nginx-configmap-*** -- cat /usr/share/nginx/html/index.html
   ```

   Expected output:

   ```
   Hello CCE
   ```

----End

Mounting a ConfigMap to the Workload Data Volume

The data stored in a ConfigMap can be referenced in a volume of type ConfigMap. You can mount such a volume to a specified container path. The platform supports the separation of workload codes and configuration files. ConfigMap volumes are used to store workload configuration parameters. Before that, create ConfigMaps in advance. For details, see **Creating a ConfigMap**.

Using the CCE console

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 **Workloads**. In the dialog box displayed, click **Create Workload** in the upper right corner.

When creating a workload, click **Data Storage** in the **Container Settings** area. Click **Add Volume** and select **ConfigMap** from the drop-down list.

Step 3 Select parameters for mounting a ConfigMap volume, as shown in **Table 14-4**.

Table 14-4 Mounting a ConfigMap volume

Parameter	Description
ConfigMap	Select the desired ConfigMap. A ConfigMap must be created beforehand. For details, see **Creating a ConfigMap**.
Mount Path	Enter a mount point. After the ConfigMap volume is mounted, a configuration file with the key as the file name and value as the file content is generated in the mount path of the container. This parameter indicates the container path to which a data volume will be mounted. Do not mount the volume to a system directory such as **/** or **/var/run**. This may lead to container errors. Mount the volume to an empty directory. If the directory is not empty, ensure that there are no files that affect container startup. Otherwise, the files will be replaced, which leads to a container startup failure or workload creation failure. **NOTICE** If the container is mounted to a high-risk directory, use an account with minimum permissions to start the container. Otherwise, high-risk files on the host may be damaged.
Subpath	Enter a subpath of the mount path. • A subpath is used to mount a local volume so that the same data volume is used in a single pod. If this parameter is left blank, the root path is used by default. • The subpath can be the key and value of a ConfigMap or secret. If the subpath is a key-value pair that does not exist, the data import does not take effect. • The data imported by specifying a subpath will not be updated along with the ConfigMap/secret updates.

Parameter	Description
Permission	Read-only, indicating that data volume in the path is read-only.

Step 4 After the configuration, click **Create Workload**.

After the workload runs properly, the **SPECIAL_LEVEL** and **SPECIAL_TYPE** files will be generated in the **/etc/config** directory in this example. The contents of the files are **Hello** and **CCE**, respectively.

Access the container and run the following statement to view the **SPECIAL_LEVEL** or **SPECIAL_TYPE** file in the container:

```
cat /etc/config/SPECIAL_LEVEL
```

Expected output:

```
Hello
```

----End

Using kubectl

Step 1 Use kubectl to connect to the cluster. For details, see **Connecting to a Cluster Using kubectl**.

Step 2 Create a file named **nginx-configmap.yaml** and edit it.

vi nginx-configmap.yaml

As shown in the following example, after the ConfigMap volume is mounted, a configuration file with the key as the file name and value as the file content is generated in the **/etc/config** directory of the container.

```
apiVersion: apps/v1
kind: Deployment
metadata:
  name: nginx-configmap
spec:
  replicas: 1
  selector:
    matchLabels:
      app: nginx-configmap
  template:
    metadata:
      labels:
        app: nginx-configmap
    spec:
      containers:
      - name: container-1
        image: nginx:latest
        volumeMounts:
        - name: config-volume
          mountPath: /etc/config          # Mount to the /etc/config directory.
          readOnly: true
    volumes:
    - name: config-volume
      configMap:
        name: cce-configmap               # Name of the referenced ConfigMap.
```

Step 3 Create a workload.

kubectl apply -f nginx-configmap.yaml

Step 4 After the workload runs properly, the **SPECIAL_LEVEL** and **SPECIAL_TYPE** files are generated in the **/etc/config** directory. The contents of the files are **Hello** and **CCE**, respectively.

1. Run the following command to view the created pod:
   ```
   kubectl get pod | grep nginx-configmap
   ```
   Expected output:
   ```
   nginx-configmap-***   1/1     Running   0          2m18s
   ```
2. Run the following command to view the **SPECIAL_LEVEL** or **SPECIAL_TYPE** file in the pod:
   ```
   kubectl exec nginx-configmap-*** -- cat /etc/config/SPECIAL_LEVEL
   ```
   Expected output:
   ```
   Hello
   ```

----End

14.3 Creating a Secret

Scenario

A secret is a type of resource that holds sensitive data, such as authentication and key information. Its content is user-defined. After creating secrets, you can use them as files or environment variables in a containerized workload.

Constraints

Secrets cannot be used in **static pods**.

Procedure

Step 1 Log in to the CCE console and click the cluster name to access the cluster console.

Step 2 Choose **ConfigMaps and Secrets** in the navigation pane, click the **Secrets** tab, and click **Create Secret** in the upper right corner.

Step 3 Configure parameters.

Table 14-5 Parameters for creating a secret

Parameter	Description
Name	Name of the secret you create, which must be unique.
Namespace	Namespace to which the secret belongs. If you do not specify this parameter, the value **default** is used by default.
Description	Description of a secret.

Parameter	Description
Type	Type of the secret you create. • Opaque: common secret. • kubernetes.io/dockerconfigjson: a secret that stores the authentication information required for pulling images from a private repository. • **kubernetes.io/tls**: Kubernetes TLS secret, which is used to store the certificate required by layer-7 load balancing Services. For details about examples of the kubernetes.io/tls secret and its description, see **TLS secrets**. • **IngressTLS**: TLS secret provided by CCE to store the certificate required by layer-7 load balancing Services. • Other: another type of secret, which is specified manually.
Secret Data	Workload secret data can be used in containers. • If **Secret Type** is **Opaque**, click +. In the dialog box displayed, enter a key-value pair and select **Auto Base64 Encoding**. • If **Secret Type** is **kubernetes.io/dockerconfigjson**, enter the account and password for logging in to the private image repository. • If **Secret Type** is **kubernetes.io/tls** or **IngressTLS**, upload the certificate file and private key file. **NOTE** – A certificate is a self-signed or CA-signed credential used for identity authentication. – A certificate request is a request for a signature with a private key.
Secret Label	Label of the secret. Enter a key-value pair and click **Confirm**.

Step 4 Click **OK**.

The new secret is displayed in the key list.

----End

Secret Resource File Configuration Example

This section describes configuration examples of secret resource description files.

- Opaque type

  The **secret.yaml** file is defined as shown below. The **data** field is filled in as a key-value pair, and the **value** field must be encoded using Base64. For details about the Base64 encoding method, see **Base64 Encoding**.

  ```
  apiVersion: v1
  kind: Secret
  ```

```
metadata:
  name: mysecret          #Secret name
  namespace: default      #Namespace. The default value is default.
data:
  <your_key>: <your_value>  # Enter a key-value pair. The value must be encoded using Base64.
type: Opaque
```

- kubernetes.io/dockerconfigjson type

  The **secret.yaml** file is defined as shown below. The value of **.dockerconfigjson** must be encoded using Base64. For details, see **Base64 Encoding**.

```
apiVersion: v1
kind: Secret
metadata:
  name: mysecret          #Secret name
  namespace: default      #Namespace. The default value is default.
data:
  .dockerconfigjson: eyJh*****    # Content encoded using Base64.
type: kubernetes.io/dockerconfigjson
```

  To obtain the **.dockerconfigjson** content, perform the following steps:

  a. Obtain the following login information of the image repository.

     - Image repository address: The section uses *address* as an example. Replace it with the actual address.
     - Username: The section uses *username* as an example. Replace it with the actual username.
     - Password: The section uses *password* as an example. Replace it with the actual password.

  b. Use Base64 to encode the key-value pair *username:password* and fill the encoded content in **3**.

```
echo -n "username:password" | base64
```

     Command output:

```
dXNlcm5hbWU6cGFzc3dvcmQ=
```

  c. Use Base64 to encode the following JSON content:

```
echo -n '{"auths":{"address":
{"username":"username","password":"password","auth":"dXNlcm5hbWU6cGFzc3dvcmQ="}}}'
| base64
```

     Command output:

```
eyJhdXRocyI6eyJhZGRyZXNzIjp7InVzZXJuYW1lIjoidXNlcm5hbWUiLCJwYXNzd29yZCI6InBhc3N3b3J
kIiwiYXV0aCI6ImRYTmxjbTVoYldVNmNHRnpjM2R2Y21RPSJ9fX0=
```

     The encoded content is the **.dockerconfigjson** content.

- kubernetes.io/tls type

  The value of **tls.crt** and **tls.key** must be encoded using Base64. For details, see **Base64 Encoding**.

```
kind: Secret
apiVersion: v1
metadata:
  name: mysecret          #Secret name
  namespace: default      #Namespace. The default value is default.
data:
  tls.crt: LS0tLS1CRU*****FURS0tLS0t  # Certificate content, which must be encoded using Base64.
  tls.key: LS0tLS1CRU*****VZLS0tLS0=  # Private key content, which must be encoded using Base64.
type: kubernetes.io/tls
```

- IngressTLS type

The value of **tls.crt** and **tls.key** must be encoded using Base64. For details, see **Base64 Encoding**.

```
kind: Secret
apiVersion: v1
metadata:
  name: mysecret          #Secret name
  namespace: default      #Namespace. The default value is default.
data:
  tls.crt: LS0tLS1CRU*****FURS0tLS0t  # Certificate content, which must be encoded using Base64.
  tls.key: LS0tLS1CRU*****VZLS0tLS0=  # Private key content, which must be encoded using Base64.
type: IngressTLS
```

Creating a Secret Using kubectl

Step 1 Use kubectl to connect to the cluster. For details, see **Connecting to a Cluster Using kubectl**.

Step 2 Create and edit the Base64-encoded **cce-secret.yaml** file.

```
# echo -n "content to be encoded" | base64
******
```

vi cce-secret.yaml

The following YAML file uses the Opaque type as an example. For details about other types, see **Secret Resource File Configuration Example**.

```
apiVersion: v1
kind: Secret
metadata:
  name: mysecret
type: Opaque
data:
  <your_key>: <your_value>  # Enter a key-value pair. The value must be encoded using Base64.
```

Step 3 Create a secret.

kubectl create -f cce-secret.yaml

You can query the secret after creation.

kubectl get secret -n default

----End

Related Operations

After creating a secret, you can update or delete it as described in **Table 14-6**.

NOTE

The secret list contains system secret resources that can be queried only. The system secret resources cannot be updated or deleted.

Table 14-6 Related Operations

Operation	Description
Editing a YAML file	Click **Edit YAML** in the row where the target secret resides to edit its YAML file.

Operation	Description
Updating a secret	1. Select the name of the secret to be updated and click **Update**. 2. Modify the secret data. For more information, see **Table 14-5**. 3. Click **OK**.
Deleting a secret	Select the secret you want to delete and click **Delete**. Follow the prompts to delete the secret.
Deleting secrets in batches	1. Select the secrets to be deleted. 2. Click **Delete** above the secret list. 3. Follow the prompts to delete the secrets.

Base64 Encoding

To Base64-encode a string, run the **echo -n *content to be encoded* | base64** command. The following is an example:

```
root@ubuntu:~# echo -n "content to be encoded" | base64
******
```

14.4 Using a Secret

After secrets are created, they can be mounted as data volumes or be exposed as environment variables to be used by a container in a pod.

NOTICE

Do not perform any operation on the following secrets. For details, see **Cluster Secrets**.

- Do not operate secrets under kube-system.
- Do not operate default-secret and paas.elb in any of the namespaces. The default-secret is used to pull the private image of SWR, and the paas.elb is used to connect the service in the namespace to the ELB service.

- **Configuring Environment Variables of a Workload**
- **Configuring the Data Volume of a Workload**

The following example shows how to use a secret.

```
apiVersion: v1
kind: Secret
metadata:
  name: mysecret
type: Opaque
data:
  username: ******  #The value must be Base64-encoded.
  password: ******  #The value must be encoded using Base64.
```

NOTICE

- When a secret is used in a pod, the pod and secret must be in the same cluster and namespace.
- When a secret is updated, Kubernetes updates the data in the data volume at the same time.

  However, when a secret data volume mounted in **subPath** mode is updated, Kubernetes cannot automatically update the data in the data volume.

Configuring Environment Variables of a Workload

Using the CCE console

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 **Workloads**. In the dialog box displayed, click **Create Workload** in the upper right corner.

When creating a workload, click **Environment Variables** in the **Container Settings** area, and click **Add Variable**.

- **Added from secret**: Select a secret and import all keys in the secret as environment variables.
- **Added from secret key**: Import the value of a key in a secret as the value of an environment variable.
  - **Variable Name**: name of an environment variable in the workload. The name can be customized and is set to the key name selected in the secret by default.
  - **Variable Value/Reference**: Select a secret and the key to be imported. The corresponding value is imported as a workload environment variable.

  For example, after you import the value of **username** in secret **mysecret** as the value of workload environment variable **username**, an environment variable named **username** exists in the container.

Step 3 Set other workload parameters and click **Create Workload**.

After the workload runs properly, **log in to the container** and run the following statement to check whether the secret has been set as an environment variable of the workload:

```
printenv username
```

If the output is the same as the content in the secret, the secret has been set as an environment variable of the workload.

----End

Using kubectl

Step 1 Use kubectl to connect to the cluster. For details, see **Connecting to a Cluster Using kubectl**.

Step 2 Create a file named **nginx-secret.yaml** and edit it.

vi nginx-secret.yaml

Content of the YAML file:

- **Added from secret**: To add all data in a secret to environment variables, use the **envFrom** parameter. The keys in the secret will become names of environment variables in a workload.

```
apiVersion: apps/v1
kind: Deployment
metadata:
  name: nginx-secret
spec:
  replicas: 1
  selector:
    matchLabels:
      app: nginx-secret
  template:
    metadata:
      labels:
        app: nginx-secret
    spec:
      containers:
      - name: container-1
        image: nginx:latest
        envFrom:              # Use envFrom to specify a secret to be referenced by environment variables.
          - secretRef:
              name: mysecret      # Name of the referenced secret.
      imagePullSecrets:
      - name: default-secret
```

- **Added from secret key**: When creating a workload, you can use a secret to set environment variables and use the **valueFrom** parameter to reference the key-value pair in the secret separately.

```
apiVersion: apps/v1
kind: Deployment
metadata:
  name: nginx-secret
spec:
  replicas: 1
  selector:
    matchLabels:
      app: nginx-secret
  template:
    metadata:
      labels:
        app: nginx-secret
    spec:
      containers:
      - name: container-1
        image: nginx:latest
        env:                        # Set the environment variable in the workload.
        - name: SECRET_USERNAME          # Name of the environment variable in the workload.
          valueFrom:                 # Use valueFrom to specify a secret to be referenced by environment variables.
            secretKeyRef:
              name: mysecret      # Name of the referenced secret.
              key: username       # Key in the referenced secret.
        - name: SECRET_PASSWORD          # Add multiple environment variables to import them at the same time.
          valueFrom:
            secretKeyRef:
              name: mysecret
              key: password
      imagePullSecrets:
      - name: default-secret
```

Step 3 Create a workload.

kubectl apply -f nginx-secret.yaml

Step 4 View the environment variables in the pod.

1. Run the following command to view the created pod:
   ```
   kubectl get pod | grep nginx-secret
   ```
   Expected output:
   ```
   nginx-secret-***  1/1     Running   0          2m18s
   ```
2. Run the following command to view the environment variables in the pod:
   ```
   kubectl exec nginx-secret-*** -- printenv SPECIAL_USERNAME SPECIAL_PASSWORD
   ```
   If the output is the same as the content in the secret, the secret has been set as an environment variable of the workload.

----End

Configuring the Data Volume of a Workload

You can mount a secret as a volume to the specified container path. Contents in a secret are user-defined. Before that, create a secret. For details, see **Creating a Secret**.

Using the CCE console

Step 1 Log in to the CCE console and click the cluster name to access the cluster console.

Step 2 In the navigation pane on the left, click **Workloads**. In the right pane, click the **Deployments** tab. Click **Create Workload** in the upper right corner.

When creating a workload, click **Data Storage** in the **Container Settings** area. Click **Add Volume** and select **Secret** from the drop-down list.

Step 3 Select parameters for mounting a secret volume, as shown in **Table 14-7**.

Table 14-7 Mounting a secret volume

Parameter	Description
Secret	Select the desired secret. A secret must be created beforehand. For details, see **Creating a Secret**.
Mount Path	Enter a mount point. After the secret volume is mounted, a secret file with the key as the file name and value as the file content is generated in the mount path of the container. This parameter indicates the container path to which a data volume will be mounted. Do not mount the volume to a system directory such as **/** or **/var/run**. This may cause container errors. Mount the volume to an empty directory. If the directory is not empty, ensure that there are no files that affect container startup. Otherwise, the files will be replaced, which leads to a container startup failure or workload creation failure. **NOTICE** If the container is mounted to a high-risk directory, use an account with minimum permissions to start the container. Otherwise, high-risk files on the host may be damaged.

Parameter	Description
Subpath	Enter a subpath of the mount path. • A subpath is used to mount a local volume so that the same data volume is used in a single pod. If this parameter is left blank, the root path is used by default. • The subpath can be the key and value of a ConfigMap or secret. If the subpath is a key-value pair that does not exist, the data import does not take effect. • The data imported by specifying a subpath will not be updated along with the ConfigMap/secret updates.
Permission	Read-only, indicating that data volume in the path is read-only.

Step 4 After the configuration, click **Create Workload**.

After the workload runs properly, the **username** and **password** files will be generated in the **/etc/foo** directory in this example. The contents of the files are secret values.

Access the container and run the following statement to view the **username** or **password** file in the container:

```
cat /etc/foo/username
```

The expected output is the same as the content in the secret.

----End

Using kubectl

Step 1 Use kubectl to connect to the cluster. For details, see **Connecting to a Cluster Using kubectl**.

Step 2 Create a file named **nginx-secret.yaml** and edit it.

vi nginx-secret.yaml

In the following example, the username and password in the **mysecret** secret are saved in the **/etc/foo** directory as files.

```
apiVersion: apps/v1
kind: Deployment
metadata:
  name: nginx-secret
spec:
  replicas: 1
  selector:
    matchLabels:
      app: nginx-secret
  template:
    metadata:
      labels:
        app: nginx-secret
    spec:
      containers:
      - name: container-1
        image: nginx:latest
```

```
    volumeMounts:
    - name: foo
      mountPath: /etc/foo          # Mount to the /etc/foo directory.
      readOnly: true
  volumes:
  - name: foo
    secret:
      secretName: mysecret      # Name of the referenced secret.
```

You can also use the **items** field to control the mapping path of secret keys. For example, store username in the **/etc/foo/my-group/my-username** directory in the container.

NOTE

- If you use the **items** field to specify the mapping path of the secret keys, the keys that are not specified will not be created as files. For example, if the **password** key in the following example is not specified, the file will not be created.
- If you want to use all keys in a secret, you must list all keys in the **items** field.
- All keys listed in the **items** field must exist in the corresponding secret. Otherwise, the volume is not created.

```
apiVersion: apps/v1
kind: Deployment
metadata:
  name: nginx-secret
spec:
  replicas: 1
  selector:
    matchLabels:
      app: nginx-secret
  template:
    metadata:
      labels:
        app: nginx-secret
    spec:
      containers:
      - name: container-1
        image: nginx:latest
        volumeMounts:
      - name: foo
        mountPath: /etc/foo          # Mount to the /etc/foo directory.
        readOnly: true
    volumes:
    - name: foo
      secret:
        secretName: mysecret      # Name of the referenced secret.
        items:
        - key: username      # Name of the referenced key.
          path: my-group/my-username    # Mapping path of the secret key
```

Step 3 Create a workload.

kubectl apply -f nginx-secret.yaml

Step 4 After the workload runs properly, the **username** and **password** files are generated in the **/etc/foo** directory.

1. Run the following command to view the created pod:
   ```
   kubectl get pod | grep nginx-secret
   ```
   Expected output:
   ```
   nginx-secret-***   1/1     Running   0          2m18s
   ```
2. Run the following command to view the **username** or **password** file in the pod:
   ```
   kubectl exec nginx-secret-*** -- cat /etc/foo/username
   ```

The expected output is the same as the content in the secret.

----End

14.5 Cluster Secrets

By default, CCE creates the following secrets in each namespace:

- default-secret
- paas.elb
- default-token-*xxxxx* (*xxxxx* is a random number.)

The functions of these secrets are described as follows.

default-secret

The type of **default-secret** is **kubernetes.io/dockerconfigjson**. The data is the credential for logging in to the SWR image repository and is used to pull images from SWR. To pull an image from SWR when creating a workload on CCE, set **imagePullSecrets** to **default-secret**.

```
apiVersion: v1
kind: Pod
metadata:
  name: nginx
spec:
  containers:
  - image: nginx:alpine
    name: container-0
    resources:
      limits:
        cpu: 100m
        memory: 200Mi
      requests:
        cpu: 100m
        memory: 200Mi
  imagePullSecrets:
  - name: default-secret
```

The data of **default-secret** is updated periodically, and the current data will expire after a certain period of time. You can run the **describe** command to view the expiration time in of default-secret.

NOTICE

Use default-secret directly instead of copying the secret content to create a new one. The credential in the copied secret will expire and the image cannot be pulled.

```
$ kubectl describe secret default-secret
Name:         default-secret
Namespace:    default
Labels:       secret-generated-by=cce
Annotations:  temporary-ak-sk-expires-at: 2021-11-26 20:55:31.380909 +0000 UTC

Type:  kubernetes.io/dockerconfigjson

Data
```

```
====
.dockerconfigjson:  347 bytes
```

paas.elb

The data of **paas.elb** is the temporary AK/SK data, which is used to create ELB load balancers during Service and ingress creation. The data of paas.elb is periodically updated and expires after a certain period of time.

In practice, you will not directly use paas.elb. However, do not delete it. Otherwise, ELB load balancers will fail to be created.

default-token-xxxxx

By default, Kubernetes creates a service account named **default** for each namespace. **default-token-*xxxxx*** is the key of the service account, and ***xxxxx*** is a random number.

```
$ kubectl get sa
NAME     SECRETS   AGE
default  1         30d
$ kubectl describe sa default
Name:                default
Namespace:           default
Labels:              <none>
Annotations:         <none>
Image pull secrets:  <none>
Mountable secrets:   default-token-xxxxx
Tokens:              default-token-xxxxx
Events:              <none>
```

15 Auto Scaling

15.1 Overview

Auto scaling is a service that automatically and economically adjusts service resources based on your service requirements and configured policies.

Context

More and more applications are developed based on Kubernetes. It becomes increasingly important to quickly scale out applications on Kubernetes to cope with service peaks and to scale in applications during off-peak hours to save resources and reduce costs.

In a Kubernetes cluster, auto scaling involves pods and nodes. A pod is an application instance. Each pod contains one or more containers and runs on a node (VM or bare-metal server). If a cluster does not have sufficient nodes to run new pods, add nodes to the cluster to ensure service running.

In CCE, auto scaling is used for online services, large-scale computing and training, deep learning GPU or shared GPU training and inference, periodic load changes, and many other scenarios.

Auto Scaling in CCE

CCE supports auto scaling for workloads and nodes.

- **Workload scaling:** Auto scaling at the scheduling layer to change the scheduling capacity of workloads. For example, you can use the HPA, a scaling component at the scheduling layer, to adjust the number of replicas of an application. Adjusting the number of replicas changes the scheduling capacity occupied by the current workload, thereby enabling scaling at the scheduling layer.
- **Node scaling:** Auto scaling at the resource layer. When the planned cluster nodes cannot allow workload scheduling, ECS resources are provided to support scheduling.

Components

Workload scaling components are described as follows:

Table 15-1 Workload scaling components

Type	Component Name	Component Description	Reference
HPA	**Kubernetes Metrics Server**	A built-in component of Kubernetes, which enables horizontal scaling of pods. It adds the application-level cooldown time window and scaling threshold functions based on the HPA.	**HPA Policies**
Customed HPA	**CCE Advanced HPA**	An enhanced auto scaling feature, used for auto scaling of Deployments based on metrics (CPU usage and memory usage) or at a periodic interval (a specific time point every day, every week, every month, or every year).	**CustomedHPA Policies**
	Prometheus **Cloud Native Cluster Monitoring**	An open-source system monitoring and alarm framework, which collects public metrics (CPU usage and memory usage) of kubelet in the Kubernetes cluster.	
CronHPA	**CCE Advanced HPA**	CronHPA can scale in or out a cluster at a fixed time. It can work with HPA policies to periodically adjust the HPA scaling scope, implementing workload scaling in complex scenarios.	**CronHPA Policies**

Node scaling components are described as follows:

Table 15-2 Node scaling components

Component Name	Component Description	Application Scenario	Reference
CCE Cluster Autoscaler	An open source Kubernetes component for horizontal scaling of nodes, which is optimized by CCE in scheduling, auto scaling, and costs.	Online services, deep learning, and large-scale computing with limited resource budgets	Creating a Node Scaling Policy

15.2 Scaling a Workload

15.2.1 Workload Scaling Rules

CCE supports multiple workload scaling modes. Comparisons between the scaling policies are listed in the following table.

Table 15-3 Comparisons between auto scaling policies

Item	HPA	CronHPA	CustomedHPA
Introduction	Horizontal Pod Autoscaling	Enhanced based on HPA, CronHPA is mainly used if the resource usage of applications changes periodically.	Enhanced CCE auto scaling that is triggered based on metrics or at a scheduled time.
Rules	Scales Deployments based on **metrics** (CPU usage and memory usage).	Scales Deployments **periodically** (daily, weekly, monthly, or yearly at a specific time).	Scales Deployments based on **metrics** (CPU usage and memory usage) or at a **periodic** interval (a specific time point every day, every week, every month, or every year).

Item	HPA	CronHPA	CustomedHPA
Enhancement	Adds the application-level cooldown time window and scaling threshold functions based on the Kubernetes HPA.	Compatible with HPA objects, which allows you to use both CronHPA and HPA. • If both CronHPA and HPA are used, CronHPA runs based on HPA and periodically adjusts the number of pods for HPA. • If CronHPA is separately used: CronHPA periodically adjusts the number of pods for workloads.	**Metric-based**: • Scaling can be performed based on the percentage of the current number of pods. • The minimum scaling step can be set. Scaling can be performed step by step. • Different scaling operations can be performed based on the actual metric values. **Periodic**: You can select a specific time point every day, every week, every month, or every year or a period as the trigger time.

How HPA Works

HPA is a controller that controls horizontal pod scaling. HPA periodically checks the pod metrics, calculates the number of replicas required to meet the target values configured for HPA resources, and then adjusts the value of the **replicas** field in the target resource object (such as a Deployment).

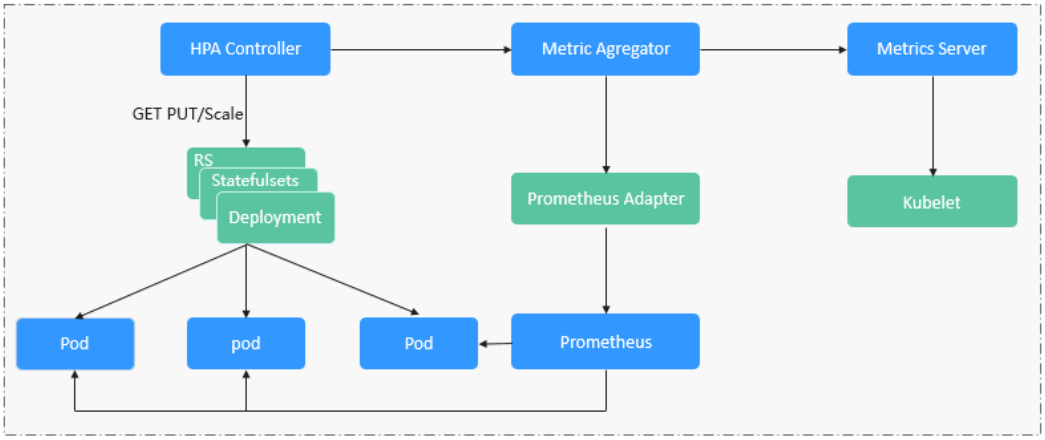
A prerequisite for auto scaling is that your container running data can be collected, such as number of cluster nodes/pods, and CPU and memory usage of containers. Kubernetes does not provide such monitoring capabilities itself. You can use extensions to monitor and collect your data. CCE integrates **Prometheus** and **Metrics Server** to realize such capabilities:

- **Prometheus** is an open-source monitoring and alarming framework that can collect multiple types of metrics. Prometheus has been a standard monitoring solution of Kubernetes.
- **Metrics Server** is a cluster-wide aggregator of resource utilization data. Metrics Server collects metrics from the Summary API exposed by kubelet. These metrics are set for core Kubernetes resources, such as pods, nodes, containers, and Services. Metrics Server provides a set of standard APIs for external systems to collect these metrics.

HPA can work with Metrics Server to implement auto scaling based on the CPU and memory usage. It can also work with Prometheus for auto scaling based on custom monitoring metrics.

Figure 15-1 shows how HPA works.

Figure 15-1 HPA working process



Two core modules of HPA:

- Data Source Monitoring

  The community provided only CPU- and memory-based HPA at the early stage. With the population of Kubernetes and Prometheus, developers need more custom metrics or monitoring information at the access layer for their own applications, for example, the QPS of the load balancer and the number of online users of the website. In response, the community defines a set of standard metric APIs to provide services externally through these aggregated APIs.

  - **metrics.k8s.io** provides monitoring metrics related to the CPU and memory of pods and nodes.
  - **custom.metrics.k8s.io** provides custom monitoring metrics related to Kubernetes objects.
  - **external.metrics.k8s.io** provides metrics that come from external systems and are irrelevant to any Kubernetes resource metrics.

- Scaling Decision-Making Algorithms

  The HPA controller calculates the scaling ratio based on the current metric values and desired metric values using the following formula:

  desiredReplicas = ceil[currentReplicas x (currentMetricValue/desiredMetricValue)]

  For example, if the current metric value is 200m and the target value is 100m, the desired number of pods will be doubled according to the formula. In practice, pods may be constantly added or reduced. To ensure stability, the HPA controller is optimized from the following aspects:

  - Cooldown interval: In v1.11 and earlier versions, Kubernetes introduced the startup parameters **horizontal-pod-autoscaler-downscale-stabilization-window** and **horizontal-pod-autoScaler-upscale-stabilization-window** to indicate the cooldown intervals after a scale-in and scale-out, respectively, in which no scaling operation will not be performed. In versions later than v1.14, the scheduling queue is introduced to store all decision-making suggestions detected within a

period of time. Then, the system makes decisions based on all valid decision-making suggestions to minimize changes of the desired number of replicas to ensure stability.

- Tolerance: It can be considered as a buffer zone. If the pod number changes can be tolerated, the number of pods remains unchanged.

  Use the formula: ratio = currentMetricValue/desiredMetricValue

  When |ratio – 1.0| ≤ tolerance, scaling will not be performed.

  When |ratio – 1.0| > tolerance, the desired value is calculated using the formula mentioned above.

  The default value is 0.1 in the current community version.

The HPA performs scaling based on metric thresholds. Common metrics include the CPU and memory usage. You can also set custom metrics, such as the QPS and number of connections, to trigger scaling. However, metric-based scaling brings in latency of minutes generated during data collection, determination, and scaling phases. Such latency may cause high CPU usage and slow response. To solve this problem, CCE allows you to configure scheduled policies to scale resources regularly for applications with periodic changes.

15.2.2 HPA Policies

Horizontal Pod Autoscaling (HPA) in Kubernetes implements horizontal scaling of pods. In a CCE HPA policy, you can configure different cooldown time windows and scaling thresholds for different applications based on the Kubernetes HPA.

Prerequisites

To use HPA, install an add-on that provides metrics APIs. Select one of the following add-ons based on your cluster version and service requirements.

- **Kubernetes Metrics Server**: provides basic resource usage metrics, such as container CPU and memory usage. It is supported by all cluster versions.
- **Cloud Native Cluster Monitoring**: available only in clusters of v1.17 or later.
  - Auto scaling based on basic resource metrics: Prometheus needs to be registered as a metrics API. For details, see **Providing Resource Metrics Through the Metrics API**.
  - Auto scaling based on custom metrics: Custom metrics need to be aggregated to the Kubernetes API server. For details, see **Creating an HPA Policy Using Custom Metrics**.
- **Prometheus** : Prometheus needs to be registered as a metrics API. For details, see **Providing Resource Metrics Through the Metrics API**. This add-on supports only clusters of v1.21 or earlier.

Constraints

- HPA policies can be created only for clusters of v1.13 or later.
- For clusters earlier than v1.19.10, if an HPA policy is used to scale out a workload with EVS volumes mounted, the existing pods cannot be read or written when a new pod is scheduled to another node.

  For clusters of v1.19.10 and later, if an HPA policy is used to scale out a workload with EVS volume mounted, a new pod cannot be started because EVS disks cannot be attached.

Creating an HPA Policy

Step 1 Log in to the CCE console and click the cluster name to access the cluster console.

Step 2 Choose **Workloads** in the navigation pane. Locate the target workload and choose **More** > **Auto Scaling** in the **Operation** column.

Step 3 Set **Policy Type** to **HPA+CronHPA**, enable the created HPA policy, and configure parameters.

This section describes only HPA policies. To enable CronHPA, see **CronHPA Policies**.

Table 15-4 HPA policy

Parameter	Description
Pod Range	Minimum and maximum numbers of pods. When a policy is triggered, the workload pods are scaled within this range.
Cooldown Period	Interval between a scale-in and a scale-out. The unit is minute. **The interval cannot be shorter than 1 minute.** **This parameter is supported only in clusters of v1.15 to v1.23.** This parameter indicates the interval between consecutive scaling operations. The cooldown period ensures that a scaling operation is initiated only when the previous one is completed and the system is running stably.
Scaling Behavior	**This parameter is supported only in clusters of v1.25 or later.** • **Default**: scales workloads using the Kubernetes default behavior. For details, see **Default Behavior**. • **Custom**: scales workloads using custom policies such as stabilization window, steps, and priorities. Unspecified parameters use the values recommended by Kubernetes. – **Disable scale-out/scale-in**: Select whether to disable scale-out or scale-in. – **Stabilization Window**: a period during which CCE continuously checks whether the metrics used for scaling keep fluctuating. CCE triggers scaling if the desired state is not maintained for the entire window. This window restricts the unwanted flapping of pod count due to metric changes. – **Step**: specifies the scaling step. You can set the number or percentage of pods to be scaled in or out within a specified period. If there are multiple policies, you can select the policy that maximizes or minimizes the number of pods.

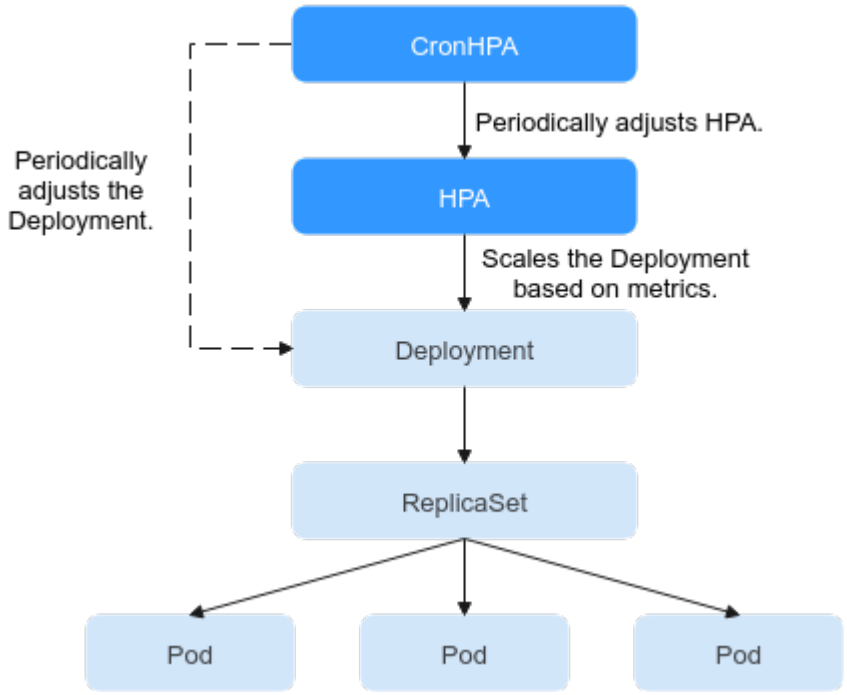
Parameter	Description
System Policy	• **Metric**: You can select **CPU usage** or **Memory usage**. **NOTE** Usage = CPUs or memory used by pods/Requested CPUs or memory. • **Desired Value**: Enter the desired average resource usage. This parameter indicates the desired value of the selected metric. Number of pods to be scaled (rounded up) = (Current metric value/Desired value) x Number of current pods **NOTE** When calculating the number of pods to be added or reduced, the HPA policy uses the maximum number of pods in the last 5 minutes. • **Tolerance Range**: Scaling is not triggered when the metric value is within the tolerance range. The desired value must be within the tolerance range. If the metric value is greater than the scale-in threshold and less than the scale-out threshold, no scaling is triggered. **This parameter is supported only in clusters of v1.15 or later.**
Custom Policy (supported only in clusters of v1.15 or later)	**NOTE** Before creating a custom policy, install an add-on that supports custom metric collection (for example, Prometheus) in the cluster. Ensure that the add-on can collect and report the custom metrics of the workloads. For details, see **Monitoring Custom Metrics Using Cloud Native Cluster Monitoring**. • **Metric Name**: name of the custom metric. You can select a name as prompted. • **Metric Source**: Select an object type from the drop-down list. You can select **Pod**. • **Desired Value**: the average metric value of all pods. Number of pods to be scaled (rounded up) = (Current metric value/ Desired value) x Number of current pods **NOTE** When calculating the number of pods to be added or reduced, the HPA policy uses the maximum number of pods in the last 5 minutes. • **Tolerance Range**: Scaling is not triggered when the metric value is within the tolerance range. The desired value must be within the tolerance range.

Step 4 Click **Create**.

----End

15.2.3 CronHPA Policies

There are predictable and unpredictable traffic peaks for some services. For such services, CCE CronHPA allows you to scale resources in fixed periods. It can work with HPA policies to periodically adjust the HPA scaling scope, implementing workload scaling.



CronHPA can periodically adjust the maximum and minimum numbers of pods in the HPA policy or directly adjust the number of pods of a Deployment.

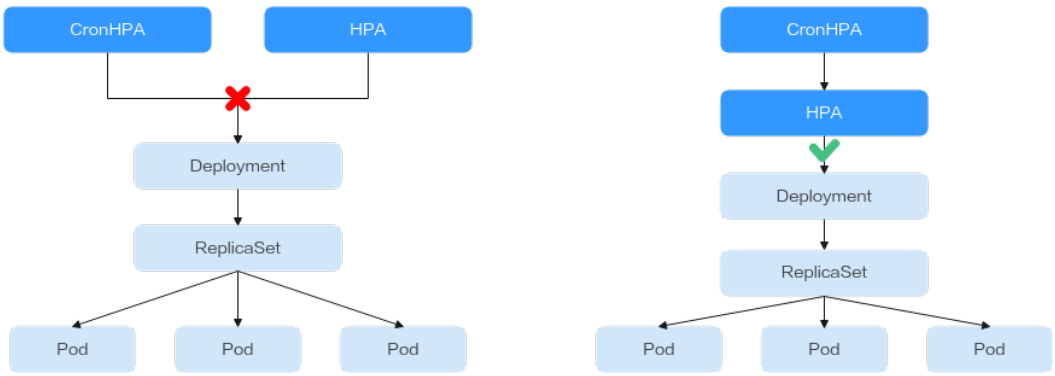
Prerequisites

The add-on **CCE Advanced HPA** of v1.2.13 or later has been installed.

Using CronHPA to Adjust the HPA Scaling Scope

CronHPA can periodically scale out/in pods in HPA policies to satisfy complex services.

HPA and CronHPA associate scaling objects using the **scaleTargetRef** field. If a Deployment is the scaling object for both CronHPA and HPA, the two scaling policies are independent of each other. The operation performed later overwrites the operation performed earlier. As a result, the scaling effect does not meet the expectation.



When CronHPA and HPA are used together, CronHPA rules take effect based on the HPA policy. CronHPA uses HPA to perform operations on the Deployment.

Understanding the following parameters can better understand the working rules of the CronHPA.

- **targetReplicas**: Number of pods set for CronHPA. When CronHPA takes effect, this parameter adjusts the maximum or minimum number of pods in HPA policies to adjust the number of Deployment pods.
- **minReplicas**: Minimum number of Deployment pods.
- **maxReplicas**: Maximum number of Deployment pods.
- **replicas**: Number of pods in a Deployment before the CronHPA policy takes effect.

When the CronHPA rule takes effect, the maximum or minimum number of pods are adjusted by comparing the number of **targetReplicas** with the actual number of pods and combining the minimum or maximum number of pods in the HPA policy.

Figure 15-2 CronHPA scaling scenarios

Figure 15-2 shows possible scaling scenarios. The following examples detail how CronHPA modifies the number of pods in HPAs.

Table 15-5 CronHPA scaling parameters

Scenario	Scenario Description	CronHPA (targetReplicas)	Deployment (replicas)	HPA (minReplicas / maxReplicas)	Result	Operation Description
1	**targetReplicas** < minReplicas ≤ replicas ≤ maxReplicas	4	5	5/10	HPA: 4/10 Deployments: 5	When the value of **targetReplicas** is smaller than that of **minReplicas**: ● Change the value of **minReplicas**. ● The value of **replicas** requires no change.
2	**targetReplicas** = minReplicas ≤ replicas ≤ maxReplicas	5	6	5/10	HPA: 5/10 Deployments: 6	When the value of **targetReplicas** is equal to that of **minReplicas**: ● The value of **minReplicas** requires no change. ● The value of **replicas** requires no change.
3	minReplicas < **targetReplicas** < replicas ≤ maxReplicas	4	5	1/10	HPA: 4/10 Deployments: 5	When the value of **targetReplicas** is greater than that of **minReplicas** and smaller than that of **replicates**: ● Change the value of **minReplicas**. ● The value of **replicas** requires no change.

Scenario	Scenario Description	CronHPA (targetReplicas)	Deployment (replicas)	HPA (minReplicas / maxReplicas)	Result	Operation Description
4	minReplicas < **targetReplicas** = replicas < maxReplicas	5	5	1/10	HPA: 5/10 Deployments: 5	When the value of **targetReplicas** is greater than that of **minReplicas** and equal to that of **replicates**: ● Change the value of **minReplicas**. ● The value of **replicas** requires no change.
5	minReplicas ≤ replicas < **targetReplicas** < maxReplicas	6	5	1/10	HPA: 6/10 Deployments: 6	When the value of **targetReplicas** is greater than that of **replicates** and less than that of **maxReplicas**: ● Change the value of **minReplicas**. ● Change the value of **replicas**.
6	minReplicas ≤ replicas < **targetReplicas** = maxReplicas	10	5	1/10	HPA: 10/10 Deployments: 10	When the value of **targetReplicas** is greater than that of **replicates** and equal to that of **maxReplicas**: ● Change the value of **minReplicas**. ● Change the value of **replicas**.

Scenario	Scenario Description	CronHPA (targetReplicas)	Deployment (replicas)	HPA (minReplicas / maxReplicas)	Result	Operation Description
7	minReplicas ≤ replicas ≤ maxReplicas < **targetReplicas**	11	5	5/10	HPA: 11/11 Deployments: 11	When the value of **targetReplicas** is greater than that of **maxReplicas**: • Change the value of **minReplicas**. • Change the value of **maxReplicas**. • Change the value of **replicas**.

Using the CCE console

Step 1 Log in to the CCE console and click the cluster name to access the cluster console.

Step 2 Choose **Workloads** in the navigation pane. Locate the target workload and choose **More** > **Auto Scaling** in the **Operation** column.

Step 3 Set **Policy Type** to **HPA+CronHPA** and enable HPA and CronHPA policies.

CronHPA periodically adjusts the maximum and minimum numbers of pods using the HPA policy.

Step 4 Configure the HPA policy. For details, see **HPA Policies**.

Table 15-6 HPA policy

Parameter	Description
Pod Range	Minimum and maximum numbers of pods. When a policy is triggered, the workload pods are scaled within this range.

Parameter	Description
Cooldown Period	Interval between a scale-in and a scale-out. The unit is minute. **The interval cannot be shorter than 1 minute.** **This parameter is supported only in clusters of v1.15 to v1.23.** This parameter indicates the interval between consecutive scaling operations. The cooldown period ensures that a scaling operation is initiated only when the previous one is completed and the system is running stably.
Scaling Behavior	**This parameter is supported only in clusters of v1.25 or later.** • **Default**: scales workloads using the Kubernetes default behavior. For details, see **Default Behavior**. • **Custom**: scales workloads using custom policies such as stabilization window, steps, and priorities. Unspecified parameters use the values recommended by Kubernetes. – **Disable scale-out/scale-in**: Select whether to disable scale-out or scale-in. – **Stabilization Window**: a period during which CCE continuously checks whether the metrics used for scaling keep fluctuating. CCE triggers scaling if the desired state is not maintained for the entire window. This window restricts the unwanted flapping of pod count due to metric changes. – **Step**: specifies the scaling step. You can set the number or percentage of pods to be scaled in or out within a specified period. If there are multiple policies, you can select the policy that maximizes or minimizes the number of pods.
System Policy	• **Metric**: You can select **CPU usage** or **Memory usage**. **NOTE** Usage = CPUs or memory used by pods/Requested CPUs or memory. • **Desired Value**: Enter the desired average resource usage. This parameter indicates the desired value of the selected metric. Number of pods to be scaled (rounded up) = (Current metric value/Desired value) x Number of current pods **NOTE** When calculating the number of pods to be added or reduced, the HPA policy uses the maximum number of pods in the last 5 minutes. • **Tolerance Range**: Scaling is not triggered when the metric value is within the tolerance range. The desired value must be within the tolerance range. If the metric value is greater than the scale-in threshold and less than the scale-out threshold, no scaling is triggered. **This parameter is supported only in clusters of v1.15 or later.**

Parameter	Description
Custom Policy (supported only in clusters of v1.15 or later)	**NOTE** Before creating a custom policy, install an add-on that supports custom metric collection (for example, Prometheus) in the cluster. Ensure that the add-on can collect and report the custom metrics of the workloads. For details, see **Monitoring Custom Metrics Using Cloud Native Cluster Monitoring**. • **Metric Name**: name of the custom metric. You can select a name as prompted. • **Metric Source**: Select an object type from the drop-down list. You can select **Pod**. • **Desired Value**: the average metric value of all pods. Number of pods to be scaled (rounded up) = (Current metric value/ Desired value) x Number of current pods **NOTE** When calculating the number of pods to be added or reduced, the HPA policy uses the maximum number of pods in the last 5 minutes. • **Tolerance Range**: Scaling is not triggered when the metric value is within the tolerance range. The desired value must be within the tolerance range.

Step 5 Click + in the CronHPA policy rule. In the dialog box displayed, configure scaling policy parameters.

Table 15-7 CronHPA policy parameters

Parameter	Description
Target Instances	When the policy is triggered, CCE will adjust the number of HPA policy pods based on service requirements. For details, see **Table 15-5**.
Trigger Time	You can select a specific time every day, every week, every month, or every year. **NOTE** This time indicates the local time of where the node is deployed.
Enable	Enable or disable the policy rule.

Step 6 After configuring the preceding parameters, click **OK**. Then, the added policy rule is displayed in the rule list. Repeat the preceding steps to add multiple policy rules, but the triggering time of the policies must be different.

Step 7 Click **Create**.

----End

Using the kubectl command

When the CronHPA is compatible with the HPA policy, the **scaleTargetRef** field in CronHPA must be set to the HPA policy, and the **scaleTargetRef** field in the HPA

policy must be set to Deployment. In this way, CronHPA adjusts the maximum and minimum numbers of pods in the HPA policy at a fixed time and the scheduled scaling is compatible with the auto scaling.

Step 1 Create an HPA policy for the Deployment.

```
apiVersion: autoscaling/v1
kind: HorizontalPodAutoscaler
metadata:
  name: hpa-test
  namespace: default
spec:
   maxReplicas: 10              #  Maximum number of pods
  minReplicas: 5              #  Minimum number of pods
  scaleTargetRef:             #  Associate a Deployment.
    apiVersion: apps/v1
    kind: Deployment
    name: nginx
  targetCPUUtilizationPercentage: 50
```

Step 2 Create a CronHPA policy and associate it with the HPA policy created in **Step 1**.

```
apiVersion: autoscaling.cce.io/v2alpha1
kind: CronHorizontalPodAutoscaler
metadata:
  name: ccetest
  namespace: default
spec:
   scaleTargetRef:                # Associate an HPA policy.
      apiVersion: autoscaling/v1
      kind: HorizontalPodAutoscaler
      name: hpa-test
   rules:
   - ruleName: "scale-down"
     schedule: "15 * * * *"        # Running time and period of a job. For details, see Cron, for example, 0 * * *
* or @hourly.
     targetReplicas: 1             # Number of target pods
     disable: false
   - ruleName: "scale-up"
     schedule: "13 * * * *"
     targetReplicas: 11
     disable: false
```

Table 15-8 Key fields of CronHPA

Field	Description
apiVersion	API version. The value is fixed at **autoscaling.cce.io/v2alpha1**.
kind	API type. The value is fixed at **CronHorizontalPodAutoscaler**.
metadata.name	Name of a CronHPA policy.
metadata.namespace	Namespace to which the CronHPA policy belongs.

Field	Description
spec.scaleTargetRef	Specifies the scaling object of CronHPA. The following fields can be configured: • **apiVersion**: API version of the CronHPA scaling object. • **kind**: API type of the CronHPA scaling object. • **name**: Name of the CronHPA scaling object. CronHPA supports HPA policies or Deployments. For details, see **Using CronHPA to Adjust the HPA Scaling Scope** or **Using CronHPA to Directly Adjust the Number of Deployment Pods**.
spec.rules	CronHPA policy rule. Multiple rules can be added. The following fields can be configured for each rule: • **ruleName**: CronHPA rule name, which must be unique. • **schedule**: Running time and period of a job. For details, see **Cron**, for example, 0 * * * * or @hourly. **NOTE** This time indicates the local time of where the node is deployed. • **targetReplicas**: indicates the number of pods to be scaled in or out. • **disable**: The value can be **true** or **false**. **false** indicates that the rule takes effect, and **true** indicates that the rule does not take effect.

----End

Using CronHPA to Directly Adjust the Number of Deployment Pods

CronHPA adjusts associated Deployments separately to periodically adjust the number of Deployment pods. The method is as follows:

Using the CCE console

Step 1 Log in to the CCE console and click the cluster name to access the cluster console.

Step 2 Choose **Workloads** in the navigation pane. Locate the target workload and choose **More** > **Auto Scaling** in the **Operation** column.

Step 3 Set **Policy Type** to **HPA+CronHPA**, disable HPA, and enable CronHPA.

CronHPA periodically adjusts the number of workload pods.

Step 4 Click + in the CronHPA policy rule. In the dialog box displayed, configure scaling policy parameters.

Table 15-9 CronHPA policy parameters

Parameter	Description
Target Instances	When a policy is triggered, the number of workload pods will be adjusted to the value of this parameter.
Trigger Time	You can select a specific time every day, every week, every month, or every year. **NOTE** This time indicates the local time of where the node is deployed.
Enable	Enable or disable the policy rule.

Step 5 After configuring the preceding parameters, click **OK**. Then, the added policy rule is displayed in the rule list. Repeat the preceding steps to add multiple policy rules, but the triggering time of the policies must be different.

Step 6 Click **Create**.

----End

Using the kubectl command

```
apiVersion: autoscaling.cce.io/v2alpha1
kind: CronHorizontalPodAutoscaler
metadata:
  name: ccetest
  namespace: default
spec:
   scaleTargetRef:             # Associate a Deployment.
      apiVersion: apps/v1
      kind: Deployment
      name: nginx
   rules:
   - ruleName: "scale-down"
     schedule: "08 * * * *"    # Running time and period of a job. For details, see Cron, for example, 0 * * * * or
@hourly.
     targetReplicas: 1
     disable: false
   - ruleName: "scale-up"
     schedule: "05 * * * *"
     targetReplicas: 3
     disable: false
```

15.2.4 CustomedHPA Policies

A CustomedHPA policy scales Deployments based on metrics (such as CPU usage and memory usage) or at a periodic interval (a specific time point every day, every week, every month, or every year). This type of policy is a CCE-enhanced auto scaling capability.

Supported functions:

- Scaling can be performed based on the percentage of the current number of pods.
- The minimum scaling step can be set.
- Different scaling operations can be performed based on the actual metric values.

Prerequisites

The **CCE Advanced HPA** add-on must be installed. If the add-on version is earlier than 1.2.11, **Prometheus** must be installed. If the **CCE Advanced HPA** version is 1.2.11 or later, an add-on that can provide metrics APIs must be installed. Select one of the following add-ons based on your cluster version and service requirements.

- **Kubernetes Metrics Server**: provides basic resource usage metrics, such as container CPU and memory usage. It is supported by all cluster versions.
- **Cloud Native Cluster Monitoring**: available only in clusters of v1.17 or later.
  - Auto scaling based on basic resource metrics: Prometheus needs to be registered as a metrics API. For details, see **Providing Resource Metrics Through the Metrics API**.
  - Auto scaling based on custom metrics: Custom metrics need to be aggregated to the Kubernetes API server. For details, see **Creating an HPA Policy Using Custom Metrics**.
- **Prometheus** : Prometheus needs to be registered as a metrics API. For details, see **Providing Resource Metrics Through the Metrics API**. This add-on supports only clusters of v1.21 or earlier.

Constraints

- CustomedHPA policies apply only to clusters of v1.15 or later.
- For clusters earlier than v1.19.10, if an HPA policy is used to scale out a workload with EVS volumes mounted, the existing pods cannot be read or written when a new pod is scheduled to another node.

  For clusters of v1.19.10 and later, if an HPA policy is used to scale out a workload with EVS volume mounted, a new pod cannot be started because EVS disks cannot be attached.
- The specifications of the CCE Advanced HPA add-on are decided based on the total number of containers in the cluster and the number of scaling policies. Configure 500m CPU cores and 1000 MiB memory for every 5000 containers, and 100m CPU cores and 500 MiB memory for every 1000 scaling policies.
- If the cce-hpa-controller add-on version is earlier than 1.2.11, the **Cloud Native Cluster Monitoring** add-on cannot provide metrics APIs to scale workloads.
- After a CustomedHPA policy is created, the type of its associated workload cannot be changed.

Creating a CustomedHPA policy

Step 1 Log in to the CCE console and click the cluster name to access the cluster console.

Step 2 Choose **Workloads** in the navigation pane. Locate the target workload and choose **More** > **Auto Scaling** in the **Operation** column.

Step 3 Set **Policy Type** to **CustomedHPA** and configure policy parameters.

Table 15-10 CustomedHPA policy parameters

Parameter	Description
Pod Range	Minimum and maximum numbers of pods. When a policy is triggered, the workload pods are scaled within this range.
Cooldown Period	Enter an interval, in minutes. This parameter indicates the interval between consecutive scaling operations. The cooldown period ensures that a scaling operation is initiated only when the previous one is completed and the system is running stably. **NOTE** The cooldown period takes effect only for metric-based policies. Periodic policies are not affected by the cooldown period.
Rules	Click +. In the dialog box displayed, set the following parameters: • **Type**: You can select **Metric-based** (Table 15-11) or **Periodic** (Table 15-12). Then, configure trigger conditions and actions. • **Enable**: Enable or disable the policy rule. After configuring the preceding parameters, click **OK**. Then, the added policy rule is displayed in the rule list.

Table 15-11 Metric-based rules

Parameter	Description
Trigger	Select **CPU usage** or **Memory usage**, choose **>** or **<**, and enter a percentage. **NOTE** Usage = CPUs or memory used by pods/Requested CPUs or memory.

Parameter	Description
Action	Set an action to be performed when the trigger condition is met. Multiple actions can be added. • **Scale To**: Adjust the number of pods to the specified value. Both a number and a percentage will do. This action can be used to scale in or out pods. If the current number of pods is less than the target value or the target percentage is greater than 100%, the number of pods will be scaled out to the target value. If the current number of pods is greater than the target value or the target percentage is less than 100%, the number of pods will be scaled in to the target value. • **Add**: Configure this parameter when **Trigger** is set to **>**. Add the number of pods. You can specify a number or a percentage. This action can only be used to scale out pods. • **Reduce**: Configure this parameter when **Trigger** is set to **<**. Reduce the number of pods. You can specify a number or a percentage. This action can only be used to scale in pods. **NOTE** You can enter a number or a percentage for the preceding actions. When entering a percentage, you are required to specify the minimum number of available pods. Final number of pods = Number of current pods x Percentage. The result is rounded up. If the result is smaller than the minimum number of available pods, the preset value is used. Otherwise, the calculation result is used.

Table 15-12 Periodic-based rules

Parameter	Description
Trigger Time	You can select a specific time every day, every week, every month, or every year.

Parameter	Description
Action	Set an action to be performed at the **Triggered Time**. • **Scale To**: Adjust the number of pods to the specified value. Both a number and a percentage will do. This action can be used to scale in or out pods. If the current number of pods is less than the target value or the target percentage is greater than 100%, the number of pods will be scaled out to the target value. If the current number of pods is greater than the target value or the target percentage is less than 100%, the number of pods will be scaled in to the target value. • **Add**: Add the number of pods. You can specify a number or a percentage. This action can only be used to scale out pods. • **Reduce**: Reduce the number of pods. You can specify a number or a percentage. This action can only be used to scale in pods. **NOTE** You can enter a number or a percentage for the preceding actions. When entering a percentage, you are required to specify the minimum number of available pods. Final number of pods = Number of current pods x Percentage. The result is rounded up. If the result is smaller than the minimum number of available pods, the preset value is used. Otherwise, the calculation result is used.

Step 4 Click **Create**.

----End

15.2.5 Managing Workload Scaling Policies

Scenario

After an HPA or CustomedHPA policy is created, you can update and delete the policy, as well as edit the YAML file.

Checking an HPA Policy

You can view the rules, status, and events of an HPA policy and handle exceptions based on the error information displayed.

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 **Policies**. On the page displayed, click the **HPA Policies** tab and then ⌄ next to the target HPA policy.

Step 3 In the expanded area, choose **View Events** in the **Operation** column. If the policy malfunctions, locate and rectify the fault based on the error message displayed on the page.

NOTE

You can also view the created HPA policy on the workload details page.

1. Log in to the CCE console and click the cluster name to access the cluster console.
2. In the navigation pane, choose **Workloads**. Click the workload name to view its details.
3. On the workload details page, switch to the **Auto Scaling** tab page to view the HPA policies or CustomedHPA policies. You can also view the scaling policies you configured on the **Policies** page.

Table 15-13 Event types and names

Event Type	Event Name	Description
Normal	SuccessfulRescale	The scaling is performed successfully.
Abnormal	InvalidTargetRange	Invalid target range.
	InvalidSelector	Invalid selector.
	FailedGetObjectMetric	Objects fail to be obtained.
	FailedGetPodsMetric	Pods fail to be obtained.
	FailedGetResourceMetric	Resources fail to be obtained.
	FailedGetExternalMetric	External metrics fail to be obtained.
	InvalidMetricSourceType	Invalid metric source type.
	FailedConvertHPA	HPA conversion failed.
	FailedGetScale	The scale fails to be obtained.
	FailedComputeMetricsReplicas	Failed to calculate metric-defined replicas.
	FailedGetScaleWindow	Failed to obtain ScaleWindow.
	FailedRescale	Failed to scale the service.

----End

Viewing a CustomedHPA Policy

You can view the rules and latest status of a CustomedHPA policy and rectify faults based on the error information displayed.

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 **Policies**. On the page displayed, click the **CustomHPA Policies** tab and then ⌄ next to the target CustomHPA policy.

Step 3 In the expanded area, if the policy is abnormal on the **Rules** tab page, click **Details** in **Latest Status** and locate the fault based on the information displayed.

NOTE

You can also view the created HPA policy on the workload details page.

1. Log in to the CCE console and click the cluster name to access the cluster console.
2. In the navigation pane, choose **Workloads**. Click the workload name to view its details.
3. On the workload details page, switch to the **Auto Scaling** tab page to view the HPA policies or CustomedHPA policies. You can also view the scaling policies you configured on the **Policies** page.

----End

Editing an HPA or CustomedHPA Policy

An HPA policy is used as an example.

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 **Policies**. On the page displayed, click the **HPA Policies** tab. Locate the row containing the target policy and choose **More** > **Edit** in the **Operation** column.

Step 3 On the **Edit HPA Policy** page, configure policy parameters listed in **Table 15-4**.

Step 4 Click **OK**.

----End

Editing the YAML File (HPA Policy)

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 **Policies**. On the page displayed, click the **HPA Policies** tab. Locate the row containing the target policy and click **Edit YAML** in the **Operation** column.

Step 3 In the dialog box displayed, edit or download the YAML file.

----End

Viewing the YAML File (CustomedHPA Policy)

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 **Policies**. On the page displayed, click the **CustomedHPA Policies** tab, locate the row containing the target policy, and choose **More** > **View YAML** in the **Operation** column.

Step 3 In the dialog box displayed, copy and download the YAML file but you are not allowed to modify it.

Step 4 Click the close button in the upper right corner.

----End

Deleting an HPA or CustomedHPA Policy

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 **Policies**. Choose **More** > **Delete** in the **Operation** column of the target policy.

Step 3 In the dialog box displayed, click **Yes**.

----End

15.3 Scaling a Node

15.3.1 Node Scaling Rules

HPA is designed for pod-level scaling and can dynamically adjust the number of replicas based on workload metrics. However, if cluster resources are insufficient and new replicas cannot run, you can only scale out the cluster.

CCE Cluster Autoscaler is a node scaling component provided by Kubernetes. It 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.

Prerequisites

Before using the node scaling function, you must install the **CCE Cluster Autoscaler** add-on of v1.13.8 or later in the cluster.

How Cluster Autoscaler Works

Cluster Autoscaler goes through two processes.

- 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.

  NOTE

  When Autoscaler checks unscheduled pods for scale outs, it uses the scheduling algorithm consistent with the Kubernetes community version for simulated scheduling calculation. If non-built-in kube-schedulers or other non-Kubernetes community scheduling policies are used for application scheduling, when Autoscaler is used to expand the capacity for such applications, the capacity may fail to be expanded or may be expanded more than expected due to inconsistent scheduling algorithms.

- Scale-in: Autoscaler scans all nodes every 10 seconds. If the number of pod requests on a node is less than the user-defined percentage for scale-in, Autoscaler simulates whether the pods on the node can be migrated to other nodes. If yes, the node will be removed after an idle time window.

  When a cluster node is idle for a period of time (10 minutes by default), cluster scale-in is triggered, and the node is automatically deleted. However, a node cannot be deleted from a cluster if the following pods exist:

  - Pods that do not meet specific requirements set in Pod Disruption Budgets (**PodDisruptionBudget**)
  - Pods that cannot be scheduled to other nodes due to constraints such as affinity and anti-affinity policies

- Pods that have the **cluster-autoscaler.kubernetes.io/safe-to-evict: 'false'** annotation
- Pods (except those created by DaemonSets in the kube-system namespace) that exist in the kube-system namespace on the node
- Pods that are not created by the controller (Deployment/ReplicaSet/job/StatefulSet)

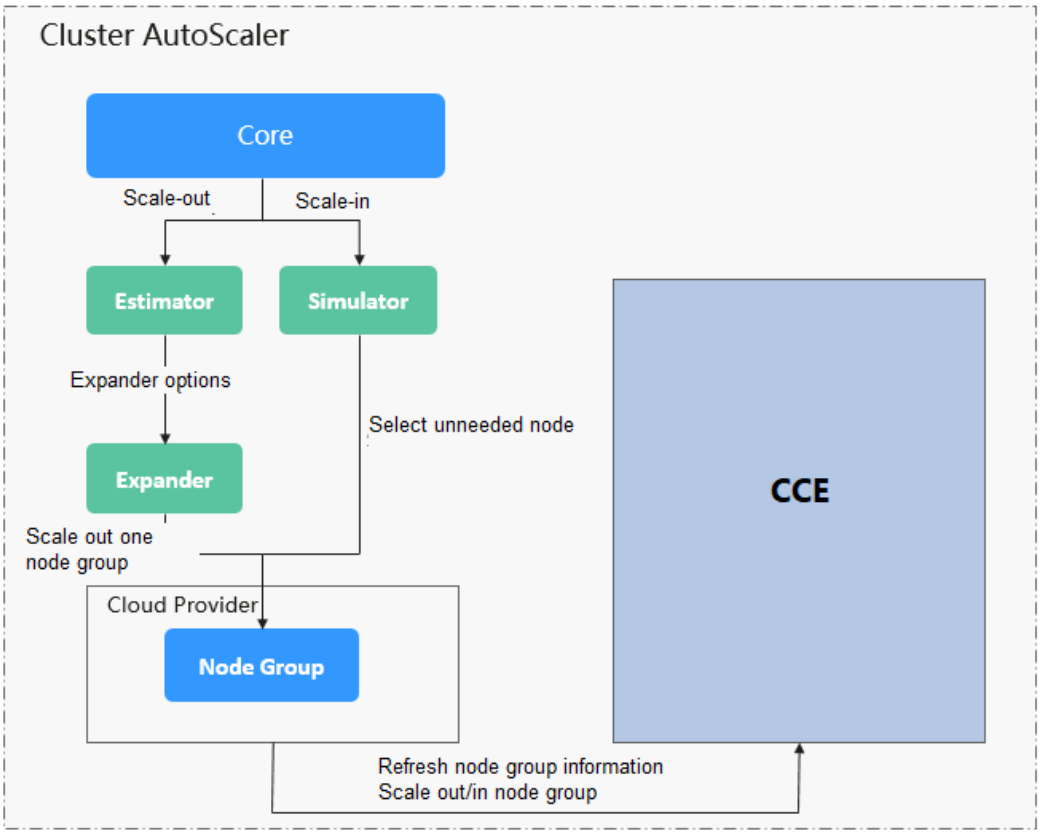
NOTE

When a node meets the scale-in conditions, Autoscaler adds the **DeletionCandidateOfClusterAutoscaler** taint to the node in advance to prevent pods from being scheduled to the node. After the Autoscaler add-on is uninstalled, if the taint still exists on the node, manually delete it.

Cluster Autoscaler Architecture

Figure 15-3 shows the Cluster Autoscaler architecture and its core modules.

Figure 15-3 Cluster Autoscaler architecture



Description

- **Estimator**: Evaluates the number of nodes to be added to each node pool to host unschedulable pods.
- **Simulator**: Finds the nodes that meet the scale-in conditions in the scale-in scenario.

- **Expander**: Selects an optimal node from the node pool picked out by the Estimator based on the user-defined policy in the scale-out scenario. Currently, the Expander has the following policies:

Table 15-14 Expander policies supported by CCE

Policy	Description	Application Scenario	Example
Random	Randomly selects a schedulable node pool to perform the scale-out.	This policy is typically used as a basic backup for other complex policies. Only use this policy if the other policies cannot be used.	Assume that auto scaling is enabled for node pools 1 and 2 in the cluster and the scale-out upper limit is not reached. The policy for scaling out the number of pods for a workload is as follows: 1. Pending pods trigger the Autoscaler to determine the scale-out process. 2. Autoscaler simulates the scheduling phase and evaluates that some pending pods can be scheduled to the added nodes in both node pools 1 and 2. 3. Autoscaler randomly selects node pool 1 or node pool 2 for scale-out.

Policy	Description	Application Scenario	Example
most-pods	A combined policy. It takes precedence over the random policy. Preferentially selects the node pool that can schedule the most pods after scale-out. If multiple node pools meet the condition, the random policy is used for further decision-making.	This policy is based on the maximum number of pods that can be scheduled.	Assume that auto scaling is enabled for node pools 1 and 2 in the cluster and the scale-out upper limit is not reached. The policy for scaling out the number of pods for a workload is as follows: 1. Pending pods trigger the Autoscaler to determine the scale-out process. 2. Autoscaler simulates the scheduling phase and evaluates that some pending pods can be scheduled to the added nodes in both node pools 1 and 2. 3. Autoscaler evaluates that node pool 1 can schedule 20 new pods and node pool 2 can schedule only 10 new pods after scale-out. Therefore, Autoscaler selects node pool 1 for scale-out.

Policy	Description	Application Scenario	Example
least-waste	A combined policy. It takes precedence over the random policy. Autoscaler evaluates the overall CPU or memory allocation rate of the node pools and selects the node pool with the minimum CPU or memory waste. If multiple node pools meet the condition, the random policy is used for further decision-making.	This policy uses the minimum waste score of CPU or memory resources as the selection criteria. The formula for calculating the minimum waste score (wastedScore) is as follows: ● wastedCPU = (Total number of CPUs of the nodes to be scaled out – Total number of CPUs of the pods to be scheduled)/Total number of CPUs of the nodes to be scaled out ● wastedMemory = (Total memory size of nodes to be scaled out – Total memory size of pods to be scheduled)/Total memory size of nodes to be scaled out ● wastedScore = wastedCPU + wastedMemory	Assume that auto scaling is enabled for node pools 1 and 2 in the cluster and the scale-out upper limit is not reached. The policy for scaling out the number of pods for a workload is as follows: 1. Pending pods trigger the Autoscaler to determine the scale-out process. 2. Autoscaler simulates the scheduling phase and evaluates that some pending pods can be scheduled to the added nodes in both node pools 1 and 2. 3. Autoscaler evaluates that the minimum waste score of node pool 1 after scale-out is smaller than that of node pool 2. Therefore, Autoscaler selects node pool 1 for scale-out.

Policy	Description	Application Scenario	Example
priority	A combined policy. The priorities for the policies are as follows: priority > least-waste > random. It is an enhanced least-waste policy configured based on the node pool or scaling group priority. If multiple node pools meet the condition, the least-waste policy is used for further decision-making.	This policy allows you to configure and manage the priorities of node pools or scaling groups through the console or API, while the least-waste policy can reduce the resource waste ratio in common scenarios. This policy has wider applicability and is used as the default selection policy.	Assume that auto scaling is enabled for node pools 1 and 2 in the cluster and the scale-out upper limit is not reached. The policy for scaling out the number of pods for a workload is as follows: 1. Pending pods trigger the Autoscaler to determine the scale-out process. 2. Autoscaler simulates the scheduling phase and evaluates that some pending pods can be scheduled to the added nodes in both node pools 1 and 2. 3. Autoscaler evaluates that node pool 1 has a higher priority than node pool 2. Therefore, Autoscaler selects node pool 1 for scale-out.

Policy	Description	Application Scenario	Example
priority-ratio	A combined policy. The priorities for the policies are as follows: priority > priority-ratio > least-waste > random. If there are multiple node pools with the same priority, evaluate the CPU to memory ratios for the nodes in the cluster. Then compare that ratio, for what was allocated to what had been requested. Finally, you should preferentially select the node pools where these two ratios are the closest.	This policy is used for rescheduling global resources for pods or nodes (instead of only adding nodes) to reduce the overall resource fragmentation rate of the cluster. Use this policy only in rescheduling scenarios.	Assume that auto scaling is enabled for node pools 1 and 2 in the cluster and the scale-out upper limit is not reached. The policy for scaling out the number of pods for a workload is as follows: 1. Pending pods trigger the Autoscaler to determine the scale-out process. 2. Autoscaler simulates the scheduling phase and evaluates that some pending pods can be scheduled to the added nodes in both node pools 1 and 2. 3. Autoscaler determines a preferentially selected node pool and evaluates that the CPU/memory ratio of pods is 1:4. The node flavor in node pool 1 is 2 vCPUs and 8 GiB of memory (the CPU/memory ratio is 1:4), and the node flavor in node pool 2 is 2 vCPUs and 4 GiB of memory (the CPU/memory ratio is 1:2). Therefore, node pool 1 is preferred for this scale-out.

15.3.2 Creating a Node Scaling Policy

CCE provides auto scaling through the **CCE Cluster Autoscaler** add-on. Nodes with different flavors can be automatically added across AZs on demand.

If both a node scaling policy and the configuration in the auto scaling add-on take effect, for example, there are pods that cannot be scheduled and the value of a

metric reaches the threshold, scale-out is performed first for the unschedulable pods.

- If the scale-out succeeds for the unschedulable pods, the system skips the metric-based rule logic and enters the next loop.
- If the scale-out fails for the unschedulable pods, the metric-based rule is executed.

Prerequisites

Before using the node scaling function, you must install the **CCE Cluster Autoscaler** add-on of v1.13.8 or later in the cluster.

Constraints

- If there are no nodes in a node pool, Autoscaler cannot obtain the CPU or memory data of the node, and the node scaling rule triggered using these metrics will not take effect.
- If the driver of a GPU or NPU node is not installed, Autoscaler determines that the node is not fully available and the node scaling rules triggered using the CPU or memory metrics will not take effect.
- Node scale-in will cause PVC/PV data loss for the **local PVs** associated with the node. These PVCs and PVs cannot be restored or used again. In a node scale-in, the pod that uses the local PV is evicted from the node. A new pod is created and stays in the pending state. This is because the PVC used by the pod has a node label, due to which the pod cannot be scheduled.
- When Autoscaler is used, some taints or annotations may affect auto scaling. Therefore, do not use the following taints or annotations in clusters:
  - **ignore-taint.cluster-autoscaler.kubernetes.io**: The taint works on nodes. Kubernetes-native Autoscaler supports protection against abnormal scale outs and periodically evaluates the proportion of available nodes in the cluster. When the proportion of non-ready nodes exceeds 45%, protection will be triggered. In this case, all nodes with the **ignore-taint.cluster-autoscaler.kubernetes.io** taint in the cluster are filtered out from the Autoscaler template and recorded as non-ready nodes, which affects cluster scaling.
  - **cluster-autoscaler.kubernetes.io/enable-ds-eviction**: The annotation works on pods, which determines whether DaemonSet pods can be evicted by Autoscaler. For details, see **Well-Known Labels, Annotations and Taints**.

Configuring Node Pool Scaling Policies

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 **Nodes**. On the **Node Pools** tab, locate the row containing the target node pool and click **Auto Scaling**.

- If the auto scaling add-on has not been installed, configure add-on parameters based on service requirements, click **Install**, and wait until the add-on is installed. For details about add-on configurations, see **CCE Cluster Autoscaler**.

- If the auto scaling add-on has been installed, directly configure auto scaling policies.

Step 3 Configure auto scaling policies.

AS Configuration

- **Customized Rule**: Click **Add Rule**. In the dialog box displayed, configure parameters. You can add multiple node scaling policies, a maximum of one CPU usage-based rule, and one memory usage-based rule. The total number of rules cannot exceed 10.

  The following table lists custom rules.

Table 15-15 Custom rules

Rule Type	Configuration
Metric-based	– **Trigger**: Select **CPU allocation rate** or **Memory allocation rate** and enter a value. The value must be greater than the scale-in percentage configured in the auto scaling add-on. **NOTE** ▪ Resource allocation (%) = Resources requested by pods in the node pool/Resources allocatable to pods in the node pool ▪ **If multiple rules meet the conditions, the rules are executed in either of the following modes:** If rules based on the **CPU allocation rate** and **memory allocation rate** are configured and two or more rules meet the scale-out conditions, the rule that will add the most nodes will be executed. If a rule based on the **CPU allocation rate** and **a periodic rule** are configured and they both meet the scale-out conditions, one of them will be executed randomly. The rule executed first (rule A) changes the node pool to the scaling state. As a result, the other rule (rule B) cannot be executed. After rule A is executed and the node pool status becomes normal, rule B will not be executed. ▪ If rules based on the **CPU allocation rate** and **memory allocation rate** are configured, the policy detection period varies with the processing logic of each loop of the Autoscaler add-on. A scale-out is triggered once the conditions are met, but it is constrained by other factors such as the cooldown period and node pool status. ▪ When the number of nodes in the cluster reaches the upper limit, or the CPU or memory usage reaches the upper limit of the autoscaler add-on, node scale-out will not be triggered. – **Action**: Configure an action to be performed when the triggering condition is met. ▪ **Custom**: Add a specified number of nodes to a node pool. ▪ **Auto calculation**: When the trigger condition is met, nodes are automatically added and the allocation rate is restored to a value lower than the threshold. The formula is as follows: Number of nodes to be added = [Resource request of pods in the node pool/(Available resources of a single node x Target allocation rate)] – Number of current nodes + 1
Periodic	– **Trigger Time**: You can select a specific time every day, every week, every month, or every year. – **Action**: specifies an action to be carried out when the trigger time is reached. A specified number of nodes will be added to the node pool.

- **Nodes**: 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.

AS Object

Specification selection: Configure whether to enable auto scaling for node flavors in a node pool.

Step 4 View cluster-level auto scaling configurations, which take effect for all node pools in the cluster. On this page, you can only view cluster-level auto scaling policies. To modify these policies, go to the **Settings** page. For details, see **Configuring an Auto Scaling Policy for a Cluster**.

Step 5 After the configuration is complete, click **OK**.

----End

Configuring an Auto Scaling Policy for a Cluster

NOTE

An auto scaling policy takes effect on all node pools in a cluster. After the policy is modified, the Autoscaler add-on will be restarted.

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 **Settings** and click the **Auto Scaling** tab.

Step 3 Configure for an elastic scale-out.

- **Auto Scale-out when the load cannot be scheduled**: When workload pods in a cluster cannot be scheduled (pods remain in pending state), CCE automatically adds nodes to the slave node pool. If a node has been configured to be affinity for pods, no node will not be automatically added when pods cannot be scheduled. Such auto scaling typically works with an HPA policy. For details, see **Using HPA and CA for Auto Scaling of Workloads and Nodes**.

  If this function is not enabled, scaling can be performed only using **custom scaling policies**.

- **Upper limit of resources to be expanded**: Configure an upper limit for the total resources in the cluster. When the upper limit is reached, nodes will not be automatically added.

  NOTE

  When the total number of nodes, CPUs, and memory is collected, unavailable nodes in custom node pools are included but unavailable nodes in the default node pool are not included.

- **Scale-Out Priority**: You can drag and drop the node pools in a list to adjust their scale-out priorities.

Step 4 Configure for an elastic scale-in. Elastic scale-in is disabled by default. After it is enabled, the following configurations are supported:

Node Scale-In Conditions: Nodes in a cluster are automatically scaled in when the scale-in conditions are met.

- **Node Resource Condition**: When the requested cluster node resources (both CPU and memory) are lower than a certain percentage (50% by default) for a period of time (10 minutes by default), a cluster scale-in is triggered.
- **Node Status Condition**: If a node is unavailable for a specified period of time, the node will be automatically reclaimed. The default value is 20 minutes.
- **Scale-in Exception Scenarios**: When a node meets the following exception scenarios, CCE will not scale in the node even if the node resources or status meets scale-in conditions:

  a. Resources on other nodes in the cluster are insufficient.

  b. Scale-in protection is enabled on the node. To enable or disable node scale-in protection, choose **Nodes** in the navigation pane and then click the **Nodes** tab. Locate the target node, choose **More**, and then enable or disable node scale-in protection in the **Operation** column.

  c. There is a pod with the non-scale label on the node.

  d. Policies such as reliability have been configured on some containers on the node.

  e. There are non-DaemonSet containers in the **kube-system** namespace on the node.

  f. (Optional) A container managed by a third-party pod controller is running on a node. Third-party pod controllers are for custom workloads except Kubernetes-native workloads such as Deployments and StatefulSets. Such controllers can be created using **CustomResourceDefinitions**.

Node Scale-in Policy

- **Number of Concurrent Scale-In Requests**: maximum number of idle nodes that can be concurrently deleted. Default value: 10.

  Only idle nodes can be concurrently scaled in. Nodes that are not idle can only be scaled in one by one.

  NOTE

  During a node scale-in, if the pods on the node do not need to be evicted (such as DaemonSet pods), the node is idle. Otherwise, the node is not idle.

- **Node Recheck Timeout**: interval for rechecking a node that could not be removed. Default value: 5 minutes.
- **Cooldown Time**
  - **Scale-in Cooldown Time After Scale-out**: Default value: 10 minutes.

    NOTE

    If both auto scale-out and scale-in exist in a cluster, set **Scale-in Cooldown Time After Scale-out** to 0 minutes. This prevents the node scale-in from being blocked due to continuous scale-out of some node pools or retries upon a scale-out failure, which results in unexpected waste of node resources.
  - **Scale-in Cooldown Time After Node Deletion**: Default value: 10 minutes.
  - **Scale-in Cooldown Time After Failure**: Default value: 3 minutes. For details, see **Cooldown Period**.

Step 5 Click **Confirm configuration**.

----End

Cooldown Period

The impact and relationship between the two cooldown periods configured for a node pool are as follows:

Cooldown Period During a Scale-out

This interval indicates the period during which nodes added to the current node pool after a scale-out cannot be deleted. This setting takes effect in the entire node pool.

Cooldown Period During a Scale-in

The interval after a scale-out indicates the period during which the entire cluster cannot be scaled in after the Autoscaler add-on triggers a scale-out (due to the unschedulable pods, metrics, and scaling policies). This interval takes effect in the entire cluster.

The interval after a node is deleted indicates the period during which the cluster cannot be scaled in after the Autoscaler add-on triggers a scale-in. This setting takes effect in the entire cluster.

The interval after a failed scale-in indicates the period during which the cluster cannot be scaled in after the Autoscaler add-on triggers a scale-in. This setting takes effect in the entire cluster.

Period for Autoscaler to Retry a Scale-out

If a node pool failed to scale out, for example, due to insufficient resources or quota, or an error occurred during node installation, Autoscaler can retry the scale-out in the node pool or switch to another node pool. The retry period varies depending on failure causes:

- When resources in a node pool are sold out or the user quota is insufficient, Autoscaler cools down the node pool for 5 minutes, 10 minutes, or 20 minutes. The maximum cooldown duration is 30 minutes. Then, Autoscaler switches to another node pool for a scale-out in the next 10 seconds until the expected node is added or all node pools are cooled down.
- If an error occurred during node installation in a node pool, the node pool enters a 5-minute cooldown period. After the period expires, Autoscaler can trigger a node pool scale-out again. If the faulty node is automatically reclaimed, Cluster Autoscaler re-evaluates the cluster status within 1 minute and triggers a node pool scale-out as needed.
- During a node pool scale-out, if a node remains in the installing state for a long time, Cluster Autoscaler tolerates the node for a maximum of 15 minutes. After the tolerance period expires, Cluster Autoscaler re-evaluates the cluster status and triggers a node pool scale-out as needed.

Example YAML

The following is a YAML example of a node scaling policy:

```
apiVersion: autoscaling.cce.io/v1alpha1
kind: HorizontalNodeAutoscaler
metadata:
  name: xxxx
  namespace: kube-system
spec:
  disable: false
  rules:
  - action:
      type: ScaleUp
      unit: Node
      value: 1
    cronTrigger:
      schedule: 47 20 * * *
    disable: false
    ruleName: cronrule
    type: Cron
  - action:
      type: ScaleUp
      unit: Node
      value: 2
    disable: false
    metricTrigger:
      metricName: Cpu
      metricOperation: '>'
      metricValue: "40"
      unit: Percent
    ruleName: metricrule
    type: Metric
  targetNodepoolIds:
  - 7d48eca7-3419-11ea-bc29-0255ac1001a8
```

Table 15-16 Key parameters

Parameter	Type	Description
spec.disable	Bool	Whether to enable the scaling policy. This parameter takes effect for all rules in the policy.
spec.rules	Array	All rules in a scaling policy.
spec.rules[x].ruleName	String	Rule name.
spec.rules[x].type	String	Rule type. **Cron** and **Metric** are supported.
spec.rules[x].disable	Bool	Rule switch. Currently, only **false** is supported.
spec.rules[x].action.type	String	Rule action type. Currently, only **ScaleUp** is supported.
spec.rules[x].action.unit	String	Rule action unit. Currently, only **Node** is supported.
spec.rules[x].action.value	Integer	Rule action value.
spec.rules[x].cronTrigger	N/A	Optional. This parameter is valid only in periodic rules.
spec.rules[x].cronTrigger.schedule	String	Cron expression of a periodic rule.

Parameter	Type	Description
spec.rules[x].metricTrigger	N/A	Optional. This parameter is valid only in metric-based rules.
spec.rules[x].metricTrigger.metricName	String	Metric of a metric-based rule. Currently, **Cpu** and **Memory** are supported.
spec.rules[x].metricTrigger.metricOperation	String	Comparison operator of a metric-based rule. Currently, only **>** is supported.
spec.rules[x].metricTrigger.metricValue	String	Metric threshold of a metric-based rule. The value can be any integer from 1 to 100 and must be a character string.
spec.rules[x].metricTrigger.Unit	String	Unit of the metric-based rule threshold. Currently, only **%** is supported.
spec.targetNodepoolIds	Array	All node pools associated with the scaling policy.
spec.targetNodepoolIds[x]	String	ID of the node pool associated with the scaling policy.

15.3.3 Managing Node Scaling Policies

Scenario

After a node scaling policy is created, you can delete, edit, disable, enable, or clone the policy.

Viewing a Node Scaling Policy

You can view the associated node pool, rules, and scaling history of a node scaling policy and rectify faults according to the error information displayed.

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 **Nodes**.On the page displayed, click the **Node Pools** tab and then the name of the node pool for which an auto scaling policy has been created to view the node pool details.

Step 3 On the node pool details page, click the **Auto Scaling** tab to view the auto scaling configuration and scaling records.

----End

Deleting a Node Scaling Policy

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 **Policies**. On the page displayed, click the **Node Scaling Policies** tab, locate the row containing the target policy and choose **More** > **Delete** in the **Operation** column.

Step 3 In the **Delete Node Scaling Policy** dialog box displayed, confirm whether to delete the policy.

Step 4 Click **Yes** to delete the policy.

----End

Editing a Node Scaling Policy

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 **Policies**. On the page displayed, click the **Node Scaling Policies** tab, locate the row containing the target policy and click **Edit** in the **Operation** column.

Step 3 On the **Edit Node Scaling Policy** page displayed, configure policy parameters listed in **Table 15-16**.

Step 4 After the configuration is complete, click **OK**.

----End

Cloning a Node Scaling Policy

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 **Policies**. On the page displayed, click the **Node Scaling Policies** tab, locate the row containing the target policy and choose **More** > **Clone** in the **Operation** column.

Step 3 On the **Clone Node Scaling Policy** page displayed, certain parameters have been cloned. Add or modify other policy parameters based on service requirements.

Step 4 Click **OK**.

----End

Enabling or Disabling a Node Scaling Policy

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 **Policies**. On the page displayed, click the **Node Scaling Policies** tab, locate the row containing the target policy click **Disable** in the **Operation** column. If the policy is in the disabled state, click **Enable** in the **Operation** column.

Step 3 In the dialog box displayed, confirm whether to disable or enable the node policy.

----End

15.4 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 pods or containers are used for deploying applications, the upper limit of available resources is typically required to set for pods or containers to prevent unlimited usage of node 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.

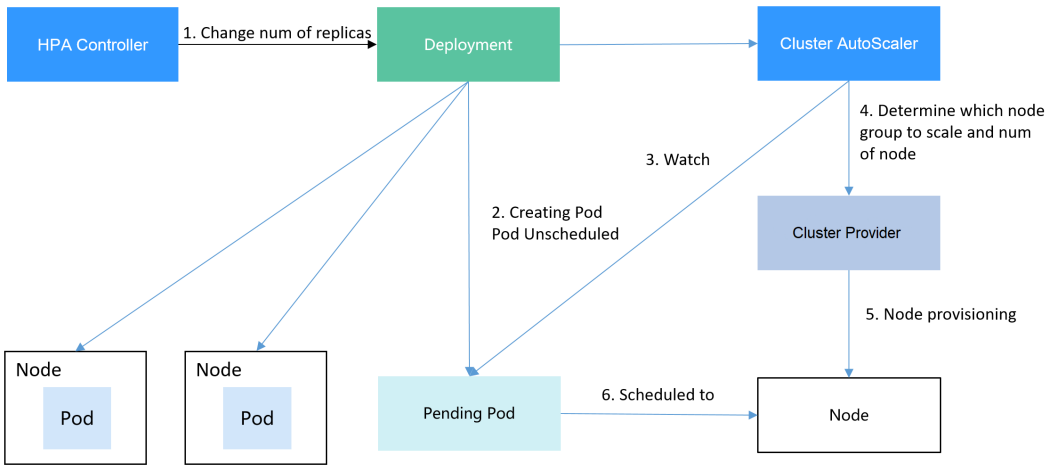
Solution

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 15-4**, 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.

Figure 15-4 HPA and CA working flows



Using HPA and CA can easily implement auto scaling in most scenarios. In addition, the scaling process of nodes and pods can be easily observed.

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 to create an organization.

   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 {*Image repository address***}/group/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 {*Image repository address***}/group/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.

- **Nodes**: Set it to **1**, indicating that one node is created by default when a node pool is created.
- **Specifications**: 2 vCPUs | 4 GiB

Retain the defaults for other parameters.

Step 3 Locate the row containing the newly created node pool and click **Auto Scaling** in the upper right corner.

If the CCE Cluster Autoscaler add-on is not installed in the cluster, install it first.

- **Automatic scale-out**: If this function is enabled, nodes in a node pool will be automatically added based on the cluster load.
- **Customized Rule**: 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.
- **Automatic scale-in**: If this function is enabled, nodes in a node pool will be automatically deleted based on the cluster load. For example, trigger scale-in when the node resource utilization is less than 50%.

- **AS Configuration**: Modify the node quantity range. During autoscaling, the number of nodes in a node pool is always within the configured quantity range.
- **AS Object**: Enable autoscaling for node specifications in a node pool.

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.

```
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
```

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. .

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 Pending state. During this period, nodes are added.

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).

----End

Summary

Using HPA and CA can easily implement auto scaling in most scenarios. In addition, the scaling process of nodes and pods can be easily observed.

16 Add-ons

16.1 Overview

CCE provides multiple types of add-ons to extend cluster functions and meet feature requirements. You can install add-ons as required.

NOTICE

CCE uses Helm charts to deploy add-ons. To modify or upgrade an add-on, perform operations on the **Add-ons** page or use open add-on management APIs. Do not directly modify resources related to add-ons in the background. Otherwise, add-on exceptions or other unexpected problems may occur.

Scheduling and Elasticity Add-ons

Add-on Name	Description
Volcano Scheduler	This add-on is a scheduler for general-purpose, high-performance computing such as job scheduling, heterogeneous chip management, and job running management, serving end users through computing frameworks for different industries such as AI, big data, gene sequencing, and rendering.
CCE Cluster Autoscaler	This add-on resizes a cluster based on pod scheduling status and resource usage.
CCE Advanced HPA	This add-on is developed by CCE. It can be used to flexibly scale in or out Deployments based on metrics such as CPU usage and memory usage.

Cloud Native Observability Add-ons

Add-on Name	Description
Cloud Native Cluster Monitoring	This add-on uses Prometheus-operator and Prometheus to provide easy-to-use, end-to-end Kubernetes cluster monitoring.
CCE Node Problem Detector	This add-on monitors abnormal events of cluster nodes and connects to a third-party monitoring platform. It is a daemon running on each node. It collects node issues from different daemons and reports them to the API server. It can run as a DaemonSet or a daemon.
CCE Network Metrics Exporter	This add-on monitors and manages container network traffic. It collects how many IPv4 packets and bytes are received and sent (including those sent to the Internet) and allows you to obtain pod labels. It supports multiple monitoring tasks, allows you to select monitoring metrics, and uses a PodSelector to select monitoring backends. The monitoring information has been adapted to Prometheus. You can call the Prometheus API to view monitoring data.
Kubernetes Metrics Server	This add-on is an aggregator for monitoring data of core cluster resources.
Prometheus	This add-on is an open-source system monitoring and alerting framework. CCE allows you to quickly install Prometheus as an add-on.

Cloud Native Heterogeneous Computing Add-ons

Add-on Name	Description
CCE AI Suite (NVIDIA GPU)	NVIDIA GPU is a device management add-on that supports GPUs in containers. It supports only NVIDIA drivers.
CCE AI Suite (Ascend NPU)	Ascend NPU is a device management add-on that supports Huawei NPUs in containers.

Container Network Add-ons

Add-on Name	Description
CoreDNS	CoreDNS is a DNS server that provides domain name resolution for Kubernetes clusters through a chain add-on.
Nginx Ingress Controller	This add-on forwards application data such as the data of virtual hosts, load balancers, SSL proxy, and HTTP routing for Services that can be directly accessed outside a cluster.

Add-on Name	Description
NodeLocal DNSCache	NodeLocal DNSCache improves cluster DNS performance by running DNS cache proxies as DaemonSets on cluster nodes.

Container Storage Add-on

Add-on Name	Description
CCE Container Storage (Everest)	This add-on is a cloud native container storage system, which enables clusters of Kubernetes v1.15.6 or later to use cloud storage through the Container Storage Interface (CSI).

Container Security Add-on

Add-on Name	Description
CCE Secrets Manager for DEW	This add-on is used to interconnect with Data Encryption Workshop (DEW), which 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.

Other Add-ons

Add-on Name	Description
Kubernetes Dashboard	This add-on is a general-purpose, web-based UI for Kubernetes clusters and integrates all commands that can be used in the CLI. It allows users to manage applications running in a cluster and troubleshoot faults, as well as manage the cluster itself.
web-terminal (EOM)	This add-on allows you to use kubectl on a web UI. It can connect to Linux by using WebSocket through a browser and provides APIs for integration into independent systems. It can be directly used as a service to obtain information through the configuration management database (CMDB) and log in to the server.

Add-on Lifecycle

An add-on lifecycle involves all the statuses of the add-on from installation to uninstallation.

Table 16-1 Add-on statuses

Status	Attribute	Description
Running	Stable state	The add-on is running properly, all add-on instances are deployed properly, and the add-on can be used properly.
Partially ready	Stable state	The add-on is running properly, but some add-on instances are not properly deployed. In this state, the add-on functions may be unavailable.
Unavailable	Stable state	The add-on malfunctions, and all add-on instances are not properly deployed.
Installing	Intermediate state	The add-on is being deployed. If all instances cannot be scheduled due to incorrect add-on configuration or insufficient resources, the system sets the add-on status to **Unavailable** 10 minutes later.
Installation failed	Stable state	Install add-on failed. Uninstall it and try again.
Upgrading	Intermediate state	The add-on is being upgraded.
Upgrade failed	Stable state	Upgrade add-on failed. Upgrade it again, or uninstall it and try again.
Rolling back	Intermediate state	The add-on is rolling back.
Rollback failed	Stable state	The add-on rollback failed. Retry the rollback, or uninstall it and try again.
Deleting	Intermediate state	The add-on is being deleted. If this state stays for a long time, an exception occurred.
Deletion failed	Stable state	Delete add-on failed. Try again.
Unknown	Stable state	No add-on chart found.

NOTE

When an add-on is in an intermediate state such as **Installing** or **Deleting**, you are not allowed to edit or uninstall the add-on.

If the add-on status is unknown and the returned **status.Reason** is "don't install the addon in this cluster", the secret associated with the Helm release of the add-on in the cluster is typically deleted by mistake. In this case, uninstall the add-on and reinstall it with the same configurations.

Related Operations

You can perform the operations listed in **Table 16-2** on the **Add-ons** page.

Table 16-2 Related operations

Operation	Description	Procedure
Install	Install a specified add-on.	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. Click **Install** under the target add-on. Each add-on has different configuration parameters. For details, see the corresponding chapter. 3. Click **OK**.
Upgrade	Upgrade an add-on to the new version.	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. If an add-on can be upgraded, the **Upgrade** button is displayed under it. Click **Upgrade**. Each add-on has different configuration parameters. For details, see the corresponding chapter. 3. Click **OK**.
Edit	Edit add-on parameters.	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. Click **Edit** under the target add-on. Each add-on has different configuration parameters. For details, see the corresponding chapter. 3. Click **OK**.
Uninstall	Uninstall an add-on from the cluster.	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. Click **Uninstall** under the target add-on. 3. In the displayed dialog box, click **Yes**. This operation cannot be undone.

Operation	Description	Procedure
Roll back	Roll back an add-on to the source version. **NOTE** • This function is used to roll back an upgraded add-on to the source version, not to undo the editing of add-on parameters. • An add-on cannot be rolled back repeatedly.	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. If an add-on can be rolled back, the **Roll Back** button is displayed under it. Click **Roll Back**. 3. In the displayed dialog box, click **Yes**.

NOTE

Add-on rollback is supported in certain add-on versions.

- CoreDNS: 1.25.11 and later versions
- Everest: 2.1.19 and later versions
- Autoscaler:
  - v1.21 clusters: v1.21.22 and later versions
  - v1.23 clusters: v1.23.24 and later versions
  - v1.25 clusters: v1.25.14 and later versions
- kube-prometheus-stack: v3.7.2 and later versions
- Volcano: 1.11.4 and later versions
- NPD: 1.18.22 and later versions

16.2 CoreDNS

Introduction

CoreDNS is a DNS server that provides domain name resolution for Kubernetes clusters through a chain add-on.

CoreDNS is an open-source software and has been a part of CNCF. It provides a means for cloud services to discover each other in cloud-native deployments. Each of the plugins chained by CoreDNS provides a particular DNS function. You can integrate CoreDNS with only the plugins you need to make it fast, efficient, and flexible. When used in a Kubernetes cluster, CoreDNS can automatically discover services in the cluster and provide domain name resolution for these services. By working with DNS server, CoreDNS can resolve external domain names for workloads in a cluster.

This add-on is installed by default during cluster creation.

Kubernetes backs CoreDNS as the official default DNS for all clusters going forward.

CoreDNS official website: **https://coredns.io/**

Open source community: **https://github.com/coredns/coredns**

NOTE

For details, see **DNS**.

Constraints

To run CoreDNS properly or upgrade CoreDNS in a cluster, ensure the number of available nodes in the cluster is greater than or equal to the number of CoreDNS instances and all CoreDNS instances are running. Otherwise, the add-on will malfunction or the upgrade will fail.

Installing the Add-on

This add-on has been installed by default. If it is uninstalled due to some reasons, you can reinstall it by performing the following steps:

Step 1 Log in to the CCE console and click the cluster name to access the cluster console. Choose **Add-ons** in the navigation pane, locate **CoreDNS** on the right, and click **Install**.

Step 2 On the **Install Add-on** page, configure the specifications.

Table 16-3 CoreDNS parameters

Parameter	Description
Pods	Number of pods for the add-on. High availability is not possible with a single add-on pod. If an error occurs on the node where the add-on instance runs, the add-on will fail.
Containers	Queries per second (QPS) of the CoreDNS add-on is positively correlated with the CPU consumption. If the number of nodes or containers in the cluster grows, the CoreDNS pods will bear heavier workloads. Adjust the number of the CoreDNS pods and their CPU and memory quotas based on the cluster scale. For details, see **Table 16-4**.

Table 16-4 Recommended CoreDNS quotas

Nodes	Recommended QPS	Pods	Requested vCPUs	vCPU Limit	Requested Memory	Memory Limit
50	2500	2	500m	500m	512 MiB	512 MiB
200	5000	2	1000m	1000m	1024 MiB	1024 MiB
1000	10000	2	2000m	2000m	2048 MiB	2048 MiB

Nodes	Recommended QPS	Pods	Requested vCPUs	vCPU Limit	Requested Memory	Memory Limit
2000	20000	4	2000m	2000m	2048 MiB	2048 MiB

Step 3 Configure the add-on parameters.

Table 16-5 CoreDNS add-on parameters

Parameter	Description
Stub Domain	A domain name server for a custom domain name. The format is a key-value pair. The key is a domain name suffix, and the value is one or more DNS IP addresses, for example, **acme.local -- 1.2.3.4,6.7.8.9**. For details, see **Configuring the Stub Domain for CoreDNS**.

Parameter	Description

Advance Config	• **parameterSyncStrategy**: indicates whether to configure consistency check when the add-on is upgraded.
	– **ensureConsistent**: indicates that the configuration consistency check is enabled. If the configuration recorded in the cluster is inconsistent with the actual configuration, the add-on cannot be upgraded.
	– **force**: indicates that the configuration consistency check is ignored during an upgrade. In this case, you must ensure that the current effective configuration is the same as the original configuration. After the add-on is upgraded, restore the value of **parameterSyncStrategy** to **ensureConsistent** to enable the configuration consistency check again.
	– **inherit**: indicates that custom settings are automatically inherited during an upgrade. After the add-on is upgraded, restore the value of **parameterSyncStrategy** to **ensureConsistent** to enable the configuration consistency check again.
	• **stub_domains**: sub domains, which allow you to configure a domain name server for a custom domain name. A sub domain is in the format of a key-value pair, where the key is the suffix of a DNS domain name and the value is one or more DNS IP addresses.
	• **upstream_nameservers**: IP address of the upstream DNS server.
	• **servers**: nameservers, which are available in CoreDNS v1.23.1 and later versions. You can customize nameservers. For details, see **dns-custom-nameservers**.
	plugins indicates the configuration of each component in CoreDNS. Retain the default settings typically to prevent CoreDNS from being unavailable due to configuration errors. Each plugin component contains **name**, **parameters** (optional), and **configBlock** (optional). The format of the generated Corefile is as follows:
	`$name  $parameters {`
	`$configBlock`
	`}`
	Table 16-6 describes common plugins. For details, see **Plugins**.
	Example:
	`{`
	`"servers": [`
	`{`
	`"plugins": [`
	`{`
	`"name": "bind",`
	`"parameters": "{$POD_IP}"`
	`},`
	`{`
	`"name": "cache",`
	`"parameters": 30`

Parameter	Description

	<pre>{
	            },
	            {
	               "name": "errors"
	            },
	            {
	               "name": "health",
	               "parameters": "{$POD_IP}:8080"
	            },
	                     {
	               "name": "ready",
	               "{$POD_IP}:8081"
	            },
	            {
	               "configBlock": "pods insecure\nfallthrough in-addr.arpa ip6.arpa",
	               "name": "kubernetes",
	               "parameters": "cluster.local in-addr.arpa ip6.arpa"
	            },
	            {
	               "name": "loadbalance",
	               "parameters": "round_robin"
	            },
	            {
	               "name": "prometheus",
	               "parameters": "{$POD_IP}:9153"
	            },
	            {
	               "configBlock": "policy random",
	               "name": "forward",
	               "parameters": ". /etc/resolv.conf"
	            },
	            {
	               "name": "reload"
	            }
	         ],
	         "port": 5353,
	         "zones": [
	            {
	               "zone": "."
	            }
	         ]
	      }
	   ],
	   "stub_domains": {
	      "acme.local": [
	         "1.2.3.4",
	         "6.7.8.9"
	      ]
	   },
	   "upstream_nameservers": ["8.8.8.8", "8.8.4.4"]
	}</pre>

Table 16-6 Default plugin configuration of the active CoreDNS zone

Plugin Name	Description
bind	Host IP address listened by CoreDNS. Retain the default value **{$POD_IP}**. For details, see **bind**.
cache	Enables DNS cache. For details, see **cache**.

Plugin Name	Description
errors	Errors are logged to stdout. For details, see **errors**.
health	Health check for CoreDNS. {$POD_IP}:8080 is listened to. Retain the default setting. Otherwise, the CoreDNS health check will fail and the add-on will restart repeatedly. For details, see **health**.
ready	Whether the backend server is ready to receive traffic. {$POD_IP}:8081 is listened to. If the backend server is not ready, CoreDNS will suspend DNS resolution until the backend server is ready. For details, see **ready**.
kubernetes	CoreDNS Kubernetes plugin, which provides the service parsing capability in a cluster. For details, see **kubernetes**.
loadbalance	Round-robin DNS load balancer that randomizes the order of A, AAAA, and MX records in an answer. For details, see **loadbalance**.
prometheus	API for obtaining CoreDNS metrics. {$POD_IP}:9153 is listened to in the default zone. Retain the default setting. Otherwise, Prometheus cannot collect CoreDNS metrics. For details, see **Prometheus**.
forward	Forwards any queries that are not within the cluster domain of Kubernetes to predefined resolvers (**/etc/resolv.conf**). For details, see **forward**.
reload	Automatically reloads modified Corefiles. After you modify a ConfigMap, wait for two minutes for the modification to take effect. For details, see **reload**.

log	Enables CoreDNS logging. For details, see **log**.
	Example:
	`{`
	`  "name": "log"`
	`}`

template	A quick response template, where **AAAA** indicates an IPv6 request. If **NXDOMAIN** is returned in an **rcode** response, no IPv6 resolution result is returned. For details, see **template**.
	Example:
	`{`
	`  "configBlock": "rcode NXDOMAIN",`
	`  "name": "template",`
	`  "parameters": "ANY AAAA"`
	`}`

Step 4 Configure scheduling policies for the add-on.

NOTE

- Scheduling policies do not take effect on add-on instances of the DaemonSet type.
- When configuring multi-AZ deployment or node affinity, ensure that there are nodes meeting the scheduling policy and that resources are sufficient in the cluster. Otherwise, the add-on cannot run.

Table 16-7 Configurations for add-on scheduling

Parameter	Description
Multi AZ	• **Preferred**: Deployment pods of the add-on will be preferentially scheduled to nodes in different AZs. If all the nodes in the cluster are deployed in the same AZ, the pods will be scheduled to that AZ. • **Equivalent mode**: Deployment pods of the add-on are evenly scheduled to the nodes in the cluster in each AZ. If a new AZ is added, you are advised to increase add-on pods for cross-AZ HA deployment. With the Equivalent multi-AZ deployment, the difference between the number of add-on pods in different AZs will be less than or equal to 1. If resources in one of the AZs are insufficient, pods cannot be scheduled to that AZ. • **Required**: Deployment pods of the add-on will be forcibly scheduled to nodes in different AZs. If there are fewer AZs than pods, the extra pods will fail to run.
Node Affinity	• **Not configured**: Node affinity is disabled for the add-on. • **Node Affinity**: Specify the nodes where the add-on is deployed. If you do not specify the nodes, the add-on will be randomly scheduled based on the default cluster scheduling policy. • **Specified Node Pool Scheduling**: Specify the node pool where the add-on is deployed. If you do not specify the node pool, the add-on will be randomly scheduled based on the default cluster scheduling policy. • **Custom Policies**: Enter the labels of the nodes where the add-on is to be deployed for more flexible scheduling policies. If you do not specify node labels, the add-on will be randomly scheduled based on the default cluster scheduling policy. If multiple custom affinity policies are configured, ensure that there are nodes that meet all the affinity policies in the cluster. Otherwise, the add-on cannot run.

Parameter	Description
Toleration	Using both taints and tolerations allows (not forcibly) the add-on Deployment to be scheduled to a node with the matching taints, and controls the Deployment eviction policies after the node where the Deployment is located is tainted. The add-on adds the default tolerance policy for the **node.kubernetes.io/not-ready** and **node.kubernetes.io/unreachable** taints, respectively. The tolerance time window is 60s. For details, see **Taints and Tolerations**.

Step 5 Click **Install**.

----End

Components

Table 16-8 Add-on components

Component	Description	Resource Type
CoreDNS	DNS server for clusters	Deployment

How Does Domain Name Resolution Work in Kubernetes?

DNS policies can be configured for each pod. Kubernetes supports DNS policies **Default**, **ClusterFirst**, **ClusterFirstWithHostNet**, and **None**. For details, see **DNS for Services and Pods**. These policies are specified in the **dnsPolicy** field in the pod-specific.

- **Default**: Pods inherit the name resolution configuration from the node that the pods run on. The custom upstream DNS server and the stub domain cannot be used together with this policy.
- **ClusterFirst**: Any DNS query that does not match the configured cluster domain suffix, such as **www.kubernetes.io**, is forwarded to the upstream name server inherited from the node. Cluster administrators may have extra stub domains and upstream DNS servers configured.
- **ClusterFirstWithHostNet**: For pods running with hostNetwork, set its DNS policy **ClusterFirstWithHostNet**.
- **None**: It allows a pod to ignore DNS settings from the Kubernetes environment. All DNS settings are supposed to be provided using the **dnsPolicy** field in the pod-specific.

NOTE

- Clusters of Kubernetes v1.10 and later support **Default**, **ClusterFirst**, **ClusterFirstWithHostNet**, and **None**. Clusters earlier than Kubernetes v1.10 support only **Default**, **ClusterFirst**, and **ClusterFirstWithHostNet**.
- **Default** is not the default DNS policy. If **dnsPolicy** is not explicitly specified, **ClusterFirst** is used.

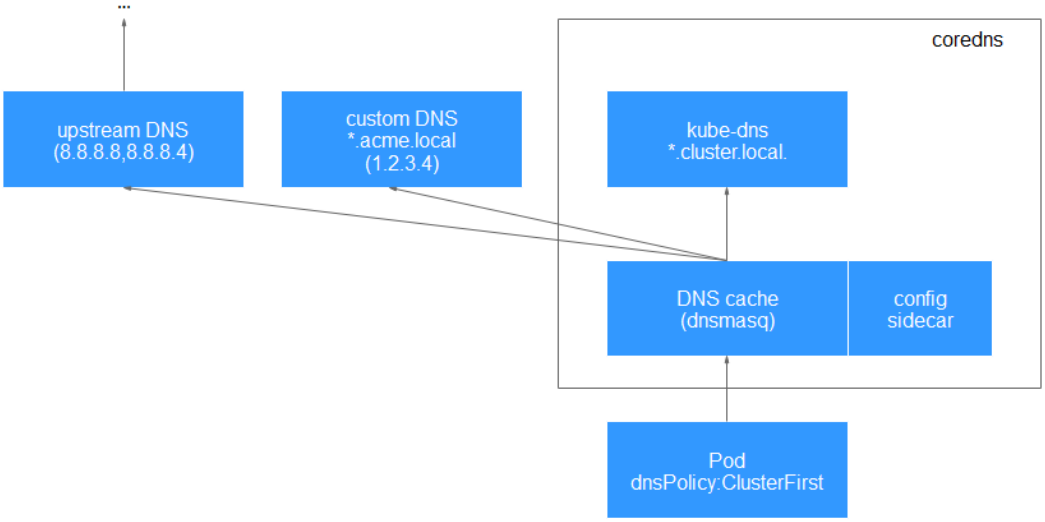
Routing

Without stub domain configurations: Any query that does not match the configured cluster domain suffix, such as **www.kubernetes.io**, is forwarded to the upstream DNS server inherited from the node.

With stub domain configurations: If stub domains and upstream DNS servers are configured, DNS queries are routed according to the following flow:

1. The query is first sent to the DNS caching layer in CoreDNS.
2. From the caching layer, the suffix of the request is examined and then the request is forwarded to the corresponding DNS:
   - Names with the cluster suffix, for example, **.cluster.local**: The request is sent to CoreDNS.
   - Names with the stub domain suffix, for example, **.acme.local**: The request is sent to the configured custom DNS resolver that listens, for example, on 1.2.3.4.
   - Names that do not match the suffix (for example, **widget.com**): The request is forwarded to the upstream DNS.

Figure 16-1 Routing



16.3 CCE Container Storage (Everest)

Introduction

Everest is a cloud native container storage system, which enables clusters of Kubernetes v1.15.6 or later to access cloud storage services through the CSI.

Everest is a system resource add-on. It is installed by default when a cluster of Kubernetes v1.15 or later is created.

Constraints

- In version 1.2.0 of the Everest add-on, **key authentication** is optimized when OBS is used. After the Everest add-on is upgraded from a version earlier than 1.2.0, restart all workloads that use OBS in the cluster. Otherwise, workloads may not be able to use OBS.

Installing the Add-on

This add-on has been installed by default. If it is uninstalled due to some reasons, you can reinstall it by performing the following steps:

Step 1 Log in to the CCE console and click the cluster name to access the cluster console. Click **Add-ons** in the navigation pane, locate **CCE Container Storage (Everest)** on the right, and click **Install**.

Step 2 On the **Install Add-on** page, configure the specifications.

Table 16-9 Everest parameters

Parameter	Description
Pods	Number of pods for the add-on. High availability is not possible with a single pod. If an error occurs on the node where the add-on instance runs, the add-on will fail.
Containers	The Everest add-on contains the Everest-csi-controller and everest-csi-driver components. For details, see **Components**. The add-on component specifications can be customized based on your requirements. Retain the default requested CPU and memory values of the add-on components. The limit values can be adjusted based on the number of cluster nodes and PVCs. For details about the configuration suggestions, see **Table 16-10**. In non-typical scenarios, the formulas for estimating the limit values are as follows: • everest-csi-controller – CPU limit: 250m for 200 or fewer nodes, 350m for 1000 nodes, and 500m for 2000 nodes – Memory limit = (200 Mi + Number of nodes x 1 Mi + Number of PVCs x 0.2 Mi) x 1.2 • everest-csi-driver – CPU limit: 300m for 200 or fewer nodes, 500m for 1000 nodes, and 800m for 2000 nodes – Memory limit: 300 Mi for 200 or fewer nodes, 600 Mi for 1000 nodes, and 900 Mi for 2000 nodes

Table 16-10 Recommended configuration limits in typical scenarios

Configuration Scenario			everest-csi-controller		everest-csi-driver	
Nodes	PVs/PVCs	Add-on Instances	vCPUs (Limit = Requested)	Memory (Limit = Requested)	vCPUs (Limit = Requested)	Memory (Limit = Requested)
50	1000	2	250m	600 MiB	300m	300 MiB
200	1000	2	250m	1 GiB	300m	300 MiB
1000	1000	2	350m	2 GiB	500m	600 MiB
1000	5000	2	450m	3 GiB	500m	600 MiB
2000	5000	2	550m	4 GiB	800m	900 MiB
2000	10000	2	650m	5 GiB	800m	900 MiB

Step 3 Configure the add-on parameters.

Table 16-11 Everest parameters

Parameter	Description
csi_attacher_worker_threads	Number of worker nodes that can be concurrently processed by Everest for attaching EVS volumes. The default value is **60**.
csi_attacher_detach_worker_threads	Number of worker nodes that can be concurrently processed by Everest for detaching EVS volumes. The default value is **60**.
volume_attaching_flow_ctrl	Maximum number of EVS volumes that can be attached by the Everest add-on within 1 minute. The default value is **0**, indicating that the performance of attaching EVS volumes is determined by the underlying storage resources.
cluster_id	Cluster ID
default_vpc_id	ID of the VPC to which the cluster belongs
disable_auto_mount_secret	Whether the default AK/SK can be used when an object bucket or parallel file system is mounted. The default value is **false**.
enable_node_attacher	Whether to enable the attacher on the agent to process the **VolumeAttachment**.
flow_control	This field is left blank by default. You do not need to configure this parameter.

Parameter	Description
number_of_reserved_disks	Number of disks on the node reserved for custom use. This parameter is supported when the add-on version is 2.3.11 or later. Assume that a maximum of 20 EVS disks can be attached to a node, and the value of this parameter is set to **6**. Then 14 (20-6) disks can be attached to this node when the system schedules the EVS disk attachment workloads. The reserved six disks include one system disk and one data disk that has been attached to the node. You can attach four EVS disks to this node as additional data disks or raw disks for a local storage pool.
over_subscription	Overcommitment ratio of the local storage pool (**local_storage**). The default value is **80**. If the size of the local storage pool is 100 GB, it can be overcommitted to 180 GB.
project_id	ID of the project to which a cluster belongs

NOTE

In Everest 1.2.26 or later, the performance of attaching a large number of EVS volumes has been optimized. The following parameters can be configured:

- csi_attacher_worker_threads
- csi_attacher_detach_worker_threads
- volume_attaching_flow_ctrl

The preceding parameters are associated with each other and are constrained by the underlying storage resources in the region where the cluster is located. To attach a large number of volumes (more than 500 EVS volumes per minute), contact administrator and configure the parameters under their guidance to prevent the Everest add-on from running abnormally due to improper parameter settings.

Step 4 Configure scheduling policies for the add-on.

NOTE

- Scheduling policies do not take effect on add-on instances of the DaemonSet type.
- When configuring multi-AZ deployment or node affinity, ensure that there are nodes meeting the scheduling policy and that resources are sufficient in the cluster. Otherwise, the add-on cannot run.

Table 16-12 Configurations for add-on scheduling

Parameter	Description
Multi AZ	• **Preferred**: Deployment pods of the add-on will be preferentially scheduled to nodes in different AZs. If all the nodes in the cluster are deployed in the same AZ, the pods will be scheduled to that AZ. • **Equivalent mode**: Deployment pods of the add-on are evenly scheduled to the nodes in the cluster in each AZ. If a new AZ is added, you are advised to increase add-on pods for cross-AZ HA deployment. With the Equivalent multi-AZ deployment, the difference between the number of add-on pods in different AZs will be less than or equal to 1. If resources in one of the AZs are insufficient, pods cannot be scheduled to that AZ. • **Required**: Deployment pods of the add-on will be forcibly scheduled to nodes in different AZs. If there are fewer AZs than pods, the extra pods will fail to run.
Node Affinity	• **Not configured**: Node affinity is disabled for the add-on. • **Node Affinity**: Specify the nodes where the add-on is deployed. If you do not specify the nodes, the add-on will be randomly scheduled based on the default cluster scheduling policy. • **Specified Node Pool Scheduling**: Specify the node pool where the add-on is deployed. If you do not specify the node pool, the add-on will be randomly scheduled based on the default cluster scheduling policy. • **Custom Policies**: Enter the labels of the nodes where the add-on is to be deployed for more flexible scheduling policies. If you do not specify node labels, the add-on will be randomly scheduled based on the default cluster scheduling policy. If multiple custom affinity policies are configured, ensure that there are nodes that meet all the affinity policies in the cluster. Otherwise, the add-on cannot run.
Toleration	Using both taints and tolerations allows (not forcibly) the add-on Deployment to be scheduled to a node with the matching taints, and controls the Deployment eviction policies after the node where the Deployment is located is tainted. The add-on adds the default tolerance policy for the **node.kubernetes.io/not-ready** and **node.kubernetes.io/unreachable** taints, respectively. The tolerance time window is 60s. For details, see **Taints and Tolerations**.

Step 5 Click **Install**.

----End

Components

Table 16-13 Add-on components

Component	Description	Resource Type
everest-csi-controller	Used to create, delete, snapshot, expand, attach, and detach storage volumes. If the cluster version is 1.19 or later and the add-on version is 1.2.*x*, the pod of the everest-csi-controller component also has an everest-localvolume-manager container by default. This container manages the creation of LVM storage pools and local PVs on the node.	Deployment
everest-csi-driver	Used to mount and unmount PVs and resize file systems. If the add-on version is 1.2.*x* and the region where the cluster is located supports node-attacher, the pod of the everest-csi-driver component also contains an everest-node-attacher container. This container is responsible for distributed EVS attaching. This configuration item is available in some regions.	DaemonSet

16.4 CCE Node Problem Detector

Introduction

CCE node problem detector (NPD) is an add-on that monitors abnormal events of cluster nodes and connects to a third-party monitoring platform. It is a daemon running on each node. It collects node issues from different daemons and reports them to the API server. The NPD add-on can run as a DaemonSet or a daemon.

For more information, see **node-problem-detector**.

Constraints

- When using this add-on, do not format or partition node disks.
- Each NPD process occupies 30 m CPU and 100 MB memory.
- If the NPD version is 1.18.45 or later, the EulerOS version of the host machine must be 2.5 or later.

Permissions

To monitor kernel logs, the NPD add-on needs to read the host **/dev/kmsg**. Therefore, the privileged mode must be enabled. For details, see **privileged**.

In addition, CCE mitigates risks according to the least privilege principle. Only the following privileges are available for NPD running:

- cap_dac_read_search: permission to access **/run/log/journal**.
- cap_sys_admin: permission to access **/dev/kmsg**.

Installing the Add-on

Step 1 Log in to the CCE console and click the cluster name to access the cluster console. Choose **Add-ons** in the navigation pane, locate **CCE Node Problem Detector** on the right, and click **Install**.

Step 2 On the **Install Add-on** page, configure the specifications.

Table 16-14 NPD configuration

Parameter	Description
Add-on Specifications	The specifications can be **Custom**.
Pods	If you select **Custom**, you can adjust the number of pods as required.
Containers	If you select **Custom**, you can adjust the container specifications as required.

Step 3 Configure the add-on parameters.

Only v1.16.0 and later versions support the configurations.

Table 16-15 NPD parameters

Parameter	Description
common.image.pullPolicy	An image pulling policy. The default value is **IfNotPresent**.
feature_gates	A feature gate
npc.maxTaintedNode	The maximum number of nodes that NPC can add taints to when a single fault occurs on multiple nodes for minimizing impact. The value can be in int or percentage format.
npc.nodeAffinity	Node affinity of the controller

Step 4 Configure scheduling policies for the add-on.

NOTE

- Scheduling policies do not take effect on add-on instances of the DaemonSet type.
- When configuring multi-AZ deployment or node affinity, ensure that there are nodes meeting the scheduling policy and that resources are sufficient in the cluster. Otherwise, the add-on cannot run.

Table 16-16 Configurations for add-on scheduling

Parameter	Description
Multi AZ	• **Preferred**: Deployment pods of the add-on will be preferentially scheduled to nodes in different AZs. If all the nodes in the cluster are deployed in the same AZ, the pods will be scheduled to that AZ. • **Equivalent mode**: Deployment pods of the add-on are evenly scheduled to the nodes in the cluster in each AZ. If a new AZ is added, you are advised to increase add-on pods for cross-AZ HA deployment. With the Equivalent multi-AZ deployment, the difference between the number of add-on pods in different AZs will be less than or equal to 1. If resources in one of the AZs are insufficient, pods cannot be scheduled to that AZ. • **Required**: Deployment pods of the add-on will be forcibly scheduled to nodes in different AZs. If there are fewer AZs than pods, the extra pods will fail to run.
Node Affinity	• **Not configured**: Node affinity is disabled for the add-on. • **Node Affinity**: Specify the nodes where the add-on is deployed. If you do not specify the nodes, the add-on will be randomly scheduled based on the default cluster scheduling policy. • **Specified Node Pool Scheduling**: Specify the node pool where the add-on is deployed. If you do not specify the node pool, the add-on will be randomly scheduled based on the default cluster scheduling policy. • **Custom Policies**: Enter the labels of the nodes where the add-on is to be deployed for more flexible scheduling policies. If you do not specify node labels, the add-on will be randomly scheduled based on the default cluster scheduling policy. If multiple custom affinity policies are configured, ensure that there are nodes that meet all the affinity policies in the cluster. Otherwise, the add-on cannot run.
Toleration	Using both taints and tolerations allows (not forcibly) the add-on Deployment to be scheduled to a node with the matching taints, and controls the Deployment eviction policies after the node where the Deployment is located is tainted. The add-on adds the default tolerance policy for the **node.kubernetes.io/not-ready** and **node.kubernetes.io/unreachable** taints, respectively. The tolerance time window is 60s. For details, see **Taints and Tolerations**.

Step 5 Click **Install**.

----End

Components

Table 16-17 Add-on components

Component	Description	Resource Type
node-problem-controller	Isolate faults basically based on fault detection results.	Deployment
node-problem-detector	Detect node faults.	DaemonSet

NPD Check Items

NOTE

Check items are supported only in 1.16.0 and later versions.

Check items cover events and statuses.

- Event-related

  For event-related check items, when a problem occurs, NPD reports an event to the API server. The event type can be **Normal** (normal event) or **Warning** (abnormal event).

  Table 16-18 Event-related check items

Check Item	Function	Description
OOMKilling	Listen to the kernel logs and check whether OOM events occur and are reported. Typical scenario: When the memory usage of a process in a container exceeds the limit, OOM is triggered and the process is terminated.	Warning event Listening object: **/dev/kmsg** Matching rule: "Killed process \\d+ (.+) total-vm:\\d+kB, anon-rss:\\d+kB, file-rss:\\d+kB.*"
TaskHung	Listen to the kernel logs and check whether taskHung events occur and are reported. Typical scenario: Disk I/O suspension causes process suspension.	Warning event Listening object: **/dev/kmsg** Matching rule: "task \ \S+:\\w+ blocked for more than \\w+ seconds\\."

Check Item	Function	Description
Readonly Filesystem	Check whether the **Remount root filesystem read-only** error occurs in the system kernel by listening to the kernel logs. Typical scenario: A user detaches a data disk from a node by mistake on the ECS, and applications continuously write data to the mount point of the data disk. As a result, an I/O error occurs in the kernel and the disk is remounted as a read-only disk. **NOTE** If the rootfs of node pods is of the device mapper type, an error will occur in the thin pool if a data disk is detached. This will affect NPD and NPD will not be able to detect node faults.	Warning event Listening object: **/dev/kmsg** Matching rule: **Remounting filesystem read-only**

- Status-related

  For status-related check items, when a problem occurs, NPD reports an event to the API server and changes the node status synchronously. This function can be used together with **Node-problem-controller fault isolation** to isolate nodes.

  If the check period is not specified in the following check items, the default period is 30 seconds.

  Table 16-19 Checking system components

Check Item	Function	Description
Container network component error CNIProblem	Check the status of the CNI components (container network components).	None
Container runtime component error CRIProblem	Check the status of Docker and containerd of the CRI components (container runtime components).	Check object: Docker or containerd

Check Item	Function	Description
Frequent restarts of Kubelet FrequentKubeletRestart	Periodically backtrack system logs to check whether the key component Kubelet restarts frequently.	• Default threshold: 10 restarts within 10 minutes If Kubelet restarts for 10 times within 10 minutes, it indicates that the system restarts frequently and a fault alarm is generated. • Listening object: logs in the **/run/log/journal** directory
Frequent restarts of Docker FrequentDockerRestart	Periodically backtrack system logs to check whether the container runtime Docker restarts frequently.	
Frequent restarts of containerd FrequentContainerdRestart	Periodically backtrack system logs to check whether the container runtime containerd restarts frequently.	
kubelet error KubeletProblem	Check the status of the key component Kubelet.	None
kube-proxy error KubeProxyProblem	Check the status of the key component kube-proxy.	None

Table 16-20 Checking system metrics

Check Item	Function	Description
Conntrack table full ConntrackFullProblem	Check whether the conntrack table is full.	• Default threshold: 90% • Usage: **nf_conntrack_count** • Maximum value: **nf_conntrack_max**
Insufficient disk resources DiskProblem	Check the usage of the system disk and CCE data disks (including the CRI logical disk and kubelet logical disk) on the node.	• Default threshold: 90% • Source: `df -h` Currently, additional data disks are not supported.
Insufficient file handles FDProblem	Check if the FD file handles are used up.	• Default threshold: 90% • Usage: the first value in **/proc/sys/fs/file-nr** • Maximum value: the third value in **/proc/sys/fs/file-nr**

Check Item	Function	Description
Insufficient node memory MemoryProblem	Check whether memory is used up.	• Default threshold: 80% • Usage: **MemTotal-MemAvailable** in **/proc/meminfo** • Maximum value: **MemTotal** in **/proc/meminfo**
Insufficient process resources PIDProblem	Check whether PID process resources are exhausted.	• Default threshold: 90% • Usage: **nr_threads in /proc/loadavg** • Maximum value: smaller value between **/proc/sys/kernel/pid_max** and **/proc/sys/kernel/threads-max**.

Table 16-21 Checking the storage

Check Item	Function	Description
Disk read-only DiskReadonly	Periodically perform write tests on the system disk and CCE data disks (including the CRI logical disk and Kubelet logical disk) of the node to check the availability of key disks.	Detection paths: • /mnt/paas/kubernetes/kubelet/ • /var/lib/docker/ • /var/lib/containerd/ • /var/paas/sys/log/cceaddon-npd/ The temporary file **npd-disk-write-ping** is generated in the detection path. Currently, additional data disks are not supported.

Check Item	Function	Description
emptyDir storage pool error EmptyDirVolumeGroupStatusError	Check whether the ephemeral volume group on the node is normal. Impact: Pods that depend on the storage pool cannot write data to the temporary volume. The temporary volume is remounted as a read-only file system by the kernel due to an I/O error. Typical scenario: When creating a node, a user configures two data disks as a temporary volume storage pool. Some data disks are deleted by mistake. As a result, the storage pool becomes abnormal.	• Detection period: 30s • Source: `vgs -o vg_name, vg_attr` • Principle: Check whether the VG (storage pool) is in the P state. If yes, some PVs (data disks) are lost. • Joint scheduling: The scheduler can automatically identify a PV storage pool error and prevent pods that depend on the storage pool from being scheduled to the node. • Exceptional scenario: The NPD add-on cannot detect the loss of all PVs (data disks), resulting in the loss of VGs (storage pools). In this case, kubelet automatically isolates the node, detects the loss of VGs (storage pools), and updates the corresponding resources in **nodestatus.allocatable** to **0**. This prevents pods that depend on the storage pool from being scheduled to the node. The damage of a single PV cannot be detected by this check item, but by the ReadonlyFilesystem check item.
PV storage pool error LocalPvVolumeGroupStatusError	Check the PV group on the node. Impact: Pods that depend on the storage pool cannot write data to the persistent volume. The persistent volume is remounted as a read-only file system by the kernel due to an I/O error. Typical scenario: When creating a node, a user configures two data disks as a persistent volume storage pool. Some data disks are deleted by mistake.	

Check Item	Function	Description
Mount point error MountPointProblem	Check the mount point on the node. Exceptional definition: You cannot access the mount point by running the **cd** command. Typical scenario: Network File System (NFS), for example, obsfs and s3fs is mounted to a node. When the connection is abnormal due to network or peer NFS server exceptions, all processes that access the mount point are suspended. For example, during a cluster upgrade, a kubelet is restarted, and all mount points are scanned. If the abnormal mount point is detected, the upgrade fails.	Alternatively, you can run the following command: `for dir in `df -h | grep -v "Mounted on" | awk "{print \\ $NF}"`;do cd $dir; done && echo "ok"`
Suspended disk I/O DiskHung	Check whether I/O suspension occurs on all disks on the node, that is, whether I/O read and write operations are not responded. Definition of I/O suspension: The system does not respond to disk I/O requests, and some processes are in the D state. Typical scenario: Disks cannot respond due to abnormal OS hard disk drivers or severe faults on the underlying network.	• Check object: all data disks • Source: /proc/diskstat Alternatively, you can run the following command: `iostat -xmt 1` • Threshold: – Average usage: ioutil >= 0.99 – Average I/O queue length: avgqu-sz >= 1 – Average I/O transfer volume: iops (w/s) + ioth (wMB/s) <= 1 **NOTE** In some OSs, no data changes during I/O. In this case, calculate the CPU I/O time usage. The value of iowait should be greater than 0.8.

Check Item	Function	Description
Slow disk I/O DiskSlow	Check whether all disks on the node have slow I/Os, that is, whether I/Os respond slowly. Typical scenario: EVS disks have slow I/Os due to network fluctuation.	• Check object: all data disks • Source: /proc/diskstat Alternatively, you can run the following command: `iostat -xmt 1` • Default threshold: Average I/O latency: await >= 5000 ms **NOTE** If I/O requests are not responded and the **await** data is not updated, this check item is invalid.

Table 16-22 Other check items

Check Item	Function	Description
Abnormal NTP NTPProblem	Check whether the node clock synchronization service ntpd or chronyd is running properly and whether a system time drift is caused.	Default clock offset threshold: 8000 ms
Process D error ProcessD	Check whether there is a process D on the node.	Default threshold: 10 abnormal processes detected for three consecutive times Source: • /proc/{PID}/stat • Alternately, you can run the **ps aux** command. Exceptional scenario: The ProcessD check item ignores the resident D processes (heartbeat and update) on which the SDI driver on the BMS node depends.
Process Z error ProcessZ	Check whether the node has processes in Z state.	

Check Item	Function	Description
ResolvConf error ResolvConfFileProblem	Check whether the ResolvConf file is lost. Check whether the ResolvConf file is normal. Exceptional definition: No upstream domain name resolution server (nameserver) is included.	Object: **/etc/resolv.conf**
Existing scheduled event ScheduledEvent	Check whether scheduled live migration events exist on the node. A live migration plan event is usually triggered by a hardware fault and is an automatic fault rectification method at the IaaS layer. Typical scenario: The host is faulty. For example, the fan is damaged or the disk has bad sectors. As a result, live migration is triggered for VMs.	Source: • http://169.254.169.254/meta-data/latest/events/scheduled This check item is an Alpha feature and is disabled by default.

The kubelet component has the following default check items, which have bugs or defects. You can fix them by upgrading the cluster or using NPD.

Table 16-23 Default kubelet check items

Check Item	Function	Description
Insufficient PID resources PIDPressure	Check whether PIDs are sufficient.	• Interval: 10 seconds • Threshold: 90% • Defect: In community version 1.23.1 and earlier versions, this check item becomes invalid when over 65535 PIDs are used. For details, see **issue 107107**. In community version 1.24 and earlier versions, thread-max is not considered in this check item.

Check Item	Function	Description
Insufficient memory MemoryPressure	Check whether the allocable memory for the containers is sufficient.	• Interval: 10 seconds • Threshold: max. 100 MiB • Allocable = Total memory of a node – Reserved memory of a node • Defect: This check item checks only the memory consumed by containers, and does not consider that consumed by other elements on the node.
Insufficient disk resources DiskPressure	Check the disk usage and inodes usage of the kubelet and Docker disks.	• Interval: 10 seconds • Threshold: 90%

Node-problem-controller Fault Isolation

NOTE

Fault isolation is supported only by add-ons of 1.16.0 and later versions.

By default, if multiple nodes become faulty, NPC adds taints to up to 10% of the nodes. You can set **npc.maxTaintedNode** to increase the threshold.

The open source NPD plugin provides fault detection but not fault isolation. CCE enhances the node-problem-controller (NPC) based on the open source NPD. This component is implemented based on the Kubernetes **node controller**. For faults reported by NPD, NPC automatically adds taints to nodes for node fault isolation.

Table 16-24 Parameters

Parameter	Description	Default
npc.enable	Whether to enable NPC This parameter is not supported in 1.18.0 or later versions.	true

Parameter	Description	Default
npc.maxTaintedNode	The maximum number of nodes that NPC can add taints to when a single fault occurs on multiple nodes for minimizing impact. The value can be in int or percentage format.	10% Value range: • The value is in int format and ranges from 1 to infinity. • The value ranges from 1% to 100%, in percentage. The minimum value of this parameter multiplied by the number of cluster nodes is 1.
npc.nodeAffinity	Node affinity of the controller	N/A

16.5 Kubernetes Dashboard

Introduction

Kubernetes Dashboard is a general purpose, web-based UI for Kubernetes clusters. It allows users to manage applications running in the cluster and troubleshoot them, as well as manage the cluster itself, by running commands.

With Kubernetes Dashboard, you can:

- Deploy containerized applications to a Kubernetes cluster.
- Diagnose containerized application problems.
- Manage cluster resources.
- View applications running in a cluster.
- Create and modify Kubernetes resources (such as Deployments, jobs, and DaemonSets).
- Check errors that occur in a cluster.

For example, you can scale a Deployment, perform a rolling update, restart a pod, or deploy a new application.

Open source community: **https://github.com/kubernetes/dashboard**

Installing the Add-on

Step 1 Log in to the CCE console and click the cluster name to access the cluster console. Choose **Add-ons** in the navigation pane, locate **Kubernetes Dashboard** on the right, and click **Install**.

Step 2 In the **Parameters** area, configure the following parameters:

- **Certificate Configuration**: Configure a certificate for the dashboard.
  - Using a custom certification

- **Certificate File**: Click to view the example certificate file.
- **Private Key**: Click to view the example private key.

– Using a default certificate

NOTICE

The default certificate generated by the dashboard is invalid, which affects the normal access to the dashboard through a browser. You are advised to manually upload a valid certificate so that the browser can verify your access and secure your connection.

Step 3 Click **Install**.

----End

Accessing the dashboard Add-on

Step 1 Log in to the CCE console and click the cluster name to access the cluster console. Choose **Add-ons** in the navigation pane. On the page displayed, verify that the dashboard add-on is in the **Running** state and click **Access**.

Step 2 Copy the token in the dialog box displayed.

Step 3 On the dashboard login page, select **Token**, paste the copied token, and click **SIGN IN**.

NOTE

By default, this add-on does not support login using kubeconfig authenticated by certificate. You are advised to use the token mode for login. For details, see **https://github.com/kubernetes/dashboard/issues/2474#issuecomment-348912376**.

----End

Modifying Permissions

After the dashboard is installed, the initial role can only view a majority of resources that are displayed on the dashboard. To apply for the permissions to perform other operations on the dashboard, modify RBAC authorization resources in the background.

Procedure

Modify the **kubernetes-dashboard-minimal** rule in the ClusterRole.

For details about how to use RBAC authorization, visit **https://kubernetes.io/docs/reference/access-authn-authz/rbac/**.

Components

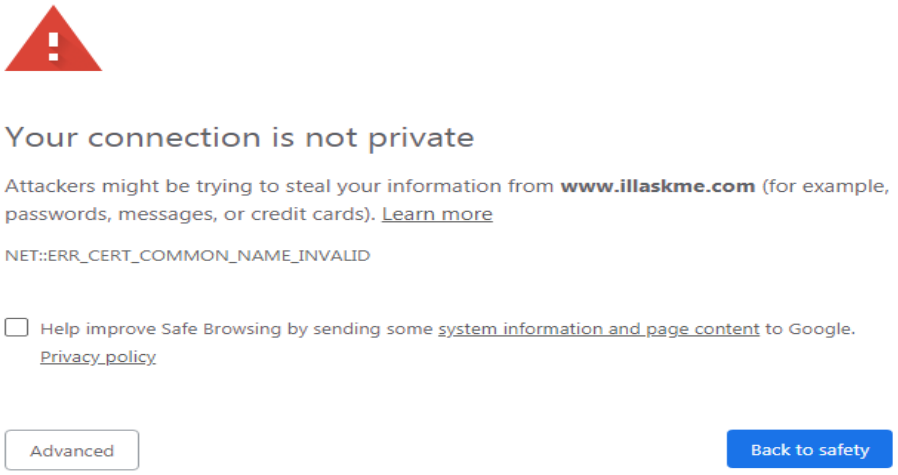
Table 16-25 Add-on components

Component	Description	Resource Type
Dashboard	Visualized monitoring UI	Deployment

Troubleshooting Access Problems

When Google Chrome is used to access the dashboard, the error message "ERR_CERT_INVALID", instead of the login page, is displayed. The possible cause is that the default certificate generated by the dashboard does not pass Google Chrome verification. There are two solutions to this problem:

Figure 16-2 Error message displayed on Google Chrome



- Solution 1: Use the Firefox browser to access the dashboard. In the **Exceptions** area of the **Proxy Settings** page, add the dashboard address to the addresses that will bypass the proxy server. Then, the dashboard login page will be displayed.
- Solution 2: Start Google Chrome with the **--ignore-certificate-errors** flag to ignore the certificate error.

  Windows: Save the dashboard address. Close all active Google Chrome windows. Press the Windows key + R to display the **Run** dialog box. Enter **chrome --ignore-certificate-errors** in the **Run** dialog box to open a new Google Chrome window. In the address bar, enter the dashboard address to open the login page.

16.6 CCE Cluster Autoscaler

Introduction

Autoscaler is an important Kubernetes controller. It supports microservice scaling and is key to serverless design.

When the CPU or memory usage of a microservice is too high, horizontal pod autoscaling is triggered to add pods to reduce the load. These pods can be automatically reduced when the load is low, allowing the microservice to run as efficiently as possible.

CCE simplifies the creation, upgrade, and manual scaling of Kubernetes clusters, in which traffic loads change over time. To balance resource usage and workload performance of nodes, Kubernetes introduces the Autoscaler add-on to automatically adjust the number of nodes a cluster based on the resource usage required for workloads deployed in the cluster. For details, see **Creating a Node Scaling Policy**.

Open source community: **https://github.com/kubernetes/autoscaler**

How the Add-on Works

Autoscaler controls auto scale-out and scale-in.

- **Auto scale-out**

  You can choose either of the following methods:

  - If pods in a cluster cannot be scheduled due to insufficient worker nodes, cluster scaling is triggered to add nodes. The nodes to be added have the same specification as configured for the node pool to which the nodes belong.

    Auto scale-out will be performed when:

    - Node resources are insufficient.
    - No node affinity policy is set in the pod scheduling configuration. If a node has been configured as an affinity node for pods, no node will not be automatically added when pods cannot be scheduled. For details about how to configure the node affinity policy, see **Scheduling Policies (Affinity/Anti-affinity)**.

  - When the cluster meets the node scaling policy, cluster scale-out is also triggered. For details, see **Creating a Node Scaling Policy**.

  NOTE

  The add-on follows the "No Less, No More" policy. For example, if three cores are required for creating a pod and the system supports four-core and eight-core nodes, Autoscaler will preferentially create a four-core node.

- **Auto scale-in**

  When a cluster node is idle for a period of time (10 minutes by default), cluster scale-in is triggered, and the node is automatically deleted. However, a node cannot be deleted from a cluster if the following pods exist:

- Pods that do not meet specific requirements set in Pod Disruption Budgets (**PodDisruptionBudget**)
- Pods that cannot be scheduled to other nodes due to constraints such as affinity and anti-affinity policies
- Pods that have the **cluster-autoscaler.kubernetes.io/safe-to-evict: 'false'** annotation
- Pods (except those created by DaemonSets in the kube-system namespace) that exist in the kube-system namespace on the node
- Pods that are not created by the controller (Deployment/ReplicaSet/job/StatefulSet)

NOTE

When a node meets the scale-in conditions, Autoscaler adds the **DeletionCandidateOfClusterAutoscaler** taint to the node in advance to prevent pods from being scheduled to the node. After the Autoscaler add-on is uninstalled, if the taint still exists on the node, manually delete it.

Constraints

- Ensure that there are sufficient resources for installing the add-on.
- The default node pool does not support auto scaling. For details, see **Description of DefaultPool**.
- When Autoscaler is used, some taints or annotations may affect auto scaling. Therefore, do not use the following taints or annotations in clusters:
  - **ignore-taint.cluster-autoscaler.kubernetes.io**: The taint works on nodes. Kubernetes-native Autoscaler supports protection against abnormal scale outs and periodically evaluates the proportion of available nodes in the cluster. When the proportion of non-ready nodes exceeds 45%, protection will be triggered. In this case, all nodes with the **ignore-taint.cluster-autoscaler.kubernetes.io** taint in the cluster are filtered out from the Autoscaler template and recorded as non-ready nodes, which affects cluster scaling.
  - **cluster-autoscaler.kubernetes.io/enable-ds-eviction**: The annotation works on pods, which determines whether DaemonSet pods can be evicted by Autoscaler. For details, see **Well-Known Labels, Annotations and Taints**.

Installing the Add-on

Step 1 Log in to the CCE console and click the cluster name to access the cluster console. Choose **Add-ons** in the navigation pane, locate **CCE Cluster Autoscaler** on the right, and click **Install**.

Step 2 On the **Install Add-on** page, configure the specifications.

Table 16-26 Specifications configuration

Parameter	Description
Pods	Number of pods for the add-on. High availability is not possible with a single pod. If an error occurs on the node where the add-on instance runs, the add-on will fail.
Containers	Adjust the number of the Autoscaler pods and their CPU and memory quotas based on the cluster scale. For details, see **Table 16-27**.

Table 16-27 Recommended Autoscaler quotas

Nodes	Pods	Requested vCPUs	vCPU Limit	Requested Memory	Memory Limit
50	2	1000m	1000m	1000 MiB	1000 MiB
200	2	4000m	4000m	2000 MiB	2000 MiB
1000	2	8000m	8000m	8000 MiB	8000 MiB
2000	2	8000m	8000m	8000 MiB	8000 MiB

Step 3 Configure the add-on parameters.

Table 16-28 Parameters

Parameter	Description
Total Nodes	Maximum number of nodes that can be managed by the cluster, within which cluster scale-out is performed.
Total CPUs	Maximum sum of CPU cores of all nodes in a cluster, within which cluster scale-out is performed.
Total Memory	Maximum sum of memory of all nodes in a cluster, within which cluster scale-out is performed.

NOTE

When the total number of nodes, CPUs, or memory is counted, unavailable nodes and resources on them in the default node pool are not included.

Step 4 Configure scheduling policies for the add-on.

NOTE

- Scheduling policies do not take effect on add-on instances of the DaemonSet type.
- When configuring multi-AZ deployment or node affinity, ensure that there are nodes meeting the scheduling policy and that resources are sufficient in the cluster. Otherwise, the add-on cannot run.

Table 16-29 Configurations for add-on scheduling

Parameter	Description
Multi AZ	• **Preferred**: Deployment pods of the add-on will be preferentially scheduled to nodes in different AZs. If all the nodes in the cluster are deployed in the same AZ, the pods will be scheduled to that AZ. • **Equivalent mode**: Deployment pods of the add-on are evenly scheduled to the nodes in the cluster in each AZ. If a new AZ is added, you are advised to increase add-on pods for cross-AZ HA deployment. With the Equivalent multi-AZ deployment, the difference between the number of add-on pods in different AZs will be less than or equal to 1. If resources in one of the AZs are insufficient, pods cannot be scheduled to that AZ. • **Required**: Deployment pods of the add-on will be forcibly scheduled to nodes in different AZs. If there are fewer AZs than pods, the extra pods will fail to run.
Node Affinity	• **Not configured**: Node affinity is disabled for the add-on. • **Node Affinity**: Specify the nodes where the add-on is deployed. If you do not specify the nodes, the add-on will be randomly scheduled based on the default cluster scheduling policy. • **Specified Node Pool Scheduling**: Specify the node pool where the add-on is deployed. If you do not specify the node pool, the add-on will be randomly scheduled based on the default cluster scheduling policy. • **Custom Policies**: Enter the labels of the nodes where the add-on is to be deployed for more flexible scheduling policies. If you do not specify node labels, the add-on will be randomly scheduled based on the default cluster scheduling policy. If multiple custom affinity policies are configured, ensure that there are nodes that meet all the affinity policies in the cluster. Otherwise, the add-on cannot run.

Parameter	Description
Toleration	Using both taints and tolerations allows (not forcibly) the add-on Deployment to be scheduled to a node with the matching taints, and controls the Deployment eviction policies after the node where the Deployment is located is tainted. The add-on adds the default tolerance policy for the **node.kubernetes.io/not-ready** and **node.kubernetes.io/unreachable** taints, respectively. The tolerance time window is 60s. For details, see **Taints and Tolerations**.

Step 5 After the configuration is complete, click **Install**.

----End

Components

Table 16-30 Add-on components

Component	Description	Resource Type
Autoscaler	Auto scaling for Kubernetes clusters	Deployment

Scale-In Cool-Down Period

Scale-in cooling intervals can be configured in the node pool settings and the Autoscaler add-on settings.

Scale-in cooling interval configured in a node pool

This interval indicates the period during which nodes added to the current node pool after a scale-out operation cannot be deleted. This interval takes effect at the node pool level.

Scale-in cooling interval configured in the Autoscaler add-on

The interval after a scale-out indicates the period during which the entire cluster cannot be scaled in after the Autoscaler add-on triggers scale-out (due to the unschedulable pods, metrics, and scaling policies). This interval takes effect at the cluster level.

The interval after a node is deleted indicates the period during which the cluster cannot be scaled in after the Autoscaler add-on triggers scale-in. This interval takes effect at the cluster level.

The interval after a failed scale-in indicates the period during which the cluster cannot be scaled in after the Autoscaler add-on triggers scale-in. This interval takes effect at the cluster level.

16.7 Nginx Ingress Controller

Introduction

Kubernetes uses kube-proxy to expose Services and provide load balancing. The implementation is at the transport layer. When it comes to Internet applications, where a bucket-load of information is generated, forwarding needs to be more fine-grained, precisely and flexibly controlled by policies and load balancers to deliver higher performance.

This is where ingresses enter. Ingresses provide application-layer forwarding functions, such as virtual hosts, load balancing, SSL proxy, and HTTP routing, for Services that can be directly accessed outside a cluster.

Kubernetes has officially released the Nginx-based Ingress controller. CCE Nginx Ingress controller directly uses community templates and images. The Nginx Ingress controller generates Nginx configuration and stores the configuration using ConfigMap. The configuration will be written to Nginx pods through the Kubernetes API. In this way, the Nginx configuration is modified and updated. For details, see **How nginx-ingress Works**.

You can visit the **open source community** for more information.

NOTE

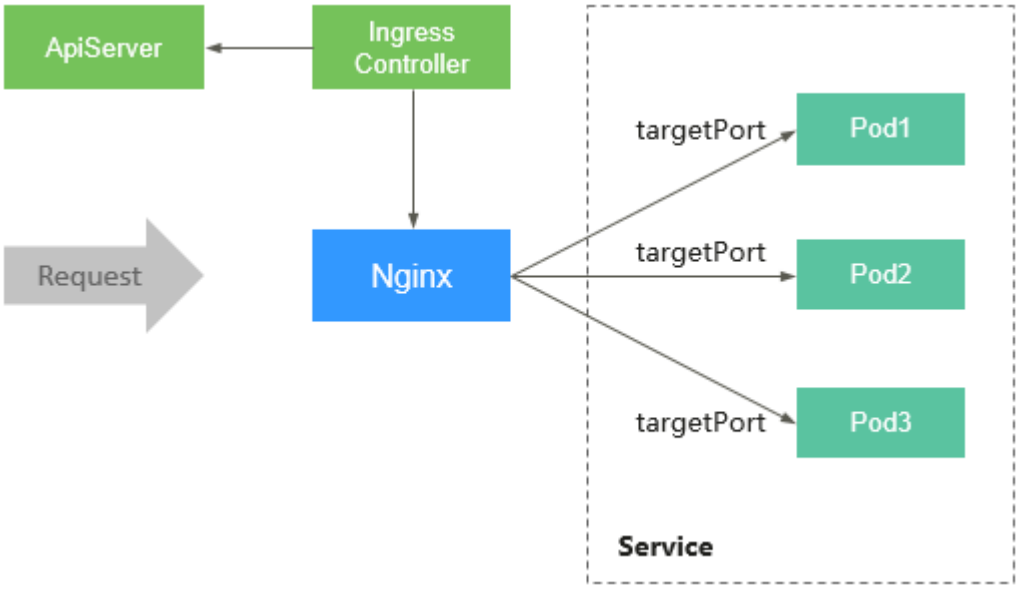
- When installing the NGINX Ingress Controller, you can specify Nginx parameters. These parameters take effect globally and are contained in the **nginx.conf** file. You can search for the parameters in **ConfigMaps**. If the parameters are not included in ConfigMaps, the configurations will not take effect.
- Do not manually modify or delete the load balancer and listener that are automatically created by CCE. Otherwise, the workload will be abnormal. If you have modified or deleted them by mistake, uninstall the nginx-ingress add-on and re-install it.

How nginx-ingress Works

nginx-ingress consists of the ingress object, ingress controller, and Nginx. The ingress controller assembles ingresses into the Nginx configuration file (nginx.conf) and reloads Nginx to make the changed configurations take effect. When it detects that the pod in a Service changes, it dynamically changes the upstream server group configuration of Nginx. In this case, the Nginx process does not need to be reloaded. **Figure 16-3** shows how nginx-ingress works.

- An ingress is a group of access rules that forward requests to specified Services based on domain names or URLs. Ingresses are stored in the object storage service etcd and are added, deleted, modified, and queried through APIs.
- The ingress controller monitors the changes of resource objects such as ingresses, Services, endpoints, secrets (mainly TLS certificates and keys), nodes, and ConfigMaps in real time and automatically performs operations on Nginx.
- Nginx implements load balancing and access control at the application layer.

Figure 16-3 Working principles of nginx-ingress



Constraints

- This add-on can be installed only in clusters of v1.15 or later.
- For clusters earlier than v1.23, **kubernetes.io/ingress.class: "nginx"** must be added to the annotation of the Ingress created through the API.
- Dedicated load balancers must be the network type (TCP/UDP) supporting private networks (with a private IP).
- The node where nginx-ingress-controller is running and the containers running on the node cannot access Nginx Ingress. In this case, perform anti-affinity deployment for the workloads and nginx-ingress-controller. For details, see **Anti-affinity Deployment for Workloads and nginx-ingress-controller**.
- During the nginx-ingress upgrade, 10s is reserved for deleting the nginx-ingress controller at the ELB backend.
- The timeout interval for the graceful exit of nginx-ingress-controller is 300s. If the timeout is more than 300s during the nginx-ingress upgrade, the persistent connection will be disconnected and services will be interrupted for a short period of time.

Prerequisites

Before creating a workload, you must have an available cluster. If no cluster is available, create one according to **Buying a CCE Standard Cluster**.

Installing the Add-on

Step 1 Log in to the CCE console and click the cluster name to access the cluster console. Choose **Add-ons** in the navigation pane, locate **NGINX Ingress Controller** on the right, and click **Install**.

Step 2 On the **Install Add-on** page, configure the specifications.

Table 16-31 nginx-ingress configuration

Parameter	Description
Add-on Specifications	Nginx Ingress can be deployed based on customized resource specifications.
Pods	You can adjust the number of add-on instances as required.
Containers	You can adjust the container specifications of an add-on instance as required.

Step 3 Configure the add-on parameters.

- **Load Balancer**: Select a shared or dedicated load balancer. If no load balancer is available, create one. The load balancer has at least two listeners, and ports 80 and 443 are not occupied by listeners.
- **Admission Check**: Admission control is performed on Ingresses to ensure that the controller can generate valid configurations. Admission verification is performed on the configuration of Nginx Ingresses. If the verification fails, the request will be intercepted. For details about admission verification, see **Access Control**.

  NOTE

  - Admission check slows down the responses to Ingress requests.
  - Only add-ons of version 2.4.1 or later support admission verification.
- **Nginx Parameters**: Configuring the **nginx.conf** file will affect all managed ingresses. You can search for related parameters through **ConfigMaps**. If the parameters you configured are not included in the options listed in the **ConfigMaps**, the parameters will not take effect.

  For example, you can use the **keep-alive-requests** parameter to describe how to set the maximum number of requests for keeping active connections to 100.

  ```
  {
    "keep-alive-requests": "100"
  }
  ```
- **404 Service**: By default, the 404 service provided by the add-on is used. To customize the 404 service, enter the namespace/service name. If the service does not exist, the add-on installation will fail.

Step 4 Configure scheduling policies for the add-on.

NOTE

- Scheduling policies do not take effect on add-on instances of the DaemonSet type.
- When configuring multi-AZ deployment or node affinity, ensure that there are nodes meeting the scheduling policy and that resources are sufficient in the cluster. Otherwise, the add-on cannot run.

Table 16-32 Configurations for add-on scheduling

Parameter	Description
Multi AZ	• **Preferred**: Deployment pods of the add-on will be preferentially scheduled to nodes in different AZs. If all the nodes in the cluster are deployed in the same AZ, the pods will be scheduled to that AZ. • **Equivalent mode**: Deployment pods of the add-on are evenly scheduled to the nodes in the cluster in each AZ. If a new AZ is added, you are advised to increase add-on pods for cross-AZ HA deployment. With the Equivalent multi-AZ deployment, the difference between the number of add-on pods in different AZs will be less than or equal to 1. If resources in one of the AZs are insufficient, pods cannot be scheduled to that AZ. • **Required**: Deployment pods of the add-on will be forcibly scheduled to nodes in different AZs. If there are fewer AZs than pods, the extra pods will fail to run.
Node Affinity	• **Not configured**: Node affinity is disabled for the add-on. • **Node Affinity**: Specify the nodes where the add-on is deployed. If you do not specify the nodes, the add-on will be randomly scheduled based on the default cluster scheduling policy. • **Specified Node Pool Scheduling**: Specify the node pool where the add-on is deployed. If you do not specify the node pool, the add-on will be randomly scheduled based on the default cluster scheduling policy. • **Custom Policies**: Enter the labels of the nodes where the add-on is to be deployed for more flexible scheduling policies. If you do not specify node labels, the add-on will be randomly scheduled based on the default cluster scheduling policy. If multiple custom affinity policies are configured, ensure that there are nodes that meet all the affinity policies in the cluster. Otherwise, the add-on cannot run.
Toleration	Using both taints and tolerations allows (not forcibly) the add-on Deployment to be scheduled to a node with the matching taints, and controls the Deployment eviction policies after the node where the Deployment is located is tainted. The add-on adds the default tolerance policy for the **node.kubernetes.io/not-ready** and **node.kubernetes.io/unreachable** taints, respectively. The tolerance time window is 60s. For details, see **Taints and Tolerations**.

Step 5 Click **Install**.

----End

Components

Table 16-33 Add-on components

Component	Description	Resource Type
cceaddon-nginx-ingress-controller	Nginx Ingress controller, which provides flexible routing and forwarding for clusters	Deployment
cceaddon-nginx-ingress-default-backend	Default backend of Nginx Ingress. The message "default backend - 404" is returned.	Deployment

Anti-affinity Deployment for Workloads and nginx-ingress-controller

The node where nginx-ingress-controller is running and the containers running on the node cannot access Nginx Ingress. To prevent this problem, configure an anti-affinity rule to tell the scheduler not to co-locate the workload and nginx-ingress-controller on the same node.

```
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:aplpine
        imagePullPolicy: IfNotPresent
        name: nginx
      imagePullSecrets:
      - name: default-secret
      affinity:
        podAntiAffinity:
          requiredDuringSchedulingIgnoredDuringExecution:
            - labelSelector:
                matchExpressions:     # Use the labels of nginx-ingress-controller to implement anti-affinity.
                  - key: app
                    operator: In
                    values:
                      - nginx-ingress
```

```
      - key: component
        operator: In
        values:
          - controller
  namespaces:
    - kube-system
  topologyKey: kubernetes.io/hostname
```

16.8 Kubernetes Metrics Server

From version 1.8 onwards, Kubernetes provides resource usage metrics, such as the container CPU and memory usage, through the Metrics API. These metrics can be directly accessed by users (for example, by using the **kubectl top** command) or used by controllers (for example, Horizontal Pod Autoscaler) in a cluster for decision-making. The specific component is metrics-server, which is used to substitute for heapster for providing the similar functions. heapster has been gradually abandoned since v1.11.

metrics-server is an aggregator for monitoring data of core cluster resources. You can quickly install this add-on on the CCE console.

After installing this add-on, you can create HPA policies. For details, see **HPA Policies**.

The official community project and documentation are available at **https://github.com/kubernetes-sigs/metrics-server**.

Installing the Add-on

Step 1 Log in to the CCE console and click the cluster name to access the cluster console. Choose **Add-ons** in the navigation pane, locate **Kubernetes Metrics Server** on the right, and click **Install**.

Step 2 On the **Install Add-on** page, configure the specifications.

Table 16-34 metrics-server configuration

Parameter	Description
Add-on Specifications	Select **Single**, **Custom**, or **HA** for **Add-on Specifications**.
Pods	Number of pods that will be created to match the selected add-on specifications. If you select **Custom**, you can adjust the number of pods as required.
Containers	CPU and memory quotas of the container allowed for the selected add-on specifications. If you select **Custom**, you can adjust the container specifications as required.

Step 3 Configure scheduling policies for the add-on.

NOTE

- Scheduling policies do not take effect on add-on instances of the DaemonSet type.
- When configuring multi-AZ deployment or node affinity, ensure that there are nodes meeting the scheduling policy and that resources are sufficient in the cluster. Otherwise, the add-on cannot run.

Table 16-35 Configurations for add-on scheduling

Parameter	Description
Multi AZ	• **Preferred**: Deployment pods of the add-on will be preferentially scheduled to nodes in different AZs. If all the nodes in the cluster are deployed in the same AZ, the pods will be scheduled to that AZ. • **Equivalent mode**: Deployment pods of the add-on are evenly scheduled to the nodes in the cluster in each AZ. If a new AZ is added, you are advised to increase add-on pods for cross-AZ HA deployment. With the Equivalent multi-AZ deployment, the difference between the number of add-on pods in different AZs will be less than or equal to 1. If resources in one of the AZs are insufficient, pods cannot be scheduled to that AZ. • **Required**: Deployment pods of the add-on will be forcibly scheduled to nodes in different AZs. If there are fewer AZs than pods, the extra pods will fail to run.
Node Affinity	• **Not configured**: Node affinity is disabled for the add-on. • **Node Affinity**: Specify the nodes where the add-on is deployed. If you do not specify the nodes, the add-on will be randomly scheduled based on the default cluster scheduling policy. • **Specified Node Pool Scheduling**: Specify the node pool where the add-on is deployed. If you do not specify the node pool, the add-on will be randomly scheduled based on the default cluster scheduling policy. • **Custom Policies**: Enter the labels of the nodes where the add-on is to be deployed for more flexible scheduling policies. If you do not specify node labels, the add-on will be randomly scheduled based on the default cluster scheduling policy. If multiple custom affinity policies are configured, ensure that there are nodes that meet all the affinity policies in the cluster. Otherwise, the add-on cannot run.

Parameter	Description
Toleration	Using both taints and tolerations allows (not forcibly) the add-on Deployment to be scheduled to a node with the matching taints, and controls the Deployment eviction policies after the node where the Deployment is located is tainted. The add-on adds the default tolerance policy for the **node.kubernetes.io/not-ready** and **node.kubernetes.io/unreachable** taints, respectively. The tolerance time window is 60s. For details, see **Taints and Tolerations**.

Step 4 Click **Install**.

----End

Components

Table 16-36 Add-on components

Component	Description	Resource Type
metrics-server	Aggregator for the monitored data of cluster core resources, which is used to collect and aggregate resource usage metrics obtained through the Metrics API in the cluster	Deployment

16.9 CCE Advanced HPA

cce-hpa-controller is a CCE-developed add-on, which can be used to flexibly scale in or out Deployments based on metrics such as CPU usage and memory usage.

After installing this add-on, you can create CustomedHPA policies. For details, see **CustomedHPA Policies**.

Main Functions

- Scaling can be performed based on the percentage of the current number of pods.
- The minimum scaling step can be set.
- Different scaling operations can be performed based on the actual metric values.

Constraints

- This add-on can be installed only in clusters of v1.15 or later.

- If the version is earlier than 1.2.11, the **Prometheus** add-on must be installed. If the version is 1.2.11 or later, the add-ons that can provide metrics API must be installed. Select one of the following add-ons based on your cluster version and requirements.
  - **Kubernetes Metrics Server**: provides basic resource usage metrics, such as container CPU and memory usage. It is supported by all cluster versions.
  - **Cloud Native Cluster Monitoring**: available only in clusters of v1.17 or later.
    - Auto scaling based on basic resource metrics: Prometheus needs to be registered as a metrics API. For details, see **Providing Resource Metrics Through the Metrics API**.
    - Auto scaling based on custom metrics: Custom metrics need to be aggregated to the Kubernetes API server. For details, see **Creating an HPA Policy Using Custom Metrics**.
  - **Prometheus** : Prometheus needs to be registered as a metrics API. For details, see **Providing Resource Metrics Through the Metrics API**. This add-on supports only clusters of v1.21 or earlier.

Installing the Add-on

Step 1 Log in to the CCE console and click the cluster name to access the cluster console. Click **Add-ons** in the navigation pane, locate **CCE Advanced HPA** on the right, and click **Install**.

Step 2 On the **Install Add-on** page, configure the specifications.

Table 16-37 cce-hpa-controller configuration

Parameter	Description
Add-on Specifications	Select **Single** or **Custom** for **Add-on Specifications**. **NOTE** Single-instance add-ons are used only for service verification. In commercial deployments, select **Custom** based on the cluster specifications. The specifications of cce-hpa-controller are decided by the total number of containers in the cluster and the number of scaling policies. You are advised to configure 500m CPU and 1,000 MiB memory for every 5,000 containers, and 100m CPU and 500 MiB memory for every 1,000 scaling policies.
Pods	Number of pods that will be created to match the selected add-on specifications. If you select **Custom**, you can adjust the number of pods as required.
Containers	CPU and memory quotas of the container allowed for the selected add-on specifications. If you select **Custom**, you can adjust the container specifications as required.

Step 3 Select **Single** or **Custom** for **Add-on Specifications**.

- **Pods**: Set the number of pods based on service requirements.
- **Containers**: Set a proper container quota based on service requirements.

Step 4 Configure scheduling policies for the add-on.

NOTE

- Scheduling policies do not take effect on add-on instances of the DaemonSet type.
- When configuring multi-AZ deployment or node affinity, ensure that there are nodes meeting the scheduling policy and that resources are sufficient in the cluster. Otherwise, the add-on cannot run.

Table 16-38 Configurations for add-on scheduling

Parameter	Description
Multi AZ	• **Preferred**: Deployment pods of the add-on will be preferentially scheduled to nodes in different AZs. If all the nodes in the cluster are deployed in the same AZ, the pods will be scheduled to that AZ. • **Equivalent mode**: Deployment pods of the add-on are evenly scheduled to the nodes in the cluster in each AZ. If a new AZ is added, you are advised to increase add-on pods for cross-AZ HA deployment. With the Equivalent multi-AZ deployment, the difference between the number of add-on pods in different AZs will be less than or equal to 1. If resources in one of the AZs are insufficient, pods cannot be scheduled to that AZ. • **Required**: Deployment pods of the add-on will be forcibly scheduled to nodes in different AZs. If there are fewer AZs than pods, the extra pods will fail to run.
Node Affinity	• **Not configured**: Node affinity is disabled for the add-on. • **Node Affinity**: Specify the nodes where the add-on is deployed. If you do not specify the nodes, the add-on will be randomly scheduled based on the default cluster scheduling policy. • **Specified Node Pool Scheduling**: Specify the node pool where the add-on is deployed. If you do not specify the node pool, the add-on will be randomly scheduled based on the default cluster scheduling policy. • **Custom Policies**: Enter the labels of the nodes where the add-on is to be deployed for more flexible scheduling policies. If you do not specify node labels, the add-on will be randomly scheduled based on the default cluster scheduling policy. If multiple custom affinity policies are configured, ensure that there are nodes that meet all the affinity policies in the cluster. Otherwise, the add-on cannot run.

Parameter	Description
Toleration	Using both taints and tolerations allows (not forcibly) the add-on Deployment to be scheduled to a node with the matching taints, and controls the Deployment eviction policies after the node where the Deployment is located is tainted. The add-on adds the default tolerance policy for the **node.kubernetes.io/not-ready** and **node.kubernetes.io/unreachable** taints, respectively. The tolerance time window is 60s. For details, see **Taints and Tolerations**.

Step 5 Click **Install**.

----End

Components

Table 16-39 Add-on components

Component	Description	Resource Type
customedhpa-controller	CCE auto scaling component, which scales in or out Deployments based on metrics such as CPU usage and memory usage	Deployment

16.10 CCE AI Suite (NVIDIA GPU)

Introduction

NVIDIA GPU is a device management add-on that supports GPUs in containers. To use GPU nodes in a cluster, this add-on must be installed.

Constraints

- The driver to be downloaded must be a **.run** file.
- Only NVIDIA Tesla drivers are supported, not GRID drivers.
- When installing or reinstalling the add-on, ensure that the driver download address is correct and accessible. CCE does not verify the address validity.
- The gpu-beta add-on only enables you to download the driver and execute the installation script. The add-on status only indicates that how the add-on is running, not whether the driver is successfully installed.
- CCE does not guarantee the compatibility between the GPU driver version and the CDUA library version of your application. You need to check the compatibility by yourself.

- If a custom OS image has had a a GPU driver installed, CCE cannot ensure that the GPU driver is compatible with other GPU components such as the monitoring components used in CCE.

Installing the Add-on

Step 1 Log in to the CCE console and click the cluster name to access the cluster console. Choose **Add-ons** in the navigation pane, locate **CCE AI Suite (NVIDIA GPU)** on the right, and click **Install**.

Step 2 Configure the add-on parameters.

- **NVIDIA Driver**: Enter the link for downloading the NVIDIA driver. All GPU nodes in the cluster will use this driver.

  NOTICE

  - If the download link is a public network address, for example, **https://us.download.nvidia.com/tesla/470.103.01/NVIDIA-Linux-x86_64-470.103.01.run**, bind an EIP to each GPU node. For details about how to obtain the driver link, see **Obtaining the Driver Link from Public Network**.
  - If the download link is an OBS URL, you do not need to bind an EIP to GPU nodes. For details about how to obtain the driver link, see **Obtaining the Driver Link from OBS**.
  - Ensure that the NVIDIA driver version matches the GPU node.
  - After the driver version is changed, restart the node for the change to take effect.

- **Driver Selection**: If you do not want all GPU nodes in a cluster to use the same driver, CCE allows you to install a different GPU driver for each node pool.

  NOTE

  - The add-on installs the driver with the version specified by the node pool. The driver takes effect only for new pool nodes.
  - After the driver version is updated, it takes effect on the nodes newly added to the node pool. Existing nodes must restart to apply the changes.

Step 3 Click **Install**.

NOTE

If the add-on is uninstalled, GPU pods newly scheduled to the nodes cannot run properly, but GPU pods already running on the nodes will not be affected.

----End

Verifying the Add-on

After the add-on is installed, run the **nvidia-smi** command on the GPU node and the container that schedules GPU resources to verify the availability of the GPU device and driver.

- GPU node:
  ```
  # If the add-on version is earlier than 2.0.0, run the following command:
  cd /opt/cloud/cce/nvidia/bin && ./nvidia-smi

  # If the add-on version is 2.0.0 or later and the driver installation path is changed, run the following command:
  cd /usr/local/nvidia/bin && ./nvidia-smi
  ```
- Container:
  ```
  cd /usr/local/nvidia/bin && ./nvidia-smi
  ```

If GPU information is returned, the device is available and the add-on has been installed.

```
+-----------------------------------------------------------------------------+
| NVIDIA-SMI 440.118.02   Driver Version: 440.118.02   CUDA Version: 10.2     |
|-------------------------------+----------------------+----------------------+
| GPU  Name        Persistence-M| Bus-Id        Disp.A | Volatile Uncorr. ECC |
| Fan  Temp  Perf  Pwr:Usage/Cap|         Memory-Usage | GPU-Util  Compute M. |
|===============================+======================+======================|
|   0  Tesla V100-SXM2...  Off  | 00000000:21:01.0 Off |                    0 |
| N/A   31C    P0    23W / 300W |      0MiB / 16160MiB |      0%      Default |
+-------------------------------+----------------------+----------------------+

+-----------------------------------------------------------------------------+
| Processes:                                                       GPU Memory |
|  GPU       PID   Type   Process name                             Usage      |
|=============================================================================|
|  No running processes found                                                 |
+-----------------------------------------------------------------------------+
```

Obtaining the Driver Link from Public Network

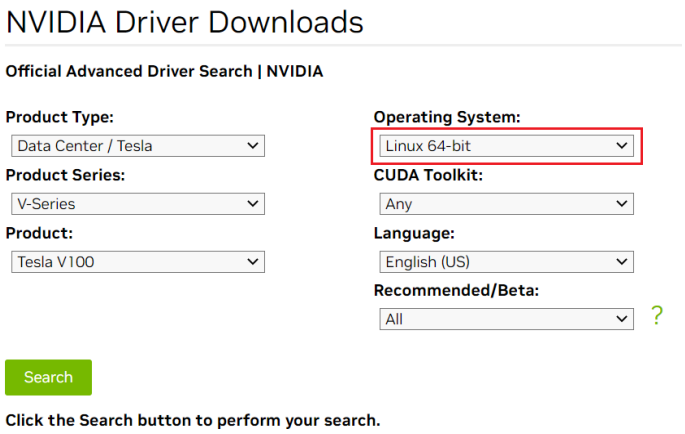
Step 1 Log in to the CCE console.

Step 2 Click **Create Node** and select the GPU node to be created in the **Specifications** area. The GPU card model of the node is displayed in the lower part of the page.

Step 3 Visit *https://www.nvidia.com/Download/Find.aspx?lang=en*.

Step 4 Select the driver information on the **NVIDIA Driver Downloads** page, as shown in Figure 16-4. **Operating System** must be **Linux 64-bit**.

Figure 16-4 Setting parameters



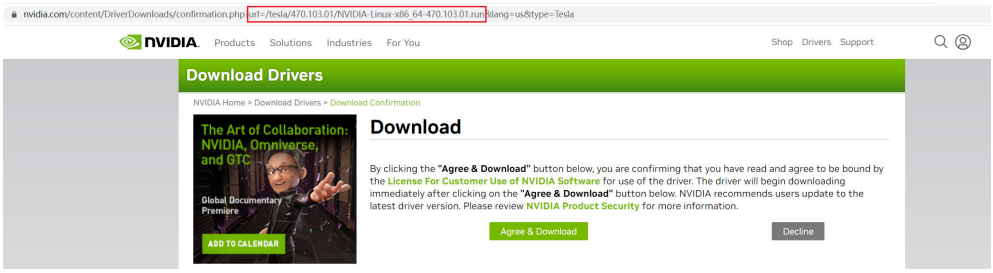
Step 5 After confirming the driver information, click **SEARCH**. A page is displayed, showing the driver information, as shown in Figure 16-5. Click **DOWNLOAD**.

Figure 16-5 Driver information

Step 6 Obtain the driver link in either of the following ways:

- Method 1: As shown in **Figure 16-6**, find *url=/tesla/470.103.01/NVIDIA-Linux-x86_64-470.103.01.run* in the browser address box. Then, supplement it to obtain the driver link **https://us.download.nvidia.com/tesla/470.103.01/NVIDIA-Linux-x86_64-470.103.01.run**. By using this method, you must bind an EIP to each GPU node.
- Method 2: As shown in **Figure 16-6**, click **AGREE & DOWNLOAD** to download the driver. Then, upload the driver to OBS and record the OBS URL. By using this method, you do not need to bind an EIP to GPU nodes.

Figure 16-6 Obtaining the link



----End

Obtaining the Driver Link from OBS

Step 1 Upload the driver to OBS and set the driver file to public read.

NOTE

When the node is restarted, the driver will be downloaded and installed again. Ensure that the OBS bucket link of the driver is valid.

Step 2 In the bucket list, click a bucket name, and then the **Overview** page of the bucket is displayed.

Step 3 In the navigation pane, choose **Objects**.

Step 4 Select the name of the target object and copy the driver link on the object details page.

----End

Components

Table 16-40 Add-on components

Component	Description	Resource Type
nvidia-driver-installer	Used for installing an NVIDIA driver on GPU nodes.	DaemonSet

16.11 CCE AI Suite (Ascend NPU)

Introduction

Ascend NPU is a device management add-on that supports Huawei NPUs in containers.

After this add-on is installed, you can create Ascend-accelerated nodes to quickly and efficiently process inference and image recognition.

Constraints

- To use Ascend-accelerated nodes in a cluster, the Ascend NPU add-on must be installed.
- After an AI-accelerated node is migrated, the node will be reset. Manually reinstall the NPU driver.

Installing the Add-on

Step 1 Log in to the CCE console and click the cluster name to access the cluster console. Choose **Add-ons** in the navigation pane, locate **CCE AI Suite (Ascend NPU)** on the right, and click **Install**.

Step 2 Set NPU parameters. The add-on uses the following parameters by default. The default NPU settings provided by the add-on can satisfy most scenarios and require no changes.

```
{
    "check_frequency_failed_threshold": 100,
    "check_frequency_fall_times": 3,
    "check_frequency_gate": false,
    "check_frequency_recover_threshold": 100,
    "check_frequency_rise_times": 2,
    "container_path": "/usr/local/HiAI_unused",
    "host_path": "/usr/local/HiAI_unused"
}
```

Step 3 Click **Install**.

----End

Components

Table 16-41 Add-on components

Component	Description	Resource Type
npu-driver-installer	Used for installing an NPU driver on NPU nodes.	DaemonSet

16.12 Volcano Scheduler

Introduction

Volcano is a batch processing platform based on Kubernetes. It provides a series of features required by machine learning, deep learning, bioinformatics, genomics, and other big data applications, as a powerful supplement to Kubernetes capabilities.

Volcano provides general computing capabilities such as high-performance job scheduling, heterogeneous chip management, and job running management. It accesses the computing frameworks for various industries such as AI, big data, gene, and rendering and schedules up to 1000 pods per second for end users, greatly improving scheduling efficiency and resource utilization.

Volcano provides job scheduling, job management, and queue management for computing applications. Its main features are as follows:

- Diverse computing frameworks, such as TensorFlow, MPI, and Spark, can run on Kubernetes in containers. Common APIs for batch computing jobs through CRD, various plugins, and advanced job lifecycle management are provided.
- Advanced scheduling capabilities are provided for batch computing and high-performance computing scenarios, including group scheduling, preemptive priority scheduling, packing, resource reservation, and task topology.
- Queues can be effectively managed for scheduling jobs. Complex job scheduling capabilities such as queue priority and multi-level queues are supported.

Volcano has been open-sourced in GitHub at **https://github.com/volcano-sh/volcano**.

Install and configure the Volcano add-on in CCE clusters. For details, see **Volcano Scheduling**.

NOTE

When using Volcano as a scheduler, use it to schedule all workloads in the cluster. This prevents resource scheduling conflicts caused by simultaneous working of multiple schedulers.

Installing the Add-on

Step 1 Log in to the CCE console and click the cluster name to access the cluster console. Choose **Add-ons** in the navigation pane, locate **Volcano Scheduler** on the right, and click **Install**.

Step 2 On the **Install Add-on** page, configure the specifications.

Table 16-42 Volcano configuration

Parameter	Description
Add-on Specifications	Select **Standalone**, **Custom**, or **HA** for **Add-on Specifications**.
Pods	Number of pods that will be created to match the selected add-on specifications. If you select **Custom**, you can adjust the number of pods as required.

Parameter	Description
Containers	CPU and memory quotas of the container allowed for the selected add-on specifications. If you select **Custom**, the recommended values for **volcano-controller** and **volcano-scheduler** are as follows: • If the number of nodes is less than 100, retain the default configuration. The requested vCPUs are 500m, and the limit is 2000m. The requested memory is 500 MiB, and the limit is 2000 MiB. • If the number of nodes is greater than 100, increase the requested vCPUs by 500m and the requested memory by 1000 MiB each time 100 nodes (10,000 pods) are added. Increase the vCPU limit by 1500m and the memory limit by 1000 MiB. **NOTE** Recommended formula for calculating the requested value: – Requested vCPUs: Calculate the number of target nodes multiplied by the number of target pods, perform interpolation search based on the number of nodes in the cluster multiplied by the number of target pods in **Table 16-43**, and round up the request value and limit value that are closest to the specifications. For example, for 2000 nodes and 20,000 pods, Number of target nodes x Number of target pods = 40 million, which is close to the specification of 700/70,000 (Number of cluster nodes x Number of pods = 49 million). According to the following table, set the requested vCPUs to 4000m and the limit value to 5500m. – Requested memory: It is recommended that 2.4 GiB memory be allocated to every 1000 nodes and 1 GiB memory be allocated to every 10,000 pods. The requested memory is the sum of these two values. (The obtained value may be different from the recommended value in **Table 16-43**. You can use either of them.) Requested memory = Number of target nodes/1000 x 2.4 GiB + Number of target pods/10,000 x 1 GiB For example, for 2000 nodes and 20,000 pods, the requested memory is 6.8 GiB (2000/1000 x 2.4 GiB + 20,000/10,000 x 1 GiB).

Table 16-43 Recommended values for volcano-controller and volcano-scheduler

Nodes/Pods in a Cluster	Requested vCPUs (m)	vCPU Limit (m)	Requested Memory (MiB)	Memory Limit (MiB)
50/5000	500	2000	500	2000
100/10,000	1000	2500	1500	2500
200/20,000	1500	3000	2500	3500

Nodes/Pods in a Cluster	Requested vCPUs (m)	vCPU Limit (m)	Requested Memory (MiB)	Memory Limit (MiB)
300/30,000	2000	3500	3500	4500
400/40,000	2500	4000	4500	5500
500/50,000	3000	4500	5500	6500
600/60,000	3500	5000	6500	7500
700/70,000	4000	5500	7500	8500

Step 3 Configure the add-on parameters.

Configure parameters of the default Volcano scheduler. For details, see **Table 16-45**.

```
colocation_enable: ''
default_scheduler_conf:
  actions: 'allocate, backfill, preempt'
  tiers:
    - plugins:
        - name: 'priority'
        - name: 'gang'
        - name: 'conformance'
        - name: 'lifecycle'
          arguments:
            lifecycle.MaxGrade: 10
            lifecycle.MaxScore: 200.0
            lifecycle.SaturatedTresh: 1.0
            lifecycle.WindowSize: 10
    - plugins:
        - name: 'drf'
        - name: 'predicates'
        - name: 'nodeorder'
    - plugins:
        - name: 'cce-gpu-topology-predicate'
        - name: 'cce-gpu-topology-priority'
        - name: 'cce-gpu'
    - plugins:
        - name: 'nodelocalvolume'
        - name: 'nodeemptydirvolume'
        - name: 'nodeCSIscheduling'
        - name: 'networkresource'
tolerations:
  - effect: NoExecute
    key: node.kubernetes.io/not-ready
    operator: Exists
    tolerationSeconds: 60
  - effect: NoExecute
    key: node.kubernetes.io/unreachable
    operator: Exists
    tolerationSeconds: 60
```

Table 16-44 Advanced Volcano configuration parameters

Plugin	Function	Description	Demonstration
colocation_enable	Whether to enable hybrid deployment.	Value: • **true**: hybrid enabled • **false**: hybrid disabled	None
default_scheduler_conf	Used to schedule pods. It consists of a series of actions and plugins and features high scalability. You can specify and implement actions and plugins based on your requirements.	It consists of actions and tiers. • **actions**: defines the types and sequence of actions to be executed by the scheduler. • **tiers**: configures the plugin list.	None

Plugin	Function	Description	Demonstration
actions	Actions to be executed in each scheduling phase. The configured action sequence is the scheduler execution sequence. For details, see **Actions**. The scheduler traverses all jobs to be scheduled and performs actions such as enqueue, allocate, preempt, and backfill in the configured sequence to find the most appropriate node for each job.	The following options are supported: • **enqueue**: uses a series of filtering algorithms to filter out tasks to be scheduled and sends them to the queue to wait for scheduling. After this action, the task status changes from **pending** to **inqueue**. • **allocate**: selects the most suitable node based on a series of pre-selection and selection algorithms. • **preempt**: performs preemption scheduling for tasks with higher priorities in the same queue based on priority rules. • **backfill**: schedules pending tasks as much as possible to maximize the utilization of node resources.	`actions: 'allocate, backfill, preempt'` **NOTE** When configuring **actions**, use either **preempt** or **enqueue**.
plugins	Implementation details of algorithms in actions based on different scenarios. For details, see **Plugins**.	For details, see **Table 16-45**.	None

tolerations	Tolerance of the add-on to node taints.	By default, the add-on can run on nodes with the **node.kubernetes.io/not-ready** or **node.kubernetes.io/unreachable** taint and the taint effect value is **NoExecute**, but it'll be evicted in 60 seconds.	`tolerations:`
			`- effect: NoExecute`
			`key: node.kubernetes.io/not-ready`
			`operator: Exists`
			`tolerationSeconds: 60`
			`- effect: NoExecute`
			`key: node.kubernetes.io/unreachable`
			`operator: Exists`
			`tolerationSeconds: 60`

Table 16-45 Supported plugins

Plugin	Function	Description	Demonstration
binpack	Schedule pods to nodes with high resource usage (not allocating pods to light-loaded nodes) to reduce resource fragments.	**arguments**: • **binpack.weight**: weight of the binpack plugin. • **binpack.cpu**: ratio of CPUs to all resources. The parameter value defaults to **1**. • **binpack.memory**: ratio of memory resources to all resources. The parameter value defaults to **1**. • **binpack.resources**: other custom resource types requested by the pod, for example, **nvidia.com/gpu**. Multiple types can be configured and be separated by commas (,). • **binpack.resources.***<your_resource>*: weight of your custom resource in all resources. Multiple types of resources can be added. *<your_resource>* indicates the resource type defined in **binpack.resources**, for example, **binpack.resources.nvidia.com/gpu**.	- plugins: - **name: binpack** arguments: binpack.weight: 10 binpack.cpu: 1 binpack.memory: 1 binpack.resources: nvidia.com/gpu, example.com/foo binpack.resources.nvidia.com/gpu: 2 binpack.resources.example.com/foo: 3
conformance	Prevent key pods, such as the pods in the **kube-system** namespace from being preempted.	None	- plugins: - name: 'priority' - name: 'gang' enablePreemptable: false - **name: 'conformance'**

Plugin	Function	Description	Demonstration
lifecycle	By collecting statistics on service scaling rules, pods with similar lifecycles are preferentially scheduled to the same node. With the horizontal scaling capability of the Autoscaler, resources can be quickly scaled in and released, reducing costs and improving resource utilization. 1. Collects statistics on the lifecycle of pods in the service load and schedules pods with similar lifecycles to the same node. 2. For a cluster configured with an automatic scaling policy, adjust the scale-in annotation of the node to preferentially scale in the node with low usage.	**arguments**: • **lifecycle.WindowSize** : The value is an integer greater than or equal to 1 and defaults to **10**. Record the number of times that the number of replicas changes. If the load changes regularly and periodically, decrease the value. If the load changes irregularly and the number of replicas changes frequently, increase the value. If the value is too large, the learning period is prolonged and too many events are recorded. • **lifecycle.MaxGrade**: The value is an integer greater than or equal to 3 and defaults to **3**. It indicates levels of replicas. For example, if the value is set to **3**, the replicas are classified into three levels. If the load changes regularly and periodically, decrease the value. If the load changes irregularly, increase the value. Setting an excessively small value may result in inaccurate lifecycle forecasts. • **lifecycle.MaxScore**: float64 floating point number. The value must be greater than or equal to 50.0. The default value is **200.0**.	- plugins: - name: priority - name: gang enablePreemptable: false - name: conformance - **name: lifecycle** arguments: lifecycle.MaxGrade: 10 lifecycle.MaxScore: 200.0 lifecycle.SaturatedTresh: 1.0 lifecycle.WindowSize: 10 **NOTE** • For nodes that do not want to be scaled in, manually mark them as long-period nodes and add the annotation **volcano.sh/long-lifecycle-node: true** to them. For an unmarked node, the lifecycle plugin automatically marks the node based on the lifecycle of the load on the node. • The default value of **MaxScore** is **200.0**, which is twice the weight of other plugins. When the lifecycle plugin does not have obvious effect or conflicts with other plugins, disable other plugins or increase the value of **MaxScore**. • After the scheduler is restarted, the lifecycle plugin needs to re-record the load change. The optimal scheduling effect can be achieved only after several periods of statistics are collected.

Plugin	Function	Description	Demonstration
		Maximum score (equivalent to the weight) of the lifecycle plugin. • **lifecycle.SaturatedTresh**: float64 floating point number. If the value is less than 0.5, use **0.5**. If the value is greater than 1, use **1**. The default value is **0.8**. Threshold for determining whether the node usage is too high. If the node usage exceeds the threshold, the scheduler preferentially schedules jobs to other nodes.	

Plugin	Function	Description	Demonstration
Gang	Consider a group of pods as a whole for resource allocation. This plugin 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. **NOTE** If a gang scheduling policy is used, if the remaining resources in the cluster are greater than or equal to half of the minimum number of resources for running a job but less than the minimum of resources for running the job, Autoscaler scale-outs will not be triggered.	• **enablePreemptable**: – **true**: Preemption enabled – **false**: Preemption not enabled • **enableJobStarving**: – **true**: Resources are preempted based on the **minAvailable** setting of jobs. – **false**: Resources are preempted based on job replicas. **NOTE** – The default value of **minAvailable** for Kubernetes-native workloads (such as Deployments) is **1**. It is a good practice to set **enableJobStarving** to **false**. – In AI and big data scenarios, you can specify the **minAvailable** value when creating a vcjob. It is a good practice to set **enableJobStarving** to **true**. – In Volcano versions earlier than v1.11.5, **enableJobStarving** is set to **true** by default. In Volcano versions later than v1.11.5, **enableJobStarving** is set to **false** by default.	- plugins: - name: priority **- name: gang** **enablePreemptable: false** **enableJobStarving: false** - name: conformance
priority	Schedule based on custom load priorities.	None	- plugins: **- name: priority** - name: gang enablePreemptable: false - name: conformance

Plugin	Function	Description	Demonstration

overcommit	Resources in a cluster are scheduled after being accumulated in a certain multiple to improve the workload enqueuing efficiency. If all workloads are Deployments, remove this plugin or set the raising factor to **2.0**.
	NOTE
	This plugin is supported in Volcano 1.6.5 and later versions.
		arguments:
		• **overcommit-factor**: inflation factor, which defaults to **1.2**.
			- plugins:
			  - **name: overcommit**
			  arguments:
			  overcommit-factor: 2.0

drf	The Dominant Resource Fairness (DRF) scheduling algorithm, which schedules jobs based on their dominant resource share. Jobs with a smaller resource share will be scheduled with a higher priority.	-	- plugins:
			  - **name: 'drf'**
			  - name: 'predicates'
			  - name: 'nodeorder'

Plugin	Function	Description	Demonstration

predicates	Determine whether a task is bound to a node by using a series of evaluation algorithms, such as node/pod affinity, taint tolerance, node repetition, volume limits, and volume zone matching.	None	- plugins:
			  - name: 'drf'
			  - **name: 'predicates'**
			  - name: 'nodeorder'

Plugin	Function	Description	Demonstration

nodeorder	A common algorithm for selecting nodes. Nodes are scored in simulated resource allocation to find the most suitable node for the current job.	Scoring parameters:
		• **nodeaffinity.weight**: Pods are scheduled based on node affinity. This parameter defaults to **2**.
		• **podaffinity.weight**: Pods are scheduled based on pod affinity. This parameter defaults to **2**.
		• **leastrequested.weight**: Pods are scheduled to the node with the least requested resources. This parameter defaults to **1**.
		• **balancedresource.weight**: Pods are scheduled to the node with balanced resource allocation. This parameter defaults to **1**.
		• **mostrequested.weight**: Pods are scheduled to the node with the most requested resources. This parameter defaults to **0**.
		• **tainttoleration.weight**: Pods are scheduled to the node with a high taint tolerance. This parameter defaults to **3**.
		• **imagelocality.weight**: Pods are scheduled to the node where the required images exist. This parameter defaults to **1**.
		• **selectorspread.weight**: Pods are evenly
			- plugins:
			  - **name: nodeorder**
			  arguments:
			  leastrequested.weight: 1
			  mostrequested.weight: 0
			  nodeaffinity.weight: 2
			  podaffinity.weight: 2
			  balancedresource.weight: 1
			  tainttoleration.weight: 3
			  imagelocality.weight: 1
			
			podtopologyspread.weight: 2

Plugin	Function	Description	Demonstration
		scheduled to different nodes. This parameter defaults to **0**. • **podtopologyspread.weight**: Pods are scheduled based on the pod topology. This parameter defaults to **2**.	

cce-gpu-topology-predicate	GPU-topology scheduling preselection algorithm	None	- plugins:
			  - **name: 'cce-gpu-topology-predicate'**
			  - name: 'cce-gpu-topology-priority'
			  - name: 'cce-gpu'

cce-gpu-topology-priority	GPU-topology scheduling priority algorithm	None	- plugins:
			  - name: 'cce-gpu-topology-predicate'
			  - **name: 'cce-gpu-topology-priority'**
			  - name: 'cce-gpu'

cce-gpu	GPU resource allocation that supports decimal GPU configurations by working with the gpu add-on.	None	- plugins:
			  - name: 'cce-gpu-topology-predicate'
			  - name: 'cce-gpu-topology-priority'
			  - **name: 'cce-gpu'**

numa-aware	NUMA affinity scheduling.	**arguments**:
		• **weight**: weight of the numa-aware plugin
			- plugins:
			  - name: 'nodelocalvolume'
			  - name: 'nodeemptydirvolume'
			  - name: 'nodeCSIscheduling'
			  - name: 'networkresource'
			  arguments:
			  NetworkType: vpc-router
			  - **name: numa-aware**
			  arguments:
			  weight: 10

network resource	The ENI requirement node can be preselected and filtered. The parameters are transferred by CCE and do not need to be manually configured.	**arguments**:
		• **NetworkType**: network type (**eni** or **vpc-router**)
			- plugins:
			  - name: 'nodelocalvolume'
			  - name: 'nodeemptydirvolume'
			  - name: 'nodeCSIscheduling'
			  - **name: 'networkresource'**
			  arguments:
			  NetworkType: vpc-router

Plugin	Function	Description	Demonstration

nodelocalvolume	Filter out nodes that do not meet local volume requirements.	None	- plugins:
			  - **name: 'nodelocalvolume'**
			  - name: 'nodeemptydirvolume'
			  - name: 'nodeCSIscheduling'
			  - name: 'networkresource'

nodeemptydirvolume	Filter out nodes that do not meet the emptyDir requirements.	None	- plugins:
			  - name: 'nodelocalvolume'
			  - **name: 'nodeemptydirvolume'**
			  - name: 'nodeCSIscheduling'
			  - name: 'networkresource'

nodeCSIscheduling	Filter out nodes with malfunctional Everest.	None	- plugins:
			  - name: 'nodelocalvolume'
			  - name: 'nodeemptydirvolume'
			  - **name: 'nodeCSIscheduling'**
			  - name: 'networkresource'

Step 4 Configure scheduling policies for the add-on.

NOTE

- Scheduling policies do not take effect on add-on instances of the DaemonSet type.
- When configuring multi-AZ deployment or node affinity, ensure that there are nodes meeting the scheduling policy and that resources are sufficient in the cluster. Otherwise, the add-on cannot run.

Table 16-46 Configurations for add-on scheduling

Parameter	Description
Multi AZ	• **Preferred**: Deployment pods of the add-on will be preferentially scheduled to nodes in different AZs. If all the nodes in the cluster are deployed in the same AZ, the pods will be scheduled to that AZ. • **Required**: Deployment pods of the add-on will be forcibly scheduled to nodes in different AZs. If there are fewer AZs than pods, the extra pods will fail to run.

Parameter	Description
Node Affinity	• **Not configured**: Node affinity is disabled for the add-on. • **Node Affinity**: Specify the nodes where the add-on is deployed. If you do not specify the nodes, the add-on will be randomly scheduled based on the default cluster scheduling policy. • **Specified Node Pool Scheduling**: Specify the node pool where the add-on is deployed. If you do not specify the node pool, the add-on will be randomly scheduled based on the default cluster scheduling policy. • **Custom Policies**: Enter the labels of the nodes where the add-on is to be deployed for more flexible scheduling policies. If you do not specify node labels, the add-on will be randomly scheduled based on the default cluster scheduling policy. If multiple custom affinity policies are configured, ensure that there are nodes that meet all the affinity policies in the cluster. Otherwise, the add-on cannot run.
Toleration	Using both taints and tolerations allows (not forcibly) the add-on Deployment to be scheduled to a node with the matching taints, and controls the Deployment eviction policies after the node where the Deployment is located is tainted. The add-on adds the default tolerance policy for the **node.kubernetes.io/not-ready** and **node.kubernetes.io/unreachable** taints, respectively. The tolerance time window is 60s. For details, see **Taints and Tolerations**.

Step 5 Click **Install**.

----End

Components

Table 16-47 Add-on components

Component	Description	Resource Type
volcano-scheduler	Schedule pods.	Deployment
volcano-controller	Synchronize CRDs.	Deployment
volcano-admission	Webhook server, which verifies and modifies resources such as pods and jobs	Deployment

Component	Description	Resource Type
volcano-agent	Cloud native hybrid agent, which is used for node QoS assurance, CPU burst, and dynamic resource oversubscription	DaemonSet
resource-exporter	Report the NUMA topology information of nodes.	DaemonSet

Modifying the volcano-scheduler Configurations Using the Console

volcano-scheduler is the component responsible for pod scheduling. It consists of a series of actions and plugins. Actions should be executed in every step. Plugins provide the action algorithm details in different scenarios. volcano-scheduler is highly scalable. You can specify and implement actions and plugins based on your requirements.

Volcano allows you to configure the scheduler during installation, upgrade, and editing. The configuration will be synchronized to volcano-scheduler-configmap.

This section describes how to configure volcano-scheduler.

NOTE

Only Volcano of v1.7.1 and later support this function. On the new add-on page, options such as **resource_exporter_enable** are replaced by **default_scheduler_conf**.

Log in to the CCE console and click the cluster name to access the cluster console. Choose **Add-ons** in the navigation pane. On the right of the page, locate **Volcano Scheduler** and click **Install** or **Upgrade**. In the **Parameters** area, configure the Volcano parameters.

- Using **resource_exporter**:

```
{
    "ca_cert": "",
    "default_scheduler_conf": {
        "actions": "allocate, backfill, preempt",
        "tiers": [
            {
                "plugins": [
                    {
                        "name": "priority"
                    },
                    {
                        "name": "gang"
                    },
                    {
                        "name": "conformance"
                    }
                ]
            },
            {
                "plugins": [
                    {
                        "name": "drf"
                    },
                    {
                        "name": "predicates"
                    },
```

```
            {
               "name": "nodeorder"
            }
         ]
      },
      {
         "plugins": [
            {
               "name": "cce-gpu-topology-predicate"
            },
            {
               "name": "cce-gpu-topology-priority"
            },
            {
               "name": "cce-gpu"
            },
            {
               "name": "numa-aware" # add this also enable resource_exporter
            }
         ]
      },
      {
         "plugins": [
            {
               "name": "nodelocalvolume"
            },
            {
               "name": "nodeemptydirvolume"
            },
            {
               "name": "nodeCSIscheduling"
            },
            {
               "name": "networkresource"
            }
         ]
      }
   ]
  },
  "server_cert": "",
  "server_key": ""
}
```

After this function is enabled, you can use the functions of both numa-aware and resource_exporter.

Retaining the Original volcano-scheduler-configmap Configurations

If you want to use the original configuration after the plugin is upgraded, perform the following steps:

Step 1 Check and back up the original volcano-scheduler-configmap configuration.

Example:

```
# kubectl edit cm volcano-scheduler-configmap -n kube-system
apiVersion: v1
data:
  default-scheduler.conf: |-
    actions: "enqueue, allocate, backfill"
    tiers:
    - plugins:
      - name: priority
      - name: gang
      - name: conformance
    - plugins:
      - name: drf
      - name: predicates
      - name: nodeorder
```

```
    - name: binpack
      arguments:
        binpack.cpu: 100
        binpack.weight: 10
        binpack.resources: nvidia.com/gpu
        binpack.resources.nvidia.com/gpu: 10000
  - plugins:
    - name: cce-gpu-topology-predicate
    - name: cce-gpu-topology-priority
    - name: cce-gpu
  - plugins:
    - name: nodelocalvolume
    - name: nodeemptydirvolume
    - name: nodeCSIscheduling
    - name: networkresource
```

Step 2 Enter the customized content in the **Parameters** area on the console.

```
{
  "ca_cert": "",
  "default_scheduler_conf": {
    "actions": "enqueue, allocate, backfill",
    "tiers": [
      {
        "plugins": [
          {
            "name": "priority"
          },
          {
            "name": "gang"
          },
          {
            "name": "conformance"
          }
        ]
      },
      {
        "plugins": [
          {
            "name": "drf"
          },
          {
            "name": "predicates"
          },
          {
            "name": "nodeorder"
          },
          {
            "name": "binpack",
            "arguments": {
              "binpack.cpu": 100,
              "binpack.weight": 10,
              "binpack.resources": "nvidia.com/gpu",
              "binpack.resources.nvidia.com/gpu": 10000
            }
          }
        ]
      },
      {
        "plugins": [
          {
            "name": "cce-gpu-topology-predicate"
          },
          {
            "name": "cce-gpu-topology-priority"
          },
          {
            "name": "cce-gpu"
          }
        ]
```

```
        },
        {
            "plugins": [
                {
                    "name": "nodelocalvolume"
                },
                {
                    "name": "nodeemptydirvolume"
                },
                {
                    "name": "nodeCSIscheduling"
                },
                {
                    "name": "networkresource"
                }
            ]
        }
    ]
  },
  "server_cert": "",
  "server_key": ""
}
```

NOTE

When this function is used, the original content in volcano-scheduler-configmap will be overwritten. Therefore, you must check whether volcano-scheduler-configmap has been modified during the upgrade. If yes, synchronize the modification to the upgrade page.

----End

Collecting Prometheus Metrics

volcano-scheduler exposes Prometheus metrics through port 8080. You can build a Prometheus collector to identify and obtain volcano-scheduler scheduling metrics from **http://{{*volcano-schedulerPodIP*}}:{{*volcano-schedulerPodPort*}}/metrics**.

NOTE

Prometheus metrics can be exposed only by the Volcano add-on of version 1.8.5 or later.

Table 16-48 Key metrics

Metric	Type	Description	Label
e2e_scheduling_latency_milliseconds	Histogram	E2E scheduling latency (ms) (scheduling algorithm + binding)	None
e2e_job_scheduling_latency_milliseconds	Histogram	E2E job scheduling latency (ms)	None
e2e_job_scheduling_duration	Gauge	E2E job scheduling duration	labels=["job_name", "queue", "job_namespace"]
plugin_scheduling_latency_microseconds	Histogram	Add-on scheduling latency (µs)	labels=["plugin", "OnSession"]

Metric	Type	Description	Label
action_scheduling_latency_microseconds	Histogram	Action scheduling latency (μs)	labels=["action"]
task_scheduling_latency_milliseconds	Histogram	Task scheduling latency (ms)	None
schedule_attempts_total	Counter	Number of pod scheduling attempts. **unschedulable** indicates that the pods cannot be scheduled, and **error** indicates that the internal scheduler is faulty.	labels=["result"]
pod_preemption_victims	Gauge	Number of selected preemption victims	None
total_preemption_attempts	Counter	Total number of preemption attempts in a cluster	None
unschedule_task_count	Gauge	Number of unschedulable tasks	labels=["job_id"]
unschedule_job_count	Gauge	Number of unschedulable jobs	None
job_retry_counts	Counter	Number of job retries	labels=["job_id"]

Uninstalling the Volcano Add-on

After the add-on is uninstalled, all custom Volcano resources (**Table 16-49**) will be deleted, including the created resources. Reinstalling the add-on will not inherit or restore the tasks before the uninstallation. It is a good practice to uninstall the Volcano add-on only when no custom Volcano resources are being used in the cluster.

Table 16-49 Custom Volcano resources

Item	API Group	API Version	Resource Level
Command	bus.volcano.sh	v1alpha1	Namespaced
Job	batch.volcano.sh	v1alpha1	Namespaced
Numatopology	nodeinfo.volcano.sh	v1alpha1	Cluster
PodGroup	scheduling.volcano.sh	v1beta1	Namespaced

Item	API Group	API Version	Resource Level
Queue	scheduling.volcano.sh	v1beta1	Cluster

16.13 CCE Secrets Manager for DEW

Introduction

The dew-provider add-on is used to interconnect with Data Encryption Workshop (DEW), which 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.

Constraints

- DEW includes Key Management Service (KMS), Cloud Secret Management Service (CSMS), and Key Pair Service (KPS). Currently, the dew-provider add-on can interconnect only with CSMS.
- The dew-provider add-on can be installed only on clusters v1.19 or later.
- The dew-provider add-on can be installed in CCE standard clusters.
- A maximum of 500 SecretProviderClass objects can be created.
- When the add-on is uninstalled, related CRD resources are deleted accordingly. Even if the add-on is reinstalled, the original SecretProviderClass object is unavailable. If you want to use the original SecretProviderClass resources after the add-on is uninstalled and then reinstalled, manually create them again.

How the Add-on Works

- Basic mounting: After the dew-provider add-on is installed, you can create a SecretProviderClass object and declare and reference the volume in a pod. When the pod is started, the secret declared in the SecretProviderClass object is mounted to the pod.
- Scheduled rotation: After a pod runs properly, if the secret declared in the SPC object and stored in CSMS is updated, the latest secret values can be updated to the pod through scheduled rotation. When using this capability, set the secret version to **latest**.
- Real-time awareness of SPC changes: After a pod runs properly, if a user modifies the secret declared in the SPC object (for example, a secret is added or the version number is changed), the add-on can detect the change in real time and update the secret to the pod.

Installing the Add-on

Step 1 Log in to the CCE console and click the cluster name to access the cluster console. Click **Add-ons** in the navigation pane, locate **CCE Secrets Manager for DEW** on the right, and click **Install**.

Step 2 On the **Install Add-on** page, configure parameters in the **Parameters** area, as listed in the following table.

Parameter	Description
rotation_poll_interval	Rotation interval, in unit of m (instead of min). The rotation interval indicates the interval for sending a request to CSMS and obtaining the latest secret. The proper interval range is [1m, 1440m]. The default value is **2m**.

Step 3 Click **Install**.

After the add-on is installed, select the cluster and click **Add-ons** in the navigation pane. On the displayed page, view the add-on in the **Add-ons Installed** area.

----End

Components

Table 16-50 Add-on components

Component	Description	Resource Type
dew-provider	A component that obtains specified secrets from CSMS and mounts them to the pods	DaemonSet
secrets-store-csi-driver	A component that maintains two CRDs, SecretProviderClass (SPC) and SecretProviderClassPodStatus (spcPodStatus). **SPC** is used to describe the secret that users are interested in (such as the secret version and name). It is created by users and will be referenced in pods. **spcPodStatus** is used to trace the binding relationships between pods and secrets. It is automatically created by csi-driver and requires no manual operation. One pod corresponds to one spcPodStatus. After a pod is started, a spcPodStatus is generated for the pod. When the pod lifecycle ends, the spcPodStatus is deleted accordingly.	DaemonSet

Mounting a Credential Using a Volume

Step 1 Create a ServiceAccount.

1. Create a ServiceAccount object, **which declares the secret names that can be used by services. If a user references a secret that is not declared here, the mounting will fail. As a result, the pod cannot run**.

   Create the **serviceaccount.yaml** file based on the template below, and declare the secret names that can be used by services in the **cce.io/dew-**

resource field. Here, **secret_1** and **secret_2** are declared, indicating that the service is allowed to reference two secrets. In subsequent operations, if the user references **secret_3** in the service, the verification fails. As a result, the secret cannot be mounted and the pod cannot run.

```
apiVersion: v1
kind: ServiceAccount
metadata:
  name: nginx-spc-sa
  annotations:
    cce.io/dew-resource: "[\"secret_1\",\"secret_2\"]"  #secrets that allow pod to use
```

Ensure that the secrets declared here exist in CSCM, as shown in the following figure. Otherwise, even if the verification is successful, an error occurs when the corresponding secret is obtained from CSCM. As a result, the pod cannot run properly.

2. Run the following command to create the ServiceAccount:

   kubectl apply -f serviceaccount.yaml

3. Check whether the ServiceAccount object is successfully created.

   ```
   $ kubectl get sa
   NAME       SECRETS   AGE
   default        1         18d   # This is the default ServiceAccount object of the system.
   nginx-spc-sa    1         19s   # This is the newly created ServiceAccount object.
   ```

   A ServiceAccount object named **nginx-spc-sa** has been created. This object will be referenced in pods.

Step 2 Create a SecretProviderClass.

1. The SecretProviderClass object is used to describe the secret information (such as the version and name) that users are interested in. It is created by users and will be referenced in pods.

   Create the **secretproviderclass.yaml** file using the template below. Pay attention to the **objects** field in **parameters**, which is an array used to declare the secret to be mounted.

   ```
   apiVersion: secrets-store.csi.x-k8s.io/v1
   kind: SecretProviderClass
   metadata:
     name: spc-test
   spec:
     provider: cce     # The value is fixed at cce.
     parameters:
       objects: |
             - objectName: "secret_1"
               objectVersion: "v1"
               objectType: "csms"
   ```

Parameter	Type	Mandatory	Description
objectName	String	Yes	Credential name. Set this parameter to the secret referenced in ServiceAccount. If there are multiple object names defined in the same SecretProviderClass, each value of the **objectName** parameter must be unique. Otherwise, the mounting fails.

Parameter	Type	Mandatory	Description
objectAlias	String	No	File name of the secret written into the container. If this parameter is not specified, the file name of the secret written into the container is the value of **objectName** by default. If this parameter is specified, the value must be different from **objectName** and from the **objectAlias** and **objectName** values of other secrets. Otherwise, the mounting fails.
objectType	String	Yes	Secret type. Only **csms** is supported. A value other than **csms** is invalid.
objectVersion	String	Yes	Secret version – Specify a version, for example, **v1** or **v2**. – Use the latest version, for example, **latest**. When **objectVersion** is set to **latest**, if the corresponding secret in CSCM is updated, the secret will be updated to the pod after a certain interval (**rotation_poll_interval**).

2. Run the following command to create a SecretProviderClass object:

   kubectl apply -f secretproviderclass.yaml

3. Check whether the SecretProviderClass object has been created.

   ```
   $ kubectl get spc
   NAME   AGE
   spc-test   20h
   ```

   A SecretProviderClass object named **spc-test** is created. This object will be referenced in pods subsequently.

Step 3 Create a pod.

The following describes how to create an Nginx application.

1. Define a workload, reference the created ServiceAccount object in **serviceAccountName**, and reference the created SPC object in **secretProviderClass**, specify the mount path of the container in **mountPath**. (Do not specify special directories such as **/** and **/var/run**. Otherwise, the container may fail to be started.)

   ```
   apiVersion: apps/v1
   kind: Deployment
   metadata:
     name: nginx-spc
     labels:
       app: nginx
   spec:
     replicas: 1
     selector:
       matchLabels:
         app: nginx
     template:
       metadata:
   ```

```
    labels:
      app: nginx
  spec:
    serviceAccountName: nginx-spc-sa   # Reference the created ServiceAccount.
    volumes:
      - name: secrets-store-inline
        csi:
          driver: secrets-store.csi.k8s.io
          readOnly: true
          volumeAttributes:
            secretProviderClass: "spc-test"  # Reference the created SPC.
    containers:
      - name: nginx-spc
        image: nginx:alpine
        imagePullPolicy: IfNotPresent
        volumeMounts:
          - name: secrets-store-inline
            mountPath: "/mnt/secrets-store"  # Define the mount path of secrets in the container.
            readOnly: true
    imagePullSecrets:
      - name: default-secret
```

2. Create a pod.

```
kubectl apply -f deployment.yaml
```

3. Check whether the pod has been created.

```
$ kubectl get pod
NAME                     READY   STATUS    RESTARTS   AGE
nginx-spc-67c9d5b594-642np     1/1     Running    0          20s
```

4. Access the container and check whether the specified secret is written properly. For example:

```
$ kubectl exec -ti nginx-spc-67c9d5b594-642np -- /bin/bash
root@nginx-spc-67c9d5b594-642np:/#
root@nginx-spc-67c9d5b594-642np:/# cd /mnt/secrets-store/
root@nginx-spc-67c9d5b594-642np:/mnt/secrets-store#
root@nginx-spc-67c9d5b594-642np:/mnt/secrets-store# ls
secret_1
```

The command output shows that **secret_1** declared in the SPC object has been written to the pod.

In addition, you can obtain **spcPodStatus** to check the binding relationship between pods and secrets. For example:

```
$ kubectl get spcps
NAME                                                    AGE
nginx-spc-67c9d5b594-642np-default-spc-test   103s
$ kubectl get spcps nginx-spc-67c9d5b594-642np-default-spc-test -o yaml
......
status:
mounted: true
objects:    # Mounted secret
- id: secret_1
version: v1
podName: nginx-spc-67c9d5b594-642np   # Pod that references the SPC object
secretProviderClassName: spc-test              # SPC object
targetPath: /mnt/paas/kubernetes/kubelet/pods/6dd29596-5b78-44fb-9d4c-a5027c420617/volumes/
kubernetes.io~csi/secrets-store-inline/mount
```

----End

Scheduled Rotation

As described before, you can use this add-on to complete the mount secrets, that is, you can write the secrets stored in CSMS to a pod.

To change the secret version declared in the SPC object to **latest**, run the following command:

```
apiVersion: secrets-store.csi.x-k8s.io/v1
kind: SecretProviderClass
metadata:
  name: spc-test
spec:
  provider: cce
  parameters:
    objects: |
          - objectName: "secret_1"
            objectVersion: "latest"  # change "v1"to "latest"
            objectType: "csms"
```

After the SPC object is updated, the add-on periodically sends a request to CSMS to obtain the value of secret_1 of the latest version and updates the value to the pod that references the SPC object. The interval for the add-on to periodically send requests is specified by **rotation_poll_interval** set in **Installing the Add-on**.

Real-Time Detection of SPC Changes

SPC changes are already detected in real time in **Mounting a Credential Using a Volume** and **Scheduled Rotation**. For demonstration, add secret **secret_2** to the SPC object as follows:

```
apiVersion: secrets-store.csi.x-k8s.io/v1
kind: SecretProviderClass
metadata:
  name: spc-test
spec:
  provider: cce
  parameters:
    objects: |
          - objectName: "secret_1"
            objectVersion: "latest"
            objectType: "csms"
          - objectName: "secret_2"
            objectVersion: "v1"
            objectType: "csms"
```

After the SPC object is updated, the new **secret_2** is quickly mounted to the pod that references the SPC object.

Viewing Component Logs

View the pod where the add-on runs.

```
$ kubectl get pod -n kube-system
NAME                       READY   STATUS      RESTARTS   AGE
csi-secrets-store-76tj2      3/3     Running     0          11h
dew-provider-hm5fq           1/1     Running     0          11h
```

View pod logs of the dew-provider component.

```
$ kubectl logs dew-provider-hm5fq -n kube-system
...Log information omitted...
...
```

View the pod logs of the csi-secrets-store component. As the pod of the csi-secrets-store component contains multiple containers, you must run the **-c** command to specify a container when viewing pod logs. The secrets-store container is the major service container of the add-on and contains the majority of the logs.

```
$ kubectl logs csi-secrets-store-76tj2 -c secrets-store -n kube-system
...Log information omitted...
...
```

16.14 CCE Network Metrics Exporter

Introduction

Dolphin is an add-on for monitoring and managing container network traffic. The current version of dolphin can collect traffic statistics of containers that do not use the host network mode in CCE Turbo clusters and performs nodewide container connectivity check.

The IP and TCP traffic can be monitored by pod or flow. You can use podSelector to select the monitoring backend. Multiple monitoring tasks can be created and monitoring metrics can be selected as required. The label information of pods can also be obtained. The monitoring information has been adapted to the Prometheus format. You can call the Prometheus API to view monitoring data.

Constraints

- This add-on can be installed only in CCE Turbo clusters 1.19 or later. The add-on pods can run only on nodes running EulerOS on x86.
- This add-on can be installed on nodes that use the containerd or Docker container engine. In containerd nodes, it can trace pod updates in real time. In Docker nodes, it can query pod updates in polling mode.
- Only traffic statistics of secure containers using the Kata container runtimes and common containers using the runC container runtimes in a CCE Turbo cluster can be collected.
- After the add-on is installed, traffic is by default not monitored. You need to create a MonitorPolicy to configure a monitoring task for traffic monitoring.
- Pods using the host network mode cannot be monitored.
- Ensure that there are sufficient resources on a node for installing the add-on.
- The source of monitoring labels and user labels must be already available before a pod is created.
- You can specify a maximum of five labels (a maximum of 10 labels in versions later than 1.3.4). You cannot specify the labels used by the system. Labels used by the system include **pod**, **task**, **ipfamily**, **srcip**, **dstip**, **srcport**, **dstport**, and **protocol**.

Installing the Add-on

Step 1 Log in to the CCE console and click the CCE Turbo cluster name to access the cluster. Click **Add-ons** in the navigation pane, locate **CCE Network Metrics Exporter** on the right, and click **Install**.

Step 2 On the Install Add-on page, view the add-on configuration.

No parameter can be configured for the current add-on.

Step 3 Click **Install**.

After the add-on is installed, select the cluster and click **Add-ons** in the navigation pane. On the displayed page, view the add-on in the **Add-ons Installed** area.

----End

Components

Table 16-51 Add-on components

Component	Description	Resource Type
dolphin	Used to monitor the container network traffic of CCE Turbo clusters	Daemon Set

Monitoring Metrics of dolphin

You can deliver a monitoring task by creating a MonitorPolicy. A MonitorPolicy can be created by calling an API or using the **kubectl apply** command after logging in to a worker node. A MonitorPolicy represents a monitoring task and provides optional parameters such as **selector** and **podLabel**. The following table describes the supported monitoring metrics.

Table 16-52 Supported monitoring metrics

Monitoring Metric	Monitoring Item	Granularity	Supported Runtime	Supported Cluster Version	Supported Add-on Version	Supported OS
Number of IPv4 packets sent to the Internet	dolphin_ip4_send_pkt_internet	Pod	runC/ Kata	v1.19 or later	1.1.2	EulerOS 2.9 on x86 EulerOS 2.10 on x86
Number of IPv4 bytes sent to the Internet	dolphin_ip4_send_byte_internet	Pod	runC/ Kata	v1.19 or later	1.1.2	EulerOS 2.9 on x86 EulerOS 2.10 on x86
Number of received IPv4 packets	dolphin_ip4_rcv_pkt	Pod	runC/ Kata	v1.19 or later	1.1.2	EulerOS 2.9 on x86 EulerOS 2.10 on x86

Monitoring Metric	Monitoring Item	Granularity	Supported Runtime	Supported Cluster Version	Supported Add-on Version	Supported OS
Number of received IPv4 bytes	dolphin_ip4_rcv_byte	Pod	runC/ Kata	v1.19 or later	1.1.2	EulerOS 2.9 on x86 EulerOS 2.10 on x86
Number of sent IPv4 packets	dolphin_ip4_send_pkt	Pod	runc/ kata	v1.19 or later	1.1.2	EulerOS 2.9 on x86 EulerOS 2.10 on x86
Number of sent IPv4 bytes	dolphin_ip4_send_byte	Pod	runC/ Kata	v1.19 or later	1.1.2	EulerOS 2.9 on x86 EulerOS 2.10 on x86
Health status of the latest health check	dolphin_health_check_status	Pod	runc/ kata	v1.19 or later	1.2.2	EulerOS 2.9 on x86 EulerOS 2.10 on x86
Total number of successful health checks	dolphin_health_check_successful_counter	Pod	runC/ Kata	v1.19 or later	1.2.2	EulerOS 2.9 on x86 EulerOS 2.10 on x86
Total number of failed health checks	dolphin_health_check_failed_counter	Pod	runC/ Kata	v1.19 or later	1.2.2	EulerOS 2.9 on x86 EulerOS 2.10 on x86

Monitoring Metric	Monitoring Item	Granularity	Supported Runtime	Supported Cluster Version	Supported Add-on Version	Supported OS
Number of received IP packets	dolphin_ip_receive_pkt	Pod	runC	v1.23 or later	1.3.5	EulerOS 2.9 on x86 EulerOS 2.10 on x86
Number of received IP bytes	dolphin_ip_receive_byte	Pod	runC	v1.23 or later	1.3.5	EulerOS 2.9 on x86 EulerOS 2.10 on x86
Number of sent IP packets	dolphin_ip_send_pkt	Pod	runC	v1.23 or later	1.3.5	EulerOS 2.9 on x86 EulerOS 2.10 on x86
Number of sent IP bytes	dolphin_ip_send_byte	Pod	runC	v1.23 or later	1.3.5	EulerOS 2.9 on x86 EulerOS 2.10 on x86
Number of received TCP packets	dolphin_tcp_receive_pkt	Pod	runC	v1.23 or later	1.3.5	EulerOS 2.9 on x86 EulerOS 2.10 on x86
Number of received TCP bytes	dolphin_tcp_receive_byte	Pod	runC	v1.23 or later	1.3.5	EulerOS 2.9 on x86 EulerOS 2.10 on x86

Monitoring Metric	Monitoring Item	Granularity	Supported Runtime	Supported Cluster Version	Supported Add-on Version	Supported OS
Number of sent TCP packets	dolphin_tcp_send_pkt	Pod	runC	v1.23 or later	1.3.5	EulerOS 2.9 on x86 EulerOS 2.10 on x86
Number of sent TCP bytes	dolphin_tcp_send_byte	Pod	runC	v1.23 or later	1.3.5	EulerOS 2.9 on x86 EulerOS 2.10 on x86
Number of retransmitted TCP packets	dolphin_tcp_retrans	Pod	runC	v1.23 or later	1.3.5	EulerOS 2.9 on x86 EulerOS 2.10 on x86
Number of new TCP connections	dolphin_tcp_connection	Pod	runC	v1.23 or later	1.3.5	EulerOS 2.9 on x86 EulerOS 2.10 on x86
Number of received IP packets	dolphin_flow_ip_receive_pkt	Flow	runC	v1.23 or later	1.3.5	EulerOS 2.9 on x86 EulerOS 2.10 on x86
Number of received IP bytes	dolphin_flow_ip_receive_byte	Flow	runC	v1.23 or later	1.3.5	EulerOS 2.9 on x86 EulerOS 2.10 on x86

Monitoring Metric	Monitoring Item	Granularity	Supported Runtime	Supported Cluster Version	Supported Add-on Version	Supported OS
Number of sent IP packets	dolphin_flow_ip_send_pkt	Flow	runC	v1.23 or later	1.3.5	EulerOS 2.9 on x86 EulerOS 2.10 on x86
Number of sent IP bytes	dolphin_flow_ip_send_byte	Flow	runC	v1.23 or later	1.3.5	EulerOS 2.9 on x86 EulerOS 2.10 on x86
Number of received TCP packets	dolphin_flow_tcp_receive_pkt	Flow	runC	v1.23 or later	1.3.5	EulerOS 2.9 on x86 EulerOS 2.10 on x86
Number of received TCP bytes	dolphin_flow_tcp_receive_byte	Flow	runC	v1.23 or later	1.3.5	EulerOS 2.9 on x86 EulerOS 2.10 on x86
Number of sent TCP packets	dolphin_flow_tcp_send_pkt	Flow	runC	v1.23 or later	1.3.5	EulerOS 2.9 on x86 EulerOS 2.10 on x86
Number of sent TCP bytes	dolphin_flow_tcp_send_byte	Flow	runC	v1.23 or later	1.3.5	EulerOS 2.9 on x86 EulerOS 2.10 on x86

Monitoring Metric	Monitoring Item	Granularity	Supported Runtime	Supported Cluster Version	Supported Add-on Version	Supported OS
Number of retransmitted TCP packets	dolphin_flow_tcp_retrans	Flow	runC	v1.23 or later	1.3.5	EulerOS 2.9 on x86 EulerOS 2.10 on x86
TCP smoothed round trip	dolphin_flow_tcp_srtt	Flow	runC	v1.23 or later	1.3.5	EulerOS 2.9 on x86 EulerOS 2.10 on x86

Delivering a Monitoring Task

The template for creating a MonitorPolicy is as follows:

```
apiVersion: crd.dolphin.io/v1
kind: MonitorPolicy
metadata:
    name: example-task            # Monitoring task name.
    namespace: kube-system        # The value must be kube-system. This field is mandatory.
spec:
    selector:                     # (Optional) Backend monitored by the dolphin add-on, for example, labelSelector. By default, all containers on the node are monitored.
    matchLabels:
      app: nginx
    matchExpressions:
      - key: app
        operator: In
        values:
          - nginx
  podLabel: [app]                 # (Optional) Pod label.
  ip4Tx:                          # (Optional) Indicates whether to collect statistics about the number of sent IPv4 packets and the number of sent IPv4 bytes. This function is disabled by default.
    enable: true
    ip4Rx:                        # (Optional) Indicates whether to collect statistics about the number of received IPv4 packets and the number of received IPv4 bytes. This function is disabled by default.
    enable: true
    ip4TxInternet:                # (Optional) Indicates whether to collect statistics about the number of sent IPv4 packets and the number of sent IPv4  bytes. This function is disabled by default.
    enable: true
  healthCheck:                    # (Optional) Whether to collect statistics about whether the latest health check result is healthy and the total number of healthy times and unhealthy times in the pod health checks of the local node. This function is disabled by default.
    enable: true                  # true false
    failureThreshold: 3           # (Optional) Number of failures that determine the health check is unhealthy. One check failure is considered as unhealthy by default.
    periodSeconds: 5              # (Optional) Interval between health checks, in seconds. The default value is 60.
    command: ""                   # (Optional) Health check command. The value can be ping (default), arping, or curl.
    ipFamilies: [""]              # (Optional) Health check IP address family. The value is IPv4 by default.
    port: 80                      # (Optional) Port number, which is mandatory when curl is used.
    path: ""                      # (Optional) HTTP API path, which is mandatory when curl is used.
```

```
monitor:
  ip:
    ipReceive:
      aggregateType: flow      # (Optional). The value can be pod (monitored by pod) or flow (monitored by flow).
    ipSend:
      aggregateType: flow      # (Optional). The value can be pod (monitored by pod) or flow (monitored by flow).
  tcp:
    tcpReceive:
      aggregateType: flow      # (Optional). The value can be pod (monitored by pod) or flow (monitored by flow).
    tcpSend:
      aggregateType: flow      # (Optional). The value can be pod (monitored by pod) or flow (monitored by flow).
    tcpRetrans:
      aggregateType: flow      # (Optional). The value can be pod (monitored by pod) or flow (monitored by flow).
    tcpRtt:
      aggregateType: flow      # (Optional). The value can be flow (monitored by flow). The unit is μs.
    tcpNewConnection:
      aggregateType: pod       # (Optional). The value can be pod (monitored by pod).
```

PodLabel: You can enter the labels of multiple pods and separate them with commas (,), for example, [app, version].

Labels must comply with the following rules. The corresponding regular expression is (^[a-zA-Z_]$)|(^([a-zA-Z][a-zA-Z0-9_]|_[a-zA-Z0-9])([a-zA-Z0-9_]){0,254}$).

- A maximum of five labels can be entered (a maximum of 10 labels in versions later than 1.3.4). A label can contain a maximum of 256 characters.
- The value cannot start with a digit or double underscores (_).
- The format of a single label must comply with A-Za-z_0-9.

You can create, modify, and delete monitoring tasks in the preceding format. A maximum of 10 monitoring tasks can be created. When multiple monitoring tasks match the same monitoring backend, each monitoring backend generates the monitoring metrics specific to the number of monitoring tasks.

NOTE

- If you modify or delete a monitoring task, monitoring data collected by the monitoring task will be lost. Therefore, exercise caution when performing this operation.
- If the add-on is uninstalled, the MonitorPolicy of the monitoring task will be removed together with the add-on.

Example application scenarios:

1. The example below monitors all pods with label **app=nginx** selected by the **labelselector** on a node and generates the three health check metrics. By default, the **ping** command is used to detect local pods. If the monitored container contains the **test** and **app** labels, the key-value information of the corresponding label is carried in the monitoring metrics. Otherwise, the value of the corresponding label is **not found**.

   ```
   apiVersion: crd.dolphin.io/v1
   kind: MonitorPolicy
   metadata:
     name: example-task
     namespace: kube-system
   spec:
     selector:
       matchLabels:
         app: nginx
   ```

```
  podLabel: [test, app]
  healthCheck:
    enable: true
    failureThreshold: 3
    periodSeconds: 5
```

2. The example below monitors all pods with label **app=nginx** selected by the **labelselector** on a node and generates the three health check metrics. Customized **curl** command is used, which considers only the network connectivity. That is, no matter what the HTTP code is returned by the program, the pod is considered healthy as long as the network is connected. If the monitored container contains the **test** and **app** labels, the key-value information of the corresponding label is carried in the monitoring metrics. Otherwise, the value of the corresponding label is **not found**.

```
apiVersion: crd.dolphin.io/v1
kind: MonitorPolicy
metadata:
  name: example-task
  namespace: kube-system
spec:
  selector:
    matchLabels:
      app: nginx
  podLabel: [test, app]
  healthCheck:
    enable: true
    failureThreshold: 3
    periodSeconds: 5
    command: "curl"
    port: 80
    path: "healthz"
```

3. The example below monitors all pods with label **app=nginx** selected by the **labelselector** on a node and generates monitoring data by pod, including the number of sent IP packets, received IP packets, sent IP bytes, received IP bytes, sent TCP packets, received TCP packets, sent TCP bytes, received TCP bytes, retransmitted TCP packets, and new TCP connections. If the monitored container contains the **test** and **app** labels, the key-value information of the corresponding label is carried in the monitoring metrics. Otherwise, the value of the corresponding label is **not found**.

```
apiVersion: crd.dolphin.io/v1
kind: MonitorPolicy
metadata:
  name: example-task
  namespace: kube-system
spec:
  selector:
    matchLabels:
      app: nginx
  podLabel: [test, app]
  monitor:
    ip:
      ipReceive:
        aggregateType: pod
      ipSend:
        aggregateType: pod
    tcp:
      tcpReceive:
        aggregateType: pod
      tcpSend:
        aggregateType: pod
      tcpRetrans:
        aggregateType: pod
      tcpNewConnection:
        aggregateType: pod
```

4. The example below monitors all pods with label **app=nginx** selected by the **labelselector** on a node and generates monitoring data by flow, including the number of sent IP packets, received IP packets, sent IP bytes, received IP bytes, sent TCP packets, received TCP packets, sent TCP bytes, received TCP bytes, retransmitted TCP packets, and TCP round-trip time (μs). If the monitored container contains the **test** and **app** labels, the key-value information of the corresponding label is carried in the monitoring metrics. Otherwise, the value of the corresponding label is **not found**. Flow-based monitoring helps you learn about detailed container traffic information. It generates a large amount of data that occupies more CPU and memory resources.Use flow-based monitoring based on your needs.

   A flow-based IP monitoring task (one or more IP monitoring items enabled in a MonitorPolicy) occupies 2.6 MB kernel memory. A flow-based TCP monitoring task (one or more TCP monitoring items enabled in a MonitorPolicy) occupies 14 MB kernel memory.

```
apiVersion: crd.dolphin.io/v1
kind: MonitorPolicy
metadata:
  name: example-task
  namespace: kube-system
spec:
  selector:
    matchLabels:
      app: nginx
  podLabel: [test, app]
  monitor:
    ip:
      ipReceive:
        aggregateType: flow
      ipSend:
        aggregateType: flow
    tcp:
      tcpReceive:
        aggregateType: flow
      tcpSend:
        aggregateType: flow
      tcpRetrans:
        aggregateType: flow
      tcpRtt:
        aggregateType: flow
```

   NOTE

   If the data generated by flow-based monitoring exceeds a certain limit, excess flow statistics will be lost. The restrictions are as follows:

   - A maximum of 50,000 TCP flows (per monitoring task) can be collected in kernel mode within 10 seconds.
   - A maximum of 10,000 IP flows (per monitoring task) can be collected in kernel mode within 10 seconds.
   - A maximum of 60,000 flow statistical records (all monitoring tasks) can be cached at the interval between two CloudScope data fetches.
   - If CloudScope does not obtain monitoring data for a long time, only the monitoring data generated within the latest hour will be cached.

5. The example below monitors all pods on a node and generates the number of sent IPv4 packets and the number of sent IPv4 bytes. If the monitored container contains the **app** label, the key-value information of the corresponding label is carried in the monitoring metrics. Otherwise, the value of the corresponding label is **not found**.

```
apiVersion: crd.dolphin.io/v1
kind: MonitorPolicy
```

```
metadata:
  name: example-task
  namespace: kube-system
spec:
  podLabel: [app]
  ip4Tx:
    enable: true
```

6. The example below monitors all pods with label **app=nginx** selected by the **labelselector** on a node and generates the number of sent IPv4 packets, received IPv4 packets, sent IPv4 bytes, received IPv4 bytes, IPv4 packets sent to the public network, and IPv4 bytes sent to the public network. If the monitored container contains the **test** and **app** labels, the key-value information of the corresponding label is carried in the monitoring metrics. Otherwise, the value of the corresponding label is **not found**.

```
apiVersion: crd.dolphin.io/v1
kind: MonitorPolicy
metadata:
  name: example-task
  namespace: kube-system
spec:
  selector:
    matchLabels:
      app: nginx
  podLabel: [test, app]
  ip4Tx:
    enable: true
  ip4Rx:
    enable: true
  ip4TxInternet:
    enable: true
```

Checking Traffic Statistics

The monitoring data collected by this add-on is exported in Prometheus exporter format, which can be obtained in the following ways:

- Directly access service port 10001 provided by the dolphin add-on, for example, http://{POD_IP}:10001/metrics.

  Note that if you access the dolphin service port on a node, allow access from the security group of the node and pod.

Examples of the monitored information:

- Example 1 (number of IPv4 packets sent to the Internet):

  ```
  dolphin_ip4_send_pkt_internet{app="nginx",pod="default/nginx-66c9c65dbf-zjg24",task="kube-system/example-task "} 241
  ```

  In the preceding example, the namespace of the pod is **default**, the pod name is **nginx-66c9c65dbf-zjg24**, the label is **app**, and the value is **nginx**. This metric is created by monitoring task **example-task**, and the number of IPv4 packets sent by the pod to the public network is **241**.

- Example 2 (number of IPv4 bytes sent to the Internet):

  ```
  dolphin_ip4_send_byte_internet{app="nginx",pod="default/nginx-66c9c65dbf-zjg24",task="kube-system/example-task" } 23618
  ```

  In the preceding example, the namespace of the pod is **default**, the pod name is **nginx-66c9c65dbf-zjg24**, the label is **app**, and the value is **nginx**. This metric is created by monitoring task **example-task**, and the number of IPv4 bytes sent by the pod to the public network is **23618**.

- Example 3 (number of sent IPv4 packets):

  ```
  dolphin_ip4_send_pkt{app="nginx",pod="default/nginx-66c9c65dbf-zjg24",task="kube-system/example-task "} 379
  ```

In the preceding example, the namespace of the pod is **default**, the pod name is **nginx-66c9c65dbf-zjg24**, the label is **app**, and the value is **nginx**. This metric is created by monitoring task **example-task**, and the number of IPv4 packets sent by the pod is **379**.

- Example 4 (number of sent IPv4 bytes):
  ```
  dolphin_ip4_send_byte{app="nginx",pod="default/nginx-66c9c65dbf-zjg24",task="kube-system/example-task "} 33129
  ```
  In the preceding example, the namespace of the pod is **default**, the pod name is **nginx-66c9c65dbf-zjg24**, the label is **app**, and the value is **nginx**. This metric is created by monitoring task **example-task**, and the number of IPv4 bytes sent by the pod is **33129**.
- Example 5 (number of received IPv4 packets):
  ```
  dolphin_ip4_rcv_pkt{app="nginx",pod="default/nginx-66c9c65dbf-zjg24",task="kube-system/example-task "} 464
  ```
  In the preceding example, the namespace of the pod is **default**, the pod name is **nginx-66c9c65dbf-zjg24**, the label is **app**, and the value is **nginx**. This metric is created by monitoring task **example-task**, and the number of IPv4 packets received by the pod is **464**.
- Example 6 (number of received IPv4 bytes):
  ```
  dolphin_ip4_rcv_byte{app="nginx",pod="default/nginx-66c9c65dbf-zjg24",task="kube-system/example-task "} 34654
  ```
  In the preceding example, the namespace of the pod is **default**, the pod name is **nginx-66c9c65dbf-zjg24**, the label is **app**, and the value is **nginx**. This metric is created by monitoring task **example-task**, and the number of IPv4 bytes received by the pod is **34654**.
- Example 7 (health check status)
  ```
  dolphin_health_check_status{app="nginx",pod="default/nginx-b74766f5f-7582p",task="kube-system/example-task"} 0
  ```
  In the preceding example, the namespace of the pod is **kube-system**, the pod name is **default/nginx-deployment-b74766f5f-7582p**, the label is **app**, and the value is **nginx**. This metric is created by monitoring task **example-task**, and the network health status of the pod is **0** (healthy). If the network status is unhealthy, the value will be **1**.
- Example 8 (number of successful health checks)
  ```
  dolphin_health_check_successful_counter{app="nginx",pod="default/nginx-b74766f5f-7582p",task="kube-system/example-task"} 5
  ```
  In the preceding example, the namespace of the pod is **kube-system**, the pod name is **default/nginx-deployment-b74766f5f-7582p**, the label is **app**, and the value is **nginx**. This metric is created by monitoring task **example-task**, and the number of successful network health checks for the pod is **5**.
- Example 9 (number of failed health check failures)
  ```
  dolphin_health_check_failed_counter{app="nginx",pod="default/nginx-b74766f5f-7582p",task="kube-system/example-task"} 0
  ```
  In the preceding example, the namespace of the pod is **kube-system**, the pod name is **default/nginx-deployment-b74766f5f-7582p**, the label is **app**, and the value is **nginx**. This metric is created by monitoring task **example-task**, and the number of failed network health checks for the pod is **0**.
- Example 10 (flow-based monitoring result):
  ```
  dolphin_flow_tcp_send_byte{app="nginx",dstip="192.168.0.89",dstport="80",ipfamily="ipv4",pod="kube-system/nginx-b74766f5f-7582p",srcip="192.168.1.67",srcport="12973",task="kube-system/example-task"} 1725 1700538280914
  ```
  In the preceding example, the namespace of the pod is **kube-system**, the pod name is **nginx-b74766f5f-7582p**, the label is **app**, and the value is **nginx**.

This metric is created by monitoring task **example-task**, and the number of IPv4 TCP bytes sent from **192.168.1.67:12973** to **192.168.0.89:80** is **1725**. The timestamp is **1700538280914**.

- Example 11 (pod-based monitoring result):

```
dolphin_tcp_send_pkt{app="nginx",ipfamily="ipv4",pod="kube-system/nginx-b74766f5f-7582p",task="kube-system/example-task"} 14
dolphin_tcp_send_pkt{app="nginx",ipfamily="ipv6",pod="kube-system/nginx-b74766f5f-7582p",task="kube-system/example-task"} 0
```

In the preceding example, the namespace of the pod is **kube-system**, the pod name is **nginx-b74766f5f-7582p**, the label is **app**, and the value is **nginx**. This metric is created by monitoring task **example-task**, and the number of IPv4 packets sent by the pod is **14**. **0** IPv6 packets were sent by this pod.

NOTE

If the container does not contain the specified label, the label value in the response body is **not found**. The format is as follows:

```
dolphin_ip4_send_byte_internet{test="not found", pod="default/nginx-66c9c65dbf-zjg24",task="default" } 23618
```

16.15 NodeLocal DNSCache

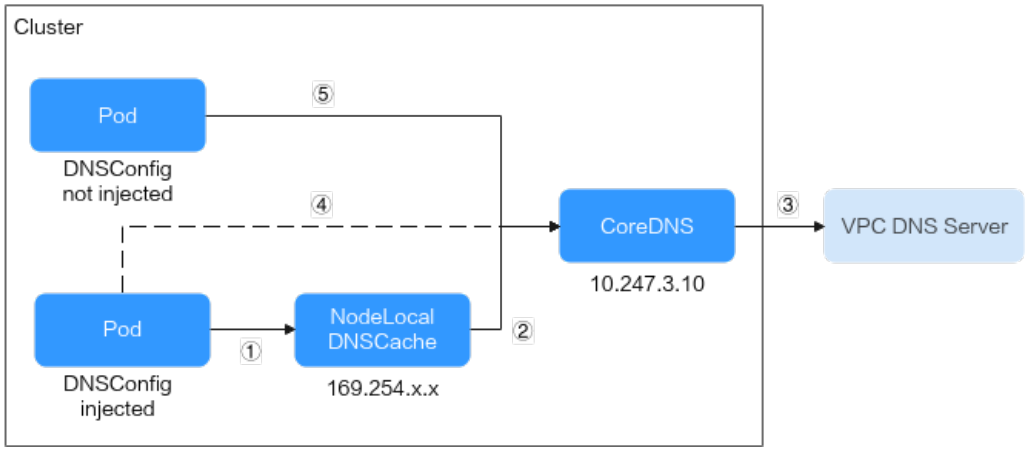
Introduction

NodeLocal DNSCache is an add-on developed based on the community **NodeLocal DNSCache**. This add-on functions as a DaemonSet to run the DNS cache proxy on cluster nodes to improve cluster DNS performance.

Open source community: **https://github.com/kubernetes/dns**

After NodeLocal DNSCache is enabled, a DNS query goes through the path as shown below.

Figure 16-7 NodeLocal DNSCache query path



The resolution lines are described as follows:

- 1. By default, pods that have been injected into the DNS local cache will use the NodeLocal DNSCache to resolve requested domain names.

- 2. If the NodeLocal DNSCache's cache cannot resolve a request, it will ask the cluster's CoreDNS for resolution.
- 3. CoreDNS resolves domain names outside of the cluster by using the DNS server in the VPC.
- 4. If a pod injected into the local DNS cache cannot access the NodeLocal DNSCache, the domain name will be resolved through CoreDNS.
- 5. By default, CoreDNS resolves domain names for pods that are not injected into the local DNS cache.

Constraints

- This feature is available only to clusters of v1.19 or later.

Installing the Add-on

Step 1 Log in to the CCE console and click the cluster name to access the cluster console. Choose **Add-ons** in the navigation pane, locate **NodeLocal DNSCache** on the right, and click **Install**.

Step 2 On the **Install Add-on** page, configure the specifications.

Table 16-53 NodeLocal DNSCache configuration

Parameter	Description
Add-on Specifications	Select **Standalone**, **HA**, or **Custom** for **Add-on Specifications**.
Pods	Number of pods that will be created to match the selected add-on specifications. If you select **Custom**, you can adjust the number of pods as required.
Containers	CPU and memory quotas of the container allowed for the selected add-on specifications. If you select **Custom**, you can adjust the container specifications as required.

Step 3 Configure the add-on parameters.

- **enable_dnsconfig_admission**: After this function is enabled, a DNSConfig dynamic injection controller will be created. The controller intercepts pod creation requests in the namespace labeled with **node-localdns-injection=enabled** based on Admission Webhook, and automatically configures **Pod dnsConfig** that uses the DNS cache. If this function is disabled or the pod belongs to a non-target namespace, you must manually configure DNSConfig for the pod.
- **Target Namespace**: This parameter is available after **DNSConfig Automatic Injection** is enabled. Only NodeLocal DNSCache of v1.3.0 or later supports this function.
  - **All Enabled**: CCE adds the **node-local-dns-injection=enabled** label to all created namespaces excluding built-in ones (such as **kube-system**),

identifies namespace creation requests, and automatically adds the label to newly created namespaces.

- **Manual configuration**: You must manually add the **node-local-dns-injection=enabled** label to the namespaces requiring the injection of DNSConfig. For details, see **Managing Namespace Labels**.

Step 4 Configure scheduling policies for the add-on.

NOTE

- Scheduling policies do not take effect on add-on instances of the DaemonSet type.
- When configuring multi-AZ deployment or node affinity, ensure that there are nodes meeting the scheduling policy and that resources are sufficient in the cluster. Otherwise, the add-on cannot run.

Table 16-54 Configurations for add-on scheduling

Parameter	Description
Multi AZ	• **Preferred**: Deployment pods of the add-on will be preferentially scheduled to nodes in different AZs. If all the nodes in the cluster are deployed in the same AZ, the pods will be scheduled to that AZ. • **Equivalent mode**: Deployment pods of the add-on are evenly scheduled to the nodes in the cluster in each AZ. If a new AZ is added, you are advised to increase add-on pods for cross-AZ HA deployment. With the Equivalent multi-AZ deployment, the difference between the number of add-on pods in different AZs will be less than or equal to 1. If resources in one of the AZs are insufficient, pods cannot be scheduled to that AZ. • **Required**: Deployment pods of the add-on will be forcibly scheduled to nodes in different AZs. If there are fewer AZs than pods, the extra pods will fail to run.
Node Affinity	• **Not configured**: Node affinity is disabled for the add-on. • **Node Affinity**: Specify the nodes where the add-on is deployed. If you do not specify the nodes, the add-on will be randomly scheduled based on the default cluster scheduling policy. • **Specified Node Pool Scheduling**: Specify the node pool where the add-on is deployed. If you do not specify the node pool, the add-on will be randomly scheduled based on the default cluster scheduling policy. • **Custom Policies**: Enter the labels of the nodes where the add-on is to be deployed for more flexible scheduling policies. If you do not specify node labels, the add-on will be randomly scheduled based on the default cluster scheduling policy. If multiple custom affinity policies are configured, ensure that there are nodes that meet all the affinity policies in the cluster. Otherwise, the add-on cannot run.

Parameter	Description
Toleration	Using both taints and tolerations allows (not forcibly) the add-on Deployment to be scheduled to a node with the matching taints, and controls the Deployment eviction policies after the node where the Deployment is located is tainted. The add-on adds the default tolerance policy for the **node.kubernetes.io/not-ready** and **node.kubernetes.io/unreachable** taints, respectively. The tolerance time window is 60s. For details, see **Taints and Tolerations**.

Step 5 Click **Install**.

----End

Components

Table 16-55 Add-on components

Component	Description	Resource Type
node-local-dns-admission-controller	Automatic DNSConfig injecting	Deployment
node-local-dns-cache	DNS cache proxy on nodes to improve the DNS performance of the cluster	DaemonSet

Using NodeLocal DNSCache

By default, application requests are sent through the CoreDNS proxy. To use node-local-dns as the DNS cache proxy, use any of the following methods:

- Auto injection: Automatically configure the **dnsConfig** field of the pod when creating the pod. (Pods cannot be automatically injected into system namespaces such as kube-system.)
- Manual configuration: Manually configure the **dnsConfig** field of the pod.

Auto injection

The following conditions must be met:

- **Automatic DNSConfig injection** has been enabled during the add-on installation.
- The **node-local-dns-injection=enabled** label has been added to the namespace. For example, run the following command to add the label to the **default** namespace:

kubectl label namespace *default* **node-local-dns-injection=enabled**

- The new pod does not run in system namespaces such as kube-system and kube-public namespace.
- The **node-local-dns-injection=disabled** label for disabling DNS injection is not added to the new pod.
- The new pod's **DNSPolicy** is **ClusterFirstWithHostNet**. Alternatively, the pod does not use the host network and **DNSPolicy** is **ClusterFirst**.

After auto injection is enabled, the following **dnsConfig** settings are automatically added to the created pod. In addition to the NodeLocal DNSCache address 169.254.20.10, the CoreDNS address 10.247.3.10 is added to **nameservers**, ensuring high availability of the service DNS server.

```
...
  dnsConfig:
    nameservers:
      - 169.254.20.10
      - 10.247.3.10
    searches:
      - default.svc.cluster.local
      - svc.cluster.local
      - cluster.local
    options:
      - name: timeout
        value: ''
      - name: ndots
        value: '5'
      - name: single-request-reopen
...
```

Manual configuration

Manually add the **dnsConfig** settings to the pod.

Create a pod and add the NodeLocal DNSCache IP address 169.254.20.10 to the DNSConfig nameservers configuration.

```
apiVersion: v1
kind: Pod
metadata:
  name: nginx
spec:
  containers:
  - image: nginx:alpine
    name: container-0
  dnsConfig:
    nameservers:
    - 169.254.20.10
    - 10.247.3.10
    searches:
    - default.svc.cluster.local
    - svc.cluster.local
    - cluster.local
    options:
    - name: ndots
      value: '2'
  imagePullSecrets:
  - name: default-secret
```

Uninstalling the Add-on

Uninstalling the add-on will affect the pods that have used the node-local-dns address for domain name resolution. Before uninstalling the add-on, delete the

node-local-dns-injection=enabled label from the involved namespaces, and delete and recreate the pods with this label.

Step 1 Check the add-on.

1. Log in to the CCE console and click the cluster name to access the cluster console. Choose **Add-ons** in the navigation pane, locate **NodeLocal DNSCache** on the right, and click **Edit**.
2. In the **Parameters** area, check whether **DNSConfig Automatic Injection** is enabled.

   If **DNSConfig Automatic Injection** has been enabled:

   a. In the navigation pane, choose **Namespaces**.
   b. Locate the rows that contain the namespaces with the **node-local-dns-injection=enabled** label and delete the label. For details, see **Managing Namespace Labels**.
   c. Delete the pods in these namespaces and recreate pods.

   If **DNSConfig Automatic Injection** has not been enabled:

   a. Use kubectl to access the cluster.
   b. Check the pods with DNSConfig manually injected. If multiple namespaces are involved, check all the pods in these namespaces.

      For example, to check pods in the **default** namespace, run the following command:

      ```
      kubectl get pod -n default -o yaml
      ```

   c. Manually remove DNSConfig and recreate pods.

Step 2 Uninstall NodeLocal DNSCache.

1. In the navigation pane, choose **Add-ons**. Locate **NodeLocal DNSCache** and click **Uninstall**.
2. In the displayed dialog box, click **Yes**.

----End

Helpful Links

Using NodeLocal DNSCache to Improve DNS Performance

16.16 Cloud Native Cluster Monitoring

Introduction

kube-prometheus-stack uses Prometheus-operator and Prometheus to provide easy-to-use, end-to-end Kubernetes cluster monitoring.

Open source community: **https://github.com/prometheus/prometheus**

Constraints

- By default, the kube-state-metrics component of the add-on does not collect labels and annotations of Kubernetes resources. To collect these labels and

annotations, manually enable the collection function in the startup parameters and check whether the corresponding metrics are added to the collection whitelist of ServiceMonitor named **kube-state-metrics**. For details, see **Collecting All Labels and Annotations of a Pod**.

- In 3.8.0 and later versions, component metrics in the kube-system and monitoring namespaces are not collected by default. If you have workloads in the two namespaces, use **Pod Monitor** or **Service Monitor** to collect these metrics.
- In 3.8.0 and later versions, etcd-server, kube-controller, kube-scheduler, autoscaler, fluent-bit, volcano-agent, volcano-scheduler and otel-collector metrics are not collected by default. Enable the collection as required.

  To enable this function, on the **ConfigMaps and Secrets** page, expand the dropdown list of **Namespace**, and select **monitoring**. Locate the row that contains the configuration item named **persistent-user-config**, and click **Edit YAML** in the operation column. Remove the **serviceMonitorDisable** or **podMonitorDisable** configuration in the **customSettings** field as required or set the configuration to an empty array.

  ```
  ...
    customSettings:
      podMonitorDisable: []
      serviceMonitorDisable: []
  ```

Permissions

The node-exporter component of the kube-prometheus-stack add-on needs to read the Docker info data from the **/var/run/docker.sock** directory on the host for monitoring the Docker disk space.

The following permission is required for running node-exporter:

- cap_dac_override: reads the Docker info data.

Installing the Add-on

Step 1 Log in to the CCE console and click the cluster name to access the cluster console. Choose **Add-ons** in the navigation pane, locate **Cloud Native Cluster Monitoring** on the right, and click **Install**.

Step 2 On the **Install Add-on** page, configure the specifications.

- **Deployment Mode**: This parameter is available for the kube-prometheus-stack version 3.7.1 or later.
  - **Agent mode**: Fewer resources than the server mode are needed. However, this mode does not support HPA.
  - **Server mode**: More resources than the agent mode are needed. In this mode, all kube-prometheus-stack functions are supported.
- **Containers**: component instance created by the add-on. For details, see **Components**. You can select or customize a specification as required.

Step 3 Configure related parameters.

- **Connect to Third Party**: To report Prometheus data to a third-party monitoring system, enter the address and token of the third-party monitoring system and determine whether to skip certificate authentication.

- **User-defined indicator collection**: Application metrics are automatically collected in the form of service discovery.
- **Prometheus HA**: The Prometheus-server, Prometheus-operator, thanos-query, custom-metrics-apiserver and alertmanager components are deployed in multi-instance mode in the cluster.
- **Install Grafana**: Use Grafana to visualize monitoring data. Grafana creates a 5 GiB storage volume by default. Uninstalling the add-on **will not delete this volume**. The default username and password for the first login are **admin**. You will be asked to change the password immediately after login.
- **Number of collected shards**: Collected targets are distributed among different Prometheus shards. This increases the upper limit of the metrics collection throughput but will consume more resources. Therefore, this parameter is recommended for large-scale clusters.
- **Collection Interval**: Configure the collection interval.
- **Storage**: Select the type and size of the disk for storing monitoring data. **After the add-on is uninstalled, the storage volumes are not deleted** if this add-on is deployed in the server mode.

  NOTE

  An available PVC named **pvc-prometheus-server** exists in namespace **monitoring** and will be used as the storage source.
- **Scheduling Policies**: Support node affinity, taint, and tolerations. Multiple scheduling policies can be configured. If no affinity node label key or toleration node taint key is configured, this function is disabled by default.
  - **Range**: You can select the add-on pods for which the scheduling policy takes effect. By default, the scheduling policy takes effect for all pods. If a pod is specified, the scheduling policies configured for all pods are overwritten.
  - **Affinity Node Label Key**: Enter a node label key to set node affinity for the add-on pods.
  - **Affinity Node Label Value**: Enter a node label value to set node affinity for the add-on pods.
  - **Toleration Node Taint Key**: A component can be scheduled to a node that has the taint key you specify.

Step 4 Click **Install**.

After the add-on is installed, you may need to perform the following operations:

- To use custom metrics to create an auto scaling policy, ensure that the add-on is in the server mode and then perform the following steps:
  a. Collect custom metrics reported by applications to Prometheus. For details, see **Monitoring Custom Metrics Using Cloud Native Cluster Monitoring**.
  b. Aggregate these custom metrics collected by Prometheus to the API server for the HPA policy to use. For details, see **Creating an HPA Policy Using Custom Metrics**.
- To use this add-on to provide system resource metrics (such as CPU and memory usage) for workload auto scaling, enable the Metric API. For details, see **Providing Resource Metrics Through the Metrics API**. After the

configuration, you can use Prometheus to collect system resource metrics. (This configuration is not recommended).

----End

Components

All Kubernetes resources created during kube-prometheus-stack add-on installation are created in the namespace named **monitoring**.

Table 16-56 Add-on components

Component	Description	Resource Type
prometheusOperator (workload name: prometheus-operator)	Deploys and manages the Prometheus Server based on CustomResourceDefinitions (CRDs), and monitors and processes the events related to these CRDs. It is the control center of the entire system.	Deployment
prometheus (workload name: prometheus-server)	A Prometheus Server cluster deployed by the operator based on the Prometheus CRDs that can be regarded as StatefulSets.	StatefulSet
alertmanager (workload name: alertmanager-alertmanager)	Alarm center of the add-on. It receives alarms sent by Prometheus and manages alarm information by deduplicating, grouping, and distributing.	StatefulSet
thanosSidecar	Available only in HA mode. Runs with prometheus-server in the same pod to implement persistent storage of Prometheus metric data.	Container
thanosQuery	Available only in HA mode. Entry for PromQL query when Prometheus is in HA scenarios. It can delete duplicate metrics from Store or Prometheus.	Deployment
adapter (workload name: custom-metrics-apiserver)	Aggregates custom metrics to the native Kubernetes API Server.	Deployment

Component	Description	Resource Type
kubeStateMetrics (workload name: kube-state-metrics)	Converts the Prometheus metric data into a format that can be identified by Kubernetes APIs. By default, the kube-state-metrics component does not collect all labels and annotations of Kubernetes resources. To collect all labels and annotations, see **Collecting All Labels and Annotations of a Pod**. **NOTE** If the components run in multiple pods, only one pod provides metrics.	Deployment
nodeExporter (workload name: node-exporter)	Deployed on each node to collect node monitoring data.	DaemonSet
grafana (workload name: grafana)	Visualizes monitoring data. Grafana creates a 5 GiB storage volume by default. Uninstalling the add-on will not delete this volume.	Deployment
clusterProblemDetector (workload name: cluster-problem-detector)	Monitors cluster exceptions.	Deployment

Providing Resource Metrics Through the Metrics API

Resource metrics of containers and nodes, such as CPU and memory usage, can be obtained through the Kubernetes Metrics API. Resource metrics can be directly accessed, for example, by using the **kubectl top** command, or used by HPA or CustomedHPA policies for auto scaling.

The add-on can provide the Kubernetes Metrics API that is disabled by default. To enable the API, create the following APIService object:

```
apiVersion: apiregistration.k8s.io/v1
kind: APIService
metadata:
  labels:
    app: custom-metrics-apiserver
    release: cceaddon-prometheus
  name: v1beta1.metrics.k8s.io
spec:
  group: metrics.k8s.io
  groupPriorityMinimum: 100
  insecureSkipTLSVerify: true
  service:
    name: custom-metrics-apiserver
    namespace: monitoring
    port: 443
  version: v1beta1
  versionPriority: 100
```

You can save the object as a file, name it **metrics-apiservice.yaml**, and run the following command:

```
kubectl create -f metrics-apiservice.yaml
```

Run the **kubectl top pod -n monitoring** command. If the following information is displayed, the Metrics API can be accessed:

```
# kubectl top pod -n monitoring
NAME                                          CPU(cores)   MEMORY(bytes)
......
custom-metrics-apiserver-d4f556ff9-l2j2m      38m          44Mi
......
```

NOTICE

To uninstall the add-on, run the following kubectl command and delete the APIService object. Otherwise, the metrics-server add-on cannot be installed due to residual APIService resources.

```
kubectl delete APIService v1beta1.metrics.k8s.io
```

Creating an HPA Policy Using Custom Metrics

HPA policies can only be used when Cloud Native Cluster Monitoring is deployed in the server mode. You can configure custom metrics required by HPA policies in the **user-adapter-config** ConfigMap.

NOTICE

To use Prometheus to monitor custom metrics, the application needs to provide a metric monitoring API. For details, see **Prometheus Monitoring Data Collection**.

In this section, the nginx metric (nginx_connections_accepted) in **Monitoring Custom Metrics Using Cloud Native Cluster Monitoring** 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 **ConfigMaps and Secrets**.

Step 2 Click the **ConfigMaps** tab, select the **monitoring** namespace, locate the row containing **user-adapter-config** (or **adapter-config**), and click **Update**.

Step 3 In **Data**, click **Edit** for the **config.yaml** file to add a custom metric collection rule under the **rules** field. Click **OK**.

You can add multiple collection rules by adding multiple configurations under the **rules** field. For details, see **Metrics Discovery and Presentation Configuration**.

Example custom metric rule:

```
rules:
# Match the metric whose name is nginx_connections_accepted. The metric name must be confirmed. Otherwise, the HPA controller cannot get the metric.
- seriesQuery: '{__name__=~"nginx_connections_accepted",container!="POD",namespace!="",pod!=""}'
  resources:
    # Specify pod and namespace resources.
    overrides:
      namespace:
        resource: namespace
```

```
    pod:
      resource: pod
  name:
    #Use nginx_connections_accepted"
    matches: "nginx_connections_accepted"
    #Use nginx_connections_accepted_per_second to represent the metric. The name is the custom metric name in a custom HPA policy.
    as: "nginx_connections_accepted_per_second"
    # Calculate rate(nginx_connections_accepted[2m]) to specify the number of requests received per second.
  metricsQuery: 'rate(<<.Series>>{<<.LabelMatchers>>,container!="POD"}[2m])'
```

Step 4 Redeploy the **custom-metrics-apiserver** workload in the **monitoring** namespace.

Step 5 In the navigation pane, choose **Workloads**. Locate the workload for which you want to create an HPA policy and choose **More** > **Auto Scaling**. In the **Custom Policy** area, you can select the preceding parameters to create an auto scaling policy.

----End

Collecting All Labels and Annotations of a Pod

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 Switch to the **monitoring** namespace, find the **kube-state-metrics** workload on the **Deployments** tab page, and click **Upgrade** in the **Operation** column.

Step 3 In the **Lifecycle** area of the container settings, edit the startup command.

To collect labels, add the following information to the end of the original **kube-state-metrics** startup parameter:

```
--metric-labels-allowlist=pods=[*],nodes=[node,failure-domain.beta.kubernetes.io/zone,topology.kubernetes.io/zone]
```

To collect annotations, add parameters in the startup parameters in the same way.

```
--metric-annotations-allowlist=pods=[*],nodes=[node,failure-domain.beta.kubernetes.io/zone,topology.kubernetes.io/zone]
```

NOTICE

When editing the startup command, do not modify other original startup parameters. Otherwise, the component may be abnormal.

Step 4 **kube-state-metrics** starts to collect the labels/annotations of pods and nodes and checks whether **kube_pod_labels/kube_pod_annotations** is in the collection task of CloudScope.

```
kubectl get servicemonitor kube-state-metrics -nmonitoring -oyaml | grep kube_pod_labels
```

----End

For more kube-state-metrics startup parameters, see **kube-state-metrics/cli-arguments**.

16.17 web-terminal (EOM)

The web-terminal add-on is a lightweight terminal server that allows you to use kubectl on the web UI. It provides a remote command-line interface (CLI) via web

browser and HTTP, and can be easily integrated into an independent system. You can directly access the add-on as a service to obtain information and log in to a server through cmdb.

web-terminal can run on all operating systems supported by Node.js and does not depend on local modules. It is fast and easy to install and supports multiple sessions.

Open source community: **https://github.com/rabchev/web-terminal**

Constraints

- This add-on can be installed only in clusters of v1.21 or earlier. Arm clusters are not supported.
- web-terminal is no longer evolved.
- The web-terminal add-on can be used only after CoreDNS is installed in a cluster.

Precautions

The web-terminal add-on can be used to manage CCE clusters. Keep the login password secure to prevent unexpected operation.

Installing the Add-on

Step 1 Log in to the CCE console and click the cluster name to access the cluster console. Choose **Add-ons** in the navigation pane, locate **web-terminal** on the right, and click **Install**.

Step 2 Configure the following parameters:

- **Access Mode**: The value is fixed to **NodePort**. The web-terminal add-on is accessed in the NodePort mode by default and can be used only if any node in the cluster has an EIP. If this access type is selected, an EIP must be bound to the cluster where web-terminal will be installed.
- **Username**: The default value is **root** and cannot be changed.
- **Password**: password for logging in to web-terminal. Keep secure the password. The web-terminal add-on can be used to manage CCE clusters. Keep the login password secure to prevent unexpected operation.
- **Confirm Password**: Enter the password again.

Step 3 Click **Install**.

----End

Connecting to a Cluster Using the web-terminal Add-on

Step 1 Log in to the CCE console and click the cluster name to access the cluster console. Choose **Add-ons** in the navigation pane.

Step 2 Find **web-terminal** on the right and click **Access**.

----End

16.18 Prometheus

Introduction

Prometheus is an open-source system monitoring and alerting framework. It is derived from Google's borgmon monitoring system, which was created by former Google employees working at SoundCloud in 2012. Prometheus was developed as an open-source community project and officially released in 2015. In 2016, Prometheus officially joined the Cloud Native Computing Foundation, after Kubernetes.

CCE allows you to quickly install Prometheus as an add-on.

Official website of Prometheus: **https://prometheus.io/**

Open source community: **https://github.com/prometheus/prometheus**

Constraints

The Prometheus add-on is supported only in clusters of v1.21 and earlier. For clusters of v1.23 and later, use add-on **Cloud Native Cluster Monitoring**.

Features

As a next-generation monitoring framework, Prometheus has the following features:

- Powerful multi-dimensional data model
  a. Time series data is identified by metric name and key-value pair.
  b. Multi-dimensional labels can be set for all metrics.
  c. Data models do not require dot-separated character strings.
  d. Data models can be aggregated, cut, and sliced.
  e. The double floating-point format is supported. Labels can all be set to unicode.
- Flexible and powerful query statement (PromQL): One query statement supports addition, multiplication, and connection for multiple metrics.
- Easy to manage: The Prometheus server is a separate binary file that can work locally. It does not depend on distributed storage.
- Efficient: Each sampling point occupies only 3.5 bytes, and one Prometheus server can process millions of metrics.
- The pull mode is used to collect time series data, which facilitates local tests and prevents faulty servers from pushing bad metrics.
- Time series data can be pushed to the Prometheus server in push gateway mode.
- Users can obtain the monitored targets through service discovery or static configuration.
- Multiple visual GUIs are available.
- Easy to scale

Installing the Add-on

Step 1 Log in to the CCE console and click the cluster name to access the cluster console. Choose **Add-ons** in the navigation pane, locate **Prometheus** on the right, and click **Install**.

Step 2 In the **Configuration** step, set the following parameters:

Table 16-57 Prometheus add-on parameters

Parameter	Description
Add-on Specifications	Select an add-on specification based on service requirements. The options are as follows: • **Demo(<= 100 containers)**: The specification type applies to the experience and function demonstration environment. In this specification, Prometheus occupies few resources but has limited processing capabilities. You are advised to use this specification when the number of containers in the cluster does not exceed 100. • **Small(<= 2000 containers)**: You are advised to use this specification when the number of containers in the cluster does not exceed 2,000. • **Medium(<= 5000 containers)**: You are advised to use this specification when the number of containers in the cluster does not exceed 5000. • **Large(> 5000 containers)**: You are advised to use this specification when the number of containers in the cluster exceeds 5,000.
Pods	Number of pods that will be created to match the selected add-on specifications. The number cannot be modified.
Containers	CPU and memory quotas of the container allowed for the selected add-on specifications. The quotas cannot be modified.
Data Retention (days)	Number of days for storing customized monitoring data. The default value is 15 days.

Parameter	Description
Storage	Cloud hard disks can be used as storage. Set the following parameters as prompted: • **AZ**: Set this parameter based on the site requirements. An AZ is a physical region where resources use independent power supply and networks. AZs are physically isolated but interconnected through an internal network. • **Disk Type**: Common I/O, high I/O, and ultra-high I/O are supported. • **Capacity**: Enter the storage capacity based on service requirements. The default value is 10 GB. **NOTE** If a PVC already exists in the namespace monitoring, the configured storage will be used as the storage source.

Step 3 Click **Install**. After the installation, the add-on deploys the following instances in the cluster.

- prometheus-operator: deploys and manages the Prometheus Server based on CustomResourceDefinitions (CRDs), and monitors and processes the events related to these CRDs. It is the control center of the entire system.
- prometheus (server): a Prometheus Server cluster deployed by the operator based on the Prometheus CRDs that can be regarded as StatefulSets.
- prometheus-kube-state-metrics: converts the Prometheus metric data into a format that can be identified by Kubernetes APIs.
- custom-metrics-apiserver: aggregates custom metrics to the native Kubernetes API server.
- prometheus-node-exporter: deployed on each node to collect node monitoring data.
- grafana: visualizes monitoring data.

----End

Providing Resource Metrics Through the Metrics API

Resource metrics of containers and nodes, such as CPU and memory usage, can be obtained through the Kubernetes Metrics API. Resource metrics can be directly accessed, for example, by using the **kubectl top** command, or used by HPA or CustomedHPA policies for auto scaling.

The add-on can provide the Kubernetes Metrics API that is disabled by default. To enable the API, create the following APIService object:

```
apiVersion: apiregistration.k8s.io/v1
kind: APIService
metadata:
  labels:
    app: custom-metrics-apiserver
    release: cceaddon-prometheus
  name: v1beta1.metrics.k8s.io
spec:
```

```
group: metrics.k8s.io
groupPriorityMinimum: 100
insecureSkipTLSVerify: true
service:
  name: custom-metrics-apiserver
  namespace: monitoring
  port: 443
version: v1beta1
versionPriority: 100
```

You can save the object as a file, name it **metrics-apiservice.yaml**, and run the following command:

```
kubectl create -f metrics-apiservice.yaml
```

Run the **kubectl top pod -n monitoring** command. If the following information is displayed, the Metrics API can be accessed:

```
# kubectl top pod -n monitoring
NAME                                        CPU(cores)   MEMORY(bytes)
......
custom-metrics-apiserver-d4f556ff9-l2j2m                 38m          44Mi
......
```

NOTICE

To uninstall the add-on, run the following kubectl command and delete the APIService object. Otherwise, the metrics-server add-on cannot be installed due to residual APIService resources.

```
kubectl delete APIService v1beta1.metrics.k8s.io
```

Reference

- For details about the Prometheus concepts and configurations, see the **Prometheus Official Documentation**.
- For details about how to install Node Exporter, see the **node_exporter GitHub**.

17 Helm Chart

17.1 Overview

CCE provides a console for managing Helm charts, helping you easily deploy applications using the charts and manage applications on the console.

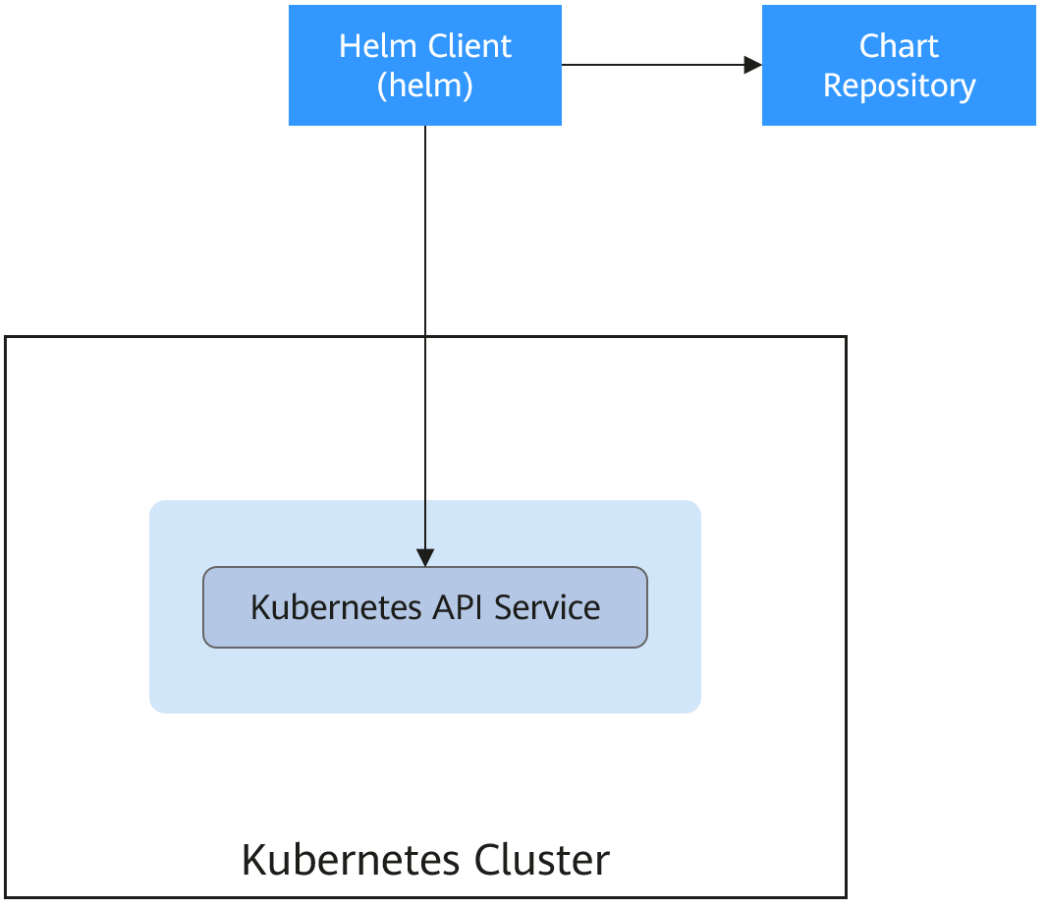
Helm

Helm is a package manager for Kubernetes and manages charts. A Helm chart is a series of YAML files used to encapsulate native Kubernetes applications. When deploying an application, you can customize some metadata of the application for easy application distribution. Application releasers can use Helm to package applications, manage application dependencies and application versions, and release applications to the software repository. After using Helm, users do not need to compile complex application deployment files. They can easily search for, install, upgrade, roll back, and uninstall applications on Kubernetes.

The relationship between Helm and Kubernetes is as follows:

- Helm <–> Kubernetes
- Apt <–> Ubuntu
- Yum <–> CentOS
- Pip <–> Python

The following figure shows the solution architecture:



Helm can help application orchestration for Kubernetes:

- Manages, edits, and updates a large number of Kubernetes configuration files.
- Deploys a complex Kubernetes application that contains a large number of configuration files.
- Shares and reuses Kubernetes configurations and applications.
- Supports multiple environments with parameter-based configuration templates.
- Manages the release of applications, including rolling back the application, finding differences (using the **diff** command), and viewing the release history.
- Controls phases in a deployment cycle.
- Tests and verifies the released version.

17.2 Deploying an Application from a Chart

On the CCE console, you can upload a Helm chart package, deploy it, and manage the deployed pods.

Constraints

- The number of charts that can be uploaded by a single user is limited. The value displayed on the console of each region is the allowed quantity.

- A chart with multiple versions consumes the same amount of portion of chart quota.
- Users with chart operation permissions can perform multiple operations on clusters. Therefore, exercise caution when assigning users the chart lifecycle management permissions, including uploading charts and creating, deleting, and updating chart releases.

Chart Specifications

The Redis workload is used as an example to illustrate the chart specifications.

- **Naming Requirement**

  A chart package is named in the format of **{name}-{version}**.tgz, where **{version}** indicates the version number in the format of *Major version number.Minor version number.Revision number*, for example, **redis-0.4.2.tgz**.

  NOTE

  The chart name {name} can contain a maximum of 64 characters.

  The version number must comply with the **semantic versioning** rules.

  - The main and minor version numbers are mandatory, and the revision number is optional.
  - The major and minor version numbers and revision number must be integers, greater than or equal to 0, and less than or equal to 99.

- **Directory Structure**

  The directory structure of a chart is as follows:

```
redis/
  templates/
  values.yaml
  README.md
  Chart.yaml
  .helmignore
```

  As listed in **Table 17-1**, the parameters marked with * are mandatory.

Table 17-1 Parameters in the directory structure of a chart

Parameter	Description
* templates	Stores all templates.
* values.yaml	Describes configuration parameters required by templates. **NOTICE** Make sure that the image address set in the **values.yaml** file is the same as the image address in the container image repository. Otherwise, an exception occurs when you create a workload, and the system displays a message indicating that the image fails to be pulled. To obtain the image address, perform the following operations: Log in to the CCE console. In the navigation pane, choose **Image Repository** to access the SWR console. Choose **My Images** > **Private Images** and click the name of the uploaded image. On the **Image Tags** tab page, obtain the image address from the pull command. You can click to copy the command in the **Image Pull Command** column.

Parameter	Description
README.md	A markdown file, including: • The workload or services provided by the chart. • Prerequisites for running the chart. • Configurations in the **values.yaml** file. • Information about chart installation and configuration.
* Chart.yaml	Basic information about the chart. Note: The API version of Helm v3 is switched from v1 to v2.
.helmignore	Files or data that does not need to read templates during workload installation.

Uploading a Chart

Step 1 Log in to the CCE console and click the cluster name to access the cluster console. Choose **App Templates** in the navigation pane and click **Upload Chart** in the upper right corner.

Step 2 Click **Select File**, select the chart to be uploaded, and click **Upload**.

NOTE

When you upload a chart, the naming rule of the OBS bucket is changed from cce-charts-{*region*}-{**domain_name**} to cce-charts-{*region*}-{**domain_id**}. In the old naming rule, the system converts the **domain_name** value into a Base64 string and uses the first 63 characters. If you cannot find the chart in the OBS bucket with the new name, search for the bucket with the old name.

----End

Creating a Release

Step 1 Log in to the CCE console and click the cluster name to access the cluster console. In the navigation pane, choose **App Templates**.

Step 2 On the **My Charts** tab page, click **Install** of the target chart.

Step 3 Set workload installation parameters by referring to **Table 17-2**.

Table 17-2 Installation parameters

Parameter	Description
Instance	Unique name of the chart release.
Namespace	Namespace to which the workload will be deployed.
Select Version	Version of a chart.

Parameter	Description
Configuration File	You can import and replace the **values.yaml** file or directly edit the chart parameters online. **NOTE** An imported **values.yaml** file must comply with YAML specifications, that is, KEY:VALUE format. The fields in the file are not restricted. The key value of the imported values.yaml must be the same as that of the selected chart package. Otherwise, the values.yaml does not take effect. That is, the key cannot be changed. 1. Click **Select File**. 2. Select the corresponding **values.yaml** file and click **Open**.

Step 4 Click **Install**.

On the **Releases** tab page, you can view the installation status of the release.

----End

Upgrading a Chart-based Workload

Step 1 Log in to the CCE console and click the cluster name to access the cluster console. Choose **App Templates** in the navigation pane and click the **Releases** tab.

Step 2 Click **Upgrade** in the row where the desired workload resides and set the parameters for the workload.

Step 3 Select a chart version for **Chart Version**.

Step 4 Follow the prompts to modify the chart parameters. Confirm the modification and click **Upgrade**.

Step 5 If the execution status is **Upgraded**, the workload has been upgraded.

----End

Rolling Back a Chart-based Workload

Step 1 Log in to the CCE console and click the cluster name to access the cluster console. Choose **App Templates** in the navigation pane and click the **Releases** tab.

Step 2 Click **More** > **Roll Back** for the workload to be rolled back, select the workload version, and click **Roll back to this version**.

In the workload list, if the status is **Rollback successful**, the workload is rolled back successfully.

----End

Uninstalling a Chart-based Workload

Step 1 Log in to the CCE console and click the cluster name to access the cluster console. Choose **App Templates** in the navigation pane and click the **Releases** tab.

Step 2 Click **More** > **Uninstall** next to the release to be uninstalled, and click **Yes**. Exercise caution when performing this operation because releases cannot be restored after being uninstalled.

----End

17.3 Differences Between Helm v2 and Helm v3 and Adaptation Solutions

Helm v2 stops at version 2.17.0. Currently, Helm v3 is the standard in the Helm community. You are advised to switch your charts to **Helm v3 format** as soon as possible.

Changes since Helm v2:

1. **Removal of Tiller**

   Helm v3 is simpler and easier to use. It removes tiller and directly connects to the API server using kubeconfig, simplifying the security model.

2. **Improved upgrade strategy: 3-way strategic merge patches**

   Helm v2 used a two-way strategic merge patch. During an upgrade, it compared the most recent chart's manifest against the proposed chart's manifest to determine what changes needed to be applied to the resources in Kubernetes. If changes were applied to the cluster out-of-band (such as during a kubectl edit), those changes were not considered. This resulted in resources being unable to roll back to its previous state.

   Helm v3 uses a three-way strategic merge patch. Helm considers the old manifest, its live state, and the new manifest when generating a patch. Helm compares the current live state with the live state of the old manifest, checks whether the new manifest is modified, and automatically supplements the new manifest to generate the final update patch.

   For details and examples, see **https://v3.helm.sh/docs/faq/changes_since_helm2**.

3. **Secrets as the default storage driver**

   Helm v2 used ConfigMaps by default to store release information. In Helm v3, Secrets are now used as the default storage driver.

4. **Release names are now scoped to the namespace**

   In Helm v2, the information about each release was stored in the same namespace as Tiller. In practice, this meant that once a name was used by a release, no other release could use that same name, even if it was deployed in a different namespace. In Helm v3, information about a particular release is now stored in the same namespace as the release itself. This means that the release name can be used in different namespaces. The namespace of the application is the same as that of the release.

5. **Verification mode change**

   Helm v3 verifies the chart format more strictly. For example, Helm v3 bumps the apiVersion in Chart.yaml from v1 to v2. For the Chart.yaml of v2, apiVersion must be set to v1. After installing the Helm v3 client, you can run the **helm lint** command to check whether the chart format complies with the Helm v3 specifications.

Adaptation solution: Adapt the Helm v3 chart based on the Helm official document **https://helm.sh/docs/topics/charts/**. The **apiVersion** field is mandatory.

6. **Removal of the crd-install hook**

   The **crd-install** hook has been removed in favor of the **crds/** directory in Helm v3. Note that the resources in the **crds/** directory are deployed only during the release installation and are not updated during the upgrade. When the resources are deleted, the resources are retained in the **crds/** directory. If the CRD already exists, it will be skipped with a warning during the repeated installation.

   Adaptation solution: According to the **Helm document**, you can hold your CRD in the **crds/** directory or a separate chart. Helm cannot upgrade or delete the CRD. Therefore, you are advised to put the CRD in one chart, and then put any resources that use that CRD in another chart.

7. **Resources that are not created using Helm are not forcibly updated. Releases are not forcibly upgraded by default.**

   The forcible upgrade logic of Helm v3 is changed. After the upgrade fails, the system does not delete and rebuild the Helm v3. Instead, the system directly uses the **put** logic. Therefore, the CCE release upgrade uses the non-forcible update logic by default. Resources that cannot be updated through patches will make the release unable to be upgraded. If a release with the same name exists in the environment and does not have the home tag **app.kubernetes.io/managed-by: Helm** of Helm v3, a conflict message is displayed.

   Adaptation solution: Delete related resources and create them using Helm.

8. **Limit on release historical records**

   Only the latest 10 release versions are retained by default.

For more changes and details, see Helm official documents.

- Differences between Helm v2 and Helm v3: **https://v3.helm.sh/docs/faq/changes_since_helm2**
- How to migrate from Helm v2 to Helm v3: **https://helm.sh/docs/topics/v2_v3_migration**

17.4 Deploying an Application Through the Helm v2 Client

Prerequisites

The Kubernetes cluster created on CCE has been connected to kubectl. For details, see **Using kubectl**.

Installing Helm v2

This section uses Helm v2.17.0 as an example.

For other versions, visit **https://github.com/helm/helm/releases**.

Step 1 Download the Helm client from the VM connected to the cluster.

```
wget https://get.helm.sh/helm-v2.17.0-linux-amd64.tar.gz
```

Step 2 Decompress the Helm package.

```
tar -xzvf helm-v2.17.0-linux-amd64.tar.gz
```

Step 3 Copy Helm to the system path, for example, **/usr/local/bin/helm**.

```
mv linux-amd64/helm /usr/local/bin/helm
```

Step 4 RBAC is enabled on the Kubernetes API server. Create the service account name **tiller** for the tiller and assign cluster-admin, a system ClusterRole, to the tiller. Create a tiller resource account as follows:

vim tiller-rbac.yaml

```
apiVersion: v1
kind: ServiceAccount
metadata:
  name: tiller
  namespace: kube-system
---
apiVersion: rbac.authorization.k8s.io/v1
kind: ClusterRoleBinding
metadata:
  name: tiller
roleRef:
  apiGroup: rbac.authorization.k8s.io
  kind: ClusterRole
  name: cluster-admin
subjects:
  - kind: ServiceAccount
    name: tiller
    namespace: kube-system
```

Step 5 Deploy the tiller resource account.

```
kubectl apply -f tiller-rbac.yaml
```

Step 6 Initialize the Helm and deploy the pod of tiller.

```
helm init --service-account tiller --skip-refresh
```

Step 7 Query the status.

```
kubectl get pod -n kube-system -l app=helm
```

Command output:

```
NAME                            READY   STATUS    RESTARTS   AGE
tiller-deploy-7b56c8dfb7-fxk5g   1/1     Running   1          23h
```

Step 8 Query the Helm version.

```
# helm version
Client: &version.Version{SemVer:"v2.17.0", GitCommit:"a690bad98af45b015bd3da1a41f6218b1a451dbe",
GitTreeState:"clean"}
Server: &version.Version{SemVer:"v2.17.0", GitCommit:"a690bad98af45b015bd3da1a41f6218b1a451dbe",
GitTreeState:"clean"}
```

----End

Installing the Helm Chart

If the charts provided by CCE do not meet requirements, download a chart and install it.

You can obtain the required chart in the **stable** directory on this **website**, download the chart, and upload it to the node.

1. Download and decompress the obtained chart. Generally, the chart is in ZIP format.
   ```
   unzip chart.zip
   ```
2. Install the Helm chart.
   ```
   helm install aerospike/
   ```
3. After the installation is complete, run the **helm list** command to check the status of the chart releases.

Common Issues

- The following error message is displayed after the **Helm version** command is run:
  ```
  Client:
  &version.Version{SemVer:"v2.17.0",
  GitCommit:"a690bad98af45b015bd3da1a41f6218b1a451dbe", GitTreeState:"clean"}
  E0718 11:46:10.132102    7023 portforward.go:332] an error occurred
  forwarding 41458 -> 44134: error forwarding port 44134 to pod
  d566b78f997eea6c4b1c0322b34ce8052c6c2001e8edff243647748464cd7919, uid : unable
  to do port forwarding: socat not found.
  Error: cannot connect to Tiller
  ```
  The preceding information is displayed because the socat is not installed. Run the following command to install the socat:
  ```
  yum install socat -y
  ```
- When the socat has been installed and the following error message is displayed after the **helm version** command is run:
  ```
  test@local:~/k8s/helm/test$ helm version
  Client: &version.Version{SemVer:"v3.3.0",
  GitCommit:"021cb0ac1a1b2f888144ef5a67b8dab6c2d45be6", GitTreeState:"clean"}
  Error: cannot connect to Tiller
  ```
  The Helm chart reads the configuration certificate from the **.Kube/config** file to communicate with Kubernetes. The preceding error indicates that the kubectl configuration is incorrect. In this case, reconnect the cluster to kubectl. For details, see **Using kubectl**.
- Storage fails to be created after you have connected to cloud storage services.

  This issue may be caused by the **annotation** field in the created PVC. Change the chart name and install the chart again.
- If kubectl is not properly configured, the following error message is displayed after the **helm install** command is run:
  ```
  [root@prometheus-57046 ~]# helm install prometheus/ --generate-name
  WARNING: This chart is deprecated
  Error: Kubernetes cluster unreachable: Get "http://localhost:8080/version?timeout=32s": dial tcp
  [::1]:8080: connect: connection refused
  ```
  Solution: Configure kubeconfig for the node. For details, see **Using kubectl**.

17.5 Deploying an Application Through the Helm v3 Client

Prerequisites

- The Kubernetes cluster created on CCE has been connected to kubectl. For details, see **Using kubectl**.
- To pull a public image when deploying Helm, ensure an EIP has been bound to the node.

Installing Helm v3

This section uses Helm v3.3.0 as an example.

For other versions, visit **https://github.com/helm/helm/releases**.

Step 1 Download the Helm client from the VM connected to the cluster.

```
wget https://get.helm.sh/helm-v3.3.0-linux-amd64.tar.gz
```

Step 2 Decompress the Helm package.

```
tar -xzvf helm-v3.3.0-linux-amd64.tar.gz
```

Step 3 Copy Helm to the system path, for example, **/usr/local/bin/helm**.

```
mv linux-amd64/helm /usr/local/bin/helm
```

Step 4 Query the Helm version.

```
helm version
version.BuildInfo{Version:"v3.3.0", GitCommit:"e29ce2a54e96cd02ccfce88bee4f58bb6e2a28b6",
GitTreeState:"clean", GoVersion:"go1.13.4"}
```

----End

Installing the Helm Chart

You can use Helm to install a chart. Before using Helm, you may need to understand the following concepts to better use Helm:

- Chart: contains resource definitions and a large number of configuration files of Kubernetes applications.
- Repository: stores shared charts. You can download charts from the repository to a local path for installation or install them online.
- Release: running result of after a chart is installed in a Kubernetes cluster using Helm. A chart can be installed multiple times in a cluster. A new release will be created for each installation. A MySQL chart is used as an example. To run two databases in a cluster, install the chart twice. Each database has its own release and release name.

For more details, see **Using Helm**.

Step 1 Search for a chart from the **Artifact Hub** repository recommended by Helm and configure the Helm repository.

```
helm repo add {repo_name} {repo_addr}
```

The following uses the **WordPress chart** as an example:

```
helm repo add bitnami https://charts.bitnami.com/bitnami
```

Step 2 Run the **helm install** command to install the chart.

```
helm install {release_name} {chart_name} --set key1=val1
```

For example, to install WordPress, the WordPress chart added in **Step 1** is **bitnami/wordpress**, the release name is **my-wordpress**, and mandatory parameters have been configured.

```
helm install my-wordpress bitnami/wordpress \
    --set mariadb.primary.persistence.enabled=true \
    --set mariadb.primary.persistence.storageClass=csi-disk \
    --set mariadb.primary.persistence.size=10Gi \
    --set persistence.enabled=false
```

Run the **helm show values** *{chart_name}* command to view the configurable options of the chart. For example, to view the configurable items of WordPress, run the following command:

```
helm show values bitnami/wordpress
```

Step 3 View the installed chart release.

```
helm list
```

----End

Common Issues

- The following error message is displayed after the **helm version** command is run:

  ```
  Client:
  &version.Version{SemVer:"v3.3.0",
  GitCommit:"012cb0ac1a1b2f888144ef5a67b8dab6c2d45be6", GitTreeState:"clean"}
  E0718 11:46:10.132102    7023 portforward.go:332] an error occurred
  forwarding 41458 -> 44134: error forwarding port 44134 to pod
  d566b78f997eea6c4b1c0322b34ce8052c6c2001e8edff243647748464cd7919, uid : unable
  to do port forwarding: socat not found.
  Error: cannot connect to Tiller
  ```

  The preceding information is displayed because the socat is not installed. Run the following command to install the socat:

  ```
  yum install socat -y
  ```

- When the socat has been installed and the following error message is displayed after the **helm version** command is run:

  ```
  $ helm version
  Client: &version.Version{SemVer:"v3.3.0",
  GitCommit:"021cb0ac1a1b2f888144ef5a67b8dab6c2d45be6", GitTreeState:"clean"}
  Error: cannot connect to Tiller
  ```

  The Helm chart reads the configuration certificate in **.Kube/config** to communicate with Kubernetes. The preceding error indicates that the kubectl configuration is incorrect. In this case, reconnect the cluster to kubectl. For details, see **Using kubectl**.

- Storage fails to be created after you have connected to cloud storage services.

  This issue may be caused by the **annotation** field in the created PVC. Change the chart name and install the chart again.

- If kubectl is not properly configured, the following error message is displayed after the **helm install** command is run:

  ```
  # helm install prometheus/ --generate-name
  WARNING: This chart is deprecated
  Error: Kubernetes cluster unreachable: Get "http://localhost:8080/version?timeout=32s": dial tcp
  [::1]:8080: connect: connection refused
  ```

  Solution: Configure kubeconfig for the node. For details, see **Using kubectl**.

17.6 Converting a Release from Helm v2 to v3

Context

CCE fully supports Helm v3. This section guides you to convert a Helm v2 release to Helm v3. Helm v3 discards or reconstructs some Helm v2 functions at the bottom layer. Therefore, the conversion is risky to some extent. Simulation is required before conversion.

For details, see the **community documentation**.

Precautions

- Helm v2 stores release information in ConfigMaps. Helm v3 does so in secrets.
- When you query, update, or operate a Helm v2 release on the CCE console, CCE will attempt to convert the release to v3. If you operate in the background, convert the release by following the instructions below.

Conversion Process (Without Using the Helm v3 Client)

Step 1 Download the helm 2-to-3 conversion plugin on the CCE node.

```
wget https://github.com/helm/helm-2to3/releases/download/v0.10.2/helm-2to3_0.10.2_linux_amd64.tar.gz
```

Step 2 Decompress the plugin package.

```
tar -xzvf helm-2to3_0.10.2_linux_amd64.tar.gz
```

Step 3 Perform the simulated conversion.

Take the test-convert release as an example. Run the following command to simulate the conversion: If the following information is displayed, the simulation is successful.

```
# ./2to3 convert --dry-run --tiller-out-cluster -s configmaps test-convert
NOTE: This is in dry-run mode, the following actions will not be executed.
Run without --dry-run to take the actions described below:
Release "test-convert" will be converted from Helm v2 to Helm v3.
[Helm 3] Release "test-convert" will be created.
[Helm 3] ReleaseVersion "test-convert.v1" will be created.
```

Step 4 Perform the conversion. If the following information is displayed, the conversion is successful.

```
# ./2to3 convert --tiller-out-cluster -s configmaps test-convert
Release "test-convert" will be converted from Helm v2 to Helm v3.
[Helm 3] Release "test-convert" will be created.
[Helm 3] ReleaseVersion "test-convert.v1" will be created.
[Helm 3] ReleaseVersion "test-convert.v1" created.
[Helm 3] Release "test-convert" created.
Release "test-convert" was converted successfully from Helm v2 to Helm v3.
Note: The v2 release information still remains and should be removed to avoid conflicts with the migrated v3 release.
v2 release information should only be removed using `helm 2to3` cleanup and when all releases have been migrated over.
```

Step 5 After the conversion is complete, simulate the resource clearance. After the simulation, clear the v2 release resources.

Simulated clearance:

```
# ./2to3 cleanup --dry-run --tiller-out-cluster -s configmaps --name test-convert
NOTE: This is in dry-run mode, the following actions will not be executed.
Run without --dry-run to take the actions described below:
WARNING: "Release 'test-convert' Data" will be removed.

[Cleanup/confirm] Are you sure you want to cleanup Helm v2 data? [y/N]: y
Helm v2 data will be cleaned up.
[Helm 2] Release 'test-convert' will be deleted.
[Helm 2] ReleaseVersion "test-convert.v1" will be deleted.
```

Formal clearance:

```
# ./2to3 cleanup --tiller-out-cluster -s configmaps --name test-convert
WARNING: "Release 'test-convert' Data" will be removed.
```

```
[Cleanup/confirm] Are you sure you want to cleanup Helm v2 data? [y/N]: y
Helm v2 data will be cleaned up.
[Helm 2] Release 'test-convert' will be deleted.
[Helm 2] ReleaseVersion "test-convert.v1" will be deleted.
[Helm 2] ReleaseVersion "test-convert.v1" d
```

----End

Conversion Process (Using the Helm v3 Client)

Step 1 Install the Helm v3 client. For details, see **Installing Helm v3**.

Step 2 Install the conversion plugin.

```
# helm plugin install https://github.com/helm/helm-2to3
Downloading and installing helm-2to3 v0.10.2 ...
https://github.com/helm/helm-2to3/releases/download/v0.10.2/helm-2to3_0.10.2_linux_amd64.tar.gz
Installed plugin: 2to3
```

Step 3 Check whether the plugin has been installed.

```
# helm plugin list
NAME VERSION DESCRIPTION
2to3  0.10.2      migrate and cleanup Helm v2 configuration and releases in-place to Helm v3
```

Step 4 Perform the simulated conversion.

Take the test-convert release as an example. Run the following command to simulate the conversion: If the following information is displayed, the simulated conversion is successful.

```
# helm 2to3 convert --dry-run --tiller-out-cluster -s configmaps test-convert
NOTE: This is in dry-run mode, the following actions will not be executed.
Run without --dry-run to take the actions described below:
Release "test-convert" will be converted from Helm v2 to Helm v3.
[Helm 3] Release "test-convert" will be created.
[Helm 3] ReleaseVersion "test-convert.v1" will be created.
```

Step 5 Perform the conversion. If the following information is displayed, the conversion is successful.

```
# helm 2to3 convert --tiller-out-cluster -s configmaps test-convert
Release "test-convert" will be converted from Helm v2 to Helm v3.
[Helm 3] Release "test-convert" will be created.
[Helm 3] ReleaseVersion "test-convert.v1" will be created.
[Helm 3] ReleaseVersion "test-convert.v1" created.
[Helm 3] Release "test-convert" created.
Release "test-convert" was converted successfully from Helm v2 to Helm v3.
Note: The v2 release information still remains and should be removed to avoid conflicts with the migrated v3 release.
v2 release information should only be removed using `helm 2to3` cleanup and when all releases have been migrated over.
```

Step 6 After the conversion, you can view the converted release by running **helm list**.

```
# helm list
NAME              NAMESPACE    REVISION UPDATED                         STATUS      CHART            APP VERSION
test-convert      default   1            2022-08-29 06:56:28.166918487 +0000 UTC      deployed    test-helmold-1
```

Step 7 After the conversion is complete, simulate the resource clearance. After the simulation, clear the v2 release resources.

Simulated clearance:

```
# helm 2to3 cleanup --dry-run --tiller-out-cluster -s configmaps --name test-convert
NOTE: This is in dry-run mode, the following actions will not be executed.
```

```
Run without --dry-run to take the actions described below:
WARNING: "Release 'test-convert' Data" will be removed.

[Cleanup/confirm] Are you sure you want to cleanup Helm v2 data? [y/N]: y
Helm v2 data will be cleaned up.
[Helm 2] Release 'test-convert' will be deleted.
[Helm 2] ReleaseVersion "test-convert.v1" will be deleted.
```

Formal clearance:

```
# helm 2to3 cleanup --tiller-out-cluster -s configmaps --name test-convert
WARNING: "Release 'test-convert' Data" will be removed.

[Cleanup/confirm] Are you sure you want to cleanup Helm v2 data? [y/N]: y
Helm v2 data will be cleaned up.
[Helm 2] Release 'test-convert' will be deleted.
[Helm 2] ReleaseVersion "test-convert.v1" will be deleted.
[Helm 2] ReleaseVersion "test-convert.v1" deleted.
[Helm 2] Release 'test-convert' deleted.
Helm v2 data was cleaned up successfully.
```

----End

18 Permissions

18.1 Permissions Overview

CCE permissions management allows you to assign permissions to IAM users and user groups under your tenant accounts. CCE combines the advantages of Identity and Access Management (IAM) and Kubernetes Role-based Access Control (RBAC) authorization to provide a variety of authorization methods, including IAM fine-grained authorization, IAM token authorization, cluster-scoped authorization, and namespace-wide authorization.

CCE allows you to manage permissions on clusters and related resources at a finer granularity, for example, to control the access of employees in different departments to cloud resources.

This section describes the CCE permissions management mechanism and related concepts. If your account has met your service requirements, you can skip this section.

CCE Permissions Management

CCE permissions are described as follows:

- **Cluster-level permissions**: Cluster-level permissions management evolves out of the system policy authorization feature of IAM. IAM users in the same user group have the same permissions. On IAM, you can configure system policies to describe which IAM user groups can perform which operations on cluster resources. For example, you can grant user group A to create and delete cluster X, add a node, or install an add-on, while granting user group B to view information about cluster X.

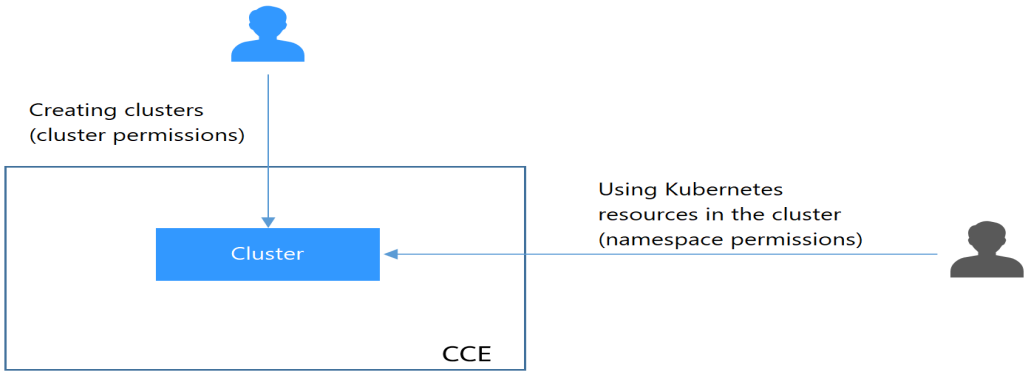
  Cluster-level permissions involve non-Kubernetes APIs in CCE clusters and support fine-grained IAM policies.
- **Namespace-level permissions**: You can regulate users' or user groups' access to Kubernetes resources in a single namespace based on their Kubernetes RBAC roles. CCE has also been enhanced based on open-source capabilities. It supports RBAC authorization based on IAM user or user group, and RBAC authentication on access to APIs using IAM tokens.

  Namespace-level permissions involve CCE Kubernetes APIs and are enhanced based on the Kubernetes RBAC capabilities. Namespace-level permissions can

be granted to IAM users or user groups for authentication and authorization, but are independent of fine-grained IAM policies.

In general, you configure CCE permissions in two scenarios. The first is creating and managing clusters and related resources, such as nodes. The second is creating and using Kubernetes resources in the cluster, such as workloads and Services.

Figure 18-1 Illustration on CCE permissions



These permissions allow you to manage resource users at a finer granularity.

Cluster Permissions (IAM-based) and Namespace Permissions (Kubernetes RBAC-based)

Users with different cluster permissions (assigned using IAM) have different namespace permissions (assigned using Kubernetes RBAC). **Table 18-1** lists the namespace permissions of different users.

Table 18-1 Differences in namespace permissions

User	Clusters of v1.13 and Later
User with the Tenant Administrator permissions	All namespace permissions
IAM user with the CCE Administrator role	All namespace permissions
IAM user with the CCE FullAccess or CCE ReadOnlyAccess role	Requires Kubernetes RBAC authorization.
IAM user with the Tenant Guest role	Requires Kubernetes RBAC authorization.

kubectl Permissions

You can use **kubectl** to access Kubernetes resources in a cluster.

When you access a cluster using kubectl, CCE uses the kubeconfig.json file generated on the cluster for authentication. This file contains user information, based on which CCE determines which Kubernetes resources can be accessed by

kubectl. The permissions recorded in a kubeconfig.json file vary from user to user. The permissions that a user has are listed in **Table 18-1**.

18.2 Granting Cluster Permissions to an IAM User

CCE cluster-level permissions are assigned based on **IAM system policies** and **custom policies**. You can use user groups to assign permissions to IAM users.

CAUTION

- Cluster permissions are granted for users to operate cluster-related resources only (such as clusters and nodes). To operate Kubernetes resources like workloads and Services, you must be granted the **namespace permissions** at the same time.
- When viewing a cluster on the CCE console, the information displayed depends on the namespace permissions. If you have no namespace permissions, you cannot view the resources in the cluster. For details, see **Permission Dependency of the CCE Console**.

Prerequisites

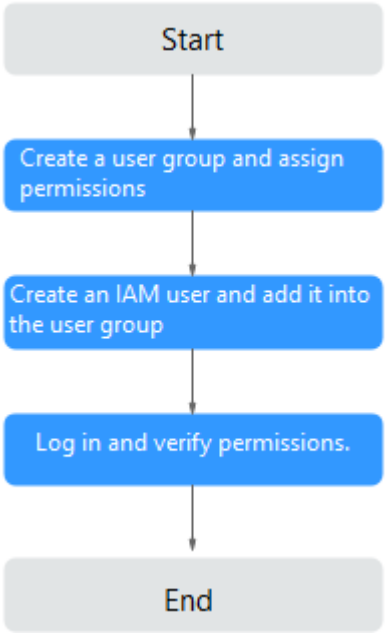
- A user with the Security Administrator role (for example, your account) has all IAM permissions except role switching. Only these users can view user groups and their permissions on the **Permissions** page on the CCE console.

Configuration

On the CCE console, when you choose **Permissions** > **Cluster-Level Permissions** to create a user group, you will be directed to the IAM console to complete the process. After the user group is created and its permissions are configured, you can view the information on the **Cluster-Level Permissions** tab page. This section describes the operations in IAM.

Process Flow

Figure 18-2 Process of assigning CCE permissions



1. Create a user group and assign permissions to it.

   Create a user group on the IAM console, and assign CCE permissions, for example, the **CCE ReadOnlyAccess** policy to the group.

   NOTE

   CCE is deployed by region. On the IAM console, select **Region-specific projects** when assigning CCE permissions.

2. Create a user and add it to a user group.

   Create a user on the IAM console and add the user to the group created in **1**.

3. Log in and verify permissions.

   Log in to the management console as the user you created, and verify that the user has the assigned permissions.

   - Log in to the management console, switch to the CCE console, and buy a cluster. If you fail to do so (assuming that only the **CCE ReadOnlyAccess** permission is assigned), the **CCE ReadOnlyAccess** policy has already taken effect.
   - Switch to the console of any other service. If a message appears indicating that you do not have the required permissions for accessing the service, the **CCE ReadOnlyAccess** policy has already taken effect.

System-defined Roles

Roles are a type of coarse-grained authorization mechanism that defines service-level permissions based on user responsibilities. Only a limited number of service-level roles are available for authorization. Roles are not ideal for fine-grained authorization and least privilege access.

The preset system role for CCE in IAM is **CCE Administrator**. When assigning this role to a user group, you must also select other roles and policies on which this role depends, such as **Tenant Guest**, **Server Administrator**, **ELB Administrator**, **OBS Administrator**, **SFS Administrator**, **SWR Admin**, and **APM FullAccess**.

System-defined Policies

The system policies preset for CCE in IAM are **CCE FullAccess** and **CCE ReadOnlyAccess**.

- **CCE FullAccess**: common operation permissions on CCE cluster resources, excluding the namespace-level permissions for the clusters (with Kubernetes RBAC enabled) and the privileged administrator operations, such as agency configuration and cluster certificate generation
- **CCE ReadOnlyAccess**: permissions to view CCE cluster resources, excluding the namespace-level permissions of the clusters (with Kubernetes RBAC enabled)

Custom Policies

Custom policies can be created as a supplement to the system-defined policies of CCE.

You can create custom policies in either of the following ways:

- Visual editor: Select cloud services, actions, resources, and request conditions. This does not require knowledge of policy syntax.
- JSON: Edit JSON policies from scratch or based on an existing policy.

This section provides examples of common custom CCE policies.

Example Custom Policies:

- Example 1: Creating a cluster named **test**

```
{
    "Version": "1.1",
    "Statement": [
        {
            "Effect": "Allow",
            "Action": [
                "cce:cluster:create"
            ]
        }
    ]
}
```

- Example 2: Denying node deletion

  A policy with only "Deny" permissions must be used in conjunction with other policies to take effect. If the permissions assigned to a user contain both "Allow" and "Deny", the "Deny" permissions take precedence over the "Allow" permissions.

  The following method can be used if you need to assign permissions of the **CCEFullAccess** policy to a user but you want to prevent the user from deleting nodes (**cce:node:delete**). Create a custom policy for denying node deletion, and attach both policies to the group to which the user belongs. Then, the user can perform all operations on CCE except deleting nodes. The following is an example of a deny policy:

```
{
   "Version": "1.1",
   "Statement": [
      {
         "Effect": "Deny",
         "Action": [
            "cce:node:delete"
         ]
      }
   ]
}
```

- Example 3: Defining permissions for multiple services in a policy

  A custom policy can contain the actions of multiple services that are of the global or project-level type. The following is an example policy containing actions of multiple services:

```
{
   "Version": "1.1",
   "Statement": [
      {
         "Action": [
            "ecs:cloudServers:resize",
            "ecs:cloudServers:delete",
            "ecs:cloudServers:delete",
            "ims:images:list",
            "ims:serverImages:create"
         ],
         "Effect": "Allow"
      }
   ]
}
```

CCE Cluster Permissions and Enterprise Projects

CCE supports resource management and permission allocation by cluster and enterprise project.

Note that:

- IAM projects are based on physical isolation of resources, whereas enterprise projects provide global logical groups of resources, which better meet the actual requirements of enterprises. In addition, IAM policies can be managed based on enterprise projects. Therefore, you are advised to use enterprise projects for permissions management.
- When there are both IAM projects and enterprise projects, IAM preferentially matches the IAM project policies.
- When creating a cluster or node using purchased cloud resources, ensure that IAM users have been granted the required permissions in the enterprise project to use these resources. Otherwise, the cluster or node may fail to be created.
- If a resource does not support enterprise projects, the permissions granted to the resource will not take effect.

Resource Type	Resource Name	Description
Supporting enterprise projects	cluster	Cluster
	node	Node
	nodepool	Node pool

Resource Type	Resource Name	Description
	job	Job
	tag	Cluster label
	addonInstance	Add-on instance
	release	Helm version
	storage	Storage
Not supporting enterprise projects	quota	Cluster quota
	chart	Chart
	addonTemplate	Add-on template

CCE Cluster Permissions and IAM RBAC

CCE is compatible with IAM system roles for permissions management. You are advised to use fine-grained policies provided by IAM to simplify permissions management.

CCE supports the following roles:

- Basic IAM roles:
  - te_admin (Tenant Administrator): Users with this role can call all APIs of all services except IAM.
  - readonly (Tenant Guest): Users with this role can call APIs with the read-only permissions of all services except IAM.
- Custom CCE administrator role: CCE Administrator

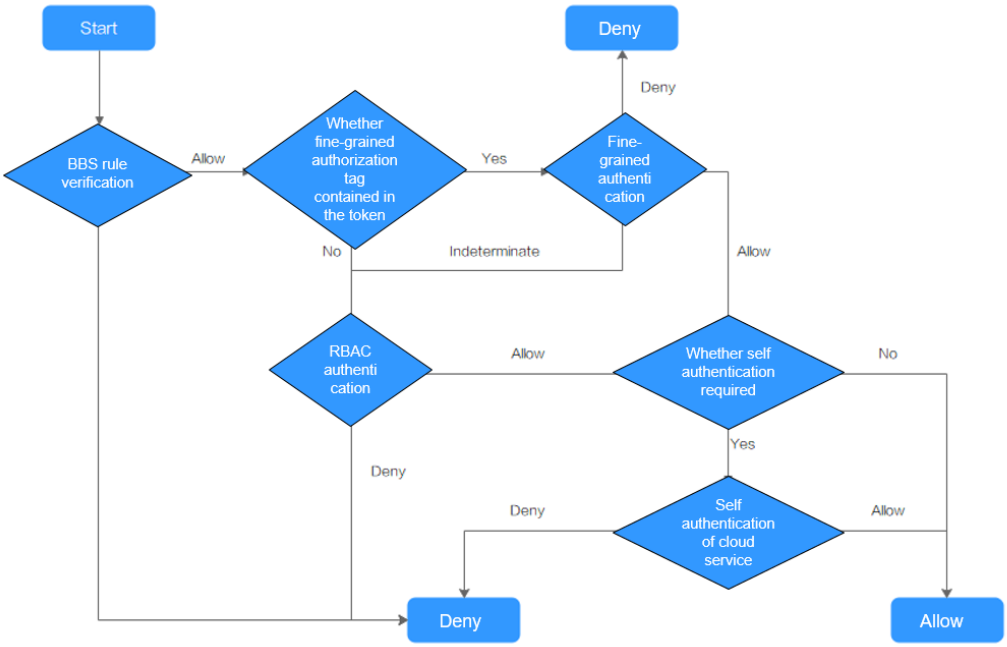
NOTE

If a user has the Tenant Administrator or CCE Administrator system role, the user has the cluster-admin permissions in Kubernetes RBAC and the permissions cannot be removed after the cluster is created.

If the user is the cluster creator, the cluster-admin permissions in Kubernetes RBAC are granted to the user by default. The permissions can be manually removed after the cluster is created.

- Method 1: Choose **Permissions Management** > **Namespace-Level Permissions** > **Delete** at the same role as cluster-creator on the CCE console.
- Method 2: Delete **ClusterRoleBinding: cluster-creator** through the API or kubectl.

When RBAC and IAM policies co-exist, the backend authentication logic for open APIs or console operations on CCE is as follows:



18.3 Namespace Permissions (Kubernetes RBAC-based)

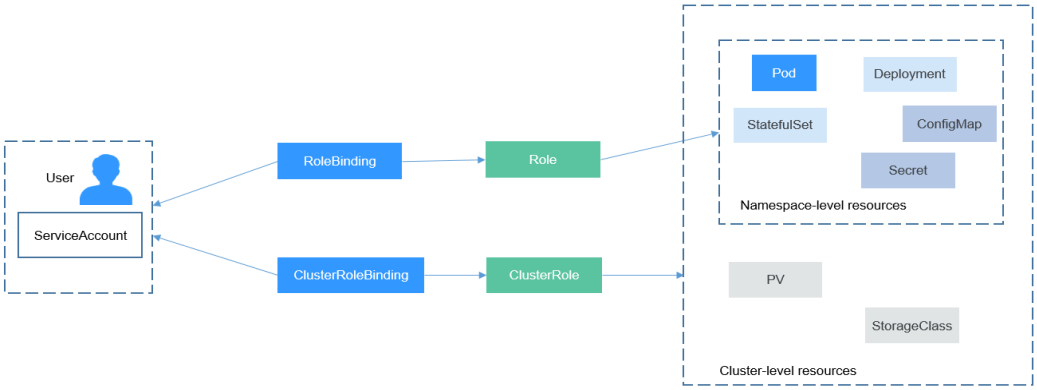
Namespace Permissions (Kubernetes RBAC-based)

You can regulate users' or user groups' access to Kubernetes resources in a single namespace based on their Kubernetes RBAC roles. The RBAC API declares four kinds of Kubernetes objects: Role, ClusterRole, RoleBinding, and ClusterRoleBinding, which are described as follows:

- 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. Illustration:

Figure 18-3 Role binding



On the CCE console, you can assign permissions to a user or user group to access resources in one or multiple namespaces. By default, the CCE console provides the following ClusterRoles:

- view (read-only): read-only permission on most resources in all or selected namespaces.
- edit (development): read and write permissions on most resources in all or selected namespaces. If this ClusterRole is configured for all namespaces, its capability is the same as the O&M permission.
- admin (O&M): read and write permissions on most resources in all namespaces, and read-only permission on nodes, storage volumes, namespaces, and quota management.
- cluster-admin (administrator): read and write permissions on all resources in all namespaces.

In addition to the preceding typical ClusterRoles, you can define Role and RoleBinding to grant the permissions to add, delete, modify, and obtain global resources (such as nodes, PVs, and CustomResourceDefinitions) and different resources (such as pods, Deployments, and Services) in namespaces for refined permission control.

Cluster Permissions (IAM-based) and Namespace Permissions (Kubernetes RBAC-based)

Users with different cluster permissions (assigned using IAM) have different namespace permissions (assigned using Kubernetes RBAC). **Table 18-2** lists the namespace permissions of different users.

Table 18-2 Differences in namespace permissions

User	Clusters of v1.13 and Later
User with the Tenant Administrator permissions	All namespace permissions
IAM user with the CCE Administrator role	All namespace permissions

User	Clusters of v1.13 and Later
IAM user with the CCE FullAccess or CCE ReadOnlyAccess role	Requires Kubernetes RBAC authorization.
IAM user with the Tenant Guest role	Requires Kubernetes RBAC authorization.

Precautions

- After you create a cluster, CCE automatically assigns the cluster-admin permission to you, which means you have full control on all resources in all namespaces in the cluster. The ID of a federated user changes upon each login and logout. Therefore, the user with the permissions is displayed as deleted. In this case, do not delete the permissions. Otherwise, the authentication fails. You are advised to grant the cluster-admin permission to a user group on CCE and add federated users to the user group.
- A user with the Security Administrator role has all IAM permissions except role switching. For example, an account in the admin user group has this role by default. Only these users can assign permissions on the **Permissions** page on the CCE console.

Configuring Namespace Permissions (on the Console)

You can regulate users' or user groups' access to Kubernetes resources in a single namespace based on their Kubernetes RBAC roles.

Step 1 Log in to the CCE console. In the navigation pane, choose **Permissions**.

Step 2 Select a cluster for which you want to add permissions from the drop-down list on the right.

Step 3 Click **Add Permissions** in the upper right corner.

Step 4 Confirm the cluster name and select the namespace to assign permissions for. For example, select **All namespaces**, the target user or user group, and select the permissions.

NOTE

If you do not have IAM permissions, you cannot select users or user groups when configuring permissions for other users or user groups. In this case, you can enter a user ID or user group ID.

Permissions can be customized as required. After selecting **Custom** for **Permission Type**, click **Add Custom Role** on the right of the **Custom** parameter. In the dialog box displayed, enter a name and select a rule. After the custom rule is created, you can select a value from the **Custom** drop-down list box.

Custom permissions 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**.

- A ClusterRole is a cluster-level resource that can be used to configure cluster access permissions.

- A Role is used to configure access permissions in a namespace. When creating a Role, specify the namespace to which the Role belongs.

Step 5 Click **OK**.

----End

Using kubectl to Configure Namespace Permissions

NOTE

When you access a cluster using kubectl, CCE uses **kubeconfig.json** generated on the cluster for authentication. This file contains user information, based on which CCE determines which Kubernetes resources can be accessed by kubectl. The permissions recorded in a kubeconfig.json file vary from user to user. The permissions that a user has are listed in **Cluster Permissions (IAM-based) and Namespace Permissions (Kubernetes RBAC-based)**.

In addition to cluster-admin, admin, edit, and view, you can define Roles and RoleBindings to configure the permissions to add, delete, modify, and obtain resources, such as pods, Deployments, and Services, in the namespace.

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**.

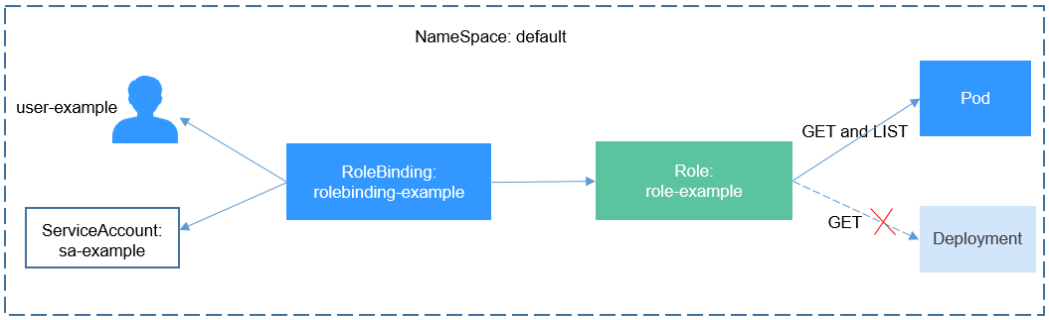
For details, see **Using RBAC Authorization**.

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 # User ID of the user-example
  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 18-4 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
```

Use the IAM user user-example to connect to the cluster and obtain the pod information. The following is an example of the returned pod information.

```
# kubectl get pod
NAME                                  READY   STATUS    RESTARTS   AGE
deployment-389584-2-6f6bd4c574-2n9rk  1/1     Running   0          4d7h
deployment-389584-2-6f6bd4c574-7s5qw  1/1     Running   0          4d7h
deployment-3895841-746b97b455-86g77   1/1     Running   0          4d7h
deployment-3895841-746b97b455-twvpn   1/1     Running   0          4d7h
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 that **user-example** does not have the required permissions. Try querying the pods in namespace kube-system. The output shows that **user-example** does not have the required permissions. 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"
```

Example: Assigning Cluster Administrator Permissions (cluster-admin)

You can use the cluster-admin role to assign all permissions on a cluster. This role contains the permissions for all cluster resources.

In the following example kubectl output, a ClusterRoleBinding has been created and binds the cluster-admin role to the user group **cce-role-group**.

```
# kubectl get clusterrolebinding
NAME                                                ROLE                        AGE
clusterrole_cluster-admin_group0c96fad22880f32a3f84c009862af6f7   ClusterRole/cluster-admin      61s

# kubectl get clusterrolebinding clusterrole_cluster-admin_group0c96fad22880f32a3f84c009862af6f7 -oyaml
apiVersion: rbac.authorization.k8s.io/v1
kind: ClusterRoleBinding
metadata:
  annotations:
    CCE.com/IAM: "true"
  creationTimestamp: "2021-06-23T09:15:22Z"
  name: clusterrole_cluster-admin_group0c96fad22880f32a3f84c009862af6f7
  resourceVersion: "36659058"
  selfLink: /apis/rbac.authorization.k8s.io/v1/clusterrolebindings/clusterrole_cluster-
admin_group0c96fad22880f32a3f84c009862af6f7
  uid: d6cd43e9-b4ca-4b56-bc52-e36346fc1320
roleRef:
  apiGroup: rbac.authorization.k8s.io
  kind: ClusterRole
  name: cluster-admin
subjects:
- apiGroup: rbac.authorization.k8s.io
  kind: Group
  name: 0c96fad22880f32a3f84c009862af6f7
```

Connect to the cluster as an authorized user. If the PVs and StorageClasses can be queried, the permission configuration takes effect.

```
# kubectl get pv
No resources found
# kubectl get sc
NAME                PROVISIONER                     RECLAIMPOLICY   VOLUMEBINDINGMODE
ALLOWVOLUMEEXPANSION   AGE
csi-disk            everest-csi-provisioner         Delete          Immediate              true                   75d
csi-disk-topology   everest-csi-provisioner         Delete          WaitForFirstConsumer   true                   75d
csi-nas             everest-csi-provisioner         Delete          Immediate              true                   75d
csi-obs             everest-csi-provisioner         Delete          Immediate              false                  75d
```

Example: Assigning Namespace O&M Permissions (admin)

The admin role has the read and write permissions on most namespace resources. You can grant the admin permission on all namespaces to a user or user group.

In the following example kubectl output, a RoleBinding has been created and binds the admin role to the user group **cce-role-group**.

```
# kubectl get rolebinding
NAME                                              ROLE                AGE
clusterrole_admin_group0c96fad22880f32a3f84c009862af6f7   ClusterRole/admin   18s
# kubectl get rolebinding clusterrole_admin_group0c96fad22880f32a3f84c009862af6f7 -oyaml
apiVersion: rbac.authorization.k8s.io/v1
kind: RoleBinding
metadata:
  annotations:
    CCE.com/IAM: "true"
  creationTimestamp: "2021-06-24T01:30:08Z"
  name: clusterrole_admin_group0c96fad22880f32a3f84c009862af6f7
  resourceVersion: "36963685"
  selfLink: /apis/rbac.authorization.k8s.io/v1/namespaces/default/rolebindings/
clusterrole_admin_group0c96fad22880f32a3f84c009862af6f7
  uid: 6c6f46a6-8584-47da-83f5-9eef1f7b75d6
roleRef:
  apiGroup: rbac.authorization.k8s.io
  kind: ClusterRole
```

```
  name: admin
subjects:
- apiGroup: rbac.authorization.k8s.io
  kind: Group
  name: 0c96fad22880f32a3f84c009862af6f7
```

Connect to the cluster as an authorized user. If the PVs and StorageClasses can be queried but a namespace cannot be created, the permission configuration takes effect.

```
# kubectl get pv
No resources found
# kubectl get sc
NAME                PROVISIONER                     RECLAIMPOLICY    VOLUMEBINDINGMODE
ALLOWVOLUMEEXPANSION    AGE
csi-disk            everest-csi-provisioner         Delete           Immediate              true                   75d
csi-disk-topology   everest-csi-provisioner         Delete           WaitForFirstConsumer   true                   75d
csi-nas             everest-csi-provisioner         Delete           Immediate              true                   75d
csi-obs             everest-csi-provisioner         Delete           Immediate              false                  75d
# kubectl apply -f namespaces.yaml
Error from server (Forbidden): namespaces is forbidden: User "0c97ac3cb280f4d91fa7c0096739e1f8" cannot
create resource "namespaces" in API group "" at the cluster scope
```

Example: Assigning Namespace Developer Permissions (edit)

The edit role has the read and write permissions on most namespace resources. You can grant the edit permission on all namespaces to a user or user group.

In the following example kubectl output, a RoleBinding has been created, the edit role is bound to the user group **cce-role-group**, and the target namespace is the default namespace.

```
# kubectl get rolebinding
NAME                                                ROLE               AGE
clusterrole_admin_group0c96fad22880f32a3f84c009862af6f7   ClusterRole/admin   18s
# kubectl get rolebinding clusterrole_admin_group0c96fad22880f32a3f84c009862af6f7 -oyaml
apiVersion: rbac.authorization.k8s.io/v1
kind: RoleBinding
metadata:
  annotations:
    CCE.com/IAM: "true"
  creationTimestamp: "2021-06-24T01:30:08Z"
  name: clusterrole_admin_group0c96fad22880f32a3f84c009862af6f7
  namespace: default
  resourceVersion: "36963685"
  selfLink: /apis/rbac.authorization.k8s.io/v1/namespaces/default/rolebindings/
clusterrole_admin_group0c96fad22880f32a3f84c009862af6f7
  uid: 6c6f46a6-8584-47da-83f5-9eef1f7b75d6
roleRef:
  apiGroup: rbac.authorization.k8s.io
  kind: ClusterRole
  name: edit
subjects:
- apiGroup: rbac.authorization.k8s.io
  kind: Group
  name: 0c96fad22880f32a3f84c009862af6f7
```

Connect to the cluster as an authorized user. In this example, you can create and obtain resources in the default namespace, but cannot query resources in the kube-system namespace or cluster resources.

```
# kubectl get pod
NAME                  READY   STATUS    RESTARTS   AGE
test-568d96f4f8-brdrp   1/1     Running   0          33m
test-568d96f4f8-cgjqp   1/1     Running   0          33m
# kubectl get pod -nkube-system
Error from server (Forbidden): pods is forbidden: User "0c97ac3cb280f4d91fa7c0096739e1f8" cannot list
```

```
resource "pods" in API group "" in the namespace "kube-system"
# kubectl get pv
Error from server (Forbidden): persistentvolumes is forbidden: User "0c97ac3cb280f4d91fa7c0096739e1f8"
cannot list resource "persistentvolumes" in API group "" at the cluster scope
```

Example: Assigning Read-Only Namespace Permissions (view)

The view role has the read-only permissions on a namespace. You can assign permissions to users to view one or multiple namespaces.

In the following example kubectl output, a RoleBinding has been created, the view role is bound to the user group **cce-role-group**, and the target namespace is the default namespace.

```
# kubectl get rolebinding
NAME                                                ROLE               AGE
clusterrole_view_group0c96fad22880f32a3f84c009862af6f7   ClusterRole/view   7s

# kubectl get rolebinding clusterrole_view_group0c96fad22880f32a3f84c009862af6f7 -oyaml
apiVersion: rbac.authorization.k8s.io/v1
kind: RoleBinding
metadata:
  annotations:
    CCE.com/IAM: "true"
  creationTimestamp: "2021-06-24T01:36:53Z"
  name: clusterrole_view_group0c96fad22880f32a3f84c009862af6f7
  namespace: default
  resourceVersion: "36965800"
  selfLink: /apis/rbac.authorization.k8s.io/v1/namespaces/default/rolebindings/
clusterrole_view_group0c96fad22880f32a3f84c009862af6f7
  uid: b86e2507-e735-494c-be55-c41a0c4ef0dd
roleRef:
  apiGroup: rbac.authorization.k8s.io
  kind: ClusterRole
  name: view
subjects:
- apiGroup: rbac.authorization.k8s.io
  kind: Group
  name: 0c96fad22880f32a3f84c009862af6f7
```

Connect to the cluster as an authorized user. In this example, you can query resources in the default namespace but cannot create resources.

```
# kubectl get pod
NAME                  READY   STATUS    RESTARTS   AGE
test-568d96f4f8-brdrp   1/1     Running   0          40m
test-568d96f4f8-cgjqp   1/1     Running   0          40m
# kubectl run -i --tty --image tutum/dnsutils dnsutils --restart=Never --rm /bin/sh
Error from server (Forbidden): pods is forbidden: User "0c97ac3cb280f4d91fa7c0096739e1f8" cannot create
resource "pods" in API group "" in the namespace "default"
```

Example: Assigning Permissions for a Specific Kubernetes Resource Object

You can assign permissions on a specific Kubernetes resource object, such as pod, Deployment, and Service. For details, see **Using kubectl to Configure Namespace Permissions**.

18.4 Example: Designing and Configuring Permissions for Users in a Department

Overview

The conventional distributed task scheduling mode is being replaced by Kubernetes. CCE allows you to easily deploy, manage, and scale containerized applications in the cloud by providing support for you to use Kubernetes.

To help enterprise administrators manage resource permissions in clusters, CCE provides multi-dimensional, fine-grained permission policies and management measures. CCE permissions are described as follows:

- **Cluster-level permissions**: allowing a user group to perform operations on clusters, nodes, node pools, charts, and add-ons. These permissions are assigned based on IAM system policies.
- **Namespace-level permissions**: allowing a user or user group to perform operations on Kubernetes resources, such as workloads, networking, storage, and namespaces. These permissions are assigned based on Kubernetes RBAC.

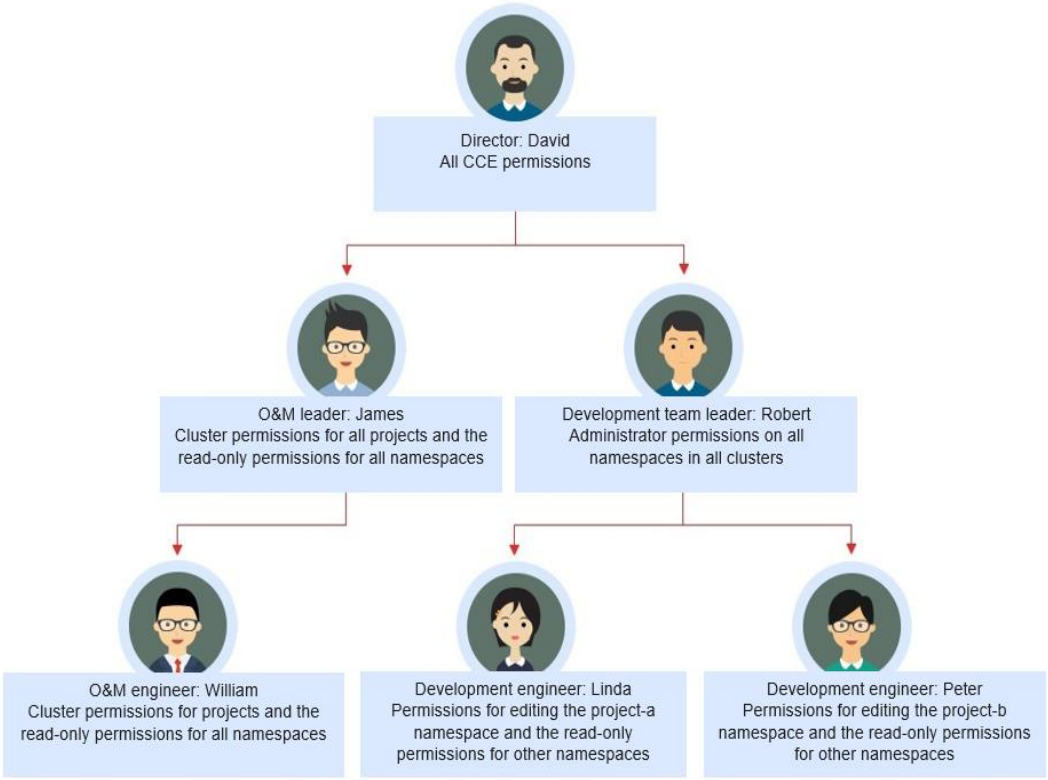
Cluster permissions and namespace permissions are independent of each other but must be used together. The permissions set for a user group apply to all users in the user group. When multiple permissions are added to a user or user group, they take effect at the same time (the union set is used).

Permission Design

The following uses company X as an example.

Generally, a company has multiple departments or projects, and each department has multiple members. Design how permissions are to be assigned to different groups and projects, and set a user name for each member to facilitate subsequent user group and permissions configuration.

The following figure shows the organizational structure of a department in a company and the permissions to be assigned to each member:



Director: David

David is a department director of company X. To assign him all CCE permissions (both cluster and namespace permissions), create the **cce-admin** user group for David on the IAM console and assign the CCE Administrator role.

NOTE

CCE Administrator: This role has all CCE permissions. You do not need to assign other permissions.

CCE FullAccess and CCE ReadOnlyAccess: These policies are related to cluster management permissions and configured only for cluster-related resources (such as clusters and nodes). You must also configure namespace permissions to perform operations on Kubernetes resources (such as workloads and Services).

O&M Leader: James

James is the O&M team leader of the department. He needs the cluster permissions for all projects and the read-only permissions for all namespaces.

To assign the permissions, create a user group named **cce-sre** on the IAM console and add James to this user group. Then, assign CCE FullAccess to the user group **cce-sre** to allow it to perform operations on clusters in all projects.

Assigning Read-only Permissions on All Clusters and Namespaces to All Team Leaders and Engineers

You can create a read-only user group named **read_only** on the IAM console and add users to the user group.

- Although the development engineers Linda and Peter do not require cluster management permissions, they still need to view data on the CCE console. Therefore, the read-only cluster permission is required.
- For the O&M engineer William, assign the read-only permission on clusters to him in this step.
- The O&M team leader James already has the management permissions on all clusters. You can add him to the **read_only** user group to assign the read-only permission on clusters to him.

Users James, Robert, William, Linda, and Peter are added to the **read_only** user group.

Assign the read-only permission on clusters to the user group **read_only**.

Return to the CCE console, and add the read-only permission on namespaces to the user group **read_only** to which the five users belong. Choose **Permissions** on the CCE console, and assign the read-only policy to the user group **read_only** for each cluster.

After the setting is complete, James has the cluster management permissions for all projects and the read-only permissions on all namespaces, and the Robert, William, Linda, and Peter have the read-only permission on all clusters and namespaces.

Development Team Leader: Robert

In the previous steps, Robert has been assigned the read-only permission on all clusters and namespaces. Now, assign the administrator permissions on all namespaces to Robert.

Therefore, assign the administrator permissions on all namespaces in all clusters to Robert.

O&M Engineer: William

In the previous steps, William has been assigned the read-only permission on all clusters and namespaces. He also requires the cluster management permissions in his region. Therefore, you can log in to the IAM console, create a user group named **cce-sre-b4** and assign CCE FullAccess to William for his region.

Now, William has the cluster management permissions for his region and the read-only permission on all namespaces.

Development Engineers: Linda and Peter

In the previous steps, Linda and Peter have been assigned the read-only permission on clusters and namespaces. Therefore, you only need to assign the edit policy to them.

By now, all the required permissions are assigned to the department members.

18.5 Permission Dependency of the CCE Console

Some CCE permissions policies depend on the policies of other cloud services. To view or use other cloud resources on the CCE console, enable the access control feature of IAM and assign dependency policies for the other cloud services.

- Dependency policies are assigned based on the CCE FullAccess or CCE ReadOnlyAccess policy you configure.
- Only users and user groups with namespace permissions can gain the view access to resources in clusters.
  - If a user is granted the view access to all namespaces of a cluster, the user can view all namespace resources (except secrets) in the cluster. To view secrets in the cluster, the user must gain the **admin** or **edit** role in all namespaces of the cluster.
  - The **view** role within a single namespace allows users to view resources only in the specified namespace.

Dependency Policy Configuration

To grant an IAM user the permissions to view or use resources of other cloud services on the CCE console, you must first grant the CCE Administrator, CCE FullAccess, or CCE ReadOnlyAccess policy to the user group to which the user belongs and then grant the dependency policies listed in **Table 18-3** to the user. These dependency policies will allow the IAM user to access resources of other cloud services.

NOTE

Enterprise projects can group and manage resources across different projects of an enterprise. Resources are thereby isolated. IAM allows you to implement fine-grained authorization. It is strongly recommended that you use IAM for permissions management.

If you use an enterprise project to set permissions for IAM users, the following restrictions apply:

- On the CCE console, enterprise projects cannot call the API used to obtain AOM monitoring data for cluster monitoring. Therefore, IAM users in these enterprise projects cannot query monitoring data.
- On the CCE console, enterprise projects cannot call the API to query the key pair created during node creation. Therefore, IAM users in these enterprise projects cannot use the key pair login mode. Only the password login mode is supported.
- On the CCE console, enterprise projects are not supported during template creation. Therefore, enterprise project sub-users cannot use template management.
- On the CCE console, the EVS disk query API does not support enterprise projects. Therefore, enterprise project IAM users cannot use existing EVS disks to create PVs. To use this function, add the fine-grained permissions such as evs:volumes:get to the IAM users.

CCE supports fine-grained permissions configuration, but has the following restrictions:

- AOM does not support resource-level monitoring. After operation permissions on specific resources are configured using IAM's fine-grained cluster resource management function, IAM users can view cluster monitoring information on the **Dashboard** page of the CCE console, but cannot view the data on non-fine-grained metrics.

Table 18-3 Dependency policies

Console Function	Dependent Service	Role or Policy Required
Cluster overview	Application Operations Management (AOM)	• An IAM user with the CCE Administrator permission assigned can use this function only after the AOM FullAccess permission is assigned. • IAM users with IAM ReadOnlyAccess, CCE FullAccess, or CCE ReadOnlyAccess assigned can directly use this function.
Workload management	Elastic Load Balance (ELB) Application Performance Management (APM) Application Operations Management (AOM) NAT Gateway Object Storage Service (OBS)	Except in the following cases, the user does not require any additional role to create workloads. • To create a Service using ELB, you must have the ELB FullAccess or ELB Administrator plus VPC Administrator permissions assigned. • To use a Java probe, you must have the AOM FullAccess and APM FullAccess permissions assigned. • To create a Service using NAT Gateway, you must have the NAT Gateway Administrator permission assigned. • To use OBS, you must have the OBS Administrator permission globally assigned. **NOTE** Because of the cache, it takes about 13 minutes for the RBAC policy to take effect after being granted to users, enterprise projects, and user groups. After an OBS-related system policy is granted, it takes about 5 minutes for the policy to take effect.
Cluster management	Application Operations Management (AOM)	• Auto scale-out or scale-up requires the AOM FullAccess policy.
Node management	Elastic Cloud Server (ECS)	If the permission assigned to an IAM user is CCE Administrator, creating or deleting a node requires the ECS FullAccess or ECS Administrator policy and the VPC Administrator policy.

Console Function	Dependent Service	Role or Policy Required
Service	Elastic Load Balance (ELB) NAT Gateway	Except in the following cases, the user does not require any additional role to create a Service. • To create a Service using ELB, you must have the ELB FullAccess or ELB Administrator plus VPC Administrator permissions assigned. • To create a Service using NAT Gateway, you must have the NAT Administrator permission assigned.
Storage	Object Storage Service (OBS) SFS Turbo	• To use OBS, you must have the OBS Administrator permission globally assigned. **NOTE** Because of the cache, it takes about 13 minutes for the RBAC policy to take effect after being granted to users, enterprise projects, and user groups. After an OBS-related system policy is granted, it takes about 5 minutes for the policy to take effect. • To use SFS Turbo, you must have the SFS Turbo FullAccess permission. The CCE Administrator role is required for importing storage devices.
Namespace management	/	/
Chart management	/	Cloud accounts and the IAM users with CCE Administrator assigned can use this function.
Add-ons	/	Cloud accounts and the IAM users with CCE Administrator, CCE FullAccess, or CCE ReadOnlyAccess assigned can use this function.

Console Function	Dependent Service	Role or Policy Required
Permissions management	/	• For cloud accounts, no additional policy/role is required. • IAM users with the CCE Administrator or global Security Administrator permission assigned can use this function. • IAM users with the CCE FullAccess or CCE ReadOnlyAccess permission can use this function. In addition, the IAM users must have the **administrator permissions (cluster-admin)** on the namespace.
ConfigMaps and Secrets	/	• Creating ConfigMaps does not require any additional policy. • Viewing secrets requires that the cluster-admin, admin, or edit permission be configured for the namespace. The DEW KeypairFullAccess or DEW KeypairReadOnlyAccess policy must be assigned for dependent services.
Help center	/	/
Switching to other related services	Software Repository for Container (SWR)	The CCE console provides links to other related services. To view or use these services, an IAM user must be assigned required permissions for the services.

18.6 Pod Security

18.6.1 Configuring a Pod Security Policy

A pod security policy (PSP) is a cluster-level resource that controls sensitive security aspects of the pod specification. The **PodSecurityPolicy** object in Kubernetes defines a group of conditions that a pod must comply with to be accepted by the system, as well as the default values of related fields.

By default, the PSP access control component is enabled for clusters of v1.17.17 and a global default PSP named **psp-global** is created. You can modify the default policy (but not delete it). You can also create a PSP and bind it to the RBAC configuration.

NOTE

- In addition to the global default PSP, the system configures independent PSPs for system components in namespace kube-system. Modifying the psp-global configuration does not affect pod creation in namespace kube-system.
- PodSecurityPolicy was deprecated in Kubernetes v1.21, and removed from Kubernetes in v1.25. You can use pod security admission as a substitute for PodSecurityPolicy. For details, see **Configuring Pod Security Admission**.

Modifying the Global Default PSP

Before modifying the global default PSP, ensure that a CCE cluster has been created and connected by using kubectl.

Step 1 Run the following command:

kubectl edit psp psp-global

Step 2 Modify the required parameters, as shown in **Table 18-4**.

Table 18-4 PSP configuration

Item	Description
privileged	Starts the privileged container.
hostPID hostIPC	Uses the host namespace.
hostNetwork hostPorts	Uses the host network and port.
volumes	Specifies the type of the mounted volume that can be used.
allowedHostPaths	Specifies the host path to which a hostPath volume can be mounted. The **pathPrefix** field specifies the host path prefix group to which a hostPath volume can be mounted.
allowedFlexVolumes	Specifies the FlexVolume driver that can be used.
fsGroup	Configures the supplemental group ID used by the mounted volume in the pod.
readOnlyRootFilesystem	Pods can only be started using a read-only root file system.
runAsUser runAsGroup supplementalGroups	Specifies the user ID, primary group ID, and supplemental group ID for starting containers in a pod.
allowPrivilegeEscalation defaultAllowPrivilegeEscalation	Specifies whether **allowPrivilegeEscalation** can be set to **true** in a pod. This configuration controls the use of Setuid and whether programs can use additional privileged system calls.

Item	Description
defaultAddCapabilities requiredDropCapabilities allowedCapabilities	Controls the Linux capabilities used in pods.
seLinux	Controls the configuration of seLinux used in pods.
allowedProcMountTypes	Controls the ProcMountTypes that can be used by pods.
annotations	Configures AppArmor or Seccomp used by containers in a pod.
forbiddenSysctls allowedUnsafeSysctls	Controls the configuration of Sysctl used by containers in a pod.

----End

Example of Enabling Unsafe Sysctls in Pod Security Policy

You can configure allowed-unsafe-sysctls for a node pool. For CCE clusters of **v1.17.17** and later versions, add configurations in **allowedUnsafeSysctls** of the pod security policy to make the configuration take effect. For details, see **Table 18-4**.

In addition to modifying the global pod security policy, you can add new pod security policies. For example, enable the **net.core.somaxconn** unsafe sysctls. The following is an example of adding a pod security policy:

```
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:
```

```
  - '*'
---
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
```

Restoring the Original PSP

If you have modified the default pod security policy and want to restore the original pod security policy, perform the following operations.

Step 1 Create a policy description file named **policy.yaml**. **policy.yaml** is an example file name. You can rename it as required.

vi policy.yaml

The content of the description file is as follows:

```
apiVersion: policy/v1beta1
kind: PodSecurityPolicy
metadata:
  name: psp-global
  annotations:
    seccomp.security.alpha.kubernetes.io/allowedProfileNames: '*'
spec:
  privileged: true
  allowPrivilegeEscalation: true
  allowedCapabilities:
    - '*'
  volumes:
    - '*'
  hostNetwork: true
  hostPorts:
    - min: 0
      max: 65535
  hostIPC: true
  hostPID: true
  runAsUser:
    rule: 'RunAsAny'
  seLinux:
    rule: 'RunAsAny'
  supplementalGroups:
    rule: 'RunAsAny'
  fsGroup:
```

```
    rule: 'RunAsAny'

---
kind: ClusterRole
apiVersion: rbac.authorization.k8s.io/v1
metadata:
  name: psp-global
rules:
  - apiGroups:
      - '*'
    resources:
      - podsecuritypolicies
    resourceNames:
      - psp-global
    verbs:
      - use

---
apiVersion: rbac.authorization.k8s.io/v1
kind: ClusterRoleBinding
metadata:
  name: psp-global
roleRef:
  kind: ClusterRole
  name: psp-global
  apiGroup: rbac.authorization.k8s.io
subjects:
- kind: Group
  name: system:authenticated
  apiGroup: rbac.authorization.k8s.io
```

Step 2 Run the following command:

kubectl apply -f policy.yaml

----End

18.6.2 Configuring Pod Security Admission

Before using **pod security admission**, understand Kubernetes **Pod Security Standards**. These standards define different isolation levels for pods. They let you define how you want to restrict the behavior of pods in a clear, consistent fashion. Kubernetes offers a built-in pod security admission controller to enforce the pod security standards. Pod security restrictions are applied at the namespace level when pods are created.

The pod security standard defines three security policy levels:

Table 18-5 Pod security policy levels

Level	Description
privileged	Unrestricted policy, providing the widest possible level of permissions, typically aimed at system- and infrastructure-level workloads managed by privileged, trusted users, such as CNIs and storage drivers.
baseline	Minimally restrictive policy that prevents known privilege escalations, typically targeted at non-critical workloads. This policy disables capabilities such as hostNetwork and hostPID.

Level	Description
restricted	Heavily restricted policy, following current Pod hardening best practices.

Pod security admission is applied at the namespace level. The controller restricts the security context and other parameters in the pod or container in the namespace. The privileged policy does not verify the **securityContext** field of the pod and container. The baseline and restricted policies have different requirements on **securityContext**. For details, see **Pod Security Standards**.

Setting security context: **Configure a Security Context for a Pod or Container**

Pod Security Admission Labels

Kubernetes defines three types of labels for pod security admission (see **Table 18-6**). You can set these labels in a namespace to define the pod security standard level to be used. However, do not change the pod security standard level in system namespaces such as kube-system. Otherwise, pods in the system namespace may be faulty.

Table 18-6 Pod security admission labels

Mode	Target Object	Description
enforce	Pods	Policy violations will cause the pod to be rejected.
audit	Workloads (such as Deployment and job)	Policy violations will trigger the addition of an audit annotation to the event recorded in the audit log, but are otherwise allowed.
warn	Workloads (such as Deployment and job)	Policy violations will trigger a user-facing warning, but are otherwise allowed.

NOTE

Pods are often created indirectly, by creating a workload object such as a Deployment or job. To help catch violations early, both the audit and warning modes are applied to the workload resources. However, the enforce mode is applied only to the resulting pod objects.

Enforcing Pod Security Admission with Namespace Labels

You can label namespaces to enforce pod security standards. Assume that a namespace is configured as follows:

```
apiVersion: v1
kind: Namespace
metadata:
  name: my-baseline-namespace
```

```
labels:
  pod-security.kubernetes.io/enforce: privileged
  pod-security.kubernetes.io/enforce-version: v1.25
  pod-security.kubernetes.io/audit: baseline
  pod-security.kubernetes.io/audit-version: v1.25
  pod-security.kubernetes.io/warn: restricted
  pod-security.kubernetes.io/warn-version: v1.25

  # The label can be in either of the following formats:
  # pod-security.kubernetes.io/<MODE>: <LEVEL>
  # pod-security.kubernetes.io/<MODE>-version: <VERSION>
  # The audit and warn modes inform you of which security behaviors are violated by the load.
```

Namespace labels indicate which policy level to apply for the mode. For each mode, there are two labels that determine the policy used:

- pod-security.kubernetes.io/<MODE>: <LEVEL>
  - <MODE>: must be **enforce**, **audit**, or **warn**. For details about the modes, see **Table 18-6**.
  - <LEVEL>: must be **privileged**, **baseline**, or **restricted**. For details about the levels, see **Table 18-5**.
- pod-security.kubernetes.io/<MODE>-version: <VERSION>

  Optional, which pins the policy to a given Kubernetes version.
  - <MODE>: must be **enforce**, **audit**, or **warn**. For details about the modes, see **Table 18-6**.
  - <VERSION>: Kubernetes version number. For example, v1.25. You can also use **latest**.

If pods are deployed in the preceding namespace, the following security restrictions apply:

1. The verification in the enforce mode is skipped (enforce mode + privileged level).
2. Restrictions related to the baseline policy are verified (audit mode + baseline level). That is, if the pod or container violates the policy, the corresponding event is recorded into the audit log.
3. Restrictions related to the restricted policy are verified (warn mode + restricted level). That is, if the pod or container violates the policy, the user will receive an alarm when creating the pod.

Migrating from Pod Security Policy to Pod Security Admission

If you use pod security policies in a cluster earlier than v1.25 and need to replace them with pod security admission in a cluster of v1.25 or later, follow the guide in **Migrate from PodSecurityPolicy to the Built-In PodSecurity Admission Controller**.

NOTICE

1. Pod security admission supports only three isolation modes, less flexible than pod security policies. If you require more control over specific constraints, you will need to use a Validating Admission Webhook to enforce those policies.
2. Pod security admission is a non-mutating admission controller, meaning it will not modify pods before validating them. If you were relying on this aspect of PSP, you will need to either modify the security context in your workloads, or use a Mutating Admission Webhook to make those changes.
3. PSP lets you bind different policies to different service accounts. This approach has many pitfalls and is not recommended, but if you require this feature anyway you will need to use a third-party webhook instead.
4. Do not apply pod security admission to namespaces where CCE components, such as kube-system, kube-public, and kube-node-lease, are deployed. Otherwise, CCE components and add-on functions will be abnormal.

Documentation

- **Pod Security Admission**
- **Mapping PodSecurityPolicies to Pod Security Standards**
- **Enforce Pod Security Standards with Namespace Labels**
- **Enforce Pod Security Standards by Configuring the Built-in Admission Controller**

18.7 Service Account Token Security Improvement

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 (one hour by default). Before expiration, Kubelet refreshes the token to ensure that the pod always uses a valid token. When the mounting pod is deleted, the token automatically becomes invalid. This approach is implemented by the **BoundServiceAccountTokenVolume** feature to improve the token security of the service account. Kubernetes clusters of v1.21 and later enable this approach by default.

For smooth transition, the community extends the token validity period to one year by default. After one year, the token becomes invalid, and clients that do not support certificate reloading cannot access the API server. It is recommended that clients of earlier versions be upgraded as soon as possible. Otherwise, service faults may occur.

If you use a Kubernetes client of a to-be-outdated version, the certificate reloading may fail. Versions of officially supported Kubernetes client libraries able to reload tokens are as follows:

- Go: >= v0.15.7
- Python: >= v12.0.0
- Java: >= v9.0.0
- Javascript: >= v0.10.3
- Ruby: master branch
- Haskell: v0.3.0.0
- C#: >= 7.0.5

For details, visit **https://github.com/kubernetes/enhancements/tree/master/keps/sig-auth/1205-bound-service-account-tokens**.

NOTE

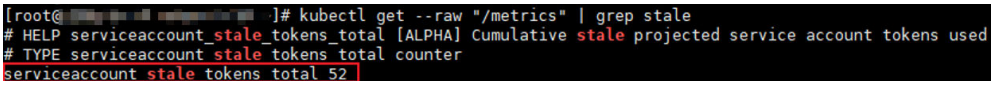
If you need a token that never expires, you can also **manually manage secrets for service accounts**. Although a permanent service account token can be manually created, you are advised to use a short-lived token by calling the **TokenRequest** API for higher security.

Diagnosis

Perform the following steps to check your CCE clusters of v1.21 or later:

1. Use kubectl to connect to the cluster and run the **kubectl get --raw "/metrics" | grep stale** command to obtain the metrics. Check the metric named **serviceaccount_stale_tokens_total**.

   If the value is greater than 0, some workloads in the cluster may be using an earlier client-go version. In this case, check whether this problem occurs in your deployed applications. If yes, upgrade client-go to the version specified by the community as soon as possible. The version must be at least two major versions of the CCE cluster. For example, if your cluster version is 1.23, the Kubernetes dependency library version must be at least 1.19.

19 Best Practices

19.1 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 19-1 System availability

Category	Check Item	Type	Impact
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.

Category	Check Item	Type	Impact
	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.
	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.
	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.
	When creating a cluster, select a proper network model as needed. • Select **VPC network** or **Tunnel network** for your CCE standard cluster.	Deployment	After a cluster is created, the network model cannot be changed. Exercise caution when selecting a network model.

Category	Check Item	Type	Impact
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.
	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.
	When creating a workload, select a proper access mode (Service). Currently, the following types of Services are supported: ClusterIP, NodePort, and LoadBalancer.	Deployment	Improper Service configuration may cause logic confusion for internal and external access and resource waste.

Category	Check Item	Type	Impact
	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.
	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.
	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.

Table 19-2 Data reliability

Category	Check Item	Type	Impact
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.
Backup	Back up application data.	Reliability	Data cannot be restored after being lost.

Table 19-3 O&M reliability

Category	Check Item	Type	Impact
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.
	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.

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

19.2 Containerization

19.2.1 Containerizing an Enterprise Application (ERP)

19.2.1.1 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 19-4 lists the advantages and disadvantages of the three modes.

Table 19-4 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.

19.2.1.2 Procedure

19.2.1.2.1 Containerizing an Entire Application

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

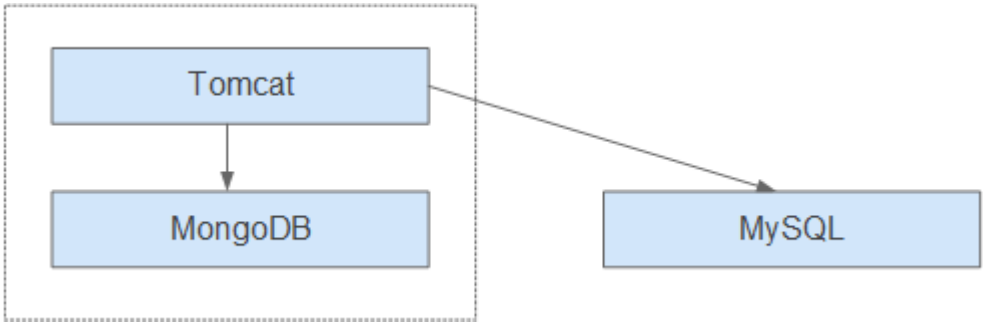
No recoding or re-architecting is required. You only need to pack the entire application into a container image and deploy the container image on CCE.

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 19-1 Application architecture



As shown in **Figure 19-1**, 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.

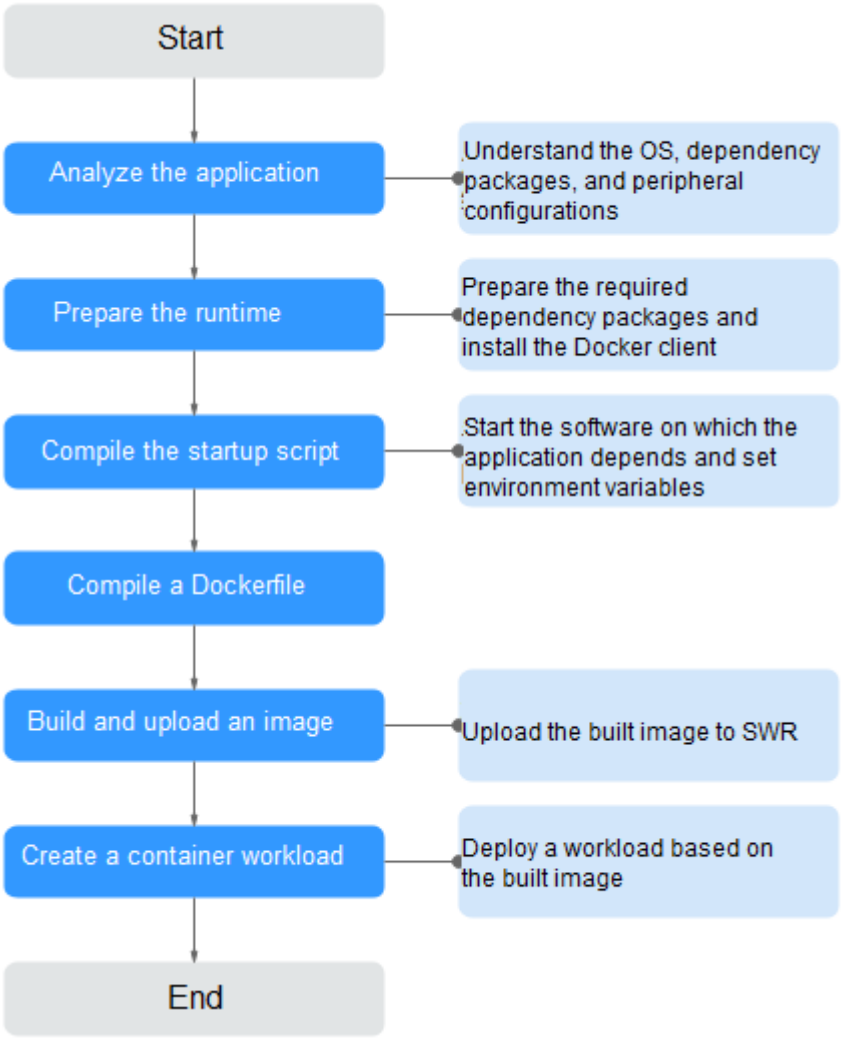
Table 19-5 Comparison between the two deployment modes

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.

19.2.1.2.2 Containerization Process

The following figure illustrates the process of containerizing an application.

Figure 19-2 Process of containerizing an application



19.2.1.2.3 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 19-6**.

Table 19-6 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.

19.2.1.2.4 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 base image tag**: Determine the base image based on the OS on which the application runs. In this example, the application runs on CentOS 7.1 and the base image can be obtained from an open-source image repository.
- **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.

You are advised to install Docker and build images as user **root**. Obtain the password of user **root** of the host where Docker is to be installed in advance.

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 query the Docker version:

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

Version indicates the version number.

----End

Obtaining the Base Image Tag

Determine the base image based on the OS on which the application runs. In this example, the application runs on CentOS 7.1 and the base image can be obtained from an open-source image repository.

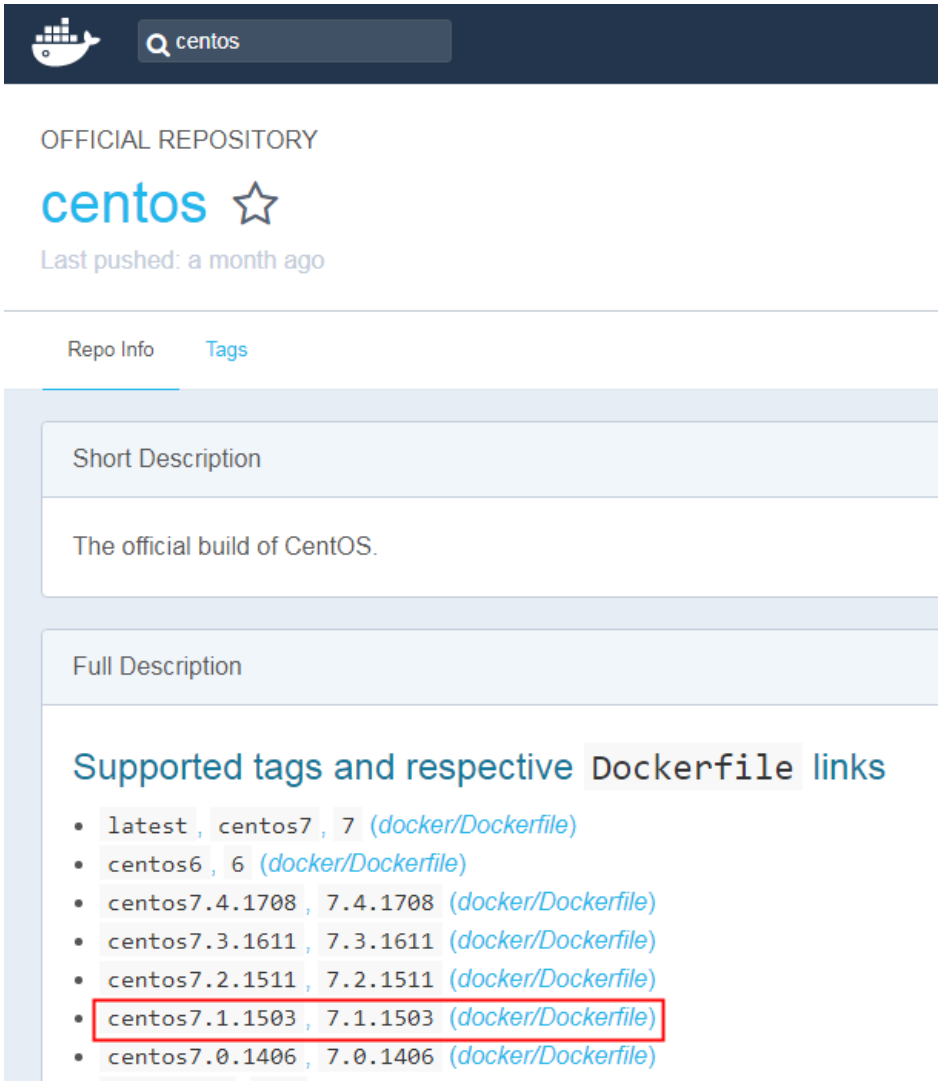
NOTE

Search for the image tag based on the OS on which the application runs.

Step 1 Visit the Docker website.

Step 2 Search for CentOS. The image corresponding to CentOS 7.1 is **centos7.1.1503**. Use this image name when editing the Dockerfile.

Figure 19-3 Obtaining the CentOS version



----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

19.2.1.2.5 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 commands to create the directory where the application is to be stored:

mkdir apptest

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

19.2.1.2.6 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.

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

19.2.1.2.7 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

ll

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 .

Step 4 Upload the image to SWR.

----End

19.2.1.2.8 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 19-7**.

Table 19-7 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.

No.	Category	Procedure
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 have the private key managed on the cloud** and **I have read and agree to the Key Pair Service Disclaimer**, and click **OK**. 5. In the dialog box displayed, click **OK**. View and save the key pair. 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**.
2. Buy a node and select the key pair created in **Step 1** as the login option.

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**.
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 19-8 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**.

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**: In this example, 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.

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.

19.3 Disaster Recovery

19.3.1 Recommended Configurations for Cluster HA

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**

Item	Description	Recommended Operations
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**
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 an Add-on 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.

Selecting a Network Model

- Network model: CCE supports VPC 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 to enable communication 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).
- 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 allows you to monitor kube-apiserver, kube-controller, kube-scheduler, and etcd-server on the master nodes with the **kube-prometheus-stack** add-on installed. With grafana, you can use the **Kubernetes monitoring overview dashboard** to monitor metrics of Kubernetes API server requests and latency and etcd latency.

If your prometheus add-on is used, you can manually add monitoring metrics. For details, see **Monitoring Metrics of the Master Node Components**.

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 **Data Disk Space Allocation**.

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. **npd** 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 **Node Fault Detection Policy**.

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.

To deploy NodeLocal DNSCache, install NodeLocal DNSCache. 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.

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 request and limit resources required by the pod. Kubernetes then selects a node with sufficient 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.

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 an Add-on 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 19-9 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 **preferredDuringSchedulingIgnoredDuringExecution**.	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 sufficient resources.	No mandatory requirements for multi-AZ DR
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.)

Mode	Configuration Description	Usage Description	Recommended Configuration Scenario
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 sufficient node resources for deploying pods. (If there are more than 1 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 pods or containers are used for deploying applications, the requested and limit values of the containers are generally configured 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
  - 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.
- 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.

19.3.2 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
```

19.3.3 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.

Viewing the Scheduling Policy of an Add-on

An add-on typically includes Deployments and daemon processes. By default, daemon processes are deployed on all nodes, while Deployments are deployed in multi-instance mode for HA scenarios.

Take the CoreDNS add-on as an example. Two pods are deployed for this add-on by default, and multi-AZ deployment is in the preferred mode. The scheduling policy is hard anti-affinity for nodes and soft anti-affinity for AZs. As a result, to

ensure that all pods run smoothly, the cluster requires two nodes. The Deployment pods of the add-on are scheduled to nodes in different AZs. However, if the nodes in the cluster are not in multiple AZs, the add-on pods will be scheduled to different nodes in a single AZ.

Creating Nodes in Different AZs for a Cluster

Step 1 Log in to the CCE console.

Step 2 In the navigation pane, choose **Clusters**. Click the target cluster name to access its details page.

Step 3 In the navigation pane, choose **Nodes**, click the **Nodes** tab, and click **Create Node** in the upper right corner.

Step 4 On the page displayed, select an AZ for the node.

Step 5 Configure other mandatory parameters following instructions to complete the creation.

----End

To create nodes in different AZs, you can simply repeat the previous steps. Alternatively, you can create multiple node pools, associate them with different AZ flavors, and increase the number of nodes in each pool to achieve the same result.

Configuring the AZ Anti-affinity Scheduling Policy for the Add-on

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. Then, set the multi-AZ deployment mode of the add-on scheduling policy to the required mode.

This section uses the CoreDNS add-on as an example to describe how to configure the multi-AZ deployment policy for an add-on.

Step 1 Log in to the CCE console and click the cluster name to access the cluster console.

Step 2 In the navigation tree, choose **Add-ons**. In the right pane, locate **CoreDNS** and click **Edit**.

Step 3 In the window that slides out from the right, set **Multi AZ** to **Required** and click **Install**.

Step 4 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.

Step 5 View that the Deployment pods of the add-on has been allocated to nodes in two AZs.

----End

19.4 Security

19.4.1 Suggestions on CCE Cluster Security Configuration

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.

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.

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.

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.

- 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.

19.4.2 Suggestions on CCE Node Security Configuration

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**.

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.

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
  ```

----End

19.4.3 Security Configuration Suggestions for Using Containers in CCE Clusters

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.

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, you are advised to write the command to the **/etc/rc.local** script.

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

19.4.4 Security Configuration Suggestions for Using Secrets in CCE Clusters

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 viewed by running the **ls -l** command in the **/etc/secret-volume/** directory, but can be viewed by running the **ls -al** command.

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, visit https://kubernetes.io/docs/reference/access-authn-authz/service-accounts-admin/.

19.5 Auto Scaling

19.5.1 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 pods or containers are used for deploying applications, the upper limit of available resources is typically required to set for pods or containers to prevent unlimited usage of node 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.

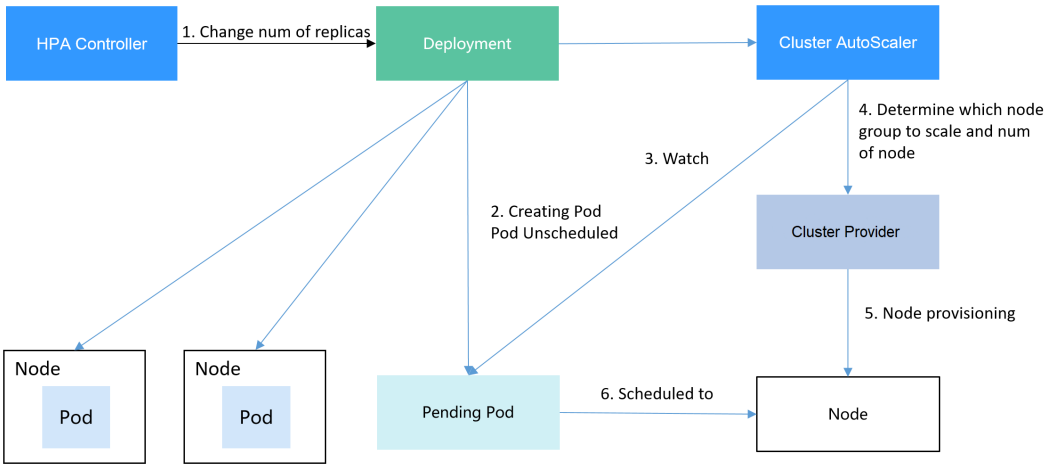
Solution

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 19-4**, 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.

Figure 19-4 HPA and CA working flows



Using HPA and CA can easily implement auto scaling in most scenarios. In addition, the scaling process of nodes and pods can be easily observed.

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 to create an organization.

   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 {*Image repository address***}/group/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 {*Image repository address***}/group/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.

- **Nodes**: Set it to **1**, indicating that one node is created by default when a node pool is created.
- **Specifications**: 2 vCPUs | 4 GiB

Retain the defaults for other parameters.

Step 3 Locate the row containing the newly created node pool and click **Auto Scaling** in the upper right corner.

If the CCE Cluster Autoscaler add-on is not installed in the cluster, install it first.

- **Automatic scale-out**: If this function is enabled, nodes in a node pool will be automatically added based on the cluster load.
- **Customized Rule**: 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.
- **Automatic scale-in**: If this function is enabled, nodes in a node pool will be automatically deleted based on the cluster load. For example, trigger scale-in when the node resource utilization is less than 50%.
- **AS Configuration**: Modify the node quantity range. During autoscaling, the number of nodes in a node pool is always within the configured quantity range.
- **AS Object**: Enable autoscaling for node specifications in a node pool.

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.

```
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
```

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. .

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 Pending state. During this period, nodes are added.

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).

----End

Summary

Using HPA and CA can easily implement auto scaling in most scenarios. In addition, the scaling process of nodes and pods can be easily observed.

19.6 Monitoring

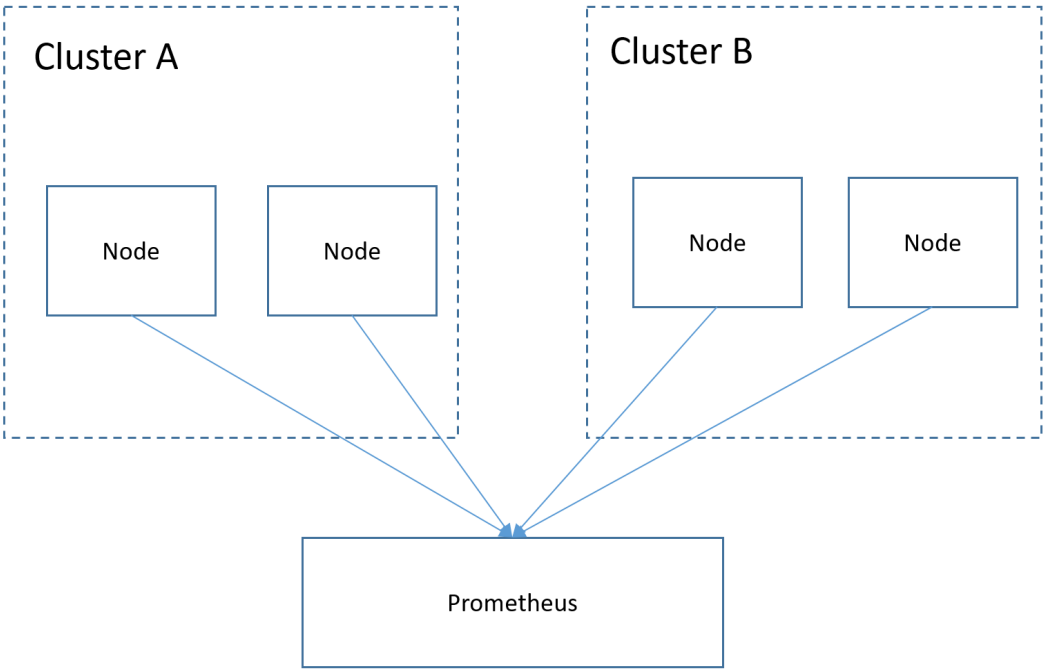
19.6.1 Using Prometheus for Multi-cluster Monitoring

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.

   - 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  sa  prometheus-test -n kube-system
Name:                prometheus-test
Namespace:           kube-system
Labels:              <none>
Annotations:         <none>
Image pull secrets:  <none>
Mountable secrets:   prometheus-test-token-hdhkg
Tokens:              prometheus-test-token-hdhkg
Events:              <none>
[ ~]#
```

   kubectl describe secret prometheus-test-token-hdhkg -n kube-system

```
[root@h2060602 23731 etskj ~]# kubectl describe secret prometheus-test-token-hdhkg -n kube-system
Name:         prometheus-test-token-hdhkg
Namespace:    kube-system
Labels:       <none>
Annotations:  kubernetes.io/service-account.name: prometheus-test
              kubernetes.io/service-account.uid: 2f8171f7-6b81-436c-8343-2aed9484673d

Type:  kubernetes.io/service-account-token

Data
====
ca.crt:     1123 bytes
namespace:  11 bytes
token:      eyJhbGciOiJSUzI1NiIsImtpZCI6IlBQWVEtbGhscUdyS3pbNjJPUTZVUDFxIHhUcmVLamplcEYMRm5U0GpXZIAifQ.eyJpc3MiOiJrdWJlcm5ldGVzL3NlcnZpY2VhY2NvdW50IiwiaXVzZXJuZXRlcy5pby9zZXJ2aWNlYWNjb3VudC9uYWlsc3BhY2UiOiJrdWJlLXN5c3RlbSIsImt1YmVybmV0ZXMuaW8vc2VydmljZWFjY291bnQvc2VjcmV0Lm5hbWUiOiJwcm9tZXRoZXVzLXRlc3QtdG9rZW4taGRoa2ciLCJrdWJlcm5ldGVzLmlvL3NlcnZpY2VhY2NvdW50L3NlcnZpY2UtYWNjb3VudC5uYW1lIjoicHJvbWV0aGV1cy10ZXN0Iiwia3ViZXJuZXRlcy5pby9zZXJ2aWNlYWNjb3VudC9zZXJ2aWNlLWFjY291bnQudWlkIjoiMmY4MTcxZjctNmI4MS00M
zZjLTgzNDMtMmFlZDk0ODQ2NzNkIiwic3ViIjoic3lzdGVtOnNlcnZpY2VhY2NvdW50Omt1YmUtc3lzdGVtOnByb21ldGhldXMtdGVzdCJ9.fYVIhVfg-6pQ4XoXaGK48EeA3I4ZXDBrr6s1gNu-179Gbm957sd4rceDtoRA
mbQ2ogctp6W0wpkk-jbmKkHeeVibT7C_eolvhiejilQrlR57v-RJzqtP6zvwrYwqOhX7PX5ySiLrA6MQEUGxCuiPQRCoy2TFhCGjlooSgVsBxnN2fdqGlphWe1IzdIn_mCumLw-6KeWGBT7n590dR5j_cB4IbwtDk3ChEVc
s_RTB-1RB-bdQ2wJO-V0XJpDJBYA0icFvJ8AGH08jU8ZJ 5mbs5Xss_bGpCufowHc30XVkU8SCeXuV5AB_WaTICWP8VG76RZ115drqzrKmjBoE6Gg
[root@h2060602 23731 etskj ~]#
```

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.

```
[root@hjm-ecs prometheus-2.23.0.linux-amd64]# pwd
/root/prometheus-2.23.0.linux-amd64
[root@hjm-ecs prometheus-2.23.0.linux-amd64]#
[root@hjm-ecs prometheus-2.23.0.linux-amd64]#
[root@hjm-ecs prometheus-2.23.0.linux-amd64]# ll
total 162488
-rw------- 1 root root     5316 Jun 23 22:37 '\'
drwxr-xr-x 2 3434 3434     4096 Nov 26  2020  console_libraries
drwxr-xr-x 2 3434 3434     4096 Nov 26  2020  consoles
drwx------ 9 root root     4096 Jun 27 11:00  data
-rw------- 1 root root      943 Jun 27 11:45  k8s02_token
-rw-r--r-- 1 root root      943 Jun 22 11:58  k8s_token
-rw-r--r-- 1 3434 3434    11357 Nov 26  2020  LICENSE
-rw-r--r-- 1 3434 3434     3420 Nov 26  2020  NOTICE
-rwxr-xr-x 1 3434 3434 88153522 Nov 26  2020  prometheus
-rw------- 1 root root     5501 Jun 27 10:46  prometheus.yml
-rw-r--r-- 1 3434 3434      926 Nov 26  2020  prometheus.yml.bak
-rwxr-xr-x 1 3434 3434 78172790 Nov 26  2020  promtool
[root@hjm-ecs prometheus-2.23.0.linux-amd64]#
```

Tokens of the target clusters

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
```

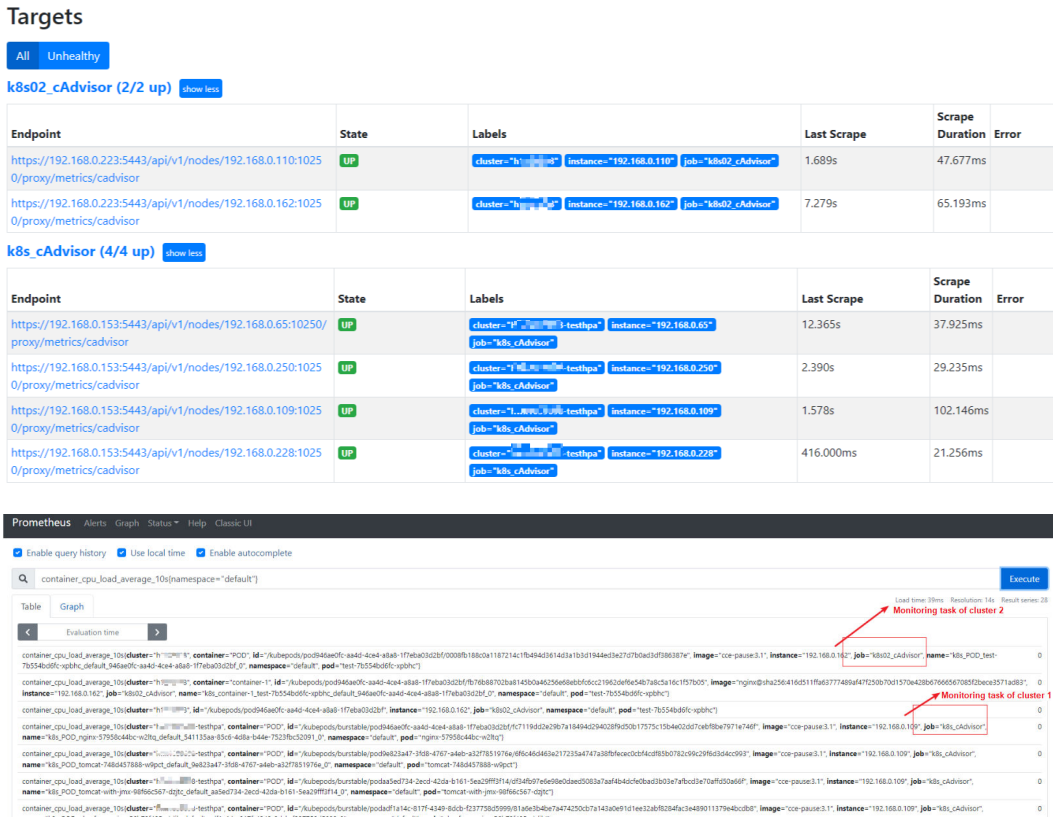
```
  bearer_token_file: k8s02_token # Token file in the previous step
  tls_config:
    insecure_skip_verify: true
  kubernetes_sd_configs:
  - role: node
    bearer_token_file: k8s02_token # Token file in the previous step
    api_server: https://192.168.0.147:5443  # API server address of the Kubernetes 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

19.7 Cluster

19.7.1 Configuring a CCE Cluster

When you use CCE to create a Kubernetes cluster, there are multiple configuration options and terms. This sections compares the key configurations for CCE clusters and provides recommendations to help you create a cluster that better suits your needs.

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 19-10 Network model comparison

Dimension	Tunnel Network	VPC Network
Application scenarios	• Common container service scenarios • Scenarios that do not have high requirements on network latency and bandwidth	• Scenarios that have high requirements on network latency and bandwidth • Containers can communicate with VMs using a microservice registration framework, such as Dubbo and CSE.
Core technology	OVS	IPvlan and VPC route
Applicable clusters	CCE standard cluster	CCE standard cluster
Network isolation	Kubernetes native NetworkPolicy for pods	No
Passthrough networking	No	No

Dimension	Tunnel Network	VPC Network
IP address management	• The container CIDR block is allocated separately. • CIDR blocks are divided by node and can be dynamically allocated (CIDR blocks can be dynamically added after being allocated.)	• The container CIDR block is allocated separately. • CIDR blocks are divided by node and statically allocated (the CIDR block cannot be changed after a node is created).
Network performance	Performance loss due to VXLAN encapsulation	No tunnel encapsulation. Cross-node packets are forwarded through VPC routers, delivering performance equivalent to that of the host network.
Networking scale	A maximum of 2000 nodes are supported.	Suitable for small- and medium-scale networks due to the limitation on VPC routing 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 routing tables. Therefore, the cluster scale is limited by the VPC routing tables.

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.

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.

19.7.2 Executing the Post-installation Command During Node Creation

Background

When creating a node, use the post-installation commands to install tools or perform security hardening on the node. This section provides guidance for you to correctly use the post-installation scripts.

Precautions

- Do not use the post-installation script that takes a long time to execute.

  The time limit to create a node in the CCE clusters is 30 minutes. If the node is not available within 30 minutes, it will be reclaimed. Therefore, do not run the post-installation script that takes a long time.

- Do not directly use the **reboot** command in the script.

  CCE executes the post-installation commands after installing mandatory components on the node. The node will be available only after the post-installation commands are 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 run the **reboot** command.

  If you need to restart the node, perform the following operations:

  – Run the **shutdown -r** *<time >* command 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 the post-installation command.

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 created and click **Next: Confirm**.

Step 5 Click **Submit**.

----End

19.7.3 Connecting to Multiple Clusters Using kubectl

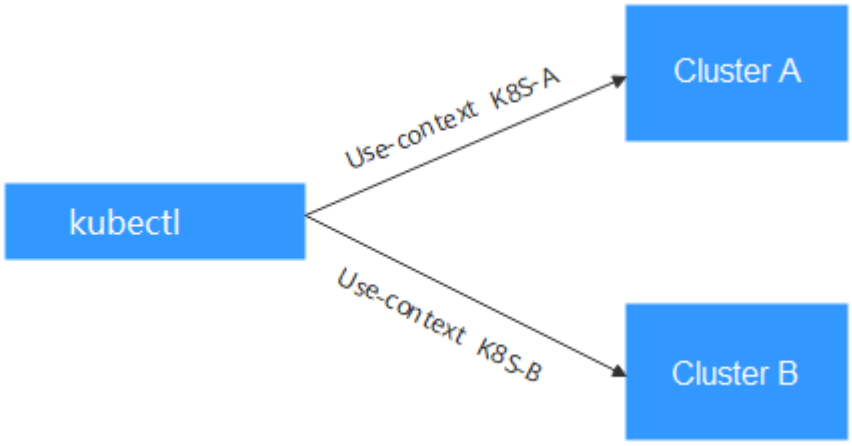
Background

When you have multiple CCE clusters, you may find it difficult to efficiently connect to all of them.

Solution

This section describes how to configure access to multiple clusters by modifying **kubeconfig.json**. The file describes multiple clusters, users, and contexts. To access different clusters, run the **kubectl config use-context** command to switch between contexts.

Figure 19-5 Using kubectl to connect to multiple clusters



Prerequisites

kubectl can access multiple clusters.

Introduction to kubeconfig.json

kubeconfig.json is the configuration file of kubectl. You can download it on the cluster details page.

The content of kubeconfig.json 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.json 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.

Configuring Access to Multiple Clusters

The following steps walk you through the procedure of configuring access to two clusters by modifying kubeconfig.json.

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 kubeconfig.json 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"
}
```

----End

Verification

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

Run the kubectl commands to check whether the two clusters can be connected.

```
# 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'.
```

19.7.4 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. 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 forthe 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 storage capacity of the dockersys volume and thinpool volume 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 the data disk on the EVS console.

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 the **dockersys** disk.

  ```
  # 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   90G  0 lvm  /var/lib/docker              # Space used by the container engine
  └─vgpaas-kubernetes 253:1    0   10G  0 lvm  /mnt/paas/kubernetes/kubelet  # Space used by Kubernetes
  ```

  Run the following commands on the node to add the new disk capacity to the **dockersys** disk:

  ```
  pvresize /dev/vdb
  lvextend -l+100%FREE -n vgpaas/dockersys
  resize2fs /dev/vgpaas/dockersys
  ```

- Devicemapper: A thin pool is allocated to store image data.

  ```
  # 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
```

- Run the following commands on the node to add the new disk capacity to the **thinpool** disk:

  ```
  pvresize /dev/vdb
  lvextend -l+100%FREE -n vgpaas/thinpool
  ```

- Run the following commands on the node to add the new disk capacity to the **dockersys** disk:

  ```
  pvresize /dev/vdb
  lvextend -l+100%FREE -n vgpaas/dockersys
  resize2fs /dev/vgpaas/dockersys
  ```

----End

19.8 Networking

19.8.1 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

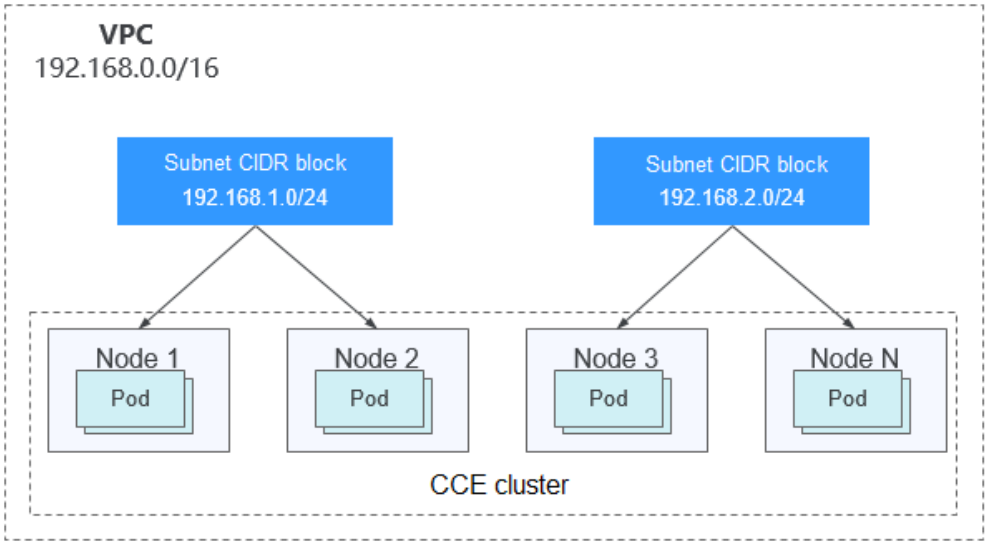
- **VPC CIDR Block**

  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 19-6 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 cannot be 192.168.0.0/18 or 192.168.1.0/18, because these addresses are included in 192.168.0.0/16.

- **Service CIDR Block**

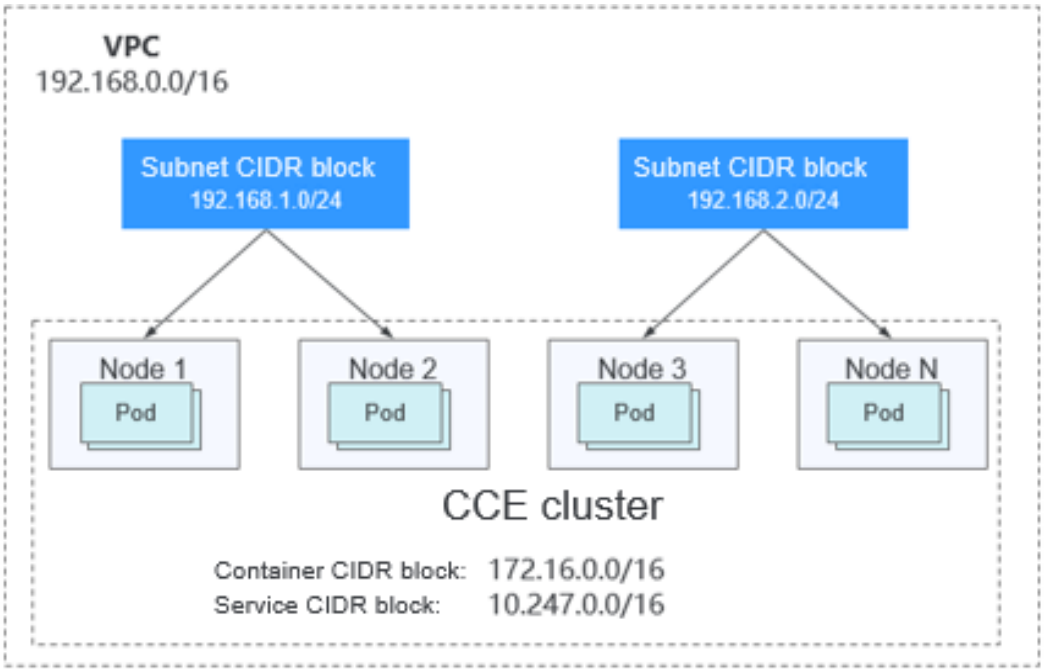
  Service is also a Kubernetes concept. Each Service has an address. When creating a cluster on CCE, you can specify the Service CIDR block. Similarly, the Service CIDR block cannot overlap with the subnet CIDR block or the container CIDR block. The Service CIDR block can be used only within a cluster.

Single-VPC Single-Cluster Scenarios

CCE Clusters: include clusters in VPC network model and container tunnel network model. **Figure 19-7** 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 19-7 Network CIDR block planning in single-VPC single-cluster scenarios (CCE cluster)



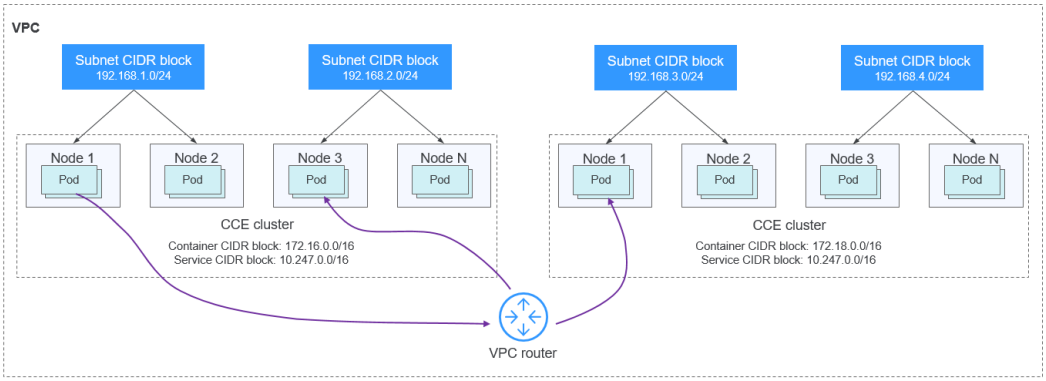
Single-VPC Multi-Cluster Scenarios

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 19-8** 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 19-8 VPC network - multi-cluster scenario

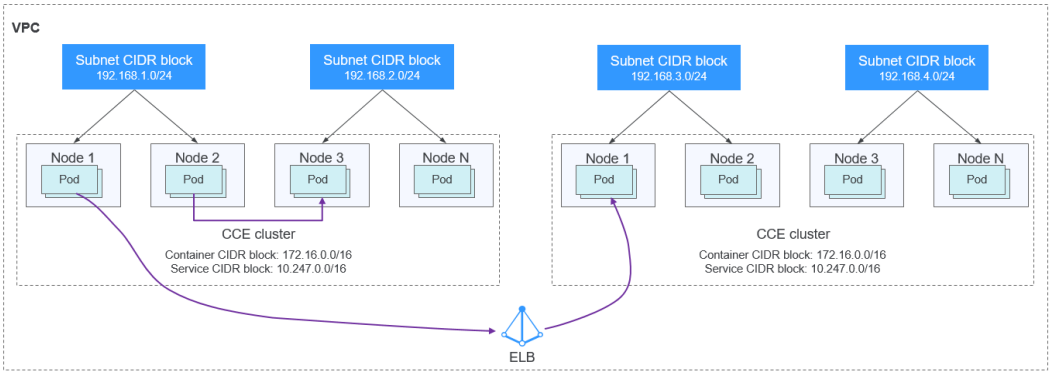


Tunnel network model

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 19-9** 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. Pods in different clusters need to access each other through Services. 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 19-9 Tunnel 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.
- 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.

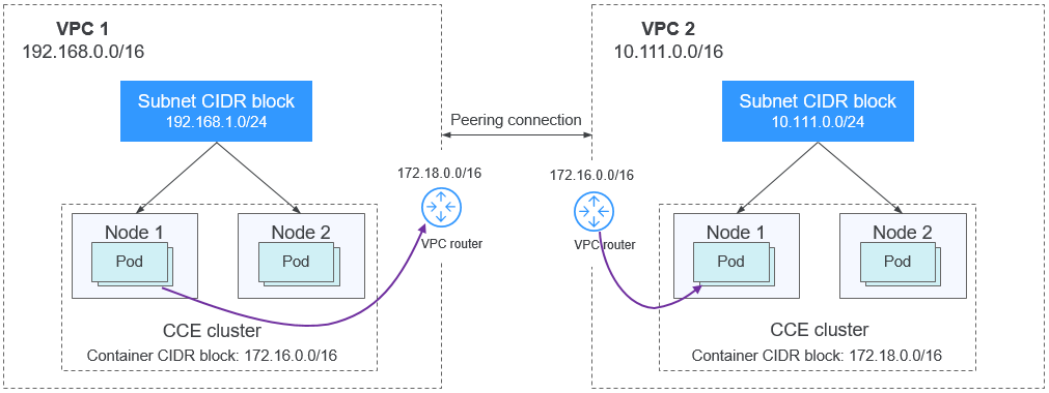
Cross-VPC Cluster Interconnection

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.

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 19-10 VPC network - VPC interconnection scenario



When creating a VPC peering connection between containers across VPCs, pay attention to the following points:

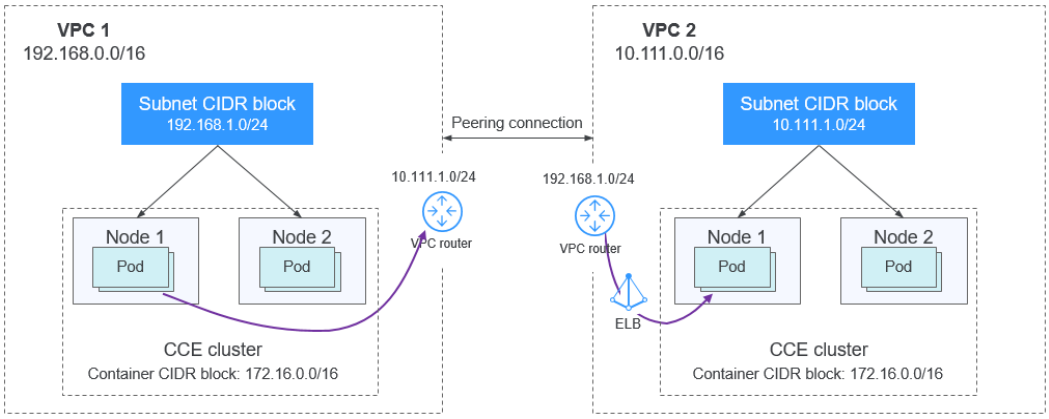
- The VPC to which the clusters belong must not overlap. In each cluster, the subnet CIDR block cannot overlap with the container CIDR block.
- The container CIDR blocks of clusters at both ends cannot overlap, but the Service CIDR blocks can.
- If the request end cluster uses the VPC network, check 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.

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 19-11 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.

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.
- 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.

19.8.2 Selecting a Network Model

CCE uses proprietary, high-performance container networking add-ons to support the tunnel network and VPC network models.

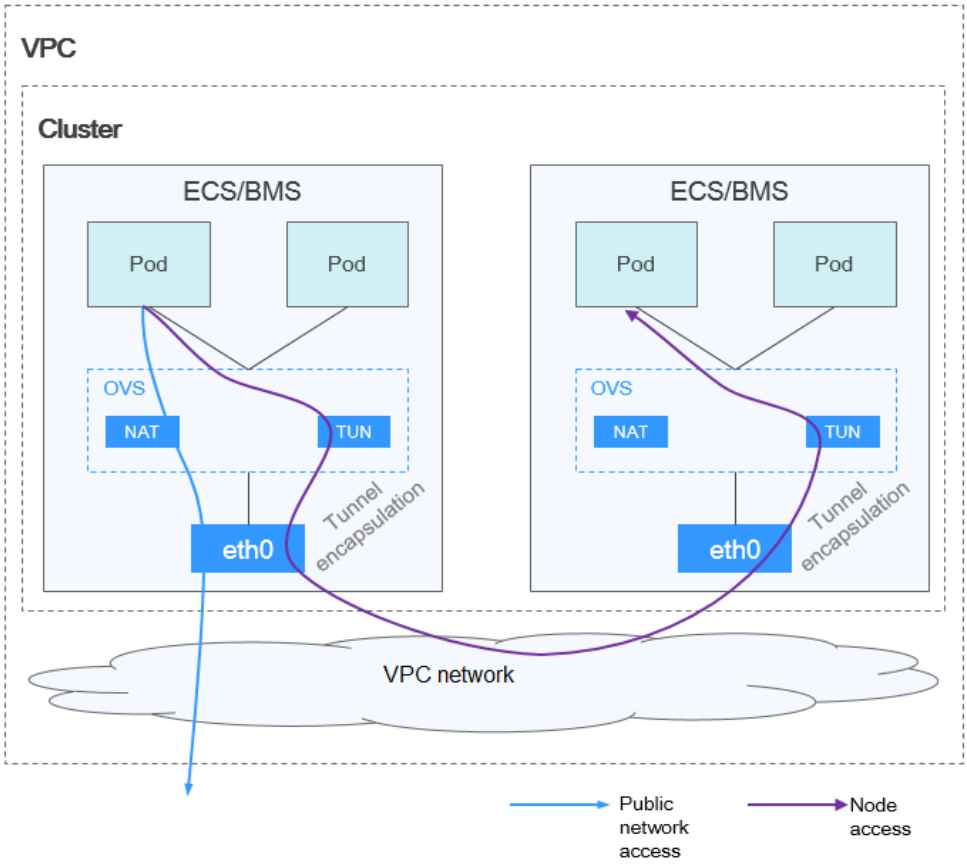
CAUTION

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

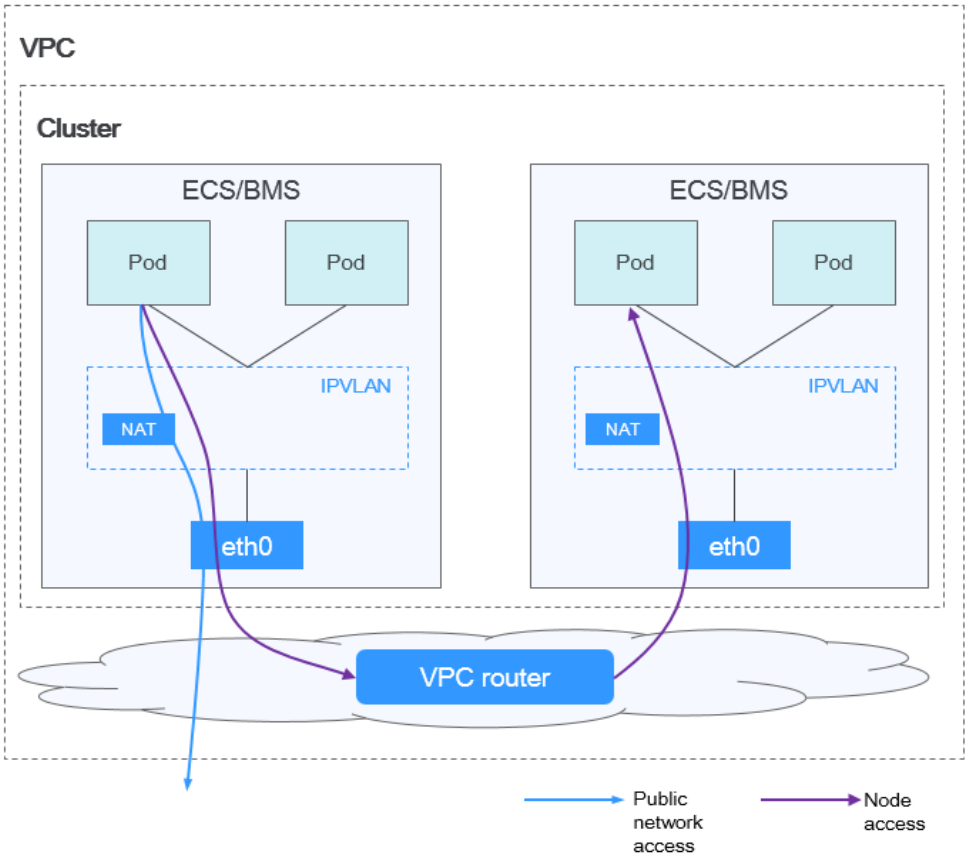
higher interoperability and compatibility with advanced features (such as network policy-based isolation), meeting the requirements of most applications.

Figure 19-12 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 19-13 VPC network



The following table lists the differences between the network models.

Table 19-11 Network model comparison

Dimension	Tunnel Network	VPC Network
Application scenarios	• Common container service scenarios • Scenarios that do not have high requirements on network latency and bandwidth	• Scenarios that have high requirements on network latency and bandwidth • Containers can communicate with VMs using a microservice registration framework, such as Dubbo and CSE.
Core technology	OVS	IPvlan and VPC route
Applicable clusters	CCE standard cluster	CCE standard cluster
Network isolation	Kubernetes native NetworkPolicy for pods	No
Passthrough networking	No	No

Dimension	Tunnel Network	VPC Network
IP address management	• The container CIDR block is allocated separately. • CIDR blocks are divided by node and can be dynamically allocated (CIDR blocks can be dynamically added after being allocated.)	• The container CIDR block is allocated separately. • CIDR blocks are divided by node and statically allocated (the CIDR block cannot be changed after a node is created).
Network performance	Performance loss due to VXLAN encapsulation	No tunnel encapsulation. Cross-node packets are forwarded through VPC routers, delivering performance equivalent to that of the host network.
Networking scale	A maximum of 2000 nodes are supported.	Suitable for small- and medium-scale networks due to the limitation on VPC routing 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 routing tables. Therefore, the cluster scale is limited by the VPC routing tables.

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.

19.8.3 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 19-12 Sticky session types

OSI Layer	Listener Protocol and Networking	Sticky Session Type	Stickiness Duration	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.	• Default: 20 minutes • Maximum: 60 minutes • Range: 1 minute to 60 minutes	• Source IP addresses of the clients have changed. • Requests from the clients exceed the session stickiness duration.

OSI Layer	Listener Protocol and Networking	Sticky Session Type	Stickiness Duration	Scenarios Where Sticky Sessions Become Invalid
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.	• Default: 20 minutes • Maximum: 1440 minutes • Range: 1 minute to 1440 minutes	• 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 Log in to the ELB console and click the target load balancer. In the backend server group of the listener, check whether sticky session is enabled.

----End

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**.

```
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
...
```

Step 3 Create an ingress and associate it with the Service.

```
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 Log in to the ELB console and click the target load balancer. In the backend server group of the listener, check whether sticky session is enabled.

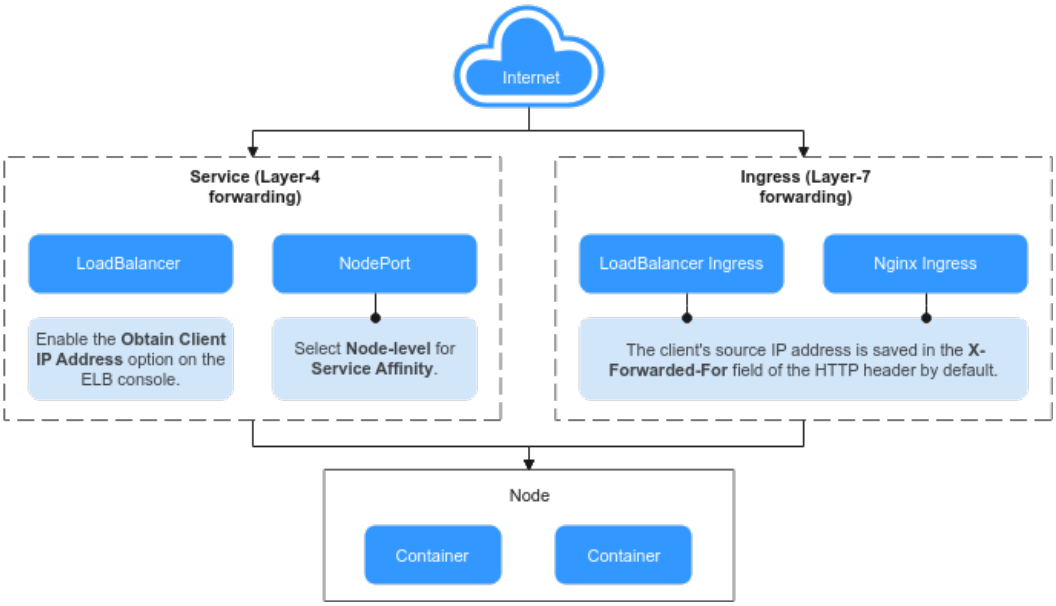
----End

19.8.4 Obtaining the Client Source IP Address for a Container

In containers, multiple types of proxy servers may exist between a client and the container servers. After an external request is forwarded for multiple times, the source IP address of the client cannot be transmitted to the containers. As a result, Services in the containers cannot obtain the real source IP addresses of the client.

Description

Figure 19-14 Obtaining the source IP addresses from the containers



Layer-7 forwarding:

Ingresses: If this access mode is used, the client's source IP address is saved in the **X-Forwarded-For** field of the HTTP header by default. No other configuration is required.

- LoadBalancer Ingresses use ELB for Layer 7 network access between the Internet and internal network (in the same VPC) based on the ELB service.
- The Nginx Ingresses implement Layer 7 network access based on nginx-ingress. The backend Service type can be either **ClusterIP** or **NodePort**.

Layer-4 forwarding:

- LoadBalancer: Use ELB to achieve load balancing. You can manually enable the **Transfer Client IP Address** option for TCP and UDP listeners of shared load balancers. By default, the **Transfer Client IP Address** option is enabled for TCP and UDP listeners of dedicated load balancers. You do not need to manually enable it.

- NodePort: The container port is mapped to the node port. If the cluster-level affinity is selected, access requests will be forwarded through the node and the client source IP address cannot be obtained. If the node-level affinity is selected, access requests will not be forwarded and the client source IP address can be obtained.

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.

The real IP address is placed in the **X-Forwarded-For** HTTP header field by the load balancer in the following format:

```
X-Forwarded-For: IP address of the client,Proxy server 1-IP address,Proxy server 2-IP address,...
```

If you use this method, the first IP address obtained is the IP address of the client.

Nginx Ingress

For the Nginx Ingresses, perform the following operations.

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 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. Log in to the ELB console.
2. Click  in the upper left corner of the management console and select a region and a project.
3. Click **Service List**. Under **Networking**, click **Elastic Load Balance**.
4. On the **Load Balancers** page, click the name of the load balancer.
5. 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.
6. Enable **Transfer Client IP Address**.

Step 3 Edit the nginx-ingress add-on. In the nginx configuration parameter area, configure the configuration fields and information. For details about the parameter range, see **community document**. After the configuration is complete, update the add-on.

```
{
   "enable-real-ip": "true",
   "forwarded-for-header": "X-Forwarded-For",
   "proxy-real-ip-cidr": "100.125.0.0/16",
   "keep-alive-requests": "100"
}
```

NOTE

The **proxy-real-ip-cidr** parameter indicates the CIDR block of the proxy server.

- For shared load balancers, add CIDR block 100.125.0.0/16 (reserved only for load balancers and therefore, there is no risk) and the high-defense CIDR block.
- For dedicated load balancers, add the CIDR block of the VPC subnet where the ELB resides.

Step 4 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

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.

VPC and Container Tunnel Network Models

To obtain source IP addresses, 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. Log in to the ELB console.
2. Click  in the upper left corner of the management console and select a region and a project.
3. Click **Service List**. Under **Networking**, click **Elastic Load Balance**.
4. On the **Load Balancers** page, click the name of the load balancer.
5. 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.
6. Enable **Transfer Client IP Address**.

----End

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**.

19.9 Storage

19.9.1 Expanding the Storage Space

The storage classes that can be expanded for CCE nodes are as follows:

Table 19-13 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	A disk that must be attached to a node for the container engine and kubelet	• **Expanding the Capacity of a Data Disk Used by Container Engines** • **Expanding the Capacity of a Data Disk Used by 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 capacity of the system disk on the EVS console.

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 the Capacity of a Data Disk Used by Container Engines

CCE divides the data disk space for two parts by default. One part is used to store the Docker/containerd working directories, container images, and image metadata. The other is reserved for kubelet and emptyDir volumes. The available container engine space affects image pulls and container startup and running. This section uses Docker as an example to describe how to expand the container engine capacity.

Step 1 Expand the capacity of the data disk on the EVS console.

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 the **dockersys** disk.

```
# 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   90G  0 lvm  /var/lib/docker             # Space used by the container engine
└─vgpaas-kubernetes 253:1    0   10G  0 lvm  /mnt/paas/kubernetes/kubelet  # Space used by Kubernetes
```

Run the following commands on the node to add the new disk capacity to the **dockersys** disk:

```
pvresize /dev/vdb
lvextend -l+100%FREE -n vgpaas/dockersys
resize2fs /dev/vgpaas/dockersys
```

- Devicemapper: A thin pool is allocated to store image data.

```
# 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
```

  - Run the following commands on the node to add the new disk capacity to the **thinpool** disk:

    ```
    pvresize /dev/vdb
    lvextend -l+100%FREE -n vgpaas/thinpool
    ```

  - Run the following commands on the node to add the new disk capacity to the **dockersys** disk:

    ```
    pvresize /dev/vdb
    lvextend -l+100%FREE -n vgpaas/dockersys
    resize2fs /dev/vgpaas/dockersys
    ```

----End

Expanding the Capacity of a Data Disk Used by kubelet

CCE divides the data disk space for container engines and pods. The container engine space stores the Docker/containerd working directories, container images, and image metadata. The other is reserved for kubelet and emptyDir volumes. To expand the kubelet space, perform the following steps:

Step 1 Expand the capacity of the data disk on the EVS console.

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
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   90G  0 lvm  /var/lib/docker             # Space used by the container engine
└─vgpaas-kubernetes 253:1    0   10G  0 lvm  /mnt/paas/kubernetes/kubelet  # Space used by Kubernetes
```

Step 5 Run the following commands on the node to add the new disk capacity to the Kubernetes disk:

```
pvresize /dev/vdb
lvextend -l+100%FREE -n vgpaas/kubernetes
resize2fs /dev/vgpaas/kubernetes
```

----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 unavailable the node-specific resources (such as local storage and workloads scheduled to this node). Exercise caution when performing this operation to avoid impact on running services.

Step 4 Click **Yes**.

Step 5 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 parameters:

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 details, see **Data Disk Space Allocation**.

Step 6 After the node is reset, log in to the node and run the following command to access the container and check whether the container storage capacity has been expanded:

docker exec -it *container_id* **/bin/sh** or **kubectl exec -it** *container_id* **/bin/sh**

df -h

```
# df -h
Filesystem                                                                    Size  Used Avail Use% Mounted on
/dev/mapper/docker-253:1-787293-631c1bde2cbe82e39f32253b216ba914cb183b168b54700b3e5b9a54ee40a0d1   15G  229M   15G   2% /
tmpfs                                                                          32G     0   32G   0% /dev
tmpfs                                                                          32G     0   32G   0% /sys/fs/cgroup
/dev/mapper/vgpaas-kubernetes                                                 9.8G   37M  9.2G   1% /etc/hosts
/dev/vda1                                                                      40G  5.2G   33G  14% /etc/hostname
shm                                                                            64M     0   64M   0% /dev/shm
tmpfs                                                                          32G   16K   32G   1% /run/secrets/kubernetes.io/serviceaccount
tmpfs                                                                          32G     0   32G   0% /proc/acpi
tmpfs                                                                          32G     0   32G   0% /sys/firmware
tmpfs                                                                          32G     0   32G   0% /proc/scsi
tmpfs                                                                          32G     0   32G   0% /proc/kbox
tmpfs                                                                          32G     0   32G   0% /proc/oom_extend
```

----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 volumes on the console. The procedure is as follows:
    i. Choose **Storage** in the navigation pane and 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 SFS Turbo, expand the capacity on the SFS console and then change the capacity in the PVC.

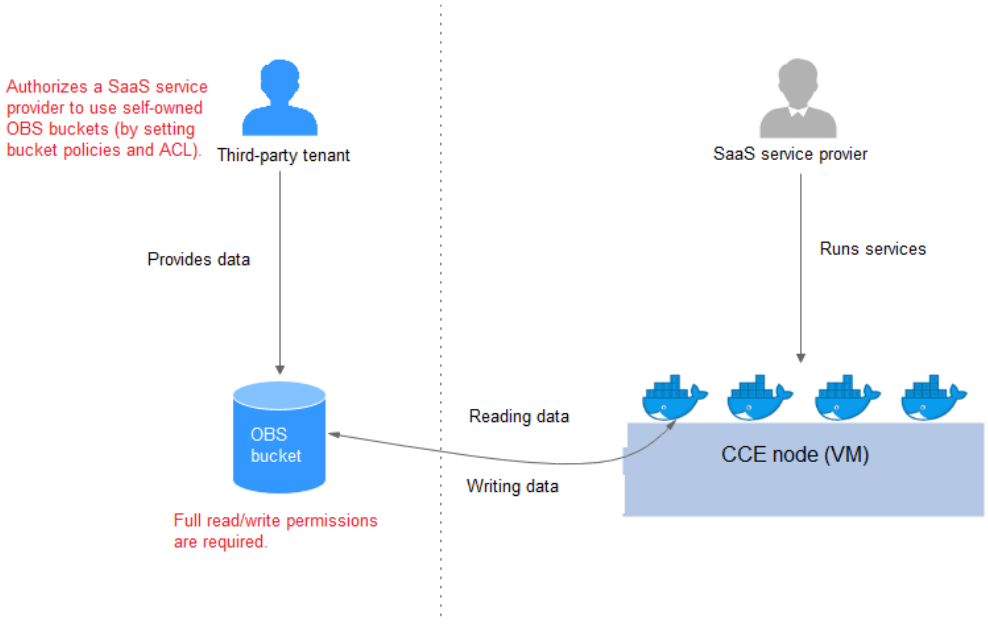
19.9.2 Mounting an Object Storage Bucket of a Third-Party Tenant

This section describes how to mount OBS buckets and OBS parallel file systems (preferred) of third-party tenants.

Application Scenarios

The CCE cluster of a SaaS service provider needs to be mounted with the OBS bucket of a third-party tenant, as shown in **Figure 19-15**.

Figure 19-15 Mounting an OBS bucket of a third-party tenant



1. **The third-party tenant authorizes the SaaS service provider to access the OBS buckets or parallel file systems** by setting the bucket policy and bucket ACL.
2. **The SaaS service provider statically imports the OBS buckets and parallel file systems of the third-party tenant**.
3. The SaaS service provider processes the service and writes the processing result (result file or result data) back to the OBS bucket of the third-party tenant.

Precautions

- Only parallel file systems and OBS buckets of third-party tenants in the same region can be mounted.
- Only clusters where the everest add-on of v1.1.11 or later has been installed (the cluster version must be v1.15 or later) can be mounted with OBS buckets of third-party tenants.
- The service platform of the SaaS service provider needs to manage the lifecycle of the third-party bucket PVs. When a PVC is deleted separately, the PV is not deleted. Instead, it will be retained. To do so, call the native Kubernetes APIs to create and delete static PVs.

Authorizing the SaaS Service Provider to Access the OBS Buckets

The following uses an OBS bucket as an example to describe how to set a bucket policy and bucket ACL to authorize the SaaS service provider. The configuration for an OBS parallel file system is the same.

Step 1 Log in to the OBS console.

Step 2 In the bucket list, click a bucket name and access the **Overview** page.

Step 3 In the navigation pane, choose **Permissions** > **Bucket Policies**. On the displayed page, click **Create** to create a bucket policy.

- **Policy Mode**: Select **Customized**.
- **Effect**: Select **Allow**.
- **Principal**: Select **Include**, select **Cloud service user**, and enter the account ID and user ID. The bucket policy is applied to the specified user.
- **Resources**: Select the resources that can be operated.
- **Actions**: Select the actions that can be operated.

Step 4 In the navigation pane, choose **Permissions** > **Bucket ACLs**. In the right pane, click **Add**. Enter the account ID or account name of the authorized user, select **Read** and **Write** for **Access to Bucket**, select **Read** and **Write** for **Access to ACL**, and click **OK**.

----End

Statically Importing OBS Buckets and Parallel File Systems

- **Static PV of an OBS bucket:**

```
apiVersion: v1
kind: PersistentVolume
metadata:
  name: objbucket      #Replace the name with the actual PV name of the bucket.
  annotations:
    pv.kubernetes.io/provisioned-by: everest-csi-provisioner
spec:
  accessModes:
  - ReadWriteMany
  capacity:
    storage: 1Gi
  mountOptions:
  - default_acl=bucket-owner-full-control      #New OBS mounting parameters
  csi:
    driver: obs.csi.everest.io
    fsType: s3fs
```

```
    volumeAttributes:
      everest.io/obs-volume-type: STANDARD
      everest.io/region:        #Set it to the ID of the current region.
      storage.kubernetes.io/csiProvisionerIdentity: everest-csi-provisioner
    volumeHandle: objbucket              #Replace the name with the actual bucket name of the third-party tenant.
  persistentVolumeReclaimPolicy: Retain    #This parameter must be set to Retain to ensure that the bucket will not be deleted when a PV is deleted.
  storageClassName: csi-obs-mountoption    #You can associate a new custom OBS storage class or the built-in csi-obs of the cluster.
```

- **mountOptions**: This field contains the new OBS mounting parameters that allow the bucket owner to have full access to the data in the bucket. This field solves the problem that the bucket owner cannot read the data written into a mounted third-party bucket. If the object storage of a third-party tenant is mounted, **default_acl** must be set to **bucket-owner-full-control**.
- **persistentVolumeReclaimPolicy**: When the object storage of a third-party tenant is mounted, this field must be set to **Retain**. In this way, the OBS bucket will not be deleted when a PV is deleted. The service platform of the SaaS service provider needs to manage the lifecycle of the third-party bucket PVs. When a PVC is deleted separately, the PV is not deleted. Instead, it will be retained. To do so, call the native Kubernetes APIs to create and delete static PVs.
- **storageClassName**: You can associate a new custom OBS storage class (**click here**) or the built-in csi-obs of the cluster.

PVC of a bound OBS bucket:

```
apiVersion: v1
kind: PersistentVolumeClaim
metadata:
  annotations:
    csi.storage.k8s.io/fstype: obsfs
    everest.io/obs-volume-type: STANDARD
    volume.beta.kubernetes.io/storage-provisioner: everest-csi-provisioner
  name: objbucketpvc      #Replace the name with the actual PVC name of the bucket.
  namespace: default
spec:
  accessModes:
  - ReadWriteMany
  resources:
    requests:
      storage: 1Gi
  storageClassName: csi-obs-mountoption     #The value must be the same as the storage class associated with the bound PV.
  volumeName: objbucket       #Replace the name with the actual PV name of the bucket to be bound.
```

- **Static PV of an OBS parallel file system:**

```
apiVersion: v1
kind: PersistentVolume
metadata:
  name: obsfscheck   #Replace the name with the actual PV name of the parallel file system.
  annotations:
    pv.kubernetes.io/provisioned-by: everest-csi-provisioner
spec:
  accessModes:
  - ReadWriteMany
  capacity:
    storage: 1Gi
  mountOptions:
  - default_acl=bucket-owner-full-control     #New OBS mounting parameters
  csi:
    driver: obs.csi.everest.io
    fsType: obsfs
    volumeAttributes:
      everest.io/obs-volume-type: STANDARD
```

```
    everest.io/region:
    storage.kubernetes.io/csiProvisionerIdentity: everest-csi-provisioner
  volumeHandle: obsfscheck              #Replace the name with the actual name of the parallel file system of the third-party tenant.
 persistentVolumeReclaimPolicy: Retain       #This parameter must be set to Retain to ensure that the bucket will not be deleted when a PV is deleted.
 storageClassName: csi-obs-mountoption       #You can associate a new custom OBS storage class or the built-in csi-obs of the cluster.
```

- **mountOptions**: This field contains the new OBS mounting parameters that allow the bucket owner to have full access to the data in the bucket. This field solves the problem that the bucket owner cannot read the data written into a mounted third-party bucket. If the object storage of a third-party tenant is mounted, **default_acl** must be set to **bucket-owner-full-control**.
- **persistentVolumeReclaimPolicy**: When the object storage of a third-party tenant is mounted, this field must be set to **Retain**. In this way, the OBS bucket will not be deleted when a PV is deleted. The service platform of the SaaS service provider needs to manage the lifecycle of the third-party bucket PVs. When a PVC is deleted separately, the PV is not deleted. Instead, it will be retained. To do so, call the native Kubernetes APIs to create and delete static PVs.
- **storageClassName**: You can associate a new custom OBS storage class (**click here**) or the built-in csi-obs of the cluster.

PVC of a bound OBS parallel file system:

```
apiVersion: v1
kind: PersistentVolumeClaim
metadata:
 annotations:
   csi.storage.k8s.io/fstype: obsfs
   everest.io/obs-volume-type: STANDARD
   volume.beta.kubernetes.io/storage-provisioner: everest-csi-provisioner
 name: obsfscheckpvc   #Replace the name with the actual PVC name of the parallel file system.
 namespace: default
spec:
 accessModes:
 - ReadWriteMany
 resources:
   requests:
     storage: 1Gi
 storageClassName: csi-obs-mountoption    #The value must be the same as the storage class associated with the bound PV.
 volumeName: obsfscheck     #Replace the name with the actual PV name of the parallel file system.
```

- **(Optional) Creating a custom OBS storage class to associate with a static PV:**

```
apiVersion: storage.k8s.io/v1
kind: StorageClass
metadata:
 name: csi-obs-mountoption
mountOptions:
 - default_acl=bucket-owner-full-control
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: Retain
volumeBindingMode: Immediate
```

- **csi.storage.k8s.io/fstype**: File type. The value can be **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.

- **reclaimPolicy**: Reclaim policy of a PV. The value will be set in **PV.spec.persistentVolumeReclaimPolicy** dynamically created based on the new PVC associated with the storage class. If the value is **Delete**, the external OBS bucket and the PV will be deleted when the PVC is deleted. If the value is **Retain**, the PV and external storage are retained when the PVC is deleted. In this case, clear the PV separately. In the scenario where an imported third-party bucket is associated, the storage class is used only for associating static PVs (with this field set to **Retain**). Dynamic creation is not involved.

19.9.3 Using StorageClass to Dynamically Create a Subdirectory in an SFS Turbo File System

Background

The minimum capacity of an SFS Turbo file system is 500 GiB. 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.

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.
- 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
```

```
mountOptions:
- 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/
  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
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. **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
  namespace: default
spec:
  accessModes:
  - ReadWriteMany
  resources:
    requests:
      storage: 50Gi
  storageClassName: sfsturbo-subpath-sc
  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
  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
      name: container-0
      volumeMounts:
      - mountPath: /tmp
        name: pvc-sfs-turbo-example
    restartPolicy: Always
    imagePullSecrets:
    - name: default-secret
    volumes:
    - name: pvc-sfs-turbo-example
      persistentVolumeClaim:
        claimName: sfs-turbo-test
```

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
  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'
          resources: {}
          volumeMounts:
```

```
          - name: sfs-turbo-160024548582479676
            mountPath: /tmp
        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:
        - ReadWriteOnce
      resources:
        requests:
          storage: 10Gi
      storageClassName: sfsturbo-subpath-sc
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

19.9.4 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).

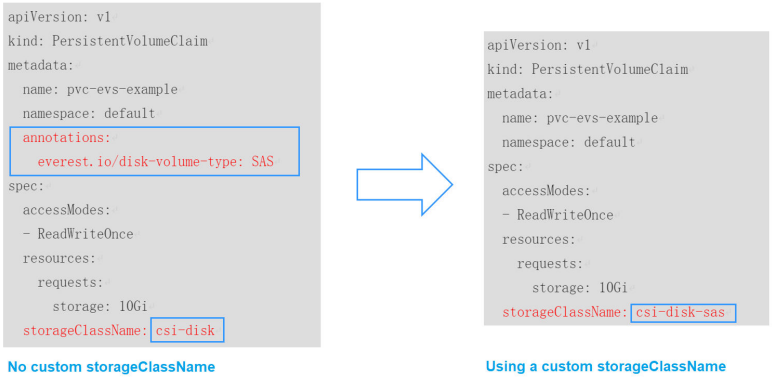
This configuration method may not work if you want to:

- 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
```

CCE Default Storage Classes

As of now, CCE provides storage classes 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 storage classes that CCE supports. Use the CSI add-on provided by CCE to create a storage class.

```
# 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 delayed
csi-nas             everest-csi-provisioner         17d         # SFS 1.0
csi-obs             everest-csi-provisioner         17d         # OBS
csi-sfsturbo        everest-csi-provisioner         17d         # SFS Turbo
```

Each storage class contains the default parameters used for dynamically creating a PV. The following is an example of storage class 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 19-14 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 19-15**.

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 created PV will be automatically destroyed. • **Retain**: indicates that a dynamically created PV will not be automatically destroyed.
allowVolumeExpansion	Specifies whether the PV of this storage class 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**: PV binding and dynamic creation are completed when a PVC is created. • **WaitForFirstConsumer**: PV binding and creation are delayed. The PV creation and binding processes are executed only when the PVC is used in the workload.
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 19-15 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
	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
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 storage class. 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**: Parallel file system, which is mounted using obsfs (recommended). ● **s3fs**: Object bucket, which is mounted using s3fs.
	everest.io/obs-volume-type	Yes	OBS storage class. ● 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.

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.

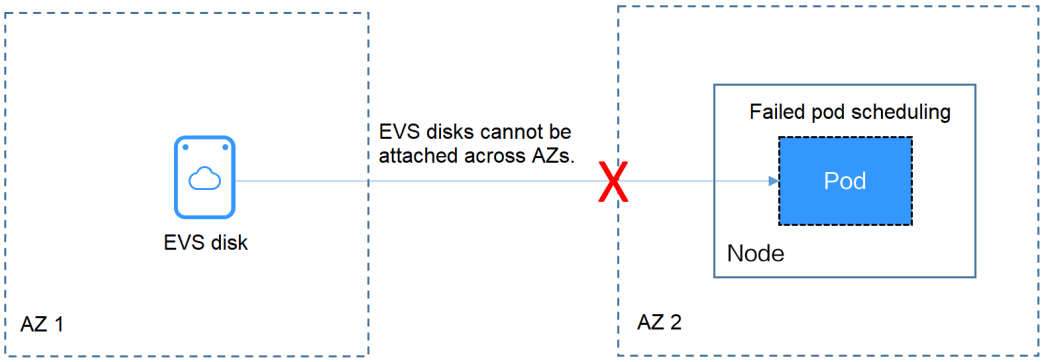
```
# kubectl create -f ssd-disk.yaml
persistentvolumeclaim/ssd-disk created
# kubectl get pvc
NAME       STATUS   VOLUME                                     CAPACITY   ACCESS MODES
STORAGECLASS   AGE
sas-disk   Bound    pvc-6e2f37f9-7346-4419-82f7-b42e79f7964c   10Gi       RWO           csi-disk-sas
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.

19.9.5 Enabling Automatic Topology for EVS Disks When Nodes Are Deployed in Different AZs (csi-disk-topology)

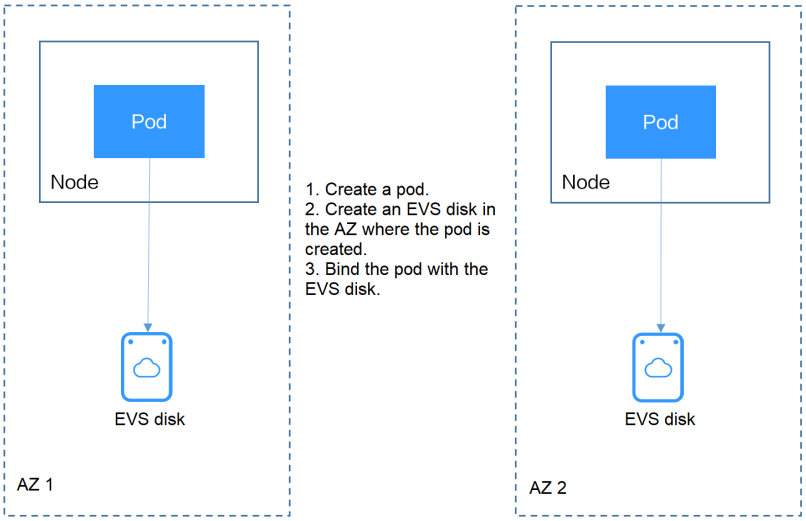
Background

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
```

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>
```

19.10 Container

19.10.1 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
```

19.10.2 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.

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

19.10.3 Using Init Containers to Initialize an Application

Concepts

Before containers running applications are started, one or some init containers are started first. If there are multiple init containers, they will be started in the defined

sequence. The application containers are started only after all init containers run to completion and exit. Storage volumes in a pod are shared. Therefore, the data generated in the init containers can be used by the application containers.

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 pod where the service is running is deployed. After the preparations are complete, the init container runs to completion and exit, 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, register a pod with a central database and download application dependencies.

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:11.23.1   "/pause"                 About a minute ago   Up About a minute
_mysql-76598b8c64-mmgw9_default_522566ea-bda5-11e9-a219-fa163e8b288b_0
```

----End

19.10.4 Using hostAliases to Configure /etc/hosts in a Pod

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 19-16 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 19-17**.

Table 19-17 spec field description

Parameter	Mandatory	Description
hostAliases	Yes	Host alias
containers	Yes	For details, see **Table 19-18**.

Table 19-18 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

19.10.5 Configuring Core Dumps

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.

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.

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
```

19.11 Permission

19.11.1 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. **/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.

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**.

19.12 Release

19.12.1 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.

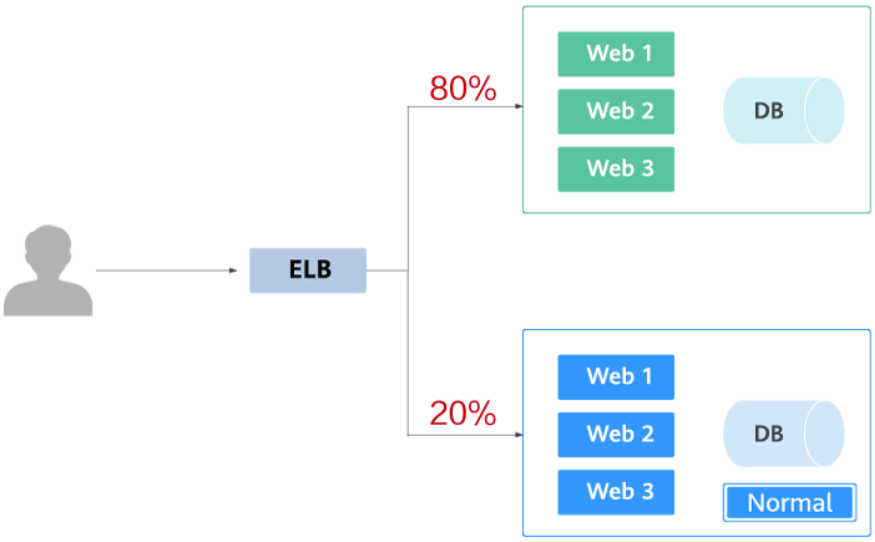
Solution

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.

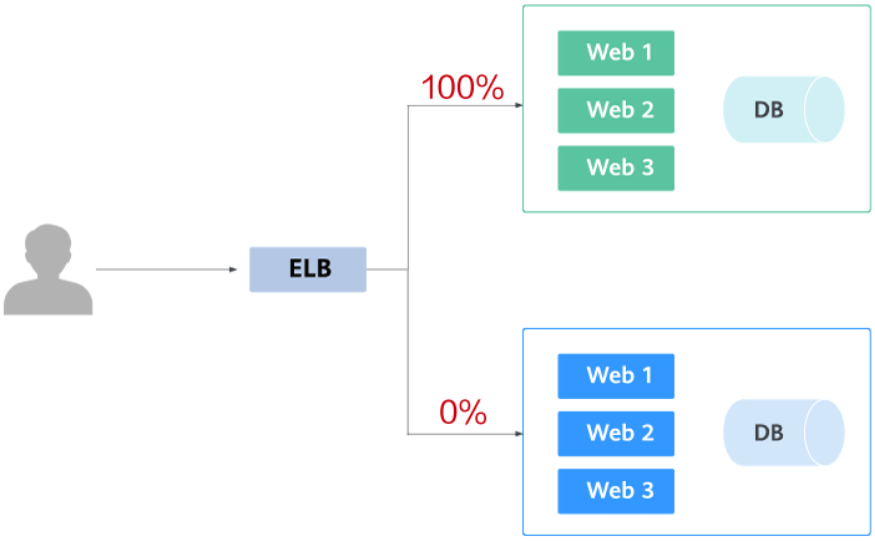
This document describes the principles and practices of grayscale release and blue-green deployment.

- 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.

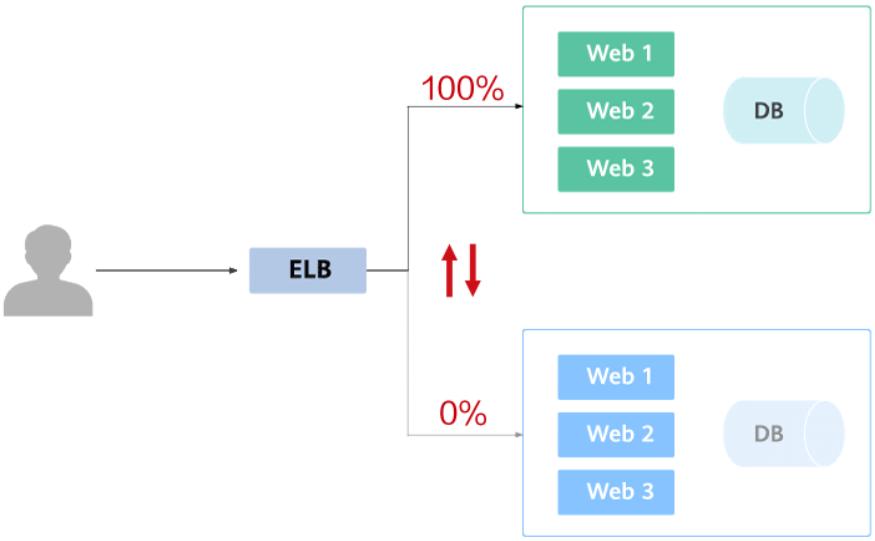


  If an exception occurs in the new version when 20% of the traffic goes to the new version, you can quickly switch back to the old version.



- 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.



19.12.2 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

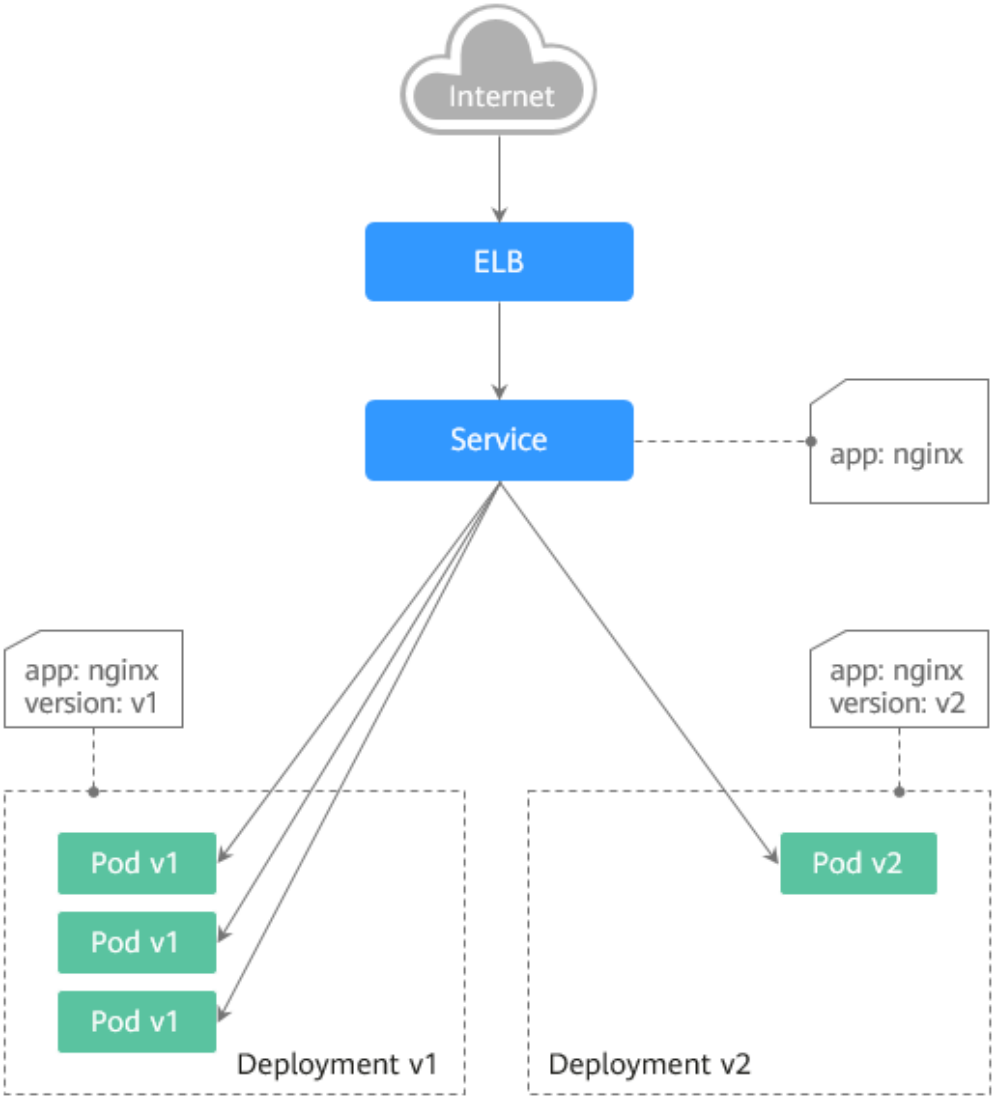
Users usually use Kubernetes objects such as Deployments and StatefulSets to deploy services. Each workload manages a group of pods. The following figure uses Deployment as an example.

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**

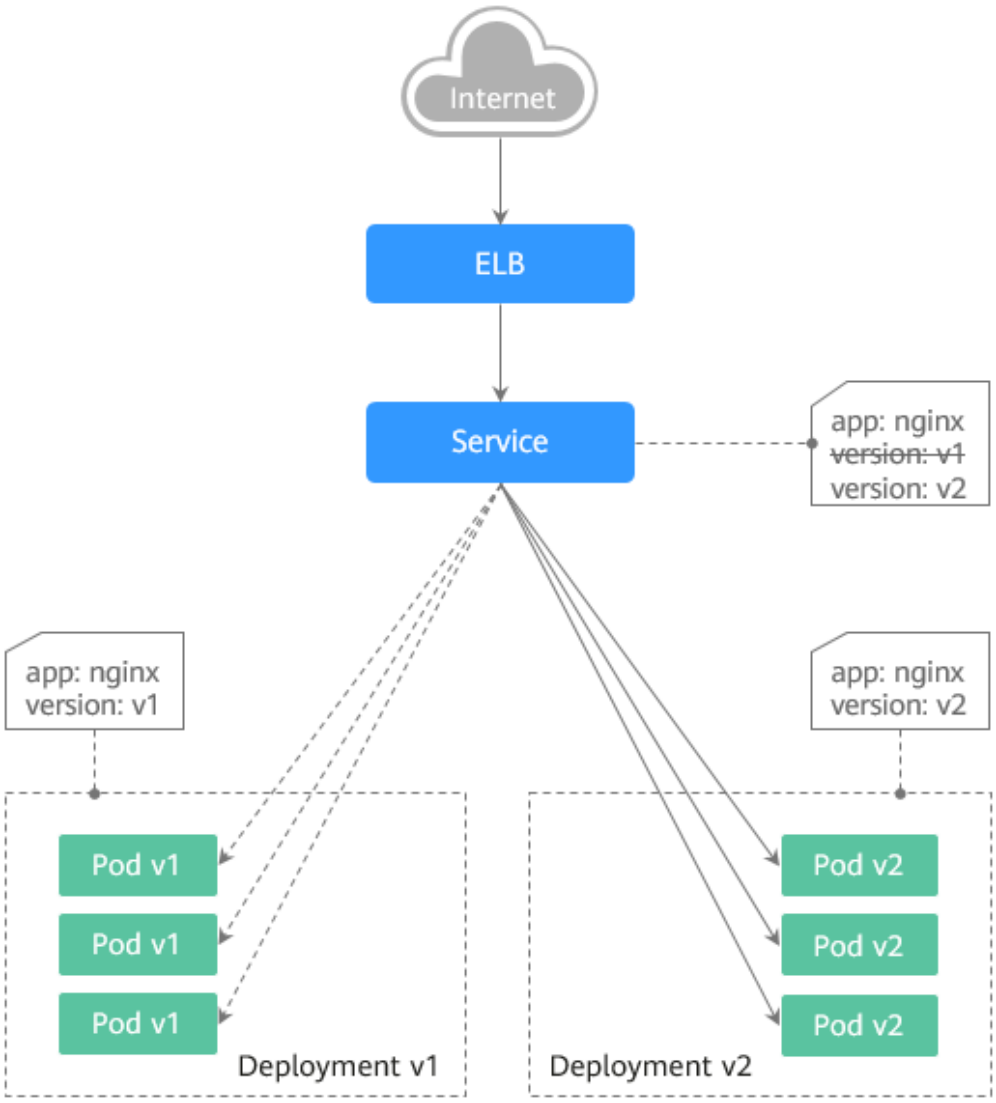
  Take a Deployment as an example. A Service, in most cases, will be created for each Deployment. However, Kubernetes does not require that Services and Deployments correspond to each other. A Service uses a selector to match backend pods. If pods of different Deployments are selected by the same selector, 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

19.12.3 Using Nginx Ingress to Implement Grayscale Release and Blue-Green Deployment

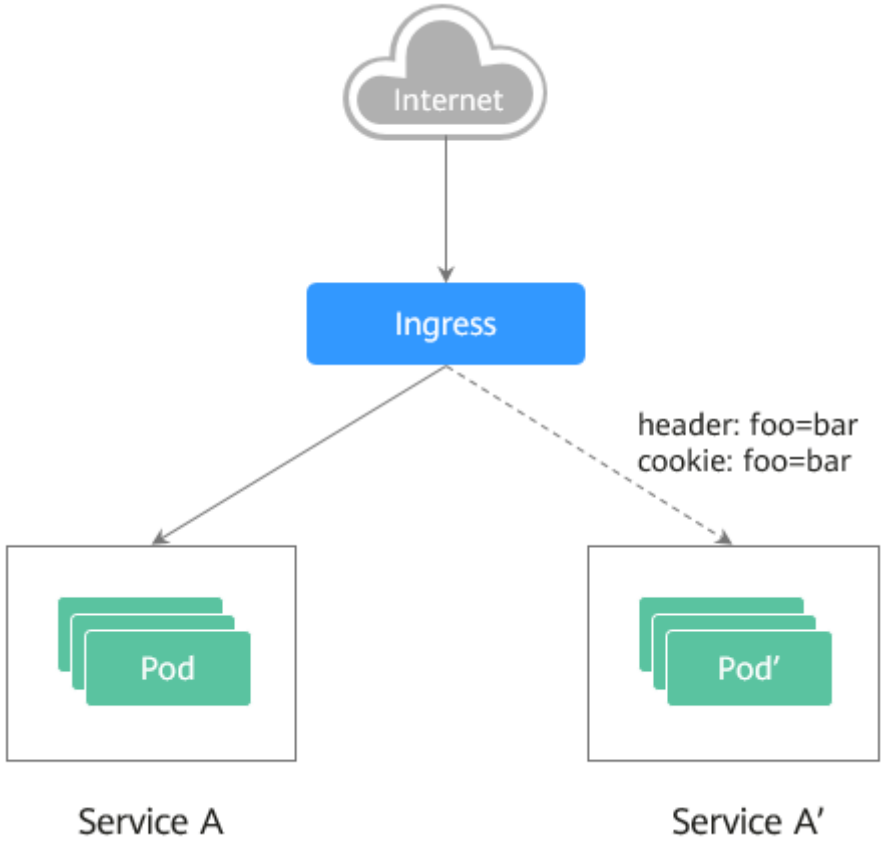
This section describes the scenarios and practices of using Nginx Ingress to implement grayscale release and blue-green deployment.

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:

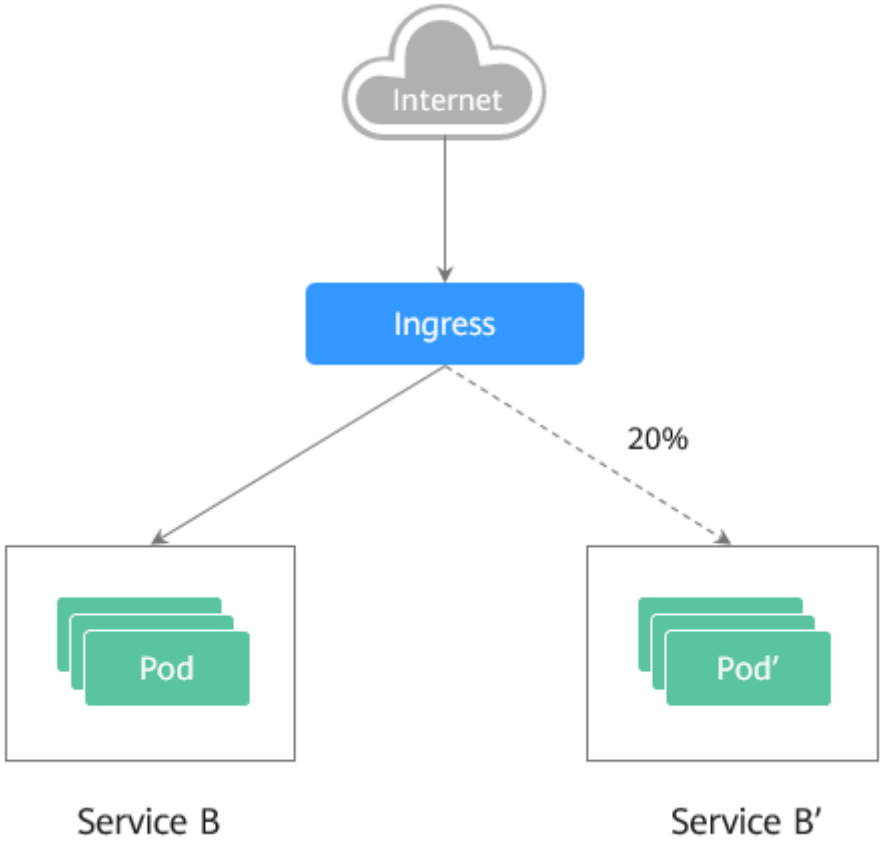
- **Scenario 1: Split some user traffic to the new version.**

  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 .
- 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/v1beta1
kind: Ingress
metadata:
  name: gray-release
  namespace: default
  annotations:
    kubernetes.io/ingress.class: nginx # Use the Nginx ingress.
    kubernetes.io/elb.port: '80'
spec:
  rules:
    - host: www.example.com
      http:
        paths:
          - path: '/'
            backend:
              serviceName: old-nginx      # Specify old-nginx as the backend service.
              servicePort: 80
```

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/v1beta1
kind: Ingress
metadata:
  name: canary-ingress
  namespace: default
  annotations:
    kubernetes.io/ingress.class: nginx
    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:
              serviceName: new-nginx      # Specify new-nginx as the backend service.
              servicePort: 80
```

  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/v1beta1
kind: Ingress
metadata:
  name: canary-ingress
  namespace: default
  annotations:
    kubernetes.io/ingress.class: nginx
    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:
              serviceName: new-nginx      # Specify new-nginx as the backend service.
              servicePort: 80
```

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/v1beta1
kind: Ingress
metadata:
  name: canary-ingress
  namespace: default
  annotations:
    kubernetes.io/ingress.class: nginx
    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:
              serviceName: new-nginx      # Specify new-nginx as the backend service.
              servicePort: 80
```

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/v1beta1
kind: Ingress
metadata:
  name: canary-ingress
  namespace: default
  annotations:
    kubernetes.io/ingress.class: nginx
    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:
              serviceName: new-nginx      # Specify new-nginx as the backend service.
              servicePort: 80
```

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.

20 FAQs

20.1 Common Questions

Cluster Management

- Why Cannot I Create a CCE Cluster?
- Is Management Scale of a Cluster Related to the Number of Master Nodes?
- How Do I Locate the Fault When a Cluster Is Unavailable?

Node/Node Pool Management

- What Should I Do If a Cluster Is Available But Some Nodes Are Unavailable?
- What Should I Do If I/O Suspension Occasionally Occurs When SCSI EVS Disks Are Used?

Workload Management

- What Should I Do If Pod Scheduling Fails?
- What Should I Do If a Pod Fails to Pull the Image?
- What Should I Do If Container Startup Fails?
- What Should I Do If Pods in the Terminating State Cannot Be Deleted?
- What Is the Image Pull Policy for Containers in a CCE Cluster?

Networking

Why Does the Browser Return Error Code 404 When I Access a Deployed Application?

What Should I Do If a Node Fails to Connect to the Internet (Public Network)?

How Do I Optimize the Configuration If the External Domain Name Resolution Is Slow or Times Out?

20.2 Cluster

20.2.1 Cluster Creation

20.2.1.1 Why Cannot I Create a CCE Cluster?

Overview

This section describes how to locate and rectify the fault if you fail to create a CCE cluster.

Details

Possible causes:

1. The Network Time Protocol daemon (ntpd) is not installed or fails to be installed, Kubernetes components fail to pass the pre-verification, or the disk partition is incorrect. The current solution is to create a cluster again. For details about how to locate the fault, see **Locating the Failure Cause**.

Locating the Failure Cause

View the cluster logs to identify the cause and rectify the fault.

Step 1 Log in to the CCE console. In the navigation pane, click **Operation Records** above the cluster list to view operation records.

Step 2 Click the record of the **Failed** status to view error information.

Step 3 Rectify the fault based on the error information and create a cluster again.

----End

20.2.1.2 Is Management Scale of a Cluster Related to the Number of Master Nodes?

Management scale indicates the maximum number of nodes that can be managed by a cluster. If you select **50 nodes**, the cluster can manage a maximum of 50 nodes.

The number of master nodes varies according to the cluster specification, but is not affected by the management scale.

After the multi-master node mode is enabled, three master nodes will be created. If one of them is faulty, the cluster can still run properly. The services will not be affected.

20.2.1.3 Which Resource Quotas Should I Pay Attention To When Using CCE?

CCE restricts **only the number of clusters**. However, when using CCE, you may also be using other cloud services, such as Elastic Cloud Server (ECS), Elastic

Volume Service (EVS), Virtual Private Cloud (VPC), Elastic Load Balance (ELB), and SoftWare Repository for Containers (SWR).

What Is Quota?

Quotas can limit the number or amount of resources available to users, such as the maximum number of ECSs or EVS disks that can be created.

If the existing resource quota cannot meet your service requirements, you can apply for a higher quota.

20.2.2 Cluster Running

20.2.2.1 How Do I Locate the Fault When a Cluster Is Unavailable?

If a cluster is **Unavailable**, perform the following operations to locate the fault.

Troubleshooting Process

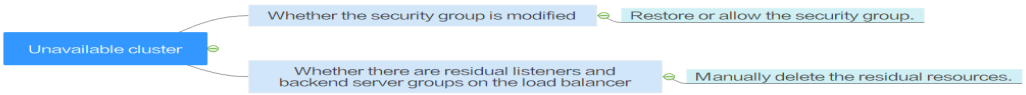
The issues here are described in order of how likely they are to occur.

Check these causes one by one until you find the cause of the fault.

- **Check Item 1: Whether the Security Group Is Modified**
- **Check Item 2: Whether There Are Residual Listeners and Backend Server Groups on the Load Balancer**

If the fault persists, and contact the customer service to help you locate the fault.

Figure 20-1 Fault locating



Check Item 1: Whether the Security Group Is Modified

Step 1 Log in to the management console, and choose **Service List** > **Networking** > **Virtual Private Cloud**. In the navigation pane on the left, choose **Access Control** > **Security Groups** to find the security group of the master node in the cluster.

The name of this security group is in the format of *Cluster name*-cce-**control**-*ID*.

Step 2 Click the security group. On the details page displayed, ensure that the security group rules of the master node are correct.

For details, see **How Can I Configure a Security Group Rule in a Cluster?**.

----End

Check Item 2: Whether There Are Residual Listeners and Backend Server Groups on the Load Balancer

Reproducing the Problem

A cluster exception occurs when a LoadBalancer Service is being created or deleted. After the fault is rectified, the Service is deleted successfully, but there are residual listeners and backend server group.

Step 1 Pre-create a CCE cluster. In the cluster, use the official Nginx image to create workloads, preset load balancers, Services, and ingresses.

Step 2 Ensure that the cluster is running properly and the Nginx workload is stable.

Step 3 Create and delete 10 LoadBalancer Services every 20 seconds.

Step 4 An injection exception occurs in the cluster. For example, the etcd pod is unavailable or the cluster is hibernated.

----End

Possible Causes

There are residual listeners and backend server groups on the load balancer.

Solution

Manually clear residual listeners and backend server groups.

Step 1 Log in to the management console and choose **Network** > **Elastic Load Balance** from the service list.

Step 2 In the load balancer list, click the name of the target load balancer to go to the details page. On the **Listeners** tab page, locate the target listener and delete it.

Step 3 On the **Backend Server Groups** tab page, locate the target backend server group and delete it.

----End

20.2.2.2 How Do I Retrieve Data After a Cluster Is Deleted?

After a cluster is deleted, the workload on the cluster will also be deleted and cannot be restored. Therefore, exercise caution when deleting a cluster.

20.2.3 Cluster Deletion

20.2.3.1 What Can I Do If a Cluster Deletion Fails Due to Residual Resources in the Security Group?

When deleting a cluster, CCE obtains the cluster's resources through kube-apiserver of the cluster. If the cluster is unavailable, frozen, or hibernated, the resources may fail to be obtained, and the cluster may not be deleted.

Symptom

The cluster cannot be deleted, and the following error information is displayed:

```
Expected HTTP response code [200 202 204 404] when accessing [DELETE https://vpc.***.com/v2.0/security-groups/46311976-7743-4c7c-8249-ccd293bcae91], but got 409 instead
{"code":"VPC.0602","message":"{\"NeutronError\":{\"message\": \"Security Group 46311976-7743-4c7c-8249-ccd293bcae91 in use.\",\"type\":\"SecurityGroupInUse\",\"detail\":\"\"}}"}
```

Possible Causes

The cluster's security group has undeleted resources, preventing its deletion and causing the creation of the cluster to fail.

Procedure

Step 1 Copy the resource ID in the error information, go to the **Security Groups** page of the VPC console, and obtain security groups by ID.

Step 2 Click the security group to view its details, and click the **Associated Instances** tab.

Obtain other resources associated with the security group, such as servers, ENIs, and sub-ENIs. You can delete residual resources. The sub ENIs will be automatically deleted.

Step 3 For a residual ENI, go to the **Network Interfaces** page and delete the ENI obtained in the previous step.

Step 4 Go to the **Security Groups** page to confirm that the security group is not associated with any instance. Then, go to the CCE console to delete the cluster.

----End

20.2.3.2 How Do I Clear Residual Resources After Deleting a Non-Running Cluster?

If a cluster is not in the running state (for example, frozen or unavailable), its resources such as PVCs, Services, and Ingresses cannot be obtained. After the cluster is deleted, residual network and storage resources may exist. In this case, manually delete these resources on their respective service console.

Deleting Residual ELB Resources

Step 1 Log in to the ELB console.

Step 2 Search for load balancers in the VPC by VPC ID used in the cluster.

Step 3 View the listener details of a load balancer. If the description contains the cluster ID and Service ID, the listener is created in the cluster.

Step 4 Delete the residual load balancer-related resources from the cluster based on the preceding information.

----End

Deleting Residual EVS Resources

An EVS disk dynamically created using a PVC is named in the format of **pvc-***{UID}*. The **metadata** field in the API contains the cluster ID. You can use this cluster ID to obtain these EVS disks automatically created in the cluster and delete them as required.

Step 1 Go to the EVS console.

Step 2 Search for EVS disks by **pvc-*{UID}*** to get all automatically created EVS disks in the cluster.

Step 3 Press **F12** to open the developer tools. Check whether the **metadata** field in the **detail** API contains the cluster ID. If yes, the EVS disks are automatically created in this cluster.

Step 4 Delete the residual EVS disk-related resources from the cluster based on the preceding information.

NOTE

Deleted data cannot be restored. Exercise caution when performing this operation.

----End

Deleting Residual SFS Resources

An SFS file system dynamically created using a PVC is named in the format of **pvc-*{UID}***. The **metadata** field in the API contains the cluster ID. You can use this cluster ID to obtain these SFS file systems automatically created in the cluster and delete them as required.

Step 1 Log in to the SFS console.

Step 2 Search for SFS file systems **pvc-*{UID}*** to get all automatically created SFS file systems in the cluster.

Step 3 Press **F12** to open the developer tools. Check whether the **metadata** field in the **detail** API contains the cluster ID. If yes, the SFS file systems are automatically created in the cluster.

Step 4 Delete the residual SFS file system-related resources from the cluster based on the preceding information.

NOTE

Deleted data cannot be restored. Exercise caution when performing this operation.

----End

20.2.4 Cluster Upgrade

20.2.4.1 What Do I Do If a Cluster Add-On Fails to be Upgraded During the CCE Cluster Upgrade?

Overview

This section describes how to locate and rectify the fault if you fail to upgrade an add-on during the CCE cluster upgrade.

Procedure

Step 1 If the add-on fails to be upgraded, try again first. If the retry fails, perform the following steps to rectify the fault.

Step 2 If a failure message is displayed on the upgrade page, go to the **Add-ons** page to view the add-on status. For an abnormal add-on, click the add-on name to view details.

Step 3 On the pod details page, click **View Events** in the **Operation** column of the abnormal pod.

Step 4 Rectify the fault based on the exception information. For example, delete the pod that is not started or restart it.

Step 5 After the processing is successful, the add-on status changes to **Running**. Ensure that all add-ons are in the **Running** status.

Step 6 Go to the cluster upgrade page and click **Retry**.

----End

20.3 Node

20.3.1 Node Creation

20.3.1.1 How Do I Troubleshoot Problems Occurred When Adding Nodes to a CCE Cluster?

Note

- The node images in the same cluster must be the same. Pay attention to this when creating, adding, or accepting nodes in a cluster.
- If you need to allocate user space from the data disk when creating a node, do not set the data storage path to any key directory. For example, to store data in the **/home** directory, set the directory to **/home/test** instead of **/home**.

NOTE

Do not set **Path inside a node** to the root directory **/**. Otherwise, the mounting fails. Set **Path inside a node** to any of the following:

- /opt/xxxx (excluding **/opt/cloud**)
- /mnt/xxxx (excluding **/mnt/paas**)
- /tmp/xxx
- /var/xxx (excluding key directories such as **/var/lib**, **/var/script**, and **/var/paas**)
- /xxxx (It cannot conflict with the system directory, such as **bin**, **lib**, **home**, **root**, **boot**, **dev**, **etc**, **lost+found**, **mnt**, **proc**, **sbin**, **srv**, **tmp**, **var**, **media**, **opt**, **selinux**, **sys**, and **usr**.)

Do not set it to **/home/paas**, **/var/paas**, **/var/lib**, **/var/script**, **/mnt/paas**, or **/opt/cloud**. Otherwise, the system or node installation will fail.

Check Item 1: Subnet Quota

Symptom

New nodes cannot be added to a CCE cluster, and a message is displayed indicating that the subnet quota is insufficient.

Cause Analysis

Example:

VPC CIDR block: 192.168.66.0/24

Subnet CIDR block: 192.168.66.0/24

In 192.168.66.0/24, all 251 private IP addresses have been used.

Solution

Step 1 Expand the VPC.

Log in to the console and choose **Virtual Private Cloud** from the service list. On the page displayed, locate the row containing the target VPC and click **Edit CIDR Block** in the **Operation** column.

Step 2 Change the subnet mask to **16** and click **OK**.

Step 3 Click the VPC name. On the **Summary** tab page, click the number next to **Subnets** on the right and click **Create Subnet** to create a subnet.

Step 4 Return to the page for adding a node on the CCE console, and select the newly created subnet.

NOTE

1. Adding subnets to the VPC does not affect the use of the existing 192.168.66.0/24 CIDR block.

   You can select a new subnet when creating a CCE node. The new subnet has a maximum of 251 private IP addresses. If the number of private IP addresses cannot meet service requirements, you can add more subnets.
2. Subnets in the same VPC can communicate with each other.

----End

Check Item 2: EIP Quota

Symptom

When a node is added, **EIP** is set to **Auto create**. The node cannot be created, and a message indicating that EIPs are insufficient is displayed.

Solution

Two methods are available to solve the problem.

- **Method 1:** Unbind the VMs bound with EIPs and add a node again.
  a. Log in to the management console.
  b. Choose **Service List** > **Compute** > **Elastic Cloud Server**.
  c. In the ECS list, locate the target ECS and click its name.
  d. On the page displayed, click the **EIPs** tab. In the EIP list, locate the row containing the target EIP, click **Unbind**, and click **Yes**.
  e. Return to the page for adding a node on the CCE console, select **Use existing** for **EIP**, and add the node again.
- **Method 2:** Increase the EIP quota.

Check Item 3: Security Group

Symptom

A node cannot be added to a CCE cluster.

Solution

You can click the cluster name to view the cluster details. In the **Networking Configuration** area, click the icon next to **Default security group of the node** to check whether the default security group is deleted and whether the security group rules comply with **How Can I Configure a Security Group Rule in a Cluster?**.

If your account has multiple clusters and you need to manage network security policies of nodes in a unified manner, you can specify custom security groups.

20.3.1.2 How Do I Troubleshoot Problems Occurred When Accepting Nodes into a CCE Cluster?

Overview

This section describes how to troubleshoot the problems occurred when you accept or add existing ECSs to a CCE cluster.

NOTICE

- While an ECS is being accepted into a cluster, the operating system of the ECS will be reset to the standard OS image provided by CCE to ensure node stability. The CCE console prompts you to select the operating system and the login mode during the reset.
- The ECS system and data disks will be formatted while the ECS is being accepted into a cluster. Ensure that data in the disks has been backed up.
- While an ECS is being accepted into a cluster, do not perform any operation on the ECS through the ECS console.

Notes and Constraints

- The cluster version must be 1.15 or later.
- If a password or key has been set when the original VM node was created, reset the password or key during management. The original password or key will become invalid.
- Data disks that have been partitioned will be ignored during node management. Ensure that there is at least one unpartitioned data disk meeting the specifications is attached to the node.

Prerequisites

A cloud server that meets the following conditions can be accepted:

- The node to be accepted must be in the **Running** state and not used by other clusters. In addition, the node to be accepted does not carry the CCE-Dynamic-Provisioning-Node tag.
- The node to be accepted and the cluster must be in the same VPC. (If the cluster version is earlier than v1.13.10, the node to be accepted and the CCE cluster must be in the same subnet.)
- Data disks must be attached to the nodes to be managed. A local disk (disk-intensive disk) or a data disk of at least 20 GiB can be attached to the node, and any data disks already attached cannot be smaller than 10 GiB.
- The node to be accepted has 2-core or higher CPU, 4 GiB or larger memory, and only one NIC.
- If an enterprise project is used, the node to be accepted and the cluster must be in the same enterprise project. Otherwise, resources cannot be identified during management. As a result, the node cannot be accepted.
- Only cloud servers with the same specifications, AZ, and data disk configuration can be added in batches.

Procedure

View the cluster log information to locate the failure cause and rectify the fault.

Step 1 Log in to the CCE console. In the navigation pane, click **Operation Records** above the cluster list to view operation records.

Step 2 Click the record of the **Failed** status to view error information.

Step 3 Rectify the fault based on the error information and accept the node into a cluster again.

----End

Common Issues

If a node fails to be managed, a message will be displayed, indicating that the disk partitioning does not work:

```
Install config-prepare failed: exit status 1, output: [ Mon Jul 17 14:26:10 CST 2023 ] start install config-prepare\nNAME MAJ:MIN RM SIZE RO TYPE MOUNTPOINT\nsda 8:0 0 40G 0 disk \n └─sda1 8:1 0 40G 0 part /\nsdb 8:16 0 100G 0 disk \n └─sdb1 8:17 0 100G 0 part
disk /dev/sda has been partition, will skip this device\nRaw disk /dev/sdb has been partition, will skip this device\nwarning: selector can not match any evs volume
```

To resolve this issue, attach an unpartitioned data disk of 20 GiB or higher to the node. After the node is managed, the unpartitioned data disk is used to store the container engine and kubelet. You can perform operations on the partitioned data disk that does not work as required.

20.3.1.3 What Should I Do If a Node Fails to Be Accepted Because It Fails to Be Installed?

Symptom

A node fails to be accepted into a cluster.

Possible Cause

Log in to the node and check the **/var/paas/sys/log/baseagent/baseagent.log** installation log. The following error information is displayed:

Check the LVM settings of the node. It is found that the LVM logical volume is not created in **/dev/vdb**.

Solution

Run the following command to manually create a logical volume:

```
pvcreate /dev/vdb
vgcreate vgpaas /dev/vdb
```

After the node is reset on the GUI, the node becomes normal.

20.3.2 Node Running

20.3.2.1 What Should I Do If a Cluster Is Available But Some Nodes Are Unavailable?

If the cluster status is available but some nodes in the cluster are unavailable, perform the following operations to rectify the fault:

Mechanism for Detecting Node Unavailability

Kubernetes provides the heartbeat mechanism to help you determine node availability. For details about the mechanism and interval, see **Heartbeats**.

Troubleshooting Process

The issues here are described in order of how likely they are to occur.

Check these causes one by one until you find the cause of the fault.

- **Check Item 1: Whether the Node Is Overloaded**
- **Check Item 2: Whether the ECS Is Deleted or Faulty**
- **Check Item 3: Whether You Can Log In to the ECS**
- **Check Item 4: Whether the Security Group Is Modified**
- **Check Item 5: Whether the Security Group Rules Contain the Security Group Policy for the Communication Between the Master Node and the Worker Node**
- **Check Item 6: Whether the Disk Is Abnormal**
- **Check Item 7: Whether Internal Components Are Normal**
- **Check Item 8: Whether the DNS Address Is Correct**
- **Check Item 9: Whether the vdb Disk on the Node Is Deleted**
- **Check Item 10: Whether the Docker Service Is Normal**

Check Item 1: Whether the Node Is Overloaded

Symptom

The node connection in the cluster is abnormal. Multiple nodes report write errors, but services are not affected.

Fault Locating

Step 1 Log in to the CCE console and click the cluster name to access the cluster console. In the navigation pane, choose **Nodes** and click the **Nodes** tab. Locate the row that contains the unavailable node and click **Monitor**.

Step 2 On the top of the displayed page, click **View More** to go to the AOM console and view historical monitoring records.

A too high CPU or memory usage of the node will result in a high network latency or trigger system OOM. Therefore, the node is displayed as unavailable.

----End

Solution

1. You are advised to migrate services to reduce the workloads on the node and set the resource upper limit for the workloads.
2. Clear data on the CCE nodes in the cluster.
3. Limit the CPU and memory quotas of each container.
4. Add more nodes to the cluster.
5. You can also restart the node on the ECS console.
6. Add nodes to deploy memory-intensive containers separately.
7. Reset the node.

After the node becomes available, the workload is restored.

Check Item 2: Whether the ECS Is Deleted or Faulty

Step 1 Check whether the cluster is available.

Log in to the CCE console and check whether the cluster is available.

- If the cluster is unavailable, for example, an error occurs, perform operations described in **How Do I Locate the Fault When a Cluster Is Unavailable?**
- If the cluster is running but some nodes in the cluster are unavailable, go to **Step 2**.

Step 2 Log in to the ECS console and view the ECS status.

- If the ECS status is **Deleted**, go back to the CCE console, delete the corresponding node from the node list of the cluster, and then create another one.
- If the ECS status is **Stopped** or **Frozen**, restore the ECS first. It takes about 3 minutes to restore the ECS.
- If the ECS is **Faulty**, restart the ECS to rectify the fault.
- If the ECS status is **Running**, log in to the ECS to locate the fault according to **Check Item 7: Whether Internal Components Are Normal**.

----End

Check Item 3: Whether You Can Log In to the ECS

Step 1 Log in to the ECS console.

Step 2 Check whether the node name displayed on the page is the same as that on the VM and whether the password or key can be used to log in to the node.

If the node names are inconsistent and the password and key cannot be used to log in to the node, Cloud-Init problems occurred when an ECS was created. In this case, restart the node and submit a service ticket to the ECS personnel to locate the root cause.

----End

Check Item 4: Whether the Security Group Is Modified

Log in to the VPC console. In the navigation pane, choose **Access Control** > **Security Groups** and locate the security group of the cluster master node.

The name of this security group is in the format of *Cluster name*-cce-**control**-*ID*. You can search for the security group by cluster name.

Check whether the rules in the security group are modified. For details, see **How Can I Configure a Security Group Rule in a Cluster?**.

Check Item 5: Whether the Security Group Rules Contain the Security Group Policy for the Communication Between the Master Node and the Worker Node

Check whether such a security group policy exists.

When a node is added to an existing cluster, if an extended CIDR block is added to the VPC corresponding to the subnet and the subnet is an extended CIDR block, you need to add the following three security group rules to the master node security group (the group name is in the format of ***Cluster name*-cce-control-*Random number***). These rules ensure that the nodes added to the cluster are available. (This step is not required if an extended CIDR block has been added to the VPC during cluster creation.)

For details about security, see **How Can I Configure a Security Group Rule in a Cluster?**.

Check Item 6: Whether the Disk Is Abnormal

A 100 GiB data disk dedicated for Docker is attached to the new node. If the data disk is uninstalled or damaged, the Docker service becomes abnormal and the node becomes unavailable.

Click the node name to check whether the data disk mounted to the node is uninstalled. If the disk is uninstalled, mount a data disk to the node again and restart the node. Then the node can be recovered.

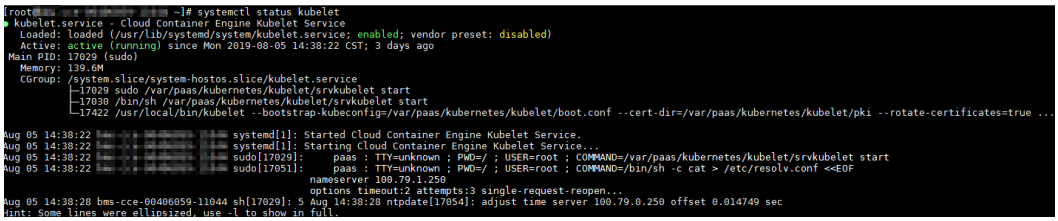
Check Item 7: Whether Internal Components Are Normal

Step 1 Log in to the ECS where the unavailable node is located.

Step 2 Run the following command to check whether the PaaS components are normal:

systemctl status kubelet

If the command is successfully executed, the status of each component is displayed as **active**, as shown in the following figure.



If the component status is not **active**, run the following commands (using the faulty component **canal** as an example):

Run **systemctl restart canal** to restart the component.

After restarting the component, run **systemctl status canal** to check the status.

Step 3 If the restart command fails to be run, run the following command to check the running status of the monitrc process:

ps -ef | grep monitrc

If the monitrc process exists, run the following command to kill this process. The monitrc process will be automatically restarted after it is killed.

kill -s 9 `ps -ef | grep monitrc | grep -v grep | awk '{print $2}'`

----End

Check Item 8: Whether the DNS Address Is Correct

Step 1 After logging in to the node, check whether any domain name resolution failure is recorded in the **/var/log/cloud-init-output.log** file.

cat /var/log/cloud-init-output.log | grep resolv

If the command output contains the following information, the domain name cannot be resolved:

Could not resolve host: Unknown error

Step 2 On the node, ping the domain name that cannot be resolved in the previous step to check whether the domain name can be resolved on the node.

- If not, the DNS cannot resolve the IP address. Check whether the DNS address in the **/etc/resolv.conf** file is the same as that configured on the VPC subnet. In most cases, the DNS address in the file is incorrectly configured. As a result, the domain name cannot be resolved. Correct the DNS configuration of the VPC subnet and reset the node.
- If yes, the DNS address configuration is correct. Check whether there are other faults.

----End

Check Item 9: Whether the vdb Disk on the Node Is Deleted

If the vdb disk on a node is deleted, you can refer to **this topic** to restore the node.

Check Item 10: Whether the Docker Service Is Normal

Step 1 Run the following command to check whether the Docker service is running:

```
systemctl status docker
```

```
● docker.service - Docker Application Container Engine
   Loaded: loaded (/usr/lib/systemd/system/docker.service; enabled; vendor preset: disabled)
   Active: active (running) since Wed 2021-02-03 16:07:02 CST; 1 day 23h ago
     Docs: https://docs.docker.com
 Main PID: 3673 (dockerd)
    Tasks: 46 (limit: 24004)
   Memory: 491.2M
   CGroup: /system.slice/docker.service
           ├─3673 /usr/bin/dockerd --live-restore --log-opt max-size=50m --log-opt max-file=20 --log-driver=json-fil
           ├─3680 containerd --config /var/run/docker/containerd/containerd.toml --log-level info
           ├─5961 containerd-shim -namespace moby -workdir /var/lib/docker/containerd/daemon/io.containerd.runtime.v
           └─6811 containerd-shim -namespace moby -workdir /var/lib/docker/containerd/daemon/io.containerd.runtime.v

Warning: Journal has been rotated since unit was started. Log output is incomplete or unavailable.
```

If the command fails or the Docker service status is not active, locate the cause or contact technical support if necessary.

Step 2 Run the following command to check the number of containers on the node:

```
docker ps -a | wc -l
```

If the command is suspended, the command execution takes a long time, or there are more than 1000 abnormal containers, check whether workloads are repeatedly created and deleted. If a large number of containers are frequently created and deleted, a large number of abnormal containers may occur and cannot be cleared in a timely manner.

In this case, stop repeated creation and deletion of the workload or use more nodes to share the workload. Generally, the nodes will be restored after a period of time. If necessary, run the **docker rm** {*container_id*} command to manually clear abnormal containers.

----End

20.3.2.2 How Do I Log In to a Node Using a Password and Reset the Password?

Context

When creating a node on CCE, you selected a key pair or specified a password for login. If you forget your key pair or password, you can log in to the ECS console to reset the password of the node. After the password is reset, you can log in to the node using the password.

Procedure

Step 1 Log in to the ECS console.

Step 2 In the ECS list, select the cloud server type of the node. In the same row as the node, choose **More** > **Stop**.

Step 3 After the node is stopped, choose **More** > **Reset Password**, and follow on-screen prompts to reset the password.

Step 4 After the password is reset, choose **More** > **Start**, and click **Remote Login** to log in to the node using the password.

----End

20.3.2.3 How Do I Collect Logs of Nodes in a CCE Cluster?

The following tables list log files of CCE nodes.

Table 20-1 Node logs

Name	Path
kubelet log	• For clusters of v1.21 or later: **/var/log/cce/kubernetes/kubelet.log** • For clusters of v1.19 or earlier: **/var/paas/sys/log/kubernetes/kubelet.log**
kube-proxy log	• For clusters of v1.21 or later: **/var/log/cce/kubernetes/kube-proxy.log** • For clusters of v1.19 or earlier: **/var/paas/sys/log/kubernetes/kube-proxy.log**
yangtse log (networking)	• For clusters of v1.21 or later: **/var/log/cce/yangtse** • For clusters of v1.19 or earlier: **/var/paas/sys/log/yangtse**
canal log	• For clusters of v1.21 or later: **/var/log/cce/canal** • For clusters of v1.19 or earlier: **/var/paas/sys/log/canal**
System logs	**/var/log/messages**
Container engine Logs	• For Docker nodes: **/var/lib/docker** • For containerd nodes: **/var/log/cce/containerd**

Table 20-2 Add-on logs

Name	Path
everest log	• For v2.1.41 or later: – everest-csi-driver: **/var/log/cce/kubernetes** – everest-csi-controller: **/var/paas/sys/log/kubernetes** • For version earlier than v2.1.41: – everest-csi-driver: **/var/log/cce/everest-csi-driver** – everest-csi-controller: **/var/paas/sys/log/everest-csi-controller**
npd log	• For v1.18.16 or later: **/var/paas/sys/log/kubernetes** • For versions earlier than v1.18.16: **/var/paas/sys/log/cceaddon-npd**
cce-hpa-controller log	• For v1.3.12 or later: **/var/paas/sys/log/kubernetes** • For versions earlier than v1.3.12: **/var/paas/sys/log/ccehpa-controller**

20.3.2.4 What Should I Do If the vdb Disk of a Node Is Damaged and the Node Cannot Be Recovered After Reset?

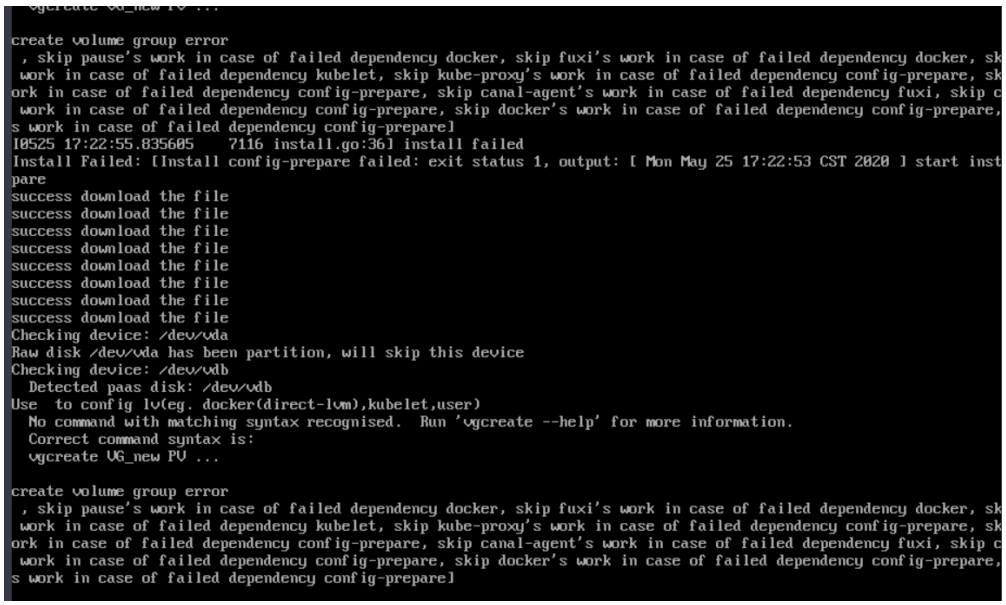
Symptom

The vdb disk of a node is damaged and the node cannot be recovered after reset.

Error Scenarios

- On a normal node, delete the LV and VG. The node is unavailable.
- Reset an abnormal node, and a syntax error is reported. The node is unavailable.

  The following figure shows the details.



Fault Locating

If the volume group (VG) on the node is deleted or damaged and cannot be identified, you need to manually restore the VG first to prevent your data disks from being formatted by mistake during the reset.

Solution

Step 1 Log in to the node.

Step 2 Create a PV and a VG again. In this example, the following error message is displayed:

```
root@host1:~# pvcreate /dev/vdb
Device /dev/vdb excluded by a filter
```

This is because the added disk is created on another VM and has a partition table. The current VM cannot identify the partition table of the disk. You need to run the **parted** commands for three times to re-create the partition table.

```
root@host1:~# parted /dev/vdb
GNU Parted 3.2
Using /dev/vdb
Welcome to GNU Parted! Type 'help' to view a list of commands.
```

```
(parted) mklabel msdos
Warning: The existing disk label on /dev/vdb will be destroyed and all data on this disk will be lost. Do you want to continue?
Yes/No? yes
(parted) quit
Information: You may need to update /etc/fstab.
```

Run **pvcreate** again. When the system asks you whether to erase the DOS signature, enter **y**. The disk is created as a PV.

```
root@host1:~# pvcreate /dev/vdb
WARNING: dos signature detected on /dev/vdb at offset 510. Wipe it? [y/n]: y
Wiping dos signature on /dev/vdb.
Physical volume "/dev/vdb" successfully created
```

Step 3 Create a VG.

Check the Docker disks of the node. If the disks are **/dev/vdb** and **/dev/vdc**, run the following command:

```
root@host1:~# vgcreate vgpaas /dev/vdb /dev/vdc
```

If there is only the **/dev/vdb** disk, run the following command:

```
root@host1:~# vgcreate vgpaas /dev/vdb
```

After the creation is complete, reset the node.

----End

20.3.2.5 What Should I Do If I/O Suspension Occasionally Occurs When SCSI EVS Disks Are Used?

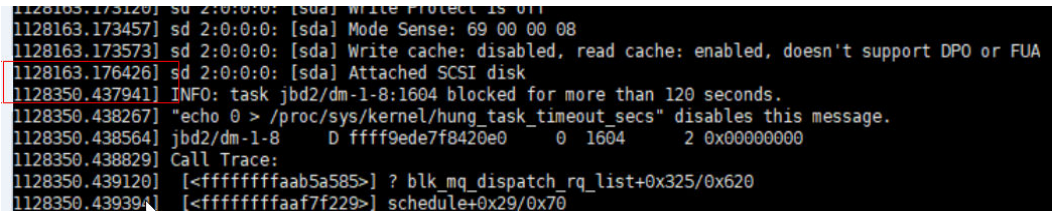
Symptom

When SCSI EVS disks are used and containers are created and deleted on a CentOS node, the disks are frequently mounted and unmounted. The read/write rate of the system disk may instantaneously surge. As a result, the system is suspended, affecting the normal node running.

When this problem occurs, the following information is displayed in the dmesg log:

```
Attached SCSI disk
task jdb2/xxx blocked for more than 120 seconds.
```

Example:



Possible Cause

After a PCI device is hot added to BUS 0, the Linux OS kernel will traverse all the PCI bridges mounted to BUS 0 for multiple times, and these PCI bridges cannot work properly during this period. During this period, if the PCI bridge used by the device is updated, due to a kernel defect, the device considers that the PCI bridge

is abnormal, and the device enters a fault mode and cannot work normally. If the front end is writing data into the PCI configuration space for the back end to process disk I/Os, the write operation may be deleted. As a result, the back end cannot receive notifications to process new requests on the I/O ring. Finally, the front-end I/O suspension occurs.

Impact

CentOS Linux kernels of versions earlier than 3.10.0-1127.el7 are affected.

Solution

Upgrade the kernel to a later version **by resetting the node**.

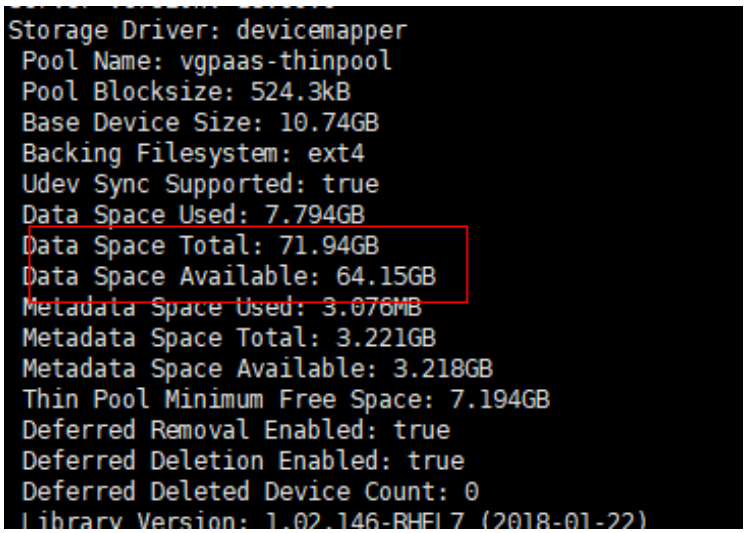
20.3.2.6 How Do I Fix an Abnormal Container or Node Due to No Thin Pool Disk Space?

Problem Description

When the disk space of a thin pool on a node is about to be used up, the following exceptions occasionally occur:

Files or directories fail to be created in the container, the file system in the container is read-only, the node is tainted disk-pressure, or the node is unavailable.

You can run the **docker info** command on the node to view the used and remaining thin pool space to locate the fault. The following figure is an example.



Possible Cause

When Docker device mapper is used, although you can configure the **basesize** parameter to limit the size of the **/home** directory of a single container (to 10 GB by default), all containers on the node still share the thin pool of the node for storage. They are not completely isolated. When the sum of the thin pool space used by certain containers reaches the upper limit, other containers cannot run properly.

In addition, after a file is deleted in the **/home** directory of the container, the thin pool space occupied by the file is not released immediately. Therefore, even if **basesize** is set to 10 GB, the thin pool space occupied by files keeps increasing until 10 GB when files are created in the container. The space released after file deletion will be reused only after a while. If **the number of service containers on the node multiplied by basesize** is greater than the thin pool space size of the node, there is a possibility that the thin pool space has been used up.

Solution

When the thin pool space of a node is used up, some services can be migrated to other nodes to quickly recover services. But you are advised to use the following solutions to resolve the root cause:

Solution 1:

Properly plan the service distribution and data plane disk space to avoid the scenario where **the number of service containers multiplied by basesize** is greater than the thin pool size of the node. To expand the thin pool size, perform the following steps:

Step 1 Expand the capacity of the data disk on the EVS console.

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 the **dockersys** disk.

```
# 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   90G  0 lvm  /var/lib/docker              # Space used by the container engine
└─vgpaas-kubernetes 253:1    0   10G  0 lvm  /mnt/paas/kubernetes/kubelet  # Space used by Kubernetes
```

  Run the following commands on the node to add the new disk capacity to the **dockersys** disk:

```
pvresize /dev/vdb
lvextend -l+100%FREE -n vgpaas/dockersys
resize2fs /dev/vgpaas/dockersys
```

- Devicemapper: A thin pool is allocated to store image data.

```
# 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
```

- Run the following commands on the node to add the new disk capacity to the **thinpool** disk:

  ```
  pvresize /dev/vdb
  lvextend -l+100%FREE -n vgpaas/thinpool
  ```

- Run the following commands on the node to add the new disk capacity to the **dockersys** disk:

  ```
  pvresize /dev/vdb
  lvextend -l+100%FREE -n vgpaas/dockersys
  resize2fs /dev/vgpaas/dockersys
  ```

----End

Solution 2:

Create and delete files in service containers in the local storage (such as emptyDir and hostPath) or cloud storage directory mounted to the container. Such files do not occupy the thin pool space.

Solution 3:

If the OS uses OverlayFS, services can be deployed on such nodes to prevent the problem that the disk space occupied by files created or deleted in the container is not released immediately.

20.3.2.7 How Do I Rectify Failures When the NVIDIA Driver Is Used to Start Containers on GPU Nodes?

Did a Resource Scheduling Failure Event Occur on a Cluster Node?

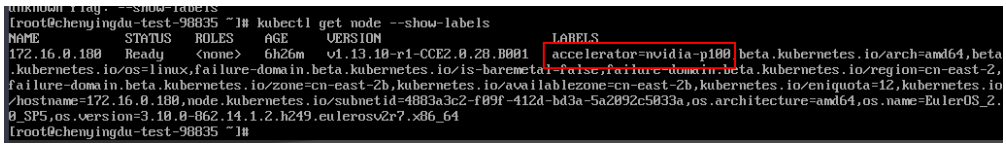
Symptom

A node is running properly and has GPU resources. However, the following error information is displayed:

0/9 nodes are available: 9 insufficient nvidia.com/gpu

Analysis

1. Check whether the node is attached with NVIDIA label.

2. Check whether the NVIDIA driver is running properly.

   Log in to the node where the add-on is running and view the driver installation log in the following path:

   ```
   /opt/cloud/cce/nvidia/nvidia_installer.log
   ```

   View standard output logs of the NVIDIA container.

   Filter the container ID by running the following command:

   ```
   docker ps –a | grep nvidia
   ```

   View logs by running the following command:

   ```
   docker logs Container ID
   ```

What Should I Do If the NVIDIA Version Reported by a Service and the CUDA Version Do Not Match?

Run the following command to check the CUDA version in the container:

```
cat /usr/local/cuda/version.txt
```

Check whether the CUDA version supported by the NVIDIA driver version of the node where the container is located contains the CUDA version of the container.

Helpful Links

What Should I Do If an Error Occurs When Deploying a Service on the GPU Node?

20.3.3 Specification Change

20.3.3.1 How Do I Change the Node Specifications in a CCE Cluster?

Solution

CAUTION

If the node whose specifications need to be changed is accepted into the cluster for management, remove the node from the cluster and then change the node specifications to avoid affecting services.

Step 1 Log in to the CCE console and click the cluster. In the navigation pane, choose **Nodes**. Click the name of the node to display the ECS details page.

Step 2 In the upper right corner of the ECS details page, click **Stop**. After the ECS is stopped, choose **More** > **Modify Specifications**.

Step 3 On the **Modify ECS Specifications** page, select a flavor name and click **Submit** to finish the specification modification. Return to ECS list page and choose **More > Start** to start the ECS.

Step 4 Log in to the CCE console and click the cluster name to access the cluster console. In the navigation pane, choose **Nodes**. Locate the target node in the node list, and click **Sync Server Data** in the **Operation** column. After the synchronization is complete, you can view that the node specifications are the same as the modified specifications of the ECS.

----End

Common Issues

After the specifications of a node configured with CPU management policies are changed, the node may fail to be rebooted or workloads may fail to be created. In this case, see **What Should I Do If I Fail to Restart or Create Workloads on a Node After Modifying the Node Specifications?** to rectify the fault.

20.3.3.2 What Should I Do If I Fail to Restart or Create Workloads on a Node After Modifying the Node Specifications?

Context

The kubelet option **cpu-manager-policy** defaults to **static**, allowing pods with certain resource characteristics to be granted increased CPU affinity and exclusivity on the node. If you modify CCE node specifications on the ECS console, the original CPU information does not match the new CPU information. As a result, workloads on the node cannot be restarted or created.

For more information, see **Control CPU Management Policies on the Node**.

Impact

The clusters that have enabled a CPU management policy will be affected.

Solution

Step 1 Log in to the CCE node (ECS) and delete the **cpu_manager_state** file.

Example command for the file deletion:

```
rm -rf /mnt/paas/kubernetes/kubelet/cpu_manager_state
```

Step 2 Restart the node or kubelet. The following is the kubelet restart command:

```
systemctl restart kubelet
```

Step 3 Verify that workloads on the node can be successfully restarted or created.

----End

20.3.4 OSs

20.3.4.1 What Should I Do If There Is a Service Access Failure After a Backend Service Upgrade or a 1-Second Latency When a Service Accesses a CCE Cluster?

Symptom

If the kernel version of a node is earlier than 5.9 and a CCE cluster runs in IPVS forwarding mode, there may be a service access failure after a backend service upgrade or a 1-second latency when a service accesses the CCE cluster. This is caused by a bug in reusing Kubernetes IPVS connections.

IPVS Connection Reuse Parameters

The port reuse policy of IPVS is determined by the kernel parameter **net.ipv4.vs.conn_reuse_mode**.

1. If **net.ipv4.vs.conn_reuse_mode** is set to **0**, IPVS does not reschedule a new connection, but forwards the new connection to the original RS (IPVS backend).

2. If **net.ipv4.vs.conn_reuse_mode** is set to **1**, IPVS reschedules a new connection.

Problems Caused by IPVS Connection Reuse

- **Problem 1**

  If **net.ipv4.vs.conn_reuse_mode** is set to **0**, IPVS does not proactively schedule new connections with port reuse or trigger any connection termination or drop operations. Data packets of the new connections will be directly forwarded to the previously used backend pod. If the backend pod has been deleted or recreated, an exception occurs. However, according to the current implementation logic, in a high-concurrency service access scenario, connection requests for port reuse are continuously forwarded, while kube-proxy did not delete the old ones, resulting in a service access failure.

- **Problem 2**

  If **net.ipv4.vs.conn_reuse_mode** is set to **1** and the source port is the same as that of a previous connection in a high-concurrency scenario, the connection is not reused but rescheduled. According to the processing logic of ip_vs_in(), if **net.ipv4.vs.conntrack** is enabled, the first SYN packet is dropped. As a result, the SYN packet will be retransmitted, leading to a 1-second latency, and the performance deteriorates.

Community Settings and Impact on CCE Clusters

The default value of **net.ipv4.vs.conn_reuse_mode** on a node is **1**. However, the Kubernetes kube-proxy resets this parameter.

Cluster Version	kube-proxy Action	Impact on CCE Cluster
1.17 or earlier	By default, kube-proxy sets **net.ipv4.vs.conn_reuse_mode** to **0**. For details, see **Fix IPVS low throughput issue**.	If CCE clusters of 1.17 or earlier versions use the IPVS service forwarding mode, kube-proxy will set the **net.ipv4.vs.conn_reuse_mode** value of all nodes to **0** by default. This causes **Problem 1**: The RS cannot be removed when the port is reused.

Cluster Version	kube-proxy Action	Impact on CCE Cluster
1.19 or later	kube-proxy sets the value of **net.ipv4.vs.conn_reuse_mode** based on the kernel version. For details, see **ipvs: only attempt setting of sysctlconnreuse on supported kernels**. • If the kernel version is later than 4.1, kube-proxy will set **net.ipv4.vs.conn_reuse_mode** to **0**. • In other cases, the default value **1** will be retained. **NOTE** This issue has been resolved in Linux kernel 5.9. Since Kubernetes 1.22, kube-proxy does not modify the **net.ipv4.vs.conn_reuse_mode** parameter of nodes that use the kernel 5.9 or later. For details, see **Don't set sysctl net.ipv4.vs.conn_reuse_mode for kernels >=5.9**.	If the IPVS service forwarding mode is used in CCE clusters of 1.19.16-r0 or later, the value of **net.ipv4.vs.conn_reuse_mode** varies with the kernel versions of node OSs. • For a node running EulerOS 2.5or CentOS 7.6, if the kernel version is earlier than 4.1, kube-proxy will keep **net.ipv4.vs.conn_reuse_mode** at **1**. This results in **Problem 2**, which is, there is a 1-second latency in the high-concurrency scenarios. • For a node running or Ubuntu 22.04, if the kernel version is later than 5.9, the problem has been resolved.

Suggestions

Evaluate the impact of these problems. If they affect your services, take the following measures:

1. Use an OS that is not affected by the preceding issues, for example, or Ubuntu 22.04.
2. Use a cluster whose forwarding mode is iptables.

20.4 Node Pool

20.4.1 What Should I Do If No Node Creation Record Is Displayed When the Node Pool Is Being Expanding?

Symptom

The node pool keeps being in the expanding state, but no node creation record is displayed in the operation record.

Troubleshooting

Check and rectify the following faults:

- Whether the specifications configured for the node pool are insufficient.
- Whether the ECS or memory quota of the tenant is insufficient.
- The ECS capacity verification of the tenant may fail if too many nodes are created at a time.

Solution

- If the resources of the ECS flavor cannot meet service requirements, use ECSs of another flavor.
- If the ECS or memory quota is insufficient, increase the quota.
- If the ECS capacity verification fails, perform the verification again.

20.4.2 What Should I Do If a Node Pool Scale-Out Fails?

Fault Locating

Locate the fault based on the event of the failure to scale out a node pool, as shown in **Table 20-3**.

Table 20-3 Node pool scale-out failure

Event	Possible Cause	Reference
...call fsp to query keypair fail, error code : Ecs.0314, reason is : the keypair *** does not match the user_id ***...	The possible causes are as follows: • The key pair selected for logging in to the node pool has been deleted. • The key pair selected for logging in to the node pool is a private one which cannot be used by the current user to log in to the node pool and create nodes in the node pool.	**Failed to Obtain the Key Pair Used for Logging In to a Node Pool**

Failed to Obtain the Key Pair Used for Logging In to a Node Pool

If a node pool scale-out fails, the event contains **Ecs.0314**. This error code indicates that the key pair used for logging in to the node pool cannot be obtained, which results in the creation failure of a new ECS.

```
...call fsp to query keypair fail, error code : Ecs.0314, reason is : the keypair *** does not match the user_id ***...
```

The possible causes are as follows:

- The key pair selected for logging in to the node pool has been deleted.
- The key pair selected for logging in to the node pool is a private one which cannot be used by the current user to log in to the node pool and create nodes in the node pool.

Solution:

- If the scale-out fails due to the first cause, you can create a key pair and then create a node pool which can be logged in to using this key pair.
- If the scale-out fails due to the second cause, only the user who created the private key pair can scale out the node pool. You can use another key pair when creating a new node pool.

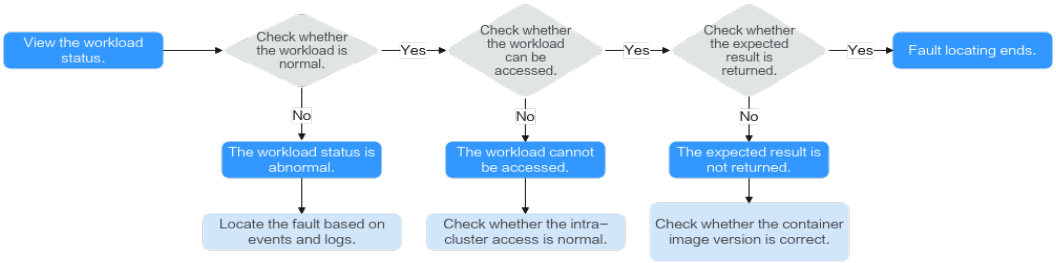
20.5 Workload

20.5.1 Workload Abnormalities

20.5.1.1 How Do I Use Events to Fix Abnormal Workloads?

If a workload is abnormal, you can check the pod events first to locate the fault and then rectify the fault.

Fault Locating



To check whether there is an abnormal pod in the workload, perform the following steps:

Step 1 Log in to the CCE console.

Step 2 Click the cluster name to access the cluster console. In the navigation pane, choose **Workloads**.

Step 3 In the upper left corner of the page, select a namespace, locate the target workload, and view its status.

- If the workload is not ready, view pod events, and determine the cause. For details, see **Viewing Pod Events**.
- If the workload is processing, wait patiently.
- If the workload is running, no action is required. If the workload status is normal but it cannot be accessed, check whether intra-cluster access is normal.

Log in to the CCE console or use kubectl to obtain the pod IP address. Then, log in to the node where this pod locates and run **curl** or use other methods to manually call the APIs. Check whether the expected result is returned.

If *{Container IP address}*:*{Port}* cannot be accessed, log in to the service container and access **127.0.0.1**:*{Port}* to locate the fault.

----End

Viewing Pod Events

Method 1

On the CCE console, click the workload name to go to the workload details page, locate the row containing the abnormal pod, and click **View Events** in the **Operation** column.

Method 2

Run **kubectl describe pod** *{Pod name}* to view pod events. The following shows an example:

```
$ kubectl describe pod prepare-58bd7bdf9-fthrp
...
Events:
  Type     Reason            Age   From               Message
  ----     ------            ----  ----               -------
  Warning  FailedScheduling  49s   default-scheduler  0/2 nodes are available: 2 Insufficient cpu.
  Warning  FailedScheduling  49s   default-scheduler  0/2 nodes are available: 2 Insufficient cpu.
```

Table 20-4 Troubleshooting methods

Event	Pod Status	Solution
PodsScheduling failed	Pending	For details, see **What Should I Do If Pod Scheduling Fails?**.
PodsFailed to pull image Failed to re-pull image	FailedPullImage ImagePullBackOff	For details, see **What Should I Do If a Pod Fails to Pull the Image?**.
PodsCreation failed Failed to restart container	CreateContainerError CrashLoopBackOff	For details, see **What Should I Do If Container Startup Fails?**.
The pod status is **Evicted**, and the pod keeps being evicted.	Evicted	For details, see **What Should I Do If a Pod Fails to Be Evicted?**.
The storage volume fails to be mounted to the pod.	Pending	For details, see **What Should I Do If a Storage Volume Cannot Be Mounted or the Mounting Times Out?**.

Event	Pod Status	Solution
The pod stays **Creating**.	Creating	For details, see **What Should I Do If a Workload Remains in the Creating State?**.
The pod stays **Terminating**.	Terminating	For details, see **What Should I Do If Pods in the Terminating State Cannot Be Deleted?**.
The pod status is **Stopped**.	Stopped	For details, see **What Should I Do If a Workload Is Stopped Caused by Pod Deletion?**.

20.5.1.2 What Should I Do If Pod Scheduling Fails?

Fault Locating

If the pod is in the **Pending** state and the event contains pod scheduling failure information, locate the cause based on the event information. For details about how to view events, see **How Do I Use Events to Fix Abnormal Workloads?**

Troubleshooting Process

Determine the cause based on the event information, as listed in **Table 20-5**.

Table 20-5 Pod scheduling failure

Event Information	Cause and Solution
no nodes available to schedule pods.	No node is available in the cluster. **Check Item 1: Whether a Node Is Available in the Cluster**
0/2 nodes are available: 2 Insufficient cpu. 0/2 nodes are available: 2 Insufficient memory.	Node resources (CPU and memory) are insufficient. **Check Item 2: Whether Node Resources (CPU and Memory) Are Sufficient**
0/2 nodes are available: 1 node(s) didn't match node selector, 1 node(s) didn't match pod affinity rules, 1 node(s) didn't match pod affinity/anti-affinity.	The node and pod affinity configurations are mutually exclusive. No node meets the pod requirements. **Check Item 3: Affinity and Anti-Affinity Configuration of the Workload**

Event Information	Cause and Solution
0/2 nodes are available: 2 node(s) had volume node affinity conflict.	The EVS volume mounted to the pod and the node are not in the same AZ. **Check Item 4: Whether the Workload's Volume and Node Reside in the Same AZ**
0/1 nodes are available: 1 node(s) had taints that the pod didn't tolerate.	Taints exist on the node, but the pod cannot tolerate these taints. **Check Item 5: Taint Toleration of Pods**
0/7 nodes are available: 7 Insufficient ephemeral-storage.	The ephemeral storage space of the node is insufficient. **Check Item 6: Ephemeral Volume Usage**
0/1 nodes are available: 1 everest driver not found at node	The everest-csi-driver on the node is not in the running state. **Check Item 7: Whether everest Works Properly**
Failed to create pod sandbox: ... Create more free space in thin pool or use dm.min_free_space option to change behavior	The node thin pool space is insufficient. **Check Item 8: Thin Pool Space**
0/1 nodes are available: 1 Too many pods.	The number of pods scheduled to the node exceeded the maximum number allowed by the node. **Check Item 9: Number of Pods Scheduled onto the Node**

Check Item 1: Whether a Node Is Available in the Cluster

Log in to the CCE console and check whether the node status is **Available**. Alternatively, run the following command to check whether the node status is **Ready**:

```
$ kubectl get node
NAME          STATUS   ROLES    AGE   VERSION
192.168.0.37   Ready    <none>   21d   v1.19.10-r1.0.0-source-121-gb9675686c54267
192.168.0.71   Ready    <none>   21d   v1.19.10-r1.0.0-source-121-gb9675686c54267
```

If the status of all nodes is **Not Ready**, no node is available in the cluster.

Solution

- Add a node. If an affinity policy is not configured for the workload, the pod will be automatically migrated to the new node to ensure that services are running properly.

- Locate the unavailable node and rectify the fault. For details, see **What Should I Do If a Cluster Is Available But Some Nodes Are Unavailable?**
- Reset the unavailable node.

Check Item 2: Whether Node Resources (CPU and Memory) Are Sufficient

0/2 nodes are available: 2 Insufficient cpu. This means insufficient CPUs.

0/2 nodes are available: 2 Insufficient memory. This means insufficient memory.

If the resources requested by the pod exceed the allocatable resources of the node where the pod runs, the node cannot provide the resources required to run new pods and pod scheduling onto the node will definitely fail.

If the number of resources that can be allocated to a node is less than the number of resources that a pod requests, the node does not meet the resource requirements of the pod. As a result, the scheduling fails.

Solution

Add nodes to the cluster. Scale-out is the common solution to insufficient resources.

Check Item 3: Affinity and Anti-Affinity Configuration of the Workload

Inappropriate affinity policies will cause pod scheduling to fail.

Example:

An anti-affinity relationship is established between workload 1 and workload 2. Workload 1 is deployed on node 1 while workload 2 is deployed on node 2.

When you try to deploy workload 3 on node 1 and establish an affinity relationship with workload 2, a conflict occurs, resulting in a workload deployment failure.

0/2 nodes are available: 1 node(s) didn't match **node selector**, 1 node(s) didn't match **pod affinity rules**, 1 node(s) didn't match **pod affinity/anti-affinity**.

- **node selector** indicates that the node affinity is not met.
- **pod affinity rules** indicate that the pod affinity is not met.
- **pod affinity/anti-affinity** indicates that the pod affinity/anti-affinity is not met.

Solution

- When adding workload-workload affinity and workload-node affinity policies, ensure that the two types of policies do not conflict each other. Otherwise, workload deployment will fail.
- If the workload has a node affinity policy, make sure that **supportContainer** in the label of the affinity node is set to **true**. Otherwise, pods cannot be scheduled onto the affinity node and the following event is generated:

  ```
  No nodes are available that match all of the following predicates: MatchNode Selector, NodeNotSupportsContainer
  ```

  If the value is **false**, the scheduling fails.

Check Item 4: Whether the Workload's Volume and Node Reside in the Same AZ

0/2 nodes are available: 2 node(s) had volume node affinity conflict. An affinity conflict occurs between volumes and nodes. As a result, the scheduling fails.

This is because EVS disks cannot be attached to nodes across AZs. For example, if the EVS volume is located in AZ 1 and the node is located in AZ 2, scheduling fails.

The EVS volume created on CCE has affinity settings by default, as shown below.

```
kind: PersistentVolume
apiVersion: v1
metadata:
  name: pvc-c29bfac7-efa3-40e6-b8d6-229d8a5372ac
spec:
  ...
  nodeAffinity:
    required:
      nodeSelectorTerms:
        - matchExpressions:
            - key: failure-domain.beta.kubernetes.io/zone
              operator: In
              values:
                -
```

Solution

In the AZ where the workload's node resides, create a volume. Alternatively, create an identical workload and select an automatically assigned cloud storage volume.

Check Item 5: Taint Toleration of Pods

0/1 nodes are available: 1 node(s) had taints that the pod didn't tolerate. This means the node is tainted and the pod cannot be scheduled to the node.

Check the taints on the node. If the following information is displayed, taints exist on the node:

```
$ kubectl describe node 192.168.0.37
Name:               192.168.0.37
...
Taints:             key1=value1:NoSchedule
...
```

In some cases, the system automatically adds a taint to a node. The current built-in taints include:

- node.kubernetes.io/not-ready: The node is not ready.
- node.kubernetes.io/unreachable: The node controller cannot access the node.
- node.kubernetes.io/memory-pressure: The node has memory pressure.
- node.kubernetes.io/disk-pressure: The node has disk pressure. Follow the instructions described in **Check Item 4: Whether the Node Disk Space Is Insufficient** to handle it.
- node.kubernetes.io/pid-pressure: The node is under PID pressure.
- node.kubernetes.io/network-unavailable: The node network is unavailable.
- node.kubernetes.io/unschedulable: The node cannot be scheduled.

- node.cloudprovider.kubernetes.io/uninitialized: If an external cloud platform driver is specified when kubelet is started, kubelet adds a taint to the current node and marks it as unavailable. After **cloud-controller-manager** initializes the node, kubelet deletes the taint.

Solution

To schedule the pod to the node, use either of the following methods:

- If the taint is added by a user, you can delete the taint on the node. If the taint is **automatically added by the system**, the taint will be automatically deleted after the fault is rectified.
- Specify a toleration for the pod containing the taint. For details, see **Taints and Tolerations**.

```
apiVersion: v1
kind: Pod
metadata:
  name: nginx
spec:
  containers:
  - name: nginx
    image: nginx:alpine
  tolerations:
  - key: "key1"
    operator: "Equal"
    value: "value1"
    effect: "NoSchedule"
```

Check Item 6: Ephemeral Volume Usage

0/7 nodes are available: 7 Insufficient ephemeral-storage. This means insufficient ephemeral storage of the node.

Check whether the size of the ephemeral volume in the pod is limited. If the size of the ephemeral volume required by the application exceeds the existing capacity of the node, the application cannot be scheduled. To solve this problem, change the size of the ephemeral volume or expand the disk capacity of the node.

```
apiVersion: v1
kind: Pod
metadata:
  name: frontend
spec:
  containers:
  - name: app
    image: images.my-company.example/app:v4
    resources:
      requests:
        ephemeral-storage: "2Gi"
      limits:
        ephemeral-storage: "4Gi"
    volumeMounts:
    - name: ephemeral
      mountPath: "/tmp"
  volumes:
    - name: ephemeral
      emptyDir: {}
```

To obtain the total capacity (**Capacity**) and available capacity (**Allocatable**) of the temporary volume mounted to the node, run the **kubectl describe node** command, and view the application value and limit value of the temporary volume mounted to the node.

The following is an example of the output:

```
...
Capacity:
  cpu:                4
  ephemeral-storage:  61607776Ki
  hugepages-1Gi:      0
  hugepages-2Mi:      0
  localssd:           0
  localvolume:        0
  memory:             7614352Ki
  pods:               40
Allocatable:
  cpu:                3920m
  ephemeral-storage:  56777726268
  hugepages-1Gi:      0
  hugepages-2Mi:      0
  localssd:           0
  localvolume:        0
  memory:             6180752Ki
  pods:               40
...
Allocated resources:
  (Total limits may be over 100 percent, i.e., overcommitted.)
  Resource           Requests      Limits
  --------           --------      ------
  cpu                1605m (40%)   6530m (166%)
  memory             2625Mi (43%)  5612Mi (92%)
  ephemeral-storage  0 (0%)        0 (0%)
  hugepages-1Gi      0 (0%)        0 (0%)
  hugepages-2Mi      0 (0%)        0 (0%)
  localssd           0             0
  localvolume        0             0
Events:              <none>
```

Check Item 7: Whether everest Works Properly

0/1 nodes are available: 1 everest driver not found at node. This means the everest-csi-driver of everest is not started properly on the node.

Check the daemon named **everest-csi-driver** in the kube-system namespace and check whether the pod is started properly. If not, delete the pod. The daemon will restart the pod.

Check Item 8: Thin Pool Space

A data disk dedicated for kubelet and the container engine will be attached to a new node. If the data disk space is insufficient, the pod cannot be created.

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

To expand a disk capacity, perform the following steps:

Step 1 Expand the capacity of the data disk on the EVS console.

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 the **dockersys** disk.

```
# 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   90G  0 lvm  /var/lib/docker              # Space used by the container engine
└─vgpaas-kubernetes 253:1    0   10G  0 lvm  /mnt/paas/kubernetes/kubelet  # Space used by Kubernetes
```

  Run the following commands on the node to add the new disk capacity to the **dockersys** disk:

```
pvresize /dev/vdb
lvextend -l+100%FREE -n vgpaas/dockersys
resize2fs /dev/vgpaas/dockersys
```

- Devicemapper: A thin pool is allocated to store image data.

```
# 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
```

  - Run the following commands on the node to add the new disk capacity to the **thinpool** disk:

```
pvresize /dev/vdb
lvextend -l+100%FREE -n vgpaas/thinpool
```

  - Run the following commands on the node to add the new disk capacity to the **dockersys** disk:

```
pvresize /dev/vdb
lvextend -l+100%FREE -n vgpaas/dockersys
resize2fs /dev/vgpaas/dockersys
```

----End

Check Item 9: Number of Pods Scheduled onto the Node

0/1 nodes are available: 1 Too many pods. indicates excessive number of pods have been scheduled to the node.

When creating a node, configure **Max. Pods** in **Advanced Settings** to specify the maximum number of pods that can run properly on the node. The default value varies with the node flavor. You can change the value as needed.

On the **Nodes** page, obtain the **Pods (Allocated/Total)** value of the node, and check whether the number of pods scheduled onto the node has reached the upper limit. If so, add nodes or change the maximum number of pods.

To change the maximum number of pods that can run on a node, do as follows:

- For nodes in the default node pool: Change the **Max. Pods** value when resetting the node.
- For nodes in a customized node pool: Change the value of the node pool parameter **max-pods**.

20.5.1.3 What Should I Do If a Pod Fails to Pull the Image?

Fault Locating

When a workload enters the state of "Pod not ready: Back-off pulling image "*xxxxx*", a Kubernetes event of **PodsFailed to pull image** or **Failed to re-pull image** will be reported. For details about how to view Kubernetes events, see **Viewing Pod Events**.

Troubleshooting Process

Determine the cause based on the event information, as listed in **Table 20-6**.

Table 20-6 FailedPullImage

Event Information	Cause and Solution
Failed to pull image "*xxx*": rpc error: code = Unknown desc = Error response from daemon: Get *xxx*: denied: You may not login yet	You have not logged in to the image repository. **Check Item 1: Whether imagePullSecret Is Specified When You Use kubectl to Create a Workload**
Failed to pull image "nginx:v1.1": rpc error: code = Unknown desc = Error response from daemon: Get https://registry-1.docker.io/v2/: dial tcp: lookup registry-1.docker.io: no such host	The image address is incorrectly configured. **Check Item 2: Whether the Image Address Is Correct When a Third-Party Image Is Used** **Check Item 3: Whether an Incorrect Secret Is Used When a Third-Party Image Is Used**

Event Information	Cause and Solution
Failed create pod sandbox: rpc error: code = Unknown desc = failed to create a sandbox for pod "nginx-6dc48bf8b6-l8xrw": Error response from daemon: mkdir xxxxx: no space left on device	The disk space is insufficient. **Check Item 4: Whether the Node Disk Space Is Insufficient**
Failed to pull image "*xxx*": rpc error: code = Unknown desc = error pulling image configuration: *xxx* x509: certificate signed by unknown authority	An unknown or insecure certificate is used by the third-party image repository from which the image is pulled. **Check Item 5: Whether the Remote Image Repository Uses an Unknown or Insecure Certificate**
Failed to pull image "*xxx*": rpc error: code = Unknown desc = context canceled	The image size is too large. **Check Item 6: Whether the Image Size Is Too Large**
Failed to pull image "docker.io/bitnami/nginx:1.22.0-debian-11-r3": rpc error: code = Unknown desc = Error response from daemon: Get https://registry-1.docker.io/v2/: net/http: request canceled while waiting for connection (Client.Timeout exceeded while awaiting headers)	**Check Item 7: Connection to the Image Repository**
ERROR: toomanyrequests: Too Many Requests. Or you have reached your pull rate limit, you may increase the limit by authenticating an upgrading	The rate is limited because the number of image pull times reaches the upper limit. **Check Item 8: Whether the Number of Public Image Pull Times Reaches the Upper Limit**

Check Item 1: Whether imagePullSecret Is Specified When You Use kubectl to Create a Workload

If the workload status is abnormal and a Kubernetes event is displayed indicating that the pod fails to pull the image, check whether the **imagePullSecrets** field exists in the YAML file.

Items to Check

- If an image needs to be pulled from SWR, the **name** parameter must be set to **default-secret**.

```
apiVersion: extensions/v1beta1
kind: Deployment
metadata:
  name: nginx
spec:
```

```
replicas: 1
selector:
  matchLabels:
    app: nginx
strategy:
  type: RollingUpdate
template:
  metadata:
    labels:
      app: nginx
  spec:
    containers:
    - image: nginx
      imagePullPolicy: Always
      name: nginx
    imagePullSecrets:
    - name: default-secret
```

- If an image needs to be pulled from a third-party image repository, the **imagePullSecrets** parameter must be set to the created secret name.

  When you use kubectl to create a workload from a third-party image, specify the **imagePullSecret** field, in which **name** indicates the name of the secret used to pull the image.

Check Item 2: Whether the Image Address Is Correct When a Third-Party Image Is Used

CCE allows you to create workloads using images pulled from third-party image repositories.

Enter the third-party image address according to requirements. The format must be **ip:port/path/name:version** or **name:version**. If no tag is specified, **latest** is used by default.

- For a private repository, enter an image address in the format of **ip:port/path/name:version**.
- For an open-source Docker repository, enter an image address in the format of **name:version**, for example, **nginx:latest**.

The following information is displayed when you fail to pull an image due to incorrect image address provided.

```
Failed to pull image "nginx:v1.1": rpc error: code = Unknown desc = Error response from daemon: Get
https://registry-1.docker.io/v2/: dial tcp: lookup registry-1.docker.io: no such host
```

Solution

You can either edit your YAML file to change the image address or log in to the CCE console to replace the image on the **Upgrade** tab on the workload details page.

Check Item 3: Whether an Incorrect Secret Is Used When a Third-Party Image Is Used

Generally, a third-party image repository can be accessed only after authentication (using your account and password). CCE uses the secret authentication mode to pull images. Therefore, you need to create a secret for an image repository before pulling images from the repository.

Solution

If your secret is incorrect, images will fail to be pulled. In this case, create a new secret.

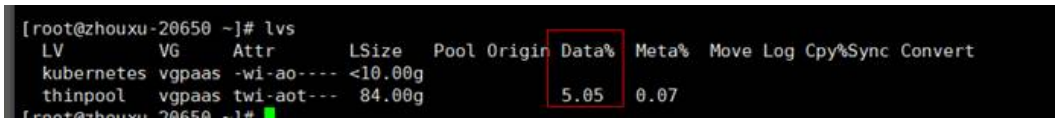
Check Item 4: Whether the Node Disk Space Is Insufficient

If the Kubernetes event contains information "no space left on device", there is no disk space left for storing the image. As a result, the image will fail to be pulled. In this case, clear the image or expand the disk space to resolve this issue.

```
Failed create pod sandbox: rpc error: code = Unknown desc = failed to create a sandbox for pod "nginx-6dc48bf8b6-l8xrw": Error response from daemon: mkdir xxxxx: no space left on device
```

Run the following command to obtain the disk space for storing images on a node:

```
lvs
```



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

To expand a disk capacity, perform the following steps:

Step 1 Expand the capacity of the data disk on the EVS console.

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 the **dockersys** disk.
  ```
  # 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   90G  0 lvm  /var/lib/docker             # Space used by the container engine
└─vgpaas-kubernetes 253:1    0   10G  0 lvm  /mnt/paas/kubernetes/kubelet  # Space used by Kubernetes
```

Run the following commands on the node to add the new disk capacity to the **dockersys** disk:

```
pvresize /dev/vdb
lvextend -l+100%FREE -n vgpaas/dockersys
resize2fs /dev/vgpaas/dockersys
```

- Devicemapper: A thin pool is allocated to store image data.

```
# 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
```

  - Run the following commands on the node to add the new disk capacity to the **thinpool** disk:

    ```
    pvresize /dev/vdb
    lvextend -l+100%FREE -n vgpaas/thinpool
    ```

  - Run the following commands on the node to add the new disk capacity to the **dockersys** disk:

    ```
    pvresize /dev/vdb
    lvextend -l+100%FREE -n vgpaas/dockersys
    resize2fs /dev/vgpaas/dockersys
    ```

----End

Check Item 5: Whether the Remote Image Repository Uses an Unknown or Insecure Certificate

When a pod pulls an image from a third-party image repository that uses an unknown or insecure certificate, the image fails to be pulled from the node. The pod event list contains the event "Failed to pull the image" with the cause "x509: certificate signed by unknown authority".

NOTE

The security of EulerOS 2.9 images is enhanced. Some insecure or expired certificates are removed from the system. It is normal that this error is reported in EulerOS 2.9 but not or some third-party images on other types of nodes. You can also perform the following operations to rectify the fault.

Solution

Step 1 Check the IP address and port number of the third-party image server for which the error message "unknown authority" is displayed.

You can see the IP address and port number of the third-party image server for which the error is reported in the event information "Failed to pull image".

```
Failed to pull image "bitnami/redis-cluster:latest": rpc error: code = Unknown desc = error pulling image configuration: Get https://production.cloudflare.docker.com/registry-v2/docker/registry/v2/blobs/sha256/e8/e83853f03a2e792614e7c1e6de75d63e2d6d633b4e7c39b9d700792ee50f7b56/data?verify=1636972064-AQbl5RActnudDZV%2F3EShZwnqOe8%3D: x509: certificate signed by unknown authority
```

The IP address of the third-party image server is *production.cloudflare.docker.com*, and the default HTTPS port number is *443*.

Step 2 Load the root certificate of the third-party image server to the node where the third-party image is to be downloaded.

Run the following commands on the EulerOS and CentOS nodes with *{server_url}:{server_port}* replaced with the IP address and port number obtained in Step 1, for example, **production.cloudflare.docker.com:443**:

If the container engine of the node is containerd, replace **systemctl restart docker** with **systemctl restart containerd**.

```
openssl s_client -showcerts -connect {server_url}:{server_port} < /dev/null | sed -ne '/-BEGIN CERTIFICATE-/,/-END CERTIFICATE-/p' > /etc/pki/ca-trust/source/anchors/tmp_ca.crt
update-ca-trust
systemctl restart docker
```

Run the following command on Ubuntu nodes:

```
openssl s_client -showcerts -connect {server_url}:{server_port} < /dev/null | sed -ne '/-BEGIN CERTIFICATE-/,/-END CERTIFICATE-/p' > /usr/local/share/ca-certificates/tmp_ca.crt
update-ca-trust
systemctl restart docker
```

----End

Check Item 6: Whether the Image Size Is Too Large

The pod event list contains the event "Failed to pull image". This may be caused by a large image size.

```
Failed to pull image "XXX": rpc error: code = Unknown desc = context canceled
```

However, the image can be manually pulled by running the **docker pull** command.

Possible Causes

In Kubernetes clusters, there is a default timeout period for pulling images. If the image pulling progress is not updated within a certain period of time, the download will be canceled. If the node performance is poor or the image size is too large, the image may fail to be pulled and the workload may fail to be started.

Solution

- Solution 1 (recommended):
  a. Log in to the node and manually pull the image.
     - containerd nodes:
       ```
       crictl pull <image-address>
       ```
     - Docker nodes:
       ```
       docker pull <image-address>
       ```
  b. When creating a workload, ensure that **imagePullPolicy** is set to **IfNotPresent** (the default configuration). In this case, the workload uses the image that has been pulled to the local host.

- Solution 2 (applies to clusters of v1.25 or later): Modify the configuration parameters of the node pools. The configuration parameters for nodes in the **DefaultPool** node pool cannot be modified.
  a. Log in to the CCE console.
  b. Click the cluster name to access the cluster console. Choose **Nodes** in the navigation pane and click the **Node Pools** tab.
  c. Locate the row that contains the target node pool and click **Manage**.
  d. In the window that slides out from the right, modify the **image-pull-progress-timeout** parameter under **Docker/containerd**. This parameter specifies the timeout interval for pulling an image.
  e. Click **OK**.

Check Item 7: Connection to the Image Repository

Symptom

The following error message is displayed during workload creation:

```
Failed to pull image "docker.io/bitnami/nginx:1.22.0-debian-11-r3": rpc error: code = Unknown desc = Error response from daemon: Get https://registry-1.docker.io/v2/: net/http: request canceled while waiting for connection (Client.Timeout exceeded while awaiting headers)
```

Possible Causes

Failed to connect to the image repository due to the disconnected network. SWR allows you to pull images only from the official Docker repository. For image pulls from other repositories, you need to access the Internet.

Solution

- Bind a public IP address to the node which needs to pull the images.
- Upload the image to SWR and then pull the image from SWR.

Check Item 8: Whether the Number of Public Image Pull Times Reaches the Upper Limit

Symptom

The following error message is displayed during workload creation:

```
ERROR: toomanyrequests: Too Many Requests.
```

Or

```
you have reached your pull rate limit, you may increase the limit by authenticating an upgrading: https://www.docker.com/increase-rate-limits.
```

Possible Causes

Docker Hub sets the maximum number of container image pull requests. For details, see **Understanding Your Docker Hub Rate Limit**.

Solution

Push the frequently used image to SWR and then pull the image from SWR.

20.5.1.4 What Should I Do If Container Startup Fails?

Fault Locating

On the details page of a workload, if an event is displayed indicating that the container fails to be started, perform the following steps to locate the fault:

Step 1 Log in to the node where the abnormal workload is located.

Step 2 Check the ID of the container where the workload pod exits abnormally.

```
docker ps -a | grep $podName
```

Step 3 View the logs of the corresponding container.

```
docker logs $containerID
```

Rectify the fault of the workload based on logs.

Step 4 Check the error logs.

```
cat /var/log/messages | grep $containerID | grep oom
```

Check whether the system OOM is triggered based on the logs.

----End

Troubleshooting Process

Determine the cause based on the event information, as listed in **Table 20-7**.

Table 20-7 Container startup failure

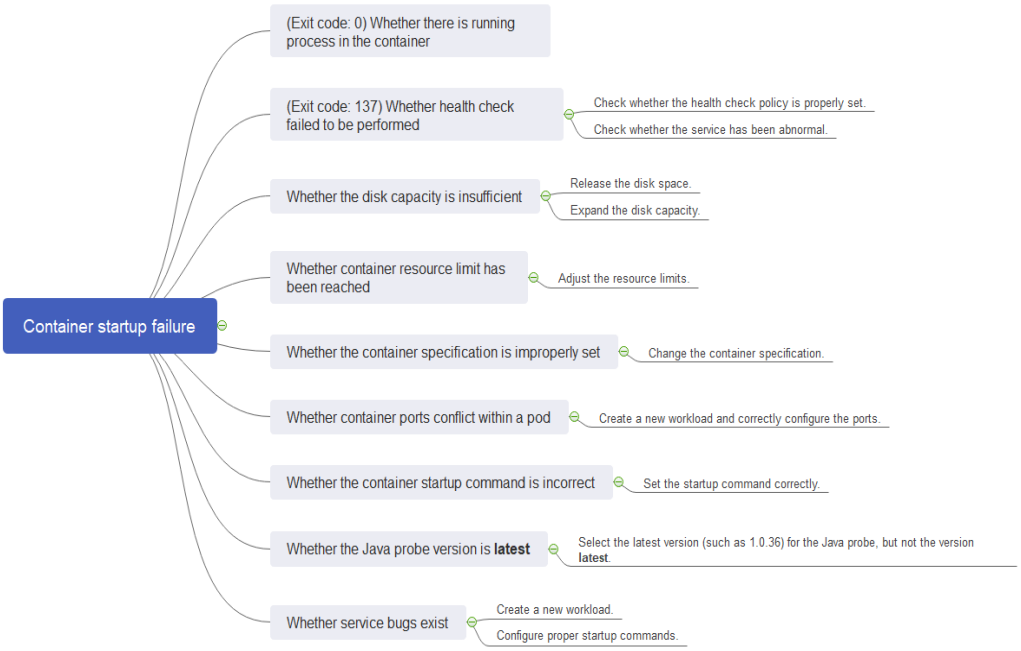
Log or Event	Cause and Solution
The log contains **exit(0)**.	No process exists in the container. Check whether the container is running properly. **Check Item 1: Whether There Are Processes that Keep Running in the Container (Exit Code: 0)**
Event information: **Liveness probe failed: Get http...** The log contains **exit(137)**.	Health check fails. **Check Item 2: Whether Health Check Fails to Be Performed (Exit Code: 137)**
Event information: Thin Pool has 15991 free data blocks which are less than minimum required 16383 free data blocks. Create more free space in thin pool or use dm.min_free_space option to change behavior	The disk space is insufficient. Clear the disk space. **Check Item 3: Whether the Container Disk Space Is Insufficient**

Log or Event	Cause and Solution
The keyword OOM exists in the log.	The memory is insufficient. **Check Item 4: Whether the Upper Limit of Container Resources Has Been Reached** **Check Item 5: Whether the Resource Limits Are Improperly Configured for the Container**
Address already in use	A conflict occurs between container ports in the pod. **Check Item 6: Whether the Container Ports in the Same Pod Conflict with Each Other**
Error: failed to start container "filebeat": Error response from daemon: OCI runtime create failed: container_linux.go:330: starting container process caused "process_linux.go:381: container init caused \"setenv: invalid argument\"": unknown	A secret is mounted to the workload, and the value of the secret is not encrypted using Base64. **Check Item 7: Whether the Value of the Secret Mounted to the Workload Meets Requirements**

In addition to the preceding possible causes, there are some other possible causes:

- **Check Item 8: Whether the Container Startup Command Is Correctly Configured**
- **Check Item 9: Whether the User Service Has a Bug**
- Use the correct image when you create a workload on an Arm node.

Figure 20-2 Troubleshooting process of the container restart failure



Check Item 1: Whether There Are Processes that Keep Running in the Container (Exit Code: 0)

Step 1 Log in to the node where the abnormal workload is located.

Step 2 View the container status.

docker ps -a | grep *$podName*

Example:

```
[root@xxx ~]# docker ps -a | grep test
1f59a7f4cf77        613055f01959                                        "/bin/bash"              10 seconds ago      Exited (0) 10 seconds ago
  k8s_container-0_test-66b79cbdb7-htcjf_default_5c388617-ac32-11e9-9168-fa163ec28742_1
2c73ac8717cc        cce-pause:2.0                                       "/pause"                 12 seconds ago      Up 12 seconds
  k8s_POD_test-66b79cbdb7-htcjf_default_5c388617-ac32-11e9-9168-fa163ec28742_0
```

If no running process exists in the container, the status code **Exited (0)** is displayed.

----End

Check Item 2: Whether Health Check Fails to Be Performed (Exit Code: 137)

The health check configured for a workload is performed on services periodically. If an exception occurs, the pod reports an event and the pod fails to be restarted.

If the liveness-type (workload liveness probe) health check is configured for the workload and the number of health check failures exceeds the threshold, the containers in the pod will be restarted. On the workload details page, if Kubernetes events contain **Liveness probe failed: Get http...**, the health check fails.

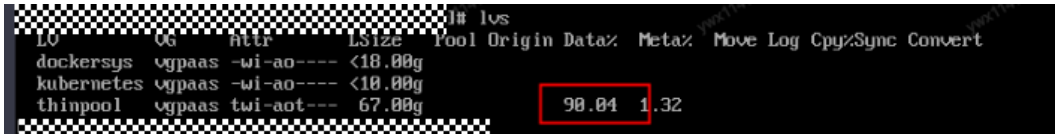
Solution

Click the workload name to go to the workload details page, click the **Containers** tab. Then select **Health Check** to check whether the policy is proper or whether services are running properly.

Check Item 3: Whether the Container Disk Space Is Insufficient

The following message refers to the thin pool disk that is allocated from the Docker disk selected during node creation. You can run the **lvs** command as user **root** to view the current disk usage.

```
Thin Pool has 15991 free data blocks which are less than minimum required 16383 free data blocks. Create more free space in thin pool or use dm.min_free_space option to change behavior
```



Solution

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

To expand a disk capacity, perform the following steps:

Step 1 Expand the capacity of the data disk on the EVS console.

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 the **dockersys** disk.
  ```
  # 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   90G  0 lvm  /var/lib/docker             # Space used by the container engine
└─vgpaas-kubernetes 253:1    0   10G  0 lvm  /mnt/paas/kubernetes/kubelet  # Space used by Kubernetes
```

Run the following commands on the node to add the new disk capacity to the **dockersys** disk:

```
pvresize /dev/vdb
lvextend -l+100%FREE -n vgpaas/dockersys
resize2fs /dev/vgpaas/dockersys
```

- Devicemapper: A thin pool is allocated to store image data.

```
# 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
```

  - Run the following commands on the node to add the new disk capacity to the **thinpool** disk:

    ```
    pvresize /dev/vdb
    lvextend -l+100%FREE -n vgpaas/thinpool
    ```

  - Run the following commands on the node to add the new disk capacity to the **dockersys** disk:

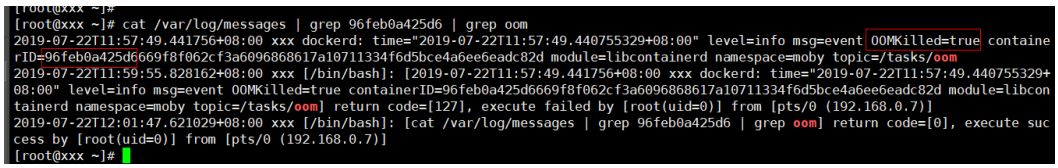
    ```
    pvresize /dev/vdb
    lvextend -l+100%FREE -n vgpaas/dockersys
    resize2fs /dev/vgpaas/dockersys
    ```

----End

Check Item 4: Whether the Upper Limit of Container Resources Has Been Reached

If the upper limit of container resources has been reached, OOM will be displayed in the event details as well as in the log:

```
cat /var/log/messages | grep 96feb0a425d6 | grep oom
```



When a workload is created, if the requested resources exceed the configured upper limit, the system OOM is triggered and the container exits unexpectedly.

Check Item 5: Whether the Resource Limits Are Improperly Configured for the Container

If the resource limits set for the container during workload creation are less than required, the container fails to be restarted.

Check Item 6: Whether the Container Ports in the Same Pod Conflict with Each Other

Step 1 Log in to the node where the abnormal workload is located.

Step 2 Check the ID of the container where the workload pod exits abnormally.

docker ps -a | grep *$podName*

Step 3 View the logs of the corresponding container.

docker logs *$containerID*

Rectify the fault of the workload based on logs. As shown in the following figure, container ports in the same pod conflict. As a result, the container fails to be started.

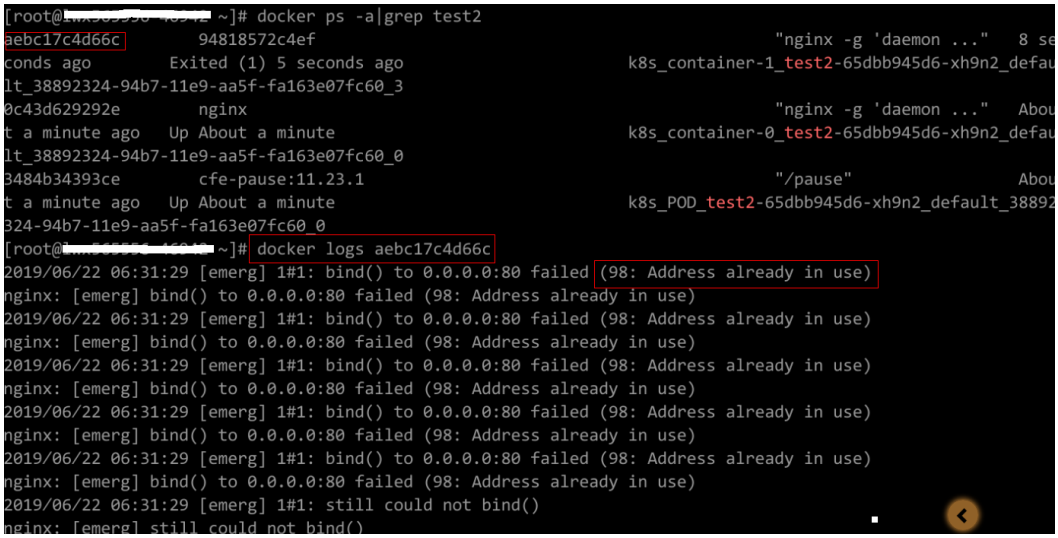


Figure 20-3 Container restart failure due to a container port conflict

```
[root@[redacted] ~]# docker ps -a|grep test2
aebc17c4d66c        94818572c4ef                                              "nginx -g 'daemon ..."   8 se
conds ago        Exited (1) 5 seconds ago                        k8s_container-1_test2-65dbb945d6-xh9n2_defau
lt_38892324-94b7-11e9-aa5f-fa163e07fc60_3
0c43d629292e        nginx                                                     "nginx -g 'daemon ..."   Abou
t a minute ago   Up About a minute                               k8s_container-0_test2-65dbb945d6-xh9n2_defau
lt_38892324-94b7-11e9-aa5f-fa163e07fc60_0
3484b34393ce        cfe-pause:11.23.1                                         "/pause"                 Abou
t a minute ago   Up About a minute                               k8s_POD_test2-65dbb945d6-xh9n2_default_38892
324-94b7-11e9-aa5f-fa163e07fc60_0
[root@[redacted] ~]# docker logs aebc17c4d66c
2019/06/22 06:31:29 [emerg] 1#1: bind() to 0.0.0.0:80 failed (98: Address already in use)
nginx: [emerg] bind() to 0.0.0.0:80 failed (98: Address already in use)
2019/06/22 06:31:29 [emerg] 1#1: bind() to 0.0.0.0:80 failed (98: Address already in use)
nginx: [emerg] bind() to 0.0.0.0:80 failed (98: Address already in use)
2019/06/22 06:31:29 [emerg] 1#1: bind() to 0.0.0.0:80 failed (98: Address already in use)
nginx: [emerg] bind() to 0.0.0.0:80 failed (98: Address already in use)
2019/06/22 06:31:29 [emerg] 1#1: bind() to 0.0.0.0:80 failed (98: Address already in use)
nginx: [emerg] bind() to 0.0.0.0:80 failed (98: Address already in use)
2019/06/22 06:31:29 [emerg] 1#1: bind() to 0.0.0.0:80 failed (98: Address already in use)
nginx: [emerg] bind() to 0.0.0.0:80 failed (98: Address already in use)
2019/06/22 06:31:29 [emerg] 1#1: still could not bind()
nginx: [emerg] still could not bind()
```

----End

Solution

Re-create the workload and set a port number that is not used by any other pod.

Check Item 7: Whether the Value of the Secret Mounted to the Workload Meets Requirements

Information similar to the following is displayed in the event:

```
Error: failed to start container "filebeat": Error response from daemon: OCI runtime create failed: container_linux.go:330: starting container process caused "process_linux.go:381: container init caused \"setenv: invalid argument\"": unknown
```

The root cause is that a secret is mounted to the workload, but the value of the secret is not encrypted using Base64.

Solution:

Create a secret on the console. The value of the secret is automatically encrypted using Base64.

If you use YAML to create a secret, you need to manually encrypt its value using Base64.

```
# echo -n "Content to be encoded" | base64
```

Check Item 8: Whether the Container Startup Command Is Correctly Configured

The error messages are as follows:

```
[root@[redacted]~]# docker ps -a|grep test1
2ae258d570c2        94818572c4ef                                                "/bin/sh -c 'sleep..."   14 s
econds ago       Up 12 seconds                                  k8s_container-0_test1-dbc59fc55-8gr9f_defau
lt_19f0d2a0-94ba-11e9-aa5f-fa163e07fc60_1
492b258c1e89        94818572c4ef                                                "/bin/sh -c 'sleep..."   Abou
t a minute ago   Exited (1) 14 seconds ago                      k8s_container-0_test1-dbc59fc55-8gr9f_defau
lt_19f0d2a0-94ba-11e9-aa5f-fa163e07fc60_0
2fcd00990111        cfe-pause:11.23.1                                           "/pause"                 Abou
t a minute ago   Up About a minute                             k8s_POD_test1-dbc59fc55-8gr9f_default_19f0d
2a0-94ba-11e9-aa5f-fa163e07fc60_0
[root@[redacted]~]# docker logs 492b258c1e89
cat: /tmp/test: No such file or directory
```

Solution

Click the workload name to go to the workload details page, click the **Containers** tab. Choose **Lifecycle**, click **Startup Command**, and ensure that the command is correct.

Check Item 9: Whether the User Service Has a Bug

Check whether the workload startup command is correctly executed or whether the workload has a bug.

Step 1 Log in to the node where the abnormal workload is located.

Step 2 Check the ID of the container where the workload pod exits abnormally.

```
docker ps -a | grep $podName
```

Step 3 View the logs of the corresponding container.

```
docker logs $containerID
```

Note: In the preceding command, *containerID* indicates the ID of the container that has exited.

Figure 20-4 Incorrect startup command of the container

```
[root@dcb-ha-11638 ~]# docker ps -a |grep nginx
cf0352f612f9        3f8a4339aadd                "/bin/bash /tmp/test."   2 minutes ago
      Exited (127) 2 minutes ago                 k8s_container-0_nginx-267
0177225-kt929_test_d6402ef7-4e0f-11e8-b4f7-fa163e74044e_5
c2176ce394a1        cfe-pause:3.7.6             "/pause"                 5 minutes ago
      Up 5 minutes                               k8s_POD_nginx-2670177225-
kt929_test_d6402ef7-4e0f-11e8-b4f7-fa163e74044e_0
[root@dcb-ha-11638 ~]# docker logs cf035
/bin/bash: /tmp/test.sh: No such file or directory
[root@dcb-ha-11638 ~]#
```

As shown in the figure above, the container fails to be started due to an incorrect startup command. For other errors, rectify the bugs based on the logs.

----End

Solution

Create a new workload and configure a correct startup command.

20.5.1.5 What Should I Do If a Pod Fails to Be Evicted?

Principle of Eviction

When a node is abnormal, Kubernetes will evict pods on the node to ensure workload availability.

In Kubernetes, both kube-controller-manager and kubelet can evict pods.

- **Eviction implemented by kube-controller-manager**

  kube-controller-manager consists of multiple controllers, and eviction is implemented by node controller. node controller periodically checks the status of all nodes. If a node is in the **NotReady** state for a period of time, all pods on the node will be evicted.

  kube-controller-manager supports the following startup parameters:

  - **pod-eviction-timeout**: indicates an interval when a node is down, after which pods on that node are evicted. The default interval is 5 minutes.
  - **node-eviction-rate**: indicates the number of nodes to be evicted per second. The default value is **0.1**, indicating that pods are evicted from one node every 10 seconds.
  - **secondary-node-eviction-rate**: specifies a rate at which nodes are evicted in the second grade. If a large number of nodes are down in the cluster, the eviction rate will be reduced to **secondary-node-eviction-rate**. The default value is **0.01**.
  - **unhealthy-zone-threshold**: specifies a threshold for an AZ to be considered unhealthy. The default value is **0.55**, meaning that if the percentage of faulty nodes in an AZ exceeds 55%, the AZ will be considered unhealthy.
  - **large-cluster-size-threshold**: specifies a threshold for a cluster to be considered large. The parameter defaults to **50**. If there are more nodes than this threshold, the cluster is considered as a large one. If there are more than 55% faulty nodes in a cluster, the eviction rate is reduced to 0.01. If the cluster is a small one, the eviction rate is reduced to 0, which means, pods running on the nodes in the cluster will not be evicted.

- **Eviction implemented by kubelet**

  If resources of a node are to be used up, kubelet executes the eviction policy based on the pod priority, resource usage, and resource request. If pods have the same priority, the pod that uses the most resources or requests for the most resources will be evicted first.

  kube-controller-manager evicts all pods on a faulty node, while kubelet evicts some pods on a faulty node. kubelet periodically checks the memory and disk resources of nodes. If the resources are insufficient, it will evict some pods based on the priority. For details about the pod eviction priority, see **Pod selection for kubelet eviction**.

  There are soft eviction thresholds and hard eviction thresholds.

  - **Soft eviction thresholds**: A grace period is configured for node resources. kubelet will reclaim node resources associated with these thresholds if that grace period elapses. If the node resource usage reaches these

thresholds but falls below them before the grace period elapses, kubelet will not evict pods on the node.

You can configure soft eviction thresholds using the following parameters:

- **eviction-soft**: indicates a soft eviction threshold. If a node's **eviction signal** reaches a certain threshold, for example, **memory.available<1.5Gi**, kubelet will not immediately evict some pods on the node but wait for a grace period configured by **eviction-soft-grace-period**. If the threshold is reached after the grace period elapses, kubelet will evict some pods on the node.
- **eviction-soft-grace-period**: indicates an eviction grace period. If a pod reaches the soft eviction threshold, it will be terminated after the configured grace period elapses. This parameter indicates the time difference for a terminating pod to respond to the threshold being met. The default grace period is 90 seconds.
- **eviction-max-pod-grace-period**: indicates the maximum allowed grace period to use when terminating pods in response to a soft eviction threshold being met.

– **Hard eviction thresholds**: Pods are immediately evicted once these thresholds are reached.

You can configure hard eviction thresholds using the following parameters:

eviction-hard: indicates a hard eviction threshold. When the **eviction signal** of a node reaches a certain threshold, for example, **memory.available<1Gi**, which means, when the available memory of the node is less than 1 GiB, a pod eviction will be triggered immediately.

kubelet supports the following default hard eviction thresholds:

- **memory.available<100Mi**
- **nodefs.available<10%**
- **imagefs.available<15%**
- **nodefs.inodesFree<5%** (for Linux nodes)

kubelet also supports other parameters:

– **eviction-pressure-transition-period**: indicates a period for which the kubelet has to wait before transitioning out of an eviction pressure condition. The default value is 5 minutes. If the time exceeds the threshold, the node is set to **DiskPressure** or **MemoryPressure**. Then some pods running on the node will be evicted. This parameter can prevent mistaken eviction decisions when a node is oscillating above and below a soft eviction threshold in some cases.

– **eviction-minimum-reclaim**: indicates the minimum number of resources that must be reclaimed in each eviction. This parameter can prevent kubelet from repeatedly evicting pods because only a small number of resources are reclaimed during pod evictions in some cases.

Fault Locating

If the pods are not evicted when the node is faulty, perform the following steps to locate the fault:

After the following command is run, the command output shows that many pods are in the **Evicted** state.

```
kubectl get pods
```

Check results will be recorded in kubelet logs of the node. You can run the following command to search for the information:

```
cat /var/paas/sys/log/kubernetes/kubelet.log | grep -i Evicted -C3
```

Troubleshooting Process

The issues here are described in order of how likely they are to occur.

Check these causes one by one until you find the cause of the fault.

- **Check Item 1: Whether the Node Is Under Resource Pressure**
- **Check Item 2: Whether Tolerations Have Been Configured for the Workload**
- **Check Item 3: Whether the Conditions for Stopping Pod Eviction Are Met**
- **Check Item 4: Whether the Allocated Resources of the Pod Are the Same as Those of the Node**
- **Check Item 5: Whether the Workload Pod Fails Continuously and Is Redeployed**

Check Item 1: Whether the Node Is Under Resource Pressure

If a node suffers resource pressure, kubelet will change the **node status** and add taints to the node. Perform the following steps to check whether the corresponding taint exists on the node:

```
$ kubectl describe node 192.168.0.37
Name:               192.168.0.37
...
Taints:             key1=value1:NoSchedule
...
```

Table 20-8 Statuses of nodes with resource pressure and solutions

Node Status	Taint	Eviction Signal	Description
MemoryPressure	node.kubernetes.io/memory-pressure	memory.available	The available memory on the node reaches the eviction thresholds.

Node Status	Taint	Eviction Signal	Description
DiskPressure	node.kubernetes.io/disk-pressure	nodefs.available, nodefs.inodesFree, imagefs.available or imagefs.inodesFree	The available disk space and inode on the root file system or image file system of the node reach the eviction thresholds.
PIDPressure	node.kubernetes.io/pid-pressure	pid.available	The available process identifier on the node is below the eviction thresholds.

Check Item 2: Whether Tolerations Have Been Configured for the Workload

Use kubectl or locate the row containing the target workload and choose **More** > **Edit YAML** in the **Operation** column to check whether tolerance is configured for the workload. For details, see **Taints and Tolerations**.

Check Item 3: Whether the Conditions for Stopping Pod Eviction Are Met

In a cluster that runs less than 50 worker nodes, if the number of faulty nodes accounts for over 55% of the total nodes, the pod eviction will be suspended. In this case, Kubernetes will not attempt to evict the workload on the faulty node. For details, see **Rate limits on eviction**.

Check Item 4: Whether the Allocated Resources of the Pod Are the Same as Those of the Node

An evicted pod will be frequently scheduled to the original node.

Possible Causes

Pods on a node are evicted based on the node resource usage. The evicted pods are scheduled based on the allocated node resources. Eviction and scheduling are based on different rules. Therefore, an evicted container may be scheduled to the original node again.

Solution

Properly allocate resources to each container.

Check Item 5: Whether the Workload Pod Fails Continuously and Is Redeployed

A workload pod fails and is being redeployed constantly.

Analysis

After a pod is evicted and scheduled to a new node, if pods in that node are also being evicted, the pod will be evicted again. Pods may be evicted repeatedly.

If a pod is evicted by kube-controller-manager, it would be in the **Terminating** state. This pod will be automatically deleted only after the node where the container is located is restored. If the node has been deleted or cannot be restored due to other reasons, you can forcibly delete the pod.

If a pod is evicted by kubelet, it would be in the **Evicted** state. This pod is only used for subsequent fault locating and can be directly deleted.

Solution

Run the following command to delete the evicted pods:

```
kubectl get pods <namespace> | grep Evicted | awk '{print $1}' | xargs kubectl delete pod <namespace>
```

In the preceding command, *<namespace>* indicates the namespace name. Configure it based on your requirements.

References

Kubelet does not delete evicted pods

20.5.1.6 What Should I Do If a Storage Volume Cannot Be Mounted or the Mounting Times Out?

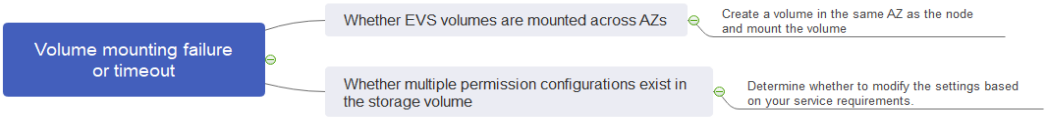
Troubleshooting Process

The issues here are described in order of how likely they are to occur.

Check these causes one by one until you find the cause of the fault.

- **Check Item 1: Whether EVS Volumes Are Mounted Across AZs**
- **Check Item 2: Whether Multiple Permission Configurations Exist in the Storage Volume**
- **Check Item 3: Whether There Is More Than One Replica for a Deployment with EVS Volumes**
- **Check Item 4: Whether the EVS Disk File System Is Damaged**

Figure 20-5 Troubleshooting for storage volume mounting failure or mounting timeout



Check Item 1: Whether EVS Volumes Are Mounted Across AZs

Symptom

Mounting an EVS volume to a StatefulSet times out.

Fault Locating

If your node is in **AZ 1** but the volume to be mounted is in **AZ 2**, the mounting times out and the volume cannot be mounted.

Solution

Create a volume in the same AZ as the node and mount the volume.

Check Item 2: Whether Multiple Permission Configurations Exist in the Storage Volume

If the volume to be mounted stores too many data and involves permission-related configurations, the file permissions need to be modified one by one, which results in mounting timeout.

Fault Locating

- Check whether the **securityContext** field contains **runAsuser** and **fsGroup**. **securityContext** is a Kubernetes field that defines the permission and access control settings of pods or containers.
- Check whether the startup commands contain commands used to obtain or modify file permissions, such as **ls**, **chmod**, and **chown**.

Solution

Determine whether to modify the settings based on your service requirements.

Check Item 3: Whether There Is More Than One Replica for a Deployment with EVS Volumes

Symptom

The pod fails to be created, and an event indicating that the storage fails to be added is reported.

```
Multi-Attach error for volume "pvc-62a7a7d9-9dc8-42a2-8366-0f5ef9db5b60" Volume is already used by pod(s) testttt-7b774658cb-lc98h
```

Fault Locating

Check whether the number of replicas of the Deployment is greater than 1.

If the Deployment uses an EVS volume, the number of replicas can only be 1. If you specify more than two pods for the Deployment on the backend, CCE does not restrict the creation of the Deployment. However, if these pods are scheduled to different nodes, some pods cannot be started because the EVS volumes used by the pods cannot be mounted to the nodes.

Solution

Set the number of replicas of the Deployment that uses an EVS volume to 1 or use other volume types.

Check Item 4: Whether the EVS Disk File System Is Damaged

Symptom

The pod fails to be created, and information similar to the following is displayed, indicating that the disk file system is damaged.

```
MountVolume.MountDevice failed for volume "pvc-08178474-c58c-4820-a828-14437d46ba6f" : rpc error: code = Internal desc = [09060def-afd0-11ec-9664-fa163eef47d0] /dev/sda has file system, but it is detected to be damaged
```

Solution

Back up the disk in EVS and run the following command to restore the file system:

fsck -y {Drive letter}

20.5.1.7 What Should I Do If a Workload Remains in the Creating State?

Symptom

The workload remains in the creating state.

Troubleshooting Process

The issues here are described in order of how likely they are to occur.

Check these causes one by one until you find the cause of the fault.

- **Check Item 1: Whether the cce-pause Image Is Deleted by Mistake**
- **Check Item 2: Modifying Node Specifications After the CPU Management Policy Is Enabled in the Cluster**

Check Item 1: Whether the cce-pause Image Is Deleted by Mistake

Symptom

When creating a workload, an error message indicating that the sandbox cannot be created is displayed. This is because the **cce-pause:3.1** image fails to be pulled.

```
Failed to create pod sandbox: rpc error: code = Unknown desc = failed to get sandbox image "cce-pause:3.1": failed to pull image "cce-pause:3.1": failed to pull and unpack image "docker.io/library/cce-pause:3.1": failed to resolve reference "docker.io/library/cce-pause:3.1": pulling from host **** failed with status code [manifests 3.1]: 400 Bad Request
```

Possible Causes

The image is a system image added during node creation. If the image is deleted by mistake, the workload cannot be created.

Solution

Step 1 Log in to the faulty node.

Step 2 Decompress the cce-pause image installation package.

```
tar -xzvf /opt/cloud/cce/package/node-package/pause-*.tgz
```

Step 3 Import the image.

- Docker nodes:
  ```
  docker load -i ./pause/package/image/cce-pause-3.1.tar
  ```
- containerd nodes:
  ```
  ctr -n k8s.io image import ./pause/package/image/cce-pause-3.1.tar
  ```

Step 4 Create a workload.

----End

Check Item 2: Modifying Node Specifications After the CPU Management Policy Is Enabled in the Cluster

The kubelet option **cpu-manager-policy** defaults to **static**. This allows granting enhanced CPU affinity and exclusivity to pods with certain resource characteristics on the node. If you modify CCE node specifications on the ECS console, the original CPU information does not match the new CPU information. As a result, workloads on the node cannot be restarted or created.

Step 1 Log in to the CCE node (ECS) and delete the **cpu_manager_state** file.

Example command for deleting the file:

```
rm -rf /mnt/paas/kubernetes/kubelet/cpu_manager_state
```

Step 2 Restart the node or kubelet. The following is the kubelet restart command:

```
systemctl restart kubelet
```

Verify that workloads on the node can be successfully restarted or created.

For details, see **What Should I Do If I Fail to Restart or Create Workloads on a Node After Modifying the Node Specifications?**.

----End

20.5.1.8 What Should I Do If Pods in the Terminating State Cannot Be Deleted?

Symptom

When a node is in the Unavailable state, CCE migrates container pods on the node and sets the pods running on the node to the **Terminating** state.

After the node is restored, the pods in the **Terminating** state are automatically deleted.

However, some pods remain in the **Terminating** state.

```
#kubectl get pod -n aos
NAME                          READY     STATUS        RESTARTS   AGE
aos-apiserver-5f8f5b5585-s9l92     1/1       Terminating    0          3d1h
aos-cmdbserver-789bf5b497-6rwrg    1/1       Running        0          3d1h
aos-controller-545d78bs8d-vm6j9    1/1       Running        3          3d1h
```

Running **kubectl delete pods <podname> -n <namespace>** cannot delete the pods.

```
kubectl delete pods aos-apiserver-5f8f5b5585-s9l92 -n aos
```

Solution

You can run the following command to forcibly delete the pods created in any ways:

```
kubectl delete pods <pod> --grace-period=0 --force
```

Therefore, run the following command to delete the pod:

```
kubectl delete pods aos-apiserver-5f8f5b5585-s9l92 --grace-period=0 --force
```

20.5.1.9 What Should I Do If a Workload Is Stopped Caused by Pod Deletion?

Problem

A workload is in **Stopped** state.

Cause:

The **metadata.enable** field in the YAML file of the workload is **false**. As a result, the pod of the workload is deleted and the workload is in the stopped status.

```
kind: Deployment
apiVersion: apps/v1
metadata:
  name: test
  namespace: default
  selfLink: /apis/apps/v1/namespaces/default/deployments/test
  uid: b130db9f-9306-11e9-a2a9-fa163eaff9f7
  resourceVersion: '7314771'
  generation: 1
  creationTimestamp: '2019-06-20T02:54:16Z'
  labels:
    appgroup: ''
  annotations:
    deployment.kubernetes.io/revision: '1'
    description: ''
  enable: false
spec:
```

Solution

Delete the **enable** field or set it to **true**.

20.5.1.10 What Should I Do If an Error Occurs When Deploying a Service on the GPU Node?

Symptom

The following exceptions occur when services are deployed on the GPU nodes in a CCE cluster:

1. The GPU memory of containers cannot be queried.
2. Seven GPU services are deployed, but only two of them can be accessed properly. Errors are reported during the startup of the remaining five services.
   - The CUDA versions of the two services that can be accessed properly are 10.1 and 10.0, respectively.
   - The CUDA versions of the failing services are also 10.0 and 10.1.
3. Files named **core.*** are found in the GPU service containers. No such files existed in any of the previous deployments.

Fault Locating

1. The driver version of the gpu add-on is too old. After a new driver is downloaded and installed, the fault is rectified.
2. The workloads do not declare that GPU resources are required.

Suggested Solution

After you install gpu-beta (gpu-device-plugin) on a node, nvidia-smi will be automatically installed. If an error is reported during GPU deployment, this issue is typically caused by an NVIDIA driver installation failure. Check whether the NVIDIA driver has been downloaded.

- GPU node:
```
# If the add-on version is earlier than 2.0.0, run the following command:
cd /opt/cloud/cce/nvidia/bin && ./nvidia-smi

# If the add-on version is 2.0.0 or later and the driver installation path is changed, run the following command:
cd /usr/local/nvidia/bin && ./nvidia-smi
```
- Container:
```
cd /usr/local/nvidia/bin && ./nvidia-smi
```

If GPU information is returned, the device is available and the add-on has been installed.

If the driver address is incorrect, uninstall the add-on, reinstall it, and configure the correct address.

NOTE

You are advised to store the NVIDIA driver in the OBS bucket and set the bucket policy to public read.

Helpful Links

- **How Do I Rectify Failures When the NVIDIA Driver Is Used to Start Containers on GPU Nodes?**

20.5.2 Container Configuration

20.5.2.1 When Is Pre-stop Processing Used?

Service processing takes a long time. Pre-stop processing makes sure that during an upgrade, a pod is killed only when the service in the pod has been processed.

20.5.2.2 How Do I Set an FQDN for Accessing a Specified Container in the Same Namespace?

Context

When creating a workload, users can specify a container, pod, and namespace as an FQDN for accessing the container in the same namespace.

FQDN stands for Fully Qualified Domain Name, which contains both the host name and domain name. These two names are combined using a period (.).

For example, if the host name is **bigserver** and the domain name is **mycompany.com**, the FQDN is **bigserver.mycompany.com**.

Solution

Solution 1: Use the domain name for service discovery. The host name and namespace must be pre-configured. The domain name of the registered service is in the format of *service name.namespace name***.svc.cluster.local**. The limitation of this solution is that the registration center must be deployed using containers.

Solution 2: Use the host network to deploy containers and then configure affinity between the containers and a node in the cluster. In this way, the service address (that is, the node address) of the containers can be determined. The registered address is the IP address of the node where the service is located. This solution allows you to deploy the registration center using VMs, whereas the disadvantage is that the host network is not as efficient as the container network.

20.5.2.3 What Should I Do If Health Check Probes Occasionally Fail?

When the liveness and readiness probes fail to perform the health check, locate the service fault first.

Common causes are as follows:

- The service processing takes a long time. As a result, the response times out.
- The Tomcat connection setup and waiting time are too long (for example, too many connections or threads). As a result, the response times out.
- The performance of the node where the container is located, such as the disk I/O, reaches the bottleneck. As a result, the service processing times out.

20.5.2.4 How Do I Set the umask Value for a Container?

Symptom

A container is started in **tailf /dev/null** mode and the directory permission is **700** after the startup script is manually executed. If the container is started by Kubernetes itself without **tailf**, the obtained directory permission is **751**.

Solution

The reason is that the umask values set in the preceding two startup modes are different. Therefore, the permissions on the created directories are different.

The umask value is used to set the default permission for a newly created file or directory. If the umask value is too small, group users or other users will have excessive permissions, posing security threats to the system. Therefore, the default umask value for all users is set to **0077**. That is, the default permission on directories created by users is **700**, and the default permission on files is **600**.

You can add the following content to the startup script to set the permission on the created directory to **700**:

1. 1. Add **umask 0077** to the **/etc/bashrc** file and all files in **/etc/profile.d/**.

2. Run the following command:
```
echo "umask 0077" >> $FILE
```

   NOTE

   FILE indicates the file name, for example, **echo "umask 0077" >> /etc/bashrc**.

3. Set the owner and group of the **/etc/bashrc** file and all files in **/etc/profile.d/** to **root**.
4. Run the following command:
```
chown root.root $FILE
```

20.5.2.5 What Is the Retry Mechanism When CCE Fails to Start a Pod?

CCE is a fully managed Kubernetes service and is fully compatible with Kubernetes APIs and kubectl.

In Kubernetes, the spec of a pod contains a **restartPolicy** field. The value of **restartPolicy** can be **Always**, **OnFailure**, or **Never**. The default value is **Always**.

- **Always**: When a container fails, kubelet automatically restarts the container.
- **OnFailure**: When a container stops running and the exit code is not **0** (indicating normal exit), kubelet automatically restarts the container.
- **Never**: kubelet does not restart the container regardless of the container running status.

restartPolicy applies to all containers in a pod.

restartPolicy only refers to restarts of the containers by kubelet on the same node. When containers in a pod exit, kubelet restarts them with an exponential back-off delay (10s, 20s, 40s, …), which is capped at five minutes. Once a container has been running for 10 minutes without any problems, kubelet resets the restart backoff timer for the container.

The settings of **restartPolicy** vary depending on the controller:

- **Replication Controller (RC)** and **DaemonSet**: **restartPolicy** must be set to **Always** to ensure continuous running of the containers.
- **Job**: **restartPolicy** must be set to **OnFailure** or **Never** to ensure that containers are not restarted after being executed.

20.5.3 Scheduling Policies

20.5.3.1 How Do I Evenly Distribute Multiple Pods to Each Node?

The kube-scheduler component in Kubernetes is responsible pod scheduling. For each newly created pod or other unscheduled pods, kube-scheduler selects an optimal node from them to run on. kube-scheduler selects a node for a pod in a 2-step operation: filtering and scoring. In the filtering step, all nodes where it is feasible to schedule the pod are filtered out. In the scoring step, kube-scheduler ranks the remaining nodes to choose the most suitable pod placement. Finally, kube-scheduler schedules the pod to the node with the highest score. If there is more than one node with the equal scores, kube-scheduler selects one of them at random.

BalancedResourceAllocation is only one of the scoring priorities. Other scoring items may also cause uneven distribution. For details about scheduling, see **Kubernetes Scheduler** and **Scheduling Policies**.

You can configure pod anti-affinity policies to evenly distribute pods onto different nodes.

Example:

```
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:                # Workload anti-affinity
          preferredDuringSchedulingIgnoredDuringExecution:    # Ensure that the following conditions are met:
            - podAffinityTerm:
                labelSelector:                  # Select the label of the pod, which is anti-affinity with 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
```

20.5.3.2 How Do I Prevent a Container on a Node from Being Evicted?

Context

During workload scheduling, two containers on a node may compete for resources. As a result, kubelet evicts both containers. This section describes how to set a policy to retain one of the containers.

Solution

kubelet uses the following criteria to evict a pod:

- Quality of Service (QoS) class: **BestEffort**, **Burstable**, and **Guaranteed**
- Consumed resources based on the pod scheduling request

Pods of different QoS classes are evicted in the following sequence:

BestEffort -> Burstable -> Guaranteed

- BestEffort pods: These pods have the lowest priority. They will be the first to be killed if the system runs out of memory.
- Burstable pods: These pods will be killed if the system runs out of memory and no BestEffort pods exist.
- Guaranteed pods: These pods will be killed if the system runs out of memory and no Burstable or BestEffort pods exist.

NOTE

- If processes in a pod are killed because of excessive resource usage (while the node resources are still sufficient), the system tends to restart the container or create a pod.
- If resources are sufficient, you can assign the QoS class of Guaranteed to all pods. In this way, more compute resources are used to improve service performance and stability, reducing troubleshooting time and costs.
- To improve resource utilization, assign the QoS class of Guaranteed to service pods and Burstable or BestEffort to other pods (for example, filebeat).

20.5.3.3 Why Are Pods Not Evenly Distributed to Nodes?

The kube-scheduler component in Kubernetes is responsible pod scheduling. For each newly created pod or other unscheduled pods, kube-scheduler selects an optimal node from them to run on. kube-scheduler selects a node for a pod in a 2-step operation: filtering and scoring. In the filtering step, all nodes where it is feasible to schedule the pod are filtered out. In the scoring step, kube-scheduler ranks the remaining nodes to choose the most suitable pod placement. Finally, kube-scheduler schedules the pod to the node with the highest score. If there is more than one node with the equal scores, kube-scheduler selects one of them at random.

BalancedResourceAllocation is only one of the scoring priorities. Other scoring items may also cause uneven distribution. For details about scheduling, see **Kubernetes Scheduler** and **Scheduling Policies**.

20.5.3.4 How Do I Evict All Pods on a Node?

You can run the **kubectl drain** command to safely evict all pods from a node.

NOTE

By default, the **kubectl drain** command retains some system pods, for example, everest-csi-driver.

Step 1 Use kubectl to connect to the cluster.

Step 2 Check the nodes in the cluster.

```
kubectl get node
```

Step 3 Select a node and view all pods on the node.

```
kubectl get pod --all-namespaces -owide --field-selector spec.nodeName=192.168.0.160
```

The pods on the node before eviction are as follows:

```
NAMESPACE     NAME                                READY   STATUS    RESTARTS   AGE     IP
NODE           NOMINATED NODE   READINESS GATES
default       nginx-5bcc57c74b-lgcvh                1/1     Running   0          7m25s   10.0.0.140
192.168.0.160   <none>           <none>
kube-system   coredns-6fcd88c4c-97p6s               1/1     Running   0          3h16m   10.0.0.138
192.168.0.160   <none>           <none>
kube-system   everest-csi-controller-56796f47cc-99dtm   1/1     Running   0          3h16m   10.0.0.139
192.168.0.160   <none>           <none>
kube-system   everest-csi-driver-dpfzl              2/2     Running   2          12d     192.168.0.160
192.168.0.160   <none>           <none>
kube-system   icagent-tpfpv                         1/1     Running   1          12d     192.168.0.160
192.168.0.160   <none>           <none>
```

Step 4 Evict all pods on the node.

```
kubectl drain 192.168.0.160
```

If a pod mounted with local storage or controlled by a DaemonSet set exists on the node, the message "error: unable to drain node "192.168.0.160", aborting command... " will be displayed. The eviction command does not take effect. You can add the following parameters to the end of the preceding command to forcibly evict the pod:

- **--delete-emptydir-data**: forcibly evicts pods mounted with local storage, for example, coredns.
- **--ignore-daemonsets**: forcibly evicts the DaemonSet pods, for example, everest-csi-driver.

In the example, both types of pods exist on the node. Therefore, the eviction command is as follows:

```
kubectl drain 192.168.0.160 --delete-emptydir-data --ignore-daemonsets
```

Step 5 After the eviction, the node is automatically marked as unschedulable. That is, the node is tainted **node.kubernetes.io/unschedulable = : NoSchedule**.

After the eviction, only system pods are retained on the node.

```
NAMESPACE     NAME                       READY   STATUS    RESTARTS   AGE   IP              NODE
NOMINATED NODE   READINESS GATES
kube-system   everest-csi-driver-dpfzl   2/2     Running   2          12d   192.168.0.160   192.168.0.160
<none>           <none>
kube-system   icagent-tpfpv              1/1     Running   1          12d   192.168.0.160   192.168.0.160
<none>           <none>
```

----End

Related Operations

Drain, cordon, and uncordon operations of kubectl:

- **drain**: Safely evicts all pods from a node and marks the node as unschedulable.
- **cordon**: Marks the node as unschedulable. That is, the node is tainted **node.kubernetes.io/unschedulable = : NoSchedule**.
- **uncordon**: Marks the node as schedulable.

For more information, see the **kubectl documentation**.

20.5.4 Others

20.5.4.1 What Should I Do If a Scheduled Task Cannot Be Restarted After Being Stopped for a Period of Time?

If a scheduled task is stopped during running, before its restart, the system calculates the difference between the last time the task was successfully executed and the current time and compares the time difference with the scheduled task period multiplied by 100. If the time difference is greater than the period multiplied by 100, the scheduled task will not be triggered again. For details, see **CronJob Limitations**.

For example, assume that a cron job is set to create a job every minute from 08:30:00 and the **startingDeadlineSeconds** field is not set. If the cron job controller stops running from 08:29:00 to 10:21:00, the job will not be started because the time difference between 08:29:00 and 10:21:00. 00 exceeds 100 minutes, that is, the number of missed scheduling times exceeds 100 (in the example, a scheduling period is 1 minute).

If the **startingDeadlineSeconds** field is set, the controller calculates the number of missed jobs in the last *x* seconds (*x* indicates the value of **startingDeadlineSeconds**). For example, if **startingDeadlineSeconds** is set to **200**, the controller counts the number of jobs missed in the last 200 seconds. In this case, if the cron job controller stops running from 08:29:00 to 10:21:00, the job will start again at 10:22:00, because only three scheduling requests are missed in the last 200 seconds (in the example, one scheduling period is 1 minute).

Solution

Configure the **startingDeadlineSeconds** parameter in a cron job. This parameter can be created or modified only by using kubectl or APIs.

Example YAML:

```
apiVersion: batch/v1
kind: CronJob
metadata:
  name: hello
spec:
  startingDeadlineSeconds: 200
  schedule: "* * * * *"
  jobTemplate:
    spec:
      template:
        spec:
          containers:
          - name: hello
            image: busybox:1.28
            imagePullPolicy: IfNotPresent
            command:
            - /bin/sh
            - -c
            - date; echo Hello
          restartPolicy: OnFailure
```

If you create a cron job again, you can temporarily avoid this issue.

20.5.4.2 What Is a Headless Service When I Create a StatefulSet?

The inter-pod discovery service of CCE corresponds to the headless Service of Kubernetes. Headless Services specify **None** for the cluster IP (spec:clusterIP) in YAML, which means no cluster IP is allocated.

Differences Between Headless Services and Common Services

- Common Services:

  One Service may be backed by multiple endpoints (pods). A client accesses the cluster IP address and the request is forwarded to the real server based on the iptables or IPVS rules to implement load balancing. For example, a Service has two endpoints, but only the Service address is returned during DNS query. The iptables or IPVS rules determine the real server that the client accesses. The client cannot access the specified endpoint.

- Headless Services:

  When a headless Service is accessed, the actual endpoint (pod IP addresses) is returned. The headless Service points directly to each endpoint, that is, each pod has a DNS domain name. In this way, pods can access each other, achieving inter-pod discovery and access.

Headless Service Application Scenarios

If there is no difference between multiple pods of a workload, you can use a common Service and use the cluster kube-proxy to implement load balancing, for example, an Nginx Deployment.

However, in some application scenarios, pods of a workload have different roles. For example, in a Redis cluster, each Redis pod is different. They have a master/slave relationship and need to communicate with each other. In this case, a common Service cannot access a specified pod through the cluster IP address. Therefore, you need to allow the headless Service to directly access the real IP address of the pod to implement mutual access among pods.

Headless Services work with **StatefulSet** to deploy stateful applications, such as Redis and MySQL.

20.5.4.3 What Should I Do If Error Message "Auth is empty" Is Displayed When a Private Image Is Pulled?

Problem Description

When you replace the image of a container in a created workload and use an uploaded image on the CCE console, an error message "Auth is empty, only accept X-Auth-Token or Authorization" is displayed when the uploaded image is pulled.

```
Failed to pull image "IP address:Port number /magicdoom/tidb-operator:latest": rpc error: code = Unknown desc = Error response from daemon: Get https:// IP address:Port number /v2/magicdoom/tidb-operator/manifests/latest: error parsing HTTP 400 response body: json: cannot unmarshal number into Go struct field Error.code of type errcode.ErrorCode: "{\"errors\":[{\"code\":400,\"message\":\"Auth is empty, only accept X-Auth-Token or Authorization.\"}]}"
```

Solution

You can select a private image to create an application on the CCE console. In this case, CCE automatically carries the secret. This problem will not occur during the upgrade.

When you create a workload using an API, you can include the secret in Deployments to avoid this problem during the upgrade.

```
imagePullSecrets:
- name: default-secret
```

20.5.4.4 Why Cannot a Pod Be Scheduled to a Node?

Step 1 Check whether the node and Docker are normal. For details, see **Check Item 7: Whether Internal Components Are Normal**.

Step 2 If the node and Docker are normal, check whether an affinity policy is configured for the pod. For details, see **Check Item 3: Affinity and Anti-Affinity Configuration of the Workload**.

Step 3 Check whether the resources on the node are sufficient. If the resources are insufficient, expand the capacity or add nodes.

----End

20.5.4.5 What Is the Image Pull Policy for Containers in a CCE Cluster?

A container image is required to create a container. Images may be stored locally or in a remote image repository.

The **imagePullPolicy** field in the Kubernetes configuration file is used to describe the image pull policy. This field has the following value options:

- **Always**: Always force a pull.
  ```
  imagePullPolicy: Always
  ```
- **IfNotPresent**: The image is pulled only if it is not already present locally.
  ```
  imagePullPolicy: IfNotPresent
  ```
- **Never**: The image is assumed to exist locally. No attempt is made to pull the image.
  ```
  imagePullPolicy: Never
  ```

Description

1. If this field is set to **Always**, the image is pulled from the remote repository each time a container is started or restarted.

   If **imagePullPolicy** is left blank, the policy defaults to **Always**.
2. If the policy is set to **IfNotPreset**:

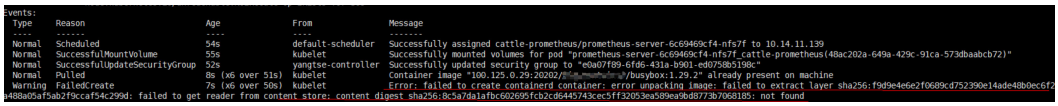
   a. If the required image does not exist locally, it will be pulled from the remote repository.

   b. If the content, except the tag, of the required image is the same as that of the local image, and the image with that tag exists only in the remote repository, Kubernetes will not pull the image from the remote repository.

20.5.4.6 What Can I Do If a Layer Is Missing During Image Pull?

Symptom

When containerd is used as the container engine, there is a possibility that the image layer is missing when an image is pulled to a node. As a result, the workload container fails to be created.



Possible Cause

Docker earlier than v1.10 supports the layer whose **mediaType** is **application/octet-stream**. However, containerd does not support **application/octet-stream**. As a result, the layer is not pulled.

Solution

You can use either of the following methods to solve this problem:

- Use Docker v1.11 or later to repackage the image.
- Manually pull the image.
  a. Log in to the node.
  b. Run the following command to pull the image:
     ctr -n k8s.io images pull --user u:p images
  c. Use the newly pulled image to create a workload.

20.6 Networking

20.6.1 Network Planning

20.6.1.1 What Is the Relationship Between Clusters, VPCs, and Subnets?

A Virtual Private Cloud (VPC) is similar to a private local area network (LAN) managed by a home gateway whose IP address is 192.168.0.0/16. A VPC is a private network built on the cloud and provides basic network environment for running elastic cloud servers (ECSs), elastic load balances (ELBs), and middleware. Networks of different scales can be configured based on service requirements. Generally, you can set the CIDR block to 10.0.0.0/8–24, 172.16.0.0/12–24, or 192.168.0.0/16–24. The largest CIDR block is 10.0.0.0/8, which corresponds to a class A network.

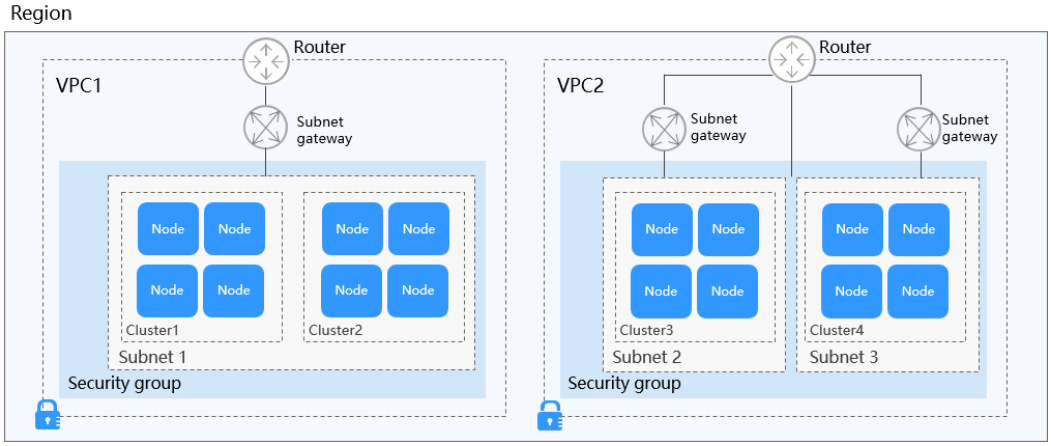
A VPC can be divided into multiple subnets. Security groups are configured to determine whether these subnets can communicate with each other. This ensures that subnets can be isolated from each other, so that you can deploy different services on different subnets.

A cluster is one or a group of cloud servers (also known as nodes) in the same VPC. It provides computing resource pools for running containers.

As shown in **Figure 20-6**, a region may comprise of multiple VPCs. A VPC consists of one or more subnets. The subnets communicate with each other through a subnet gateway. A cluster is created in a subnet. There are three scenarios:

- Different clusters are created in different VPCs.
- Different clusters are created in the same subnet.
- Different clusters are created in different subnets.

Figure 20-6 Relationship between clusters, VPCs, and subnets



20.6.1.2 How Can I Configure a Security Group Rule in a Cluster?

CCE is a universal container platform. Its default security group rules apply to common scenarios. When a cluster is created, a security group is automatically created for the master node and worker node, separately. The security group name of the master node is *{Cluster name}*-**cce-control**-*{Random ID}*, and the security group name of the worker node is *{Cluster name}*-**cce-node**-*{Random ID}*.

You can log in to the management console, choose **Service List** > **Networking** > **Virtual Private Cloud**. On the page displayed, choose **Access Control** > **Security Groups** in the navigation pane, locate the security group of the cluster, and modify the security group rules as required.

The default security group rules of the clusters using different networks are as follows:

- **Security Group Rules of a Cluster Using a VPC Network**
- **Security Group Rules of a Cluster Using the Tunnel Network**

NOTICE

- Modifying or deleting security group rules may affect cluster running. Exercise caution when performing this operation. If you need to modify security group rules, do not modify the rules of the port on which CCE running depends.
- When adding a new security group rule to a cluster, ensure that the new rule does not conflict with the original rules. Otherwise, the original rules may become invalid, affecting the cluster running.

Security Group Rules of a Cluster Using a VPC Network

Security group of a worker node

A security group named *{Cluster name}*-**cce-node**-*{Random ID}* is automatically created for each worker node. For details about the default ports, see **Table 20-9**.

Table 20-9 Default ports in the security group for a worker node that uses a VPC network

Direction	Port	Default Source Address	Description	Modifiable	Modification Suggestion
Inbound rules	All UDP ports	VPC CIDR block	Used for mutual access between worker nodes and between a worker node and a master node.	No	N/A
	All TCP ports				
	All ICMP ports	Security group of the master node	Used for the master node to access worker nodes.	No	N/A
	TCP port range: 30000 to 32767	All IP addresses: **0.0.0.0/0**	Allow access from NodePort.	Yes	These ports must permit requests from VPC, container, and ELB CIDR blocks.
	UDP port range: 30000 to 32767				
	All	Container CIDR block	Used for mutual access between nodes and containers.	No	N/A

Direction	Port	Default Source Address	Description	Modifiable	Modification Suggestion
	All	Security group of worker nodes	Used for mutual access between worker nodes.	No	N/A
	TCP port 22	All IP addresses: **0.0.0.0/0**	Port that allows remote access to Linux ECSs using SSH.	**Recommended**	N/A
Outbound rule	All	All IP addresses: **0.0.0.0/0**	Allow traffic on all ports by default. You are advised to retain this setting.	Yes	If you want to harden security by allowing traffic only on specific ports, remember to allow such ports. For details, see **Hardening Outbound Rules**.

Security group of the master node

A security group named *{Cluster name}*-**cce-control-***{Random ID}* is automatically created for the master node. For details about the default ports, see **Table 20-10**.

Table 20-10 Default ports in the security group for the master node that uses a VPC network

Direction	Port	Default Source Address	Description	Modifiable	Modification Suggestion
Inbound rules	TCP port 5444	VPC CIDR block	Allow access from kube-apiserver, which provides lifecycle management for Kubernetes resources.	No	N/A
	TCP port 5444	Container CIDR block			
	TCP port 9443	VPC CIDR block	Allow the network add-on of a worker node to access the master node.	No	N/A

Direction	Port	Default Source Address	Description	Modifiable	Modification Suggestion
	TCP port 5443	All IP addresses: **0.0.0.0/0**	Allow kube-apiserver of the master node to listen to the worker nodes.	**Recommended**	The port must allow traffic from the CIDR blocks of the VPC, container, and the control plane of the hosted service mesh.
	TCP port 8445	VPC CIDR block	Allow the storage add-on of a worker node to access the master node.	No	N/A
	All	IP addresses of this security group	Allow traffic from all IP addresses of this security group.	No	N/A
Outbound rule	All	All IP addresses: **0.0.0.0/0**	Allow traffic on all ports by default.	No	N/A

Security Group Rules of a Cluster Using the Tunnel Network

Security group of a worker node

A security group named *{Cluster name}*-**cce-node**-*{Random ID}* is automatically created for each worker node. For details about the default ports, see **Table 20-11**.

Table 20-11 Default ports in the security group for a worker node that uses a tunnel network

Direction	Port	Default Source Address	Description	Modifiable	Modification Suggestion
Inbound rules	UDP port 4789	All IP addresses: **0.0.0.0/0**	Allow access between containers.	No	N/A

Direction	Port	Default Source Address	Description	Modifiable	Modification Suggestion
	TCP port 10250	CIDR block of the master node	Allow the master node to access kubelet on a worker node, for example, by running **kubectl exec** *{pod}*.	No	N/A
	TCP port range: 30000 to 32767	All IP addresses: **0.0.0.0/0**	Allow access from NodePort.	Yes	These ports must permit requests from VPC, container, and ELB CIDR blocks.
	UDP port range: 30000 to 32767				
	TCP port 22	All IP addresses: **0.0.0.0/0**	Port that allows remote access to Linux ECSs using SSH.	**Recommended**	N/A
	All	IP addresses of this security group	Allow traffic from all IP addresses of this security group.	No	N/A
Outbound rule	All	All IP addresses: **0.0.0.0/0**	Allow traffic on all ports by default. You are advised to retain this setting.	Yes	If you want to harden security by allowing traffic only on specific ports, remember to allow such ports. For details, see **Hardening Outbound Rules**.

Security group of the master node

A security group named *{Cluster name}*-**cce-control-***{Random ID}* is automatically created for the master node. For details about the default ports, see **Table 20-12**.

Table 20-12 Default ports in the security group for the master node that uses a tunnel network

Direction	Port	Default Source Address	Description	Modifiable	Modification Suggestion
Inbound rules	UDP port 4789	All IP addresses: **0.0.0.0/0**	Allow access between containers.	No	N/A
	TCP port 5444	VPC CIDR block	Allow access from kube-apiserver, which provides lifecycle management for Kubernetes resources.	No	N/A
	TCP port 5444	Container CIDR block			
	TCP port 9443	VPC CIDR block	Allow the network add-on of a worker node to access the master node.	No	N/A
	TCP port 5443	All IP addresses: **0.0.0.0/0**	Allow kube-apiserver of the master node to listen to the worker nodes.	**Recommended**	The port must allow traffic from the CIDR blocks of the VPC, container, and the control plane of the hosted service mesh.
	TCP port 8445	VPC CIDR block	Allow the storage add-on of a worker node to access the master node.	No	N/A
	All	IP addresses of this security group	Allow traffic from all IP addresses of this security group.	No	N/A
Outbound rule	All	All IP addresses: **0.0.0.0/0**	Allow traffic on all ports by default.	No	N/A

Hardening Outbound Rules

By default, all security groups created by CCE allow all the **outbound** traffic. You are advised to retain this configuration. To harden outbound rules, ensure that the ports listed in the following table are enabled.

Table 20-13 Minimum configurations of outbound security group rules for a worker node

Port	Allowed CIDR	Description
UDP port 53	DNS server of the subnet	Allow traffic on the port for domain name resolution.
UDP port 4789 (required only for clusters that use the tunnel networks)	All IP addresses	Allow access between containers.
TCP port 5443	CIDR block of the master node	Allow kube-apiserver of the master node to listen to the worker nodes.
TCP port 5444	CIDR blocks of the VPC and container	Allow access from kube-apiserver, which provides lifecycle management for Kubernetes resources.
TCP port 6443	CIDR block of the master node	None
TCP port 8445	VPC CIDR block	Allow the storage add-on of a worker node to access the master node.
TCP port 9443	VPC CIDR block	Allow the network add-on of a worker node to access the master node.
All ports	198.19.128.0/17	Allow a worker node to access the VPC Endpoint (VPCEP) service.
UDP port123	100.126.0.0/16	Allow a worker node to access the internal NTP server.
TCP port 443	100.126.0.0/16	Allow a worker node to access OBS over internal networks to pull the installation package.
TCP port 6443	100.126.0.0/16	Allow a worker node to report that the worker node is installed.

20.6.2 Network Fault

20.6.2.1 How Do I Locate a Workload Networking Fault?

Troubleshooting Process

The issues here are described in order of how likely they are to occur.

Check these causes one by one until you find the cause of the fault.

- **Check Item 1: Container and Container Port**
- **Check Item 2: Node IP Address and Node Port**
- **Check Item 3: ELB IP Address and Port**
- **Check Item 4: NAT Gateway + Port**
- **Check Item 5: Whether the Security Group of the Node Where the Container Is Located Allows Access**

Check Item 1: Container and Container Port

Log in to the CCE console or use kubectl to query the IP address of the pod. Then, log in to the node or container in the cluster and run the **curl** command to manually call the API. Check whether the expected result is returned.

If <container IP address>:<port> cannot be accessed, you are advised to log in to the application container and access <127.0.0.1>:<port> to locate the fault.

Common issues:

1. The container port is incorrectly configured (the container does not listen to the access port).
2. The URL does not exist (no related path exists in the container).
3. A Service exception (a Service bug in the container) occurs.
4. Check whether the cluster network kernel component is abnormal (container tunnel network model: openswitch kernel component; VPC network model: ipvlan kernel component).

Check Item 2: Node IP Address and Node Port

Only NodePort or LoadBalancer Services can be accessed using the node IP address and node port.

- **NodePort Services:**

  The access port of a node is the port exposed externally by the node.
- **LoadBalancer Service:**

  You can view the node port of a LoadBalancer Service by editing the YAML file.

Example:

nodePort: 30637 indicates the exposed node port. **targetPort: 80** indicates the exposed pod port. **port: 123** is the exposed Service port. LoadBalancer Services also use this port to configure the ELB listener.

```
spec:
  ports:
    - name: cce-service-0
      protocol: TCP
      port: 123
      targetPort: 80
      nodePort: 30637
```

After finding the node port (nodePort), access <IP address>:<port> of the node where the container is located and check whether the expected result is returned.

Common issues:

1. The service port is not allowed in the inbound rules of the node.
2. A custom route is incorrectly configured for the node.
3. The label of the pod does not match that of the Service (created using kubectl or API).

Check Item 3: ELB IP Address and Port

There are several possible causes if <IP address>:<port> of the ELB cannot be accessed, but <IP address>:<port> of the node can be accessed.

Possible causes:

- The backend server group of the port or URL does not meet the expectation.
- The security group on the node has not exposed the related protocol or port to the ELB.
- The health check of the layer-4 load balancing is not enabled.
- The certificate used for Services of layer-7 load balancing has expired.

Common issues:

1. When exposing a layer-4 ELB load balancer, if you have not enabled health check on the console, the load balancer may route requests to abnormal nodes.
2. For UDP access, the ICMP port of the node has not been allowed in the inbound rules.
3. The label of the pod does not match that of the Service (created using kubectl or API).

Check Item 4: NAT Gateway + Port

Generally, no EIP is configured for the backend server of NAT. Otherwise, exceptions such as network packet loss may occur.

Check Item 5: Whether the Security Group of the Node Where the Container Is Located Allows Access

Log in to the management console, choose **Service List** > **Networking** > **Virtual Private Cloud**. On the Network console, choose **Access Control** > **Security Groups**, locate the security group rule of the CCE cluster, and modify and harden the security group rule.

- CCE cluster:

  The security group name of the node is **{*Cluster name*}-cce-node-{*Random characters*}**.

Check the following:

- IP address, port, and protocol of an external request to access the workloads in the cluster. They must be allowed in the inbound rule of the cluster security group.
- IP address, port, and protocol of a request by a workload to visit external applications outside the cluster. They must be allowed in the outbound rule of the cluster security group.

For details about security group configuration, see **How Can I Configure a Security Group Rule in a Cluster?**.

20.6.2.2 Why Does the Browser Return Error Code 404 When I Access a Deployed Application?

CCE does not return any error code when you fail to access your applications using a browser. Check your services first.

404 Not Found

If the error code shown in the following figure is returned, it indicates that the ELB cannot find the corresponding forwarding policy. Check the forwarding policies.

Figure 20-7 404:ALB

If the error code shown in the following figure is returned, it indicates that errors occur on Nginx (your services). In this case, check your services.

Figure 20-8 404:nginx/1.**.*

20.6.2.3 What Should I Do If a Container Fails to Access the Internet?

If a container cannot access the Internet, check whether the node where the container is located can access the Internet. Then check whether the network configuration of the container is correct. For example, check whether the DNS configuration can resolve the domain name.

Check Item 1: Whether the Node Can Access the Internet

Step 1 Log in to the ECS console.

Step 2 Check whether an EIP has been bound to the ECS (node) or whether the ECS has a NAT gateway configured.

If no EIP is displayed, bind an EIP to the ECS.

----End

Check Item 2: Whether a Network ACL Has Been Configured for the Node

Step 1 Log in to the VPC console.

Step 2 In the navigation pane on the left, choose **Access Control** > **Network ACLs**.

Step 3 Check whether a network ACL has been configured for the subnet where the node is located and whether external access is restricted.

----End

Check Item 3: Whether the DNS Configuration of the Container Is Correct

Run **cat /etc/resolv.conf** in the container to check the DNS configuration. An example is as follows:

```
nameserver 10.247.x.x
search default.svc.cluster.local svc.cluster.local cluster.local
options ndots:5
```

If **nameserver** is set to **10.247.x.x**, DNS is connected to the CoreDNS of the cluster. Ensure that the CoreDNS of the cluster is running properly. If another IP address is displayed, an in-cloud or on-premises DNS server is used. Ensure that the domain name resolution is correctly configured.

20.6.2.4 What Should I Do If a Node Fails to Connect to the Internet (Public Network)?

If a node fails to be connected to the Internet, perform the following operations:

Check Item 1: Whether an EIP Has Been Bound to the Node

Log in to the ECS console and check whether an EIP has been bound to the ECS corresponding to the node.

If there is an IP address in the EIP column, an EIP has been bound. If there is no IP address in that column, bind one.

Check Item 2: Whether a Network ACL Has Been Configured for the Node

Log in to the VPC console. In the navigation pane, choose **Access Control** > **Network ACLs**. Check whether a network ACL has been configured for the subnet where the node is located and whether external access is restricted.

20.6.2.5 What Should I Do If an Nginx Ingress Access in the Cluster Is Abnormal After the Add-on Is Upgraded?

Symptom

An Nginx Ingress whose type is not specified (**kubernetes.io/ingress.class: nginx** is not added to annotations) exists in the cluster. After the nginx-ingress add-on is upgraded from 1.*x* to 2.*x*, services are interrupted.

Fault Locating

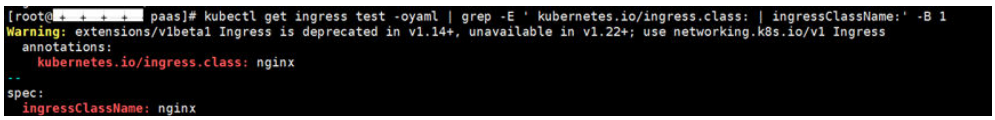
For an Nginx Ingress, check the YAML. If the Ingress type is not specified in the YAML file and the Ingress is managed by the Nginx Ingress Controller, the Ingress is at risk.

Step 1 Check the Ingress type.

Run the following command:

```
kubectl get ingress <ingress-name> -oyaml | grep -E ' kubernetes.io/ingress.class: | ingressClassName:'
```

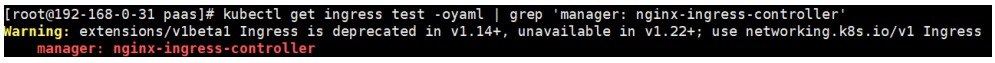
- Fault scenario: If the command output is empty, the Ingress type is not specified.
- Normal scenario: The command output is not empty, indicating that the Ingress type has been specified by **annotations** or **ingressClassName**.



Step 2 Ensure that the Ingress is managed by the Nginx Ingress Controller. The LoadBalancer Ingresses are not affected by this issue.

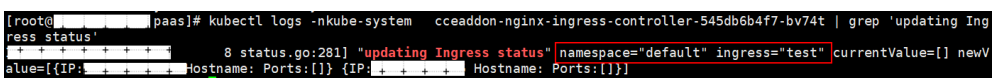
- For clusters of v1.19, confirm this issue using **managedFields**.

  ```
  kubectl get ingress <ingress-name> -oyaml | grep 'manager: nginx-ingress-controller'
  ```

- For clusters of other versions, check the logs of the Nginx Ingress Controller pod.

  ```
  kubectl logs -nkube-system cceaddon-nginx-ingress-controller-545db6b4f7-bv74t | grep 'updating Ingress status'
  ```

If the fault persists, contact technical support personnel.

----End

Solution

Add an annotation to the Nginx Ingress as follows:

```
kubectl annotate ingress <ingress-name> kubernetes.io/ingress.class=nginx
```

NOTICE

There is no need to add this annotation to LoadBalancer Ingresses. **Verify** that these Ingresses are managed by Nginx Ingress Controller.

Possible Causes

The nginx-ingress add-on is developed based on the Nginx Ingress Controller template and image of the open source community.

For the Nginx Ingress Controller of an earlier version (community version v0.49 or earlier, corresponding to CCE nginx-ingress version v1.*x.x*), the Ingress type is not specified as nginx during Ingress creation, which is, **kubernetes.io/ingress.class: nginx** is not added to annotations. This Ingress can also be managed by Nginx Ingress Controller. For details, see the **GitHub code**.

For the Nginx Ingress Controller of a later version (community version v1.0.0 or later, corresponding to CCE nginx-ingress version 2.*x.x*), if the Ingress type is not specified as nginx during Ingress creation, this Ingress will be ignored by the Nginx Ingress Controller and the Ingress rules become invalid. The services will be interrupted. For details, see the **GitHub code**.

Related link: **https://github.com/kubernetes/ingress-nginx/pull/7341**

You can specify the Ingress type in either of the following ways:

- Add the **kubernetes.io/ingress.class: nginx** annotation to the Ingress.
- Use spec. Set the **.spec.ingressClassName** field to **nginx**. IngressClass resources are required.

An example is as follows:

```
apiVersion: networking.k8s.io/v1beta1
kind: Ingress
metadata:
  name: test
  namespace: default
  annotations:
    kubernetes.io/ingress.class: nginx
spec:
  ingressClassName: nginx
  rules:
...
status:
  loadBalancer: {}
```

20.6.3 Security Hardening

20.6.3.1 How Do I Prevent Cluster Nodes from Being Exposed to Public Networks?

- If access to port 22 of a cluster node is not required, you can define a security group rule that disables access to port 22.

- Do not bind an EIP to a cluster node unless necessary.

20.6.3.2 How Do I Configure an Access Policy for a Cluster?

After the public API Server address is bound to the cluster, modify the security group rules of port 5443 on the master node to harden the access control policy of the cluster.

Step 1 Log in to the CCE console and click the cluster name to access the cluster console. On the **Overview** page, copy the cluster ID in the **Basic Info** area.

Step 2 Log in to the VPC console. In the navigation pane, choose **Access Control** > **Security Groups**.

Step 3 Select **Description** as the filter criterion and paste the cluster ID to search for the target security groups.

Step 4 Locate the row that contains the security group (starting with *{CCE cluster name}*-**cce-control**) of the master node and click **Manage Rules** in the **Operation** column.

Step 5 On the page displayed, locate the row that contains port 5443 and click **Modify** in the **Operation** column to modify its inbound rules.

Step 6 Change the source IP address that can be accessed as required. For example, if the IP address used by the client to access the API Server is **100.*.*.***, you can add an inbound rule for port 5443 and set the source IP address to **100.*.*.***.

NOTE

In addition to the client IP address, the port must allow traffic from the CIDR blocks of the VPC, container, and the control plane of the hosted service mesh to ensure that the API Server can be accessed from within the cluster.

Step 7 Click **Confirm**.

----End

20.6.4 Others

20.6.4.1 How Do I Change the Security Group of Nodes in a Cluster in Batches?

Notes and Constraints

Do not add more than 1000 instances to the same security group. Otherwise, the security group performance may deteriorate.

Procedure

Step 1 Log in to the VPC console and select the desired region and project in the upper left corner.

Step 2 In the navigation pane on the left, choose **Access Control** > **Security Groups**.

Step 3 On the **Security Groups** page, click **Manage Instance** in the **Operation** column.

Step 4 On the **Servers** tab page, click **Add**.

Step 5 Select the servers to be added to the security group and click **OK**. You can also search for servers by name, ID, private IP address, status, enterprise project, or tag.

You can change the maximum number of servers displayed on a page in the lower left corner to add a maximum of 20 servers to a security group at a time.

NOTE

After the node is added to a new security group, the original security group is retained. To remove the instance, click **Manage Instance** of the original security group and select the node servers to be removed.

----End

20.7 Storage

20.7.1 What Are the Differences Among CCE Storage Classes in Terms of Persistent Storage and Multi-node Mounting?

Container storage provides storage for container workloads. It supports multiple storage classes. A pod can use any amount of storage.

Currently, CCE supports local, EVS, SFS, SFS Turbo, and OBS volumes.

The following table lists the differences among these storage classes.

Table 20-14 Differences among storage classes

Storage Class	Persistent Storage	Automatic Migration with Containers	Multi-node Mounting
Local disks	Supported	Not supported	Not supported
EVS	Supported	Supported	Not supported
OBS	Supported	Supported	Supported. This type of volumes can be shared among multiple nodes or workloads.
SFS Turbo	Supported	Supported	Supported. This type of volumes can be shared among multiple nodes or workloads.

Selecting a Storage Class

You can use the following types of storage volumes when creating a workload. You are advised to store workload data on EVS volumes. If you store workload

data on a local volume, the data cannot be restored when a fault occurs on the node.

- Local volumes: Mount the file directory of the host where a container is located to a specified container path (corresponding to hostPath in Kubernetes). Alternatively, you can leave the source path empty (corresponding to emptyDir in Kubernetes). If the source path is left empty, a temporary directory of the host will be mounted to the mount point of the container. A specified source path is used when data needs to be persistently stored on the host, while emptyDir is used when temporary storage is needed. A ConfigMap is a type of resource that stores configuration data required by a workload. Its contents are user-defined. A Secret is an object that contains sensitive data such as workload authentication information and keys. Information stored in a Secret is determined by users.
- EVS volumes: Mount an EVS volume to a container path. When the container is migrated, the mounted EVS volume is migrated together. This storage class is applicable when data needs to be stored permanently.
- 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.

20.7.2 Can I Add a Node Without a Data Disk?

No. A data disk is mandatory.

A data disk dedicated for kubelet and the container engine will be attached to a new node. By default, CCE uses Logical Volume Manager (LVM) to manage data disks. With LVM, you can adjust the disk space ratio for different resources on a data disk.

If the data disk is uninstalled or damaged, the container engine will malfunction and the node becomes unavailable.

20.7.3 What Should I Do If the Host Cannot Be Found When Files Need to Be Uploaded to OBS During the Access to the CCE Service from a Public Network?

When a Service deployed on CCE attempts to upload files to OBS after receiving an access request from an offline machine, an error message is displayed, indicating that the host cannot be found.

Fault Locating

After receiving the HTTP request, the Service transfers files to OBS through the proxy.

If too many files are transferred, a large number of resources are consumed. Currently, the proxy is assigned 128 MiB memory. According to pressure test results, resource consumption is large, resulting in request failure.

The test results show that all traffic passes through the proxy. Therefore, if the service volume is large, more resources need to be allocated.

Solution

1. File transfer involves a large number of packet copies, which occupies a large amount of memory. In this case, increase the proxy memory based on the actual scenario and then try to access the Service and upload files again.
2. Additionally, remove the Service from the mesh because the proxy only forwards packets and does not perform any other operations. If requests pass through the ingress gateway, the grayscale release function of the Service is not affected.

20.7.4 How Can I Achieve Compatibility Between ExtendPathMode and Kubernetes client-go?

Application Scenarios

The Kubernetes pod structure does not contain **ExtendPathMode**. Therefore, when a user calls the API for creating a pod or deployment by using client-go, the created pod does not contain **ExtendPathMode**. CCE provides a solution to ensure compatibility with the Kubernetes client-go.

Solution

NOTICE

- When creating a pod, you need to add **kubernetes.io/extend-path-mode** to **annotation** of the pod.
- When creating a Deployment, you need to add **kubernetes.io/extend-path-mode** to **kubernetes.io/extend-path-mode** in the template.

The following is an example YAML of creating a pod. After the **kubernetes.io/extend-path-mode** keyword is added to **annotation**, the **containername**, **name**, and **mountpath** fields are matched, and the corresponding **extendpathmode** is added to **volumeMount**.

```
apiVersion: v1
kind: Pod
metadata:
  name: test-8b59d5884-96vdz
  generateName: test-8b59d5884-
  namespace: default
  selfLink: /api/v1/namespaces/default/pods/test-8b59d5884-96vdz
  labels:
    app: test
    pod-template-hash: 8b59d5884
  annotations:
    kubernetes.io/extend-path-mode:
'[{"containername":"container-0","name":"vol-156738843032165499","mountpath":"/
tmp","extendpathmode":"PodUID"}]'
    metrics.alpha.kubernetes.io/custom-endpoints: '[{"api":"","path":"","port":"","names":""}]'
  ownerReferences:
    - apiVersion: apps/v1
      kind: ReplicaSet
```

```
    name: test-8b59d5884
    uid: 2633020b-cd23-11e9-8f83-fa163e592534
    controller: true
    blockOwnerDeletion: true
spec:
  volumes:
    - name: vol-156738843032165499
      hostPath:
        path: /tmp
        type: ''
    - name: default-token-4s959
      secret:
        secretName: default-token-4s959
        defaultMode: 420
  containers:
    - name: container-0
      image: 'nginx:latest'
      env:
        - name: PAAS_APP_NAME
          value: test
        - name: PAAS_NAMESPACE
          value: default
        - name: PAAS_PROJECT_ID
          value: b6315dd3d0ff4be5b31a963256794989
      resources:
        limits:
          cpu: 250m
          memory: 512Mi
        requests:
          cpu: 250m
          memory: 512Mi
      volumeMounts:
        - name: vol-156738843032165499
          mountPath: /tmp
          extendPathMode: PodUID
        - name: default-token-4s959
          readOnly: true
          mountPath: /var/run/secrets/kubernetes.io/serviceaccount
      terminationMessagePath: /dev/termination-log
      terminationMessagePolicy: File
      imagePullPolicy: Always
  restartPolicy: Always
  terminationGracePeriodSeconds: 30
  dnsPolicy: ClusterFirst
  serviceAccountName: default
  serviceAccount: default
  nodeName: 192.168.0.24
  securityContext: {}
  imagePullSecrets:
    - name: default-secret
    - name: default-secret
  affinity: {}
  schedulerName: default-scheduler
  tolerations:
    - key: node.kubernetes.io/not-ready
      operator: Exists
      effect: NoExecute
      tolerationSeconds: 300
    - key: node.kubernetes.io/unreachable
      operator: Exists
      effect: NoExecute
      tolerationSeconds: 300
  priority: 0
  dnsConfig:
    options:
      - name: timeout
        value: ''
      - name: ndots
        value: '5'
```

```
    - name: single-request-reopen
enableServiceLinks: true
```

Table 20-15 Descriptions of key parameters

Parameter	Type	Description
containername	String	Name of a container.
name	String	Name of a volume.
mountpath	String	Mount path.
extendpathmode	String	A third-level directory is added to the created volume directory/subdirectory to facilitate the obtaining of a single pod output file. The following types are supported. • **None**: The extended path is not configured. • **PodUID**: ID of a pod. • **PodName**: Name of a pod. • **PodUID/ContainerName**: ID of a pod or name of a container. • **PodName/ContainerName**: Name of a pod or container.

20.7.5 Can CCE PVCs Detect Underlying Storage Faults?

CCE PersistentVolumeClaims (PVCs) are implemented as they are in Kubernetes. A PVC is defined as a storage declaration and is decoupled from underlying storage. It is not responsible for detecting underlying storage details. Therefore, CCE PVCs cannot detect underlying storage faults.

Cloud Eye allows users to view cloud service metrics. These metrics are built-in based on cloud service attributes. After users enable a cloud service on the cloud platform, Cloud Eye automatically associates its built-in metrics. Users can track the cloud service status by monitoring these metrics.

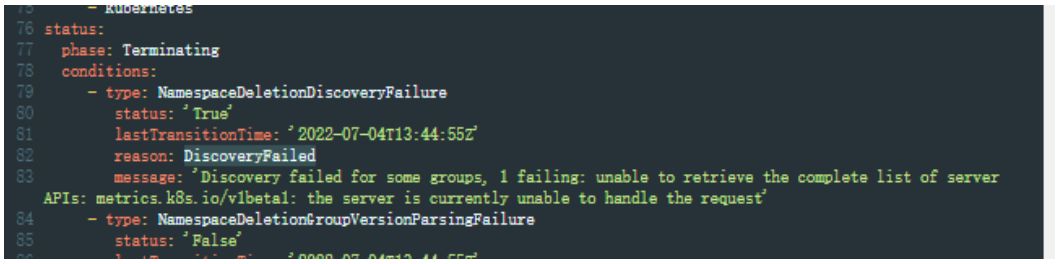
It is recommended that users who have storage fault detection requirements use Cloud Eye to monitor underlying storage and send alarm notifications.

20.8 Namespace

20.8.1 What Should I Do If a Namespace Fails to Be Deleted Due to an APIService Object Access Failure?

Symptom

The namespace remains in the Deleting state. The error message "DiscoveryFailed" is displayed in **status** in the YAML file.



In the preceding figure, the full error message is "Discovery failed for some groups, 1 failing: unable to retrieve the complete list of server APIs: metrics.k8s.io/v1beta1: the server is currently unable to handle the request".

This indicates that the namespace deletion is blocked when kube-apiserver accesses the APIService resource object of the metrics.k8s.io/v1beta1 API.

Possible Causes

If an APIService object exists in the cluster, deleting the namespace will first access the APIService object. If the access fails, the namespace deletion will be blocked. In addition to the APIService objects created by users, add-ons like metrics-server and prometheus in the CCE cluster automatically create APIService objects.

NOTE

For details, see https://kubernetes.io/docs/concepts/extend-kubernetes/api-extension/apiserver-aggregation/.

Solution

Use either of the following methods:

- Rectify the APIService object in the error message. If the object is created by an add-on, ensure that the pod where the add-on locates is running properly.
- Delete the APIService object in the error message. If the object is created by an add-on, uninstall the add-on.

20.9 Chart and Add-on

20.9.1 Why Does Add-on Installation Fail and Prompt "The release name is already exist"?

Symptom

When an add-on fails to be installed, the error message "The release name is already exist" is returned.

Possible Cause

The add-on release record remains in the Kubernetes cluster. Generally, it is because the cluster etcd has backed up and restored the add-on, or the add-on fails to be installed or deleted.

Solution

Use kubectl to connect to the cluster and manually clear the Secret and Configmap corresponding to add-on release. The following uses autoscaler add-on release as an example.

Step 1 Connect to the cluster using kubectl, and run the following command to view the Secret list of add-on releases:

kubectl get secret -A |grep cceaddon

```
[root@cce-123-vpc-node2 ~]# kubectl get secret -nkube-system |grep cceaddon
sh.helm.release.v1.cceaddon-autoscaler.v1       helm.sh/release.v1                    1      61s
sh.helm.release.v1.cceaddon-autoscaler.v2       helm.sh/release.v1                    1      47s
sh.helm.release.v1.cceaddon-coredns.v1          helm.sh/release.v1                    1      6h2m
sh.helm.release.v1.cceaddon-everest.v1          helm.sh/release.v1                    1      6h2m
[root@cce-123-vpc-node2 ~]#
```

The Secret name of an add-on release is in the format of **sh.helm.release.v1.cceaddon-{*add-on name*}.v***. If there are multiple release versions, you can delete their Secrets at the same time.

Step 2 Run the **release secret** command to delete the Secrets.

Example:

kubectl delete secret sh.helm.release.v1.cceaddon-autoscaler.v1 sh.helm.release.v1.cceaddon-autoscaler.v2 -nkube-system

```
[root@cce-123-vpc-node2 ~]# kubectl delete secret sh.helm.release.v1.cceaddon-autoscaler.v1 sh.helm.release.v1.cceaddon-autoscaler.v2 -nkube-system
secret "sh.helm.release.v1.cceaddon-autoscaler.v1" deleted
secret "sh.helm.release.v1.cceaddon-autoscaler.v2" deleted
[root@cce-123-vpc-node2 ~]#
```

Step 3 If the add-on is created when Helm v2 is used, CCE automatically bumps the v2 release in Configmaps to v3 release in Secrets when viewing the add-ons and their details. The v2 release in the original Configmap is not deleted. Run the following command to view the ConfigMap list of add-on releases:

kubectl get configmap -A | grep cceaddon

```
cluster-autoscaler-th-config            1      7d10h
[paas@192-168-0-64 ~]$ kubectl get configmap -nkube-system | grep cceaddon
cceaddon-autoscaler.v1                  1      7d10h
cceaddon-autoscaler.v2                  1      52m
cceaddon-coredns.v1                     1      14d
cceaddon-everest.v1                     1      14d
[paas@192-168-0-64 ~]$
```

The ConfigMap name of an add-on release is in the format of **cceaddon-{*add-on name*}.v***. If there are multiple release versions, you can delete their ConfigMaps at the same time.

Step 4 Run the **release configmap** command to delete the ConfigMaps.

Example:

kubectl delete configmap cceaddon-autoscaler.v1 cceaddon-autoscaler.v2 -nkube-system

```
[paas@192-168-0-64 ~]$ kubectl delete configmap cceaddon-autoscaler.v1 cceaddon-autoscaler.v2 -nkube-system
configmap "cceaddon-autoscaler.v1" deleted
configmap "cceaddon-autoscaler.v2" deleted
[paas@192-168-0-64 ~]$
```

CAUTION

Deleting resources in kube-system is a high-risk operation. Ensure that the command is correct before running it to prevent resources from being deleted by mistake.

Step 5 On the CCE console, install add-on and then uninstall it. Ensure that the residual add-on resources are cleared. After the uninstall is complete, install the add-on again.

NOTE

When installing the add-on for the first time, you may find it abnormal after the installation due to the residual resources of the previous add-on release, which is normal. In this case, you can uninstall the add-on on the console to ensure that the residual resources are cleared and the add-on can run properly after being installed again.

----End

20.9.2 How Do I Configure the Add-on Resource Quotas Based on Cluster Scale?

After changing the cluster scale, adjust the add-on resource quotas based on the cluster scale to ensure that the add-on pods can run properly. For example, if you expand the cluster scale from 50 worker nodes to 200 worker nodes or more, increase the CPU and memory quotas of the add-on pods to avoid exceptions such as OOM caused by too many nodes required for scheduling the add-on pods.

Configuring Resource Quotas for coredns

Queries per Second (QPS) of the coredns add-on is positively correlated with the CPU consumption. If the number of nodes or containers in the cluster grows, the coredns pod will bear heavier workloads. Adjust the number of the coredns pods and their CPU and memory quotas based on the cluster scale.

Table 20-16 Recommended values for coredns

Node	Recommended Configuration	Pod	CPU Request	CPU Limit	Memory Request	Memory Limit
50	2500 QPS	2	500m	500m	512Mi	512Mi
200	5000 QPS	2	1000m	1000m	1024Mi	1024Mi
1000	10,000 QPS	2	2000m	2000m	2048Mi	2048Mi
2,000	20,000 QPS	4	2000m	2000m	2048Mi	2048Mi

Configuring Resource Quotas for everest

After the cluster scale is adjusted, the everest specifications need to be modified based on the cluster scale and the number of PVCs. The requested CPU and memory can be increased based on the number of nodes and PVCs. For details, see **Table 20-17**.

In non-typical scenarios, the formulas for estimating the limit values are as follows:

- everest-csi-controller
  - CPU limit: 250m for 200 or fewer nodes, 350m for 1000 nodes, and 500m for 2000 nodes
  - Memory limit = (200 Mi + Number of nodes x 1 Mi + Number of PVCs x 0.2 Mi) x 1.2
- everest-csi-driver
  - CPU limit: 300m for 200 or fewer nodes, 500m for 1000 nodes, and 800m for 2000 nodes
  - Memory limit: 300 Mi for 200 or fewer nodes, 600 Mi for 1000 nodes, and 900 Mi for 2000 nodes

Table 20-17 Recommended configuration limits in typical scenarios

Configuration Scenario			everest-csi-controller		everest-csi-driver	
Nodes	PVs/PVCs	Add-on Instances	vCPUs (Limit = Requested)	Memory (Limit = Requested)	vCPUs (Limit = Requested)	Memory (Limit = Requested)
50	1000	2	250m	600 MiB	300m	300 MiB
200	1000	2	250m	1 GiB	300m	300 MiB
1000	1000	2	350m	2 GiB	500m	600 MiB

Configuration Scenario			everest-csi-controller		everest-csi-driver	
1000	5000	2	450m	3 GiB	500m	600 MiB
2000	5000	2	550m	4 GiB	800m	900 MiB
2000	10000	2	650m	5 GiB	800m	900 MiB

Configuring Resource Quotas for autoscaler

autoscaler automatically adjusts the number of nodes in a cluster based on workloads. Adjust the number of add-on pods and their CPU and memory quotas based on the cluster scale.

Table 20-18 Recommended values for autoscaler

Node	Pod	CPU Request	CPU Limit	Memory Request	Memory Limit
50	2	1000m	1000m	1000Mi	1000Mi
200	2	4000m	4000m	2000Mi	2000Mi
1,000	2	8000m	8000m	8000Mi	8000Mi
2,000	2	8000m	8000m	8000Mi	8000Mi

Configuring Resource Quotas for volcano

After the cluster scale is increased, the resource quotas required by volcano need to be modified based on the cluster scale.

- If the number of nodes is less than 100, retain the default configuration. The requested CPU is 500 m, and the limit is 2000 m. The requested memory is 500 MiB, and the limit is 2000 MiB.
- If the number of nodes is greater than 100, increase the requested CPU by 500 m and the requested memory by 1000 MiB each time 100 nodes (10,000 pods) are added. Increase the CPU limit by 1500 m and the memory limit by 1000 MiB.

NOTE

Formulas for calculating the requests:

- CPU request: Calculate the number of nodes multiplied by the number of pods, perform interpolation search using the product of the number of nodes in the cluster multiplied by the number of pods in **Table 20-19**, and round up the request and limit that are closest to the specifications.

  For example, for 2000 nodes (20,000 pods), the product of the number of nodes multiplied by the number of pods is 40 million, which is close to 700/70,000 in the specification (Number of nodes x Number of pods = 49 million). Set the CPU request to 4000 m and the limit to 5500 m.

- Memory request: Allocate 2.4 GiB of memory to every 1000 nodes and 1 GiB of memory to every 10,000 pods. The memory request is the sum of the two values. (The obtained value may be different from the recommended value in **Table 20-19**. You can use either of them.)

  Memory request = Number of nodes/1000 x 2.4 GiB + Number of pods/10000 x 1 GiB

  For example, for 2000 nodes and 20,000 pods, the memory request value is 6.8 GiB (2000/1000 x 2.4 GiB + 20000/10000 x 1 GiB).

Table 20-19 Recommended values for volcano-controller and volcano-scheduler

Nodes/Pods in a Cluster	Requested vCPUs (m)	vCPU Limit (m)	Requested Memory (MiB)	Memory Limit (MiB)
50/5000	500	2000	500	2000
100/10,000	1000	2500	1500	2500
200/20,000	1500	3000	2500	3500
300/30,000	2000	3500	3500	4500
400/40,000	2500	4000	4500	5500
500/50,000	3000	4500	5500	6500
600/60,000	3500	5000	6500	7500
700/70,000	4000	5500	7500	8500

Configuring Resource Quotas for Other Add-ons

Resource quotas of other add-ons may also be insufficient due to cluster scale expansion. If, for example, the CPU or memory usage of the add-on pods increases and even OOM occurs, modify the resource quotas as required.

For example, the resources occupied by the kube-prometheus-stack add-ons are related to the number of pods in the cluster. If the cluster scale is expanded, the number of pods may also grow. In this case, increase the resource quotas of the prometheus pods.

20.10 API & kubectl FAQs

20.10.1 How Can I Access a Cluster API Server?

You can use either of the following methods to access a cluster API server:

- (Recommended) Through the cluster API. This access mode uses certificate authentication. It is suitable for API calls on scale thanks to its direct connection to the API Server. This is a recommended option.
- API Gateway. This access mode uses token authentication. You need to obtain a toke using your account. This access mode applies to small-scale API calls. API gateway flow control may be triggered when APIs are called on scale.

20.10.2 Can the Resources Created Using APIs or kubectl Be Displayed on the CCE Console?

The CCE console does not support the display of the following Kubernetes resources: DaemonSets, ReplicationControllers, ReplicaSets, and endpoints.

To query these resources, run the kubectl commands.

In addition, Deployments, StatefulSets, Services, and pods can be displayed on the console only when the following conditions are met:

- Deployments and StatefulSets: At least one label uses **app** as its key.
- Pods: Pods are displayed on the **Pods** tab page in the workload details only after a Deployment or StatefulSet has been created.
- Services: Services are displayed on the **Access Mode** tab page in the Deployment or StatefulSet details.

  The Services displayed on this tab page are associated with the workload.

  a. At lease one label of the workload uses **app** as its key.
  b. The label of a Service is the same as that of the workload.

20.10.3 How Do I Download kubeconfig for Connecting to a Cluster Using kubectl?

Step 1 Log in to the CCE console. Click the target cluster to go to its details page.

Step 2 In the **Connection Information** area, view the kubectl connection mode.

Step 3 In the window that is displayed, download the kubectl configuration file (**kubeconfig.json**).

----End

20.10.4 How Do I Rectify the Error Reported When Running the kubectl top node Command?

Symptom

The error message "Error from server (ServiceUnavailable): the server is currently unable to handle the request (get nodes.metrics.k8s.io)" is displayed after the **kubectl top node** command is executed.

Possible Causes

"Error from server (ServiceUnavailable)" indicates that the cluster is not connected. In this case, you need to check whether the network between kubectl and the master node in the cluster is normal.

Solution

- If the kubectl command is executed outside the cluster, check whether the cluster is bound to an EIP. If yes, download the **kubeconfig** file and run the kubectl command again.
- If the kubectl command is executed on a node in the cluster, check the security group of the node and check whether the TCP/UDP communication between the worker node and master node is allowed. For details about the security group, see **How Can I Configure a Security Group Rule in a Cluster?**.

20.10.5 Why Is "Error from server (Forbidden)" Displayed When I Use kubectl?

Symptom

When you use kubectl to create or query Kubernetes resources, the following output is returned:

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"

Possible Cause

This user has no permissions to operate Kubernetes resources.

Solution

Assign permissions to the user.

Step 1 Log in to the CCE console. In the navigation pane, choose **Permissions**.

Step 2 Select a cluster for which you want to add permissions from the drop-down list on the right.

Step 3 Click **Add Permissions** in the upper right corner.

Step 4 Confirm the cluster name and select the namespace to assign permissions for. For example, select **All namespaces**, the target user or user group, and select the permissions.

NOTE

If you do not have IAM permissions, you cannot select users or user groups when configuring permissions for other users or user groups. In this case, you can enter a user ID or user group ID.

Permissions can be customized as required. After selecting **Custom** for **Permission Type**, click **Add Custom Role** on the right of the **Custom** parameter. In the dialog box displayed, enter a name and select a rule. After the custom rule is created, you can select a value from the **Custom** drop-down list box.

Custom permissions 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**.

- A ClusterRole is a cluster-level resource that can be used to configure cluster access permissions.
- A Role is used to configure access permissions in a namespace. When creating a Role, specify the namespace to which the Role belongs.

Step 5 Click **OK**.

----End

20.11 DNS FAQs

20.11.1 What Should I Do If Domain Name Resolution Fails?

Check Item 1: Whether the coredns Add-on Has Been Installed

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** and check whether the CoreDNS add-on has been installed.

Step 3 If not, install the add-on. For details, see **Why Does a Container in a CCE Cluster Fail to Perform DNS Resolution?**.

----End

Check Item 2: Whether the coredns Instance Reaches the Performance Limit

CoreDNS QPS is positively correlated with the CPU usage. If the QPS is high, adjust the the coredns instance specifications based on the QPS.

Step 1 Log in to the CCE console and click the cluster name to access the cluster console.

Step 2 In the navigation tree, choose **Add-ons** and verify that CoreDNS is running.

Step 3 Click the coredns add-on name to view the add-on list.

Step 4 Click **Monitor** of the the coredns add-on to view the CPU and memory usage.

If the add-on performance reaches the bottleneck, adjust the coredns add-on specifications.

----End

Check Item 3: Whether the External Domain Name Resolution Is Slow or Times Out

If the domain name resolution failure rate is lower than 1/10000, optimize parameters by referring to **How Do I Optimize the Configuration If the External Domain Name Resolution Is Slow or Times Out?** or add a retry policy in the service.

Check Item 4: Whether UnknownHostException Occurs

When service requests in the cluster are sent to an external DNS server, a domain name resolution error occurs due to occasional UnknownHostException. UnknownHostException is a common exception. When this exception occurs, check whether there is any domain name-related error or whether you have entered a correct domain name.

To locate the fault, perform the following steps:

Step 1 Check the host name carefully (spelling and extra spaces).

Step 2 Check the DNS settings. Before running the application, run the **ping hostname** command to ensure that the DNS server has been started and running. If the host name is new, you need to wait for a period of time before the DNS server is accessed.

Step 3 Check the CPU and memory usage of the coredns add-on to determine whether the performance bottleneck has been reached. For details, see **Check Item 2: Whether the coredns Instance Reaches the Performance Limit**.

Step 4 Check whether traffic limiting is performed on the coredns add-on. If traffic limiting is triggered, the processing time of some requests may be prolonged. In this case, you need to adjust the coredns add-on specifications.

Log in to the node where the coredns add-on is installed and view the following content:

```
cat /sys/fs/cgroup/cpu/kubepods/pod<pod_uid>/<coredns container ID>/cpu.stat
```

- *<pod uid>* indicates the pod UID of the coredns add-on, which can be obtained by running the following command:

  ```
  kubectl get po <pod name> -nkube-system -ojsonpath='{.metadata.uid}{"\n"}'
  ```

  In the preceding command, *<pod name>* indicates the name of the coredns add-on running on the current node.

- *<coredns container ID>* must be a complete container ID, which can be obtained by running the following command:

  Docker nodes:

  ```
  docker ps --no-trunc | grep k8s_coredns | awk '{print $1}'
  ```

  containerd nodes:

  ```
  crictl ps --no-trunc | grep k8s_coredns | awk '{print $1}'
  ```

Example:

```
cat /sys/fs/cgroup/cpu/kubepods/
pod27f58662-3979-448e-8f57-09b62bd24ea6/6aa98c323f43d689ac47190bc84cf4fadd23bd8dd25307f773df25003ef0eef0/cpu.stat
```

Pay attention to the following metrics:

- **nr_throttled**: number of times that traffic is limited.
- **throttled_time**: total duration of traffic limiting, in nanoseconds.

----End

If the host name and DNS settings are correct, you can use the following optimization policies.

Optimization policies:

1. Change the coredns cache time.
2. Configure the stub domain.
3. Modify the value of **ndots**.

NOTE

- **Increasing the cache time of coredns** helps resolve the same domain name for the N time, reducing the number of cascading DNS requests.
- **Configuring the stub domain** can reduce the number of DNS request links.

How to modify:

1. Modifying the coredns cache time and configuring the stub domain:

   Restart the coredns add-on after you modify the configurations.
2. Modifying **ndots**:

   How Do I Optimize the Configuration If the External Domain Name Resolution Is Slow or Times Out?

   Example:

   ```
   dnsConfig:
     options:
       - name: timeout
         value: '2'
       - name: ndots
         value: '5'
       - name: single-request-reopen
   ```

   You are advised to change the value of **ndots** to **2**.

20.11.2 Why Does a Container in a CCE Cluster Fail to Perform DNS Resolution?

Symptom

A customer bound its domain name to the private domain names in the DNS service and also to a specific VPC. It is found that the ECSs in the VPC can properly resolve the private domain name but the containers in the VPC cannot.

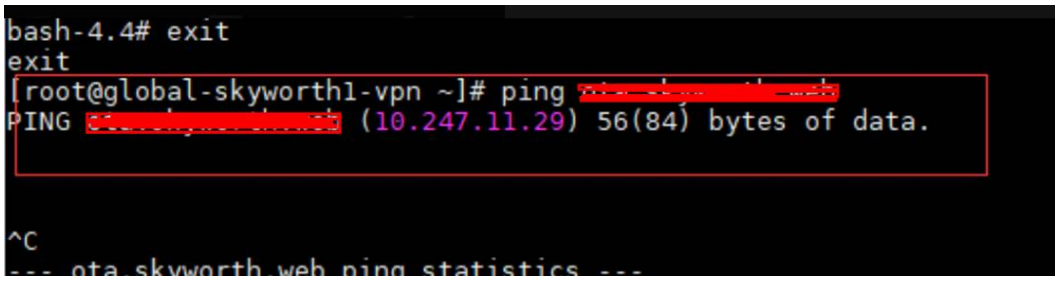
Application Scenario

Containers in a VPC cannot resolve domain names.

Solution

According to the resolution rules of private domain names, the subnet DNS in the VPC must be set to the cloud DNS. You can find the details of the private network DNS service on its console.

The customer can perform domain name resolution on the ECSs in the VPC subnet, which indicates that the preceding configuration has been completed in the subnet.



However, when the domain name resolution is performed in a container, the message "bad address" is displayed, indicating that the domain name cannot be resolved.

Log in to the CCE console and check the add-ons installed in the cluster.

If you find that the coredns add-on does not exist in **Add-ons Installed**, the coredns add-on may have been incorrectly uninstalled.

Install it and add the corresponding domain name and DNS service address to resolve the domain name.

20.11.3 How Do I Optimize the Configuration If the External Domain Name Resolution Is Slow or Times Out?

The following is an example **resolv.conf** file for a container in a workload:

In the preceding information:

- **nameserver**: IP address of the DNS. Set this parameter to the cluster IP address of CoreDNS.

- **search**: domain name search list, which is a common suffix of Kubernetes.
- **ndots**: If the number of dots (.) is less than the domain name, **search** is preferentially used for resolution.
- **timeout**: timeout interval.
- **single-request-reopen**: indicates that different source ports are used to send different types of requests.

By default, when you create a workload on the CCE console, the preceding parameters are configured as follows:

```
dnsConfig:
  options:
    - name: timeout
      value: '2'
    - name: ndots
      value: '5'
    - name: single-request-reopen
```

These parameters can be optimized or modified based on service requirements.

Scenario 1: Slow External Domain Name Resolution

Optimization Solution

1. If the workload does not need to access the Kubernetes Service in the cluster, see **How Do I Configure a DNS Policy for a Container?**.
2. If the number of dots (.) in the domain name used by the working Service to access other Kubernetes Services is less than 2, set **ndots** to **2**.

Scenario 2: External Domain Name Resolution Timeout

Optimization Solution

1. Generally, the timeout of a Service must be greater than the value of **timeout** multiplied by **attempts**.
2. If it takes more than 2s to resolve the domain name, you can set **timeout** to a larger value.

20.11.4 How Do I Configure a DNS Policy for a Container?

CCE uses **dnsPolicy** to identify different DNS policies for each pod. The value of **dnsPolicy** can be either of the following:

- **None:** No DNS policy is configured. In this mode, you can customize the DNS configuration, and **dnsPolicy** needs to be used together with **dnsConfig** to customize the DNS.
- **Default**: The pod inherits the name resolution configuration from the node where the pod is running. The container's DNS configuration file is the DNS configuration file that the kubelet's **--resolv-conf** flag points to. In this case, a cloud DNS is used for CCE clusters.
- **ClusterFirst:** In this mode, the DNS in the pod uses the DNS service configured in the cluster. That is, the kube-dns or CoreDNS service in the Kubernetes is used for domain name resolution. If the resolution fails, the DNS configuration of the host machine is used for resolution.

If the type of dnsPolicy is not specified, **ClusterFirst** is used by default.

- If the type of dnsPolicy is set to **Default**, the name resolution configuration is inherited from the worker node where the pod is running.
- If the type of dnsPolicy is set to **ClusterFirst**, DNS queries will be sent to the kube-dns service.

  The kube-dns service responds to queries on the domains that use the configured cluster domain suffix as the root. All other queries (for example, www.kubernetes.io) are forwarded to the upstream name server inherited from the node. Before this feature was supported, stub domains were typically introduced by a custom resolver, instead of the upstream DNS. However, this causes the custom resolver itself to be the key path to DNS resolution, where scalability and availability issues can make the DNS functions unavailable to the cluster. This feature allows you to introduce custom resolvers without taking over the entire resolution path.

If a workload does not need to use CoreDNS in the cluster, you can use kubectl or call the APIs to set the dnsPolicy to Default.

20.12 Image Repository FAQs

20.12.1 How Do I Upload My Images to CCE?

SoftWare Repository for Container (SWR) manages images for CCE. It provides the following ways to upload images:

- **Uploading an Image Through the Client**
- **Uploading an Image Through the SWR Console**

20.13 Permissions

20.13.1 Can I Configure Only Namespace Permissions Without Cluster Management Permissions?

Namespace permissions and cluster management permissions are independent and complementary to each other.

- Namespace permissions: apply to clusters and are used to manage operations on cluster resources (such as creating workloads).
- Cluster management (IAM) permissions: apply to cloud services and used to manage CCE clusters and peripheral resources (such as VPC, ELB, and ECS).

Administrators of the IAM Admin user group can grant cluster management permissions (such as CCE Administrator and CCE FullAccess) to IAM users or grant namespace permissions on a cluster on the CCE console. However, the permissions you have on the CCE console are determined by the IAM system policy. If the cluster management permissions are not configured, you do not have the permissions for accessing the CCE console.

If you only run kubectl commands to work on cluster resources, you only need to obtain the kubeconfig file with the namespace permissions. For details, see **Can I**

Use kubectl If the Cluster Management Permissions Are Not Configured?. Note that information leakage may occur when you use the kubeconfig file.

20.13.2 Can I Use CCE APIs If the Cluster Management Permissions Are Not Configured?

CCE has cloud service APIs and cluster APIs.

- Cloud service APIs: You can perform operations on the infrastructure (such as creating nodes) and cluster resources (such as creating workloads).

  When using cloud service APIs, the cluster management (IAM) permissions must be configured.

- Cluster APIs: You can perform operations on cluster resources (such as creating workloads) through the Kubernetes native API server, but not on cloud infrastructure resources (such as creating nodes).

  When using cluster APIs, you only need to add the cluster certificate. Only the users with the cluster management (IAM) permissions can download the cluster certificate. Note that information leakage may occur during certificate transmission.

20.13.3 Can I Use kubectl If the Cluster Management Permissions Are Not Configured?

IAM authentication is not required for running kubectl commands. Therefore, you can run kubectl commands without configuring cluster management (IAM) permissions. However, you need to obtain the kubectl configuration file (kubeconfig) with the namespace permissions. In the following scenarios, information leakage may occur during file transmission.

- Scenario 1

  If an IAM user has been configured with the cluster management permissions and namespace permissions, downloads the kubeconfig authentication file and then deletes the cluster management permissions (reserving the namespace permissions), kubectl can still be used to perform operations on Kubernetes clusters. Therefore, if you want to permanently delete the permission of a user, you must also delete the cluster management permissions and namespace permissions of the user.

- Scenario 2

  An IAM user has certain cluster management and namespace permissions and downloads the kubeconfig authentication file. In this case, CCE determines which Kubernetes resources can be accessed by kubectl based on the user information. That is, the authentication information of a user is recorded in kubeconfig. Anyone can use kubeconfig to access the cluster.

20.14 Reference

20.14.1 How Do I Expand the Storage Capacity of a Container?

Application Scenarios

The default storage size of a container is 10 GB. If a large volume of data is generated in the container, expand the capacity using the method described in this topic.

Solution

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 unavailable the node-specific resources (such as local storage and workloads scheduled to this node). Exercise caution when performing this operation to avoid impact on running services.

Step 4 Click **Yes**.

Step 5 Reconfigure node parameters.

If you need to adjust the container storage space, pay attention to the following configurations:

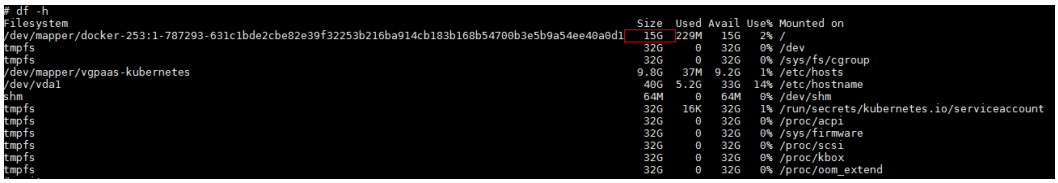
Storage Settings: Click **Expand** next to the data disk to set the following parameters:

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 details, see **Data Disk Space Allocation**.

Step 6 After the node is reset, log in to the node and run the following command to access the container and check whether the container storage capacity has been expanded:

docker exec -it *container_id* **/bin/sh** or **kubectl exec -it** *container_id* **/bin/sh**

df -h



----End

20.14.2 How Can Container IP Addresses Survive a Container Restart?

If Containers Will Run in a Single-Node Cluster

Add **hostNetwork: true** to the **spec.spec.** in the YAML file of the workload to which the containers will belong.

If Containers Will Run in a Multi-Node Cluster

Configure node affinity policies, in addition to perform the operations described in "If the Container Runs in a Single-Node Cluster". However, after the workload is created, the number of running pods cannot exceed the number of affinity nodes.

Expected Result

After the previous settings are complete and the workload is running, the IP addresses of the workload's pods are the same as the node IP addresses. After the workload is restarted, these IP addresses will keep unchanged.