

Cloud Container Engine

User Guide

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1 Service Overview

1.1 What Is CCE?

Cloud Container Engine (CCE) is a Kubernetes cluster hosting service for enterprises. It offers complete lifecycle management for containerized applications and delivers scalable, high-performance solutions for deploying and managing cloud-native apps.

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 (DR) ensures high availability (HA) of **Kubernetes** clusters.

For more information, see [Product Advantages](#) and [Application Scenarios](#).

CCE Cluster Types

There are multiple CCE products.

Category	Subcategory	CCE Standard
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

Category	Subcategory	CCE Standard
Specification difference	Network model	Cloud native 1.0 networks: for scenarios where requirements on performance are not high and there are not so many containers <ul style="list-style-type: none"> • Tunnel network • Virtual Private Cloud (VPC) network
	Network performance	The container network is overlaid with the VPC network, causing certain performance loss.
	Network isolation	<ul style="list-style-type: none"> • Tunnel network model: network policies supported for communications within a cluster • VPC network model: isolation not supported
	Security isolation	cgroups are used to isolate common containers.

1.2 Product Advantages

Why CCE?

CCE is a container service developed on Docker and Kubernetes. It offers a wide range of features that allow you to run containers on a large scale. CCE containers are highly reliable, have high-performance, and compatible with open-source communities, making them an ideal choice for enterprise needs.

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.

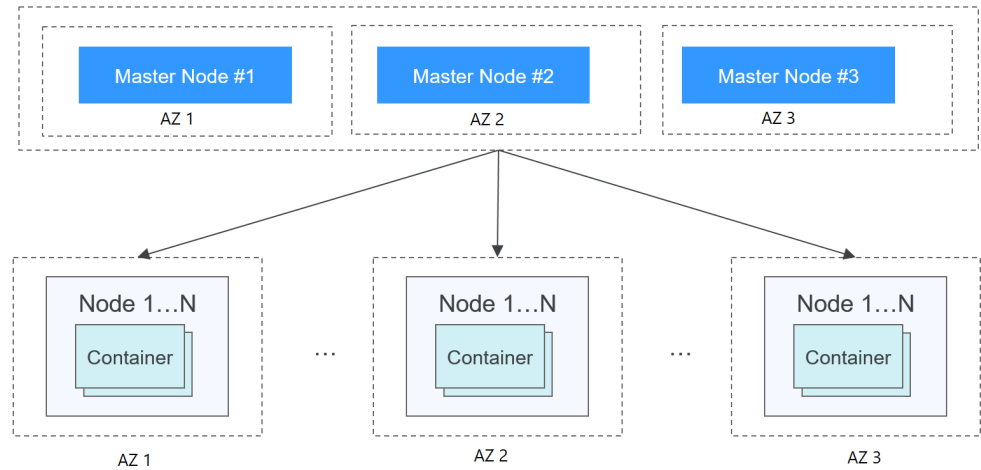
High Performance

- 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 management 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.	<p>Easy to manage and use clusters</p> <p>You can create and update a Kubernetes container cluster in a few clicks. There is no need to set up Docker or Kubernetes environments. CCE automates deployment and O&M of containerized applications throughout their lifecycle.</p> <p>CCE supports turnkey Helm charts.</p> <p>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.</p>
Scalability	You have to assess service loads and cluster health before resizing a Kubernetes cluster.	<p>Managed scaling service</p> <p>CCE auto scales clusters and workloads according to resource metrics and scaling policies.</p>
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.	<p>Enterprise-class security and reliability</p> <p>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.</p>
Efficiency	You have to either build an image repository or turn to a third-party one. Images are pulled in serial.	<p>Rapid deployment with images</p> <p>CCE connects to SWR to pull images in parallel. Faster pulls, faster container build.</p>

Why Containers?

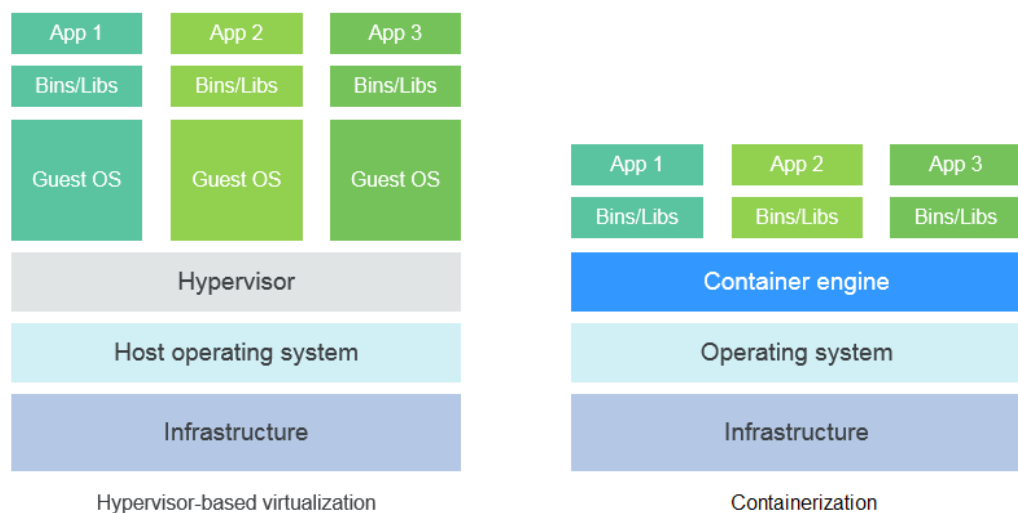
Docker is written in the Go language designed by Google. It provides operating-system-level virtualization. Linux Control Groups (cgroups), namespaces, and

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 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

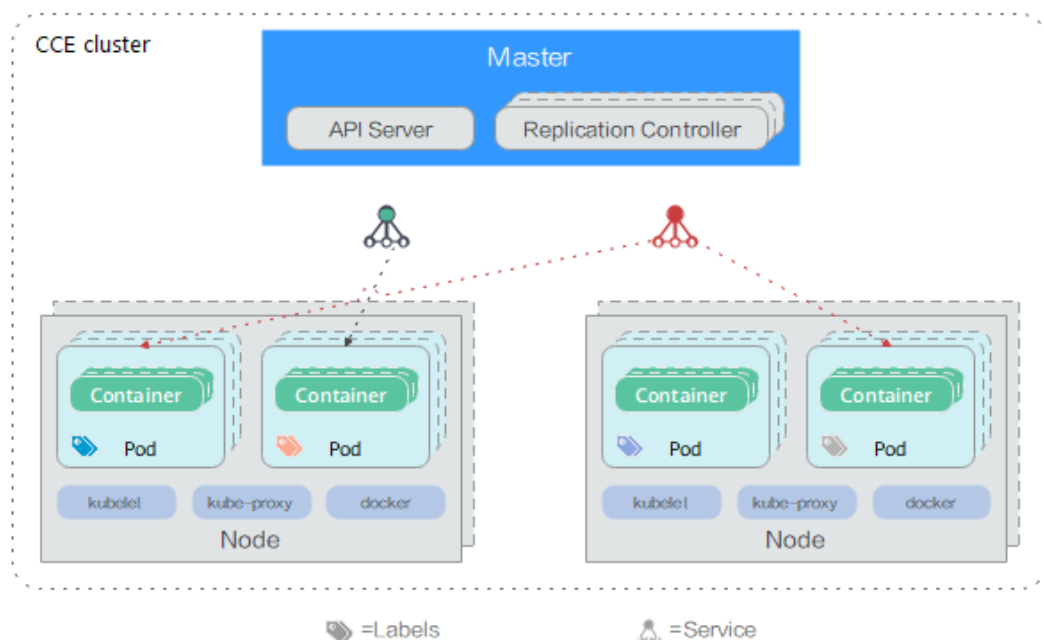
1.3.1 Containerized Application Management

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



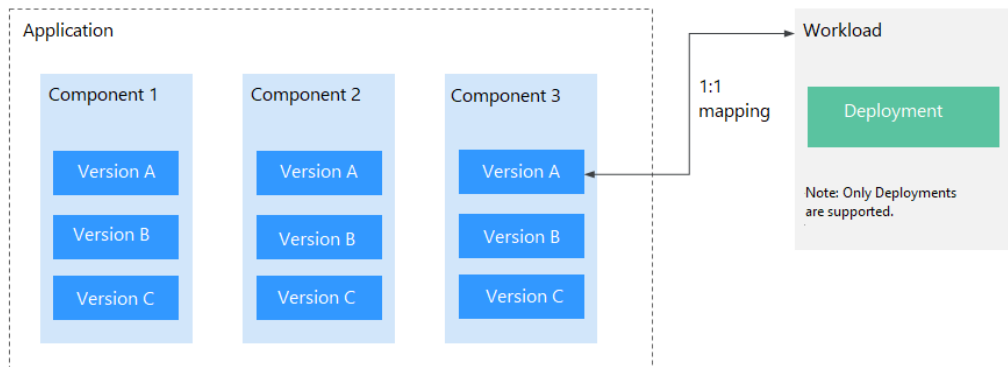
Benefits

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

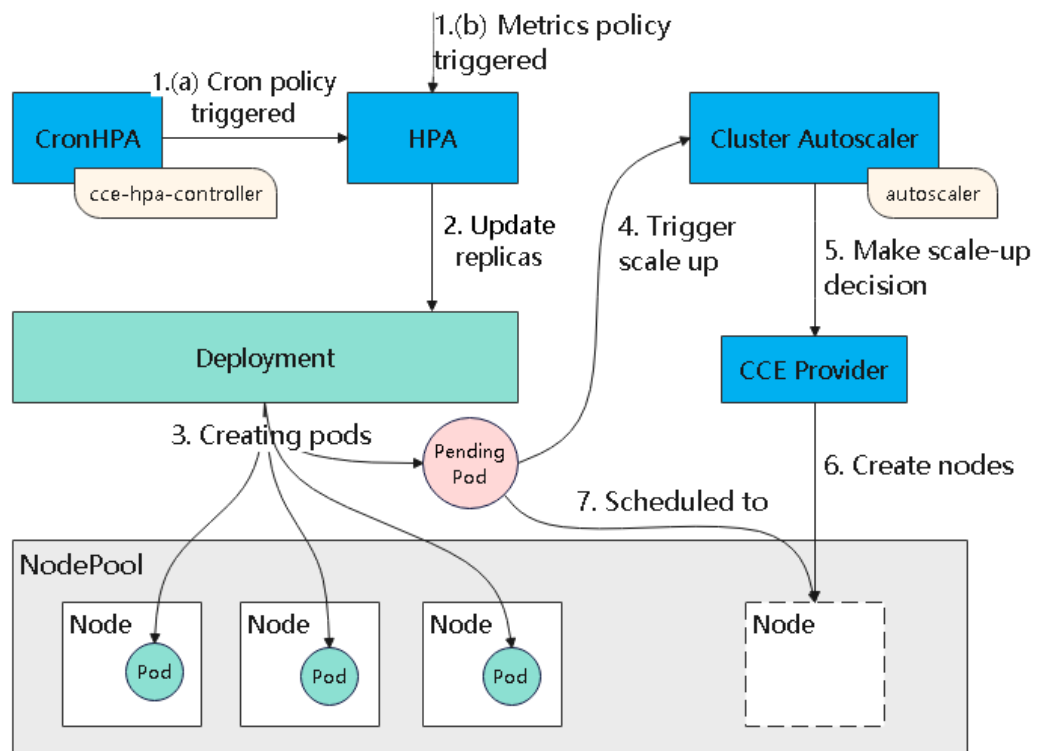
- Flexible
Allows diverse types of scaling policies and scales containers within seconds once triggered.
- Highly available
Monitors pod running and replaces unhealthy pods with new ones.

Related Services

Add-ons: autoscaler and cce-hpa-controller

- Auto scaling for workloads: CronHPA (CronHorizontalPodAutoscaler) + 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.

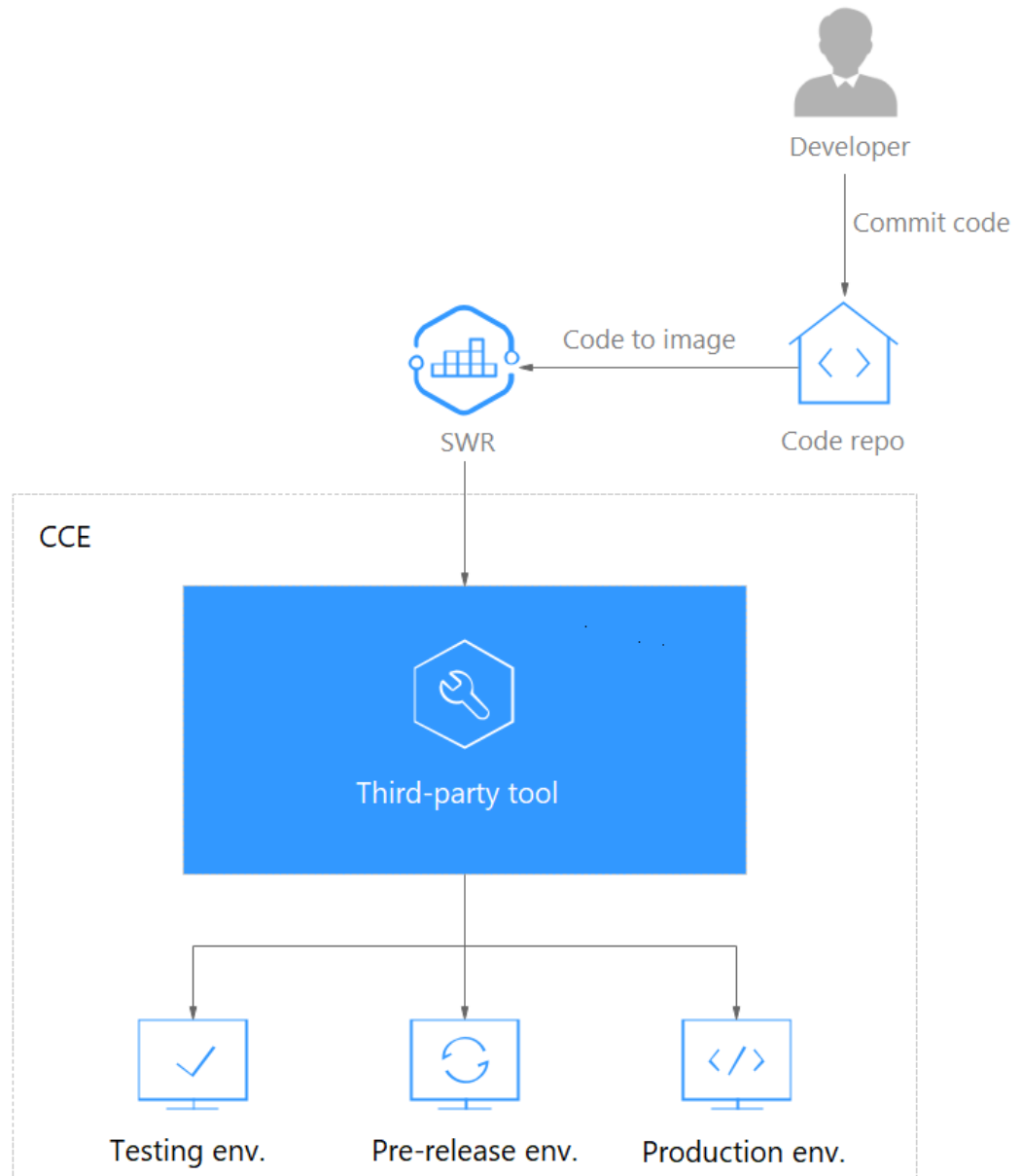
Advantages

- 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. 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.

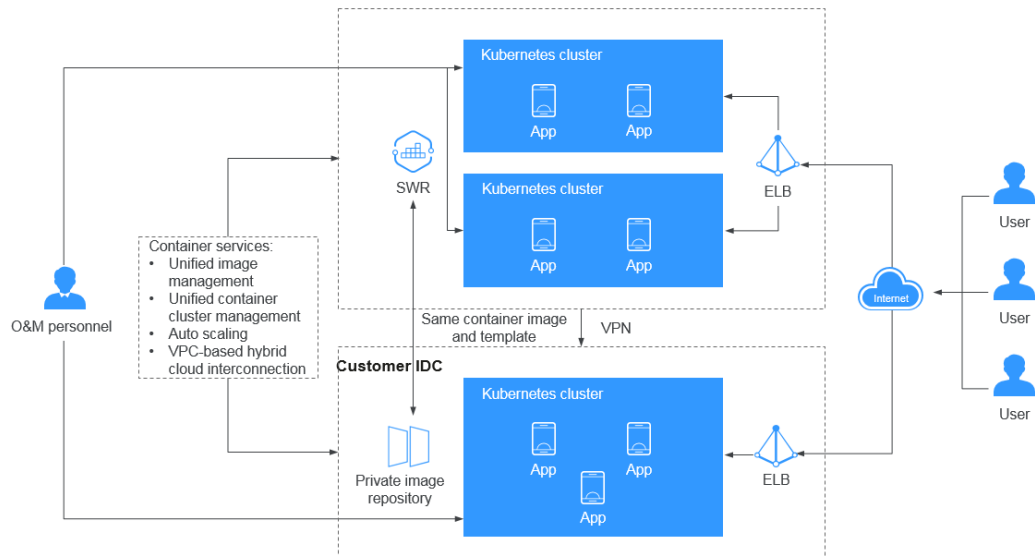
Advantages

- 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 can quickly be scaled out to handle traffic bursts. Manual operations are no longer needed and you can save big.

Related Services

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

Figure 1-7 How hybrid cloud works



1.4 Notes and 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 \geq 2 cores, memory \geq 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: Only the following OSs and cluster versions support egress rules.

OS	Cluster Version	Verified Kernel Version
CentOS	v1.23 or later	3.10.0-1062.18.1.el7.x86_64 3.10.0-1127.19.1.el7.x86_64 3.10.0-1160.25.1.el7.x86_64
EulerOS 2.5	v1.23 or later	3.10.0-862.14.1.5.h591.eulerosv2r7.x86_64 3.10.0-862.14.1.5.h687.eulerosv2r7.x86_64
EulerOS 2.9	v1.23 or later	4.18.0-147.5.1.6.h541.eulerosv2r9.x86_64 4.18.0-147.5.1.6.h766.eulerosv2r9.x86_64 4.18.0-147.5.1.6.h998.eulerosv2r9.x86_64 4.18.0-147.5.1.6.h1305.eulerosv2r9.x86_64

- Network isolation is not supported for IPv6 addresses.
- If upgrade to a cluster version that supports egress rules is performed in in-place mode, you cannot use egress rules because the node OS is not upgraded. In this case, reset the node.

Storage Volumes

- Constraints on using 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 attached to multiple nodes, I/O conflicts and data cache conflicts may occur. Therefore, select 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.
- Constraints on using SFS volumes:

- Multiple PVs can use the same SFS or SFS Turbo file system with the following restrictions:
 - Do not mount the PVCs/PVs that use the same underlying SFS or SFS Turbo volume to one pod. This will lead to a pod startup failure because not all PVCs can be mounted to the pod due to the same **volumeHandle** value.
 - 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 using OBS volumes:
 - If OBS volumes are used, the owner group and permission of the mount point cannot be modified.
 - Every time an OBS volume is mounted to a workload through a PVC, a resident process is created in the backend. When a workload uses too many OBS volumes or reads and writes a large number of object storage files, resident processes will consume a significant amount of memory. To ensure stable running of the workload, make sure that the number of OBS volumes used does not exceed the requested memory. For example, if the workload requests for 4 GiB of memory, the number of OBS volumes should be **no more than 4**.
 - Hard links are not supported when common buckets are mounted.
- Constraints on using 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.
 - Removing, deleting, 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 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.
 - 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 using 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 using 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 checked or configured.
 - 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.
 - A PVC of the `xfs` file system type can generate snapshots. The file system of the disk associated with the PVC created using these snapshots remains `xfs`.

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

Cluster Capacity Limit

The capacity of a cluster is made up of various resource types, including container groups (pods), cloud storage instances (persistent volumes), and Services. Additionally, the size of these resource objects can also impact the cluster capacity.

For example:

- If there are too many pods, the maximum number of pods will decrease within a certain performance range.
- As the number of pods approaches the upper limit, the upper limits of other resource types in the cluster will also decrease accordingly.

Since clusters in actual application environments contain multiple resource types, it is possible that the number of resources for a single type may not reach its upper limit. It is important to monitor cluster usage regularly and plan and manage the cluster effectively to ensure the best performance of all resources. If the current specifications do not meet your requirements, you can scale out the cluster to ensure stability.

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
	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

Category	Item	Constraints on Common Users
	Load balancer backend host group	500
	Load balancer backend server	500

1.5 Billing

Billing Items

CCE is free of charge. You only pay for the resources (such as nodes) created when you are using CCE. There are two types of billing items:

1. **Clusters:** the cost of resources used by master nodes, varying depending on the cluster type and size. Cluster types include VM cluster and BMS cluster (the number of master nodes determines whether a cluster is highly available). Cluster size (also called management scale) indicates the maximum number of nodes allowed in a cluster.

 **NOTE**

The management scale indicates the number of ECSs or BMSs in a cluster.

2. **IaaS resource costs** are incurred from the IaaS resources you use to run worker nodes in your cluster. These resources, created either manually or automatically, include ECSs, EVS disks, EIPs, bandwidth, and load balancers.

Billing Modes

CCE is billed on a pay-per-use basis.

- **Pay-per-use:** It is a pay-after-use mode. Billing starts when a resource is provisioned and stops when the resource is deleted. You can use cloud resources as required and stop paying for them when you no longer need them. There is no upfront payment for excess capacity.

 **NOTE**

The following are pricing principles in the case of CCE cluster hibernation or node shutdown. Note that there are many types of cluster nodes and ECS is used as an example.

- **Cluster hibernation:** For a hibernated cluster, you will not be billed for resources on the master nodes, but the resources used by or bound to the cluster, such as the EVS disks, EIPs, and bandwidth, will be billed in their own ways such as pay-per-use.
- **Node shutdown:** Hibernating a cluster will not stop worker nodes in the cluster. You can select **Stop all nodes in the cluster** to do so. You can also stop a node on the ECS console after hibernating a cluster..

NOTICE

- Clusters follow a tiered pricing plan. Pricing for each tier varies with cluster size and type.
- Once a pay-per-use resource becomes in arrears, provides a grace period and a retention period during which you can top up your account or renew resources. Within the grace period, you can still access and use your cloud service.

1.6 Permissions

CCE permissions management 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.

- **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)

New IAM users do not have any permissions assigned by default. You need to first add them to one or more groups and then attach policies or roles to these groups. The users then inherit permissions from the groups and can perform specified operations on cloud services based on the permissions they have been assigned.

CCE is a project-level service deployed for specific 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 the authorized region.

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-defined permissions for CCE.

Table 1-3 System-defined permissions for CCE

Role/ Policy Name	Description	Type	Dependencies
CCE Administrator	Read and write permissions for CCE clusters and all resources (including workloads, nodes, jobs, and Services) in the clusters	System-defined roles	<p>Users granted permissions of this policy must also be granted permissions of the following policies:</p> <p>Global service project: OBS Buckets Viewer and OBS Administrator</p> <p>Region-specific projects: Tenant Guest, Server Administrator, ELB Administrator, SFS Administrator, SWR Admin, and APM FullAccess</p> <p>NOTE</p> <ul style="list-style-type: none"> • 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	Dependencies
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 system-defined permissions

Operation	CCE ReadOnlyAccess	CCE FullAccess	CCE Administrator
Creating a cluster	Not supported	Supported	Supported
Deleting a cluster	Not supported	Supported	Supported
Updating a cluster, for example, updating cluster node scheduling parameters and providing RBAC support to clusters	Not supported	Supported	Supported
Upgrading a cluster	Not supported	Supported	Supported
Waking up a cluster	Not supported	Supported	Supported
Hibernating a cluster	Not supported	Supported	Supported
Listing all clusters	Supported	Supported	Supported
Querying cluster details	Supported	Supported	Supported
Adding a node	Not supported	Supported	Supported
Deleting one or more nodes	Not supported	Supported	Supported
Updating a node. For example, changing the node name.	Not supported	Supported	Supported
Querying node details	Supported	Supported	Supported
Listing all nodes	Supported	Supported	Supported
Listing all jobs	Supported	Supported	Supported

Operation	CCE ReadOnlyAccess	CCE FullAccess	CCE Administrator
Deleting one or more cluster jobs	Not supported	Supported	Supported
Querying job details	Supported	Supported	Supported
Creating a storage volume	Not supported	Supported	Supported
Deleting a storage volume	Not supported	Supported	Supported
Performing operations on all Kubernetes resources	Supported (Kubernetes RBAC required)	Supported (Kubernetes RBAC required)	Supported
Viewing all CIA resources	Supported	Supported	Supported
Performing operations on all CIA resources	Not supported	Supported	Supported
Performing all operations on ECSs	Not supported	Supported	Supported
Performing all operations on EVS disks EVS disks can be attached to cloud servers and scaled to a higher capacity whenever needed.	Not supported	Supported	Supported
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.	Not supported	Supported	Supported
Viewing details of all resources on an ECS In CCE, a node is an ECS with multiple EVS disks.	Supported	Supported	Supported
Listing all resources on an ECS	Supported	Supported	Supported

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.	Supported	Supported	Supported
Listing all EVS resources	Supported	Supported	Supported
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.	Supported	Supported	Supported
Listing all VPC resources	Supported	Supported	Supported
Viewing details about all ELB resources	Not supported	Not supported	Supported
Listing all ELB resources	Not supported	Not supported	Supported
Viewing details about all SFS resources	Supported	Supported	Supported
Listing all SFS resources	Supported	Supported	Supported
Viewing details about all AOM resources	Supported	Supported	Supported
Listing AOM resources	Supported	Supported	Supported
Performing all operations on AOM auto scaling rules	Supported	Supported	Supported

Namespace-level Permissions (Assigned by Using Kubernetes RBAC)

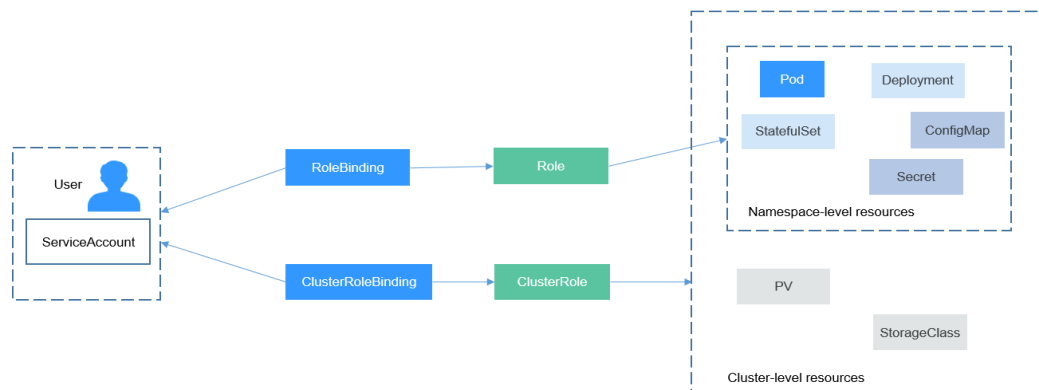
You can regulate users' or user groups' access to Kubernetes resources in a single namespace based on their Kubernetes RBAC roles. The RBAC API declares four kinds of Kubernetes objects: Role, ClusterRole, RoleBinding, and ClusterRoleBinding, which are described as follows:

- 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 1-8 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:

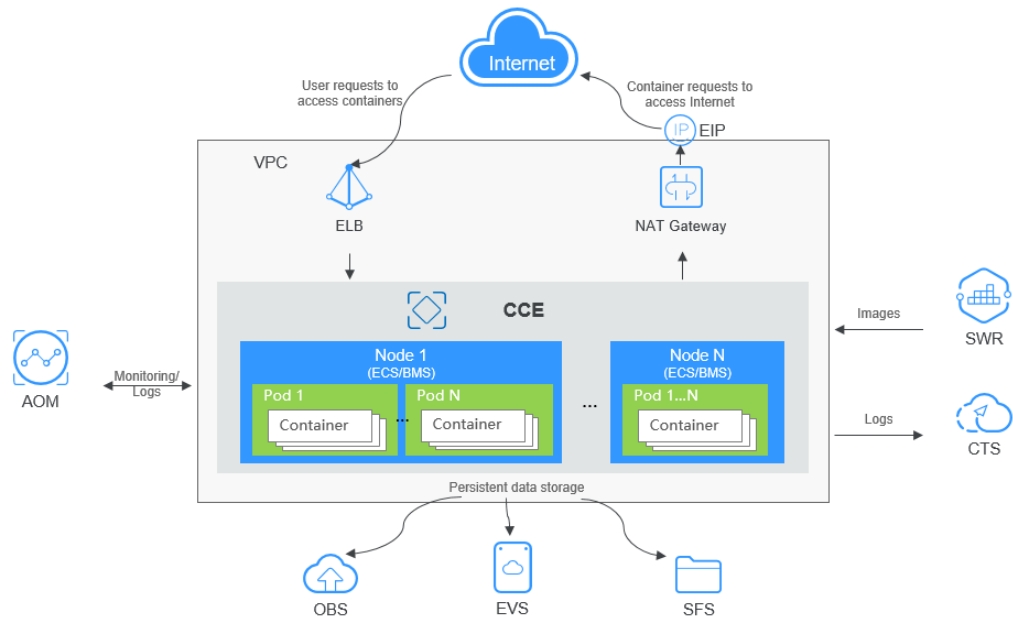
- view (read-only): read-only permission on most resources in all or selected namespaces.
- edit (development): read and write permissions on most resources in all or selected namespaces. If this ClusterRole is configured for all namespaces, its capability is the same as the O&M permission.
- admin (O&M): 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.
- drainage-editor: drain a node.
- drainage-viewer: view the nodal drainage status but cannot drain a node.

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.

1.7 Related Services

CCE needs to be interconnected with the following cloud services. It requires permissions to access these cloud services.

Figure 1-9 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.

1.8 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 now 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 Product Bulletin

2.1 Risky Operations on Cluster Nodes

Precautions for Using a Cluster

- When performing operations such as creating, deleting, and scaling clusters, do not change user permissions on the Identity and Access Management (IAM) console. Otherwise, these operations may fail.
- Canal, the CNI plug-ins used by CCE nodes, uses a CIDR block as the CIDR block of the container network. This CIDR block can be configured during cluster creation and defaults to 172.16.0.0/16. The Docker service creates a docker0 bridge by default. The default docker0 address is 172.17.0.1. When creating a cluster, ensure that the CIDR block of the VPC in the cluster is different from those of the container network and the docker0 bridge. If VPC peering connections are used, ensure that the CIDR block of the peer VPC is different from those of the container network and the docker0 bridge.
- For clusters of Kubernetes v1.15, the DNS server of nodes in the cluster uses the DNS server in the VPC subnet. The CoreDNS address of Kubernetes is not added. Ensure that the DNS address in the subnet exists and is configurable.
- For clusters of Kubernetes v1.17, the network of a node is a single network plane. In the multi-network plane scenario, if you bind a new NIC to the ECS, you need to configure the NIC information on the node and restart the NIC after the binding.
- Do not modify the security groups, Elastic Volume Service (EVS) disks, and other resources created by CCE. Otherwise, clusters may not function properly. The resources created by CCE are labeled "cce", for example, "cce-evs-jwh9pcl7-****".
- When a node is added, the DNS server in the subnet must be able to resolve the domain name of the corresponding service. Otherwise, the node cannot be installed properly.

Precautions for Using a Node

Some of the node resources will be used to run necessary Kubernetes system components and resources to make the node as part of your cluster. Therefore, the

amount of your node resources differs from that of node allocatable resources in Kubernetes. 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 amount of CCE node resources will be reserved for Kubernetes components (such as kubelet, kube-proxy, and docker) based on the node specifications.

 **NOTE**

You are advised not to install private software or modify the operating system (OS) configuration on a cluster node. This may cause exceptions on Kubernetes components installed on the node, and make the node unavailable.

Risky Operations on Nodes

After logging in to a node created by CCE, do not perform the following operations. Otherwise, the node will become unready.

Table 2-1 Operations that will cause nodes to become unready

No.	Operation	Impact	Solution
1	Reinstalling the operating system using the original image or another image	The node will become unavailable.	Delete the node and create a new one.
2	Modifying OS configuration	The node will become unavailable.	Restore the original configuration or create a new node.
3	Deleting the opt directory, /var/paas directory, or a data disk	The node will become unavailable.	Delete the node and create a new one.
4	Formatting and partitioning a node disk	The node will become unavailable.	Delete the node and create a new one.
5	Modifying a security group	The node will become unready or the cluster will exhibit unexpected behavior.	Correct the security group settings based on security group settings of normal clusters.

2.2 CCE Security Guide

Node Security Hardening

Cloud Container Engine (CCE) cluster nodes are created from the public images published by Image Management Service (IMS) in the public cloud. CCE performs

security hardening on the CCE software installed on nodes. The OS configurations are the same as those of public images by default. You need to perform security hardening based on your own security requirements.

Container Security Suggestions

CCE provides you with an exclusive cluster. You are not advised to share a cluster with multiple tenants. If a cluster must be shared by multiple tenants, perform security hardening by following the suggestions in the following table.

Table 2-2 Container security configuration suggestions

Category	Suggestion
Least privilege	<p>1. Use the sudo whitelist to restrict the Docker commands that can be run in containers by common users.</p> <p>2. It is recommended that privileged containers be disabled for Kubernetes pods. To be specific, do not use the following settings:</p> <pre>apiVersion: v1 kind: Pod metadata: name: hello-world spec: containers: - name: hello-world-container # The container definition # ... securityContext: privileged: true</pre> <p>By default, the token of ServiceAccount default is not used.</p> <ul style="list-style-type: none"> The automatic mounting function is disabled for ServiceAccount default by default. If automountServiceAccountToken is set to false, the created workload will not be mounted to a token by default. <p>CAUTION Set this field for each namespace as required. After the setting is complete, perform a rolling restart for the pods in the corresponding namespace.</p> <pre>apiVersion: v1 kind: ServiceAccount metadata: name: default automountServiceAccountToken: false</pre> <ul style="list-style-type: none"> Mount the token of ServiceAccount default to specific workloads. <pre>... spec: template: spec: serviceAccountName: default automountServiceAccountToken: true ...</pre>

Category	Suggestion
Network isolation	<p>Network isolation between containers in a cluster Use network policies to implement access control.</p> <p>Network isolation between containers and hosts outside the cluster Use security groups in a VPC to implement access control.</p> <p>Network isolation between containers and the cluster control plane CCE clusters are private and workloads would access the cluster API server. Therefore, CCE does not restrict the network communication between containers and the Kubernetes control plane. You can harden the network security by limiting the pod QoS.</p>
Mounting of sensitive host directories	<ul style="list-style-type: none"> • If not necessary, do not mount the /var/run/docker.sock file on the host to a container when starting the container. • Do not mount the hostPath directory, such as /, /boot, /dev, /etc, /lib, /proc, /sys, and /usr, on the host to the container. If necessary, mount the hostPath directory in read-only mode.

2.3 Cluster Node OS Patch Notes

CCE Cluster

In a CCE cluster, the OSs and the corresponding kernel versions supported by nodes are as follows:

Table 2-3 Mapping between node OSs and cluster types

OS	Cluster Version	CCE Standard Cluster		Latest Kernel
		VPC Network	Tunnel Network	
Ubuntu 22.04	v1.29	√	×	5.15.0-46-generic
	v1.28	√	×	5.15.0-46-generic
	v1.27	√	×	5.15.0-46-generic
	v1.25	√	×	5.15.0-46-generic
	v1.23	√	×	5.15.0-46-generic
EulerOS release 2.9	v1.29	√	√	4.18.0-147.5.1.6.h541.eule rosv2r9.x86_64

OS	Cluster Version	CCE Standard Cluster		Latest Kernel
		VPC Network	Tunnel Network	
	v1.28	√	√	4.18.0-147.5.1.6.h541.eule rosv2r9.x86_64
	v1.27	√	√	4.18.0-147.5.1.6.h541.eule rosv2r9.x86_64
	v1.25	√	√	4.18.0-147.5.1.6.h541.eule rosv2r9.x86_64
	v1.23	√	√	4.18.0-147.5.1.6.h541.eule rosv2r9.x86_64
	v1.21	√	√	4.18.0-147.5.1.6.h541.eule rosv2r9.x86_64
	v1.19.10	√	√	4.18.0-147.5.1.6.h541.eule rosv2r9.x86_64
CentOS Linux release 7.7	v1.23	√	√	3.10.0-1062.12.1.el7.x86_64
	v1.21	√	√	3.10.0-1062.12.1.el7.x86_64
	v1.19.10	√	√	3.10.0-1062.12.1.el7.x86_64
	v1.17.9	√	√	3.10.0-1062.12.1.el7.x86_64
EulerOS release 2.5	v1.25	√	√	3.10.0-862.14.1.0.h197.eul erosv2r7.x86_64
	v1.23	√	√	3.10.0-862.14.1.0.h197.eul erosv2r7.x86_64
	v1.21	√	√	3.10.0-862.14.1.0.h197.eul erosv2r7.x86_64
	v1.19.10	√	√	3.10.0-862.14.1.0.h197.eul erosv2r7.x86_64
	v1.17.9	√	√	3.10.0-862.14.1.5.h470.eul erosv2r7.x86_64
	v1.15.11	√	√	3.10.0-862.14.1.5.h470.eul erosv2r7.x86_64

The OS patch release and verification results will be updated periodically. You can update the operating system if needed.

2.4 Vulnerability Notice

2.4.1 Notice on the Kubernetes Security Vulnerability (CVE-2022-3172)

Recently, the Kubernetes community detected a security issue in kube-apiserver. This issue allows the aggregated API server to redirect client traffic to any URL, which may cause the client to perform unexpected operations and forward the client's API server credentials to a third party.

Vulnerability Details

Table 2-4 Vulnerability information

Vulnerability Type	CVE-ID	Discovered
SSRF	CVE-2022-3172	2022-09-09

Threat Severity

Medium

Impact Scope

Affected versions:

- kube-apiserver <= v1.23.10

CCE clusters of the preceding versions configured with the aggregated API server will be affected, especially for CCE clusters with logical multi-tenancy.

Identification Method

For CCE clusters and CCE Turbo clusters of version 1.23 or earlier, use kubectl to connect to the cluster. Run the following command to check whether the aggregated API server is running:

```
kubectl get apiservices.apiregistration.k8s.io -o=jsonpath='{range .items[?(@.spec.service)]}{.metadata.name}{"\n"}{end}'
```

If the returned value is not empty, the aggregated API server exists.

Preventive Measures

Upgrades are the currently available solution. The cluster administrator must control permissions to prevent untrusted personnel from deploying and controlling the aggregated API server through the API service interface. A fixed version will be provided soon. Please follow the official announcement.

Helpful Links

<https://github.com/kubernetes/kubernetes/issues/112513>

2.4.2 Privilege Escalation Vulnerability in Linux openvswitch Kernel Module (CVE-2022-2639)

A privilege escalation vulnerability (CVE-2022-2639) was found in the Linux openvswitch kernel module. The `reserve_sfa_size()` function in this module has a defect. As a result, a local user can exploit this vulnerability to escalate their privileges on the system. Currently, the POC of this vulnerability have been disclosed and the risk is high.

Vulnerability Details

Table 2-5 Vulnerability information

Vulnerability Type	CVE-ID	Discovered
Privilege escalation	CVE-2022-2639	2022-09-01

Threat Severity

Critical

Affected Products

1. CCE clusters that use the container tunnel network model; node OS images that use EulerOS 2.9;
2. Node OS images that use Ubuntu

Cluster nodes running EulerOS 2.5 and CentOS 7.6 **are not affected by this vulnerability.**

Workarounds and Mitigation Measures

1. If a process in a container is started by a non-root user, you can configure seccomp, the security computing mode, for the workload. You are advised to use the RuntimeDefault mode or disable system calls such as unshare. For details about the configuration, see the community documentation [Restrict a Container's Syscalls with seccomp](#).
2. Ubuntu images are embedded with the openvswitch kernel module. You can disable the loading of this module to avoid this problem. The procedure is as follows:

```
echo "blacklist openvswitch" >>/etc/modprobe.d/blacklist.conf
```


Then, restart the node for the settings to take effect.

Helpful Links

<https://github.com/torvalds/linux/commit/cefa91b2332d7009bc0be5d951d6cbbf349f90f8>

2.4.3 Notice on CRI-O Container Runtime Engine Arbitrary Code Execution Vulnerability (CVE-2022-0811)

The CrowdStrike security team disclosed a security vulnerability (tracked as CVE-2022-0811) in CRI-O v1.19. An attacker can exploit this vulnerability to escape to the host.

Vulnerability Details

Table 2-6 Information

Vulnerability Type	CVE-ID	Discovered
Container escape	CVE-2022-0811	2021-03-16

Threat Severity

Critical

Root Cause

A vulnerability is introduced in CRI-O v1.19. An attacker can exploit this vulnerability to bypass protection measures and set arbitrary kernel parameters on the host. As a result, any user with permissions to deploy a pod on a Kubernetes cluster that uses CRI-O runtime can abuse the **kernel.core_pattern** kernel parameter to achieve container escape and arbitrary code execution as root on any node in the cluster.

Impact Scope

1. Kubernetes clusters that use CRI-O v1.19 or later, including patch versions 1.19.6, 1.20.7, 1.21.6, 1.22.3, 1.23.2, and 1.24.0.

CCE clusters are not affected by this vulnerability because they do not use CRI-O.

Workarounds and Mitigation Measures

- For CRI-O v1.19 and v1.20, set **manage_ns_lifecycle** to **false**, and use Open Container Initiative (OCI) runtimes to configure sysctls.
- Create a PodSecurityPolicy and set all sysctls to **false**.
- Upgrade the CRI-O runtime to the latest version.

References

- Red Hat community vulnerability notice: <https://access.redhat.com/security/cve/cve-2022-0811>
- cr8escape: New Vulnerability in CRI-O Container Engine Discovered by CrowdStrike*: <https://www.crowdstrike.com/blog/cr8escape-new-vulnerability-discovered-in-cri-o-container-engine-cve-2022-0811/>

2.4.4 Notice on the Container Escape Vulnerability Caused by the Linux Kernel (CVE-2022-0492)

Recently, the security team detected that in some scenarios, the **release_agent** feature of the Linux kernel cgroup v1 can be exploited to escalate privileges and bypass the namespace isolation unexpectedly.

Vulnerability Details

Table 2-7 Vulnerability information

Vulnerability Type	CVE-ID	Discovered
Container escape	CVE-2022-0492	2021-02-07

Threat Severity

Critical

Trigger Conditions

On an affected node, workloads use the **root** user to run a process (or has the **CAP_SYS_ADMIN** permission), and **seccomp** is not configured.

Root Cause

The Linux kernel does not check whether the process that sets the **release_agent** file has the proper permission.

Impact Scope

1. For x86 nodes, EulerOS 2.5 and CentOS images are not affected by this vulnerability.
2. EulerOS (Arm) whose kernel version is earlier than 4.19.36-vhulk1907.1.0.h962.eulerosv2r8.aarch64 is affected by this vulnerability.
3. EulerOS (x86) whose kernel version is earlier than 4.18.0-147.5.1.6.h541.eulerosv2r9.x86_64 is affected by this vulnerability.
4. Ubuntu nodes whose kernel version is 4.15.0-136-generic or earlier is affected by this vulnerability.

Workarounds and Mitigation Measures

1. A fix version has been provided for EulerOS 2.9 images. Migrate to the 4.18.0-147.5.1.6.h541.eulerosv2r9.x86_64 nodes as soon as possible.
2. Configure **seccomp** for workloads to restrict unshare system calls. For details, see the [Kubernetes documentation](#).
3. Restrict the process permissions in a container and minimize the process permissions in the container. For example, use a non-root user to start

processes and use the **capability** mechanism to refine the process permissions.

References

1. Kernel repair commit: <https://git.kernel.org/pub/scm/linux/kernel/git/torvalds/linux.git/commit/?id=24f6008564183aa120d07c03d9289519c2fe02af>
2. Red Hat community vulnerability notice: <https://access.redhat.com/security/cve/cve-2022-0492>

2.4.5 Linux Kernel Integer Overflow Vulnerability (CVE-2022-0185)

Recently, the security team detected that security researchers William Liu and Jamie Hill-Daniel discovered an integer underflow vulnerability in the Linux kernel, which may lead to out-of-bounds writes. A local attacker can use this vulnerability to cause a denial of service (system crash) or execute arbitrary code. In a container scenario, a user with the CAP_SYS_ADMIN permission can escape from the container to the host machine. Currently, the vulnerability POC already exists, but no disclosed exploit code is found.

Vulnerability Details

Table 2-8 Vulnerability information

Vulnerability Type	CVE-ID	Discovered
Resource management flaw	CVE-2022-0185	2022-01-27

Threat Severity

Critical

Impact and Risks

The system that uses Linux kernel 5.1 or later will be affected by this vulnerability, but **CCE is not affected**.

Trigger Conditions

In a container scenario, users have the CAP_SYS_ADMIN permission, and the kernel version is 5.1 or later. In a standard Docker environment, the Docker seccomp filter is used. Therefore, the system is not affected by this vulnerability by default. In the Kubernetes scenario, the seccomp filter is disabled by default. The system is affected by this vulnerability if the kernel and permission conditions are met.

Identification Method

Run the `uname -a` command to view the kernel version.

Workarounds and Mitigation Measures

CCE clusters are not affected by this vulnerability. For a Kubernetes cluster, you are advised to:

1. Run containers with the least privilege.
2. Configure [seccomp](#) based on the configuration method provided by Kubernetes.

References

<https://blog.aquasec.com/cve-2022-0185-linux-kernel-container-escape-in-kubernetes>

<https://ubuntu.com/security/CVE-2022-0185>

<https://access.redhat.com/security/cve/CVE-2022-0185>

<https://www.openwall.com/lists/oss-security/2022/01/18/7>

2.5 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 2-9 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	CCE Node Problem Detector	npd	CCE proprietary
	Kubernetes Metrics Server	metrics-server	Featured open source
Cloud native heterogeneous computing	CCE AI Suite (NVIDIA GPU)	gpu-device-plugin (gpu-beta)	CCE proprietary
Network	CoreDNS	coredns	CCE proprietary
	NodeLocal DNSCache	node-local-dns	Featured open source

Category	New Name	Original Name	Remarks
	NGINX Ingress Controller	nginx-ingress	Featured open source
Storage	CCE Container Storage (Everest)	everest	CCE proprietary
	CCE Container Storage (FlexVolume)	storage-driver	CCE proprietary
Security	CCE Secrets Manager for DEW	dew-provider	CCE proprietary
Other	Kubernetes Dashboard	dashboard	Featured open source

3 Kubernetes Basics

3.1 Overview

Kubernetes is an open source container orchestration system for automating containerized application deployment, scaling, and management across cloud servers.

One of the core features of Kubernetes is that it can independently manage containers to ensure that the containers run as expected. For example, if you want your Apache application to run all the time, Kubernetes will automatically monitor the running status, restart containers, and create new containers to keep Apache running. Administrator can load a microservice for the service planner. In addition, Kubernetes systematically improves tools and makes itself more user-friendly to deploy applications.

You can access CCE, a hosted Kubernetes service, using the CCE console, kubectl, or Kubernetes APIs. Before using CCE, you can learn the following Kubernetes concepts.

Containers and Kubernetes

- [Containers](#)
- [Kubernetes](#)

Pods, Labels, and Namespaces

- [Pod: the Smallest Scheduling Unit in Kubernetes](#)
- [Liveness Probe](#)
- [Label for Managing Pods](#)
- [Namespaces: Grouping Resources](#)

Pod Orchestration and Scheduling

- [Deployment](#)
- [StatefulSet](#)
- [Job and Cron Job](#)

- [DaemonSet](#)
- [Affinity and Anti-Affinity Scheduling](#)

Configuration Management

- [ConfigMap](#)
- [Secret](#)

Kubernetes Networking

- [Container Networking](#)
- [Services](#)
- [Ingresses](#)
- [Readiness Probe](#)
- [NetworkPolicy](#)

Persistent Storage

- [Volume](#)
- [PersistentVolumes, PersistentVolumeClaims, and StorageClasses](#)

Authentication and Authorization

- [ServiceAccounts](#)
- [RBAC](#)

Auto Scaling

- [Auto Scaling](#)

3.2 Container and Kubernetes

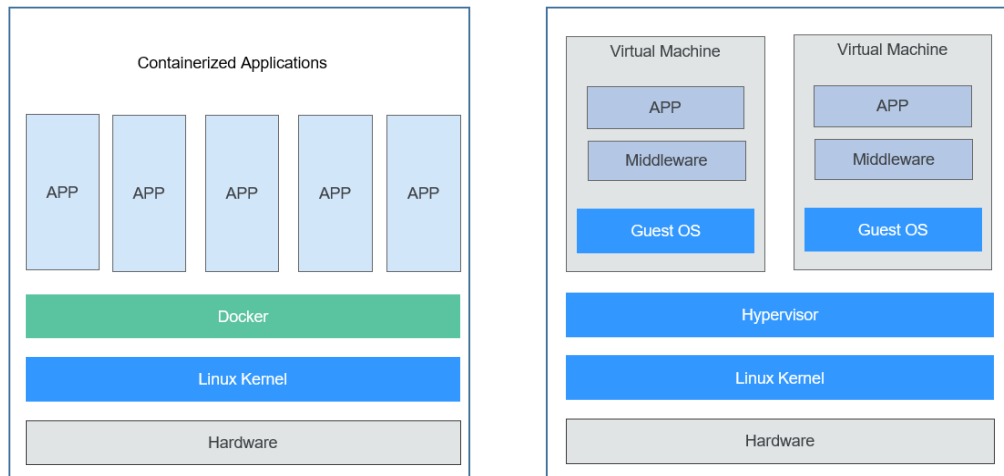
3.2.1 Containers

Container and Docker

Container technologies originate from Linux. Containers provide lightweight virtualization and allow process and resource isolation. Containers become popular since the emergence of Docker. Docker is the first system that allows containers to be portable in different machines. It simplifies both the application packaging and the application library and dependency packaging. Even the OS file system can be packaged into a simple portable package, which can be used on any other machine that runs Docker.

Except for similar resource isolation and allocation modes as VMs, containers virtualize OSs, making them more portable and efficient.

Figure 3-1 Containers vs VMs



Containers have the following advantages over VMs:

- **Higher system resource utilization**
 With no overhead for virtualizing hardware and running a complete OS, containers outperform VMs no matter in application execution speed, memory loss, and file storage speed. Therefore, with same configurations, containers can run more applications than VMs.
- **Faster startup**
 Traditional VMs usually take several minutes to start an application. However, Docker containerized applications run directly on the host kernel with no need to start the entire OS, so they can start within seconds or even milliseconds, greatly saving your time in development, testing, and deployment.
- **Consistent running environments**
 One of the biggest problems in development is the inconsistency of application running environment. Due to inconsistent development, testing, and production environments, some bugs cannot be discovered prior to rollout. A Docker container image provides a complete runtime to ensure consistency in application running environments.
- **Easier migration**
 Docker ensures the consistency in execution environment, so migrating applications becomes much easier. Docker can run on many platforms, and no matter on physical machines or virtual ones, its running results remains the same. Therefore, you can easily migrate an application from one platform to another without worrying that the environment change will cause the applications fail to function.
- **Easier maintenance and extension**
 Tiered storage and image technology applied by Docker facilitate the reuse of applications and simplify application maintenance and update as well as further image extension based on base images. In addition, Docker collaborates with open-source project teams to maintain a large number of high-quality official images. You can directly use them in the production environment or form new images based on them, greatly reducing the image production cost of applications.

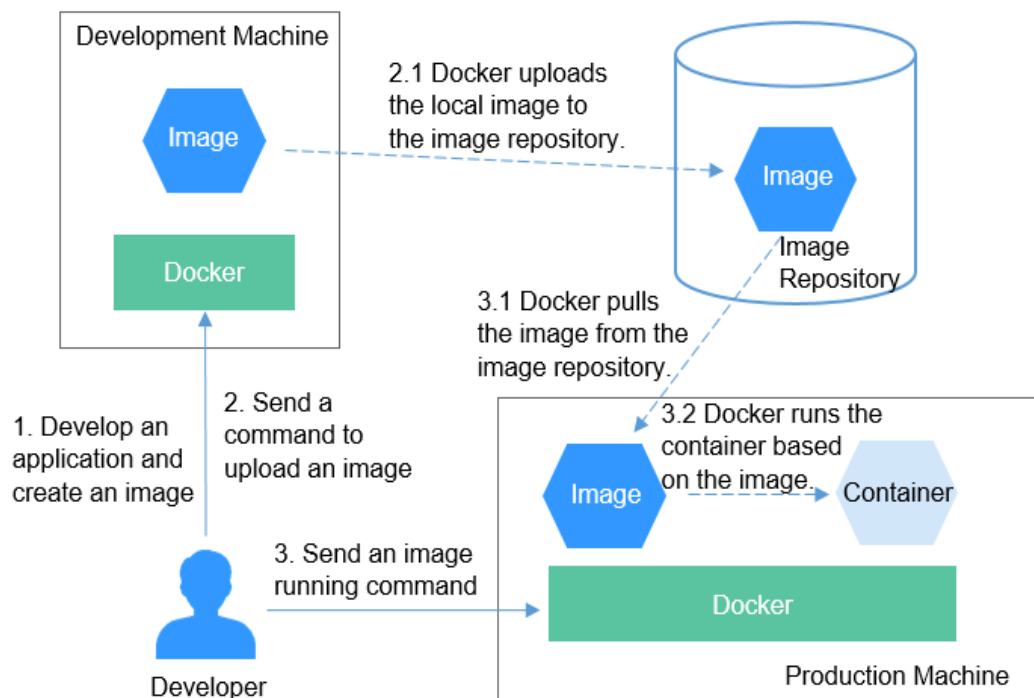
Typical Process of Using Docker Containers

Before using a Docker container, you should know the core components in Docker.

- **Image:** A Docker image is a software package that contains everything needed to run an application, such as the code and the runtime it requires, file systems, and executable file path of the runtime and other metadata.
- **Image repository:** A Docker image repository is used to store Docker images, which can be shared between different users and computers. You can run the image you compiled on the computer where it is compiled, or upload it to an image repository and then download it to another computer and run it. Some repositories are public, allowing everyone to pull images from them. Others are private, which are accessible only to some users and machines.
- **Container:** A Docker container is usually a Linux container created from a Docker image. A running container is a process running on the Docker host. However, it is isolated from the host and all other processes running on the host. The process is also resource-limited, meaning that it can access and use only resources (such as CPU and memory) allocated to it.

Figure 3-2 shows the typical process of using containers.

Figure 3-2 Typical process of using Docker containers



1. A developer develops an application and creates an image in the development machine.
Docker runs the commands to create an image and store it on the machine.
2. The developer sends a command to upload the image.
After receiving the command, Docker uploads the local image to the image repository.

3. The developer sends an image running command to the machine.
After the command is received, Docker pulls the image from the image repository to the machine, and then runs a container based on the image.

Example

In the following example, Docker packages a container image based on the Nginx image, runs an application based on the container image, and pushes the image to the image repository.

Installing Docker

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

In Linux, you can run the following command to install Docker:

```
curl -fsSL get.docker.com -o get-docker.sh
sh get-docker.sh
systemctl restart docker
```

Packaging a Docker Image

Docker provides a convenient way to package your application, which is called Dockerfile.

```
# Use the official Nginx image as the base image.
FROM nginx:alpine

# Run a command to modify the content of the nginx image index.html.
RUN echo "hello world" > /usr/share/nginx/html/index.html

# Permit external access to port 80 of the container.
EXPOSE 80
```

Run the **docker build** command to package the image.

```
docker build -t hello .
```

In the preceding command, **-t** indicates that a tag is added to the image, that is, the image is named. In this example, the image name is **hello**. **.** indicates that the packaging command is executed in the current directory.

Run the **docker images** command to view the image. You can see the hello image has been created successfully. You can also see an Nginx image, which is downloaded from the image repository and used as the base image of the hello image.

```
# docker images
REPOSITORY    TAG       IMAGE ID       CREATED        SIZE
hello         latest   d120ec16dcea  17 minutes ago 158MB
nginx        alpine   eeb27ee6b893  2 months ago  148MB
```

Running the Container Image Locally

After obtaining the image, you can run the **docker run** command on the local host to run the container image.

```
#docker run -p 8080:80 hello
```

The **docker run** command will start a container. In the preceding command, **-p** indicates that port 8080 of the local host is mapped to port 80 of the container. That is, the traffic of port 8080 of the local host will be forwarded to port 80 of

the container. When you access `http://127.0.0.1:8080` on the local host, you can access the container. In this case, the content returned by the browser is **hello world**.

Pushing the Image to the Image Repository

You can push images to SoftWare Repository for Container (SWR). The following describes how to push images to SWR.

Log in to the SWR console. In the navigation pane, choose **My Images**. On the page that is displayed, click **Upload Through Client**. In the dialog box that is displayed, click **Generate a temporary login command**. Then, copy the command and run it on the local host to log in to the SWR image repository.

Before uploading an image, you need to specify a complete name for the image.

```
# docker tag hello registry.eu-west-0.prod-cloud-ocb.orange-business.com/container/hello:v1
```

In the preceding command, **registry.eu-west-0.prod-cloud-ocb.orange-business.com** indicates the repository address. The address varies depending on the region. **v1** indicates the tag allocated to the hello image.

- **registry.eu-west-0.prod-cloud-ocb.orange-business.com** is the repository address. Addresses of each region are different.
- **container** is the organization name. Generally, an organization is created in SWR. If no organization is created, an organization is automatically created when the image is uploaded for the first time. The organization name is globally unique in a single region. You need to select a proper organization name.
- **v1** is the version number allocated to the hello image.

Run the **docker push** command to upload the image to SWR.

```
# docker push registry.eu-west-0.prod-cloud-ocb.orange-business.com/container/hello:v1
```

If you need to use the image, run the **docker pull** command to pull (download) the image.

```
# docker pull registry.eu-west-0.prod-cloud-ocb.orange-business.com/container/hello:v1
```

3.2.2 Kubernetes

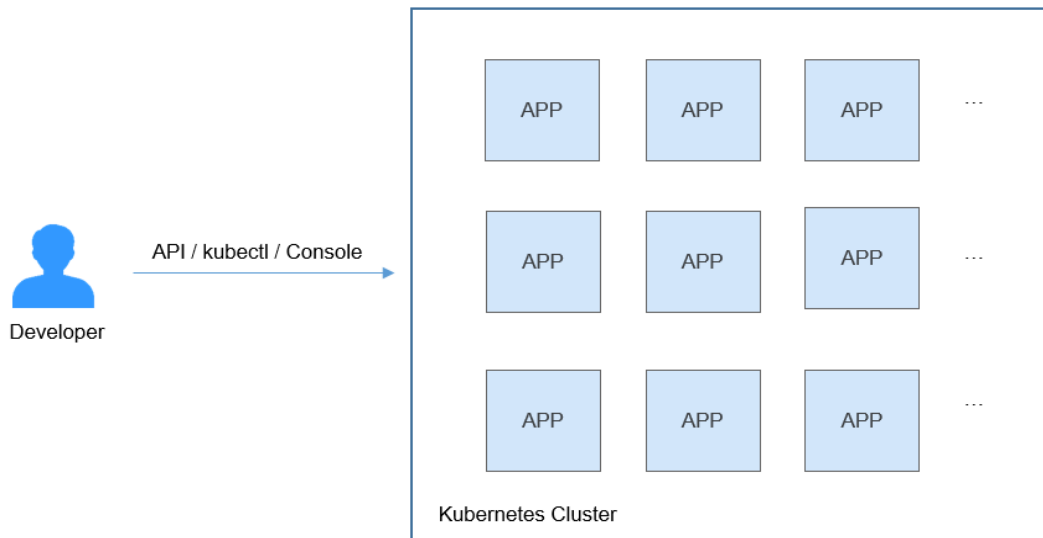
What Is Kubernetes?

Kubernetes is a containerized application software system that can be easily deployed and managed. It facilitates container scheduling and orchestration.

For application developers, Kubernetes can be regarded as a cluster operating system. Kubernetes provides functions such as service discovery, scaling, load balancing, self-healing, and even leader election, freeing developers from infrastructure-related configurations.

When you use Kubernetes, it is like you run a large number of servers as one on which your applications run. Regardless of the number of servers in a Kubernetes cluster, the method for deploying applications in Kubernetes is always the same.

Figure 3-3 Running applications in a Kubernetes cluster

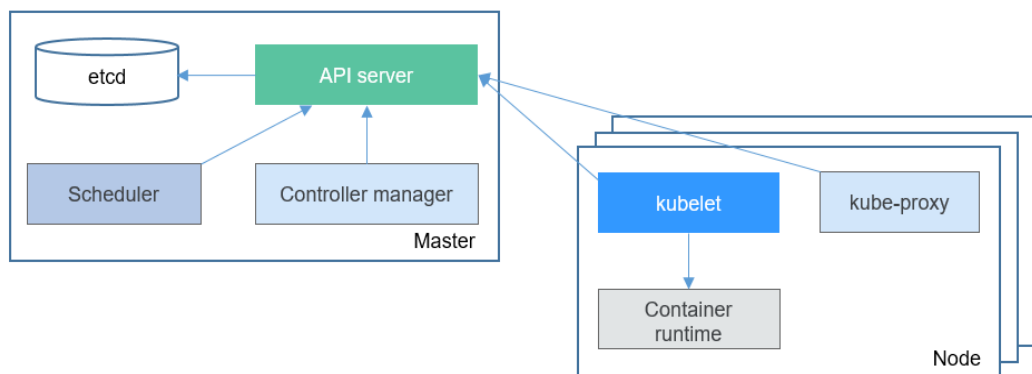


Kubernetes Cluster Architecture

A Kubernetes cluster consists of master nodes (masters) and worker nodes (nodes). Applications are deployed on nodes, and you can deploy applications on specific nodes as configured.

The following figure shows the architecture of a Kubernetes cluster.

Figure 3-4 Kubernetes cluster architecture



Master node

A master node is the machine where the control plane components run, including API server, Scheduler, Controller manager, and etcd.

- API server: functions as a transit station for components to communicate with each other, receives external requests, and writes information to etcd.
- Controller manager: performs cluster-level functions, such as component replication, node tracing, and node fault fixing.
- Scheduler: schedules containers to nodes based on various conditions (such as available resources and node affinity).

- etcd: serves as a distributed data storage component that stores cluster configuration information.

In the production environment, multiple master nodes are deployed to ensure cluster high availability. For example, three master nodes will be deployed to create a CCE cluster in HA mode.

Worker node

A worker node is a compute node in a cluster, that is, a node running containerized applications. A worker node has the following components:

- kubelet: communicates with the container runtime, interacts with the API server, and manages containers on the node.
- kube-proxy: serves as an access proxy between application components.
- Container runtime: functions as the software for running containers. You can download images to build your container runtime, such as Docker.

Kubernetes Scalability

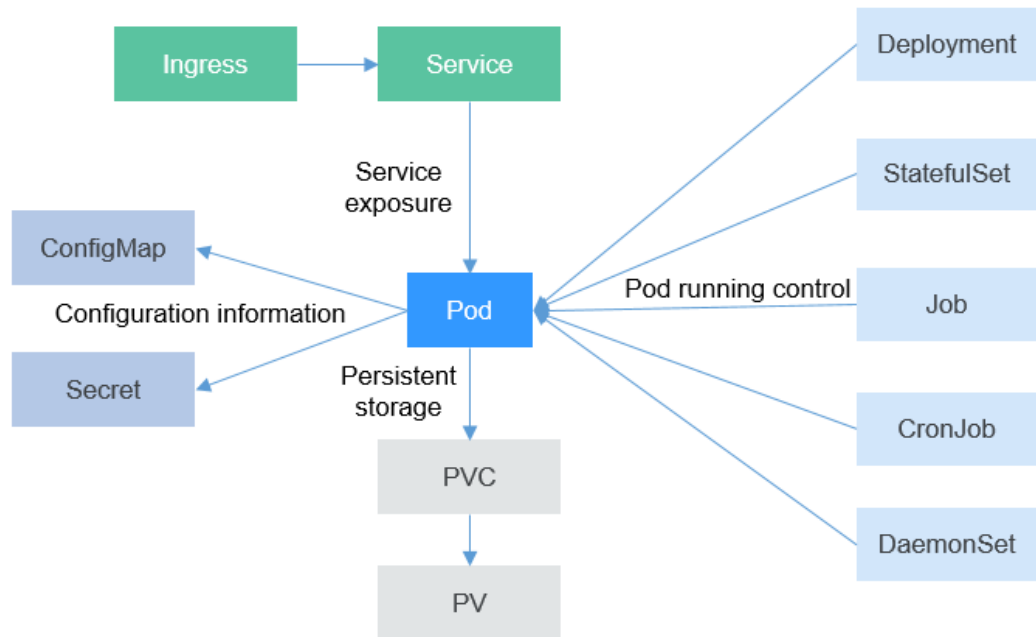
Kubernetes opens the Container Runtime Interface (CRI), Container Network Interface (CNI), and Container Storage Interface (CSI). These interfaces maximize Kubernetes scalability and allow Kubernetes to focus on container scheduling.

- Container Runtime Interface (CRI): provides computing resources when a container is running. It shields differences between container engines and interacts with each container engine through a unified interface.
- Container Network Interface (CNI): enables Kubernetes to support different networking implementations. For example, CCE has developed customized CNI plug-ins that allow your Kubernetes clusters to run in VPCs.
- Container Storage Interface (CSI): enables Kubernetes to support various classes of storage. For example, CCE is interconnected with block storage (EVS), file storage (SFS), and object storage (OBS) services.

Basic Objects in Kubernetes

The following figure describes the basic objects in Kubernetes and the relationships between them.

Figure 3-5 Basic Kubernetes objects



- **Pod**
A pod is the smallest and simplest unit that you create or deploy in Kubernetes. A pod encapsulates one or more containers, storage resources, a unique network IP address, and options that govern how the containers should run.
- **Deployment**
A Deployment can be viewed as an application encapsulating pods. It can contain one or more pods. Each pod has the same role, and the system automatically distributes requests to the pods of a Deployment.
- **StatefulSet**
A StatefulSet is used to manage stateful applications. Like Deployments, StatefulSets manage a group of pods based on an identical container spec. Where they differ is that StatefulSets maintain a fixed ID for each of their pods. These pods are created based on the same declaration but cannot replace each other. Each pod has a permanent ID regardless of how it is scheduled.
- **Job**
A job is used to control batch tasks. Jobs are different from long-term servo tasks (such as Deployments). The former can be started and terminated at specific time, while the latter runs unceasingly unless it is terminated. Pods managed by a job will be automatically removed after successfully completing tasks based on user configurations.
- **Cron job**
A cron job is a time-based job. Similar to the crontab of the Linux system, it runs a specified job in a specified time range.
- **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.

- Service

A Service is used for pod access. With a fixed IP address, a Service forwards access traffic to pods and performs load balancing for these pods.

- Ingress

Services forward requests using TCP and UDP protocols at Layer 4. Ingresses forward requests using HTTP and HTTPS at Layer 7. You can use domain names and paths to achieve finer granularity.

- ConfigMap

A ConfigMap stores configuration information in key-value pairs required by applications. With a ConfigMap, you can easily decouple configurations and use different configurations in different environments.

- Secret

A secret lets you store and manage sensitive information, such as password, authentication information, certificates, and private keys. Storing confidential information in a secret is safer and more flexible than putting it verbatim in a pod definition or in a container image.

- PersistentVolume (PV)

A PV describes a persistent data storage volume. It defines a directory for persistent storage on a host machine, for example, a mount directory of a network file system (NFS).

- PersistentVolumeClaim (PVC)

Kubernetes provides PVCs to apply for persistent storage. With PVCs, you only need to specify the type and capacity of storage without concerning about how to create and release underlying storage resources.

Setting Up a Kubernetes Cluster

Kubernetes introduces multiple methods for setting up a Kubernetes cluster, such as minikube and kubeadm.

If you do not want to create a Kubernetes cluster by coding, you can create one on the CCE console. The following sections use clusters created on the CCE console as examples.

kubectl

kubectl is a command line tool for Kubernetes clusters. You can install kubectl on any machine and run kubectl commands to operate your Kubernetes cluster.

For details about how to install kubectl, see [Connecting to a Cluster Through kubectl](#). After connection, you can run the **kubectl cluster-info** command to view the cluster information, as shown below.

```
# kubectl cluster-info
Kubernetes master is running at https://*.*.*:5443
CoreDNS is running at https://*.*.*:5443/api/v1/namespaces/kube-system/services/coredns/dns/proxy
```

To further debug and diagnose cluster problems, use 'kubectl cluster-info dump'.

Run the **kubectl get nodes** command to view information about nodes in the cluster.

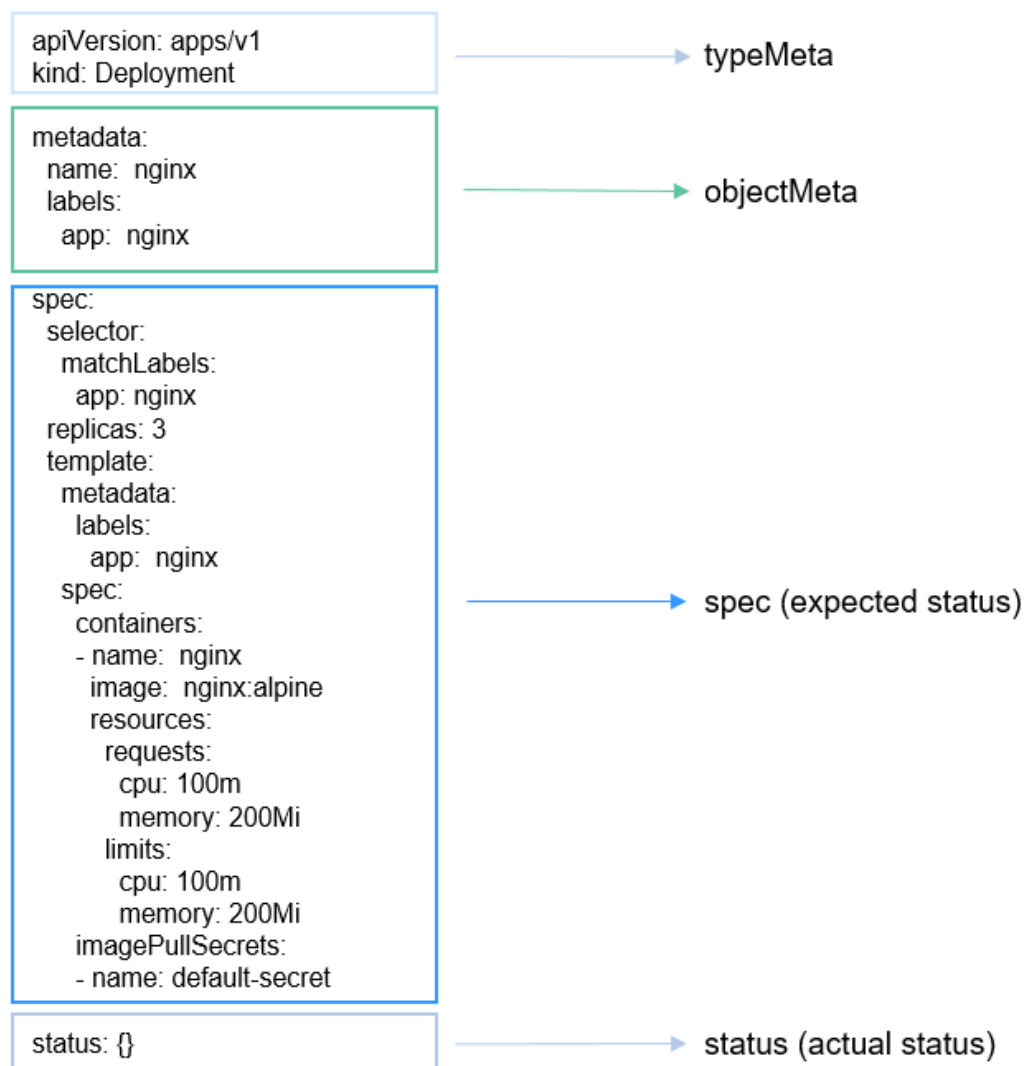
NAME	STATUS	ROLES	AGE	VERSION
192.168.0.153	Ready	<none>	7m	v1.15.6-r1-20.3.0.2.B001-15.30.2
192.168.0.207	Ready	<none>	7m	v1.15.6-r1-20.3.0.2.B001-15.30.2
192.168.0.221	Ready	<none>	7m	v1.15.6-r1-20.3.0.2.B001-15.30.2

Description of Kubernetes Objects

Resources in Kubernetes can be described using a YAML or JSON file. An object description can be divided into the following four parts:

- typeMeta: metadata of the object type, specifying the API version and type of the object.
- objectMeta: metadata about the object, including the object name and used labels.
- spec: expected status of the object, for example, which image the object uses and how many replicas the object has.
- status: actual status of the object, which can be viewed only after the object is created. You do not need to specify the status when creating an object.

Figure 3-6 YAML description file



Running Applications on Kubernetes

Delete **status** from the content in [Figure 3-6](#) and save it as the **nginx-deployment.yaml** file, as shown below:

```
apiVersion: apps/v1
kind: Deployment
metadata:
  name: nginx
  labels:
    app: nginx
spec:
  selector:
    matchLabels:
      app: nginx
  replicas: 3
  template:
    metadata:
      labels:
        app: nginx
    spec:
      containers:
        - name: nginx
          image: nginx:alpine
          resources:
            requests:
              cpu: 100m
              memory: 200Mi
            limits:
              cpu: 100m
              memory: 200Mi
      imagePullSecrets:
        - name: default-secret
```

Use `kubectl` to connect to the cluster and run the following command:

```
# kubectl create -f nginx-deployment.yaml
deployment.apps/nginx created
```

After the command is executed, three pods are created in the Kubernetes cluster. You can run the following command to query the Deployment and pods:

```
# kubectl get deploy
NAME    READY  UP-TO-DATE  AVAILABLE  AGE
nginx   3/3    3           3          9s

# kubectl get pods
NAME                                READY  STATUS   RESTARTS  AGE
nginx-685898579b-qrt4d             1/1    Running  0         15s
nginx-685898579b-t9zd2             1/1    Running  0         15s
nginx-685898579b-w59jn             1/1    Running  0         15s
```

By now, we have walked you through the Kubernetes basics of containers and clusters, and provided you an example of how to use `kubectl`. The following sections will go deeper into Kubernetes objects, such as how they are used and related.

3.3 Pod, Label, and Namespace

3.3.1 Pod: the Smallest Scheduling Unit in Kubernetes

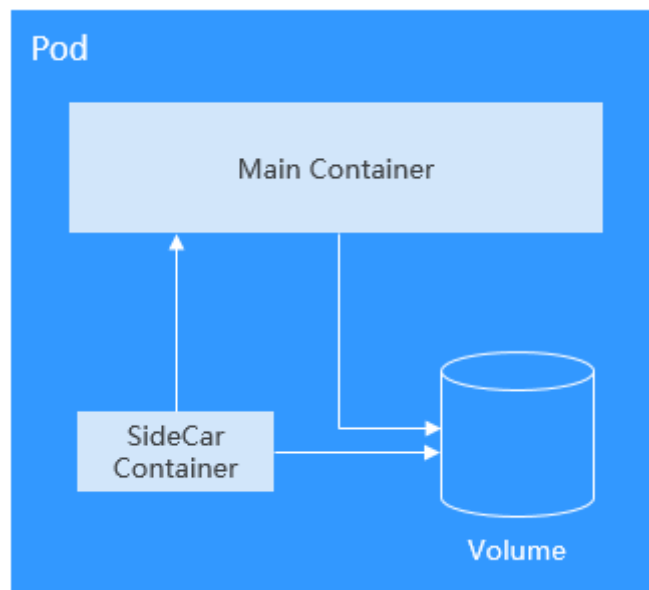
Pod

A pod is the smallest and simplest unit in the Kubernetes object model that you create or deploy. A pod encapsulates one or more containers, storage volumes, a unique network IP address, and options that govern how the containers should run.

Pods can be used in either of the following ways:

- A container is running in a pod. This is the most common usage of pods in Kubernetes. You can view the pod as a single encapsulated container, but Kubernetes directly manages pods instead of containers.
- Multiple containers that need to be coupled and share resources run in a pod. In this scenario, an application contains a main container and several sidecar containers, as shown in [Figure 3-7](#). For example, the main container is a web server that provides file services from a fixed directory, and a sidecar container periodically downloads files to the directory.

Figure 3-7 Pod



In Kubernetes, pods are rarely created directly. Instead, controllers such as Deployments and jobs, are used to manage pods. Controllers can create and manage multiple pods, and provide replica management, rolling upgrade, and self-healing capabilities. A controller generally uses a pod template to create corresponding pods.

Creating a Pod

Kubernetes resources can be described using YAML or JSON files. The following example describes a pod named **nginx**. This pod contains a container named **container-0** and uses the **nginx:alpine** image, 100m CPU, and 200 MiB memory.

```
apiVersion: v1          # Kubernetes API version
kind: Pod               # Kubernetes resource type
```

```
metadata:
  name: nginx          # Pod name
spec:                 # Pod specifications
  containers:
  - image: nginx:alpine # The image used is nginx:alpine.
    name: container-0  # Container name
    resources:         # Resources required for a container
      limits:
        cpu: 100m
        memory: 200Mi
      requests:
        cpu: 100m
        memory: 200Mi
    imagePullSecrets:  # Secret used to pull the image, which must be default-secret on CCE
  - name: default-secret
```

As shown in the annotation of YAML, the YAML description file includes:

- **metadata**: information such as name, label, and namespace
- **spec**: pod specification such as image and volume used

If you query a Kubernetes resource, you can see the **status** field. This field indicates the status of the Kubernetes resource, and does not need to be set when the resource is created. This example is a minimum set. Other parameter definition will be described later.

After the pod is defined, you can create it using `kubectl`. Assume that the preceding YAML file is named **nginx.yaml**, run the following command to create the file. **-f** indicates that it is created in the form of a file.

```
$ kubectl create -f nginx.yaml
pod/nginx created
```

After the pod is created, you can run the **kubectl get pods** command to query the pod information, as shown below.

```
$ kubectl get pods
NAME      READY  STATUS   RESTARTS  AGE
nginx    1/1    Running  0         40s
```

The preceding information indicates that the **nginx** pod is in the **Running** state, indicating that the pod is running. **READY** is **1/1**, indicating that there is one container in the pod, and the container is in the **Ready** state.

You can run the **kubectl get** command to query the configuration information about a pod. In the following command, **-o yaml** indicates that the pod is returned in YAML format. **-o json** indicates that the pod is returned in JSON format.

```
$ kubectl get pod nginx -o yaml
```

You can also run the **kubectl describe** command to view the pod details.

```
$ kubectl describe pod nginx
```

When a pod is deleted, Kubernetes stops all containers in the pod. Kubernetes sends the SIGTERM signal to the process and waits for a period (30 seconds by default) to stop the container. If it is not stopped within the period, Kubernetes sends a SIGKILL signal to kill the process.

You can stop and delete a pod in multiple methods. For example, you can delete a pod by name, as shown below.

```
$ kubectl delete po nginx  
pod "nginx" deleted
```

Delete multiple pods at one time.

```
$ kubectl delete po pod1 pod2
```

Delete all pods.

```
$ kubectl delete po --all  
pod "nginx" deleted
```

Delete pods by labels. For details about labels, see [Label for Managing Pods](#).

```
$ kubectl delete po -l app=nginx  
pod "nginx" deleted
```

Environment Variables

Environment variables are set in the container running environment.

Environment variables add flexibility to workload configuration. The environment variables for which you have assigned values during container creation will take effect when the container is running. This saves you the trouble of rebuilding the container image.

The following shows how to use an environment variable. You only need to configure the `spec.containers.env` field.

```
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  
    env:  
      # Environment variable  
      - name: env_key  
        value: env_value  
  imagePullSecrets:  
  - name: default-secret
```

Run the following command to check the environment variables in the container. The value of the `env_key` environment variable is `env_value`.

```
$ kubectl exec -it nginx -- env  
PATH=/usr/local/sbin:/usr/local/bin:/usr/sbin:/usr/bin:/sbin:/bin  
HOSTNAME=nginx  
TERM=xterm  
env_key=env_value
```

Environment variables can also reference **ConfigMap** and **secret**. For details, see [Referencing a ConfigMap as an Environment Variable](#) and [Referencing a Secret as an Environment Variable](#).

Setting Container Startup Commands

Starting a container is to start the main process. Some preparations must be made before the main process is started. For example, you may configure or initialize

MySQL databases before running MySQL servers. You can set **ENTRYPOINT** or **CMD** in the Dockerfile when creating an image. As shown in the following example, the **ENTRYPOINT ["top", "-b"]** command is set in the Dockerfile. This command will be executed during container startup.

```
FROM ubuntu
ENTRYPOINT ["top", "-b"]
```

When calling an API, you only need to configure the **containers.command** field of the pod. This field is of the list type. The first parameter in the field is the command to be executed, and the subsequent parameters are the command arguments.

```
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
    command:
      - top
      - "-b"
  imagePullSecrets:
  - name: default-secret
```

Container Lifecycle

Kubernetes provides **container lifecycle hooks**. The hooks enable containers to run code triggered by events during their management lifecycle. For example, if you want a container to perform a certain operation before it is stopped, you can register a hook. The following lifecycle hooks are provided:

- **postStart**: triggered immediately after the workload is started
- **preStop**: triggered immediately before the workload is stopped

You only need to set the **lifecycle.postStart** or **lifecycle.preStop** parameter of the pod, as shown in the following:

```
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
    lifecycle:
      postStart:
        exec:
          # Post-start processing
```

```
command:
- "/postStart.sh"
preStop:      # Pre-stop processing
exec:
command:
- "/preStop.sh"
imagePullSecrets:
- name: default-secret
```

3.3.2 Liveness Probe

Overview

Kubernetes applications have the self-healing capability, that is, when an application container crashes, the container can be detected and restarted automatically. However, this mechanism does not work for deadlocks. Assume that a Java program is having a memory leak. The program is unable to make any progress, while the JVM process is running. To address this issue, Kubernetes introduces liveness probes to check whether containers response normally and determine whether to restart containers. This is a good health check mechanism.

It is advised to define the liveness probe for every pod to gain a better understanding of pods' running statuses.

Supported detection mechanisms are as follows:

- **HTTP GET:** The kubelet sends an HTTP GET request to the container. Any 2XX or 3XX code indicates success. Any other code returned indicates failure.
- **TCP Socket:** The kubelet attempts to open a socket to your container on the specified port. If it can establish a connection, the container is considered healthy. If it fails to establish a connection, the container is considered a failure.
- **Exec:** kubelet executes a command in the target container. If the command succeeds, it returns **0**, and kubelet considers the container to be alive and healthy. If the command returns a non-zero value, kubelet kills the container and restarts it.

In addition to liveness probes, readiness probes are also available for you to detect pod status. For details, see [Readiness Probe](#).

HTTP GET

HTTP GET is the most common detection method. An HTTP GET request is sent to a container. Any 2xx or 3xx code returned indicates that the container is healthy. The following example shows how to define such a request:

```
apiVersion: v1
kind: Pod
metadata:
name: liveness-http
spec:
containers:
- name: liveness
image: nginx:alpine
livenessProbe:      # liveness probe
httpGet:            #HTTP GET definition
path: /
port: 80
imagePullSecrets:
- name: default-secret
```

Create pod **liveness-http**.

```
$ kubectl create -f liveness-http.yaml
pod/liveness-http created
```

The probe sends an HTTP Get request to port 80 of the container. If the request fails, Kubernetes restarts the container.

View details of pod **liveness-http**.

```
$ kubectl describe po liveness-http
Name:          liveness-http
.....
Containers:
  liveness:
    .....
    State:      Running
      Started:   Mon, 03 Aug 2020 03:08:55 +0000
    Ready:      True
    Restart Count: 0
    Liveness:    http-get http://:80/ delay=0s timeout=1s period=10s #success=1 #failure=3
    Environment: <none>
    Mounts:
      /var/run/secrets/kubernetes.io/serviceaccount from default-token-vssmw (ro)
    .....
.....
```

The preceding output reports that the pod is **Running** with **Restart Count** being **0**, which indicates that the container is normal and no restarts have been triggered. If the value of **Restart Count** is not **0**, the container has been restarted.

TCP Socket

TCP Socket: The kubelet attempts to open a socket to your container on the specified port. If it can establish a connection, the container is considered healthy. If it fails to establish a connection, the container is considered a failure. For detailed defining method, see the following example.

```
apiVersion: v1
kind: Pod
metadata:
  labels:
    test: liveness
  name: liveness-tcp
spec:
  containers:
  - name: liveness
    image: nginx:alpine
    livenessProbe:
      tcpSocket:
        port: 80
    # liveness probe
  imagePullSecrets:
  - name: default-secret
```

Exec

kubelet executes a command in the target container. If the command succeeds, it returns **0**, and kubelet considers the container to be alive and healthy. The following example shows how to define the command.

```
apiVersion: v1
kind: Pod
metadata:
  labels:
    test: liveness
  name: liveness-exec
```



```
spec:
  containers:
  - name: liveness
    image: nginx:alpine
    args:
    - /bin/sh
    - -c
    - touch /tmp/healthy; sleep 30; rm -rf /tmp/healthy; sleep 600
    livenessProbe:      # liveness probe
      exec:             # Exec definition
        command:
        - cat
        - /tmp/healthy
    imagePullSecrets:
    - name: default-secret
```

In the preceding configuration file, kubelet executes the command **cat /tmp/healthy** in the container. If the command succeeds and returns **0**, the container is considered healthy. For the first 30 seconds, there is a **/tmp/healthy** file. So during the first 30 seconds, the command **cat /tmp/healthy** returns a success code. After 30 seconds, the **/tmp/healthy** file is deleted. The probe will then consider the pod to be unhealthy and restart it.

Advanced Settings of a Liveness Probe

The **describe** command of **liveness-http** returns the following information:

```
Liveness: http-get http://:80/ delay=0s timeout=1s period=10s #success=1 #failure=3
```

This is the detailed configuration of the liveness probe.

- **delay=0s** indicates that the probe starts immediately after the container is started.
- **timeout=1** indicates that the container must respond within one second. Otherwise, the health check is recorded as failed.
- **period=10s** indicates that the probe checks containers every 10 seconds.
- **#success=1** indicates that the operation is recorded as successful if it is successful for once.
- **#failure=3** indicates that a container will be restarted after three consecutive failures.

The preceding liveness probe indicates that the probe checks containers immediately after they are started. If a container does not respond within one second, the check is recorded as failed. The health check is performed every 10 seconds. If the check fails for three consecutive times, the container is restarted.

These are the default configurations when the probe is created. You can customize them as follows:

```
apiVersion: v1
kind: Pod
metadata:
  name: liveness-http
spec:
  containers:
  - name: liveness
    image: nginx:alpine
    livenessProbe:
      httpGet:
        path: /
        port: 80
      initialDelaySeconds: 10 # Liveness probes are initiated after the container has started for 10s.
```

```
timeoutSeconds: 2    # The container must respond within 2s. Otherwise, it is considered as a
failure.
periodSeconds: 30    # The probe is performed every 30s.
successThreshold: 1  # The container is considered healthy as long as the probe succeeds once.
failureThreshold: 3  # The container is considered unhealthy after three consecutive failures.
```

Normally, the value of **initialDelaySeconds** must be greater than **0**, because it takes a while for the application to be ready. The probe often fails if the probe is initiated before the application is ready.

In addition, you can set the value of **failureThreshold** to be greater than **1**. In this way, the kubelet checks the container for multiple times in one probe rather than performing the probe for multiple times.

Configuring a Liveness Probe

- **What to check**

An effective liveness probe should check all the key parts of an application and use a dedicated URL, such as **/health**. When the URL is accessed, the probe is triggered and a result is returned. Note that no authentication should be involved. Otherwise, the probe keeps failing and restarting the container.

In addition, a probe must not check parts that have external dependencies. For example, if a frontend web server cannot connect to a database, the web server should not be considered unhealthy for the connection failure.

- **To be lightweight**

A liveness probe must not occupy too many resources or certain resources for too long. Otherwise, resource shortage may affect service running. For example, the HTTP GET method is recommended for a Java application. If the Exec method is used, the JVM startup process occupies too many resources.

3.3.3 Label for Managing Pods

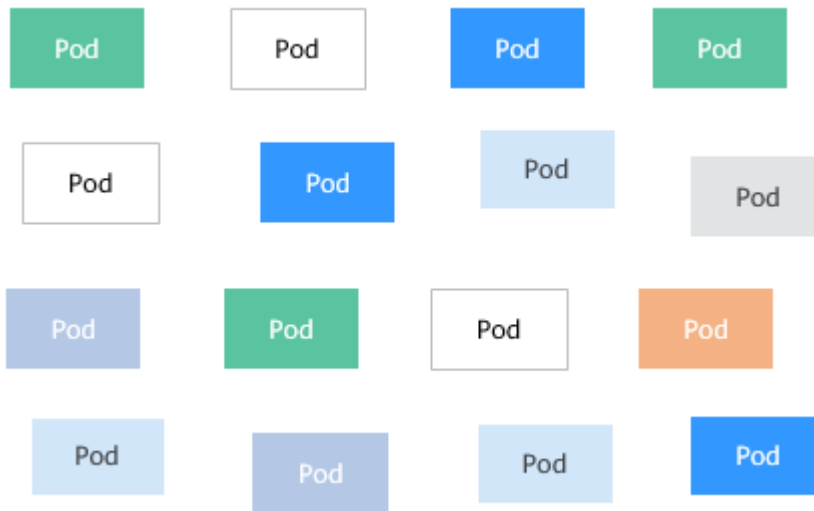
Why We Need Labels

As resources increase, how to classify and manage resources becomes important. Kubernetes provides a mechanism to classify resources, that is, using labels. Labels are simple but powerful. Almost all resources in the Kubernetes can be organized by labels.

A label is a key-value pair. It can be set either during or after resource creation. You can easily modify it when needed at any time.

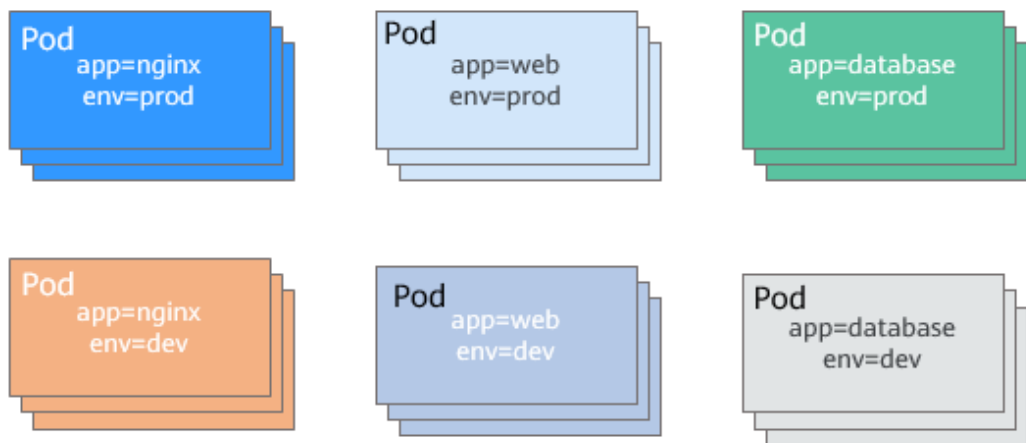
The following figures show how labels work. Assume that you have multiple pods of various kinds. It could be challenging when you manage them.

Figure 3-8 Pods without classification



After we add labels to them. It is much clearer.

Figure 3-9 Pods classified using labels



Adding a Label

The following example shows how to add labels when you are creating a pod.

```
apiVersion: v1
kind: Pod
metadata:
  name: nginx
  labels:           # Add labels app=nginx and env=prod to the pod.
    app: nginx
    env: prod
spec:
  containers:
  - image: nginx:alpine
    name: container-0
  resources:
    limits:
      cpu: 100m
      memory: 200Mi
```

```
requests:
  cpu: 100m
  memory: 200Mi
imagePullSecrets:
- name: default-secret
```

After you add labels to a pod, you can view the labels by adding **--show-labels** when querying the pod.

```
$ kubectl get pod --show-labels
NAME          READY STATUS  RESTARTS  AGE  LABELS
nginx         1/1   Running  0         50s  app=nginx,env=prod
```

You can also use **-L** to query only certain labels.

```
$ kubectl get pod -L app,env
NAME          READY STATUS  RESTARTS  AGE  APP  ENV
nginx         1/1   Running  0         1m   nginx  prod
```

For an existing pod, you can run the **kubectl label** command to add labels.

```
$ kubectl label pod nginx creation_method=manual
pod/nginx labeled

$ kubectl get pod --show-labels
NAME          READY STATUS  RESTARTS  AGE  LABELS
nginx         1/1   Running  0         50s  app=nginx, creation_method=manual,env=prod
```

Modifying a Label

Add **--overwrite** to the command to modify a label.

```
$ kubectl label pod nginx env=debug --overwrite
pod/nginx labeled

$ kubectl get pod --show-labels
NAME          READY STATUS  RESTARTS  AGE  LABELS
nginx         1/1   Running  0         50s  app=nginx,creation_method=manual,env=debug
```

3.3.4 Namespaces: Grouping Resources

Why We Need Namespaces

Although labels are simple and efficient, too many labels can cause chaos and make querying inconvenient. Labels can overlap with each other, which is not suitable for certain scenarios. This is where namespace comes in. Namespaces allow you to isolate and manage resources in a more systematic way. Multiple namespaces can divide systems that contain multiple components into different non-overlapped groups. Namespaces also enable you to divide cluster resources between users. In this way, multiple teams can share one cluster.

Resources of the same type can share the same name as long as they are in different namespaces. Unlike most resources in Kubernetes can be managed by namespace, global resources do not belong to a specific namespace. Later sections will discuss this topic in detail.

Run the following command to query namespaces in the current cluster:

```
$ kubectl get ns
NAME          STATUS AGE
default       Active 36m
kube-node-release Active 36m
kube-public   Active 36m
kube-system   Active 36m
```

By now, we are performing operations in the default namespace. When **kubectl get** is used but no namespace is specified, the default namespace is used by default.

You can run the following command to view resources in namespace **kube-system**.

```
$ 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
everest-csi-controller-6d796fb9c5-v22df 2/2   Running 0      9m11s
everest-csi-driver-snzrr             1/1   Running 0      12m
everest-csi-driver-ttj28             1/1   Running 0      12m
everest-csi-driver-wtrk6             1/1   Running 0      12m
icagent-2kz8g                       1/1   Running 0      12m
icagent-hjz4h                       1/1   Running 0      12m
icagent-m4bbl                       1/1   Running 0      12m
```

You can see that there are many pods in **kube-system**. **coredns** is used for service discovery, **everest-csi** for connecting to storage services, and **icagent** for connecting to the monitoring system.

These general, must-have applications are put in the **kube-system** namespace to isolate them from other pods. They are invisible to and free from being affected by resources in other namespaces.

Creating 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
```

Create resources in the namespace.

```
$ kubectl create -f nginx.yaml -n custom-namespace
pod/nginx created
```

By now, namespaces **default** and **custom-namespace** both have a pod named **nginx**.

The Isolation function of Namespaces

Namespaces are used to group resources only for organization purposes. Running objects in different namespaces are not essentially isolated. For example, if pods in two namespaces know the IP address of each other and the underlying network on which Kubernetes depends does not provide network isolation between namespaces, the two pods can access each other.

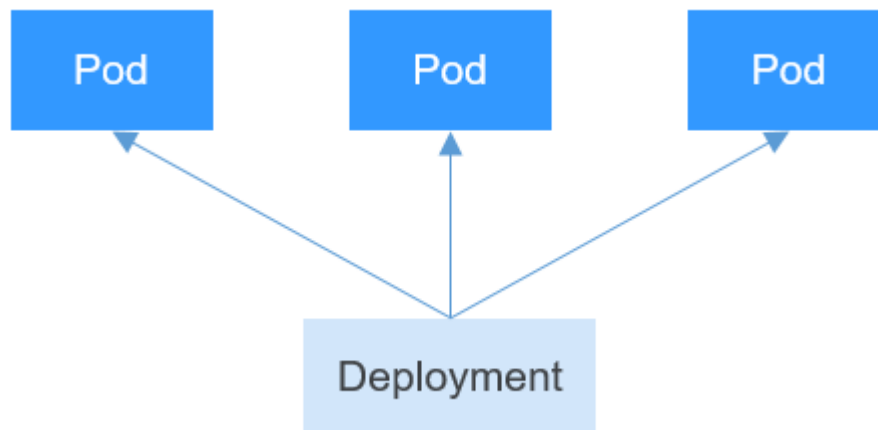
3.4 Pod Orchestration and Scheduling

3.4.1 Deployment

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 3-10 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.

Creating a Deployment

In the following example, a Deployment named **nginx** is created, and two pods are created from the **nginx:latest** image. Each pod occupies 100m CPU and 200 MiB memory.

```

apiVersion: apps/v1      # Note the difference with a pod. It is apps/v1 instead of v1 for a Deployment.
kind: Deployment        # The resource type is Deployment.
metadata:
  name: nginx           # Name of the Deployment
spec:
  replicas: 2           # Number of pods. The Deployment ensures that two pods are running.
  selector:             # Label Selector
    matchLabels:
  
```

```
  app: nginx
  template:      # Definition of a pod, which is used to create pods. It is also known as pod 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
```

In this definition, the name of the Deployment is **nginx**, and **spec.replicas** defines the number of pods. That is, the Deployment controls two pods. **spec.selector** is a label selector, indicating that the Deployment selects the pod whose label is **app=nginx**. **spec.template** is the definition of the pod and is the same as that defined in [Pods](#).

Save the definition of the Deployment to **deployment.yaml** and use `kubectl` to create the Deployment.

Run `kubectl get` to view the Deployment and pods. In the following example, the value of **READY** is **2/2**. The first **2** indicates that two pods are running, and the second **2** indicates that two pods are expected in this Deployment. The value **2** of **AVAILABLE** indicates that two pods are available.

```
$ kubectl create -f deployment.yaml
deployment.apps/nginx created

$ kubectl get deploy
NAME      READY   UP-TO-DATE   AVAILABLE   AGE
nginx    2/2     2            2           4m5s
```

How Does the Deployment Control Pods?

Continue to query pods, as shown below.

```
$ kubectl get pods
NAME                READY   STATUS    RESTARTS   AGE
nginx-7f98958cdf-tdmqk 1/1     Running   0          13s
nginx-7f98958cdf-txckx 1/1     Running   0          13s
```

If you delete a pod, a new pod is immediately created, as shown below. As mentioned above, the Deployment ensures that there are two pods running. If a pod is deleted, the Deployment creates a new pod. If a pod becomes faulty, the Deployment automatically restarts the pod.

```
$ kubectl get pods
NAME                READY   STATUS    RESTARTS   AGE
nginx-7f98958cdf-tdmqk 1/1     Running   0          21s
nginx-7f98958cdf-tesqr 1/1     Running   0          21s
```

You see two pods, **nginx-7f98958cdf-tdmqk** and **nginx-7f98958cdf-tesqr**. **nginx** is the name of the Deployment. **-7f98958cdf-tdmqk** and **-7f98958cdf-tesqr** are the suffixes randomly generated by Kubernetes.

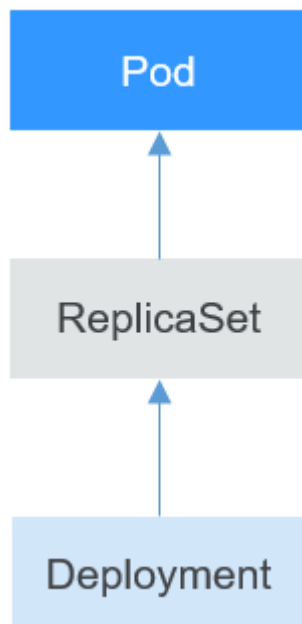
You may notice that the two suffixes share the same content **7f98958cdf** in the first part. This is because the Deployment does not control the pods directly, but through a controller named ReplicaSet. You can run the following command to query the ReplicaSet. In the command, **rs** is the abbreviation of ReplicaSet.

```
$ kubectl get rs
NAME          DESIRED  CURRENT  READY  AGE
nginx-7f98958cdf  2        2        2      1m
```

The ReplicaSet is named **nginx-7f98958cdf**, in which the suffix **-7f98958cdf** is generated randomly.

As shown in **Figure 3-11**, the Deployment controls the ReplicaSet, which then controls pods.

Figure 3-11 How does the Deployment control the pod



If you run the **kubectl describe** command to view the details of the Deployment, you can see the ReplicaSet (**NewReplicaSet: nginx-7f98958cdf (2/2 replicas created)**). In **Events**, the number of pods of the ReplicaSet is scaled out to 2. In practice, you may not operate ReplicaSet directly, but understanding that a Deployment controls a pod by controlling a ReplicaSet helps you locate problems.

```
$ kubectl describe deploy nginx
Name:          nginx
Namespace:    default
CreationTimestamp:  Sun, 16 Dec 2018 19:21:58 +0800
Labels:       app=nginx
...

NewReplicaSet: nginx-7f98958cdf (2/2 replicas created)
Events:
  Type      Reason          Age    From          Message
  ----      -
  Normal    ScalingReplicaSet  5m    deployment-controller  Scaled up replica set nginx-7f98958cdf to 2
```


Upgrade

In actual applications, upgrade is a common operation. A Deployment can easily support application upgrade.

You can set different upgrade policies for a Deployment:

- **RollingUpdate:** New pods are created gradually and then old pods are deleted. This is the default policy.
- **Recreate:** The current pods are deleted and then new pods are created.

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-6f9f58dff  2        2        2      1m
nginx-7f98958cdf  0        0        0      48m

$ kubectl get pods
NAME                READY  STATUS  RESTARTS  AGE
nginx-6f9f58dff-tdmqk  1/1    Running  0         21s
nginx-6f9f58dff-tesqr  1/1    Running  0         21s
```

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
```

- **maxSurge** specifies the maximum number of pods that can exist over **spec.replicas** in the Deployment. The default value is 25%. For example, if **spec.replicas** is set to **4**, no more than 5 pods can exist during the upgrade process, that is, the upgrade step is 1. The absolute number is calculated from the percentage by rounding up. The value can also be set to an absolute number.
- **maxUnavailable:** specifies the maximum number of pods that can be unavailable during the update process. The default value is 25%. For example, if **spec.replicas** is set to **4**, at least 3 pods exist during the upgrade process, that is, the deletion step is 1. The value can also be set to an absolute number.

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 ($2 \times 1.25 = 2.5$, rounded up to 3), and **maxUnavailable** does not allow a maximum of two pods to be unavailable ($2 \times 0.75 = 1.5$, 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.

3.4.2 StatefulSet

StatefulSet

All pods under a Deployment have the same characteristics except for the name and IP address. If required, a Deployment can use the pod template to create a new pod. If not required, the Deployment can delete any one of the pods.

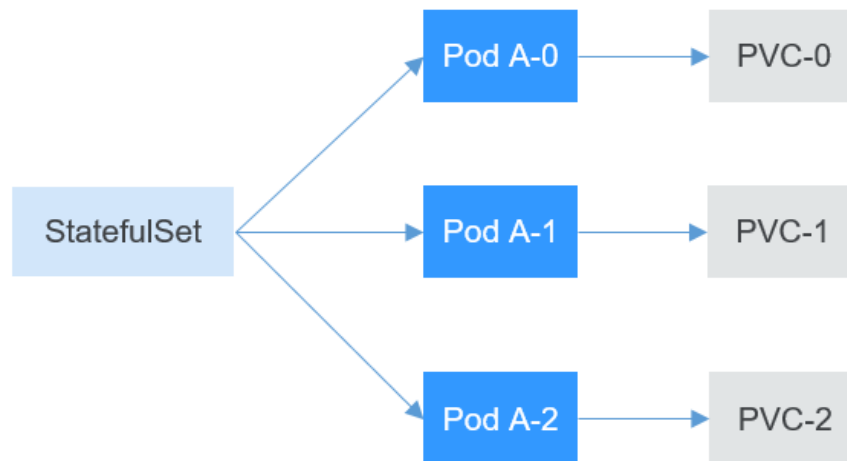
However, Deployments cannot meet the requirements in some distributed scenarios when each pod requires its own status or in a distributed database where each pod requires independent storage.

With detailed analysis, it is found that each part of distributed stateful applications plays a different role. For example, the database nodes are deployed in active/standby mode, and pods are dependent on each other. In this case, you need to meet the following requirements for the pods:

- A pod can be recognized by other pods. Therefore, a pod must have a fixed identifier.
- Each pod has an independent storage device. After a pod is deleted and then restored, the data read from the pod must be the same as the previous one. Otherwise, the pod status is inconsistent.

To address the preceding requirements, Kubernetes provides StatefulSets.

1. A StatefulSet provides 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 host name remain unchanged.
2. A StatefulSet provides a fixed access domain name for each pod through the headless Service (described in following sections).
3. The StatefulSet creates PersistentVolumeClaims (PVCs) with fixed identifiers to ensure that pods can access the same persistent data after being rescheduled.



The following describes how to create a StatefulSet and experience its features.

Creating a Headless Service

As described above, a headless Service is required for pod access when a StatefulSet is created. For details about the Service, see [Services](#). The following describes how to create a headless Service.

Use the following file to describe the headless Service:

- **spec.clusterIP:** Set it to **None**, which indicates a headless Service is to be created.
- **spec.ports.port:** indicates the number of the port used for communication between pods.
- **spec.ports.name:** indicates the name of the port used for communication between pods.

```

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.
  
```

Run the following command to create a headless Service:

```

# kubectl create -f headless.yaml
service/nginx created
  
```

After the Service is created, you can query the Service information.

```

# kubectl get svc
NAME      TYPE      CLUSTER-IP  EXTERNAL-IP  PORT(S)  AGE
nginx     ClusterIP None         <none>       80/TCP   5s
  
```

Creating a StatefulSet

The YAML definition of StatefulSets is basically the same as that of other objects. The differences are as follows:

- **serviceName** specifies the headless Service used by the StatefulSet. You need to specify the name of the headless Service.
- **volumeClaimTemplates** is used to apply for a **PVC**. A template named **data** is defined, which will create a PVC for each pod. **storageClassName** specifies the persistent storage class. For details, see [PersistentVolumes, PersistentVolumeClaims, and StorageClasses](#). **volumeMounts** is used to mount storage to pods. If no storage is required, you can delete the **volumeClaimTemplates** and **volumeMounts** fields.

```
apiVersion: apps/v1
kind: StatefulSet
metadata:
  name: nginx
spec:
  serviceName: nginx           # Name of the headless Service
  replicas: 3
  selector:
    matchLabels:
      app: nginx
  template:
    metadata:
      labels:
        app: nginx
    spec:
      containers:
        - name: container-0
          image: nginx:alpine
          resources:
            limits:
              cpu: 100m
              memory: 200Mi
            requests:
              cpu: 100m
              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
          spec:
            accessModes:
              - ReadWriteMany
            resources:
              requests:
                storage: 1Gi
            storageClassName: csi-nas           # Persistent storage class
```

Run the following command to create a StatefulSet:

```
# kubectl create -f statefulset.yaml
statefulset.apps/nginx created
```

After the command is executed, query the StatefulSet and pods. The suffix of the pod names starts from 0 and increases to 2.

```
# kubectl get statefulset
NAME    READY  AGE
nginx  3/3    107s
```

```
# kubectl get pods
NAME     READY   STATUS    RESTARTS   AGE
nginx-0  1/1     Running   0           112s
nginx-1  1/1     Running   0           69s
nginx-2  1/1     Running   0           39s
```

In this case, if you manually delete the **nginx-1** pod and query the pods again, you can see that a pod with the same name is created. According to **5s** under **AGE**, it is found that the **nginx-1** pod is newly created.

```
# kubectl delete pod nginx-1
pod "nginx-1" deleted

# kubectl get pods
NAME     READY   STATUS    RESTARTS   AGE
nginx-0  1/1     Running   0           3m4s
nginx-1  1/1     Running   0           5s
nginx-2  1/1     Running   0           1m10s
```

Access the container and check its host names. The host names are **nginx-0**, **nginx-1**, and **nginx-2**.

```
# kubectl exec nginx-0 -- sh -c 'hostname'
nginx-0
# kubectl exec nginx-1 -- sh -c 'hostname'
nginx-1
# kubectl exec nginx-2 -- sh -c 'hostname'
nginx-2
```

In addition, you can view the PVCs created by the StatefulSet. These PVCs are named in the format of **PVC name-StatefulSet name-No.** and are in the **Bound** state.

```
# kubectl get pvc
NAME          STATUS   VOLUME                                     CAPACITY   ACCESS MODES   STORAGECLASS   AGE
data-nginx-0  Bound   pvc-f58bc1a9-6a52-4664-a587-a9a1c904ba29  1Gi        RWX            csi-nas        2m24s
data-nginx-1  Bound   pvc-066e3a3a-fd65-4e65-87cd-6c3fd0ae6485  1Gi        RWX            csi-nas        101s
data-nginx-2  Bound   pvc-a18cf1ce-708b-4e94-af83-766007250b0c  1Gi        RWX            csi-nas        71s
```

Network Identifier of a StatefulSet

After a StatefulSet is created, you can see that each pod has a fixed name. The headless Service provides a fixed domain name for pods by using DNS. In this way, pods can be accessed using the domain name. Even if the IP address of the pod changes when the pod is re-created, the domain name remains unchanged.

After a headless Service is created, the IP address of each pod corresponds to a domain name in the following format:

<pod-name>.<svc-name>.<namespace>.svc.cluster.local

For example, the domain names of the three pods are as follows:

- nginx-0.nginx.default.svc.cluster.local
- nginx-1.nginx.default.svc.cluster.local
- nginx-2.nginx.default.svc.cluster.local

In actual access, **.<namespace>.svc.cluster.local** can be omitted.

Create a pod from the **tutum/dnsutils** image. Then, access the container of the pod and run the **nslookup** command to view the domain name of the pod. The IP

address of the pod can be parsed. The IP address of the DNS server is **10.247.3.10**. When a CCE cluster is created, the `coredns` add-on is installed by default to provide the DNS service. The functions of `coredns` will be described in [Kubernetes Networking](#).

```
$ kubectl run -i --tty --image tutum/dnsutils dnsutils --restart=Never --rm /bin/sh
If you don't 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

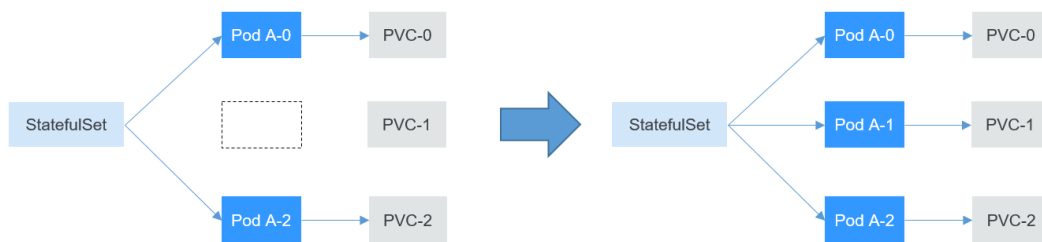
/# nslookup nginx-2.nginx
Server:      10.247.3.10
Address:    10.247.3.10#53
Name:      nginx-2.nginx.default.svc.cluster.local
Address: 172.16.0.19
```

In this case, if you manually delete the two pods, query the IP addresses of the pods re-created by the StatefulSet, and run the `nslookup` command to resolve the domain names of the pods, you can still get `nginx-0.nginx` and `nginx-1.nginx`. This ensures that the network identifier of the StatefulSet remains unchanged.

StatefulSet Storage Status

As mentioned above, StatefulSets can use PVCs for persistent storage to ensure that the same persistent data can be accessed after pods are rescheduled. When pods are deleted, PVCs are not deleted.

Figure 3-12 Process for a StatefulSet to re-create a pod



After the Pod A-1 is deleted and recreated, the PVC-1 is rebound to the Pod A-1.

Run the following command to write some data into the `/usr/share/nginx/html` directory of `nginx-1`. For example, change the content of `index.html` to **hello world**.

```
# kubectl exec nginx-1 -- sh -c 'echo hello world > /usr/share/nginx/html/index.html'
```

After the modification, if you access `https://localhost`, **hello world** is returned.

```
# kubectl exec -it nginx-1 -- curl localhost
hello world
```

In this case, if you manually delete the **nginx-1** pod and query the pods again, you can see that a pod with the same name is created. According to **4s** under **AGE**, it is found that the **nginx-1** pod is newly created.

```
# kubectl delete pod nginx-1
pod "nginx-1" deleted

# kubectl get pods
NAME      READY   STATUS    RESTARTS   AGE
nginx-0   1/1     Running   0           14m
nginx-1   1/1     Running   0           4s
nginx-2   1/1     Running   0           13m
```

Access the **index.html** page of the pod again. **hello world** is still returned, which indicates that the same storage medium is accessed.

```
# kubectl exec -it nginx-1 -- curl localhost
hello world
```

3.4.3 Job and Cron Job

Job and Cron Job

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).

Creating a Job

The following is an example job, which calculates π till the 2000th digit and prints the output. 50 pods need to be run before the job is ended. In this example, print π calculation results for 50 times, and run five pods concurrently. If a pod fails to be run, a maximum of five retries are supported.

```
apiVersion: batch/v1
kind: Job
metadata:
  name: pi-with-timeout
spec:
  completions: 50      # Number of pods that need to run successfully to end the job
  parallelism: 5       # Number of pods that run concurrently. The default value is 1.
  backoffLimit: 5      # Maximum number of retries performed if a pod fails. When the limit is reached,
  it will not try again.
  activeDeadlineSeconds: 10 # Timeout interval of pods. Once the time is reached, all pods of the job are
  terminated.
  template:            # Pod definition
    spec:
      containers:
        - name: pi
          image: perl
          command:
```

```
- perl
- "-Mbignum=bpi"
- "-wle"
- print bpi(2000)
restartPolicy: Never
```

Based on the **completions** and **Parallelism** settings, jobs can be classified as follows:

Table 3-1 Job types

Job Type	Description	Example
One-off job	One pod runs until it is successfully ends.	Database migration
Jobs with a fixed completion count	One pod runs until the specified completion count is reached.	Pod for processing work queues
Parallel jobs with a fixed completion count	Multiple pods run until the specified completion count is reached.	Multiple pods for processing work queues concurrently
Parallel jobs	One or more pods run until one pod is successfully ended.	Multiple pods for processing work queues concurrently

Creating a Cron Job

Compared with a job, a cron job is a scheduled job. A cron job runs a job periodically on a specified schedule, and the job creates pods.

```
apiVersion: batch/v1beta1
kind: CronJob
metadata:
  name: cronjob-example
spec:
  schedule: "0,15,30,45 * * * *"      # Scheduling configuration
  jobTemplate:                        # Job definition
    spec:
      template:
        spec:
          restartPolicy: OnFailure
          containers:
            - name: main
              image: pi
```

The format of the cron job is as follows:

- Minute
- Hour
- Day of month
- Month
- Day of week

For example, in **0,15,30,45 * * * ***, commas separate minutes, the first asterisk (*) indicates the hour, the second asterisk indicates the day of the month, the third asterisk indicates the month, and the fourth asterisk indicates the day of the week.

If you want to run the job every half an hour on the first day of each month, set this parameter to **0,30 * 1 * ***. If you want to run the job on 3:00 a.m. every Sunday, set this parameter to **0 3 * * 0**.

For details about the cron job format, visit <https://en.wikipedia.org/wiki/Cron>.

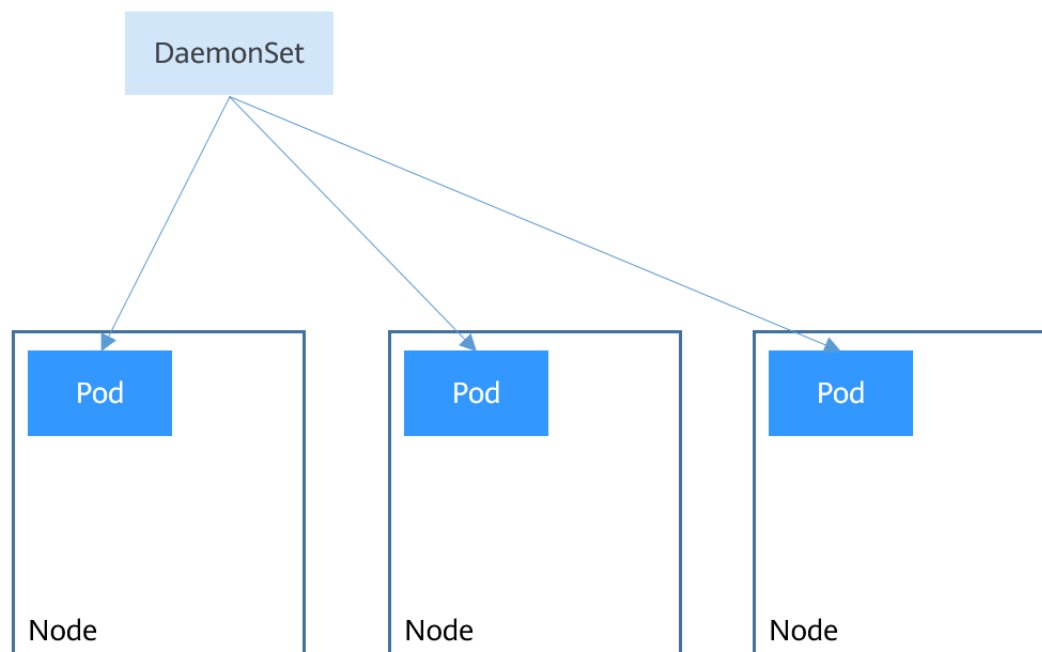
3.4.4 DaemonSet

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 3-13 DaemonSet



Creating a DaemonSet

The following is an example of a DaemonSet:

```
apiVersion: apps/v1
kind: DaemonSet
metadata:
  name: nginx-daemonset
  labels:
    app: nginx-daemonset
spec:
```

```

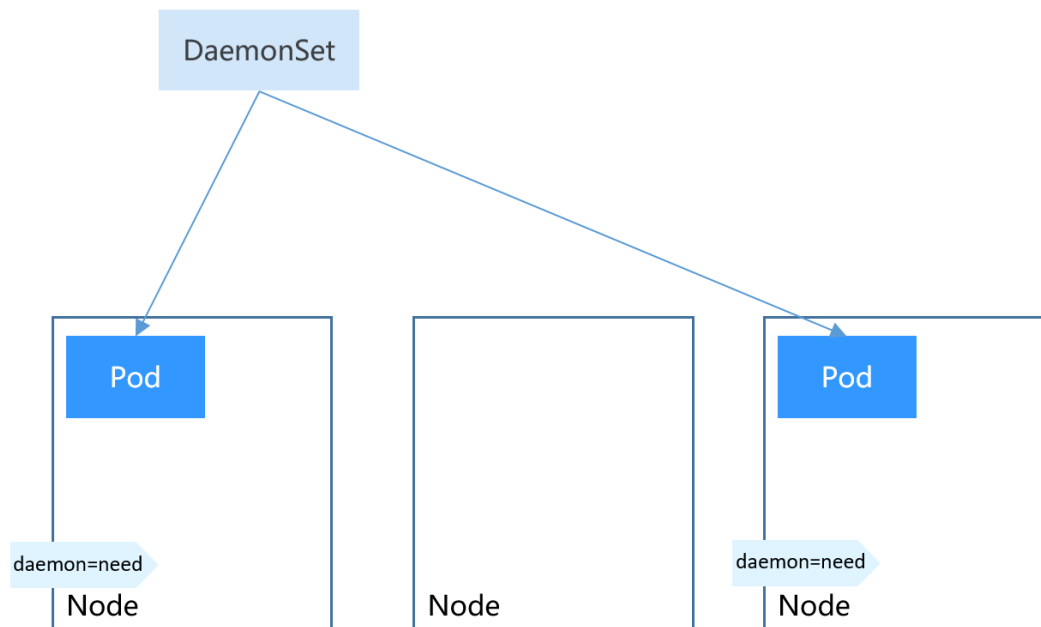
selector:
  matchLabels:
    app: nginx-daemonset
template:
  metadata:
    labels:
      app: nginx-daemonset
  spec:
    nodeSelector:           #Node selection. A pod is created on a node only when the node meets
daemon=need.
    daemon: need
  containers:
  - name: nginx-daemonset
    image: nginx:alpine
  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**, as shown in the following figure. If you want to create a pod on each node, delete the label.

Figure 3-14 DaemonSet creating a pod on nodes with a specified label



Create a DaemonSet.

```

$ kubectl create -f daemonset.yaml
daemonset.apps/nginx-daemonset created

```

Run the following command. The output shows that **nginx-daemonset** creates no pods on nodes.

```
$ kubectl get ds
NAME           DESIRED  CURRENT  READY  UP-TO-DATE  AVAILABLE  NODE SELECTOR  AGE
nginx-daemonset  0        0        0      0           0          daemon=need    16s
```

```
$ kubectl get pods
No resources found in default namespace.
```

This is because no nodes have the **daemon=need** label. Run the following command to query the labels of nodes:

```
$ kubectl get node --show-labels
NAME           STATUS  ROLES  AGE  VERSION  LABELS
192.168.0.212  Ready  <none>  83m  v1.15.6-r1-20.3.0.2.B001-15.30.2  beta.kubernetes.io/arch=amd64 ...
192.168.0.94   Ready  <none>  83m  v1.15.6-r1-20.3.0.2.B001-15.30.2  beta.kubernetes.io/arch=amd64 ...
192.168.0.97   Ready  <none>  83m  v1.15.6-r1-20.3.0.2.B001-15.30.2  beta.kubernetes.io/arch=amd64 ...
```

Add the **daemon=need** label to node **192.168.0.212**, and then query the pods of **nginx-daemonset** again. It is found that a pod has been created on node **192.168.0.212**.

```
$ kubectl label node 192.168.0.212 daemon=need
node/192.168.0.212 labeled
```

```
$ kubectl get ds
NAME           DESIRED  CURRENT  READY  UP-TO-DATE  AVAILABLE  NODE SELECTOR  AGE
nginx-daemonset  1        1        0      1           0          daemon=need    116s
```

```
$ kubectl get pod -o wide
NAME           READY  STATUS  RESTARTS  AGE  IP           NODE
nginx-daemonset-g9b7j  1/1   Running  0          18s  172.16.3.0  192.168.0.212
```

Add the **daemon=need** label to node **192.168.0.94**. You can find that a pod is created on this node as well.

```
$ kubectl label node 192.168.0.94 daemon=need
node/192.168.0.94 labeled
```

```
$ kubectl get ds
NAME           DESIRED  CURRENT  READY  UP-TO-DATE  AVAILABLE  NODE SELECTOR  AGE
nginx-daemonset  2        2        1      2           1          daemon=need    2m29s
```

```
$ kubectl get pod -o wide
NAME           READY  STATUS             RESTARTS  AGE  IP           NODE
nginx-daemonset-6jjxz  0/1   ContainerCreating  0      8s   <none>      192.168.0.94
nginx-daemonset-g9b7j  1/1   Running            0      42s  172.16.3.0  192.168.0.212
```

Modify the **daemon=need** label of node **192.168.0.94**. You can find the DaemonSet deletes its pod from the node.

```
$ kubectl label node 192.168.0.94 daemon=no --overwrite
node/192.168.0.94 labeled
```

```
$ kubectl get ds
NAME           DESIRED  CURRENT  READY  UP-TO-DATE  AVAILABLE  NODE SELECTOR  AGE
nginx-daemonset  1        1        1      1           1          daemon=need    4m5s
```

```
$ kubectl get pod -o wide
NAME           READY  STATUS  RESTARTS  AGE  IP           NODE
nginx-daemonset-g9b7j  1/1   Running  0          2m23s  172.16.3.0  192.168.0.212
```

3.4.5 Affinity and Anti-Affinity Scheduling

A nodeSelector provides a very simple way to constrain pods to nodes with particular labels, as mentioned in [DaemonSet](#). The affinity and anti-affinity feature greatly expands the types of constraints you can express.

You can define affinity and anti-affinity in node and pod levels. 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.

Node Affinity

Node affinity is conceptually similar to a nodeSelector as it allows you to constrain which nodes your pod is eligible to be scheduled on, based on labels on the node. The following output lists the labels of node **192.168.0.212**.

```
$ 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=eu-west-0
              failure-domain.beta.kubernetes.io/zone=eu-west-0a
              kubernetes.io/arch=amd64
              kubernetes.io/availablezone=eu-west-0a
              kubernetes.io/eniquotea=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
```

These labels are automatically added by CCE during node creation. The following describes a few that are frequently used during scheduling.

- **failure-domain.beta.kubernetes.io/region**: region where the node is located. In the preceding output, the label value is **eu-west-0**, which indicates that the node is located in the Paris (France) region.
- **failure-domain.beta.kubernetes.io/zone**: availability zone to which the node belongs.
- **kubernetes.io/hostname**: host name of the node.

In addition to these automatically added labels, you can tailor labels to your service requirements, as introduced in [Label for Managing Pods](#). Generally, large Kubernetes clusters have various kinds of labels.

When you deploy pods, you can use a nodeSelector, as described in [DaemonSet](#), to constrain pods to nodes with specific labels. The following example shows how to use a nodeSelector to deploy pods only on the nodes with the **gpu=true** label.

```
apiVersion: v1
kind: Pod
metadata:
  name: nginx
spec:
  nodeSelector:      #Node selection. A pod is deployed on a node only when the node has the
                    gpu=true label.
                    gpu: true
...
```

Node affinity rules can achieve the same results, as shown in the following example.

```
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"
```

Even though the node affinity rule requires more lines, it is more expressive, which will be further described later.

requiredDuringSchedulingIgnoredDuringExecution seems to be complex, but it can be easily understood as a combination of two parts.

- The **requiredDuringScheduling** part indicates that the rule is a hard requirement, which means that the rule must be met for a pod to be scheduled onto a node.
- The **IgnoredDuringExecution** part indicates that the pods that have been running on the node are not affected. Currently, all node affinity rules provided by Kubernetes end with **IgnoredDuringExecution** as these rules affect only the pods that are being scheduled. In the future, affinity rules end with **RequiredDuringExecution** will be supported, which means that pods will be evicted from nodes that cease to satisfy the pods' label requirements.

In addition, the value of **operator** is **In**, indicating that the label value must be in the values list. Other available operator values are as follows:

- **NotIn**: The label value is not in a list.
- **Exists**: A specific label exists.
- **DoesNotExist**: A specific label does not exist.
- **Gt**: The label value is greater than a specified value (string comparison).
- **Lt**: The label value is less than a specified value (string comparison).

Note that there is no such thing as **nodeAntiAffinity** because operators **NotIn** and **DoesNotExist** provide the same function.

Now, check whether the node affinity rule takes effect. Add the **gpu=true** tag 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 Rule

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 demonstrate its effect, add a node to the cluster and ensure that the node is not in the same AZ with other nodes. After the node is created, query the AZ of the node. As shown in the following output, the newly added node is in eu-west-0a.

```
$ kubectl get node -L failure-domain.beta.kubernetes.io/zone,gpu
NAME          STATUS  ROLES  AGE  VERSION          ZONE  GPU
192.168.0.100 Ready  <none> 7h23m v1.15.6-r1-20.3.0.2.B001-15.30.2  eu-west-0a  true
192.168.0.212 Ready  <none> 8h    v1.15.6-r1-20.3.0.2.B001-15.30.2  eu-west-0b  true
192.168.0.94  Ready  <none> 8h    v1.15.6-r1-20.3.0.2.B001-15.30.2  eu-west-0b
192.168.0.97  Ready  <none> 8h    v1.15.6-r1-20.3.0.2.B001-15.30.2  eu-west-0b
```

Define a Deployment. Use the **preferredDuringSchedulingIgnoredDuringExecution** rule to set the weight of nodes in **eu-west-0a** as **80** and nodes with the **gpu=true** label as **20**. In this way, pods are preferentially deployed on the node in eu-west-0a.

```
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: failure-domain.beta.kubernetes.io/zone
          operator: In
          values:
          - eu-west-0a
    - weight: 20
      preference:
        matchExpressions:
        - key: gpu
          operator: In
          values:
          - "true"

```

After the deployment, you can find that five pods are deployed on the **192.168.0.212** node, and two pods are deployed on the **192.168.0.100** node.

```

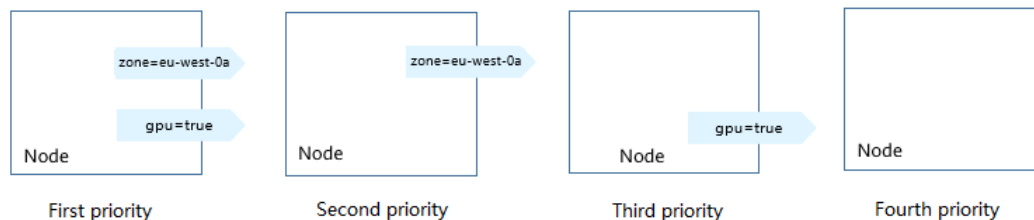
$ kubectl create -f affinity2.yaml
deployment.apps/gpu created

$ 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 **eu-west-0a** and **gpu=true** labels have the highest priority. Nodes with the **eu-west-0a** label but no **gpu=true** label have the second priority (weight: 80). Nodes with the **gpu=true** label but no **eu-west-0a** label have the third priority. Nodes without any of these two labels have the lowest priority.

Figure 3-15 Scheduling priority



From the preceding output, you can find that no pods of the Deployment are scheduled to node **192.168.0.94**. 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.

Pod Affinity

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**.

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:
                matchLabels:
                  app: 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 specifies the selection range. The scheduler selects nodes within the range based on the affinity rule defined. 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 PERFER
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
```

Define **topologyKey** in the **podAffinity** section as **prefer**.

```
affinity:
  podAffinity:
    requiredDuringSchedulingIgnoredDuringExecution:
      - topologyKey: prefer
        labelSelector:
          matchLabels:
            app: backend
```

The scheduler recognizes the nodes with the **prefer** label, that is, **192.168.0.97** and **192.168.0.94**, and then find the pods with the **app=backend** label. In this way, all frontend pods are deployed onto **192.168.0.97**.

```
$ 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
```

Pod Anti-affinity

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.

The following example defines an inter-pod anti-affinity rule, which specifies that pods must not be scheduled to nodes that already have pods with the

app=frontend label, that is, to deploy the pods of the frontend to different nodes with each node has only one replica.

```
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
          labelSelector:
            matchLabels:
              app: frontend
```

Deploy the frontend and query the deployment results. You can find that each node has only one frontend pod and one pod of the Deployment is **Pending**. This is because when the scheduler is deploying the fifth pod, all nodes already have one pod with the **app=frontend** label on them. There is no available node. Therefore, the fifth pod will remain in the **Pending** status.

```
$ 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
```

3.5 Configuration Management

3.5.1 ConfigMap

A ConfigMap is a type of resource used to store the configurations required by applications. It is used to store configuration data or configuration files in key-value pairs.

A ConfigMap allows you to decouple configurations from your environments, so that your environments can use different configurations.

Creating a ConfigMap

In the following example, a ConfigMap named **configmap-test** is created. The ConfigMap configuration data is defined in the **data** field.

```
apiVersion: v1
kind: ConfigMap
metadata:
  name: configmap-test
data:
  # Configuration data
  property_1: Hello
  property_2: World
```

Referencing a ConfigMap as an Environment Variable

ConfigMaps are usually referenced as environment variables and in volumes.

In the following example, **property_1** of **configmap-test** is used as the value of the environment variable **EXAMPLE_PROPERTY_1**. After the container is started, it will reference the value of **property_1** as the value of **EXAMPLE_PROPERTY_1**, that is, **Hello**.

```
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
    env:
    - name: EXAMPLE_PROPERTY_1
      valueFrom:
        configMapKeyRef:
          # Reference the ConfigMap.
          name: configmap-test
          key: property_1
  imagePullSecrets:
  - name: default-secret
```

Referencing a ConfigMap in a Volume

Referencing a ConfigMap in a volume is to fill its data in configuration files in the volume. Each piece of data is saved in a file. The key is the file name, and the key value is the file content.

In the following example, create a volume named **vol-configmap**, reference the ConfigMap named **configmap-test** in the volume, and mount the volume to the **/tmp** directory of the container. After the pod is created, the two files **property_1** and **property_2** are generated in the **/tmp** directory of the container, and the values are **Hello** and **World**.

```
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
    volumeMounts:
    - name: vol-configmap          # Mount the volume named vol-configmap.
      mountPath: "/tmp"
  imagePullSecrets:
  - name: default-secret
  volumes:
  - name: vol-configmap
    configMap:                    # Reference the ConfigMap.
      name: configmap-test
```

3.5.2 Secret

A secret is a resource object that is encrypted for storing the authentication information, certificates, and private keys. The sensitive data will not be exposed in images or pod definitions, which is safer and more flexible.

Similar to a ConfigMap, a secret stores data in key-value pairs. The difference is that a secret is encrypted, and is suitable for storing sensitive information.

Base64 Encoding

A secret stores data in key-value pairs, the same form as that of a ConfigMap. The difference is that the value must be encoded using Base64 when a secret is created.

To encode a character string using Base64, run the **echo -n *to-be-encoded content* | base64** command. The following is an example:

```
root@ubuntu:~# echo -n "3306" | base64
MzMwNg==
```

Creating a Secret

The secret defined in the following example contains two key-value pairs.

```
apiVersion: v1
kind: Secret
metadata:
  name: mysecret
data:
  key1: aGVsbG8gd29ybGQ= # hello world, a value encoded using Base64
  key2: MzMwNg==        # 3306, a value encoded using Base64
```

Referencing a Secret as an Environment Variable

Secrets are usually injected into containers as environment variables, as shown in the following example.

```
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
    env:
    - name: key
      valueFrom:
        secretKeyRef:
          name: mysecret
          key: key1
    imagePullSecrets:
    - name: default-secret
```

Referencing a Secret in a Volume

Referencing a secret in a volume is to fill its data in configuration files in the volume. Each piece of data is saved in a file. The key is the file name, and the key value is the file content.

In the following example, create a volume named **vol-secret**, reference the secret named **mysecret** in the volume, and mount the volume to the **/tmp** directory of the container. After the pod is created, the two files **key1** and **key2** are generated in the **/tmp** directory of the container.

```
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
    volumeMounts:
    - name: vol-secret          # Mount the volume named vol-secret.
      mountPath: "/tmp"
    imagePullSecrets:
    - name: default-secret
  volumes:
  - name: vol-secret
    secret:                    # Reference the secret.
      secretName: mysecret
```

In the pod container, you can find the two files **key1** and **key2** in the **/tmp** directory. The values in the files are the values encoded using Base64, which are **hello world** and **3306**.

3.6 Kubernetes Networking

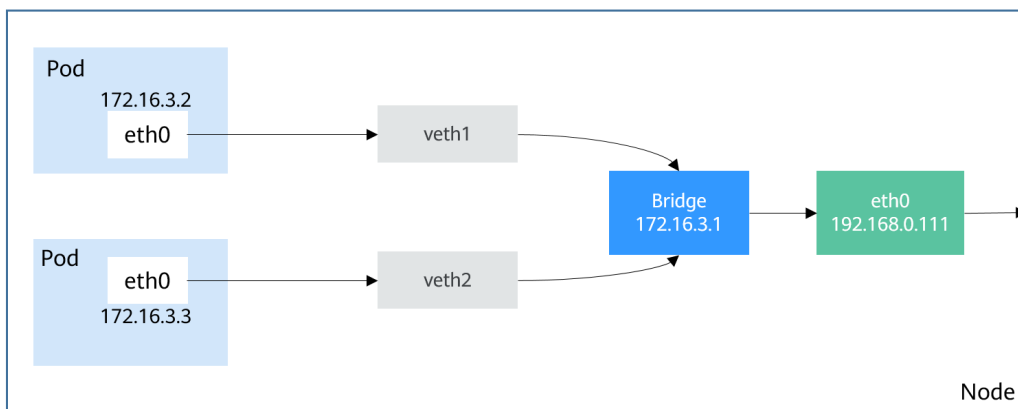
3.6.1 Container Networking

Networking among pods, clusters, and nodes is not implemented by Kubernetes itself, but by the Container Network Interface (CNI) plug-ins. There are many open-source CNI plug-ins, such as Flannel and Calico. CCE also provides customized CNI plug-ins for you to use VPCs when running Kubernetes.

Kubernetes requires that pods in a cluster can communicate with each other and the pods must be connected through a non-NAT network. That is, the source IP address of the received data packet is that of the pod that sends the data packet. Pods are also required to communicate with nodes through a non-NAT network. However, when the pod accesses an object outside the cluster, the source IP address is changed to the node IP address.

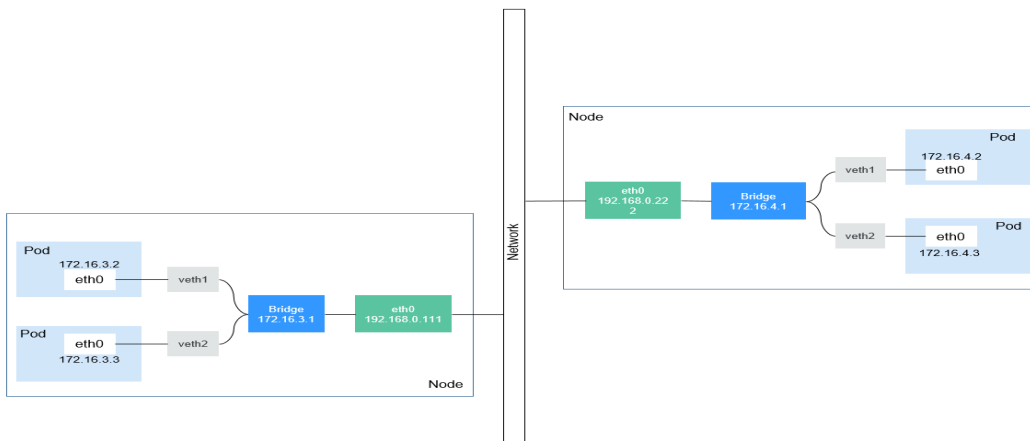
A pod is connected to external systems through a virtual Ethernet interface pair (veth pair). For pods on the same node, they communicate with each other through a Linux bridge, as shown in the following figure.

Figure 3-16 Communication for pods on the same node



Bridges between different nodes can be implemented in multiple modes. However, in a cluster, the pod IP address must be unique. Therefore, cross-node bridges will use different CIDR blocks to prevent duplicate pod IP addresses.

Figure 3-17 Communication for pods on different nodes



The following sections [Services](#) and [Ingresses](#) will describe how Kubernetes provides access solutions for users based on the container networking.

3.6.2 Services

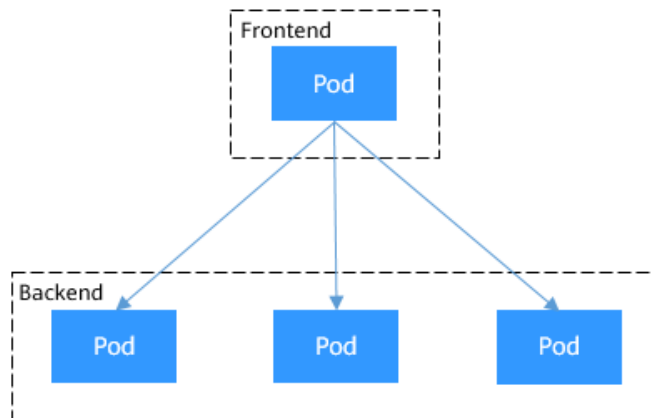
Direct Access to a Pod

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 3-18](#). 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 3-18 Inter-pod access

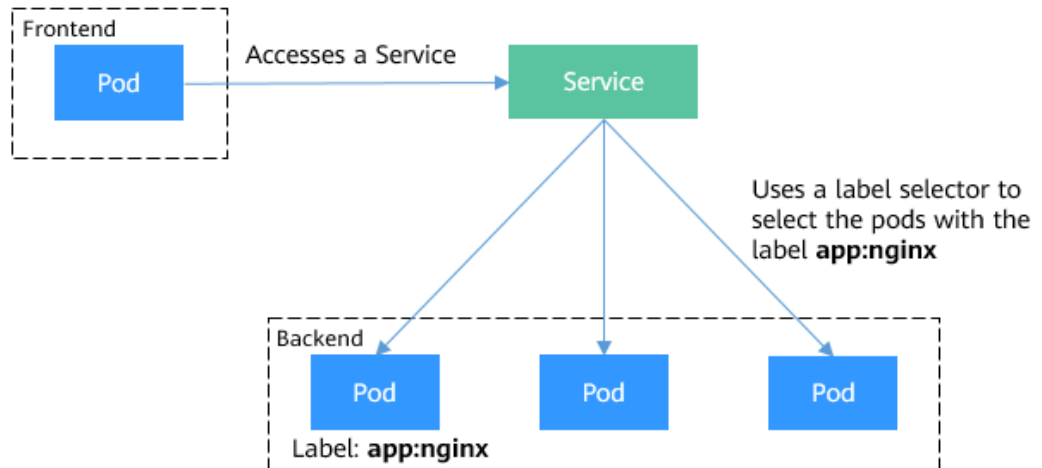


Using Services for Pod Access

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 3-19](#).

Figure 3-19 Accessing pods through a Service



Creating Backend Pods

Create a Deployment with three replicas, that is, three pods with label **app: nginx**.

```
apiVersion: apps/v1
kind: Deployment
metadata:
  name: nginx
spec:
  replicas: 3
  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
```

Creating a Service

In the following example, we create a Service named **nginx**, and use a selector to select the pod with the label **app:nginx**. The port of the target pod is port 80 while the exposed port of the Service is port 8080.

The Service can be accessed using **Service name:Exposed port**. In the example, **nginx:8080** is used. In this case, other pods can access the pod associated with **nginx** using **nginx:8080**.

```
apiVersion: v1
kind: Service
metadata:
```



```
name: nginx      #Service name
spec:
  selector:      #Label selector, which selects pods with the label of app=nginx
    app: nginx
  ports:
    - name: service0
      targetPort: 80 #Pod port
      port: 8080    #Service external port
      protocol: TCP #Forwarding protocol type. The value can be TCP or UDP.
      type: ClusterIP #Service type
```

Save the Service definition to **nginx-svc.yaml** and use `kubectl` to create the Service.

```
$ kubectl create -f nginx-svc.yaml
service/nginx created

$ kubectl get svc
NAME         TYPE        CLUSTER-IP   EXTERNAL-IP  PORT(S)    AGE
kubernetes  ClusterIP   10.247.0.1   <none>       443/TCP    7h19m
nginx       ClusterIP   10.247.124.252 <none>       8080/TCP   5h48m
```

You can see that the Service has a ClusterIP, which is fixed unless the Service is deleted. You can use this ClusterIP to access the Service inside the cluster.

Create a pod and use the ClusterIP to access the pod. Information similar to the following is returned.

```
$ kubectl run -i --tty --image nginx:alpine test --rm /bin/sh
If you don't see a command prompt, try pressing enter.
/ # curl 10.247.124.252:8080
<!DOCTYPE html>
<html>
<head>
<title>Welcome to nginx!</title>
...
```

Using ServiceName to Access a Service

After the DNS resolves the domain name, you can use **ServiceName:Port** to access the Service, the most common practice in Kubernetes. When you are creating a CCE cluster, you are required to install the `coredns` add-on by default. You can view the pods of CoreDNS 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.

For example, if the Service named **nginx** is created, you can access the Service through **nginx:8080** and then access backend pods.

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.

Now, create a pod and access the pod. Query the IP address of the nginx Service domain name, which is 10.247.124.252. Access the domain name of the pod and information similar to the following is returned.

```
$ kubectl run -i --tty --image tutum/dnsutils dnsutils --restart=Never --rm /bin/sh
If you don't see a command prompt, try pressing enter.
/ # nslookup nginx
Server:      10.247.3.10
Address:    10.247.3.10#53

Name:   nginx.default.svc.cluster.local
Address: 10.247.124.252

/ # curl nginx:8080
<!DOCTYPE html>
<html>
<head>
<title>Welcome to nginx!</title>
...
```

Using Services for Service Discovery

After a Service is deployed, it can discover the pod no matter how the pod changes.

If you run the **kubectl describe** command to query the Service, information similar to the following is displayed:

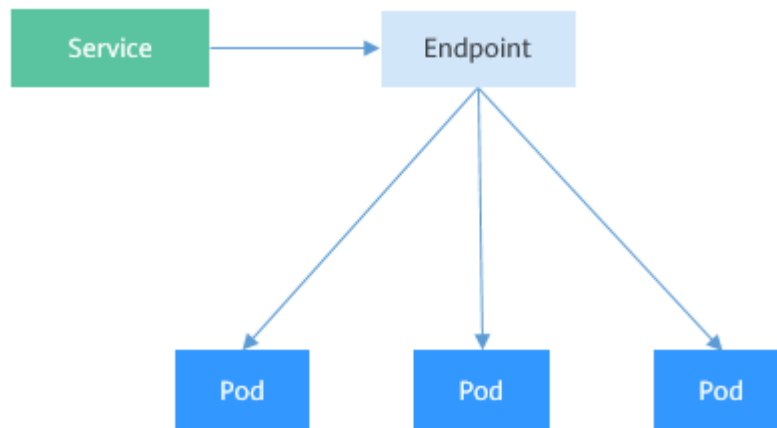
```
$ kubectl describe svc nginx
Name:          nginx
.....
Endpoints:    172.16.2.132:80,172.16.3.6:80,172.16.3.7:80
.....
```

One Endpoints record is displayed. An endpoint is also a resource object in Kubernetes. Kubernetes monitors the pod IP addresses through endpoints so that a Service can discover pods.

```
$ kubectl get endpoints
NAME           ENDPOINTS                                     AGE
kubernetes    192.168.0.127:5444                           7h19m
nginx         172.16.2.132:80,172.16.3.6:80,172.16.3.7:80 5h48m
```

In this example, **172.16.2.132:80** is the **IP:port** of the pod. You can run the following command to view the IP address of the pod, which is the same as the preceding IP address.

```
$ kubectl get po -o wide
NAME           READY   STATUS    RESTARTS   AGE   IP           NODE
nginx-869759589d-dnknn 1/1     Running   0          5h40m 172.16.3.7   192.168.0.212
nginx-869759589d-fcxhh 1/1     Running   0          5h40m 172.16.3.6   192.168.0.212
nginx-869759589d-r69kh 1/1     Running   0          5h40m 172.16.2.132 192.168.0.94
```



If a pod is deleted, the Deployment re-creates the pod and the IP address of the new pod changes.

```
$ kubectl delete po nginx-869759589d-dnknn
pod "nginx-869759589d-dnknn" deleted
```

```
$ kubectl get po -o wide
NAME                READY STATUS RESTARTS AGE IP          NODE
nginx-869759589d-fcxhh 1/1   Running 0       5h41m 172.16.3.6 192.168.0.212
nginx-869759589d-r69kh 1/1   Running 0       5h41m 172.16.2.132 192.168.0.94
nginx-869759589d-w98wg 1/1   Running 0       7s    172.16.3.10 192.168.0.212
```

Check the endpoints again. You can see that the content under **ENDPOINTS** changes with the pod.

```
$ kubectl get endpoints
NAME      ENDPOINTS
kubernetes 192.168.0.127:5444
nginx     172.16.2.132:80,172.16.3.10:80,172.16.3.6:80
```

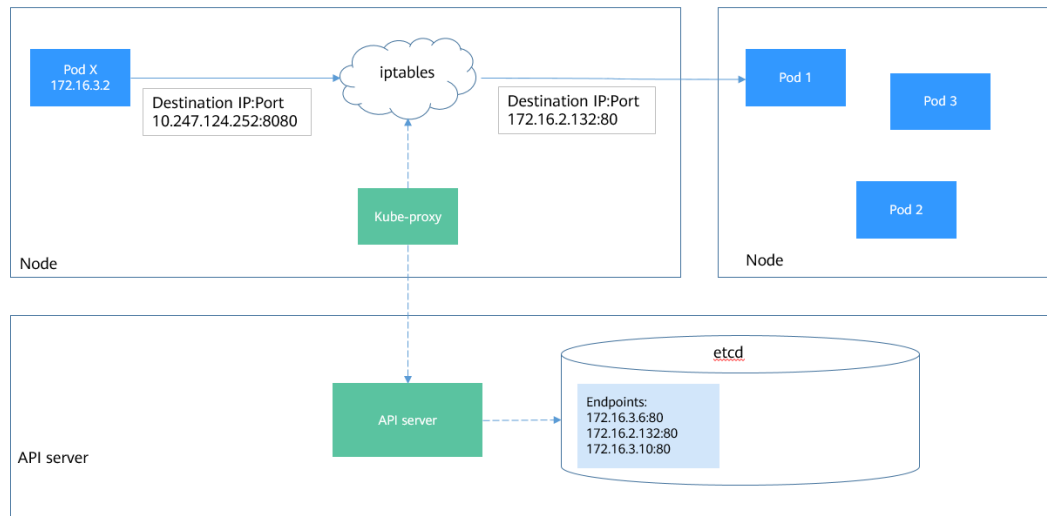
Let's take a closer look at how this happens.

We have introduced kube-proxy on worker nodes in [Figure 3-4](#). Actually, all Service-related operations are performed by kube-proxy. When a Service is created, Kubernetes allocates an IP address to the Service and notifies kube-proxy on all nodes of the Service creation through the API server. After receiving the notification, each kube-proxy records the relationship between the Service and the IP address/port pair through iptables. In this way, the Service can be queried on each node.

The following figure shows how a Service is accessed. Pod X accesses the Service (10.247.124.252:8080). When pod X sends data packets, the destination IP:Port is replaced with the IP:Port of pod 1 based on the iptables rule. In this way, the real backend pod can be accessed through the Service.

In addition to recording the relationship between Services and IP address/port pairs, kube-proxy also monitors the changes of Services and endpoints to ensure that pods can be accessed through Services after pods are rebuilt.

Figure 3-20 Service access process



Service Types and Application Scenarios

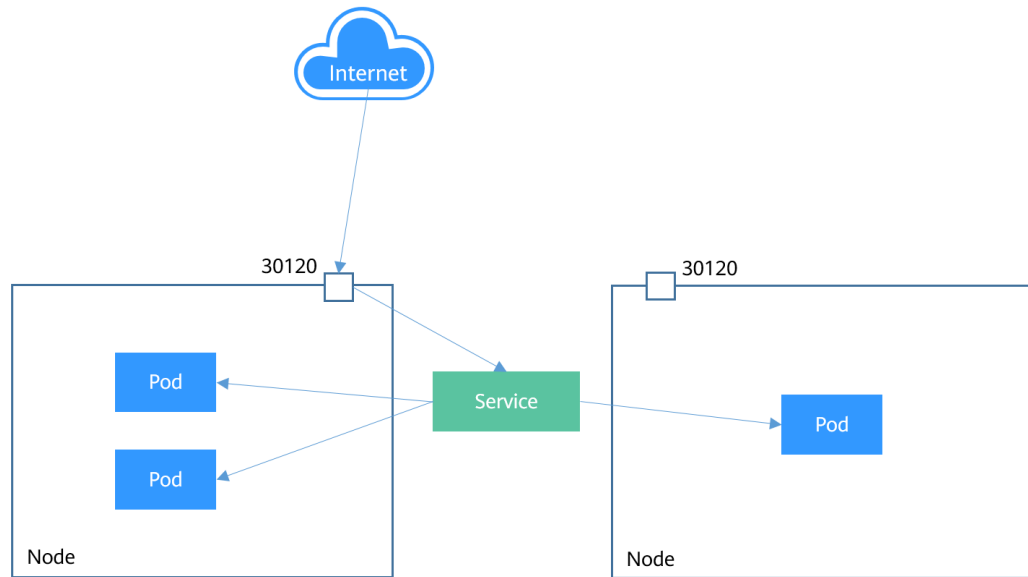
Services of the ClusterIP, NodePort, LoadBalancer, and None types have different functions.

- 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. For details, see [NodePort Services](#).
- 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. For details, see [LoadBalancer Services](#).
- None: used for mutual discovery between pods. This type of Service is also called headless Service. For details, see [Headless Service](#).

NodePort Services

A NodePort Service enables each node in a Kubernetes cluster to reserve the same port. External systems first access the node IP:Port and then the NodePort Service forwards the requests to the pod corresponding to the Service.

Figure 3-21 NodePort Service



The following is an example of creating a NodePort Service. After the Service is created, you can access backend pods through IP:Port of the node.

```
apiVersion: v1
kind: Service
metadata:
  name: nodeport-service
spec:
  type: NodePort
  ports:
    - port: 8080
      targetPort: 80
      nodePort: 30120
  selector:
    app: nginx
```

Create and view the Service. The value of **PORT** for the NodePort Service is **8080:30120/TCP**, indicating that port 8080 of the Service is mapped to port 30120 of the node.

```
$ kubectl create -f nodeport.yaml
service/nodeport-service created

$ kubectl get svc -o wide
NAME          TYPE          CLUSTER-IP    EXTERNAL-IP  PORT(S)          AGE  SELECTOR
kubernetes    ClusterIP    10.247.0.1    <none>       443/TCP          107m <none>
nginx         ClusterIP    10.247.124.252 <none>       8080/TCP          16m  app=nginx
nodeport-service NodePort     10.247.210.174 <none>       8080:30120/TCP  17s  app=nginx
```

Access the Service by using Node IP:Port number to access the pod.

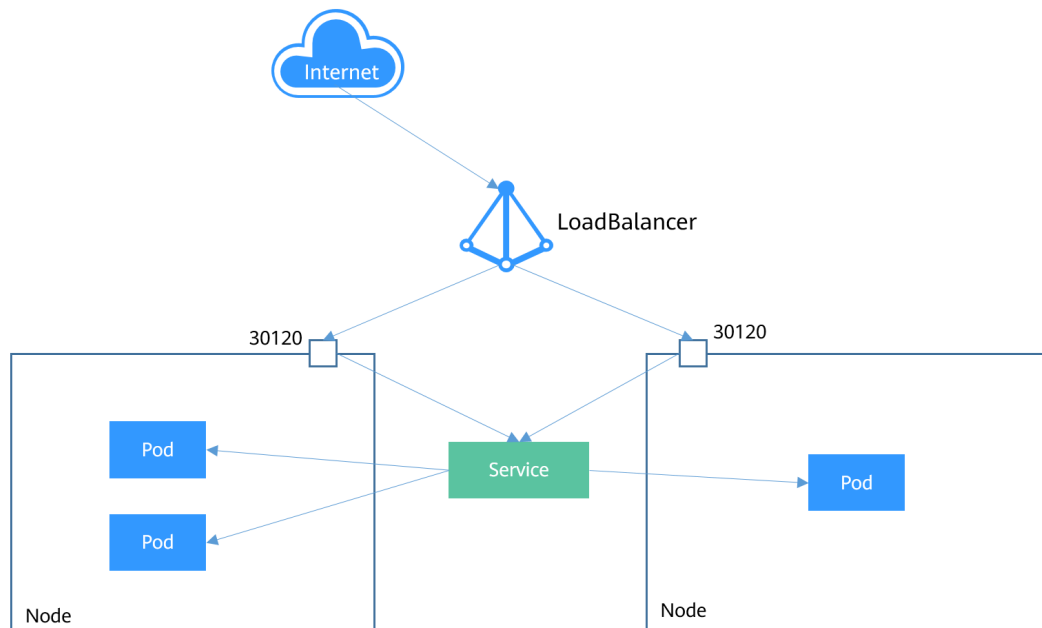
```
$ kubectl run -i --tty --image nginx:alpine test --rm /bin/sh
If you don't see a command prompt, try pressing enter.
/ # curl 192.168.0.212:30120
<!DOCTYPE html>
<html>
<head>
<title>Welcome to nginx!</title>
.....
```

LoadBalancer Services

A Service is exposed externally using a load balancer that forwards requests to the NodePort of the node.

Load balancers are not a Kubernetes component. Different cloud service providers have different load balancers. For example, CCE interconnects with Elastic Load Balance (ELB) for you to use load balancers. As a result, there are different implementation methods of creating a LoadBalancer Service.

Figure 3-22 LoadBalancer Service



The following is an example of creating a LoadBalancer Service. After the LoadBalancer Service is created, you can access backend pods through IP:Port of the load balancer.

```
apiVersion: v1
kind: Service
metadata:
  annotations:
    kubernetes.io/elb.id: 3c7caa5a-a641-4bff-801a-feace27424b6
  labels:
    app: nginx
    name: nginx
spec:
  loadBalancerIP: 10.78.42.242 # IP address of the load balancer
  ports:
  - name: service0
    port: 80
    protocol: TCP
    targetPort: 80
    nodePort: 30120
  selector:
    app: nginx
  type: LoadBalancer # Service type (LoadBalancer)
```

The parameters in **annotations** under **metadata** are required for CCE LoadBalancer Services. They specify the load balancer to which the Service is bound. CCE also allows you to create a load balancer when creating a LoadBalancer Service. For details, see [LoadBalancer](#).

Headless Service

The preceding types of 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 in [StatefulSet](#) 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 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.
```

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 don't 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

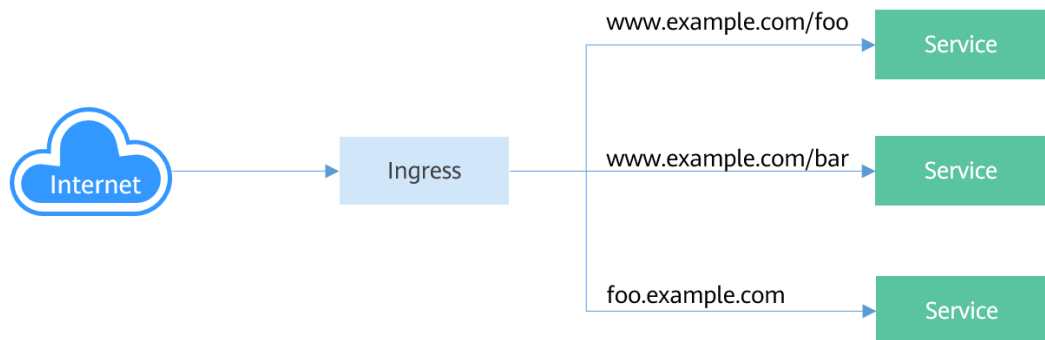
/ # nslookup nginx-2.nginx
Server:      10.247.3.10
Address:    10.247.3.10#53
Name:   nginx-2.nginx.default.svc.cluster.local
Address: 172.16.0.19
```

3.6.3 Ingresses

Why We Need Ingresses

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 3-23 Ingress and Service

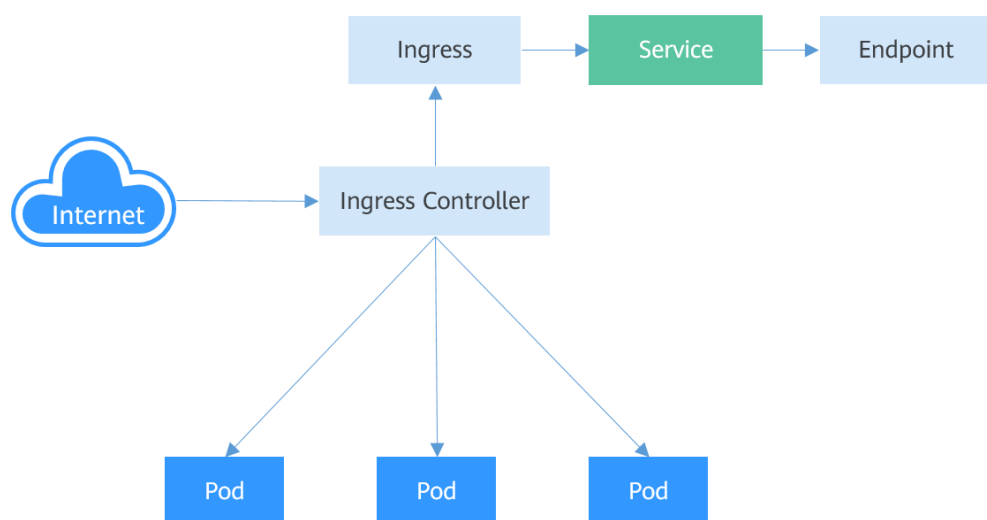


Ingress Working Mechanism

To use ingresses, you must install Ingress Controller on your Kubernetes cluster. Ingress Controller can be implemented in multiple modes. The most common one is **NGINX Ingress Controller** maintained by Kubernetes. CCE works with Elastic Load Balance (ELB) to implement layer-7 load balancing (via ingresses).

An external request is first sent to Ingress Controller. Then, Ingress Controller locates the corresponding Service based on the routing rule of an ingress, queries the IP address of the pod through the Endpoint, and forwards the request to the pod.

Figure 3-24 Ingress working mechanism



Creating an Ingress

In the following example, an ingress that uses the HTTP protocol, associates with backend Service **nginx:8080**, and uses a load balancer (specified by **metadata.annotations**) is created. After the request for accessing **http://192.168.10.155:8080/test** is initiated, the traffic is forwarded to Service **nginx:8080**, which in turn forwards the traffic to the corresponding pod.

```
apiVersion: networking.k8s.io/v1beta1
kind: Ingress
metadata:
  name: test-ingress
  annotations:
    kubernetes.io/ingress.class: cce
    kubernetes.io/elb.port: '8080'
    kubernetes.io/elb.ip: 192.168.10.155
    kubernetes.io/elb.id: aa7cf5ec-7218-4c43-98d4-c36c0744667a
spec:
  rules:
  - host: ""
    http:
      paths:
      - backend:
          serviceName: nginx
          servicePort: 8080
        path: "/test"
    property:
      ingress.beta.kubernetes.io/url-match-mode: STARTS_WITH
```

You can also set the external domain name in an ingress so that you can access the load balancer through the domain name and then access backend Services.

NOTE

Domain name-based access depends on domain name resolution. You need to point the domain name to the IP address of the load balancer. For example, you can use Domain Name Service (DNS) to resolve domain names.

```
spec:
  rules:
  - host: www.example.com # Domain name
    http:
      paths:
      - path: /
        backend:
          serviceName: nginx
          servicePort: 80
```

Accessing Multiple Services

An ingress can access multiple Services at the same time. The configuration is as follows:

- When you access **http://foo.bar.com/foo**, the backend Service **s1:80** is accessed.
- When you access **http://foo.bar.com/bar**, the backend Service **s2:80** is accessed.

```
spec:
  rules:
  - host: foo.bar.com # Host address
    http:
      paths:
      - path: "/foo"
        backend:
          serviceName: s1
```

```
servicePort: 80
- path: "/bar"
backend:
  serviceName: s2
  servicePort: 80
```

3.6.4 Readiness Probe

After a pod is created, the Service can immediately select it and forward requests to it. However, it takes time to start a pod. If the pod is not ready (it takes time to load the configuration or data, or a preheating program may need to be executed), the pod cannot process requests, and the requests will fail.

Kubernetes solves this problem by adding a readiness probe to pods. A pod with containers reporting that they are not ready does not receive traffic through Kubernetes Services.

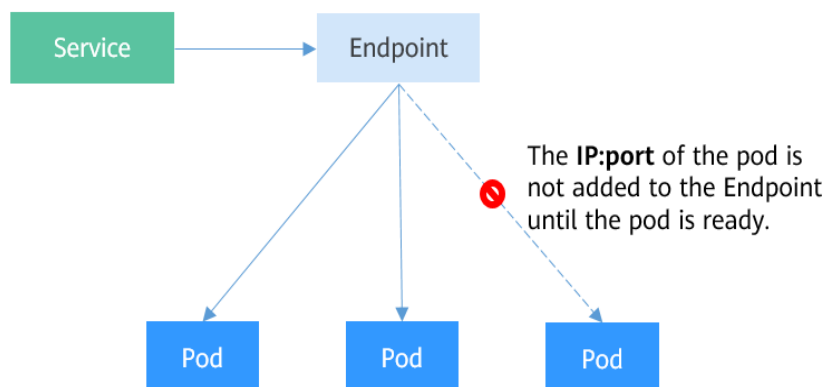
A readiness probe periodically detects a pod and determines whether the pod is ready based on its response. Similar to **Liveness Probe**, there are three types of readiness probes.

- Exec: kubelet executes a command in the target container. If the command succeeds, it returns **0**, and kubelet considers the container to be ready.
- HTTP GET: The probe sends an HTTP GET request to **IP:port** of the container. If the probe receives a 2xx or 3xx status code, the container is considered to be ready.
- TCP Socket: The kubelet attempts to establish a TCP connection with the container. If it succeeds, the container is considered ready.

How Readiness Probes Work

Endpoints can be used as a readiness probe. When a pod is not ready, the **IP:port** of the pod is deleted from the Endpoint and is added to the Endpoint after the pod is ready, as shown in the following figure.

Figure 3-25 How readiness probes work



Exec

The Exec mode is the same as the HTTP GET mode. As shown below, the probe runs the **ls /ready** command. If the file exists, **0** is returned, indicating that the pod is ready. Otherwise, a non-zero status code is returned.

```
apiVersion: apps/v1
kind: Deployment
metadata:
  name: nginx
spec:
  replicas: 3
  selector:
    matchLabels:
      app: nginx
  template:
    metadata:
      labels:
        app: nginx
    spec:
      containers:
      - image: nginx:alpine
        name: container-0
        resources:
          limits:
            cpu: 100m
            memory: 200Mi
          requests:
            cpu: 100m
            memory: 200Mi
        readinessProbe: # Readiness Probe
        exec: # Define the ls /ready command.
        command:
        - ls
        - /ready
      imagePullSecrets:
      - name: default-secret
```

Save the definition of the Deployment to the **deploy-read.yaml** file, delete the previously created Deployment, and use the **deploy-read.yaml** file to recreate the Deployment.

```
# kubectl delete deploy nginx
deployment.apps "nginx" deleted

# kubectl create -f deploy-read.yaml
deployment.apps/nginx created
```

The **nginx** image does not contain the **/ready** file. Therefore, the container is not in the **Ready** status after the creation, as shown below. Note that the values in the **READY** column are **0/1**, indicating that the containers are not ready.

```
# kubectl get po
NAME                READY   STATUS    RESTARTS   AGE
nginx-7955fd7786-686hp 0/1     Running  0          7s
nginx-7955fd7786-9tgwq 0/1     Running  0          7s
nginx-7955fd7786-bqsbj 0/1     Running  0          7s
```

Create a Service.

```
apiVersion: v1
kind: Service
metadata:
  name: nginx
spec:
  selector:
    app: nginx
  ports:
```

```
- name: service0
  targetPort: 80
  port: 8080
  protocol: TCP
  type: ClusterIP
```

Check the Service. If there are no values in the **Endpoints** line, no Endpoints are found.

```
$ kubectl describe svc nginx
Name:          nginx
.....
Endpoints:
.....
```

If a **/ready** file is created in the container to make the readiness probe succeed, the container is in the **Ready** status. Check the pod and endpoints. It is found that the container for which the **/ready** file is created is ready and an endpoint is added.

```
# kubectl exec nginx-7955fd7786-686hp -- touch /ready

# kubectl get po -o wide
NAME                READY   STATUS    RESTARTS   AGE   IP
nginx-7955fd7786-686hp 1/1     Running   0          10m   192.168.93.169
nginx-7955fd7786-9tgwq 0/1     Running   0          10m   192.168.166.130
nginx-7955fd7786-bqsbj 0/1     Running   0          10m   192.168.252.160

# kubectl get endpoints
NAME      ENDPOINTS          AGE
nginx    192.168.93.169:80 14d
```

HTTP GET

The configuration of a readiness probe is the same as that of a **liveness probe** and is also in the **containers** field of the pod description template. As shown below, the readiness probe sends an HTTP request to the pod. If the probe receives **2xx** or **3xx**, the pod is ready.

```
apiVersion: apps/v1
kind: Deployment
metadata:
  name: nginx
spec:
  replicas: 3
  selector:
    matchLabels:
      app: nginx
  template:
    metadata:
      labels:
        app: nginx
    spec:
      containers:
        - image: nginx:alpine
          name: container-0
          resources:
            limits:
              cpu: 100m
              memory: 200Mi
            requests:
              cpu: 100m
              memory: 200Mi
          readinessProbe:
            httpGet:
              path: /read
              port: 80
            # readinessProbe
            # HTTP GET definition
```

```
imagePullSecrets:
- name: default-secret
```

TCP Socket

The following example shows how to define a TCP Socket-type probe.

```
apiVersion: apps/v1
kind: Deployment
metadata:
  name: nginx
spec:
  replicas: 3
  selector:
    matchLabels:
      app: nginx
  template:
    metadata:
      labels:
        app: nginx
    spec:
      containers:
      - image: nginx:alpine
        name: container-0
        resources:
          limits:
            cpu: 100m
            memory: 200Mi
          requests:
            cpu: 100m
            memory: 200Mi
        readinessProbe:
          # readinessProbe
          tcpSocket:
            # TCP Socket definition
            port: 80
        imagePullSecrets:
          - name: default-secret
```

Advanced Settings of a Readiness Probe

Similar to a liveness probe, a readiness probe also has the same advanced configuration items. The output of the **describe** command of the **nginx** pod is as follows:

```
Readiness: exec [ls /var/ready] delay=0s timeout=1s period=10s #success=1 #failure=3
```

This is the detailed configuration information of the readiness probe.

- **delay=0s** indicates that the probe starts immediately after the container is started.
- **timeout=1s** indicates that the container must respond to the probe within 1s. Otherwise, it is considered as a failure.
- **period=10s** indicates that the probe is performed every 10s.
- **#success=1** indicates that the probe is considered successful as long as the probe succeeds once.
- **#failure=3** indicates that the probe is considered failed if it fails for three consecutive times.

These are the default configurations when the probe is created. You can customize them as follows:

```
readinessProbe: # Readiness Probe
  exec: # Define the ls /readiness/ready command
```

```
command:
- ls
- /readiness/ready
initialDelaySeconds: 10 # Readiness probes are initiated after the container has started for 10s.
timeoutSeconds: 2 # The container must respond within 2s. Otherwise, it is considered as a
failure.
periodSeconds: 30 # The probe is performed every 30s.
successThreshold: 1 # The container is considered ready as long as the probe succeeds once.
failureThreshold: 3 # The probe is considered to be failed after three consecutive failures.
```

3.6.5 NetworkPolicy

NetworkPolicy is a Kubernetes object used to restrict pod access. By setting a NetworkPolicy, you can define ingress rules specifying what addresses can be allowed to the selected pods or egress rules specifying what addresses can be allowed from the selected pods. This is equivalent to setting up a firewall at the application layer to further ensure network security.

NetworkPolicy is implemented by the network plugin of the cluster to which NetworkPolicy will apply. Therefore, the type of rules supported by NetworkPolicy depends on the network plugin. For example, CCE clusters support only ingress rules of pods.

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.

NetworkPolicy rules are classified into the following types:

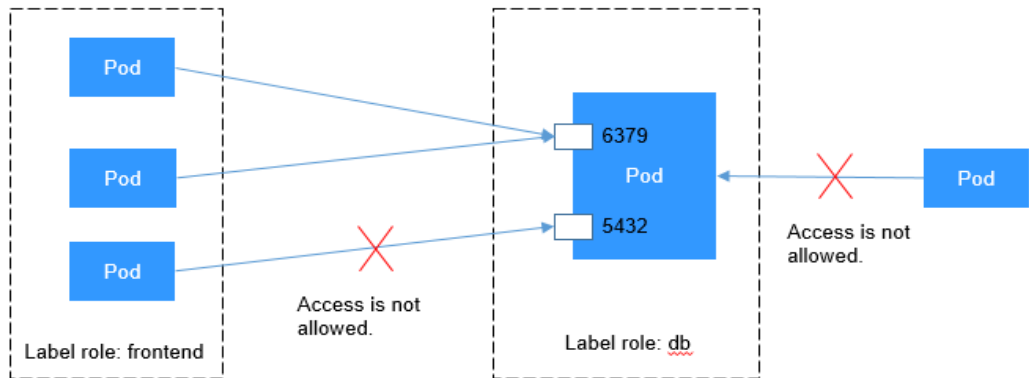
- namespaceSelector: This selects particular namespaces for which all pods should be allowed as ingress sources or egress destinations.
- podSelector: This selects particular pods in the same namespace as the NetworkPolicy which should be allowed as ingress sources or egress destinations.
- ipBlock: This selects particular IP CIDR ranges to allow as ingress sources or egress destinations. Currently, CCE does not support ipBlock.

Using podSelector to Select Ingress Sources and Egress Destinations

```
apiVersion: networking.k8s.io/v1
kind: NetworkPolicy
metadata:
  name: test-network-policy
  namespace: default
spec:
  podSelector:
    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
```

Figure 3-26 shows how podSelector selects ingress sources.

Figure 3-26 podSelector



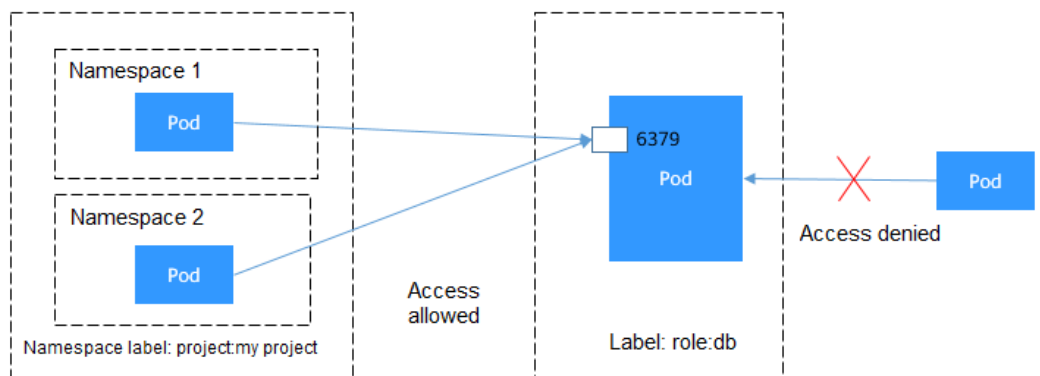
Using namespaceSelector to Select Ingress Sources

```

apiVersion: networking.k8s.io/v1
kind: NetworkPolicy
metadata:
  name: test-network-policy
spec:
  podSelector:
    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
    
```

Figure 3-27 shows how namespaceSelector selects ingress sources.

Figure 3-27 namespaceSelector



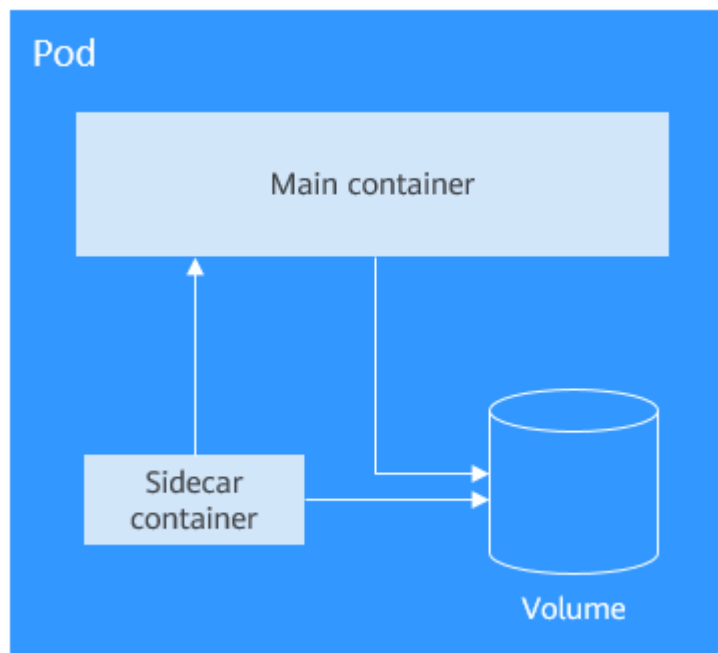
3.7 Persistent Storage

3.7.1 Volume

On-disk files in a container are ephemeral. When a container crashes and is then restarted, the files in the container will be lost. When multiple containers run in a pod, files often need to be shared between these containers. Kubernetes provides an abstraction to solve these two problems, that is, storage volumes. 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 be attached and can be attached to any directory in the container.

The following figure shows how a storage volume is used between containers in a pod.



A volume will no longer exist if the pod to which it is attached does not exist. However, files in the volume may outlive the volume, depending on the volume type.

Volume Types

Kubernetes supports multiple types of volumes. The most commonly used ones are as follows:

- `emptyDir`: an empty volume used for temporary storage
- `hostPath`: a volume that mounts a directory of the host into your pod
- `ConfigMap` and `secret`: special volumes that inject or pass information to your pod. For details about how to mount ConfigMaps and secrets, see [ConfigMap](#) and [Secret](#).
- `persistentVolumeClaim`: Kubernetes persistent storage class. For details, see [PersistentVolumes](#), [PersistentVolumeClaims](#), and [StorageClasses](#).

emptyDir

emptyDir is an empty volume in which your applications can read and write the same files. The lifetime of an emptyDir volume is the same as that of the pod it belongs to. After the pod is deleted, data in the volume is also deleted.

Some uses of an emptyDir volume are as follows:

- scratch space, such as for a disk-based merge sort
- checkpointing a long computation for recovery from crashes

Example emptyDir configuration:

```
apiVersion: v1
kind: Pod
metadata:
  name: nginx
spec:
  containers:
    - image: nginx:alpine
      name: test-container
      volumeMounts:
        - mountPath: /cache
          name: cache-volume
  volumes:
    - name: cache-volume
      emptyDir: {}
```

emptyDir volumes are stored on the disks of the node where the pod is located. You can also set the storage medium to the node memory, for example, by setting **medium** to **Memory**.

```
volumes:
  - name: html
    emptyDir:
      medium: Memory
```

HostPath

hostPath is a persistent storage volume. Data in an emptyDir volume will be deleted when the pod is deleted, but not the case for a hostPath volume. Data in a hostPath volume will still be stored in the node path to which the volume was mounted. If the pod is re-created and scheduled to the same node, after a new hostPath volume is mounted, previous data written by the pod can still be read.

Data stored in hostPath volumes is related to the node. Therefore, hostPath is not suitable for applications such as databases. For example, if the pod in which a database instance runs is scheduled to another node, the read data will be totally different.

Therefore, you are not advised to use hostPath to store cross-pod data, because after the pod is rebuilt, it will be randomly scheduled to a node, which may cause inconsistency when data is written.

```
apiVersion: v1
kind: Pod
metadata:
  name: test-hostpath
spec:
  containers:
    - image: nginx:alpine
      name: hostpath-container
      volumeMounts:
```

```
- mountPath: /test-pd
  name: test-volume
volumes:
- name: test-volume
  hostPath:
    path: /data
```

3.7.2 PersistentVolumes, PersistentVolumeClaims, and StorageClasses

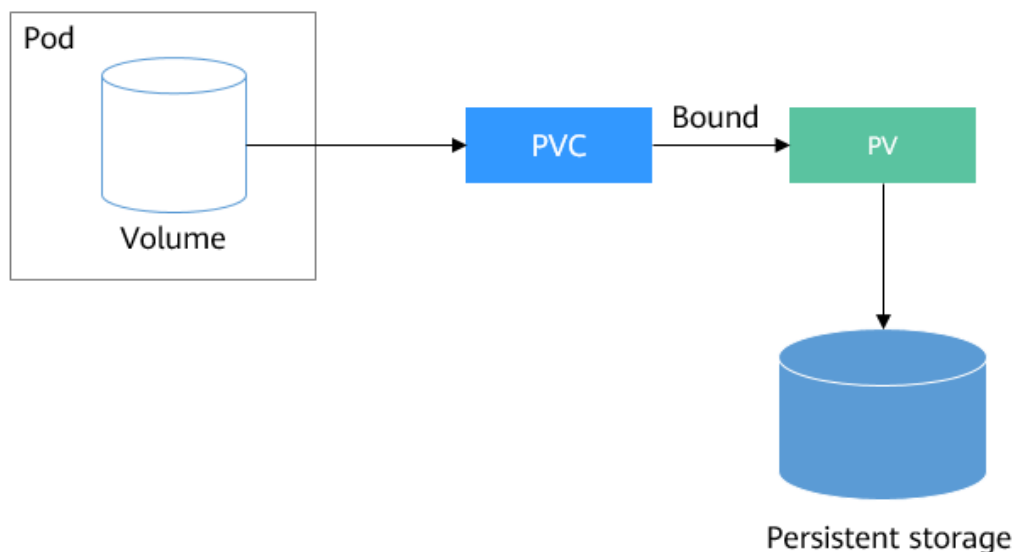
hostPath volumes are used for persistent storage. However, hostPath volumes are node-specific. Writing data into hostPath volumes after a node restart may cause data inconsistency.

If you want to read the previously written data after a pod is rebuilt and scheduled again, you can count on network storage. Typically, a cloud vendor provides at least three classes of network storage: block storage, file storage, and object storage. Kubernetes decouples how storage is provided from how it is consumed by introducing two API objects: PersistentVolume (PV) and PersistentVolumeClaim (PVC). You only need to request the storage resources you want, without being exposed to the details of how they are implemented.

- A PV describes a persistent data storage volume. It defines a directory for persistent storage on a host machine, for example, a mount directory of a network file system (NFS).
- A PVC describes the attributes of the PV that a pod wants to use, such as the volume capacity and read/write permissions.

To allow a pod to use PVs, a Kubernetes cluster administrator needs to set the network storage class and provides the corresponding PV descriptors to Kubernetes. You only need to create a PVC and bind the PVC with the volumes in the pod so that you can store data. The following figure shows the relationship between PVs and PVCs.

Figure 3-28 Binding a PVC to a PV



CSI

Kubernetes Container Storage Interface (CSI) can be used to develop plug-ins to support specific storage volumes. For example, in the namespace named kube-system, as shown in [Namespaces: Grouping Resources](#), **everest-csi-controller-*** and **everest-csi-driver-*** are the storage controllers and drivers developed by CCE. With these drivers, you can use cloud storage services such as EVS, SFS, and OBS.

```
$ kubectl get po --namespace=kube-system
NAME                                READY  STATUS   RESTARTS  AGE
everest-csi-controller-6d796fb9c5-v22df  2/2    Running  0          9m11s
everest-csi-driver-snzrr                1/1    Running  0          12m
everest-csi-driver-ttj28                1/1    Running  0          12m
everest-csi-driver-wtrk6                1/1    Running  0          12m
```

PV

Each PV contains the specification and status of the volume. For example, a file system is created in SFS. The file system ID is **68e4a4fd-d759-444b-8265-20dc66c8c502**, and the mount point is **sfs-nas01.eu-west-0a.prod-cloud-ocb.orange-business.com:/share-96314776**. If you want to use this file system in CCE, you need to create a PV to describe the volume. The following is an example PV.

```
apiVersion: v1
kind: PersistentVolume
metadata:
  name: pv-example
spec:
  accessModes:
    - ReadWriteMany          # Read/write mode
  capacity:
    storage: 10Gi           # PV capacity
  csi:
    driver: nas.csi.everest.io # Driver to be used.
    fsType: nfs              # File system type
    volumeAttributes:
      everest.io/share-export-location: sfs-nas01.eu-west-0a.prod-cloud-ocb.orange-business.com:/share-96314776 # Mount point
      volumeHandle: 68e4a4fd-d759-444b-8265-20dc66c8c502 # File system ID
```

Fields under **csi** in the example above are exclusively used in CCE.

Next, create the PV.

```
$ kubectl create -f pv.yaml
persistentvolume/pv-example created

$ kubectl get pv
NAME          CAPACITY  ACCESS MODES  RECLAIM POLICY  STATUS   CLAIM  STORAGECLASS
REASON  AGE
pv-example   10Gi     RWX           Retain          Available  4s
```

RECLAIM POLICY indicates the PV reclaim policy. The value **Retain** indicates that the PV is retained after the PVC is released. If the value of **STATUS** is **Available**, the PV is available.

PVC

A PVC can be bound to a PV. The following is an example:

```
apiVersion: v1
kind: PersistentVolumeClaim
```

```

metadata:
  name: pvc-example
spec:
  accessModes:
  - ReadWriteMany
  resources:
    requests:
      storage: 10Gi          # Storage capacity
      volumeName: pv-example # PV name
  
```

Create the PVC.

```

$ kubectl create -f pvc.yaml
persistentvolumeclaim/pvc-example created

$ kubectl get pvc
NAME          STATUS  VOLUME      CAPACITY  ACCESS MODES  STORAGECLASS  AGE
pvc-example  Bound  pv-example  10Gi      RWX            9s
  
```

The command output shows that the PVC is in **Bound** state and the value of **VOLUME** is **pv-example**, indicating that the PVC is bound to a PV.

Now check the PV status.

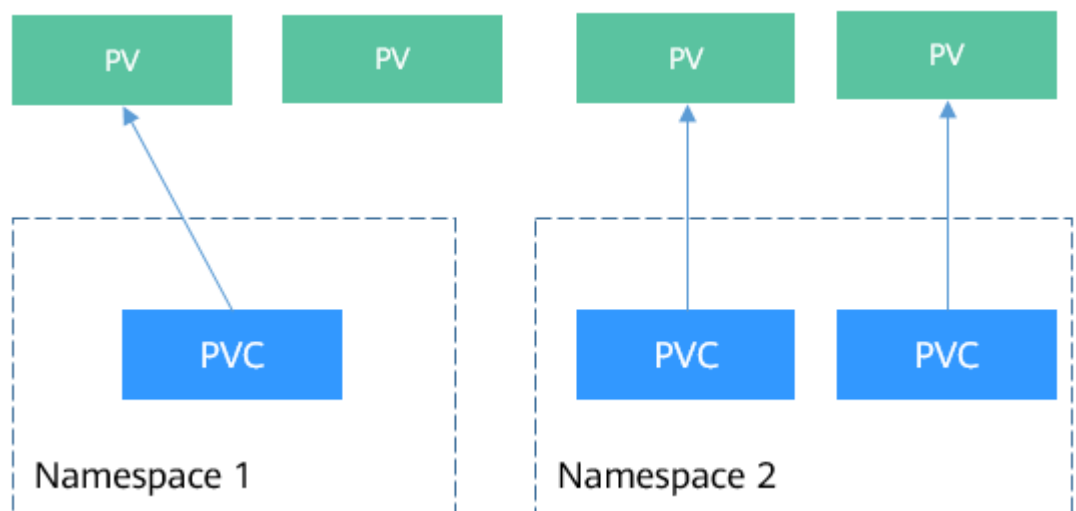
```

$ kubectl get pv
NAME          CAPACITY  ACCESS MODES  RECLAIM POLICY  STATUS  CLAIM              STORAGECLASS  REASON  AGE
pv-example    10Gi      RWX           Retain          Bound   default/pvc-example  50s
  
```

The status of the PVC is also **Bound**. The value of **CLAIM** is **default/pvc-example**, indicating that the PV is bound to the PVC named **pvc-example** in the default namespace.

Note that PVs are cluster-level resources and do not belong to any namespace, while PVCs are namespace-level resources. PVs can be bound to PVCs of any namespace. Therefore, the namespace name "default" is displayed under **CLAIM**.

Figure 3-29 Relationship between PVs and PVCs



StorageClass

Although PVs and PVCs allow you to consume abstract storage resources, you may need to configure multiple fields to create PVs and PVCs (such as the **csi** field

structure in the PV), and PVs/PVCs are generally managed by the cluster administrator, which can be inconvenient when you need PVs with varying attributes for different problems.

To solve this problem, Kubernetes supports dynamic PV provisioning to create PVs automatically. The cluster administrator can deploy a PV provisioner and define the corresponding StorageClass. In this way, developers can select the storage class to be created when creating a PVC. The PVC transfers the StorageClass to the PV provisioner, and the provisioner automatically creates a PV. In CCE, storage classes such as csi-disk, csi-nas, and csi-obs are supported. After StorageClassName is added to a PVC, PVs can be automatically provisioned and underlying storage resources can be automatically created.

 **NOTE**

The following examples are for CCE clusters of v1.15 and later, different from those for CCE clusters of v1.13 and earlier.

Run the following command to query the storage classes that CCE supports. You can use the CSI plug-ins provided by CCE to customize a storage class, which functions similarly as the default storage classes in CCE.

```
# kubectl get sc
NAME          PROVISIONER          AGE
csi-disk      everest-csi-provisioner 17d # Storage class for EVS disks
csi-disk-topology everest-csi-provisioner 17d # Storage class for EVS disks with delayed
association
csi-nas       everest-csi-provisioner 17d # Storage class for SFS file systems
csi-obs       everest-csi-provisioner 17d # Storage class for OBS buckets
csi-sfsturbo everest-csi-provisioner 17d # Storage class for SFS Turbo file systems
```

Use **storageClassName** to create a PVC.

```
apiVersion: v1
kind: PersistentVolumeClaim
metadata:
  name: pvc-sfs-auto-example
spec:
  accessModes:
    - ReadWriteMany
  resources:
    requests:
      storage: 10Gi
  storageClassName: csi-nas # StorageClass
```

Create a PVC and view the PVC and PV details.

```
$ kubectl create -f pvc2.yaml
persistentvolumeclaim/pvc-sfs-auto-example created

$ kubectl get pvc
NAME          STATUS  VOLUME                                     CAPACITY  ACCESS MODES  STORAGECLASS  AGE
pvc-sfs-auto-example Bound   pvc-1f1c1812-f85f-41a6-a3b4-785d21063ff3 10Gi      RWX           csi-nas       29s

$ kubectl get pv
NAME          CAPACITY  ACCESS MODES  RECLAIM POLICY  STATUS
CLAIM        STORAGECLASS  REASON  AGE
pvc-1f1c1812-f85f-41a6-a3b4-785d21063ff3 10Gi      RWO          Delete          Bound   default/pvc-sfs-auto-example csi-nas 20s
```

The command output shows that after a StorageClass is used, a PVC and a PV are created and they are bound to each other.

After a StorageClass is set, PVs can be automatically created and maintained. Users only need to specify StorageClassName when creating a PVC, which greatly reduces the workload.

Note that the types of **storageClassName** vary among vendors. In this section, SFS is used as an example. For details about other storage classes, see [Storage Overview](#).

Using a PVC in a Pod

After a PVC is available, you can directly bind the PVC to a volume in the pod template and then mount the volume to the pod, as shown in the following example. You can also directly create a PVC in a StatefulSet. For details, see [StatefulSet](#).

```
apiVersion: apps/v1
kind: Deployment
metadata:
  name: nginx-deployment
spec:
  selector:
    matchLabels:
      app: nginx
  replicas: 2
  template:
    metadata:
      labels:
        app: nginx
    spec:
      containers:
        - image: nginx:alpine
          name: container-0
          volumeMounts:
            - mountPath: /tmp                # Mount path
              name: pvc-sfs-example
      restartPolicy: Always
      volumes:
        - name: pvc-sfs-example
          persistentVolumeClaim:
            claimName: pvc-example          # PVC name
```

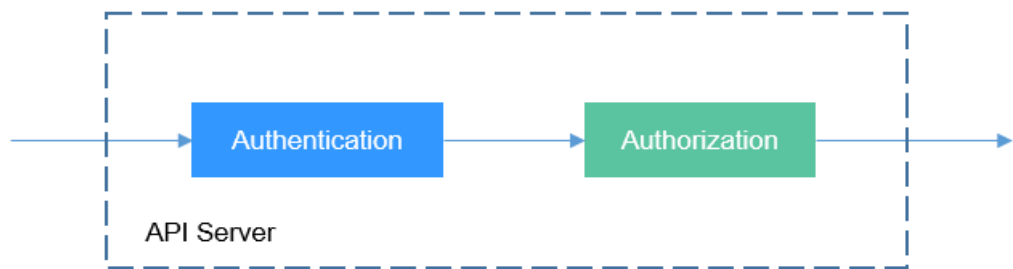
3.8 Authentication and Authorization

3.8.1 ServiceAccounts

All access requests to Kubernetes resources are processed by the API Server, regardless of whether the requests are from an external system. Therefore, the requests must be authenticated and authorized before they are sent to Kubernetes resources.

- **Authentication:** used for user identity authentication. Kubernetes uses different authentication mechanisms for external and internal service accounts. For details, see [Authentication and ServiceAccounts](#).
- **Authorization:** used for controlling users' access to resources. Currently, the role-based access control (RBAC) mechanism is used to authorize users to access resources. For details, see [RBAC](#).

Figure 3-30 Authentication and authorization of the API Server



Authentication and ServiceAccounts

Kubernetes users are classified into service accounts (ServiceAccounts) and common accounts.

- A ServiceAccount is bound to a namespace and associated with a set of credentials stored in a secret. When a pod is created, the secret is mounted to the pod so that the pod can be called by the API Server.
- Kubernetes does not have objects that represent common accounts. By default, these accounts are managed by external services. For example, CCE users are managed by Identity and Access Management (IAM).

The following only focuses on ServiceAccounts.

Similar to pods and ConfigMaps, ServiceAccounts are resources in Kubernetes and apply to independent namespaces. That is, a ServiceAccount named **default** is automatically created when a namespace is created.

Run the following command to view ServiceAccounts:

```
$ kubectl get sa
NAME      SECRETS  AGE
default  1        30d
```

In addition, Kubernetes automatically creates a secret for a ServiceAccount. Run the following command to view the secret:

```
$ kubectl describe sa default
Name:         default
Namespace:    default
Labels:       <none>
Annotations:  <none>
Image pull secrets: <none>
Mountable secrets: default-token-vssmw
Tokens:       default-token-vssmw
Events:       <none>
```

In the pod definition file, you can assign a ServiceAccount to a pod by specifying an account name. If no account name is specified, the default ServiceAccount is used. When receiving a request with an authentication token, the API Server uses the token to check whether the ServiceAccount associated with the client that sends the request allows the request to be executed.

Creating a ServiceAccount

Run the following command to create a ServiceAccount:

```
$ kubectl create serviceaccount sa-example
serviceaccount/sa-example created

$ kubectl get sa
NAME          SECRETS  AGE
default       1        30d
sa-example    1        2s
```

The token associated with the ServiceAccount has been created.

```
$ kubectl describe sa sa-example
Name:          sa-example
Namespace:     default
Labels:        <none>
Annotations:   <none>
Image pull secrets: <none>
Mountable secrets: sa-example-token-c7bqx
Tokens:        sa-example-token-c7bqx
Events:        <none>
```

Check the secret content. You can find the **ca.crt**, **namespace**, and **token** data.

```
$ kubectl describe secret sa-example-token-c7bqx
Name:          sa-example-token-c7bqx
...
Data
====
ca.crt:       1082 bytes
namespace:    7 bytes
token:        <token content>
```

Using a ServiceAccount in a Pod

It is convenient to use a ServiceAccount in a pod. You only need to specify the name of the ServiceAccount.

```
apiVersion: v1
kind: Pod
metadata:
  name: sa-example
spec:
  serviceAccountName: sa-example
  containers:
  - image: nginx:alpine
    name: container-0
    resources:
      limits:
        cpu: 100m
        memory: 200Mi
      requests:
        cpu: 100m
        memory: 200Mi
    imagePullSecrets:
    - name: default-secret
```

Create a pod and view its information. You can see that **sa-example-token-c7bqx** is mounted to the pod, that is, the token corresponding to the ServiceAccount **sa-example**. That is, the pod uses the token for authentication.

```
$ kubectl create -f sa-pod.yaml
pod/sa-example created

$ kubectl get pod
NAME          READY  STATUS   RESTARTS  AGE
sa-example    0/1    running  0         5s

$ kubectl describe pod sa-example
...
```



```
Containers:
  sa-example:
    Mounts:
      /var/run/secrets/kubernetes.io/serviceaccount from sa-example-token-c7bqx (ro)
```

You can also view the corresponding file in the pod.

```
$ kubectl exec -it sa-example -- /bin/sh
/ # cd /run/secrets/kubernetes.io/serviceaccount
/run/secrets/kubernetes.io/serviceaccount # ls
ca.crt  namespace  token
```

As shown above, in a containerized application, **ca.crt** and **token** can be used to access the API Server.

Then check whether the authentication takes effect. In a Kubernetes cluster, a Service named **kubernetes** is created for the API Server by default. The API Server can be accessed through this service.

```
$ kubectl get svc
NAME         TYPE        CLUSTER-IP   EXTERNAL-IP  PORT(S)    AGE
kubernetes  ClusterIP   10.247.0.1   <none>       443/TCP    34
```

Go to the pod and run the **curl** command. If the following information is displayed, you do not have the permission.

```
$ kubectl exec -it sa-example -- /bin/sh
/ # curl https://kubernetes
curl: (60) SSL certificate problem: unable to get local issuer certificate
More details here: https://curl.haxx.se/docs/sslcerts.html
```

curl failed to verify the legitimacy of the server and therefore could not establish a secure connection to it. To learn more about this situation and how to fix it, please visit the web page mentioned above.

Use **ca.crt** and **token** for authentication. The specific procedure is as follows: Place **ca.crt** in the environment variable **CURL_CA_BUNDLE**, and run the **curl** command to specify the certificate using **CURL_CA_BUNDLE**. Place the token content in **TOKEN** and use the token to access the API Server.

```
# export CURL_CA_BUNDLE=/var/run/secrets/kubernetes.io/serviceaccount/ca.crt
# TOKEN=$(cat /var/run/secrets/kubernetes.io/serviceaccount/token)
# curl -H "Authorization: Bearer $TOKEN" https://kubernetes
{
  "kind": "Status",
  "apiVersion": "v1",
  "metadata": {
  },
  "status": "Failure",
  "message": "forbidden: User \"system:serviceaccount:default:sa-example\" cannot get path \"/\",",
  "reason": "Forbidden",
  "details": {
  },
  "code": 403
}
```

As shown above, the authentication is successful, but the API Server returns **cannot get path \"/\",** indicating that the API Server can be accessed only after being authorized. For details about the authorization mechanism, see [RBAC](#).

3.8.2 RBAC

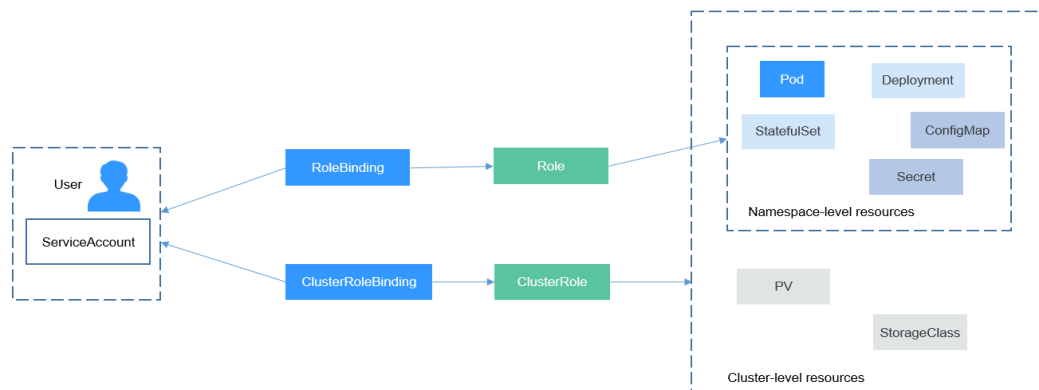
RBAC Resources

In Kubernetes, the RBAC mechanism is used for authorization. RBAC authorization uses four types of resources for configuration.

- 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 3-31 Role binding



Creating a Role

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.
```

Creating a RoleBinding

After creating a Role, you can bind the Role to a specific user, which is called RoleBinding. The following is an example.

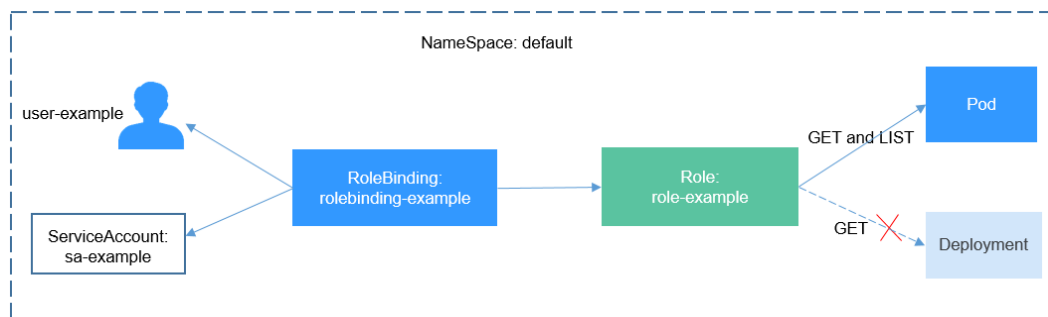
```
kind: RoleBinding
apiVersion: rbac.authorization.k8s.io/v1
metadata:
```

```

name: rolebinding-example
namespace: default
subjects:
- kind: User          # Specified user
  name: user-example  # Common user
  apiGroup: rbac.authorization.k8s.io
- kind: ServiceAccount # ServiceAccount
  name: sa-example
  namespace: default
roleRef:
  kind: Role
  name: role-example
  apiGroup: rbac.authorization.k8s.io
    
```

The **subjects** is used to bind the Role to a user. The user can be an external common user or a ServiceAccount. For details about the two user types, see [ServiceAccounts](#). The following figure shows the binding relationship.

Figure 3-32 A RoleBinding binds the Role to the user.



Then check whether the authorization takes effect.

In [Using a ServiceAccount](#), a pod is created and the ServiceAccount **sa-example** is used. The Role **role-example** is bound to **sa-example**. Access the pod and run the **curl** command to access resources through the API Server to check whether the permission takes effect.

Use **ca.crt** and **token** corresponding to **sa-example** for authentication and query all pod resources (**LIST** in [Creating a Role](#)) in the default namespace.

```

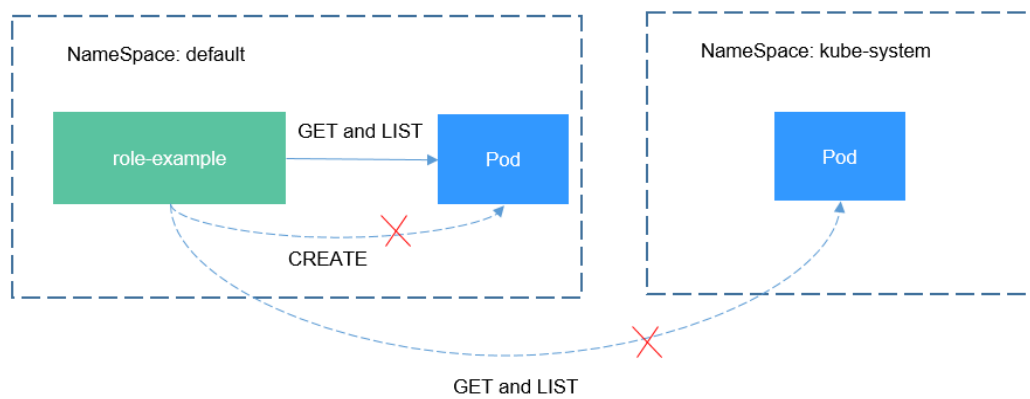
$ kubectl exec -it sa-example -- /bin/sh
# export CURL_CA_BUNDLE=/var/run/secrets/kubernetes.io/serviceaccount/ca.crt
# TOKEN=$(cat /var/run/secrets/kubernetes.io/serviceaccount/token)
# curl -H "Authorization: Bearer $TOKEN" https://kubernetes/api/v1/namespaces/default/pods
{
  "kind": "PodList",
  "apiVersion": "v1",
  "metadata": {
    "selfLink": "/api/v1/namespaces/default/pods",
    "resourceVersion": "10377013"
  },
  "items": [
    {
      "metadata": {
        "name": "sa-example",
        "namespace": "default",
        "selfLink": "/api/v1/namespaces/default/pods/sa-example",
        "uid": "c969fb72-ad72-4111-a9f1-0a8b148e4a3f",
        "resourceVersion": "10362903",
        "creationTimestamp": "2020-07-15T06:19:26Z"
      },
      "spec": {
        ...
    }
  ]
}
    
```

If the returned result is normal, **sa-example** has permission to list pods. Query the Deployment again. If the following information is displayed, you do not have the permission to access the Deployment.

```
# curl -H "Authorization: Bearer $TOKEN" https://kubernetes/api/v1/namespaces/default/deployments
...
"status": "Failure",
"message": "deployments is forbidden: User \"system:serviceaccount:default:sa-example\" cannot list resource \"deployments\" in API group \"\" in the namespace \"default\"",
...
```

Role and RoleBinding apply to namespaces and can isolate permissions to some extent. As shown in the following figure, **role-example** defined above cannot access resources in the **kube-system** namespace.

Figure 3-33 Role and RoleBinding applied to namespaces



Continue to access the pod. If the following information is displayed, you do not have the permission.

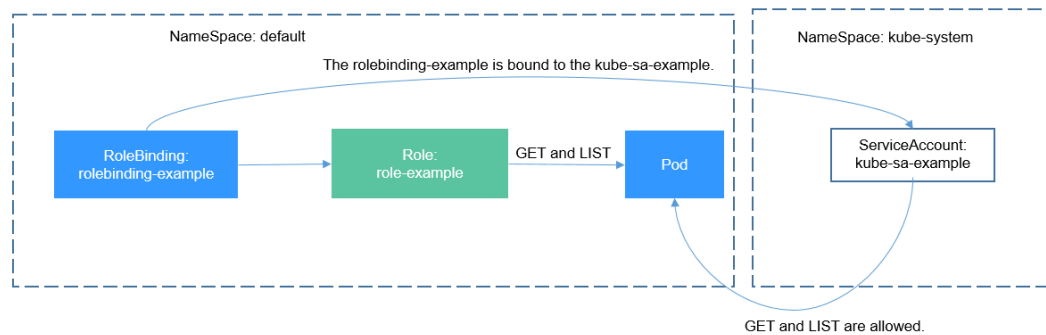
```
# curl -H "Authorization: Bearer $TOKEN" https://kubernetes/api/v1/namespaces/kube-system/pods
...
"status": "Failure",
"message": "pods is forbidden: User \"system:serviceaccount:default:sa-example\" cannot list resource \"pods\" in API group \"\" in the namespace \"kube-system\"",
"reason": "Forbidden",
...
```

In RoleBinding, you can also bind the ServiceAccounts of other namespaces by adding them under the **subjects** field.

```
subjects:
  # Specified user
  - kind: ServiceAccount
    name: kube-sa-example
    namespace: kube-system
    # ServiceAccount
```

Then the ServiceAccount **kube-sa-example** in **kube-system** can perform GET and LIST operations on pods in the default namespace, as shown in the following figure.

Figure 3-34 Cross-namespace access



ClusterRole and ClusterRoleBinding

Compared with Role and RoleBinding, ClusterRole and ClusterRoleBinding have the following differences:

- ClusterRole and ClusterRoleBinding do not need to define the **namespace** field.
- ClusterRole can define cluster-level resources.

You can see that ClusterRole and ClusterRoleBinding control cluster-level permissions.

In Kubernetes, many ClusterRoles and ClusterRoleBindings are defined by default.

```
$ kubectl get clusterroles
NAME                                     AGE
admin                                   30d
cceaddon-prometheus-kube-state-metrics 6d3h
cluster-admin                           30d
coredns                                 30d
custom-metrics-resource-reader          6d3h
custom-metrics-server-resources        6d3h
edit                                    30d
prometheus                              6d3h
system:aggregate-customedhorizontalpodautoscalers-admin 6d2h
system:aggregate-customedhorizontalpodautoscalers-edit 6d2h
system:aggregate-customedhorizontalpodautoscalers-view 6d2h
....
view                                    30d

$ kubectl get clusterrolebindings
NAME                                     AGE
authenticated-access-network            30d
authenticated-packageversion            30d
auto-approve-csrs-for-group             30d
auto-approve-renewals-for-nodes         30d
auto-approve-renewals-for-nodes-server  30d
cceaddon-prometheus-kube-state-metrics  6d3h
cluster-admin                           30d
cluster-creator                          30d
coredns                                 30d
csrs-for-bootstrapping                  30d
system:basic-user                        30d
system:ccehpa-rolebinding               6d2h
system:cluster-autoscaler               6d1h
...
```

The most important and commonly used ClusterRoles are as follows:

- **view**: has the permission to view namespace resources.

- `edit`: has the permission to modify namespace resources.
- `admin`: has all permissions on the namespace.
- `cluster-admin`: has all permissions on the cluster.

Run the `kubectl describe clusterrole` command to view the permissions of each rule.

Generally, the four ClusterRoles are bound to users to isolate permissions. Note that Roles (rules and permissions) are separated from users. You can flexibly control permissions by combining the two through RoleBinding.

3.9 Auto Scaling

In [Pod Orchestration and Scheduling](#), we introduce controllers such as Deployment to control the number of pod replicas. You can adjust the number of replicas to manually scale your applications. However, manual scaling is sometimes complex and fails to cope with unexpected traffic spikes.

Kubernetes supports auto scaling of pods and cluster nodes. You can set rules to trigger auto scaling when certain metrics (such as CPU usage) reach the configured threshold.

Prometheus and Metrics Server

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.

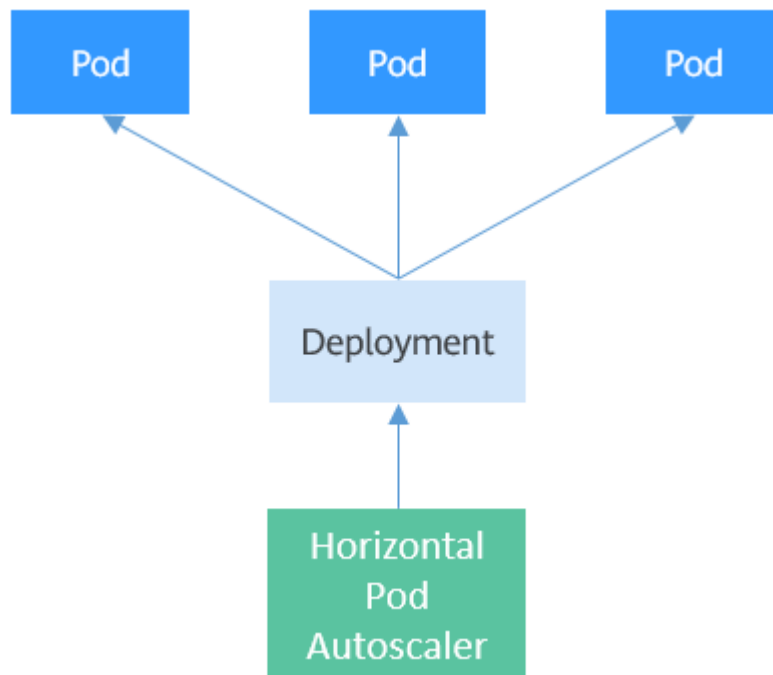
- **Prometheus** is an open-source monitoring and alarming framework that can collect multiple types of metrics. Prometheus has been a standard monitoring solution of Kubernetes.
- **Metrics Server** is a cluster-wide aggregator of resource utilization data. Metrics Server collects metrics from the Summary 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.

Horizontal Pod Autoscaler (HPA) can work with Metrics Server to implement auto scaling based on the CPU and memory usage. It can also work with Prometheus to implement auto scaling based on custom monitoring metrics.

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).

Figure 3-35 HPA working mechanism



You can configure one or more metrics for the HPA. When configuring a single metric, you only need to sum up the current pod metrics, divide the sum by the expected target value, and then round up the result to obtain the expected number of replicas. For example, if a Deployment controls three pods, the CPU usage of each pod is 70%, 50%, and 90%, and the expected CPU usage configured in the HPA is 50%, the expected number of replicas is calculated as follows: $(70 + 50 + 90)/50 = 4.2$. The result is rounded up to 5. That is, the expected number of replicas is 5.

If multiple metrics are configured, the expected number of replicas of each metric is calculated and the maximum value will be used.

Using the HPA

The following example demonstrates how to use the HPA. First, use the Nginx image to create a Deployment with four replicas.

```

$ kubectl get deploy
NAME          READY   UP-TO-DATE   AVAILABLE   AGE
nginx-deployment  4/4     4            4           77s

$ kubectl get pods
NAME                                READY   STATUS    RESTARTS   AGE
nginx-deployment-7cc6fd654c-5xzlz  1/1     Running   0          82s
nginx-deployment-7cc6fd654c-cwjzq  1/1     Running   0          82s
nginx-deployment-7cc6fd654c-dffkp  1/1     Running   0          82s
nginx-deployment-7cc6fd654c-j7mp8  1/1     Running   0          82s
  
```

Create an HPA. The expected CPU usage is 70% and the number of replicas ranges from 1 to 10.

```

apiVersion: autoscaling/v2beta1
kind: HorizontalPodAutoscaler
metadata:
  
```

```

name: scale
namespace: default
spec:
  maxReplicas: 10          # Maximum number of replicas of the target resource
  minReplicas: 1          # Minimum number of replicas of the target resource
  metrics:                # Metric. The expected CPU usage is 70%.
  - resource:
    name: cpu
    targetAverageUtilization: 70
    type: Resource
  scaleTargetRef:         # Target resource
  apiVersion: apps/v1
  kind: Deployment
  name: nginx-deployment

```

Query the created HPA.

```

$ kubectl create -f hpa.yaml
horizontalpodautoscaler.autoscaling/celue created

$ kubectl get hpa
NAME      REFERENCE                TARGETS  MINPODS  MAXPODS  REPLICAS  AGE
scale    Deployment/nginx-deployment  0%/70%  1        10       4         18s

```

In the command output, the expected value of **TARGETS** is **70%**, but the actual value is **0%**. This means that the HPA will perform scale-in. The expected number of replicas can be calculated as follows: $(0 + 0 + 0 + 0)/70 = 0$. However, the minimum number of replicas has been set to **1**. Therefore, the number of pods is changed to 1. After a while, the number of pods changes to 1.

```

$ kubectl get pods
NAME                                READY  STATUS   RESTARTS  AGE
nginx-deployment-7cc6fd654c-5xzlz  1/1    Running  0         7m41s

```

Query the HPA again and a record similar to the following is displayed under **Events**. In this example, the record indicates that the HPA successfully performed a scale-in 21 seconds ago and the number of pods is changed to 1, and the scale-in is triggered because the values of all metrics are lower than the target values.

```

$ kubectl describe hpa scale
...
Events:
  Type     Reason             Age   From              Message
  ----     -
  Normal   SuccessfulRescale  21s   horizontal-pod-autoscaler  New size: 1; reason: All metrics below target

```

If you want to query the Deployment details, you can check the records similar to the following under **Events**. In this example, the second record indicates that the number of replicas of the Deployment is set to **1**, which is the same as that in the HPA.

```

$ kubectl describe deploy nginx-deployment
...
Events:
  Type     Reason             Age   From              Message
  ----     -
  Normal   ScalingReplicaSet  7m    deployment-controller  Scaled up replica set nginx-deployment-7cc6fd654c to 4
  Normal   ScalingReplicaSet  1m    deployment-controller  Scaled down replica set nginx-deployment-7cc6fd654c to 1

```

Cluster AutoScaler

The HPA is designed for pods. However, if the cluster resources are insufficient, you can only add nodes. Scaling of cluster nodes could be laborious. Now with clouds, you can add or delete nodes by simply calling APIs.

Cluster Autoscaler is a component provided by Kubernetes for auto scaling of cluster nodes based on the pod scheduling status and resource usage. You can refer to the API documentation of your cloud service provider to implement auto scaling.

For details about the implementation on CCE, see [Creating a Node Scaling Policy](#).

4 Getting Started

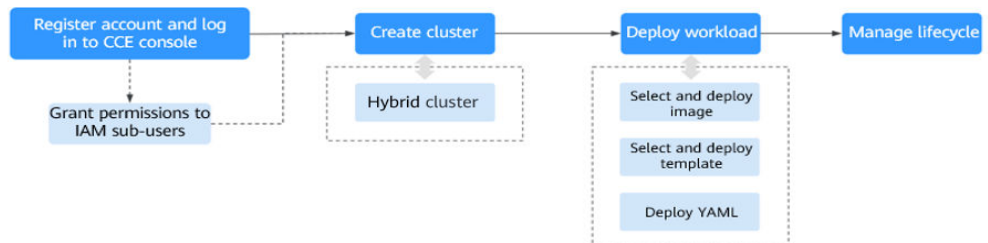
4.1 Introduction

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 4-1 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`.

4.2 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 Server (ECS).

- 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

4.3 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 **Create CCE Standard Cluster** on the wizard page.
- If you have CCE clusters, choose **Clusters** in the navigation pane, click **Create 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 4-1](#).

Table 4-1 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.
*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 **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

4.4 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 4-2 Accessed the Nginx web page

Welcome to nginx!

If you see this page, the nginx web server is successfully installed and working. Further configuration is required.

For online documentation and support please refer to nginx.org.
Commercial support is available at nginx.com.

Thank you for using nginx.

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

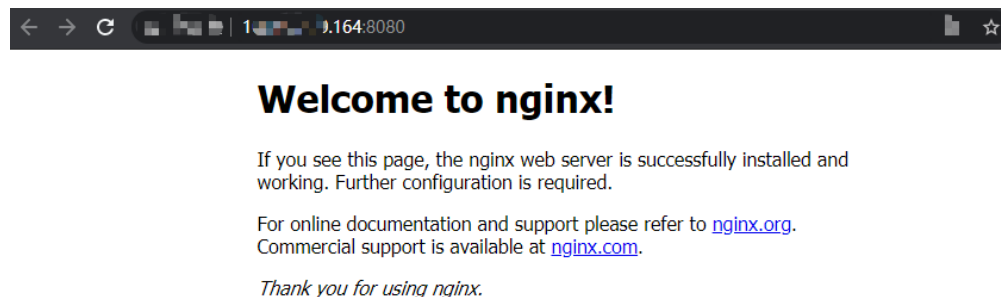
Accessing Nginx

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 4-3 Accessing Nginx



----End

4.5 Deploying WordPress and MySQL That Depend on Each Other

4.5.1 Overview

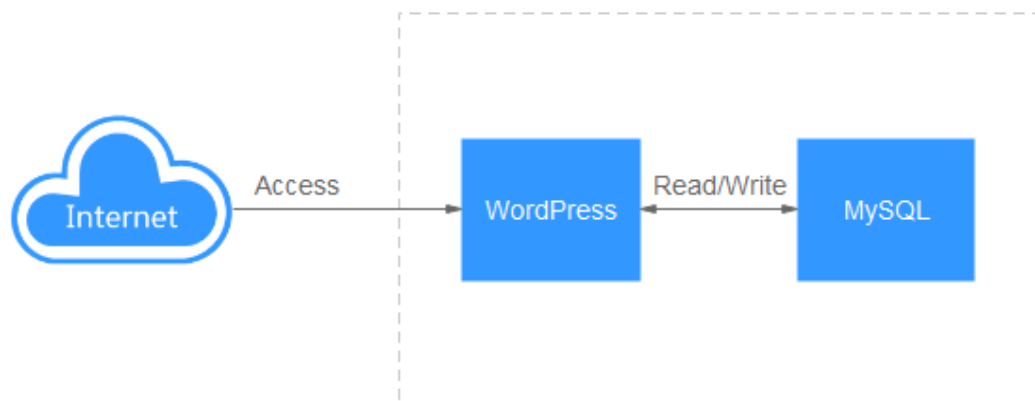
WordPress was originally a blog platform based on PHP and MySQL. It is gradually evolved into a content management system. You can set up your own blog

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 4-4 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.

4.5.2 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 mysql;`

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

4.5.3 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 4-5 WordPress

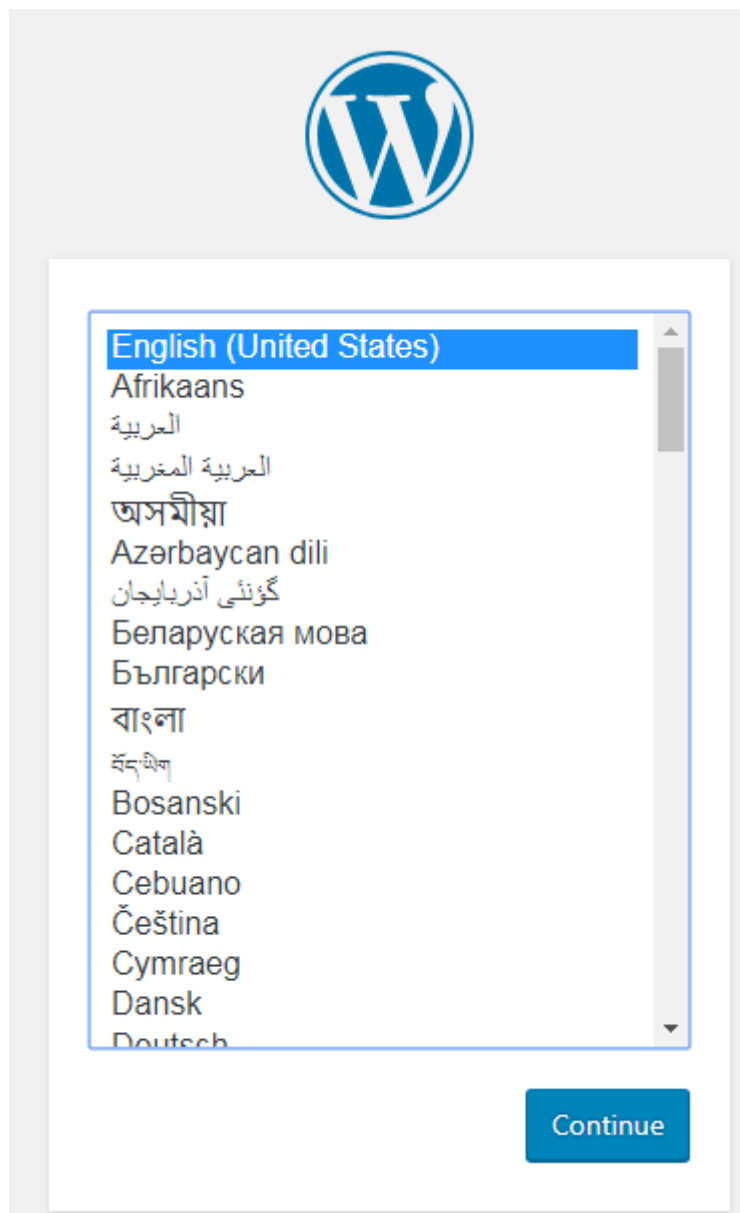
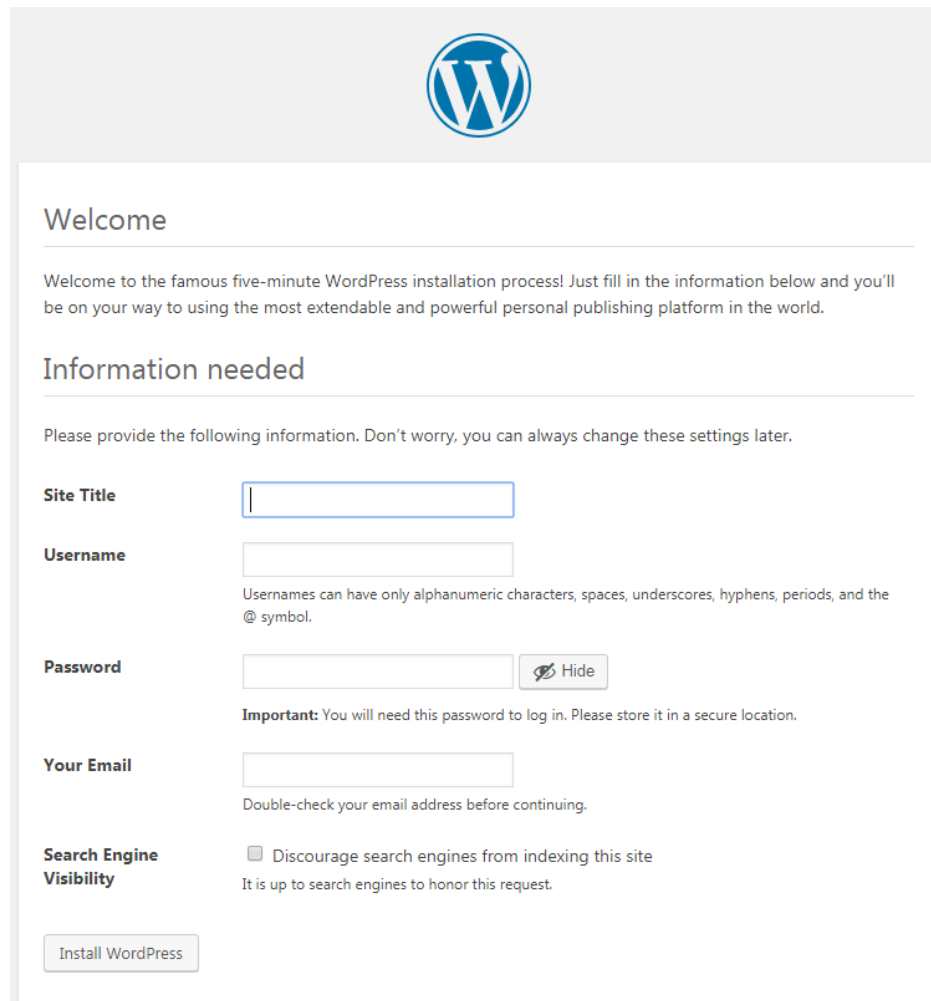



Figure 4-6 WordPress



----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

5 High-Risk Operations

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 5-1 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: <i>Cluster name-cce-control-Random digits</i>	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 Modifying Cluster Configurations .
	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: <i>Cluster name-cce-node-Random digits</i>	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 Modifying Node Pool Configurations .
	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 5-2 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 Creating 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 5-3 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.

Operation	Impact	Solution
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.
Changing the private IPv4 address of a load balancer on the ELB console	<ul style="list-style-type: none"> 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	<ul style="list-style-type: none"> 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
<p>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</p>	<ul style="list-style-type: none"> ● 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. <ul style="list-style-type: none"> – Deleted backend servers will be restored. – Added backend servers will be removed. 	<p>Re-create or update the Service or ingress.</p>
<p>Replacing the backend server group of a listener created by CCE on the ELB console</p>	<ul style="list-style-type: none"> ● 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. 	<p>Re-create or update the Service or ingress.</p>
<p>Modifying the forwarding policy of a listener created by CCE on the ELB console, including adding or deleting forwarding rules</p>	<ul style="list-style-type: none"> ● 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. 	<p>Do not modify the forwarding policy of such a listener. Restore the configurations if they have been modified.</p>
<p>Changing the ELB certificate on the ELB console for a load balancer managed by CCE</p>	<p>After master nodes are restarted, for example, due to a cluster upgrade, all servers in the backend server group will be reset by CCE.</p>	<p>Use the YAML file of the ingress to automatically manage certificates.</p>

Logs

Table 5-4 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 5-5 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 5-6 Add-ons

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

6 Clusters

6.1 Cluster Overview

6.1.1 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](#).

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 6-1 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.

6.1.2 Kubernetes Version Release Notes

6.1.2.1 Kubernetes 1.29 Release Notes

CCE has passed the Certified Kubernetes Conformance Program and is a certified Kubernetes offering. CCE allows you to create Kubernetes clusters 1.29. This section describes the changes made in Kubernetes 1.29.

Indexes

- [New and Enhanced Features](#)
- [API Changes and Removals](#)
- [Enhanced Kubernetes 1.29 on CCE](#)
- [References](#)

New and Enhanced Features

- The load balancer IP mode for Services is in the alpha state.
The load balancer IP mode for Services is promoted to alpha. Kubernetes 1.29 adds the **ipMode** field to the Services' **status** field for configuring traffic forwarding from Services within a cluster to pods. If **ipMode** is set to **VIP**, traffic delivered to a node with the destination set to the load balancer's IP address and port will be redirected to the target node by kube-proxy. If it is set to **Proxy**, traffic delivered to a node will be sent to the load balancer and

then redirected to the target node by the load balancer. This feature addresses the issue of load balancer functions being missed due to traffic bypassing it. For details, see [Load Balancer IP Mode for Services](#).

- The **nftables proxy mode** is in the alpha state.
The **nftables proxy mode** is promoted to alpha. This feature allows kube-proxy to run in **nftables mode**. In this mode, kube-proxy configures packet forwarding rules using the **nftables API** of the kernel netfilter subsystem. For details, see [nftables proxy mode](#).
- **Garbage collection for unused container images** is in the alpha state.
The garbage collection for unused container images is promoted to alpha. This feature allows you to specify the maximum time a local image can be unused for each node. If the time expires, the image will be garbage collected. To configure the setting, specify the **ImageMaximumGCAge** field for kubelet. For details, see [Garbage collection for unused container images](#).
- **PodLifecycleSleepAction** is in the alpha state.
PodLifecycleSleepAction is promoted to alpha. This feature introduces the sleep hook to the container lifecycle hooks. You can pause a container for a specified duration after it starts or before it is stopped by enabling this feature. For details, see [Hook handler implementations](#).
- **KubeletSeparateDiskGC** is in the alpha state.
KubeletSeparateDiskGC is promoted to alpha. With this feature enabled, container images and containers can be garbage collected even if they are on separate file systems.
- **matchLabelKeys** and **mismatchLabelKeys** are in the alpha state.
matchLabelKeys and **mismatchLabelKeys** are promoted to alpha. With these features enabled, the **matchLabelKeys** and **mismatchLabelKeys** fields are added to the pod affinity and anti-affinity configurations. This allows for configurations of more affinity and anti-affinity policies between pods. For details, see [matchLabelKeys and mismatchLabelKeys](#).
- The **clusterTrustBundle** projected volumes are in the alpha state.
The **clusterTrustBundle** projected volumes are promoted to alpha. With this feature enabled, the **clusterTrustBundle** projected volume source injects the contents of one or more **ClusterTrustBundle** objects as an automatically-updating file. For details, see [clusterTrustBundle projected volumes](#).
- Pulling images based on runtime classes of pods is in the alpha state.
Pulling images based on runtime classes is promoted to alpha. With this feature enabled, the kubelet references container images by a tuple (of image name or runtime handler) rather than just the image name or digest. Your container runtime may adapt its behavior based on the selected runtime handler. Pulling images based on runtime classes will be helpful for VM based containers. For details, see [Image pull per runtime class](#).
- The **PodReadyToStartContainers** condition is in the beta state.
The **PodReadyToStartContainers** condition is promoted to beta. Kubernetes 1.29 introduces the **PodReadyToStartContainers** condition to the pods' **status** field. If it is set to **true**, the sandbox of a pod is ready and service containers can be created. This feature enables cluster administrators to gain a clearer and more comprehensive view of pod sandbox creation completion and container readiness. This enhanced visibility allows them to make better-

informed decisions and troubleshoot issues more effectively. For details, see [PodReadyToStartContainers Condition Moves to Beta](#).

- Two job-related features are in the beta state.
 - Pod replacement policy (beta)

The pod replacement policy feature moves to beta. This feature ensures that a pod is replaced only when it reaches the **Failed** state, which means that **status.phase** becomes **Failed**. It does not recreate a pod when the deletion timestamp is not empty and the pod is still being deleted. This prevents two pods from occupying index and node resources concurrently.
 - Backoff limit per index (beta)

The backoff limit per index moves to beta. By default, pod failures for indexed jobs are counted and restricted by the global limit of retries, specified by **.spec.backoffLimit**. This means that if there is a consistently failing index in a job, pods specified by the job will be restarted repeatedly until pod failures exhaust the limit. Once the limit is reached, the job is marked failed and pods for other indexes in the job may never be even started. The feature allows you to complete execution of all indexes, despite some indexes failing, and to better use the compute resources by avoiding unnecessary retries of consistently failing indexes.
- Native sidecar containers are in the beta state.

Native sidecar containers are promoted to beta. The **restartPolicy** field is added to **initContainers**. When this field is set to **Always**, the sidecar container is enabled. The sidecar container and service container are deployed in the same pod. This cannot prolong the pod lifecycle. Sidecar containers are commonly used in scenarios such as network proxy and log collection. For details, see [Sidecar Containers](#).
- The legacy ServiceAccount token cleaner is in the beta state.

Legacy ServiceAccount token cleaner is promoted to beta. It runs as part of **kube-controller-manager** and checks every 24 hours to see if any auto-generated legacy ServiceAccount token has not been used in a specific amount of time (one year by default, specified by **--legacy-service-account-token-clean-up-period**). If so, the cleaner marks those tokens as invalid and adds the **kubernetes.io/legacy-token-invalid-since** label whose value is the current date. If an invalid token is not used for a specific period of time (one year by default, specified by **--legacy-service-account-token-clean-up-period**), the cleaner deletes it. For details, see [Legacy ServiceAccount token cleaner](#).
- **DevicePluginCDIDevices** is in the beta state.

DevicePluginCDIDevices moves to beta. With this feature enabled, plugin developers can use the **CDIDevices** field added to **DeviceRunContainerOptions** to pass CDI device names directly to CDI enabled runtimes.
- **PodHostIPs** is in the beta state.

The **PodHostIPs** feature moves to beta. With this feature enabled, Kubernetes adds the **hostIPs** field to **Status** of pods and downward API to expose node IP addresses to workloads. This field specifies the dual-stack protocol version of the host IP address. The first IP address is always the same as the host IP address.

- The API Priority and Fairness (APF) feature is in the GA state.
APF moves to GA. APF classifies and isolates requests in a more fine-grained way. It improves max-inflight limitations. It also introduces a limited amount of queuing, so that the API server does not reject any request in cases of very brief bursts. Requests are dispatched from queues using a fair queuing technique so that, for example, a poorly-behaved controller does not cause others (even at the same priority level) to become abnormal. For details, see [API Priority and Fairness](#).
- **APIListChunking** is in the GA state.
The **APIListChunking** feature moves to GA. This feature allows clients to perform pagination in List requests to avoid performance problems caused by returning too much data at a time.
- **ServiceNodePortStaticSubrange** is in the GA state.
The **ServiceNodePortStaticSubrange** feature moves to GA. With this feature enabled, kubelet calculates the size of reserved IP addresses based on the ranges of the NodePort Services and divides node ports into static band and dynamic band. During automatic node port assignment, dynamic band is preferentially assigned, which helps avoid port conflicts during static band assignment. For details, see [ServiceNodePortStaticSubrange](#).
- The phase transition timestamp of PersistentVolume (PV) is in the beta state.
The PV phase transition timestamp moves to beta. With this feature enabled, Kubernetes adds the **lastPhaseTransitionTime** field to the **status** field of a PV to indicate the time when the PV phase changes last time. Cluster administrators are now able to track the last time a PV transitioned to a different phase, allowing for more efficient and informed resource management. For details, see [PersistentVolume Last Phase Transition Time in Kubernetes](#).
- **ReadWriteOncePod** is in the GA state.
The **ReadWriteOncePod** feature moves to GA. With this feature enabled, you can set the access mode to **ReadWriteOncePod** in a PersistentVolumeClaim (PVC) to ensure that only one pod can modify data in the volume at a time. This can prevent data conflicts or damage. For details, see [ReadWriteOncePod](#).
- **CSINodeExpandSecret** is in the GA state.
The **CSINodeExpandSecret** feature moves to GA. This feature allows secret authentication data to be passed to a CSI driver for use when a node is added.
- The CEL-based CRD verification capability is in the GA state.
The CEL-based CRD verification capability moves to GA. With this feature enabled, you are allowed to use the CEL to define validation rules in CRDs, which are more efficient than webhook. For details, see [CRD verification rules](#).

API Changes and Removals

- The time zone of a newly created cron job cannot be configured using **TZ** or **CRON_TZ** in **.spec.schedule**. Use **.spec.timeZone** instead. Cron jobs that have been created are not affected by this change.
- The alpha API **ClusterCIDR** is removed.

- The startup parameter **--authentication-config** is added to kube-apiserver to specify the address of the **AuthenticationConfiguration** file. This startup parameter is mutually exclusive with the **--oidc-*** startup parameter.
- The API version **kubescheduler.config.k8s.io/v1beta3** of **KubeSchedulerConfiguration** is removed. Migrate **kube-scheduler** configuration files to **kubescheduler.config.k8s.io/v1**.
- The CEL expressions are added to **v1alpha1 AuthenticationConfiguration**.
- The **ServiceCIDR** type is added. It allows you to dynamically configure the IP address range used by a cluster to allocate the Service ClusterIPs.
- The startup parameters **--contrack-udp-timeout** and **--contrack-udp-timeout-stream** are added to **kube-proxy**. They are options for configuring the kernel parameters **nf_contrack_udp_timeout** and **nf_contrack_udp_timeout_stream**.
- Support for CEL expressions is added to **WebhookMatchCondition** of **v1alpha1 AuthenticationConfiguration**.
- The type of **PVC.spec.Resource** is changed from **ResourceRequirements** to **VolumeResourceRequirements**.
- **onPodConditions** in **PodFailurePolicyRule** is marked as optional.
- The API version **flowcontrol.apiserver.k8s.io/v1beta3** of **FlowSchema** and **PriorityLevelConfiguration** has been promoted to **flowcontrol.apiserver.k8s.io/v1**, and the following changes have been made:
 - **PriorityLevelConfiguration**:
The **.spec.limited.nominalConcurrencyShares** field defaults to **30** if the field is omitted. To ensure compatibility with 1.28 API servers, specifying an explicit **0** value is not allowed in the **v1** version in 1.29. In 1.30, explicit **0** values will be allowed in this field in the **v1** API. The **flowcontrol.apiserver.k8s.io/v1beta3** APIs are deprecated and will no longer be served in 1.32.
- The kube-proxy command line document is updated. kube-proxy does not bind any socket to the IP address specified by **--bind-address**.
- The **selectorSpread** scheduler plugin is replaced by **podTopologySpread**.
- If CSI-Node-Driver is not running, NodeStageVolume calls will be retried.
- **ValidatingAdmissionPolicy** type checking now supports CRDs. To use this feature, the **ValidatingAdmissionPolicy** feature gate must be enabled.
- The startup parameter **--nf-contrack-tcp-be-liberal** is added to **kube-proxy**. You can configure it by setting the kernel parameter **nf_contrack_tcp_be_liberal**.
- The startup parameter **--init-only** is added to **kube-proxy**. Setting the flag makes **kube-proxy** init container run in the privileged mode, perform its initial configuration, and then exit.
- The **fileSystem** field of container is added to the response body of CRI. It specifies the file system usage of a container. Originally, the **fileSystem** field contains only the file system of the container images.
- All built-in cloud providers are disabled by default. If you still need to use them, you can configure the **DisableCloudProviders** and **DisableKubeletCloudCredentialProvider** feature gates to disable or enable cloud providers.

- **--node-ips** can be used in kubelet to configure IPv4/IPv6 dual-stack. If **--cloud-provider** is set to **external**, you are allowed to use **--node-ips** to configure IPv4/IPv6 dual-stack for node IP addresses. To use **--node-ips**, you need to enable the **CloudDualStackNodeIPs** feature gate.

Enhanced Kubernetes 1.29 on CCE

During a version maintenance period, CCE periodically updates Kubernetes 1.29 and provides enhanced functions.

For details about cluster version updates, see [Patch Versions](#).

References

For more details about the performance comparison and function evolution between Kubernetes 1.29 and other versions, see [Kubernetes v1.29 Release Notes](#).

6.1.2.2 Kubernetes 1.28 Release Notes

CCE has passed the Certified Kubernetes Conformance Program and is a certified Kubernetes offering. CCE allows you to create Kubernetes clusters 1.28. This section describes the changes made in Kubernetes 1.28.

Indexes

- [Important Notes](#)
- [New and Enhanced Features](#)
- [API Changes and Removals](#)
- [Feature Gate and Command Line Parameter Changes and Removals](#)
- [Enhanced Kubernetes 1.28 on CCE](#)
- [References](#)

Important Notes

- In Kubernetes 1.28, the scheduling framework is improved to reduce useless retries. The overall scheduling performance is enhanced. If a custom scheduler plugin is used in a cluster, you can perform the adaptation upgrade following instructions in [GitHub](#).
- The Ceph FS in-tree plugin has been deprecated in Kubernetes 1.28 and will be removed in Kubernetes 1.31. (The community does not plan to support CSI migration.) Use [Ceph CSI driver](#) instead.
- The Ceph RBD in-tree plugin has been deprecated in Kubernetes 1.28 and will be removed in Kubernetes 1.31. (The community does not plan to support CSI migration.) Use RBD [Ceph CSI driver](#) instead.

New and Enhanced Features

Features in alpha stage are disabled by default, those in beta stage are enabled by default, and those in GA stage are always enabled and they cannot be disabled. The function of turning on or off the features in GA stage will be removed in later

Kubernetes versions. CCE policies for new features are the same as those in the community.

- The version skew policy is expanded to three versions.
Starting with control planes 1.28 and worker nodes 1.25, the Kubernetes skew policy expands the supported control plane and worker node skew to three versions. This enables annual minor version upgrades of nodes while staying on supported minor versions. For details, see [Version Skew Policy](#).
- Retroactive Default StorageClass moves to GA.
The retroactive default StorageClass assignment graduates to GA. This enhancement brings a significant improvement to how default StorageClasses are assigned to PersistentVolumeClaims (PVCs).
The PV controller has been modified to automatically assign a default StorageClass to any unbound PVC with **storageClassName** not configured. Additionally, the PVC admission validation mechanism within the API server has been adjusted to allow changing values from an unset state to an actual StorageClass name. For details, see [Retroactive default StorageClass assignment](#).
- Native sidecar containers are introduced.
The native sidecar containers are available in alpha. Kubernetes 1.28 adds **restartPolicy** to Init containers. This field is available when the SidecarContainers feature gate is enabled. However, there are still some problems to be solved in the native sidecar containers. Therefore, the Kubernetes community recommends only using this feature gate in [short lived testing clusters](#) at the alpha phase. For details, see [Introducing native sidecar containers](#).
- Mixed version proxy is introduced.
A new mechanism (mixed version proxy) is released to improve cluster upgrade. It is an alpha feature in Kubernetes 1.28. When a cluster undergoes an upgrade, API servers of different versions in the cluster can serve different sets (groups, versions, or resources) of built-in resources. A resource request made in this scenario may be served by any of the available API servers, potentially resulting in the request ending up at an API server that may not be aware of the requested resource. As a result, the request fails. This feature can solve this problem. (Note that CCE provides hitless upgrade. Therefore, this feature is not used in CCE clusters.) For details, see [A New \(alpha\) Mechanism For Safer Cluster Upgrades](#).
- Non-graceful node shutdown moves to GA.
The non-graceful node shutdown is now GA in Kubernetes 1.28. When a node was shut down and that shutdown was not detected by the kubelet's Node Shutdown Manager, the StatefulSet pods that run on this node will stay in the terminated state and cannot be moved to a running node. If you have confirmed that the shutdown node is unrecoverable, you can add an **out-of-service** taint to the node. This ensures that the StatefulSet pods and VolumeAttachments on this node can be forcibly deleted and the corresponding pods will be created on a healthy node. For details, see [Non-Graceful Node Shutdown Moves to GA](#).
- NodeSwap moves to beta.
Support for NodeSwap goes to beta in Kubernetes 1.28. NodeSwap is disabled by default and can be enabled using the NodeSwap feature gate. NodeSwap

allows you to configure swap memory usage for Kubernetes workloads running on Linux on a per-node basis. Note that although NodeSwap has reached beta, there are still some problems to be solved and security risks to be enhanced. For details, see [Beta Support for Using Swap on Linux](#).

- Two job-related features are added.

Two alpha features are introduced: [delayed creation of replacement pods](#) and [backoff limit per index](#).

- Delayed creation of replacement pods

By default, when a pod enters the terminating state (for example, due to the preemption or eviction), Kubernetes immediately creates a replacement pod. Therefore, both pods are running concurrently.

In Kubernetes 1.28, this feature can be enabled by turning on the JobPodReplacementPolicy feature gate. With this feature gate enabled, you can set the **podReplacementPolicy** field under **spec** of a job to **Failed**. In this way, pods would only be replaced when they reached the failed phase, and not when they are terminating. Additionally, you can check the **.status.termination** field of a job. The value of this field is the number of pods owned by the job that are currently terminating.

- Backoff limit per index

By default, pod failures for indexed jobs are recorded and restricted by the global limit of retries, specified by **.spec.backoffLimit**. This means that if there is a consistently failing index in a job, pods specified by the job will be restarted repeatedly until pod failures exhaust the limit. Once the limit is reached, the job is marked failed and pods for other indexes in the job may never be even started.

In Kubernetes 1.28, this feature can be enabled by turning on the JobBackoffLimitPerIndex feature gate of a cluster. With this feature gate enabled, **.spec.backoffLimitPerIndex** can be specified when an indexed job is created. Only if the failures of pods with all indexes specified in this job exceed the upper limit, pods specified by the job will not be restarted.

- Some CEL related features are improved.

CEL related capabilities are enhanced.

- CEL used to validate CRDs moves to beta.

This feature has been upgraded to beta since Kubernetes 1.25. By embedding CEL expressions into CRDs, developers can solve most of the CR validation use cases without using webhooks. More CEL functions, such as support for default value and CRD conversion, will be developed in later Kubernetes versions.

- CEL admission control graduates to beta.

CEL admission control is customizable. With CEL expressions, you can decide whether to accept or reject requests received by kube-apiserver. CEL expressions can also serve as a substitute for admission webhooks. Kubernetes 1.28 has upgraded CEL admission control to beta and introduced new functions, such as:

- ValidatingAdmissionPolicy can correctly handle the **authorizer** variable.
- ValidatingAdmissionPolicy can have the **messageExpression** field checked.

- The ValidatingAdmissionPolicy controller is added to kube-controller-manager to check the type of the CEL expression in ValidatingAdmissionPolicy and save the reason in the **status** field.
- CEL expressions can contain a combination of one or more variables, which can be defined in ValidatingAdmissionPolicy. These variables can be used to define other variables.
- CEL library functions can be used to parse resources specified by **resource.Quantity** in Kubernetes.
- Other features
 - The ServiceNodePortStaticSubrange feature gate moves to beta. With this feature enabled, static port range can be reserved to avoid conflicts with dynamically allocated ports. For details, see [Avoiding Collisions Assigning Ports to NodePort Services](#).
 - The alpha feature ConsistentListFromCache is added to allow the API server to serve consistent lists from cache. Get and list requests can read data from the cache instead of etcd.
 - In Kubernetes 1.28, kubelet can configure the drop-in directory (alpha). This feature allows you to add support for the **--config-dir** flag to kubelet so that you can specify an insert directory that overwrites the kubelet configuration in **/etc/kubernetes/kubelet.conf**.
 - ExpandedDNSConfig moves to GA and is enabled by default. With this feature enabled, DNS configurations can be expanded.
 - The alpha feature CRDValidationRatcheting is added. This feature allows CRs with failing validations to pass if a Patch or Update request does not alter any of the invalid fields.
 - **--concurrent-cron-job-syncs** is added to kube-controller-manager to configure the number of workers for the cron job controller.

API Changes and Removals

- **NetworkPolicyStatus** is removed. There is no status attribute in a network policy.
- **annotationbatch.kubernetes.io/cronJob-scheduled-timestamp** is added to job objects to indicate the creation time of a job.
- The **podReplacementPolicy** and **terminating** fields are added to job APIs. With these fields specified, once a previously created pod is terminated in a job, the job immediately starts a new pod to replace the pod. The new fields allow you to specify whether to replace the pod immediately after the previous pod is terminated (original behavior) or replace the pod after the existing pod is completely terminated (new behavior). This is an alpha feature, and you can enable it by turning on the [JobPodReplacementPolicy](#) feature gate in your cluster.
- The **BackoffLimitPerIndex** field is available in a job. Pods specified by a job share a backoff mechanism. When backoff times of the job reach the limit, this job is marked as failed and resources, including indexes that are not running, are cleared up. This field allows you to configure backoff limit for a single index. For details, see [Backoff limit per index](#).

- The **ServedVersions** field is added to the **StorageVersion** API. This change is introduced by mixed version proxy. The new field is used to indicate a version that can be provided by the API server.
- **SelfSubjectReview** is added to **authentication.k8s.io/v1**, and **kubectl auth whoami** goes to GA.
- **LastPhaseTransitionTime** is added to **PersistentVolume**. The new field is used to store the last time when a volume changes to a different phase.
- **resizeStatus** in **PVC.Status** is replaced by **AllocatedResourceStatus**. The new field indicates the statuses of the storage resize operation. The default value is an empty string.
- If **hostNetwork** is set to **true** and ports are specified for a pod, the **hostport** field will be automatically configured.
- StatefulSet pods have the pod index set as a pod label **statefulset.kubernetes.io/pod-index**.
- **PodHasNetwork** in the **Condition** field of pods has been renamed to **PodReadyToStartContainers**. The new field specifies that containers are ready to start after the network, volumes, and sandbox pod have been created.
- A new configuration option **delayCacheUntilActive** is added to **KubeSchedulerConfiguration**. If **delayCacheUntilActive** is set to **true**, kube-scheduler on the leader will not cache scheduling information. This reduces the memory pressure of other master nodes, but slows down the failover speed after the leader failed.
- The **namespaceParamRef** field is added to **admissionregistration.k8s.io/v1alpha1.ValidatingAdmissionPolicy**.
- The **reason** and **fieldPath** fields are added to CRD validation rules to allow you to specify reason and field path after verification failed.
- The CEL expression of ValidatingAdmissionPolicy supports namespace access via namespaceObject.
- API groups ValidatingAdmissionPolicy and ValidatingAdmissionPolicyBinding are promoted to beta1.
- A ValidatingAdmissionPolicy now has its **messageExpression** field checked against resolved types.

Feature Gate and Command Line Parameter Changes and Removals

- **-short** is removed from kubelet. Therefore, the default output of **kubectl version** is the same as that of **kubectl version -short**.
- **--volume-host-cidr-denylist** and **--volume-host-allow-local-loopback** are removed from kube-controller-manager. **--volume-host-cidr-denylist** is a comma-separated list of CIDR ranges. Volume plugins at these IP addresses are not allowed. If **--volume-host-allow-local-loopback** is set to **false**, the local loopback IP address and the CIDR ranges specified in **--volume-host-cidr-denylist** are disabled.
- **--azure-container-registry-config** is deprecated in kubelet and will be deleted in later Kubernetes versions. Use **--image-credential-provider-config** and **--image-credential-provider-bin-dir** instead.
- **--lock-object-namespace** and **--lock-object-name** are removed from kube-scheduler. Use **--leader-elect-resource-namespace** and **--leader-elect-**

resource-name or **ComponentConfig** instead. (**--lock-object-namespace** is used to define the namespace of a lock object, and **--lock-object-name** is used to define the name of a lock object.)

- KMS v1 is deprecated and will only receive security updates. Use KMS v2 instead. In later Kubernetes versions, use **--feature-gates=KMSv1=true** to configure a KMS v1 provider.
- The **DelegateFSGroupToCSIDriver**, **DevicePlugins**, **KubeletCredentialProviders**, **MixedProtocolLBService**, **ServiceInternalTrafficPolicy**, **ServiceIPStaticSubrange**, and **EndpointSliceTerminatingCondition** feature gates are removed.

Enhanced Kubernetes 1.28 on CCE

During a version maintenance period, CCE periodically updates Kubernetes 1.28 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 1.28 and other versions, see [Kubernetes v1.28 Release Notes](#).

6.1.2.3 Kubernetes 1.27 Release Notes

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

Indexes

- [New Features](#)
- [Deprecations and Removals](#)
- [Enhanced Kubernetes 1.27 on CCE](#)
- [References](#)

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 retained 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 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. 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 **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](#)

6.1.2.4 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.

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- [Deprecations and Removals](#)

- [Enhanced Kubernetes 1.25 on CCE](#)
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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 containers are stable.
An [ephemeral container](#) 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 [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 enough 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](#)

6.1.2.5 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](#)

6.1.2.6 Kubernetes 1.21 (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 1.21.

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 is 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](#)

6.1.2.7 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](#)

6.1.2.8 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](#)

6.1.3 Patch Version Release Notes

Version 1.29

Table 6-2 Release notes for the v1.29 patch

CCE Cluster Patch Version	Kubernetes Version	Feature Updates	Optimization	Vulnerability Fixing
v1.29.2-r0	v1.29.3	<ul style="list-style-type: none"> • CCE ingresses support traffic distribution based on custom HTTP headers. • Scaling priority policies can be configured for third-party workloads. 	<ul style="list-style-type: none"> • An in-progress node drainage can be canceled. • When updating a node pool, you can change its agency name, prefix, and suffix. • Kubernetes labels and taints of a node are retained after the node is reset. • Both the Kubernetes service account token volume projection and the load scaling controller can be configured. 	Fixed some security issues.

CCE Cluster Patch Version	Kubernetes Version	Feature Updates	Optimization	Vulnerability Fixing
v1.29.1-r0	v1.29.1	CCE clusters of v1.29 are released for the first time. For more information, see Kubernetes 1.29 Release Notes .	None	None

Version 1.28

Table 6-3 Release notes for the v1.28 patch

CCE Cluster Patch Version	Kubernetes Version	Feature Updates	Optimization	Vulnerability Fixing
v1.28.6-r0	v1.28.8	<ul style="list-style-type: none"> • CCE ingresses support traffic distribution based on custom HTTP headers. • Scaling priority policies can be configured for third-party workloads. 	<ul style="list-style-type: none"> • An in-progress node drainage can be canceled. • When updating a node pool, you can change its agency name, prefix, and suffix. • Kubernetes labels and taints of a node are retained after the node is reset. • Both the Kubernetes service account token volume projection and the load scaling controller can be configured. 	Fixed some security issues.

CCE Cluster Patch Version	Kubernetes Version	Feature Updates	Optimization	Vulnerability Fixing
v1.28.3-r0	v1.28.3	LoadBalancer Services and ingresses allow you to: <ul style="list-style-type: none"> • Configure SNI. • Enable HTTP/2. • Configure idle timeout, request timeout, and response timeout. 	None	Fixed some security issues.
v1.28.2-r0	v1.28.3	<ul style="list-style-type: none"> • You can configure an ELB blocklist/trustlist for access control when creating a Service or ingress. 	None	Fixed some security issues.
v1.28.1-r4	v1.28.3	None	None	Fixed CVE-2024-21626 issues.
v1.28.1-r0	v1.28.3	CCE clusters of v1.28 are released for the first time. For more information, see Kubernetes 1.28 Release Notes . <ul style="list-style-type: none"> • The prefix and suffix of a node name can be customized in node pools. • LoadBalancer ingresses support gRPC. • LoadBalancer Services allow you to specify a private IP address for a load balancer during Service creation using YAML. 	None	None

Version 1.27

Table 6-4 Release notes for the v1.27 patch

CCE Cluster Patch Version	Kubernetes Version	Feature Updates	Optimization	Vulnerability Fixing
v1.27.8-r0	v1.27.12	<ul style="list-style-type: none"> • CCE ingresses support traffic distribution based on custom HTTP headers. • Scaling priority policies can be configured for third-party workloads. 	<ul style="list-style-type: none"> • An in-progress node drainage can be canceled. • When updating a node pool, you can change its agency name, prefix, and suffix. • Kubernetes labels and taints of a node are retained after the node is reset. • Both the Kubernetes service account token volume projection and the load scaling controller can be configured. 	Fixed some security issues.
v1.27.5-r0	v1.27.4	LoadBalancer Services and ingresses allow you to: <ul style="list-style-type: none"> • Configure SNI. • Enable HTTP/2. • Configure idle timeout, request timeout, and response timeout. 	None	Fixed some security issues.

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	<ul style="list-style-type: none"> 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	<p>CCE clusters of v1.27 are released for the first time. For more information, see Kubernetes 1.27 Release Notes.</p> <ul style="list-style-type: none"> Both soft eviction and hard eviction are supported in node pool configurations. 	None	None

Version 1.25

NOTICE

In CCE clusters of v1.25, containerd is the default runtime for nodes, except for nodes running EulerOS 2.5. In addition, clusters of v1.25 or later no longer support EulerOS 2.5.

Table 6-5 Release notes for the v1.25 patch

CCE Cluster Patch Version	Kubernetes Version	Feature Updates	Optimization	Vulnerability Fixing
v1.25.11-r0	v1.25.16	<ul style="list-style-type: none"> CCE ingresses support traffic distribution based on custom HTTP headers. Scaling priority policies can be configured for third-party workloads. 	<ul style="list-style-type: none"> An in-progress node drainage can be canceled. When updating a node pool, you can change its agency name, prefix, and suffix. Kubernetes labels and taints of a node are retained after the node is reset. Both the Kubernetes service account token volume projection and the load scaling controller can be configured. 	Fixed some security issues.
v1.25.8-r0	v1.25.10	LoadBalancer Services and ingresses allow you to: <ul style="list-style-type: none"> Configure SNI. Enable HTTP/2. Configure idle timeout, request timeout, and response timeout. 	None	Fixed some security issues.
v1.25.6-r4	v1.25.10	None	None	Fixed CVE-2024-21626 issues.
v1.25.5-r0	v1.25.5	<ul style="list-style-type: none"> Volcano supports node pool affinity scheduling. Volcano supports workload rescheduling. 	None	Fixed some security issues.

CCE Cluster Patch Version	Kubernetes Version	Feature Updates	Optimization	Vulnerability Fixing
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	<ul style="list-style-type: none"> 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 6-6 Release notes for the v1.23 patch

CCE Cluster Patch Version	Kubernetes Version	Feature Updates	Optimization	Vulnerability Fixing
v1.23.16-r0	v1.23.17	<ul style="list-style-type: none"> CCE ingresses support traffic distribution based on custom HTTP headers. Scaling priority policies can be configured for third-party workloads. 	<ul style="list-style-type: none"> An in-progress node drainage can be canceled. When updating a node pool, you can change its agency name, prefix, and suffix. Kubernetes labels and taints of a node are retained after the node is reset. Both the Kubernetes service account token volume projection and the load scaling controller can be configured. 	Fixed some security issues.
v1.23.13-r0	v1.23.17	LoadBalancer Services and ingresses allow you to: <ul style="list-style-type: none"> Configure SNI. Enable HTTP/2. Configure idle timeout, request timeout, and response timeout. 	None	Fixed some security issues.
v1.23.11-r4	v1.23.17	None	None	Fixed CVE-2024-21626 issues.

CCE Cluster Patch Version	Kubernetes Version	Feature Updates	Optimization	Vulnerability Fixing
v1.23.10-r0	v1.23.11	<ul style="list-style-type: none"> 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	<ul style="list-style-type: none"> 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	<ul style="list-style-type: 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	<ul style="list-style-type: none"> • Fault detection and isolation are supported on GPU nodes. • Security groups can be customized by cluster. • containerd is supported. 	<ul style="list-style-type: none"> • 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: <ul style="list-style-type: none"> • 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 6-7 Release notes for the v1.21 patch

CCE Cluster Patch Version	Kubernetes Version	Feature Updates	Optimization	Vulnerability Fixing
v1.21.14-r0	v1.21.14	A PVC can be used to dynamically create and mount an SFS Turbo subdirectory.	None	Fixed some security issues.
v1.21.12-r4	v1.21.14	None	None	Fixed CVE-2024-21626 issues.
v1.21.11-r20	v1.21.14	<ul style="list-style-type: none"> 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	<ul style="list-style-type: none"> 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	<ul style="list-style-type: 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	<ul style="list-style-type: none"> 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: <ul style="list-style-type: none"> 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 6-8 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	<ul style="list-style-type: none"> 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	<ul style="list-style-type: none"> 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	<ul style="list-style-type: 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	<ul style="list-style-type: none"> Fault detection and isolation are supported on GPU nodes. Security groups can be customized by cluster. 	<ul style="list-style-type: none"> 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: <ul style="list-style-type: none"> 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: <ul style="list-style-type: none"> 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

6.2 Creating a Cluster

6.2.1 Comparison Between Cluster Types

Comparison

CCE provides different types of clusters for you to select. The following table lists the differences between them.

Category	Subcategory	CCE Standard
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 1.0 networks: for scenarios where requirements on performance are not high and there are not so many containers <ul style="list-style-type: none"> • Tunnel network • Virtual Private Cloud (VPC) network
	Network performance	The container network is overlaid with the VPC network, causing certain performance loss.
	Network isolation	<ul style="list-style-type: none"> • Tunnel network model: network policies supported for communications within a cluster • VPC network model: isolation not supported
	Security isolation	cgroups are used to isolate common containers.

6.2.2 Creating 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.

Precautions

- 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 **Create Cluster** in the upper right corner.

----End

Step 2: Configure the Cluster

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

Basic Settings

Parameter	Description
Cluster Name	Enter a cluster name. Cluster names under the same account must be unique.
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.

Parameter	Description
Master Nodes	<p>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.</p> <ul style="list-style-type: none"> • 3 Masters: Three master nodes will be created for high cluster availability. • Single: Only one master node will be created in your cluster. <p>You can also select AZs for the master nodes. By default, AZs are allocated automatically for the master nodes.</p> <ul style="list-style-type: none"> • 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. <ul style="list-style-type: none"> - 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 6-9 Cluster 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.

Table 6-10 Container 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 6-11 Service network settings

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.
Request Forwarding	Select IPVS or iptables for your cluster. For details, see Comparing iptables and IPVS . <ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> 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. <p>CAUTION</p> <ul style="list-style-type: none"> 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 Enabling Overload Control for a Cluster .
Resource Tag	You can add resource tags to classify resources. A maximum of 20 resource tags can be added. 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.
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.

Observability

Parameter	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.

Observability

Parameter	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](#).

6.2.3 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	A mature, stable kube-proxy mode, but its performance is average. It applies to scenarios where the number of Services is small (less than 3000) or there are a large number of short concurrent connections on the client. For details, see iptables .	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 3000 Services in a cluster, network delay may occur.	<ul style="list-style-type: none"> 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 number 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](#).

6.3 Connecting to a Cluster

6.3.1 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. The process is as follows:

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. Replace it as required.
```

2. Install kubectl.

```
chmod +x kubectl
mv -f kubectl /usr/local/bin
```

Step 2 Obtain the kubectl configuration file.

In the **Connection Info** pane on the **Overview** page, click **Configure** next to **kubectl** to check the kubectl connection. On the displayed page, choose **Intranet access** or **Public network access** and 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 configuration file (for example, **kubeconfig.yaml**) 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 6-1**. To use two-way authentication, download the **kubeconfig.yaml** file again and enable two-way authentication for the domain names.

Figure 6-1 Two-way authentication disabled for domain names

```
"clusters": [{
  "name": "mycluster",
  "cluster": {
    "server": "https://10.100.0.52:5443",
    "insecure-skip-tls-verify": true
  }
}]
```

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](#).

6.3.2 Accessing a Cluster Using an X.509 Certificate

Scenario

This section describes how to obtain the cluster certificate from the console and use it to 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 obtain the pod information. In the following information, *192.168.0.18:5443* indicates the private IP address or EIP and port number 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 API](#).

----End

6.3.3 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 domain name mapping by either adding 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.


Prerequisites

A cluster of v1.19 or later is available.

Customizing a SAN

Step 1 Log in to the CCE console.

Step 2 Click the name of the target cluster in the cluster list to go to the cluster **Overview** 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 an API to obtain 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

6.3.4 Configuring a Cluster's API Server for Internet Access

You can bind an EIP to an API server of a Kubernetes cluster so that the API server can access the Internet.

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 **Bind** next to **EIP**.

Step 3 Select an existing EIP. If no EIP is available, click **Create EIP** to go to the EIP console and assign one.

NOTE

- Binding an EIP to an API server for Internet access can pose a risk to the cluster's security. To mitigate this risk, configure Advanced Anti-DDoS or API server access policies ([Configuring Access Policies for an API Server](#)) for the bound EIP.
- Binding an EIP to an API server will cause the API server to restart briefly and update the kubeconfig certificate. Do not make any changes to the cluster during this period.

Step 4 Click **OK**.

----End

Configuring Access Policies for an API Server

To ensure the security of a cluster's API server, it is important to modify the security group rules for the master nodes. This is because the EIP, which is exposed to the Internet, is at risk of being attacked.

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 management plane of the hosted service mesh to ensure that the API Server can be accessed from within the cluster.

- Step 7** Click **Confirm**.

----End

6.4 Managing a Cluster

6.4.1 Modifying Cluster Configurations

Scenario

CCE allows you to manage cluster parameters, through which you can let core components work under your requirements.

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 6-12 kube-apiserver configurations

Item	Parameter	Description	Value
Toleration time for nodes in NotReady state	default-not-ready-toleration-seconds	<p>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 Configuring Tolerance Policies.</p> <p>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.</p>	Default: 300s
Toleration time for nodes in unreachable state	default-unreachable-toleration-seconds	<p>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 Configuring Tolerance Policies.</p> <p>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.</p>	Default: 300s

Item	Parameter	Description	Value
Maximum Number of Concurrent Modification API Calls	max-mutating-requests-inflight	<p>Maximum number of concurrent mutating requests. When the value of this parameter is exceeded, the server rejects requests.</p> <p>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.</p>	<p>Manual configuration is no longer supported since cluster v1.21. The value is automatically specified based on the cluster scale.</p> <ul style="list-style-type: none"> • 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	<p>Maximum number of concurrent non-mutating requests. When the value of this parameter is exceeded, the server rejects requests.</p> <p>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.</p>	<p>Manual configuration is no longer supported since cluster v1.21. The value is automatically specified based on the cluster scale.</p> <ul style="list-style-type: none"> • 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	<p>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.</p> <p>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.</p>	<p>Default: 30000 to 32767</p> <p>Value range: Min > 20105 Max < 32768</p>
Request Timeout	request-timeout	<p>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.</p> <p>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.</p>	<p>Default: 1m0s</p> <p>Value range: Min ≥ 1s Max ≤ 1 hour</p>

Item	Parameter	Description	Value
ServerSideApply	feature-gates: ServerSideApply	<p>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.</p> <p>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.</p>	Default: true
Overload Control	support-overload	<p>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.</p> <p>This parameter is available only in clusters of v1.23 or later.</p>	<ul style="list-style-type: none"> • false: Overload control is disabled. • true: Overload control is enabled.
Node Restriction Add-on	enable-admission-plugin-node-restriction	<p>This add-on allows the Kubelet of a node to operate only the objects of the current node for enhanced isolation in multi-tenant scenarios or the scenarios with high security requirements.</p> <p>This parameter is available only in clusters of v1.23.14-r0, v1.25.9-r0, v1.27.6-r0, v1.28.4-r0, or later versions.</p>	Default: true

Item	Parameter	Description	Value
Pod Node Selector Add-on	enable-admission-plugin-pod-node-selector	<p>This add-on allows cluster administrators to configure the default node selector through namespace annotations. In this way, pods run only on specific nodes and configurations are simplified.</p> <p>This parameter is available only in clusters of v1.23.14-r0, v1.25.9-r0, v1.27.6-r0, v1.28.4-r0, or later versions.</p>	Default: true
Pod Toleration Limit Add-on	enable-admission-plugin-pod-toleration-restriction	<p>This add-on allows cluster administrators to configure the default value and limits of pod tolerations through namespaces for fine-grained control over pod scheduling and key resource protection.</p> <p>This parameter is available only in clusters of v1.23.14-r0, v1.25.9-r0, v1.27.6-r0, v1.28.4-r0, or later versions.</p>	Default: false

Item	Parameter	Description	Value
API Audience Settings	api-audiences	<p>Audiences for a service account token. The Kubernetes component for authenticating service account tokens checks whether the token used in an API request specifies authorized audiences.</p> <p>Configuration suggestion: Accurately configure audiences according to the communication needs among cluster services. By doing so, the service account token is used for authentication only between authorized services, which enhances security.</p> <p>NOTE An incorrect configuration may lead to an authentication communication failure between services or an error during token verification.</p> <p>This parameter is available only in clusters of v1.23.16-r0, v1.25.11-r0, v1.27.8-r0, v1.28.6-r0, v1.29.2-r0, or later versions.</p>	<p>Default value: "https://kubernetes.default.svc.cluster.local"</p> <p>Multiple values can be configured, which are separated by commas (,).</p>
Service Account Token Issuer Identity	service-account-issuer	<p>Entity identifier for issuing a service account token, which is the value identified by the iss field in the payload of the service account token.</p> <p>Configuration suggestion: Ensure the configured issuer URL can be accessed in the cluster and trusted by the authentication system in the cluster.</p> <p>NOTE If your specified issuer URL is untrusted or inaccessible, the authentication process based on the service account may fail.</p> <p>This parameter is available only in clusters of v1.23.16-r0, v1.25.11-r0, v1.27.8-r0, v1.28.6-r0, v1.29.2-r0, or later versions.</p>	<p>Default value: "https://kubernetes.default.svc.cluster.local"</p> <p>Multiple values can be configured, which are separated by commas (,).</p>

Table 6-13 Scheduler configurations

Item	Parameter	Description	Value
QPS for communicating with kube-apiserver	kube-api-qps	QPS for communicating with kube-apiserver.	<ul style="list-style-type: none"> If the number of nodes in a cluster is less than 1000, the default value is 100. If the number of nodes in a cluster is 1000 or more, the default value is 200.
Burst for communicating with kube-apiserver	kube-api-burst	Burst for communicating with kube-apiserver.	<ul style="list-style-type: none"> If the number of nodes in a cluster is less than 1000, the default value is 100. If the number of nodes in a cluster is 1000 or more, the default value is 200.

Item	Parameter	Description	Value
Whether to enable GPU sharing	enable-gpu-share	<p>Whether to enable GPU sharing. This parameter is supported only by clusters of v1.23.7-r10, v1.25.3-r0, and later.</p> <ul style="list-style-type: none"> When disabled, ensure that pods in the cluster cannot use shared GPUs (no cce.io/gpu-decision annotation in pods). When enabled, ensure that there is a cce.io/gpu-decision annotation on all pods that use GPU resources in the cluster. 	Default: true

Table 6-14 kube-controller-manager configurations

Item	Parameter	Description	Value
Number of concurrent processing of deployment	concurrent-deployment-syncs	Number of deployment objects that can be synchronized 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 can be synchronized concurrently	Default: 20
Number of job objects allowed to sync simultaneously	concurrent-job-syncs	Number of job objects that can be synchronized concurrently	Default: 5
Number of CronJob objects allowed to sync simultaneously	concurrent-cron-job-syncs	Number of scheduled jobs that can be synchronized concurrently	Default: 5

Item	Parameter	Description	Value
Number of concurrent processing of namespace	concurrent-namespace-syncs	Number of namespace objects that can be synchronized concurrently	Default: 10
Concurrent processing number of replicaset	concurrent-replicaset-syncs	Number of replica sets that can be synchronized concurrently	Default: 5
ResourceQuota	concurrent-resource-quota-syncs	Number of resource quotas that can be synchronized concurrently	Default: 5
Concurrent processing number of service	concurrent-service-syncs	Number of services that can be synchronized concurrently	Default: 10
Concurrent processing number of serviceaccount-token	concurrent-serviceaccount-token-syncs	Number of service account token objects that can be synchronized concurrently	Default: 5
Concurrent processing of ttl-after-finished	concurrent-ttl-after-finished-syncs	Number of ttl-after-finished-controller workers that can be synchronized concurrently	Default: 5
RC	concurrent_rc_syncs (used in clusters of v1.19 or earlier) concurrent-rc-syncs (used in clusters of v1.21 through v1.25.3-r0)	Number of replication controllers that can be synchronized concurrently NOTE This parameter is no longer supported in clusters of v1.25.3-r0 and later versions.	Default: 5
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 of v1.27 or later Value range: 1 to 50

Item	Parameter	Description	Value
Cluster elastic computing period	horizontal-pod-autoscaler-sync-period	<p>Period for the horizontal pod autoscaler to perform auto scaling on pods. A smaller value will result in a faster auto scaling response and higher CPU load.</p> <p>NOTE Make sure to configure this parameter properly as a lengthy period can cause the controller to respond slowly, while a short period may overload the cluster management plane.</p>	Default: 15 seconds
Horizontal Pod Scaling Tolerance	horizontal-pod-autoscaler-tolerance	<p>The configuration determines how quickly HPA will act to auto scaling policies. If the parameter is set to 0, auto scaling will be triggered immediately when the related metrics are met.</p> <p>Configuration suggestion: If the service resource usage increases sharply over time, retain a certain tolerance to prevent auto scaling which is beyond expectation in high resource usage scenarios.</p>	Default: 0.1

Item	Parameter	Description	Value
HPA CPU Initialization Period	horizontal-pod-autoscaler-cpu-initialization-period	<p>During the period specified by this parameter, the CPU usage data used in HPA calculation is limited to pods that are both ready and have recently had their metrics collected. You can use this parameter to filter out unstable CPU usage data during the early stage of pod startup. This helps prevent incorrect scaling decisions based on momentary peak values.</p> <p>Configuration suggestion: If you find that HPA is making incorrect scaling decisions due to CPU usage fluctuations during pod startup, increase the value of this parameter to allow for a buffer period of stable CPU usage.</p> <p>NOTE</p> <p>Make sure to configure this parameter properly as a small value may trigger unnecessary scaling based on peak CPU usage, while a large value may cause scaling to be delayed.</p> <p>This parameter is available only in clusters of v1.23.16-r0, v1.25.11-r0, v1.27.8-r0, v1.28.6-r0, v1.29.2-r0, or later versions.</p>	Default: 5 minutes

Item	Parameter	Description	Value
HPA Initial Readiness Delay	horizontal-pod-autoscaler-initial-readiness-delay	<p>After CPU initialization, this period allows HPA to use a less strict criterion for filtering CPU metrics. During this period, HPA will gather data on the CPU usage of the pod for scaling, regardless of any changes in the pod's readiness status. This parameter ensures continuous tracking of CPU usage, even when the pod status changes frequently.</p> <p>Configuration suggestion: If the readiness status of pods fluctuates after startup and you want to prevent HPA misjudgment caused by the fluctuation, increase the value of this parameter to allow HPA to gather more comprehensive CPU usage data.</p> <p>NOTE Configure this parameter properly. If it is set to a small value, an unnecessary scale-out may occur due to CPU data fluctuations when the pod enters the ready state. If it is set to a large value, HPA may not be able to make a quick decision when a rapid response is needed.</p> <p>This parameter is available only in clusters of v1.23.16-r0, v1.25.11-r0, v1.27.8-r0, v1.28.6-r0, v1.29.2-r0, or later versions.</p>	Default: 30s

Item	Parameter	Description	Value
QPS for communicating with kube-apiserver	kube-api-qps	QPS for communicating with kube-apiserver	<ul style="list-style-type: none"> • If the number of nodes in a cluster is less than 1000, the default value is 100. • If the number of nodes in a cluster is 1000 or more, the default value is 200.
Burst for communicating with kube-apiserver	kube-api-burst	Burst for communicating with kube-apiserver	<ul style="list-style-type: none"> • If the number of nodes in a cluster is less than 1000, the default value is 100. • If the number of nodes in a cluster is 1000 or more, 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	<p>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.</p> <p>NOTE If this parameter is set to 0, all pods in the terminated state are retained.</p>	<p>Default: 1000</p> <p>Value range: 10 to 12500</p> <p>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.</p>
Unhealthy AZ Threshold	unhealthy-zone-threshold	<p>When more than a certain proportion of pods in an AZ are unhealthy, the AZ itself will be considered unhealthy, and scheduling pods to nodes in that AZ will be restricted to limit the impacts of the unhealthy AZ.</p> <p>This parameter is available only in clusters of v1.23.14-r0, v1.25.9-r0, v1.27.6-r0, v1.28.4-r0, or later versions.</p> <p>NOTE If the parameter is set to a large value, pods in unhealthy AZs will be migrated in a large scale, which may lead to risks such as overloaded clusters.</p>	<p>Default: 0.55</p> <p>Value range: 0 to 1</p>

Item	Parameter	Description	Value
Node Eviction Rate	node- eviction-rate	<p>This parameter specifies the number of nodes that pods are deleted from per second in a cluster when the AZ is healthy. The default value is 0.1, indicating that pods can be evicted from at most one node every 10 seconds.</p> <p>This parameter is available only in clusters of v1.23.14-r0, v1.25.9-r0, v1.27.6-r0, v1.28.4-r0, or later versions.</p> <p>NOTE If the parameter is set to a large value, the cluster may be overloaded. Additionally, if too many pods are evicted, they cannot be rescheduled, which will slow down fault recovery.</p>	Default: 0.1
Secondary Node Eviction Rate	secondary- node- eviction-rate	<p>This parameter specifies the number of nodes that pods are deleted from per second in a cluster when the AZ is unhealthy. The default value is 0.01, indicating that pods can be evicted from at most one node every 100 seconds.</p> <p>This parameter is available only in clusters of v1.23.14-r0, v1.25.9-r0, v1.27.6-r0, v1.28.4-r0, or later versions.</p> <p>NOTE There is no need to set the parameter to a large value for nodes in an unhealthy AZ, and this configuration may result in overloaded clusters.</p>	Default: 0.01 Configure this parameter with node- eviction-rate and set it to one-tenth of node- eviction-rate .

Item	Parameter	Description	Value
Large Cluster Threshold	large-cluster-size-threshold	<p>If the number of nodes in a cluster is greater than the value of this parameter, this is a large cluster.</p> <p>This parameter is available only in clusters of v1.23.14-r0, v1.25.9-r0, v1.27.6-r0, v1.28.4-r0, or later versions.</p> <p>NOTE kube-controller-manager automatically adjusts configurations for large clusters to optimize the cluster performance. Therefore, an excessively small threshold for small clusters will deteriorate the cluster performance.</p>	<p>Default: 50</p> <p>For the clusters with a large number of nodes, configure a relatively larger value than the default one for higher performance and faster responses of controllers. Retain the default value for small clusters. Before adjusting the value of this parameter in a production environment, check the impact of the change on cluster performance in a test environment.</p>

Table 6-15 Networking component configurations (supported only by the clusters using a VPC network)

Item	Parameter	Description	Value
Retaining the non-masqueraded CIDR block of the original pod IP address	nonMasqueradeCIDRs	<p>In a CCE cluster using the VPC network model, if a container in the cluster needs to access externally, the source pod IP address must be masqueraded as the IP address of the node where the pod resides through SNAT. After the configuration, the node will not SNAT the IP addresses in the CIDR block by default. This function is available only in clusters of v1.23.14-r0, v1.25.9-r0, v1.27.6-r0, v1.28.4-r0, or later versions.</p> <p>By default, nodes in a cluster do not perform SNAT on packets destined for 10.0.0.0/8, 172.16.0.0/12, or 192.168.0.0/16 that is detected by CCE as a private CIDR block. Instead, these packets are directly transferred using the upper-layer VPC. (The three CIDR blocks are considered as internal networks in the cluster and are reachable at Layer 3 by default.)</p>	<p>Default: 10.0.0.0/8, 172.16.0.0/12, or 192.168.0.0/16</p> <p>NOTE To enable cross-node pod access, the CIDR block of the node where the target pod runs must be added.</p> <p>Similarly, to enable cross-ECS pod access in a VPC, the CIDR block of the ECS where the target pod runs must be added.</p>

Table 6-16 Extended controller configurations (supported only by clusters of v1.21 and later)

Item	Parameter	Description	Value
Enable resource quota management	enable-resource-quota	<p>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.</p> <ul style="list-style-type: none"> ● false: Auto creation is disabled. ● true: Auto creation is enabled. For details about the resource quota defaults, see Configuring Resource Quotas. <p>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.</p>	Default: false

Step 4 Click **OK**.

----End

References

- [kube-apiserver](#)
- [kube-controller-manager](#)
- [kube-scheduler](#)

6.4.2 Enabling Overload Control for a Cluster

Scenario

After overload control is enabled, the number of simultaneous requests is dynamically regulated according to the resource pressure on the master nodes. This ensures that both the nodes and the cluster remain accessible.

Notes and 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

Overload Monitoring

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. The overload level metric will be displayed.

The overload levels are as follows:

- Circuit breaking: Rejects all external traffic.
- Severe overload: Rejects 75% external traffic.
- Moderate overload: Rejects 50% external traffic.
- Slight overload: Rejects 25% external traffic.
- Normal: Does not reject external traffic.

----End

Disabling Cluster Overload Control

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 In the navigation pane, choose **Settings**.

Step 3 On the **Cluster Access** tab page, disable overload control.

Step 4 Click **OK**.

----End

6.4.3 Changing Cluster Scale

Scenario

CCE allows you to change the number of nodes managed in a cluster.

Notes and Constraints

- A cluster that has only one master node supports fewer than 1000 worker nodes.
- The number of master nodes cannot be changed when you modify cluster specifications.
- A cluster can only be scaled out to a larger specification, but cannot be scaled in.
- To ensure proper cluster functionality, perform any specifications changes during off-peak hours. This is because master nodes will need to be powered off and on, which can disrupt normal operations.

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 **Modify Specifications**.

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 [Modifying Cluster Configurations](#).

----End

6.4.4 Deleting a Cluster

Precautions

- Deleting a cluster will delete the workloads and Services in the cluster, and the deleted data cannot be recovered. Before performing this operation, ensure that related data has been backed up or migrated.
- If you choose to delete a cluster with the nodes in it, the system disks and data disks attached to the nodes will also be deleted. Back up data before the deletion.
- 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

6.4.5 Hibernating or Waking Up a Cluster

Scenario

If a pay-per-use cluster is not needed temporarily, hibernate it to reduce costs.

After a cluster is hibernated, resources such as workloads cannot be created or managed in the cluster.

Precautions

- 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.

After a cluster is hibernated, the billing of master node resources will stop. Resources, such as worker nodes (ECSs), bound EIPs, and bandwidth, are still billed based on their own billing modes. To shut down nodes, select **Shut down all nodes in the cluster** in the dialog box or see [Stopping a Node](#).

Most nodes are no longer billed after they are stopped, excluding certain types of ECSs (ones with local disks attached, such as disk-intensive and ultra-high I/O ECSs).

----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.

NOTE

After the cluster is woken up, the cluster management fee continues to be billed.

----End

6.5 Upgrading a Cluster

6.5.1 Process and Method of Upgrading a Cluster

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:

- 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.
- 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](#).
- 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.

- 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, v1.27, or v1.28
v1.25	v1.27 or v1.28
v1.27	v1.28
v1.28	1.29

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 or 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

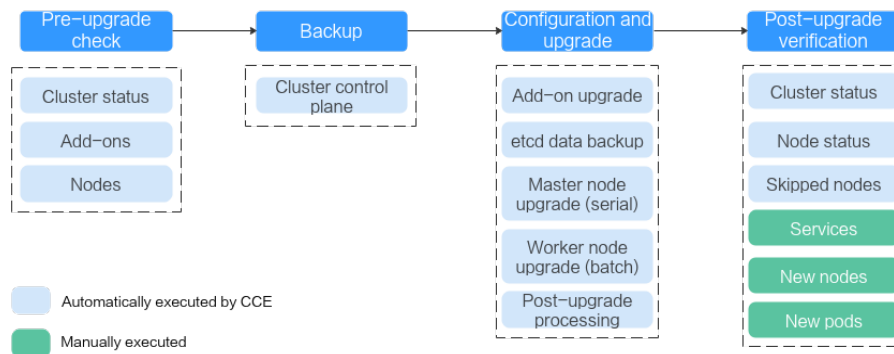
Patch version management is available for CCE clusters of v1.19 or later to provide new features and fix bugs and vulnerability for in-maintenance clusters without requiring a major version upgrade.

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 6-2 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 Duration	Rollback Duration	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.


Backup Type	Backup Object	Backup Mode	Backup Duration	Rollback Duration	Description
CBR cloud server backup	Master node disks, including component images, configurations, logs, and etcd data	One-click backup on a web page (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 6-17 Upgrade modes

Upgrade Mode	Description	Upgrade Scope	Advantage	Constraint
In-place upgrade	<p>Kubernetes components, network components, and CCE management components are upgraded on nodes. During an upgrade, service pods and networks are not affected.</p> <p>Nodes are upgraded in batches. Only the nodes that have been upgraded can be used to schedule services.</p>	<ul style="list-style-type: none"> 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.

6.5.2 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 [Process and Method of Upgrading a Cluster](#).

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 and 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

Notes and 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 Engines .	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 .	<ul style="list-style-type: none"> • To migrate PodSecurityPolicy capabilities to pod Security Admission, perform the following steps: <ol style="list-style-type: none"> 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
<p>v1.21 or v1.19 Upgraded to v1.23</p>	<p>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.</p>	<p>This item has been included in the pre-upgrade check. You can also perform the self-check by referring to nginx-ingress.</p>
<p>v1.19 to v1.21</p>	<p>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.</p>	<p>Before the upgrade, check whether the timeout is properly set for the exec probe.</p>

Upgrade Path	Version Difference	Self-Check
	<p>kube-apiserver of CCE v1.19 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.</p> <p>Root cause: X.509 CommonName is discarded in Go v1.15. kube-apiserver of CCE v1.19 is compiled using Go v1.15. 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.</p>	<p>Before the upgrade, check whether the SAN field is configured in the certificate of your webhook server.</p> <ul style="list-style-type: none"> 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 6-18 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

Deprecated APIs

With the evolution of Kubernetes APIs, APIs are periodically reorganized or upgraded, and certain 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 v1.29](#)
- No APIs deprecated in Kubernetes v1.28
- [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 6-19 APIs deprecated in Kubernetes v1.29

Resource	Deprecated API Version	Substitute API Version	Change Description
FlowSchema and PriorityLevelConfiguration	flowcontrol.apiserver.k8s.io/v1beta2	flowcontrol.apiserver.k8s.io/v1 (This API has been available since v1.29.) flowcontrol.apiserver.k8s.io/v1beta3 (This API has been available since v1.26.)	<ul style="list-style-type: none"> • Significant changes in flowcontrol.apiserver.k8s.io/v1: spec.limited.assuredConcurrencyShares of PriorityLevelConfiguration has been renamed spec.limited.nominalConcurrencyShares. The default value is 30 only when it is not specified, and the explicit value 0 does not change to 30. • Key changes in flowcontrol.apiserver.k8s.io/v1beta3: spec.limited.assuredConcurrencyShares of PriorityLevelConfiguration has been renamed spec.limited.nominalConcurrencyShares.

Table 6-20 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
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 6-21 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: <ul style="list-style-type: none"> • 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.)	<p>Pay attention to the following changes:</p> <ul style="list-style-type: none"> • 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
			<p>events.k8s.io/v1 event object).</p> <ul style="list-style-type: none"> 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).
HorizontalPod Autoscaler	autoscaling/v2beta1	autoscaling/v2 (This API is available since v1.23.)	None
PodDisruption Budget	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 6-22 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.)	<ul style="list-style-type: none"> • 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.)	<ul style="list-style-type: none"> • 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
			<p>unknown-fields: true in the schema definition.</p> <ul style="list-style-type: none"> In v1, the JSONPath field in the additionalPrinterColumns entry is renamed jsonPath (patch #66531).
APIService	apiregistration.k8s.io/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.)	<p>Pay attention to the following changes in certificates.k8s.io/v1:</p> <ul style="list-style-type: none"> • For an API client that requests a certificate: <ul style="list-style-type: none"> - 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: <ul style="list-style-type: none"> - 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.)	<ul style="list-style-type: none"> 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	<ul style="list-style-type: none"> 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 6-23 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.)	<ul style="list-style-type: none"> 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.)	<ul style="list-style-type: none"> • 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.)	<ul style="list-style-type: none"> • 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

The following table lists how to back up cluster data.

Backup Type	Backup Object	Backup Method	Backup Duration	Rollback Duration	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 a web page (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.

6.5.3 Performing Post-Upgrade Verification

6.5.3.1 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.

6.5.3.2 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.

6.5.3.3 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.

6.5.3.4 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.

6.5.3.5 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.

6.5.3.6 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 **nginx: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.

6.5.4 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 6-24 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	<ol style="list-style-type: none"> 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	<ol style="list-style-type: none"> 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 [Creating 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 shared storage such as OBS and SFS Turbo. If non-shared storage is used, suspend the workloads in the old cluster to switch the storage resources. In this case, 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

6.5.5 Troubleshooting for Pre-upgrade Check Exceptions

6.5.5.1 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 6-25 Check items

No.	Check Item	Description
1	Node Restrictions	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • 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 your master nodes can be accessed using SSH.
6	Node Pools	Check the node pool status.
7	Security Groups	Check whether the Protocol & Port of the worker node security groups is 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	<ul style="list-style-type: none"> • Check whether the cluster contains Arm nodes.
9	Residual Nodes	Check whether nodes need to be migrated.
10	Discarded Kubernetes Resources	Check whether there are discarded resources in the cluster.
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	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • 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 CPU Cores	Check and make sure that the master nodes in your cluster have more than 2 CPU cores.
23	Node Python Commands	Check whether the Python commands are available on a node.
24	ASM Version	<ul style="list-style-type: none"> • 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 is on the node. This file affects the startup of container runtime in the Euler OS.

No.	Check Item	Description
28	Internal Error	This check item is not typical and implies that an internal error was found during the pre-upgrade check.
29	Node Mount Points	Check whether there are inaccessible mount points 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 Limitations	Check whether there are compatibility limitations between the current and target cce-controller-hpa add-on versions.
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 cluster components such as the Kubernetes component, container runtime component, and network component are running properly before the upgrade.
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	<p>The system scans the audit logs of the past day to check whether the user calls the deprecated APIs of the target Kubernetes version.</p> <p>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.</p>
38	IPv6 Support in CCE Turbo Clusters	If IPv6 is enabled for a CCE Turbo cluster, check whether the target cluster version supports IPv6.
39	NetworkManager	Check whether NetworkManager of a node is normal.
40	Node ID File	Check the ID file format.
41	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:

No.	Check Item	Description
42	Node Configuration File	Check whether the configuration files of key components exist on the node.
43	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.
44	sudo	Check whether the sudo commands and sudo-related files of the node are working.
45	Key Node Commands	Whether some key commands that the node upgrade depends on are working
46	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.
47	HTTPS Load Balancer Certificate Consistency	Check whether the certificate used by an HTTPS load balancer has been modified on ELB.
48	Node Mounting	Check whether the default mount directory and soft link on the node have been manually mounted or modified.
49	Login Permissions of User paas on a Node	Check whether user paas is allowed to log in to a node.
50	Private IPv4 Addresses of Load Balancers	Check whether the load balancer associated with a Service is allocated with a private IPv4 address.
51	Historical Upgrade Records	Check the historical upgrade records of the cluster and confirm that the current version of the cluster meets the requirements for upgrading to the target version.
52	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.

No.	Check Item	Description
53	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.
54	Nodes' System Parameters	Check whether the default system parameter settings on your nodes are modified.
55	Residual Package Version Data	Check whether there are residual package version data in the current cluster.
56	Node Commands	Check whether the commands required for the upgrade are available on the node.
57	Node Swap	Check whether swap has been enabled on cluster nodes.
58	nginx-ingress Upgrade	Check whether there are compatibility issues that may occur during nginx-ingress upgrade.
59	containerd Pod Restart Risks	Check whether the service pods running on a containerd node are restarted when containerd is upgraded.
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 Pod Rebuild Risks	Check whether GPU service pods are rebuilt in a cluster when kubelet is restarted during the upgrade of the cluster.
62	ELB Listener Access Control	If access control is configured, check whether the configurations are correct.
63	Master Node Flavor	Check whether the flavor of the master nodes in the cluster is the same as the actual flavor of these nodes.
64	Subnet Quota of Master Nodes	Check whether the number of available IP addresses in the cluster subnet supports rolling upgrade.
65	Node Runtime	Check whether an alarm is generated when a cluster is upgraded to v1.27 or later. Do not use Docker in clusters of versions later than 1.27.
66	Node Pool Runtime	Check whether an alarm is generated when a cluster is upgraded to v1.27 or later. Do not use Docker in clusters of versions later than 1.27.
67	Number of Node Images	Check the number of images on your node. If there are more than 1000 images, it takes a long time for Docker to start, affecting the standard Docker output and functions such as Nginx.

6.5.5.2 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. In the right pane, 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 6-26 OSs that support the upgrade

OS	Constraint
EulerOS 2.x	If the target version is earlier than v1.27, there are no constraints. If the target version is v1.27 or later, only EulerOS 2.9 and EulerOS 2.10 support the upgrade.
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 CNIPProblem 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 version to 1.25 or 1.28. If you choose to upgrade the version to 1.28, EulerOS 2.5 will be upgraded to HCE 2.0 during the upgrade. If you have other requirements, submit a service ticket.

6.5.5.3 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.

6.5.5.4 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.

6.5.5.5 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.

6.5.5.6 SSH Connectivity of Master Nodes

Check Items

Check whether your master nodes can be accessed using SSH.

Solution

There is a low probability that the SSH connectivity check fails due to network fluctuations. Perform the pre-upgrade check again.

If the check still fails, submit a service ticket to contact technical support.

6.5.5.7 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](#).

6.5.5.8 Security Groups

Check Items

Check whether the **Protocol & Port** of the worker node security groups is 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.

6.5.5.9 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.

6.5.5.10 Residual Nodes

Check Items

Check whether nodes need 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.

6.5.5.11 Discarded Kubernetes Resources

Check Items

Check whether there are discarded resources in the clusters.

Solution

- **Scenario 1: 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 **tolerate-unready-endpoint**. If so, replace the annotation with the following fields in Service **spec**:

publishNotReadyAddresses: true

- **Scenario 2: The Service in the clusters of v1.27 or later has discarded annotation service.kubernetes.io/topology-aware-hints.**

Error log:

some check failed in cluster upgrade: this cluster has deprecated service list: map[***] with deprecated annotation list [service.kubernetes.io/topology-aware-hints]

Check whether the Service provided in the log information contains the annotation **service.kubernetes.io/topology-aware-hints**. If so, replace it with the annotation **service.kubernetes.io/topology-mode** in the affected Service.

6.5.5.12 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 Engines .	This item has been included in the pre-upgrade check.

Upgrade Path	Version Difference	Self-Check
v1.23 to v1.25	<p>Since Kubernetes v1.25, PodSecurityPolicy has been replaced by pod Security Admission. For details, see Configuring Pod Security Admission.</p>	<ul style="list-style-type: none"> ● To migrate PodSecurityPolicy capabilities to pod Security Admission, perform the following steps: <ol style="list-style-type: none"> 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	<p>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.</p>	<p>This item has been included in the pre-upgrade check. You can also perform the self-check by referring to nginx-ingress.</p>

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 v1.19 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 v1.15. kube-apiserver of CCE v1.19 is compiled using Go v1.15. 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. <ul style="list-style-type: none"> • 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 6-27 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

6.5.5.13 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.**

This issue occurs if cce-agent is not restarted. To resolve it, 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.**

This issue occurs if 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

 - Log in to the affected node and run the following command to obtain a valid OBS address:


```
cat /home/paas/upgrade/agentConfig | python -m json.tool
```



```
[root@192-168-11-235 upgrade]# cat agentConfig | python -m json.tool
{
  "role": "master",
  "packageDir": "/opt/cloud/cce/package/master-package",
  "manager": {
    "server": ""
  },
  "agentServer": {},
  "packageFrom": [
    {
      "type": "OBS",
      "addr": "https://obs-192-168-11-235.obs.cn-east-3.myhuaweicloud.com"
    },
    {
      "type": "OBS",
      "addr": "https://obs-192-168-11-235.obs.cn-east-3.myhuaweicloud.com"
    }
  ],
  "volumeAttach": 2,
  "localDiskECS": false,
  "cleanPackage": true,
  "localDir": "/opt/cloud/cce/.cce-package/",
  "reportMode": ""
}
```

- 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.

6.5.5.14 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.

6.5.5.15 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.

6.5.5.16 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
```

6.5.5.17 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.

6.5.5.18 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.

6.5.5.19 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.

6.5.5.20 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.

6.5.5.21 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 6-3 Running status of ntpd

```
[root@xxxxxxxxx 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 6-4 Running status of chronyd

```
root@xxxxxxxxxxxxxxxxxxxxx~# 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.

6.5.5.22 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.

6.5.5.23 Node CPU Cores

Check Items

Check and make sure that the master nodes in your cluster have more than 2 CPU cores.

Solution

The number of CPU cores on the master nodes is 2, which may lead to a cluster upgrade failure.

Contact technical support to expand the number of CPU cores to four or more.

6.5.5.24 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

Reset the node or manually install Python before attempting the upgrade again.

6.5.5.25 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 6-28 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 or v1.17
1.8	v1.15, v1.17, v1.19, or v1.21

ASM Version	Cluster Version
1.13	v1.21 or v1.23
1.15	v1.21, v1.23, v1.27, or v1.25
1.18	v1.25, v1.27, or v1.28

- 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 v1.25, upgrade ASM to v1.15 first.
- If you have not installed ASM, check whether the open-source Istio is installed in the cluster. If it is, check whether the current Istio version is compatible with the target cluster version. If they are compatible, skip this step and perform the check again. If they are not compatible, upgrade the Istio version and then upgrade the cluster.

6.5.5.26 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.

6.5.5.27 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 6-5 Running status of journald

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

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

6.5.5.28 containerd.sock

Check Items

Check whether the **containerd.sock** file is 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 **stat /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

6.5.5.29 Internal Error

Check Items

This check item is not typical and implies that an internal error was found during the pre-upgrade check.

Solution

Perform the pre-upgrade check again.
If it fails again, submit a service ticket to contact technical support.

6.5.5.30 Node Mount Points

Check Items

Check whether there are inaccessible mount points 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 Create a script file, for example, `/tmp/check_hang_mount.sh` on the node. The content of the script file is as follows:

```
for mount_path in `cat /proc/self/mountinfo | awk '{print $5}' | grep -v netns`
do
    timeout 10 sh -c "cd $mount_path"
    if [ $? == 124 ];then
        echo "$mount_path hang mount"
    fi
done
```

Step 3 Run the saved script and check the output.

```
[root@test-02-upgrade-v115-v119-vpc-06491 ~]# bash test.sh
/root/foo hang mount
/root/bar hang mount
[root@test-02-upgrade-v115-v119-vpc-06491 ~]#
```

The mount points of the `/root/foo` and `/root/bar` folders are incorrect.

Step 4 Run the following command to check the suspended mount points:

```
mount -n | grep /root/foo
```

```
/root/bar hang mount
[root@test-02-upgrade-v115-v119-vpc-06491 ~]# mount -n | grep /root/foo
localhost:/tmp/nfs on /root/foo type nfs (rw,relatime,vers=3,rsize=524288,wsize=524288,namlen=255,hard,proto=tcp,timeo=600,retr=2,sec=sys,mountaddr=127.0.0.1,mountvers=3,mountport=20048,mountproto=udp,local_lock=none,addr=127.0.0.1)
[root@test-02-upgrade-v115-v119-vpc-06491 ~]#
```

When a mount point is suspended, it typically indicates that services are not using it anymore. After confirming that the mount point is no longer required, run the following command to unmount it and then re-execute the previously mentioned script:

```
umount -l -f localhost:/tmp/nfs
```

```
[root@test-02-upgrade-v115-v119-vpc-06491 ~]# umount -l -f localhost:/tmp/nfs
[root@test-02-upgrade-v115-v119-vpc-06491 ~]# bash test.sh
[root@test-02-upgrade-v115-v119-vpc-06491 ~]#
[root@test-02-upgrade-v115-v119-vpc-06491 ~]#
[root@test-02-upgrade-v115-v119-vpc-06491 ~]#
```

After the execution, perform the check again on the pre-upgrade check page.

----End

6.5.5.31 Kubernetes Node Taints

Check Items

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

Table 6-29 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 6-6 kubelet version

```
[root@10-3-120-59 paas]# kubectl get node
NAME              STATUS    ROLES    AGE    VERSION
10.3.5[REDACTED] Ready     <none>   28h    v1.19.16-r4-CCE22.11.1
10.3.5[REDACTED] Ready     <none>   28h    v1.19.16-r4-CCE22.11.1
```

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

6.5.5.32 Everest Restrictions

Check Items

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

Table 6-30 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.

6.5.5.33 cce-hpa-controller Limitations

Check Items

Check whether there are compatibility limitations between the current and target cce-controller-hpa add-on versions.

Solution

There are compatibility limitations between the current and target versions of the cce-controller-hpa add-on. To address this, install an add-on that provides metrics APIs, like metrics-server, in the cluster.

Install the metrics add-on in the cluster and try again.

6.5.5.34 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 6-31 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

6.5.5.35 Health of Worker Node Components

Check Items

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

Solution

- Issue 1: CNI Agent is not active.
If your cluster version is earlier than v1.17.17, or you are using the `underlay_ipvlan` network model and your cluster version is later than v1.17.17, log in to the node and run the **`systemctl status canal`** command to check the status of canal. If you encounter an error, run the **`systemctl restart canal`** command and check the status again.
If you are using the VPC or Cloud Native 2.0 network model and your cluster version is later than v1.17.17, log in to the node and run the **`systemctl status yangtse`** command to check the status of Yangtse. If you encounter an error, run the **`systemctl restart yangtse`** command and check the status again.
- Issue 2: kube-proxy is not active.
Log in to the node and run the **`systemctl is-active kube-proxy`** command to check the status of kube-proxy. If you encounter an error, run the **`systemctl restart kube-proxy`** command and check the status again.
If the fault persists, reset the node. For details, see [Resetting a Node](#).

6.5.5.36 Health of Master Node Components

Check Items

Check whether cluster components such as the Kubernetes component, container runtime component, and network component are running properly before the upgrade.

Solution

Perform the pre-upgrade check again.

If it fails again, submit a service ticket to contact technical support.

6.5.5.37 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](#).

6.5.5.38 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](#).

6.5.5.39 IPv6 Support in CCE Turbo Clusters

Check Items

If IPv6 is enabled for a CCE Turbo cluster, check whether the target cluster version supports IPv6.

Solution

CCE Turbo clusters support IPv6 since v1.23. This feature is available in the following versions:

- v1.23: 1.23.8-r0 or later
- v1.25: 1.25.3-r0 or later
- v1.25 or later

If IPv6 has been enabled in the cluster before the upgrade, the target cluster version must also support IPv6. Select a proper cluster version.

6.5.5.40 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 fault persists, reset the node. For details, see [Resetting a Node](#). Alternatively, contact technical support to restore the file and then perform the upgrade.

6.5.5.41 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

6.5.5.42 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 6-32 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

Component	Configuration File	Parameter	Upgrade Version
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.

6.5.5.43 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

Reset the node. For details, see [Resetting a Node](#). Alternatively, contact technical support to restore the file and then perform the upgrade.

6.5.5.44 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 **kubectrl** command. For details, see [Connecting to a Cluster Using kubectrl](#).

Step 2 Obtain the Corefile that takes effect currently.

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

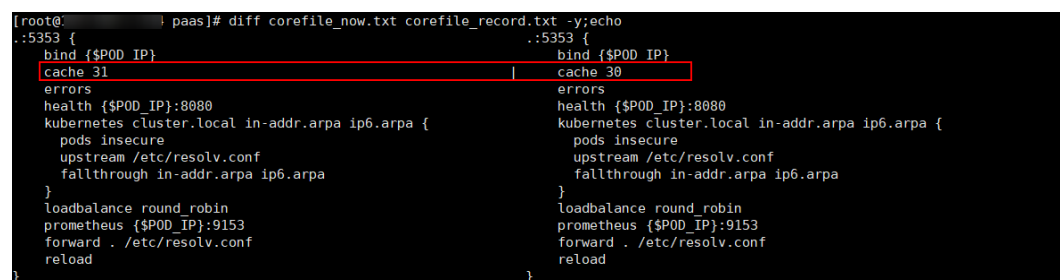
Step 3 Obtain the Corefile in the Helm Release records.

```
latest_release=`kubectrl get secret -nkube-system -l owner=helm -l name=cceaddon-coredns --sort-
by=.metadata.creationTimestamp | awk 'END{print $1}'`
kubectrl 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 6-7 Viewing output differences



```
[root@... ~]# diff corefile_now.txt corefile_record.txt -y;echo
.:5353 {
  bind {$POD_IP}
  cache 31
  errors
  health {$POD_IP}:8080
  kubernetes cluster.local in-addr.arpa ip6.arpa {
    pods insecure
    upstream /etc/resolv.conf
    fallthrough in-addr.arpa ip6.arpa
  }
  loadbalance round robin
  prometheus {$POD_IP}:9153
  forward . /etc/resolv.conf
  reload
}
.:5353 {
  bind {$POD_IP}
  cache 30
  errors
  health {$POD_IP}:8080
  kubernetes cluster.local in-addr.arpa ip6.arpa {
    pods insecure
    upstream /etc/resolv.conf
    fallthrough in-addr.arpa ip6.arpa
  }
  loadbalance round robin
  prometheus {$POD_IP}:9153
  forward . /etc/resolv.conf
  reload
}
```

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

6.5.5.45 sudo

Check Items

Check 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
```

If the sudo command is unavailable, copy this command from another node to the target node.

- 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
```

6.5.5.46 Key Node Commands

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
```


Run the following command for recovery:

```
rpm --rebuilddb
```
 - dpkg:

```
dpkg -l
```


Run the following command for recovery:

```
dpkg --configure -a
```
- 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
```

If the fault persists, reset the node. For details, see [Resetting a Node](#).

6.5.5.47 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.

6.5.5.48 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 **secretName** parameter in **spec.tls** of the ingress YAML files.

Run the following kubectl command to obtain the ingresses using a certificate (replace `<secret_name>` 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

6.5.5.49 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.

- CCE creates the `/var/lib/kubelet` to `/mnt/paas/kubernetes/kubelet` link by default. Check whether the link has been manually modified.
- Shared disk
 - By default, `/mnt/paas/` is mounted to CCE nodes. Check whether `/mnt` has been manually mounted.
 - CCE creates the `/var/lib/kubelet` to `/mnt/paas/kubernetes/kubelet` and `/var/lib/docker` or `/var/lib/containerd` to `/mnt/paas/runtime` soft links by default. Check whether the 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 6-8 Checking whether a shared disk is used

```
[root@test-os-upgrade-35777 ~]# lsblk
NAME                MAJ:MIN RM   SIZE RO TYPE MOUNTPOINT
vda                  253:0    0    50G  0 disk
└─vda1                253:1    0    50G  0 part /
vdb                  253:16   0   100G  0 disk
└─vgpaas-share       252:0    0   100G  0 lvm  /mnt/paas
```

----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 links.

6.5.5.50 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
```

6.5.5.51 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 to these 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. In the right pane, 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

6.5.5.52 Historical Upgrade Records

Check Items

Check the historical upgrade records of the cluster and confirm that the current version of the cluster meets the requirements for upgrading to the target version.

Solution

Upgrading your cluster from an earlier version can be risky and may result in this issue. To avoid this, it is recommended that you migrate the cluster beforehand.

If you still want to proceed with the cluster upgrade, submit a service ticket to contact technical support for evaluation.

6.5.5.53 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

The CIDR block of the management plane has been modified in your region. As a result, the CIDR block of the management plane and that of the backbone network are inconsistent.

Submit a service ticket to contact technical support to modify the settings, and recheck the configurations.

6.5.5.54 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

6.5.5.55 Nodes' System Parameters

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.

6.5.5.56 Residual Package Version Data

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

6.5.5.57 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.

6.5.5.58 Node Swap

Check Items

Check whether swap has been enabled on CCE 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.

If there is no impact, run the **swapoff -a** command to disable swap and perform the check again.

6.5.5.59 nginx-ingress Upgrade

Check Items

- Check item 1: 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.
- Check item 2: Check whether the DefaultBackend Service specified by the Nginx Ingress Controller backend is available.

Fault Locating

For Check Item 1

For 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@ ~]# 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@192-168-0-31 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=[] newV
alue={{IP: + + + + + Hostname: Ports:[]}} {IP: + + + + + Hostname: Ports:[]}}
```

If the fault persists, contact technical support personnel.

----End

For Check Item 2

- Step 1** View the DefaultBackend Service in the namespace where the Nginx Ingress Controller is deployed.

```
kubectl get pod cceaddon-nginx-ingress-<controller-name>-controller-*** -n <namespace> -oyaml | grep 'default-backend'
```

In the preceding command, *cceaddon-nginx-ingress-<controller-name>-controller-**** is the controller pod name, *<controller-name>* is the controller name specified during add-on installation, and *<namespace>* is the namespace where the controller is deployed.

Command output:

```
- '--default-backend-service=<namespace>/<backend-svc-name>'
```

In the preceding command, *<backend-svc-name>* is the name of the DefaultBackend Service for the Nginx Ingress Controller.

- Step 2** Check whether the DefaultBackend Service of the Nginx Ingress Controller is available.

```
kubectl get svc <backend-svc-name> -n <namespace>
```

If the Service is unavailable, this check item failed.

----End

Solution

For Check Item 1

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.

For Check Item 2

Create the DefaultBackend Service again.

- If a custom DefaultBackend Service has been specified in the default 404 service configuration during add-on installation, create the same Service.
- If the default DefaultBackend Service is used during add-on installation, the re-created YAML example is as follows:

```
apiVersion: v1
kind: Service
metadata:
  name: cceaddon-nginx-ingress-<controller-name>-default-backend # <controller-name> is the
controller name.
namespace: kube-system
labels:
  app: nginx-ingress-<controller-name>
  app.kubernetes.io/managed-by: Helm
  chart: nginx-ingress-<version> # <version> is the add-on version.
  component: default-backend
  heritage: Helm
  release: cceaddon-nginx-ingress-<controller-name>
annotations:
  meta.helm.sh/release-name: cceaddon-nginx-ingress-<controller-name>
  meta.helm.sh/release-namespace: kube-system # Namespace where the add-on is installed
spec:
  ports:
    - name: http
      protocol: TCP
      port: 80
      targetPort: http
  selector:
    app: nginx-ingress-<controller-name>
    component: default-backend
    release: cceaddon-nginx-ingress-<controller-name>
  type: ClusterIP
  sessionAffinity: None
  ipFamilies:
    - IPv4
  ipFamilyPolicy: SingleStack
  internalTrafficPolicy: Cluster
```

6.5.5.60 containerd Pod Restart Risks

Check Items

Check whether the service pods running on a containerd node are restarted when containerd is upgraded.

Solution

containerd on your node may need to be restarted. To minimize the impact on service containers, upgrade the cluster during controllable times, such as off-peak hours.

If you need help, submit a service ticket to contact O&M personnel.

6.5.5.61 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

6.5.5.62 GPU Pod Rebuild Risks

Check Items

Check whether GPU 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, submit a service ticket to contact O&M personnel.

6.5.5.63 ELB Listener Access Control

Check Items

Check whether ELB listener access control has been configured using annotations for the Services in the current cluster.

If so, check whether their configurations are correct.

Solution

If the configurations are incorrect, contact O&M personnel.

6.5.5.64 Master Node Flavor

Check Items

Check whether the flavor of the master nodes in the cluster is the same as the actual flavor of these nodes.

Solution

This issue is typically caused by modifications made to the master node. This upgrade may reset the node.

If you are unsure about the impact, submit a service ticket to contact O&M personnel.

6.5.5.65 Subnet Quota of Master Nodes

Check Items

Check whether the number of available IP addresses in the cluster subnet supports rolling upgrade.

Solution

Rolling upgrade is not supported if there are not enough IP addresses in the selected cluster subnet.

Move nodes out of the target subnet and check again. If you are unsure about the impact of migration, submit a service ticket to contact O&M personnel.

6.5.5.66 Node Runtime

Check Items

Check whether an alarm is generated when a cluster is upgraded to v1.27 or later. Do not use Docker in clusters of versions later than 1.27.

Solution

If your node's runtime is not containerd, change it to containerd by resetting the node.

If you plan to create and use Docker nodes in clusters of versions later than v1.27, ignore this alarm. However, you are advised to switch to containerd as soon as possible for a better user experience and more powerful functions.

6.5.5.67 Node Pool Runtime

Check Items

Check whether an alarm is generated when a cluster is upgraded to v1.27 or later. Do not use Docker in clusters of versions later than 1.27.

Solution

If your node pool's runtime is not containerd, change it to containerd by updating the node pool.

If you plan to create and use Docker node pools in clusters of versions later than v1.27, ignore this alarm. However, you are advised to switch to containerd as soon as possible for a better user experience and more powerful functions.

6.5.5.68 Number of Node Images

Check Items

Check the number of images on your node. If there are more than 1000 images, it takes a long time for Docker to start, affecting the standard Docker output and functions such as Nginx.

Solution

Manually delete residual images.

Perform the pre-upgrade check again.

7 Nodes

7.1 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 (EC2s) 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 7-1 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 .

7.2 Container Engines

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 7-2 Comparison between container engines

Item	containerd	Docker
Tracing	kubelet --> CRI plugin (in the containerd process) --> containerd	<ul style="list-style-type: none"> Docker (Kubernetes v1.23 and earlier versions): 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 7-3 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 7-4 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 7-5 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 v1.23 and earlier versions):
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
- 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.**

7.3 Creating a Node

Prerequisites

- At least one cluster has been created.
- A key pair has been created for identity authentication upon remote node login.

Notes and Constraints

- The DNS configuration of a subnet where a node is located cannot be modified because OBS and other dependent services are necessary for creating nodes.

Precautions

- To maintain node stability, Kubernetes components such as kubelet, kube-proxy, and docker, as well as the Kubernetes system, will be allocated a specific number of node resources based on the node flavor. 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 ENI named **gw_11cbf51a@eth0** on the node is the container network gateway and cannot be modified.

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 7-6 Node configuration parameters

Parameter	Description
AZ	<p>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.</p> <p>Select Random to deploy your node in a random AZ based on the selected node flavor.</p> <p>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.</p>
Node Type	<p>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.</p> <p>CCE standard clusters support the following node types:</p> <ul style="list-style-type: none"> • 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	<p>Select node flavors as needed. A node needs at least two vCPU cores and 4 GiB of memory.</p> <p>The available node flavors vary depending on AZs. Obtain the flavors displayed on the console.</p>
Container Engine	<p>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.</p>
OS	<p>Select an OS type. Different types of nodes support different OSs.</p> <ul style="list-style-type: none"> • Public image: Select a public image for the node. <p>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.</p>

Parameter	Description
Node Name	<p>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.</p> <p>The system generates a default name for you, which can be modified.</p> <p>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 (.).</p>
Login Mode	<ul style="list-style-type: none"> 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 7-7 Storage configuration parameters

Parameter	Description
System Disk	<p>System disk used by the node OS. The value ranges from 40 GiB to 1024 GiB. The default value is 50 GiB.</p> <p>Encryption: System disk encryption safeguards your data. Snapshots generated from encrypted disks and disks created using these snapshots automatically inherit the encryption setting. Only the nodes of the Elastic Cloud Server (VM) type in certain regions support system disk encryption. For details, see the console.</p> <ul style="list-style-type: none"> Not encrypted is selected by default. If you select Enabled (key) for System Disk Encryption, 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 text box. If you select Enabled (KMS key ID) for System Disk Encryption, enter a KMS key (which can be shared by others) in the current region.

Parameter	Description
Data Disk	<p>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.</p> <ul style="list-style-type: none"> • 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. <p>NOTE</p> <ul style="list-style-type: none"> • 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. <p>Advanced Settings</p> <p>Expand the area and configure the following parameters:</p> <ul style="list-style-type: none"> • 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. • Data Disk Encryption: Data disk encryption safeguards your data. Snapshots generated from encrypted disks and disks created using these snapshots automatically inherit the encryption setting. <ul style="list-style-type: none"> – Not encrypted is selected by default. – If you select Enabled (key) for Data Disk Encryption, 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 text box. – If you select Enabled (KMS key ID) for Data Disk Encryption, enter a KMS key (which can be shared by others) in the current region. <p>Adding data disks</p> <p>A maximum of 16 data disks can be attached to an ECS. By default, a raw disk is created without any processing. You can also click Expand and select any of the following options:</p> <ul style="list-style-type: none"> • 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.

Parameter	Description
	<ul style="list-style-type: none"> • Use as ephemeral volume: applicable when there is a high performance requirement on emptyDir. <p>NOTE</p> <ul style="list-style-type: none"> • 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. <p>Local PVs and local EVs can be written in the following modes:</p> <ul style="list-style-type: none"> • 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. This allows 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 7-8 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 7-9 Advanced configuration parameters

Parameter	Description
Resource Tag	<p>You can add resource tags to classify resources. A maximum of eight resource tags can be added.</p> <p>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.</p> <p>CCE will automatically create the 'CCE-Dynamic-Provisioning-Node=<i>Node ID</i>' tag.</p>
Kubernetes Label	<p>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.</p> <p>Labels can be used to distinguish nodes. With workload affinity settings, pods can be scheduled to a specified node. For more information, see Labels and Selectors.</p>
Taint	<p>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:</p> <ul style="list-style-type: none"> • 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 contain 1 to 63 characters, starting with a letter or digit. Only letters, digits, hyphens (-), underscores (_), and periods (.) are allowed. • Effect: Available options are NoSchedule, PreferNoSchedule, and NoExecute. <p>For details, see Managing Node Taints.</p> <p>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.</p>
Max. Pods	<p>Maximum number of pods that can run on the node, including the default system pods.</p> <p>This limit prevents the node from being overloaded with pods.</p> <p>This number is also decided by other factors. For details, see Maximum Number of Pods That Can Be Created on a Node.</p>

Parameter	Description
ECS Group	<p>An ECS group logically groups ECSs. The ECSs in the same ECS group comply with the same policy associated with the ECS group.</p> <p>Anti-affinity: ECSs in an ECS group are deployed on different physical hosts to improve service reliability.</p> <p>Select an existing ECS group, or click Add ECS Group to create one. After the ECS group is created, click the refresh icon.</p>
Pre-installation Command	<p>Pre-installation script command, in which Chinese characters are not allowed. The script command will be Base64-transcoded. The characters of both the pre-installation and post-installation scripts are centrally calculated, and the total number of characters after transcoding cannot exceed 10240.</p> <p>The script will be executed before Kubernetes software is installed. Note that if the script is incorrect, Kubernetes software may fail to be installed.</p>
Post-installation Command	<p>Pre-installation script command, in which Chinese characters are not allowed. The script command will be Base64-transcoded. The characters of both the pre-installation and post-installation scripts are centrally calculated, and the total number of characters after transcoding cannot exceed 10240.</p> <p>The script will be executed after Kubernetes software is installed, which does not affect the installation.</p> <p>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.</p>
Agency	<p>An agency is created by the account administrator on the IAM console. Using an agency, you can share your cloud server resources with another account, or entrust a more professional person or team to manage your resources.</p> <p>If no agency is available, click Create Agency on the right to create one.</p>

Step 4 Configure the number of nodes to be created. 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

7.4 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

- When accepting an ECS, you can reset the ECS OS to a standard public image offered by CCE. If you choose to do so, you need to reset the password or key pair, and the previous password or key pair will become invalid.
 - 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 acceptance. Ensure that the information has been backed up.
 - During the acceptance of an ECS, do not perform any operation on the ECS through the ECS console.
-

Notes and Constraints

- ECSs can be managed.

Prerequisites

The cloud servers to be managed must meet the following requirements:

- 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.
- Only cloud servers with the same data disk configurations can be added in batches.
- 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.

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 7-10 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. <ul style="list-style-type: none"> • 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.
Login Mode	<ul style="list-style-type: none"> • 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 7-11 Storage configuration parameters

Parameter	Description
System Disk	Directly use the system disk of the cloud server.

Parameter	Description
Data Disk	<p>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.</p> <p>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.</p> <p>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.</p>

Advanced Settings

Table 7-12 Advanced configuration parameters

Parameter	Description
Resource Tag	<p>You can add resource tags to classify resources. A maximum of eight resource tags can be added.</p> <p>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.</p> <p>CCE will automatically create the "CCE-Dynamic-Provisioning-Node=<i>Node ID</i>" tag.</p>
Kubernetes Label	<p>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.</p> <p>Labels can be used to distinguish nodes. With workload affinity settings, pods can be scheduled to a specified node. For more information, see Labels and Selectors.</p>

Parameter	Description
Taint	<p>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:</p> <ul style="list-style-type: none"> • 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 contain 1 to 63 characters, starting with a letter or digit. Only letters, digits, hyphens (-), underscores (_), and periods (.) are allowed. • Effect: Available options are NoSchedule, PreferNoSchedule, and NoExecute. <p>NOTICE</p> <ul style="list-style-type: none"> • 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	<p>Maximum number of pods that can run on the node, including the default system pods.</p> <p>This limit prevents the node from being overloaded with pods.</p>
Pre-installation Command	<p>Pre-installation script command, in which Chinese characters are not allowed. The script command will be Base64-transcoded. The characters of both the pre-installation and post-installation scripts are centrally calculated, and the total number of characters after transcoding cannot exceed 10240.</p> <p>The script will be executed before Kubernetes software is installed. Note that if the script is incorrect, Kubernetes software may fail to be installed.</p>
Post-installation Command	<p>Pre-installation script command, in which Chinese characters are not allowed. The script command will be Base64-transcoded. The characters of both the pre-installation and post-installation scripts are centrally calculated, and the total number of characters after transcoding cannot exceed 10240.</p> <p>The script will be executed after Kubernetes software is installed, which does not affect the installation.</p>

Step 4 Click **Next: Confirm**. Click **Submit**.

----End

7.5 Logging In to a Node

Notes and 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 cloud 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 cloud.
- 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 7-13 Linux ECS login modes

EIP Binding	On-Premises OS	Connection Method
Yes	Windows	Use a remote login tool, such as PuTTY or Xshell. <ul style="list-style-type: none"> • SSH key authentication: Login Using an SSH Key
Yes	Linux	Run commands. <ul style="list-style-type: none"> • SSH key authentication: Login Using an SSH Key
Yes/No	Windows/ Linux	Remote login using the management console: Login Using VNC

7.6 Management Nodes

7.6.1 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 7-14](#).

 **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 7-14 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/container-engine	Container engine Example: docker or containerd

Key	Description
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.
os.architecture	Node processor architecture For example, amd64 indicates a AMD64-bit processor.
os.name	Node OS name
os.version	Node OS kernel version
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 operation** 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

7.6.2 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

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"
```

7.6.3 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.

Notes and Constraints

- To enable node resetting in CCE standard clusters, 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 on the ECS console, 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.

Resetting Nodes in the Default 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 displayed page, click the **Nodes** tab.
- Step 3** In the node list of the default pool, 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**.
- Step 5** Specify node parameters.

Compute Settings

Table 7-15 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	<p>Select an OS type. Different types of nodes support different OSs.</p> <ul style="list-style-type: none"> • Public image: Select a public image for the node. <p>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.</p>
Login Mode	<ul style="list-style-type: none"> • 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 7-16 Storage configuration parameters

Parameter	Description
System Disk	Directly use the system disk of the cloud server.
Data Disk	<p>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.</p> <p>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.</p> <p>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.</p>

Advanced Settings

Table 7-17 Advanced configuration parameters

Parameter	Description
Resource Tag	<p>You can add resource tags to classify resources. A maximum of eight resource tags can be added.</p> <p>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.</p> <p>CCE will automatically create the "CCE-Dynamic-Provisioning-Node=<i>Node ID</i>" tag.</p>
Kubernetes Label	<p>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.</p> <p>Labels can be used to distinguish nodes. With workload affinity settings, pods can be scheduled to a specified node. For more information, see Labels and Selectors.</p>
Taint	<p>This field 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:</p> <ul style="list-style-type: none"> • 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 contain 1 to 63 characters, starting with a letter or digit. Only letters, digits, hyphens (-), underscores (_), and periods (.) are allowed. • Effect: Available options are NoSchedule, PreferNoSchedule, and NoExecute. <p>NOTICE</p> <ul style="list-style-type: none"> • 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	<p>Maximum number of pods that can run on the node, including the default system pods.</p> <p>This limit prevents the node from being overloaded with pods.</p>

Parameter	Description
Pre-installation Command	<p>Pre-installation script command, in which Chinese characters are not allowed. The script command will be Base64-transcoded. The characters of both the pre-installation and post-installation scripts are centrally calculated, and the total number of characters after transcoding cannot exceed 10240.</p> <p>The script will be executed before Kubernetes software is installed. Note that if the script is incorrect, Kubernetes software may fail to be installed.</p>
Post-installation Command	<p>Pre-installation script command, in which Chinese characters are not allowed. The script command will be Base64-transcoded. The characters of both the pre-installation and post-installation scripts are centrally calculated, and the total number of characters after transcoding cannot exceed 10240.</p> <p>The script will be executed after Kubernetes software is installed, which does not affect the installation.</p>

Step 6 Click **Next: Confirm**.

Step 7 Click **Submit**.

----End

Resetting Nodes in a Node Pool

NOTE

Parameter configurations are not supported when resetting a node you created in a node pool. The image configured for the node pool is used to reset the 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 of the target node pool, select a node to be reset and choose **More > Reset Node** in the **Operation** column.

Step 4 In the displayed dialog box, click **Yes**.

----End

Resetting Nodes in a Batch

Resetting nodes in a batch varies depending on application scenarios.

Scenario	Supported or Not	Description
Resetting nodes in the default pool in a batch	Supported in some scenarios	This operation can be performed only if the flavors, AZs, and disk configurations of all nodes are the same.
Resetting nodes in a node pool in a batch	Supported in some scenarios	This operation can be performed only if the disk configurations of all nodes are the same.
Resetting nodes in different node pools in a batch	Not supported	Only the nodes in the same node pool can be reset in a batch.

7.6.4 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.

Notes and Constraints

- 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 beforehand.
- 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
    done
    return
}
init_data_disk
lsblk
```

Run the following command:

```
bash clean.sh
```

----End

7.6.5 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.

Notes and 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

7.6.6 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 [Rules for Draining Nodes](#) 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.

NOTICE

To ensure service availability during drainage, [specify a disruption budget](#) for your application. Otherwise, the application may become unavailable during pod rescheduling.

Prerequisites

- A cluster is available and the cluster version meets the following requirements:
 - v1.21: v1.21.10-r0 or later
 - v1.23: v1.23.8-r0 or later
 - v1.25: v1.25.3-r0 or later

- Versions later than v1.25
- To drain a node as an IAM user, you 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.

Rules for Draining Nodes

When a node is drained, all pods on the node will be safely evicted. However, CCE will take specific actions for pods that meet certain filtering criteria.

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 node 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 [Rules for Draining Nodes](#).
- Step 5** Click **OK** and wait until the node drainage is complete.
- End

Cancelling Node Drainage

NOTE

In clusters of v1.23.16-r0, v1.25.11-r0, v1.27.8-r0, v1.28.6-r0, v1.29.2-r0, or later versions, node drainage can be canceled.

This operation will abort drainage on nodes, but workloads that have been evicted from these nodes will not be automatically migrated back.

- 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 node that is being drained and click **Cancel Drainage**.
- Step 4** In the displayed dialog box, click **OK**. The node status changes to **Drainage cancelled**. You can click **Enable Scheduling** to restore the node to the schedulable state.
- End

7.6.7 Deleting a Node

Scenario

You can delete a pay-per-use node that is not needed from the node list.

Deleting or unsubscribing from a node in a CCE cluster will release the node and services running on the node. Drain the node and back up data before the deletion or unsubscription to prevent services running on the node from being affected.

Precautions

- Deleting a node will lead to pod migration, which may affect services. Perform this operation during off-peak hours. It is a good practice to drain the node before deletion. For details, see [Draining a Node](#).
- Unexpected risks may occur during the operation. Back up data beforehand.
- Deleting 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.

Deleting 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** 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

7.6.8 Stopping a Node

Scenario

When a node in the cluster is stopped, all services on that node will also be stopped, and the node will no longer be available for scheduling. Check if your services will be affected before stopping a node.

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 data beforehand.

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**.

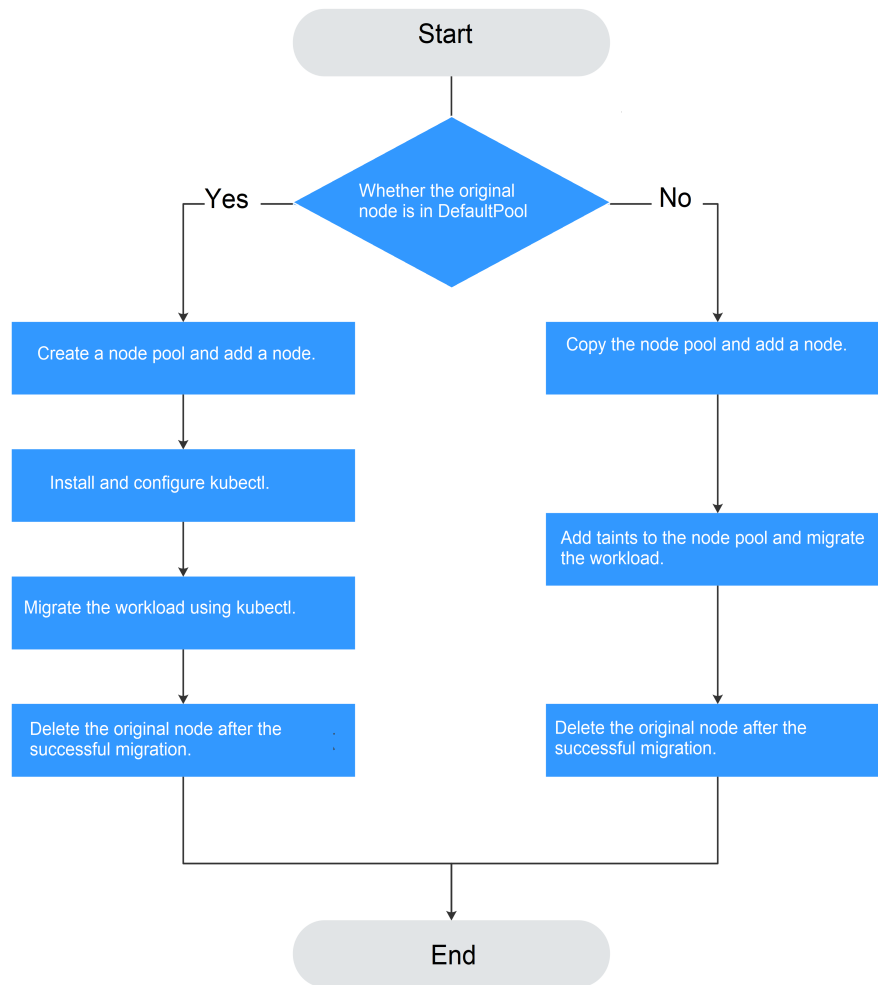
----End

7.6.9 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 7-1](#) shows the migration process.

Figure 7-1 Workload migration



Notes and 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 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 has been 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 has been 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

7.7 Node O&M

7.7.1 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:

$$\text{Allocatable resources} = \text{Total amount} - \text{Reserved amount} - \text{Eviction threshold}$$

The memory eviction threshold is fixed at 100 MiB.

 **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:

$$\text{Total reserved amount} = \text{Reserved memory for system components} + \text{Reserved memory for kubelet to manage pods}$$

Table 7-18 Reservation rules for system components

Total Memory (TM)	Reserved Memory for System Components
TM ≤ 8 GiB	0 MiB
8 GiB < TM ≤ 16 GiB	[(TM - 8 GiB) × 1024 × 10%] MiB
16 GiB < TM ≤ 128 GiB	[8 GiB × 1024 × 10% + (TM - 16 GiB) × 1024 × 6%] MiB
TM > 128 GiB	(8 GiB × 1024 × 10% + 112 GiB × 1024 × 6% + (TM - 128 GiB) × 1024 × 2%) MiB

Table 7-19 Reservation rules for kubelet

Total Memory (TM)	Number of Pods	Reserved Memory for kubelet
$TM \leq 2 \text{ GiB}$	None	$TM \times 25\%$
$TM > 2 \text{ GiB}$	$0 < \text{Max. pods on a node} \leq 16$	700 MiB
	$16 < \text{Max. pods on a node} \leq 32$	$[700 + (\text{Max. pods on a node} - 16) \times 18.75] \text{ MiB}$
	$32 < \text{Max. pods on a node} \leq 64$	$[1024 + (\text{Max. pods on a node} - 32) \times 6.25] \text{ MiB}$
	$64 < \text{Max. pods on a node} \leq 128$	$[1230 + (\text{Max. pods on a node} - 64) \times 7.80] \text{ MiB}$
	$\text{Max. pods on a node} > 128$	$[1740 + (\text{Max. pods on a node} - 128) \times 11.20] \text{ MiB}$

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 [Modifying Node Pool Configurations](#).

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 7-20 Rules for reserving node memory v2

Reserved for	Basic/Floating	Reservation	Used by
OS	Basic	Fixed at 400 MiB	OS service components such as sshd and systemd-journald.

Reserved for	Basic/Floating	Reservation	Used by
	Floating (depending on the node memory)	25MiB/GiB	Kernel
CCE	Basic	Fixed at 500 MiB	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 MiB/Pod containerd: 5 MiB/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 7-23 .

Rules for Reserving Node CPU

Table 7-21 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.

7.7.2 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.

NOTE

If the sum of the container engine and container image space and the kubelet and emptyDir space is less than 100%, the remaining space will be allocated for user data. You can mount the storage volume to a service path. Do not leave the path empty or set it to a key OS path such as the root directory.

- Shared disk space: In clusters of v1.21.10-r0, v1.23.8-r0, v1.25.3-r0, or later versions, CCE allows **a container engine (Docker/containerd) and kubelet components to share data disk space**.
- **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**.

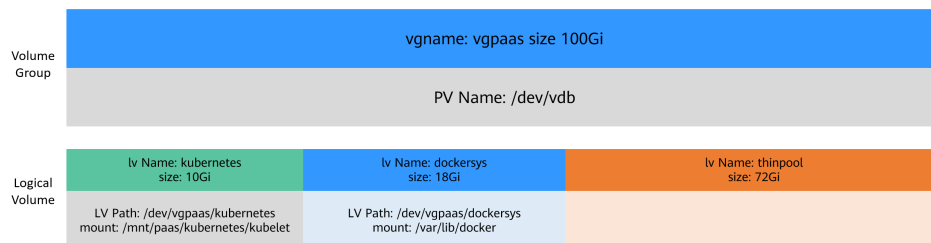
- **Rootfs (Device Mapper)**

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.

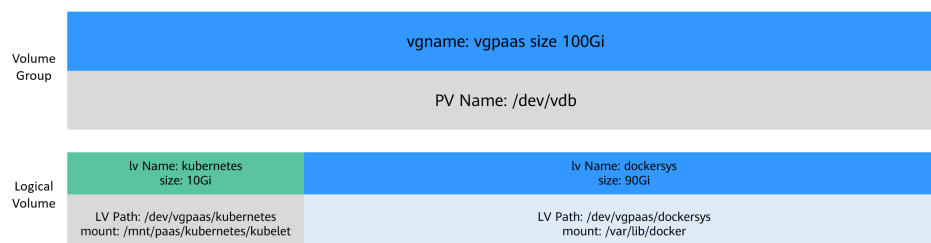
Figure 7-2 Space allocation for container engines of Device Mapper



- **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 7-3 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**, you need to consider the maximum number of pods during node creation. The container engine space should be greater than the total disk space used by containers. Formula: **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 GiB 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 GiB, the thin pool space occupied by files keeps increasing until 10 GiB 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 7-22 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. If Rootfs is set to OverlayFS, the basesize cannot be customized.
EulerOS 2.5	Device Mapper	Supported only when the runtime is Docker. The default value is 10 GiB.
EulerOS 2.9	OverlayFS	Supported by clusters of v1.19.16, v1.21.3, v1.23.3, or later. Both Docker and containerd are supported. There are no limits by default. Not supported if the cluster versions are earlier than v1.19.16, v1.21.3, or v1.23.3.
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.

Data Disk Shared Between a Container Engine and kubelet Components

Docker/containerd and kubelet components share the space of a data disk.

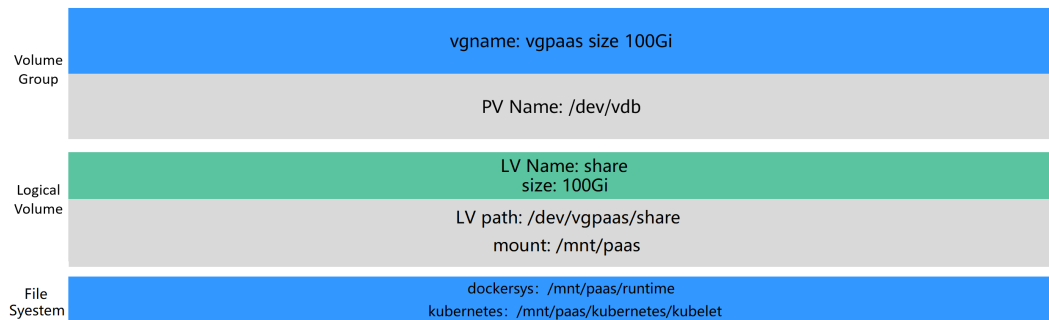
NOTICE

- This function is available only to clusters of v1.21.10-r0, v1.23.8-r0, v1.25.3-r0, or later versions.
- If Rootfs is set to OverlayFS, shared data disks are supported. If Rootfs is set to Device Mapper, shared data disks are not supported.
- If you have installed an NPD add-on in the cluster, upgrade the add-on to v1.18.10 or later. Otherwise, false alarms will be generated.
- If you have installed a log-agent add-on in the cluster, upgrade the add-on to v1.3.0 or later. Otherwise, log collection will be affected.
- If you have installed ICAgent in the cluster, upgrade it to v5.12.140 or later. Otherwise, log collection will be affected.

For nodes using a shared data disk, the container storage Rootfs is of the **OverlayFS** type. After such a node is created, the data disk space (for example, 100 GiB) will not be divided for the container engines, container images, and kubelet components. The data disk is mounted to **/mnt/paas**, and the storage space is divided using two file systems.

- dockersys: /mnt/paas/runtime
- Kubernetes: /mnt/paas/kubernetes/kubelet

Figure 7-4 Allocating the storage space of a shared data disk



7.7.3 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:

Network Model	Calculation of the Maximum Number of Pods That Can Be Created on a Node	Suggestions
Container tunnel network	Depends on maximum number of pods on a node .	None
VPC network	Depends on the smaller value between the maximum number of pods on a node and the number of container IP addresses that can be allocated on a node .	To ensure proper functioning of new pods on a node, it is recommended that you limit maximum number of pods on the node to the number of container IP addresses that can be allocated on the node. If the number of container IP addresses on the node is insufficient, new pods may not run properly.

Number of Container IP Addresses That Can Be Allocated on a Node

When creating a cluster using a **VPC network**, you need to configure the number of container IP addresses that can be allocated on each node (that is, the **alpha.cce/fixPoolMask** parameter) based on the allocation rules. For details about the VPC network's IP address allocation rules, see [Container IP Address Management](#).

This parameter affects the maximum number of pods that can be created on a node. When **container network** is used, an IP address is allocated to every pod. If

the container IP addresses pre-allocated on the node are insufficient, pods cannot be created. If pods use the **host network** (`hostNetwork: true` configured in the YAML file), the pods do not occupy the allocatable container IP addresses. For details, see [Pod IP Address Allocation Differences Between the Container Network and Host 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 7-23](#) lists the default maximum number of pods on a node based on node specifications.

Table 7-23 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

Pod IP Address Allocation Differences Between the Container Network and 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 a specific application must use a specific port on the host.

7.7.4 Differences Between CCE Node mountPath Configurations and Community Native Configurations

To maintain the stability of nodes, CCE stores Kubernetes and container runtime components on separate data disks. Kubernetes uses the **/mnt/paas/kubernetes** directory, and the container runtime uses the **/mnt/paas/runtime** directory. The paths to these directories are the same as the default paths used in the community through soft links.

Configuration Differences Between CCE and Community Native

Item	Kubernetes Native Path	CCE Path
kubelet root-dir	/var/lib/kubelet	/mnt/paas/kubernetes/kubelet
kubelet	/var/lib/kubelet	/mnt/paas/kubernetes/kubelet The soft link from /var/lib/kubelet to /mnt/paas/kubernetes/kubelet is also available.
Container runtime (Docker)	/var/lib/docker	<ul style="list-style-type: none"> • Data Disk Space Allocation set to shared: /mnt/paas/runtime The soft link from /var/lib/docker to /mnt/paas/runtime is also available. • Data Disk Space Allocation set to specific: /var/lib/docker, which is identical to the Kubernetes native path
Container runtime (containerd)	/var/lib/containerd	<ul style="list-style-type: none"> • Data Disk Space Allocation set to shared: /mnt/paas/runtime The soft link from /var/lib/containerd to /mnt/paas/runtime is also available. • Data Disk Space Allocation set to specific: /var/lib/containerd, which is identical to the Kubernetes native path

Item	Kubernetes Native Path	CCE Path
containerd logs	/var/log/pods	/var/lib/containerd/container_logs The soft link from /var/log/pods to /var/lib/containerd/container_logs is also available.

 NOTE

In clusters of v1.23.16-r0, v1.25.11-r0, v1.27.8-r0, v1.28.6-r0, v1.29.2-r0, or later versions, modified soft links will be mounted in both Kubernetes and CCE paths.

Possible Impact of Differences

- If a soft link file is mounted into a container, the real path that the soft link file points to cannot be accessed.

For example, if **/var/log** is mounted to **/mnt/log** in a container through a hostPath, **/mnt/log/pods** is an abnormal soft link file in the container, and the actual data in **/var/log/pods** cannot be accessed.

Mount the actual file path to the container to prevent a file read failure caused by soft links.

- The kubelet **root-dir** path (**/mnt/paas/kubernetes/kubelet**) is inconsistent with the community path (**/var/lib/kubelet**). If the container mount path of a third-party CSI add-on is the community path, the file mounting does not take effect.

For example, when Vault (an open-source third-party add-on) uses secrets-store-csi-driver to mount a secret, if the **root-dir** path to the add-on is inconsistent with the CCE configuration path (the default value of the add-on is the same as the community path **/var/lib/kubelet**), the Vault secret cannot be obtained in the container.

This is because CSI uses mountPropagation to mount volumes to target containers. kubelet includes the mount path (**/mnt/paas/kubernetes/kubelet/pods/{podID}/volume/...**) related to kubelet **root-dir** into the CSI request for mounting a volume. When the CSI container mounts a volume to the mount path requested by kubelet CSI, if the mount path is irrelevant to the hostPath, the mount propagation will be invalid. For example, the CSI container mounts host **/var/lib/kubelet** to container **/var/lib/kubelet**, and **/mnt/paas/kubernetes/kubelet/pods/{podID}/volume/...** in the CSI container is irrelevant to the hostPath.

Update the **root-dir** path in CSI to match the kubelet **root-dir** path on the current CCE node.

7.7.5 Migrating Nodes from Docker to containerd

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 Engines](#).

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

7.7.6 Configuring Node Fault Detection Policies

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 7-24 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 7-25 Event-related check items

Check Item	Function	Description
OOMKilling	<p>Listen to the kernel logs and check whether OOM events occur and are reported.</p> <p>Typical scenario: When the memory usage of a process in a container exceeds the limit, OOM is triggered and the process is terminated.</p>	<p>Warning event</p> <p>Listening object: /dev/kmsg</p> <p>Matching rule: "Killed process \\d+ (.+) total-vm:\\d+kB, anon-rss:\\d+kB, file-rss:\\d+kB.*"</p>
TaskHung	<p>Listen to the kernel logs and check whether taskHung events occur and are reported.</p> <p>Typical scenario: Disk I/O suspension causes process suspension.</p>	<p>Warning event</p> <p>Listening object: /dev/kmsg</p> <p>Matching rule: "task \\S+:\\w+ blocked for more than \\w+ seconds\\."</p>
Readonly Filesystem	<p>Check whether the Remount root filesystem read-only error occurs in the system kernel by listening to the kernel logs.</p> <p>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.</p> <p>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.</p>	<p>Warning event</p> <p>Listening object: /dev/kmsg</p> <p>Matching rule: Remounting filesystem read-only</p>

- 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 7-26 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
Frequent restarts of Kubelet FrequentKubeletRestart	Periodically backtrack system logs to check whether the key component Kubelet restarts frequently.	<ul style="list-style-type: none"> • 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 7-27 Checking system metrics

Check Item	Function	Description
Contrack table full ContrackFullProblem	Check whether the contrack table is full.	<ul style="list-style-type: none"> • Default threshold: 90% • Usage: nf_contrack_count • Maximum value: nf_contrack_max

Check Item	Function	Description
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.	<ul style="list-style-type: none"> • Default threshold: 90% • Source: <code>df -h</code> <p>Currently, additional data disks are not supported.</p>
Insufficient file handles FDProblem	Check if the FD file handles are used up.	<ul style="list-style-type: none"> • Default threshold: 90% • Usage: the first value in <code>/proc/sys/fs/file-nr</code> • Maximum value: the third value in <code>/proc/sys/fs/file-nr</code>
Insufficient node memory MemoryProblem	Check whether memory is used up.	<ul style="list-style-type: none"> • Default threshold: 80% • Usage: MemTotal-MemAvailable in <code>/proc/meminfo</code> • Maximum value: MemTotal in <code>/proc/meminfo</code>
Insufficient process resources PIDProblem	Check whether PID process resources are exhausted.	<ul style="list-style-type: none"> • Default threshold: 90% • Usage: nr_threads in <code>/proc/loadavg</code> • Maximum value: smaller value between <code>/proc/sys/kernel/pid_max</code> and <code>/proc/sys/kernel/threads-max</code>.

Table 7-28 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: <ul style="list-style-type: none"> • /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
<p>emptyDir storage pool error</p> <p>EmptyDirVolumeGroupStatusError</p>	<p>Check whether the ephemeral volume group on the node is normal.</p> <p>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.</p> <p>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.</p>	<ul style="list-style-type: none"> • 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.
<p>PV storage pool error</p> <p>LocalPvVolumeGroupStatusError</p>	<p>Check the PV group on the node.</p> <p>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.</p> <p>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.</p>	

Check Item	Function	Description
Mount point error MountPointProblem	<p>Check the mount point on the node.</p> <p>Exceptional definition: You cannot access the mount point by running the cd command.</p> <p>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.</p>	<p>Alternatively, you can run the following command:</p> <pre>for dir in `df -h grep -v "Mounted on" awk "{print \\\$NF}"`;do cd \$dir; done && echo "ok"</pre>
Suspended disk I/O DiskHung	<p>Check whether I/O suspension occurs on all disks on the node, that is, whether I/O read and write operations are not responded.</p> <p>Definition of I/O suspension: The system does not respond to disk I/O requests, and some processes are in the D state.</p> <p>Typical scenario: Disks cannot respond due to abnormal OS hard disk drivers or severe faults on the underlying network.</p>	<ul style="list-style-type: none"> • Check object: all data disks • Source: /proc/diskstat Alternatively, you can run the following command: iostat -xmt 1 • Threshold: <ul style="list-style-type: none"> - 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 <p>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.</p>

Check Item	Function	Description
Slow disk I/O DiskSlow	<p>Check whether all disks on the node have slow I/Os, that is, whether I/Os respond slowly.</p> <p>Typical scenario: EVS disks have slow I/Os due to network fluctuation.</p>	<ul style="list-style-type: none"> 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 <p>NOTE If I/O requests are not responded and the await data is not updated, this check item is invalid.</p>

Table 7-29 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: <ul style="list-style-type: none"> /proc/{PID}/stat Alternately, you can run the ps aux command.
Process Z error ProcessZ	Check whether the node has processes in Z state.	
ResolvConf error ResolvConfFileProblem	<p>Check whether the ResolvConf file is lost.</p> <p>Check whether the ResolvConf file is normal.</p> <p>Exceptional definition: No upstream domain name resolution server (nameserver) is included.</p>	Object: /etc/resolv.conf

Check Item	Function	Description
Existing scheduled event ScheduledEvent	<p>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.</p> <p>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.</p>	<p>Source:</p> <ul style="list-style-type: none"> • http://169.254.169.254/metadata/latest/events/scheduled <p>This check item is an Alpha feature and is disabled by default.</p>

The kubelet component has the following default check items, which have bugs or defects. You can fix them by upgrading the cluster or using NPDP.

Table 7-30 Default kubelet check items

Check Item	Function	Description
Insufficient PID resources PIDPressure	<p>Check whether PIDs are sufficient.</p>	<ul style="list-style-type: none"> • 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.	<ul style="list-style-type: none"> ● 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.	<ul style="list-style-type: none"> ● Interval: 10 seconds ● Threshold: 90%

8 Node Pools

8.1 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 login mode
- Node container runtime
- Startup parameters of Kubernetes components on a node
- Custom 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 custom 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.

Application 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 8-1 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	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.	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.
Disabling 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.
Modifying node pool configurations	You can change the node pool name and number of nodes, add or delete Kubernetes labels, resource tags, and taints, and adjust node pool configurations such as the disk, OS, and container engine of the node pool.	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.	<ul style="list-style-type: none"> • 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 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 \(Affinity/Anti-affinity\)](#)

8.2 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](#).

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. In the right pane, click the **Node Pools** tab.
- Step 3** In the upper right corner of the page, click **Create Node Pool**.

Basic Settings

Table 8-2 Basic settings

Parameter	Description
Node Pool Name	Name of a node pool. By default, the name is in the format of <i>Cluster name-nodepool-Random number</i> . If you do not want to use the default name format, you can customize the name.

Configurations

You can configure the flavor and OS of a cloud server, on which your containerized applications run.

Table 8-3 Node configuration parameters

Parameter	Description
Node Type	<p>Select a node type based on service requirements. Then, you can select a proper flavor from the node flavor list.</p> <p>CCE standard clusters support the following node types:</p> <ul style="list-style-type: none"> • 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	<p>Select a node flavor based on service requirements. The available node flavors vary depending on regions or AZs. For details, see the CCE console.</p> <p>NOTE</p> <ul style="list-style-type: none"> • If a node pool is configured with multiple node flavors, only the flavors (which can be located in different AZs) of the same node type are supported. For example, a node pool consisting of general computing-plus nodes supports only general computing-plus node flavors, but not the flavors of general computing nodes. • A maximum of 10 node flavors can be added to a node pool (the flavors in different AZs are counted separately). When adding a node flavor, you can choose multiple AZs, but you need to specify them. • Nodes in a newly created node pool are created using the default flavor. If the resources for the default flavor are insufficient, node creation will fail. • After a node pool is created, the flavors of existing nodes cannot be deleted.
Container Engine	<p>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.</p>
OS	<p>Select an OS type. Different types of nodes support different OSs.</p> <ul style="list-style-type: none"> • Public image: Select a public image for the node. <p>NOTE</p> <p>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.</p>

Parameter	Description
Login Mode	<ul style="list-style-type: none"> 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 8-4 Storage configuration parameters

Parameter	Description
System Disk	<p>System disk used by the node OS. The value ranges from 40 GiB to 1024 GiB. The default value is 50 GiB.</p> <p>Encryption: System disk encryption safeguards your data. Snapshots generated from encrypted disks and disks created using these snapshots automatically inherit the encryption setting. Only the nodes of the Elastic Cloud Server (VM) type in certain regions support system disk encryption. For details, see the console.</p> <ul style="list-style-type: none"> Not encrypted is selected by default. If you select Enabled (key) for System Disk Encryption, 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 text box. If you select Enabled (KMS key ID) for System Disk Encryption, enter a KMS key (which can be shared by others) in the current region.

Parameter	Description
Data Disk	<p>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.</p> <ul style="list-style-type: none"> • 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. <p>NOTE</p> <ul style="list-style-type: none"> • 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. <p>Advanced Settings</p> <p>Expand the area and configure the following parameters:</p> <ul style="list-style-type: none"> • 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. • Data Disk Encryption: Data disk encryption safeguards your data. Snapshots generated from encrypted disks and disks created using these snapshots automatically inherit the encryption setting. <ul style="list-style-type: none"> - Not encrypted is selected by default. - If you select Enabled (key) for Data Disk Encryption, 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 text box. - If you select Enabled (KMS key ID) for Data Disk Encryption, enter a KMS key (which can be shared by others) in the current region. <p>Adding data disks</p> <p>A maximum of 16 data disks can be attached to an ECS. By default, a raw disk is created without any processing. You can also click Expand and select any of the following options:</p> <ul style="list-style-type: none"> • 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.

Parameter	Description
	<ul style="list-style-type: none"> • Use as ephemeral volume: applicable when there is a high performance requirement on emptyDir. <p>NOTE</p> <ul style="list-style-type: none"> • 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. <p>Local PVs and local EVs can be written in the following modes:</p> <ul style="list-style-type: none"> • 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. This allows 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 8-5 Configuration parameters

Parameter	Description
Virtual Private Cloud	The VPC to which the cluster belongs by default, which cannot be changed.
Node Subnet	<p>The node subnet selected during cluster creation is used by default. You can choose another subnet instead.</p> <ul style="list-style-type: none"> • Multiple subnets: You can select multiple subnets in the same VPC for nodes. Newly added nodes will preferentially use the IP addresses from the top-ranking subnet. • 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	<p>Security group used by the nodes created in the node pool. A maximum of five security groups can be selected.</p> <p>When a cluster is created, a node security group named {Cluster name}-cce-node-{Random ID} is created and used by default.</p> <p>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.</p> <p>NOTE After a node pool is created, its associated security group cannot be modified.</p>

Advanced Settings

Configure advanced node capabilities such as labels, taints, and startup command.

Table 8-6 Advanced configuration parameters

Parameter	Description
Resource Tag	<p>You can add resource tags to classify resources.</p> <p>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.</p> <p>CCE will automatically create the "CCE-Dynamic-Provisioning-Node=<i>Node ID</i>" tag.</p>
Kubernetes Label	<p>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.</p> <p>Labels can be used to distinguish nodes. With workload affinity settings, pods can be scheduled to a specified node. For more information, see Labels and Selectors.</p>

Parameter	Description
Taint	<p>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:</p> <ul style="list-style-type: none"> • 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 contain 1 to 63 characters, starting with a letter or digit. Only letters, digits, hyphens (-), underscores (_), and periods (.) are allowed. • Effect: Available options are NoSchedule, PreferNoSchedule, and NoExecute. <p>For details, see Managing Node Taints.</p> <p>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.</p>
Synchronization for Existing Nodes	<p>After the options are selected, changes to resource tags and Kubernetes labels/taints in a node pool will be synchronized to existing nodes in the node pool.</p>
New Node Scheduling	<p>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.</p> <p>Scheduled Scheduling: After scheduled scheduling is enabled, new nodes will be automatically scheduled after the custom time expires.</p> <ul style="list-style-type: none"> • 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. <p>NOTE</p> <ul style="list-style-type: none"> • 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	<p>Maximum number of pods that can run on the node, including the default system pods.</p> <p>This limit prevents the node from being overloaded with pods.</p> <p>This number is also decided by other factors. For details, see Maximum Number of Pods That Can Be Created on a Node.</p>
ECS Group	<p>An ECS group logically groups ECSs. The ECSs in the same ECS group comply with the same policy associated with the ECS group.</p> <p>Anti-affinity: ECSs in an ECS group are deployed on different physical hosts to improve service reliability.</p> <p>Select an existing ECS group, or click Add ECS Group to create one. After the ECS group is created, click the refresh icon.</p>
Pre-installation Command	<p>Pre-installation script command, in which Chinese characters are not allowed. The script command will be Base64-transcoded. The characters of both the pre-installation and post-installation scripts are centrally calculated, and the total number of characters after transcoding cannot exceed 10240.</p> <p>The script will be executed before Kubernetes software is installed. Note that if the script is incorrect, Kubernetes software may fail to be installed.</p>
Post-installation Command	<p>Pre-installation script command, in which Chinese characters are not allowed. The script command will be Base64-transcoded. The characters of both the pre-installation and post-installation scripts are centrally calculated, and the total number of characters after transcoding cannot exceed 10240.</p> <p>The script will be executed after Kubernetes software is installed, which does not affect the installation.</p> <p>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.</p>
Agency	<p>An agency is created by the account administrator on the IAM console. Using an agency, you can share your cloud server resources with another account, or entrust a more professional person or team to manage your resources.</p> <p>If no agency is available, click Create Agency on the right to create one.</p>

Parameter	Description
User-defined node name prefix and suffix	<p>Custom name prefix and suffix of a node in a node pool. After the configuration, the nodes in the node pool will be named with the configured prefix and suffix. For example, if the prefix is prefix- and the suffix is -suffix, the nodes in the node pool will be named in the format of "prefix-Node pool name with five-digit random characters-suffix".</p> <p>NOTICE</p> <ul style="list-style-type: none"> • A prefix and suffix can be customized only when a node pool is created, and they cannot be modified after the node pool is created. • A prefix can end with a special character, and a suffix can start with a special character. • A node name consists of a maximum of 56 characters in the format of "Prefix-Node pool name with five-digit random characters-Suffix". • A node name does not support the combination of a period (.) and special characters (such as .., .-, or -.). • This function is available only in clusters of v1.28.1, v1.27.3, v1.25.6, v1.23.11, v1.21.12, or later.

Step 4 Click **Next: Confirm**.

Step 5 Click **Submit**.

----End

8.3 Scaling a Node Pool

You can specify a specification in a node pool for scaling.

NOTICE

The default node pool does not support scaling. Use [Creating a Node](#) to add a 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. In the right pane, click the **Node Pools** tab.

Step 3 Choose **Scaling** next to the target node pool.

Step 4 In the displayed **Node Pool Scaling** window, configure scaling parameters.

- Add or reduce nodes for scaling.
- Use the selected flavor to increase or decrease the number of nodes.
- Configure the number of nodes to be added or deleted.

- When scaling out a node pool, make sure that the total number of nodes, both existing and new, does not exceed the management scale of the current cluster.
- When scaling in a node pool, make sure that the number of nodes to be removed does not exceed the number of nodes currently in the pool.

Scaling in can result in the unavailability of resources associated with a node, such as local storage and workloads that were scheduled to that node. Exercise caution when performing this operation to avoid impact on running services.

Step 5 Click **OK**.

----End

8.4 Managing a Node Pool

8.4.1 Updating a Node Pool

Precautions

- Changes to the container engine, OS, or pre-/post-installation script in a node pool take effect only on new nodes. To synchronize the modification onto existing nodes, manually reset these nodes.
- Changes to resource tags and Kubernetes labels/taints in a node pool will be automatically synchronized to existing nodes. 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. In the right pane, click the **Node Pools** tab.

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 8-7 Basic settings

Parameter	Description
Node Pool Name	Name of the node pool.

Configurations

Table 8-8 Node configuration parameters

Parameter	Description
Specifications	<p>Select node specifications that best fit your service needs.</p> <p>NOTE</p> <ul style="list-style-type: none"> • If a node pool is configured with multiple node flavors, only the flavors (which can be located in different AZs) of the same node type are supported. For example, a node pool consisting of general computing-plus nodes supports only general computing-plus node flavors, but not the flavors of general computing nodes. • A maximum of 10 node flavors can be added to a node pool (the flavors in different AZs are counted separately). When adding a node flavor, you can choose multiple AZs, but you need to specify them. • Nodes in a newly created node pool are created using the default flavor. If the resources for the default flavor are insufficient, node creation will fail. • After a node pool is created, the flavors of existing nodes cannot be deleted.
Container Engine	<p>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.</p> <p>NOTE</p> <p>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.</p>
OS	<p>Select an OS type. Different types of nodes support different OSs.</p> <ul style="list-style-type: none"> • Public image: Select a public image for the node. <p>NOTE</p> <ul style="list-style-type: none"> • 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 8-9 Configuration parameters

Parameter	Description
System Disk	<p>System disk used by the node OS. The value ranges from 40 GiB to 1024 GiB. The default value is 50 GiB.</p> <p>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.</p> <p>System Disk Encryption: System disk encryption safeguards your data. Snapshots generated from encrypted disks and disks created using these snapshots automatically inherit the encryption setting. Only the nodes of the Elastic Cloud Server (VM) type in certain regions support system disk encryption. For details, see the console.</p> <ul style="list-style-type: none"> • Not encrypted is selected by default. • After setting System Disk Encryption to Enabled (key), 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. <p>NOTE The modified system disk encryption automatically takes effect on new nodes. For existing nodes, manually reset the nodes for the modification to take effect.</p>

Parameter	Description
Data Disk	<p>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.</p> <ul style="list-style-type: none"> • 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. <p>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.</p> <p>Advanced Settings Expand the area and configure the following parameters:</p> <ul style="list-style-type: none"> • 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. <p>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.</p> <ul style="list-style-type: none"> • Enabled: Data disk encryption safeguards your data. Snapshots generated from encrypted disks and disks created using these snapshots automatically inherit the encryption setting. <ul style="list-style-type: none"> – 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. <p>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.</p> <p>Adding data disks A maximum of 16 data disks can be attached to an ECS. By default, a raw disk is created without any processing. You can also click Expand and select any of the following options:</p> <ul style="list-style-type: none"> • 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
	<p>persistent label is added to the node with PV configured. The value is linear or striped.</p> <ul style="list-style-type: none"> • Use as ephemeral volume: applicable when there is a high performance requirement on emptyDir. <p>NOTE</p> <ul style="list-style-type: none"> • 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. <p>Local PVs and local EVs can be written in the following modes:</p> <ul style="list-style-type: none"> • 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. This allows 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. <p>Local Disk Description</p> <p>If the node flavor is disk-intensive or ultra-high I/O, one data disk can be a local disk.</p> <p>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.</p>

Advanced Settings

Table 8-10 Advanced settings

Parameter	Description
Resource Tag	<p>You can add resource tags to classify resources.</p> <p>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.</p> <p>CCE will automatically create the "CCE-Dynamic-Provisioning-Node=<i>node id</i>" tag.</p> <p>NOTE</p> <p>Modified resource tags automatically take effect on new nodes.</p>

Parameter	Description
Kubernetes Label	<p>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.</p> <p>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.</p> <p>NOTE Modified Kubernetes labels automatically take effect on new nodes.</p>
Taint	<p>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:</p> <ul style="list-style-type: none"> • 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 contain 1 to 63 characters, starting with a letter or digit. Only letters, digits, hyphens (-), underscores (_), and periods (.) are allowed. • Effect: Available options are NoSchedule, PreferNoSchedule, and NoExecute. <p>For details, see Managing Node Taints.</p> <p>NOTE Modified taints automatically take effect on new nodes.</p>

Parameter	Description
Synchronization for Existing Nodes	<p>After the options are selected, changes to resource tags and Kubernetes labels/taints in a node pool will be synchronized to existing nodes in the node pool.</p> <p>NOTE</p> <p>When you update a node pool, pay attention to the following if you change the state of Resource tags synchronized:</p> <ul style="list-style-type: none"> • After the option is selected: <ul style="list-style-type: none"> - CCE will synchronize the resource tags configured in the node pool to existing nodes. If a resource tag with the same key of a resource tag in the node pool already exists on an ECS, the value of the tag on the ECS will be changed to that of the resource tag in the node pool. - Typically, it takes less than 10 minutes to synchronize resource tags onto existing nodes, depending on the number of nodes in the node pool. - Issue a resource tag synchronization request only after the previous synchronization is complete. Otherwise, the resource tags may be inconsistent between existing nodes. <p>When you update a node pool, pay attention to the following if you change the state of Kubernetes labels or Taints:</p> <ul style="list-style-type: none"> • 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: <ul style="list-style-type: none"> - 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.

Parameter	Description
New Node Scheduling	<p>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.</p> <p>Scheduled Scheduling: After scheduled scheduling is enabled, new nodes will be automatically scheduled after the custom time expires.</p> <ul style="list-style-type: none"> • 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. <p>NOTE</p> <ul style="list-style-type: none"> • 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.
Edit key pair	<p>Only node pools that use key pairs for login support key pair editing. You can select another key pair.</p> <p>NOTE</p> <p>The edited key pair automatically takes effect on newly added nodes. For existing nodes, manually reset the nodes for the modification to take effect.</p>
Pre-installation Command	<p>Pre-installation script command, in which Chinese characters are not allowed. The script command will be Base64-transcoded. The characters of both the pre-installation and post-installation scripts are centrally calculated, and the total number of characters after transcoding cannot exceed 10240.</p> <p>The script will be executed before Kubernetes software is installed. Note that if the script is incorrect, Kubernetes software may fail to be installed.</p> <p>NOTE</p> <p>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.</p>

Parameter	Description
Post-installation Command	<p>Pre-installation script command, in which Chinese characters are not allowed. The script command will be Base64-transcoded. The characters of both the pre-installation and post-installation scripts are centrally calculated, and the total number of characters after transcoding cannot exceed 10240.</p> <p>The script will be executed after Kubernetes software is installed, which does not affect the installation.</p> <p>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.</p>
Agency	<p>An agency is created by the account administrator on the IAM console. Using an agency, you can share your cloud server resources with another account, or entrust a more professional person or team to manage your resources.</p> <p>If no agency is available, click Create Agency on the right to create one.</p> <p>NOTE After an agency is modified, the modification will only apply to new nodes and not to existing ones, even if they are reset.</p>
User-defined node name prefix and suffix	<p>Custom name prefix and suffix of a node in a node pool. After the configuration, the nodes in the node pool will be named with the configured prefix and suffix. For example, if the prefix is prefix- and the suffix is -suffix, the nodes in the node pool will be named in the format of "prefix-Node pool name with five-digit random characters-suffix".</p> <ul style="list-style-type: none"> • A prefix and suffix can be customized only when a node pool is created, and they cannot be modified after the node pool is created. • A prefix can end with a special character, and a suffix can start with a special character. • A node name consists of a maximum of 56 characters in the format of "Prefix-Node pool name with five-digit random characters-Suffix". • A node name does not support the combination of a period (.) and special characters (such as .., .-, or -.). • This function is available only in clusters of v1.28.1, v1.27.3, v1.25.6, v1.23.11, v1.21.12, or later. <p>NOTE After the custom name prefix and suffix are modified, the modification will only apply to new nodes and not to existing ones, even if they are reset.</p>

Step 4 After the configuration, click **OK**.

After node pool parameters are modified, you can find the update on the **Nodes** page. Reset the nodes in the target node pool to synchronize the configuration update.

----End

8.4.2 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.

Notes and 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 Autoscaler 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 Autoscaler 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 8-11 Custom rules

Rule Type	Configuration
Metric-based	<p>– Trigger: Select CPU allocation rate or Memory allocation rate and enter a value. The percentage must be greater than the value specified in the node resource requirements for a node scale-in when you configure a scaling policy (Configuring an Auto Scaling Policy for a Cluster).</p> <p>NOTE</p> <ul style="list-style-type: none"> ▪ 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 is configured based on the CPU allocation rate and a periodic rule and both the rules meet the scale-out conditions, the periodic rule executed early changes the node pool to the scaling state. As a result, the metric-based rule cannot be executed. After the periodic rule is executed and the node pool status becomes normal, the metric-based rule will not be executed. If the metric-based rule is executed early, the periodic rule will be executed after the metric-based rule is executed. ▪ If a rule is configured based on the CPU allocation rate and memory allocation rate, 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. ▪ If the number of nodes reaches the upper limit of the cluster scale, the upper limit of the nodes supported in a node pool, or the upper limit of the nodes of a specific flavor, a metric-based scale-out will not be triggered. ▪ If the number of nodes, CPUs, or memory resources reaches the upper limit for a node scale-out, a metric-based scale-out will not be triggered. <p>– Action: Configure an action to be performed when the triggering condition is met.</p> <ul style="list-style-type: none"> ▪ 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

Rule Type	Configuration
Periodic	<ul style="list-style-type: none"> - 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

- **Specifications:** Configure whether to enable auto scaling for node flavors in a node pool.

NOTE

If multiple flavors are configured for a node pool, you can specify the upper limit for the number of nodes and the priority for each flavor separately.

Step 4 Click **OK**.

----End

8.4.3 Modifying Node Pool Configurations

Notes and Constraints

The default node pool 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. In the right pane, click the **Node Pools** tab.

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 8-12 kubelet

Item	Parameter	Description	Value	Modification
CPU management policy	cpu-management-policy	<p>CPU management policy configuration. For details, see CPU Scheduling.</p> <ul style="list-style-type: none"> 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.	<ul style="list-style-type: none"> 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
Upper Limit for Burst Events	event-burst	Upper limit for burst event creation. The number of burst events can be temporarily increased to the specified value.	Default: 10	None

Item	Parameter	Description	Value	Modification
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
Node oversubscription	oversubscription-resource	Whether to enable node oversubscription. If this parameter is set to true , node oversubscription is enabled on nodes.	<ul style="list-style-type: none"> 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
Hybrid deployment	colocation	<p>Whether to enable hybrid deployment on nodes.</p> <p>If this parameter is set to true, hybrid deployment is enabled on nodes.</p>	<ul style="list-style-type: none"> 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	<p>Set the topology management policy. Valid values are as follows:</p> <ul style="list-style-type: none"> • 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	<p>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.</p>
Topology management scope	topology-manager-scope	<p>Configure the resource alignment granularity of the topology management policy. Valid values are as follows:</p> <ul style="list-style-type: none"> • 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	<p>Pull an image in serial mode.</p> <ul style="list-style-type: none"> 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. 	<ul style="list-style-type: none"> 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.	<p>Default: 5</p> <p>The value ranges from 1 to 50.</p>	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.
Maximum Number of Container Log Files	container-log-max-files	Maximum number of container log files. When the number of existing log files exceeds this value, the earliest log file will be deleted to release space for new log files.	Default: 10 Value range: 2 to 100	This parameter is available only in clusters of v1.23.14-r0, v1.25.9-r0, v1.27.6-r0, v1.28.4-r0, or later versions.
Maximum Container Log File Size	container-log-max-size	Maximum size of a single container log file. When the size of a log file reaches this value, the current log file will be closed and a new log file will be created to continue logging.	Default: 50 Value range: 1 to 4096	This parameter is available only in clusters of v1.23.14-r0, v1.25.9-r0, v1.27.6-r0, v1.28.4-r0, or later versions.
Upper Limit for Image Garbage Collection	image-gc-high-threshold	When the kubelet disk usage reaches this value, kubelet starts to collect image garbage.	Default: 80 Value range: 1 to 100	To disable image garbage collection, set this parameter to 100 . This parameter is available only in clusters of v1.23.14-r0, v1.25.9-r0, v1.27.6-r0, v1.28.4-r0, or later versions.

Item	Parameter	Description	Value	Modification
Lower Limit for Image Garbage Collection	image-gc-low-threshold	When the disk usage reduces to this value, image garbage collection stops.	Default: 70 Value range: 1 to 100	The value of this parameter cannot be greater than the upper limit for image garbage collection. This parameter is available only in clusters of v1.23.14-r0, v1.25.9-r0, v1.27.6-r0, v1.28.4-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 as 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.	<p>For details, see Node-pressure Eviction.</p> <p>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.</p> <p>kubelet can identify the following specific file system identifiers:</p> <ul style="list-style-type: none"> • 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 <code>/var/lib/kubelet/</code>. • imagefs: file system partition used by a container engine. <p>For a shared data disk, kubelet and the container engine share the disk space. In this case, configure only the nodefs threshold or set the imagefs threshold to the same value as the nodefs threshold.</p>
	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	
	nodefs.available	Percentage of the available capacity in	This parameter is	

Item	Parameter	Description	Value	Modification
		<p>the filesystem used by kubelet.</p> <p>The value must be greater than the hard eviction value of the same parameter, and the eviction grace period (evictionSoftGracePeriod) must be configured accordingly.</p>	<p>left blank by default.</p> <p>Value range: 1% to 99%</p>	
	nodefs.inodesFree	<p>Percentage of available inodes in the filesystem used by kubelet.</p> <p>The value must be greater than the hard eviction value of the same parameter, and the eviction grace period (evictionSoftGracePeriod) must be configured accordingly.</p>	<p>This parameter is left blank by default.</p> <p>Value range: 1% to 99%</p>	
	imagefs.available	<p>Percentage of the available capacity in the filesystem used by container runtimes to store resources such as images.</p> <p>The value must be greater than the hard eviction value of the same parameter, and the eviction grace period (evictionSoftGracePeriod) must be configured accordingly.</p>	<p>This parameter is left blank by default.</p> <p>Value range: 1% to 99%</p>	

Item	Parameter	Description	Value	Modification
	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%	
	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 (evictionSoftGracePeriod) must be configured accordingly.	This parameter is left blank by default. Value range: 1% to 99%	

Table 8-13 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

Item	Parameter	Description	Value	Modification
Wait time of a closed TCP connection	contrack-tcp-timeout-close-wait	Wait time of a closed TCP connection To obtain the value, run the following command: sysctl -w net.netfilter.nf_contrack_tcp_timeout_close_wait	Default: 1h0m0s	None

Table 8-14 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

Item	Parameter	Description	Value	Modification
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.
Maximum Number of Concurrent Requests for Downloading an Image at a Time	max-concurrent-downloads	This parameter specifies the maximum number of concurrent requests for downloading an image at a time.	Default: 3 Value range: 1 to 20	If this parameter is set to a large value, the network performance of other services on the node may be affected or the disk I/O and CPU usage may increase. This parameter is available only in clusters of v1.23.14-r0, v1.25.9-r0, v1.27.6-r0, v1.28.4-r0, or later versions.
Maximum Container Log File Size	max-size	Maximum size of a container log file to be dumped. When the size of a log file reaches this value, the current log file will be closed and a new log file will be created to continue logging.	Default: 50 Value range: 1 to 4096	If this parameter is set to a small value, important logs may be lost. If this parameter is set to a large value, too much disk space may be occupied. This parameter is available only in clusters of v1.23.14-r0, v1.25.9-r0, v1.27.6-r0, v1.28.4-r0, or later versions.

Item	Parameter	Description	Value	Modification
Maximum Number of Container Log Files	max-file	Maximum number of log files that can be retained in a container. When the number of existing log files exceeds this value, the earliest log file will be deleted to release space for new log files.	Default: 20 Value range: 2 to 100	If this parameter is set to a small value, important logs may be lost. If this parameter is set to a large value, too much disk space may be occupied. This parameter is available only in clusters of v1.23.14-r0, v1.25.9-r0, v1.27.6-r0, v1.28.4-r0, or later versions.

Table 8-15 containerd (available only for node pools that use containerd)

Item	Parameter	Description	Value	Modification
Available data space for a single container	devmap-per-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

Item	Parameter	Description	Value	Modification
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 insecure skips	insecure-skip-verify	Whether to skip repository certificate verification.	Default: false	The parameter value cannot be changed.
Maximum Number of Concurrent Requests for Downloading an Image at a Time	max-concurrent-downloads	This parameter specifies the maximum number of concurrent requests for downloading an image at a time.	Default: 3 Value range: 1 to 20	If this parameter is set to a large value, the network performance of other services on the node may be affected or the disk I/O and CPU usage may increase. This parameter is available only in clusters of v1.23.14-r0, v1.25.9-r0, v1.27.6-r0, v1.28.4-r0, or later versions.
Maximum Container Log Line Size	max-container-log-line-size	Maximum log line size of a container, in the unit of bytes. The log lines exceeding the limit will be split into multiple lines.	Default: 16384 Value range: 1 to 2097152	A larger value will lead to more containerd memory consumption. This parameter is available only in clusters of v1.23.14-r0, v1.25.9-r0, v1.27.6-r0, v1.28.4-r0, or later versions.

Step 5 Click **OK**.

----End

8.4.4 Accepting Nodes in a Node Pool

If you want to add a newly created ECS to a node pool in a cluster, or remove a node from a node pool and add it to the node pool again, accept the node.

NOTICE

- When an ECS is accepted for management, the ECS OS will be reset to the standard image provided by CCE to ensure node stability.
 - 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 acceptance. Ensure that the information has been backed up.
 - During the acceptance of an ECS, do not perform any operation on the ECS through the ECS console.
 - After a node is managed by a node pool, if a scaling-in task is triggered in the node pool, the node will be deleted.
-

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. In the right pane, click the **Node Pools** tab.

Step 3 Choose **More > Accept Node** in the operation bar of the target node pool.

Step 4 Select one or more nodes that meet the requirements.

- The nodes and the current node pool are deployed in the same VPC and subnet.
- The billing mode of the nodes must be the same as that of the current node pool. For example, a pay-per-use node pool can accept only pay-per-use nodes.
- The cloud server group of the nodes must be the same as that of the current node pool.
- The nodes must be running and cannot be labeled with **CCE-Dynamic-Provisioning-Node**.
- Data disks must be attached to the nodes. 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 flavor of the nodes must be at least 2 vCPUs and 4 GiB memory, and only one NIC can be bound to each of the nodes.
- Only the cloud servers that have the same flavor, AZ, resource reservation, system disk, and data disk configurations as the node pool can be added for batch acceptance.
- Partitioned disks on cloud servers will not be accepted as data disks. Back up data and clear the disks before node acceptance.

Step 5 Click **OK**.

----**End**

8.4.5 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. In the right pane, click the **Node Pools** tab.
- Step 3** Choose **More > Copy** in the **Operation** column of the target node pool.
- 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

8.4.6 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:
 - Changes to the container engine, OS, or pre-/post-installation script in a node pool take effect only on new nodes. To synchronize the modification onto existing nodes, manually reset these nodes.
 - Changes to resource tags and Kubernetes labels/taints in a node pool will be automatically synchronized to existing nodes. 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. In the right pane, click the **Nodes** tab.
- 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. In the right pane, click the **Node Pools** tab.
- 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

8.4.7 Upgrading an OS

After CCE releases a new OS image, if existing nodes cannot be automatically upgraded, you can manually upgrade them in batches.

Precautions

- 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.
- The system disk and data disks of the node will be cleared. **Back up important data** before resetting the node.
- Resetting a node will clear your configured Kubernetes labels and taints. As a result, resources (such as local storage and load of specified scheduling nodes) associated with the node may be unavailable. Exercise caution when performing this operation to avoid impact on running services.

- After the OS is upgraded, the node automatically starts.
- To ensure node stability, CCE will reserve some CPU and memory resources to run necessary system components.

Notes and 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. In the right pane, click the **Node Pools** tab.

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:
 - **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 characters of both the pre-installation and post-installation scripts are centrally calculated, and the total number of characters after transcoding cannot exceed 10240.
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 characters of both the pre-installation and post-installation scripts are centrally calculated, and the total number of characters after transcoding cannot exceed 10240.
The script will be executed after Kubernetes software is installed, which does 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. In the right pane, click the **Node Pools** tab.

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

8.4.8 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

8.4.9 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. In the right pane, click the **Node Pools** tab.

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

9 Workloads

9.1 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.

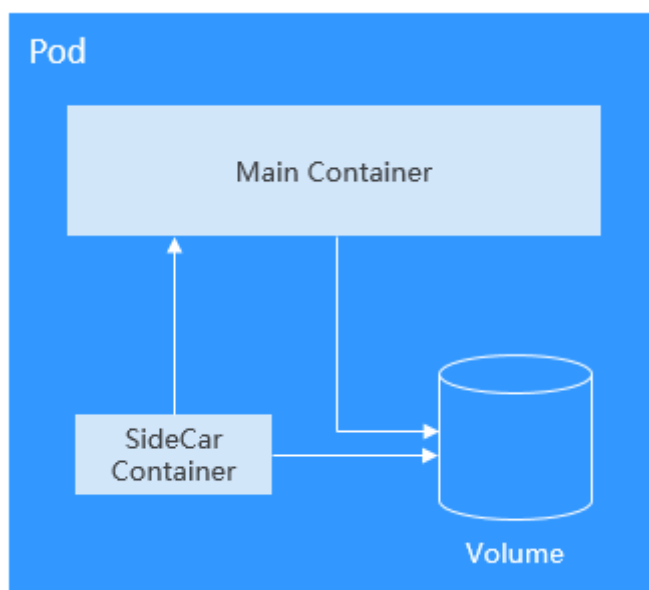
Overview of Pod

A pod is the smallest, 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 9-1](#). 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 9-1 Pod running multiple containers

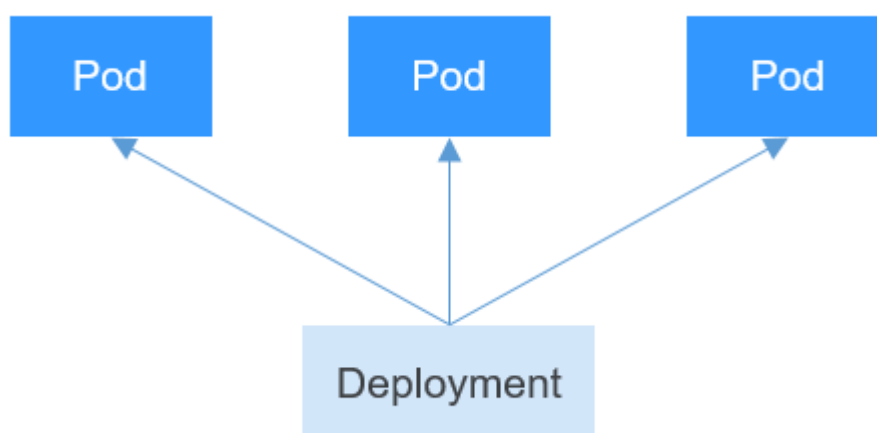


In Kubernetes, pods are rarely created directly. Instead, Kubernetes controller manages pods through pod instances such as Deployments and jobs. A controller typically uses a pod template to create pods. The controller can also manage multiple pods and provide functions such as replica management, rolling 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 9-2 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.

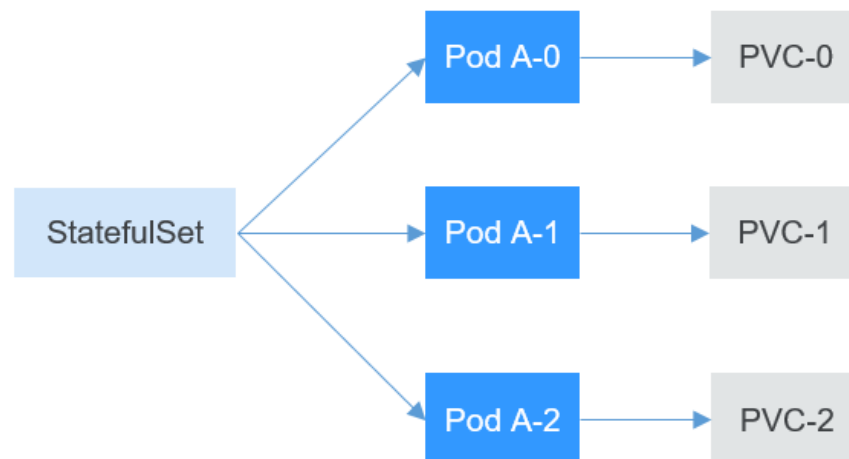
Distributed stateful applications involve different roles for different responsibilities. For example, databases work in active/standby mode, and pods depend on each other. To deploy stateful applications in Kubernetes, ensure pods meet the following requirements:

- 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 PVCs with fixed identifiers to ensure that pods can access the same persistent data after being rescheduled.

Figure 9-3 StatefulSet

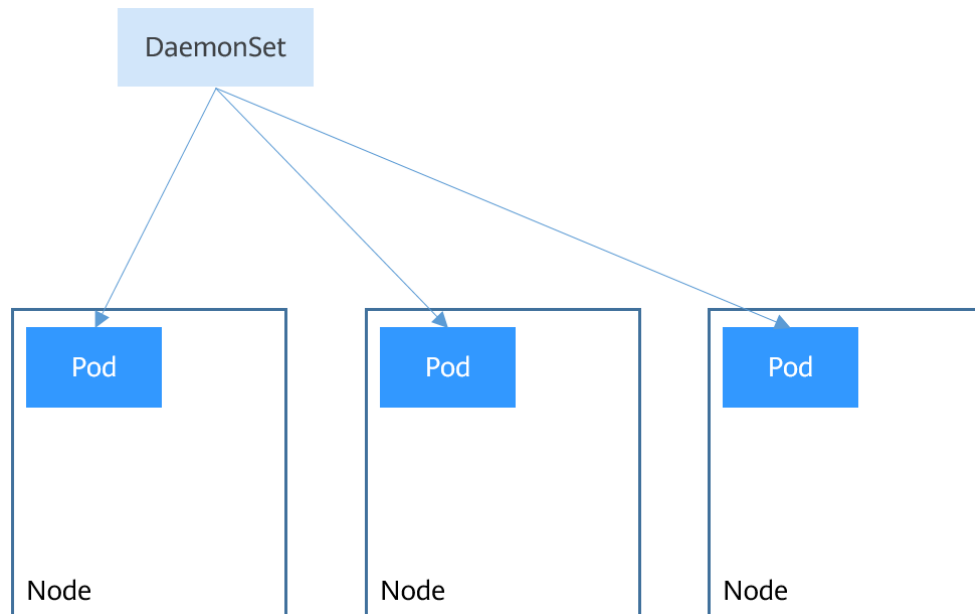


Overview of DaemonSet

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 9-4 DaemonSet



Overview of Job and CronJob

Jobs and CronJobs 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 CronJob runs a job periodically on a specified schedule. A CronJob 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 9-1 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.

9.2 Creating a Workload

9.2.1 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 [Creating 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	<ul style="list-style-type: none"> ▪ 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. <p>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.</p>

Parameter	Description
Memory Quota	<ul style="list-style-type: none"> ▪ 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. <p>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.</p>
(Optional) GPU Quota	<p>Configurable only when the cluster contains GPU nodes and the CCE AI Suite (NVIDIA GPU) add-on is installed.</p> <ul style="list-style-type: none"> ▪ 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. <p>For details about how to use GPUs in the cluster, see Default GPU Scheduling in Kubernetes.</p>
(Optional) Privileged Container	<p>Programs in a privileged container have certain privileges.</p> <p>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.</p>
(Optional) Init Container	<p>Whether to use the container as an init container. An init container does not support health check.</p> <p>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.</p>

- (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 9-18](#).

- **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 [Configuring 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 [Configuring Tolerance Policies](#).
- **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 [Configuring 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 access 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 the parameters, see [Table 9-2](#).

Table 9-2 Deployment YAML parameters

Parameter	Description	Mandatory/Optional
apiVersion	API version. NOTE Set this parameter based on the cluster version. <ul style="list-style-type: none"> 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
replicas	Number of pods.	Mandatory

Parameter	Description	Mandatory/Optional
selector	Determines container pods that can be managed by the Deployment.	Mandatory
strategy	Upgrade mode. Possible values: <ul style="list-style-type: none"> 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	<ul style="list-style-type: none"> 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. <ul style="list-style-type: none"> 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
```

Parameters

- **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

9.2.2 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.

Notes and 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 [Creating 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	<ul style="list-style-type: none"> ▪ 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. <p>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.</p>
Memory Quota	<ul style="list-style-type: none"> ▪ 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. <p>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.</p>
(Optional) GPU Quota	<p>Configurable only when the cluster contains GPU nodes and the CCE AI Suite (NVIDIA GPU) add-on is installed.</p> <ul style="list-style-type: none"> ▪ 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. <p>For details about how to use GPUs in the cluster, see Default GPU Scheduling in Kubernetes.</p>
(Optional) Privileged Container	<p>Programs in a privileged container have certain privileges.</p> <p>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.</p>

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](#) or [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 9-18](#).

- **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 [Configuring 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 [Configuring Tolerance Policies](#).
- **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 [Configuring 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 access 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: eu-west-0 # 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 # StorageClass 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

9.2.3 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 [Creating 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	<ul style="list-style-type: none"> ▪ 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. <p>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.</p>
Memory Quota	<ul style="list-style-type: none"> ▪ 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. <p>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.</p>
(Optional) GPU Quota	<p>Configurable only when the cluster contains GPU nodes and the CCE AI Suite (NVIDIA GPU) add-on is installed.</p> <ul style="list-style-type: none"> ▪ 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. <p>For details about how to use GPUs in the cluster, see Default GPU Scheduling in Kubernetes.</p>
(Optional) Privileged Container	<p>Programs in a privileged container have certain privileges.</p> <p>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.</p>

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 9-18](#).

- **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 [Configuring 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 [Configuring Tolerance Policies](#).
- **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 [Configuring 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 access 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

9.2.4 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	<ul style="list-style-type: none"> ▪ 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. <p>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.</p>
Memory Quota	<ul style="list-style-type: none"> ▪ 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. <p>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.</p>

Parameter	Description
(Optional) GPU Quota	<p>Configurable only when the cluster contains GPU nodes and the CCE AI Suite (NVIDIA GPU) add-on is installed.</p> <ul style="list-style-type: none"> ▪ 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. <p>For details about how to use GPUs in the cluster, see Default GPU Scheduling in Kubernetes.</p>
(Optional) Privileged Container	<p>Programs in a privileged container have certain privileges.</p> <p>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.</p>
(Optional) Init Container	<p>Whether to use the container as an init container. An init container does not support health check.</p> <p>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.</p> <p>Application containers in a pod are started and run only after the running of all init containers completes.</p> <p>For details, see Init Containers.</p>

- (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 9-18](#).

- **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 [Configuring 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, the job and all pods 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 9-3 Job types

Job Type	Description	.spec.comple tions	.spec.parall elism
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,  $\pi$  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
3.141592653589793238462643383279502884197169399375105820974944592307816406286208998628034
8253421170679821480865132823066470938446095505822317253594081284811174502841027019385211
0555964462294895493038196442881097566593344612847564823378678316527120190914564856692346
0348610454326648213393607260249141273724587006606315588174881520920962829254091715364367
8925903600113305305488204665213841469519415116094330572703657595919530921861173819326117
9310511854807446237996274956735188575272489122793818301194912983367336244065664308602139
4946395224737190702179860943702770539217176293176752384674818467669405132000568127145263
5608277857713427577896091736371787214684409012249534301465495853710507922796892589235420
1995611212902196086403441815981362977477130996051870721134999999837297804995105973173281
6096318595024459455346908302642522308253344685035261931188171010003137838752886587533208
3814206171776691473035982534904287554687311595628638823537875937519577818577805321712268
0661300192787661119590921642019893809525720106548586327886593615338182796823030195203530
1852968995773622599413891249721775283479131515574857242454150695950829533116861727855889
0750983817546374649393192550604009277016711390098488240128583616035637076601047101819429
5559619894676783744944825537977472684710404753464620804668425906949129331367702898915210
4752162056966024058038150193511253382430035587640247496473263914199272604269922796782354
7816360093417216412199245863150302861829745557067498385054945885869269956909272107975093
0295532116534498720275596023648066549911988183479775356636980742654252786255181841757467
2890977772793800081647060016145249192173217214772350141441973568548161361157352552133475
7418494684385233239073941433345477624168625189835694855620992192221842725502542568876717
9049460165346680498862723279178608578438382796797668145410095388378636095068006422512520
5117392984896084128488626945604241965285022210661186306744278622039194945047123713786960
9563643719172874677646575739624138908658326459958133904780275901
```

----End

Related Operations

After a one-off job is created, you can perform operations listed in [Table 9-4](#).

Table 9-4 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	<ol style="list-style-type: none"> Select the target job and choose More > Delete in the Operation column. Click Yes. Deleted jobs cannot be restored. Exercise caution when deleting a job.

9.2.5 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	<ul style="list-style-type: none"> ▪ 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. <p>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.</p>

Parameter	Description
Memory Quota	<ul style="list-style-type: none"> ▪ 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. <p>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.</p>
(Optional) GPU Quota	<p>Configurable only when the cluster contains GPU nodes and the CCE AI Suite (NVIDIA GPU) add-on is installed.</p> <ul style="list-style-type: none"> ▪ 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. <p>For details about how to use GPUs in the cluster, see Default GPU Scheduling in Kubernetes.</p>
(Optional) Privileged Container	<p>Programs in a privileged container have certain privileges.</p> <p>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.</p>
(Optional) Init Container	<p>Whether to use the container as an init container. An init container does not support health check.</p> <p>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.</p>

- (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 [Configuring 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	*/* * * * *	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 9-5](#).

Table 9-5 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.

Operation	Description
Stopping a CronJob	<ol style="list-style-type: none"> 1. Select the job to be stopped and click Stop in the Operation column. 2. Click Yes.
Deleting a CronJob	<ol style="list-style-type: none"> 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.

9.3 Configuring a Workload

9.3.1 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
```

9.3.2 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.

9.3.3 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 access 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

9.3.4 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

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 9-6 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 \geq Sum of CPU limits of all containers on the current node \geq 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 9-7 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 \geq Sum of memory limits of all containers on the current node \geq 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. EV does not ensure long-term data availability. Pods can use local EVs to buffer data and store logs, or mount emptyDir 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
```

9.3.5 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 9-8 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 9-9 Container startup command

Configuration Item	Procedure
Command	<p>Enter an executable command, for example, /run/server.</p> <p>If there are multiple executable commands, write them in different lines.</p> <p>NOTE In the case of multiple commands, you are advised to run /bin/sh or other shell commands. Other commands are used as parameters.</p>
Args	<p>Enter the argument that controls the container running command, for example, --port=8080.</p> <p>If there are multiple arguments, separate them in different lines.</p>

----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 9-10 Post-start processing parameters

Parameter	Description
CLI	<p>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.</p> <p>Example command:</p> <pre>exec: command: - /install.sh - install_agent</pre> <p>Enter /install install_agent in the script. This command indicates that install.sh will be executed after the container is created successfully.</p>
HTTP request	<p>Send an HTTP request for post-start processing. The related parameters are described as follows:</p> <ul style="list-style-type: none"> • 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 9-11 Pre-stop processing parameters

Parameter	Description
CLI	<p>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.</p> <p>Example command:</p> <pre>exec: command: - /uninstall.sh - uninstall_agent</pre> <p>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.</p>
HTTP request	<p>Send an HTTP request for pre-stop processing. The related parameters are described as follows:</p> <ul style="list-style-type: none"> • 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

YAML Example

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
```

9.3.6 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 9-12 Common parameters

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
```

9.3.7 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.

```

9.3.8 Configuring Workload Upgrade Policies

Upgrades are a common operation. A Deployment, StatefulSet, or DaemonSet can easily support application upgrades.

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 (revisionHistoryLimit)	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-6f9f58dff  2        2        2      1m
nginx-7f98958cdf  0        0        0      48m

$ kubectl get pods
NAME                READY  STATUS  RESTARTS  AGE
nginx-6f9f58dff-tdmqk  1/1    Running  0         1m
nginx-6f9f58dff-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 ($2 \times 1.25 = 2.5$, rounded up to 3), and `maxUnavailable` does not allow a maximum of two pods to be unavailable ($2 \times 0.75 = 1.5$, 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 an earlier version when a fault occurs during an 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**.

9.3.9 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](#) or [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 9-13](#).


Select a proper policy type and click  to add a policy. For details about the parameters, see [Table 9-14](#).

Table 9-13 Load affinity policies

Policy	Type	Description
Workload affinity	Required	<p>Hard constraint, which corresponds to requiredDuringSchedulingIgnoredDuringExecution in YAML for specifying the conditions that must be met.</p> <p>Select pods that require affinity by label. If such pods already run on a node in the topology key, the scheduler will forcibly schedule the created pods to that topology key.</p> <p>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 key for scheduling.</p>

Policy	Type	Description
	Preferred	<p>Soft constraint, which corresponds to preferredDuringSchedulingIgnoredDuringExecution in YAML for specifying the conditions that need to be met as much as possible.</p> <p>Select pods that require affinity by label. If such pods already run on a node in the topology key, the scheduler will preferentially schedule the created pods to that topology key.</p> <p>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 key will be selected for scheduling.</p>
Workload anti-affinity	Required	<p>Hard constraint, which corresponds to requiredDuringSchedulingIgnoredDuringExecution in YAML for specifying the conditions that must be met.</p> <p>Select one or more pods that require anti-affinity by label. If such pods already run on a node in the topology key, the scheduler will not schedule the created pods to that topology key.</p> <p>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 keys where the pods that meet the label filtering conditions locate will not be scheduled.</p>
	Preferred	<p>Soft constraint, which corresponds to preferredDuringSchedulingIgnoredDuringExecution in YAML for specifying the conditions that need to be met as much as possible.</p> <p>Select one or more pods that require anti-affinity by label. If such pods already run on a node in the topology key, the scheduler will preferentially schedule the created pods to other topology keys.</p> <p>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 keys involve the pods that require anti-affinity, a topology key will be selected for scheduling.</p>

Table 9-14 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 key (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 keys. In this case, a topology key 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 keys. In this case, a topology key may contain multiple nodes. After the node range is determined using the topology key, configure the policy for scheduling, including the label key, operator, and label value. The minimum unit for scheduling is a topology key. For example, if a node in a topology key meets the load affinity policy, all nodes in the topology key 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: <ul style="list-style-type: none"> – 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 key. – DoesNotExist: The affinity or anti-affinity object does not have a specified label key.
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 according to 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 according to 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 9-15](#).

Select a proper policy type and click  to add a policy. For details about the parameters, see [Table 9-16](#). 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 9-15 Node affinity settings

Parameter	Description
Required	Hard constraint, which corresponds to <code>requiredDuringSchedulingIgnoredDuringExecution</code> 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 <code>preferredDuringSchedulingIgnoredDuringExecution</code> for specifying the conditions that need to be met as much as possible. If multiple rules that are preferentially met are added, scheduling will be performed even if one or none of the rules is met.

Table 9-16 Parameters for configuring node affinity scheduling policies

Parameter	Description
Label Key	When configuring node affinity, enter the node label to be matched. Both default labels and custom labels are supported.

Parameter	Description
Operator	<p>The following operators are supported:</p> <ul style="list-style-type: none"> - 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 key. - DoesNotExist: The affinity or anti-affinity object does not have a specified label key. - 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**: hostname 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 any changes to the node label after Kubernetes schedules the pod will not affect the pod's running or cause it to 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 configuring 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**).

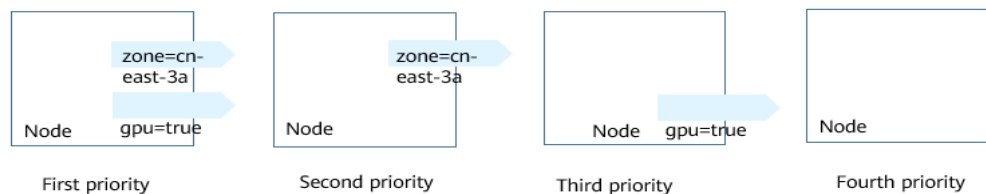
From the preceding output, you can find that no pods of the Deployment are scheduled to node **192.168.0.94** (label: **DISK=SSD**). This is because the node already has many pods on it and its resource usage is high. This also indicates that the **preferredDuringSchedulingIgnoredDuringExecution** rule 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 9-5 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 keys 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 key. 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**.

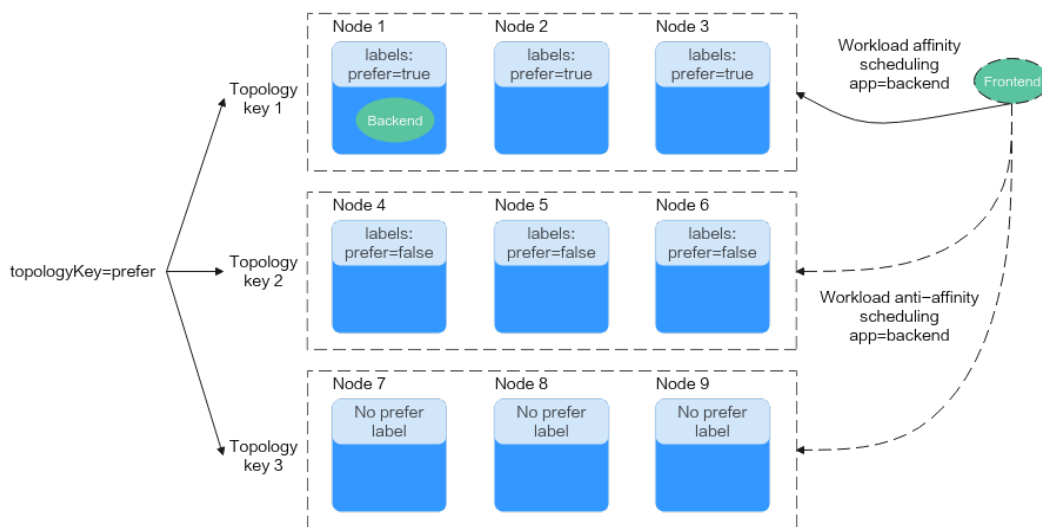
```
$ kubectl label node 192.168.0.97 prefer=true
node/192.168.0.97 labeled
$ kubectl label node 192.168.0.94 prefer=true
node/192.168.0.94 labeled
$ kubectl get node -L prefer
```

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 keys are divided as shown in **Figure 9-6**.

```
affinity:
  podAffinity:
    requiredDuringSchedulingIgnoredDuringExecution:
      - topologyKey: prefer
        labelSelector:
          matchExpressions:
            - key: app
              operator: In
              values:
                - backend
```

Figure 9-6 Topology keys



During scheduling, node topology keys 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 key. If a pod with the **app=backend** label runs in the topology key, even if not all nodes in the topology key 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 key (**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 keys by the **kubernetes.io/hostname** label. If a pod with the **app=frontend** label already exists on a node in the topology key, pods with the same label cannot be scheduled to other nodes in the topology key.

```
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 key 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 keys 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 key. If a topology key contains only one node where a frontend pod already exists, pods with the same label will not be scheduled to that topology key. 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 key.
- **DoesNotExist:** The affinity or anti-affinity object does not have a specified label key.
- **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).

9.3.10 Configuring Tolerance Policies

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	<ul style="list-style-type: none"> • Pods running on the node will be evicted immediately. • Inactive pods will not be scheduled to the node. 	<ul style="list-style-type: none"> • If the tolerance time window tolerationSeconds is not specified, pods can always run on this node. • 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	<ul style="list-style-type: none"> Pods running on the node will not be evicted. Inactive pods will not be scheduled to the node to the best extend. 	Pods can always run on this node.
NoSchedule	<ul style="list-style-type: none"> Pods running on the node will not be evicted. Inactive pods will not be scheduled to the node. 	Pods can always run on this node.

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 9-17 Parameters for configuring a taint tolerance policy

Parameter	Description
Taint key	Key of a node taint
Operator	<ul style="list-style-type: none"> 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	<ul style="list-style-type: none"> 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	<p>tolerationSeconds, which is configurable only when Taint Policy is set to NoExecute.</p> <p>Within the tolerance time window, pods still run on the node with taints. After the time expires, the pods will be evicted.</p>

----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
```

9.3.11 Configuring 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 9-18 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: <ul style="list-style-type: none"> 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
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.

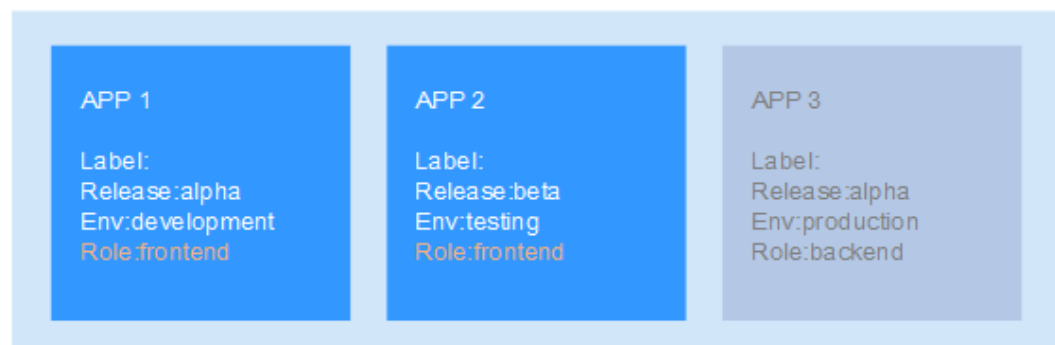
Example YAML:

```
...
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 9-7 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 \(podAffinity\)](#).

9.4 Logging In to a Container

Scenario

If you encounter unexpected problems when using a container, you can log in to the container to debug it.

Using kubectl

Step 1 Use kubectl to access 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
```

9.5 Managing Workloads

Scenario

After a workload is created, you can upgrade, monitor, roll back, or delete the workload, as well as edit its YAML file.

Table 9-19 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.

Operation	Description
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 pods 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 pods continue 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 **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 pods 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 and 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. 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 a Deployment as an example to describe how to view events of a workload. To view the event of a job or CronJob, 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

9.6 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

9.7 Pod Security

9.7.1 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 9-20](#).

Table 9-20 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.
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 9-20](#).

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-ppsp
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-ppsp
rules:
  - apiGroups:
    - "*"
    resources:
    - podsecuritypolicies
    resourceNameNames:
    - sysctl-ppsp
    verbs:
    - use
---
apiVersion: rbac.authorization.k8s.io/v1
kind: ClusterRoleBinding
metadata:
  name: sysctl-ppsp
roleRef:
  kind: ClusterRole
  name: sysctl-ppsp
  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
    resourceName:
    - 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

9.7.2 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 9-21 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.
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 9-22](#)). 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 9-22 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 9-22](#).
 - <LEVEL>: must be **privileged**, **baseline**, or **restricted**. For details about the levels, see [Table 9-21](#).
- 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 9-22](#).

- `<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](#)

10 Scheduling

10.1 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 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

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
NUMA affinity scheduling	Volcano targets to lift the limitation to make scheduler NUMA topology aware so that: <ul style="list-style-type: none"> Pods are not scheduled to the nodes that NUMA topology does not match. Pods are scheduled to the most suitable node for NUMA topology. 	NUMA Affinity Scheduling

Cloud Native Hybrid Deployment

The cloud native hybrid deployment solution focuses on the Volcano and Kubernetes ecosystems to help users improve resource utilization and efficiency and reduce costs.

Function	Description	Documentation
Dynamic resource oversubscription	Based on the types of online and offline jobs, Volcano scheduling is used to utilize the resources that are requested but not used in the cluster (the difference between the number of requested resources and the number of used resources) for resource oversubscription and hybrid deployment to improve cluster resource utilization.	Dynamic Resource Oversubscription

10.2 CPU Scheduling

10.2.1 CPU Policy

Scenarios

By default, kubelet uses [CFS quotas](#) to enforce pod CPU limits. 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 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.

Notes and 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
```

10.3 GPU Scheduling

10.3.1 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 CCE AI Suite (NVIDIA GPU) add-on has been installed. During the installation, select the driver corresponding to the GPU model on the node. For details, see [CCE AI Suite \(NVIDIA GPU\)](#).
- When the default GPU scheduling is used in clusters of v1.27 or earlier, the CCE AI Suite (NVIDIA GPU) add-on mounts the driver directory to **/usr/local/nvidia/lib64**, so you need to add **/usr/local/nvidia/lib64** to the **LD_LIBRARY_PATH** environment variable to use GPUs in a container. You can skip this step for clusters of v1.28 or later.

You can add environment variables in any of the following ways:

- 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
```

- 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 && ..."
```

- 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
    
```

10.4 Volcano Scheduling

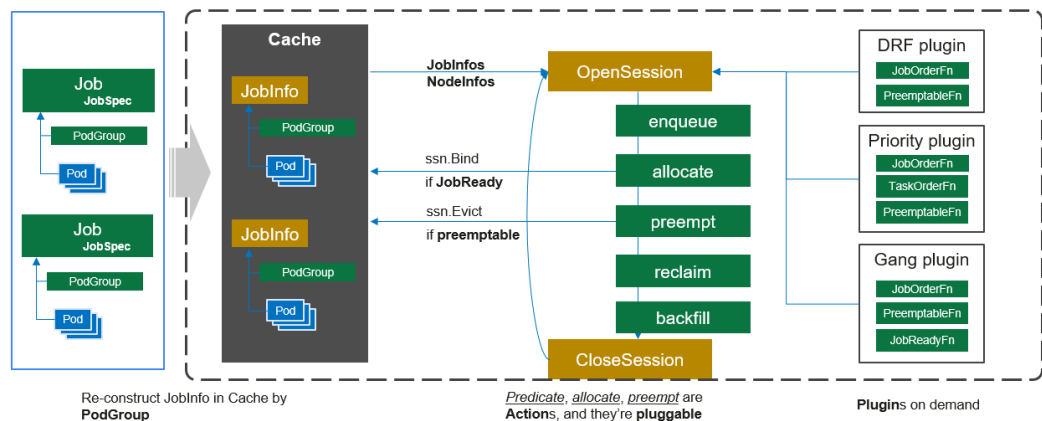
10.4.1 Overview

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 10-1 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.

10.4.2 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](#).

Notes and 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 10-1 Pod annotations supported by Volcano

Pod Annotations	Description
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: <ul style="list-style-type: none"> 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
```

10.4.3 Resource Usage-based Scheduling

10.4.3.1 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 [Creating 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

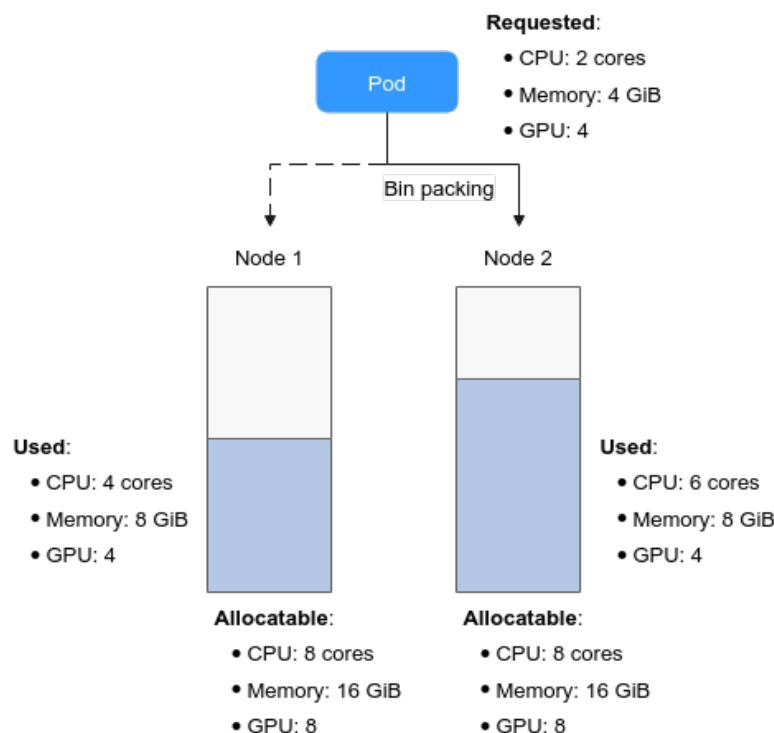
The bin packing add-on calculates the score of a node using the following formula:

$$\text{Binpack.weight} \times (\text{CPU.score} + \text{Memory.score} + \text{GPU.score}) / (\text{CPU.weight} + \text{Memory.weight} + \text{GPU.weight}) \times 100$$

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 10-2 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: $\text{CPU.weight} \times (\text{Requested} + \text{Used}) / \text{Allocatable}$

- CPU score: $1 \times (2 + 4)/8 = 0.75$
- Memory score: $1 \times (4 + 8)/16 = 0.75$
- GPU score: $2 \times (4 + 4)/8 = 1$

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: $5 \times (0.75 + 0.75 + 1)/(1 + 1 + 2) \times 100 = 312.5$

2. The scoring for node 2 is as follows:

- CPU score: $1 \times (2 + 6)/8 = 1$
- Memory score: $1 \times (4 + 8)/16 = 0.75$
- GPU score: $2 \times (4 + 4)/8 = 1$

Score of node 2: $5 \times (1 + 0.75 + 1)/(1 + 1 + 2) \times 100 = 343.75$

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. In the right pane, click the **Scheduling** tab.
- Step 3** In the **Resource utilization optimization scheduling** area, modify the bin packing settings.

Table 10-2 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

10.4.3.2 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.

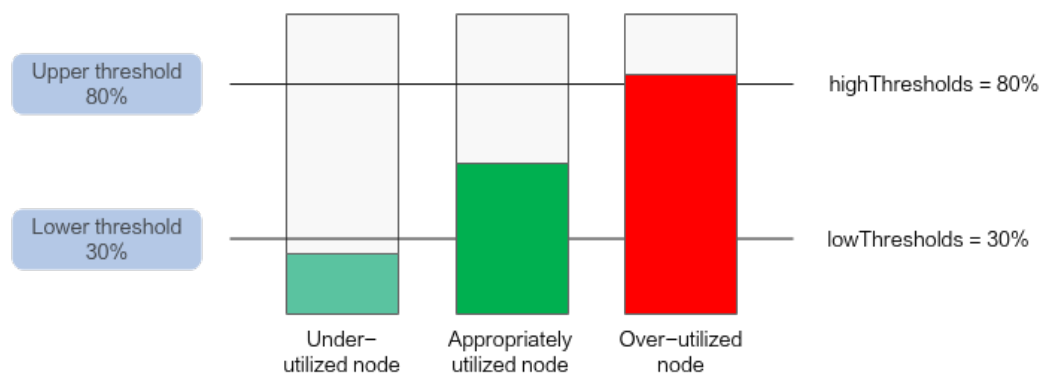
CCE has resolved this issue by using Volcano Scheduler to evict pods that do not comply with the configured policy so that pods can be rescheduled. In this way, the cluster load is balanced and resource fragmentation is minimized.

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 10-3 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 [Creating a CCE Standard Cluster](#).
- Volcano of v1.11.5 or later has been installed in the cluster. For details, see [Volcano Scheduler](#).

Notes and 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 10-3 Key parameters of a cluster descheduling policy

Parameter	Description
descheduler_enable	Whether to enable a cluster descheduling policy. <ul style="list-style-type: none"> 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 10-4 .

Table 10-4 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: <ul style="list-style-type: none"> • DefaultEvictor: default eviction policy • LoadAware: a load-aware descheduling policy

Parameter	Description
<p>profiles. [].pluginConfig. [].args</p>	<p>Descheduling policy configuration of a cluster.</p> <ul style="list-style-type: none"> ● Configurations for the DefaultEvictor policy: <ul style="list-style-type: none"> – 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: <pre>{ "value": 100 }</pre> ● Configurations for the LoadAware policy: <ul style="list-style-type: none"> – evictableNamespaces: namespaces where the eviction policy takes effect. The default value is the namespaces other than kube-system. Example: <pre>{ "exclude": ["kube-system"] }</pre> – 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: <pre>{ "type": "prometheus_adaptor" }</pre> 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: <pre>{ "address": "http://10.247.119.103:9090", "type": "prometheus" }</pre> – 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: <pre>{ "cpu": 60,</pre>

Parameter	Description
	<pre> "memory": 65 } </pre> <ul style="list-style-type: none"> – 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: <pre> { "cpu": 30, "memory": 30 } </pre>

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 10-5 Key parameters of a cluster descheduling policy

Parameter	Description
descheduler_enable	Whether to enable a cluster descheduling policy. <ul style="list-style-type: none"> • 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 10-6 .

Table 10-6 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: <ul style="list-style-type: none"> • DefaultEvictor: default eviction policy • HighNodeUtilization: policy for minimizing CPU and memory fragments

Parameter	Description
profiles. [].pluginConfig. [].args	<p>Descheduling policy configuration of a cluster.</p> <ul style="list-style-type: none"> ● Configurations for the DefaultEvictor policy: <ul style="list-style-type: none"> – 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: <pre style="background-color: #f0f0f0;">{ "value": 100 }</pre> ● Configurations for the HighNodeUtilization policy: <ul style="list-style-type: none"> – evictableNamespaces: namespaces where the eviction policy takes effect. The default value is the namespaces other than kube-system. Example: <pre style="background-color: #f0f0f0;">{ "exclude": ["kube-system"] }</pre> – 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: <pre style="background-color: #f0f0f0;">{ "cpu": 25, "memory": 25 }</pre>

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.

10.4.3.3 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 [Creating 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. In the right pane, 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.

```
...
"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"
      }
    ]
  },
  ]
},
...

```

Step 3 Click **OK**.

----End

10.4.4 Priority-based Scheduling

10.4.4.1 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 [Creating 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 10-7](#) lists the priority-based scheduling supported by CCE clusters.

Table 10-7 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. In the right pane, 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

10.4.5 AI Performance-based Scheduling

10.4.5.1 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 [Creating 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:

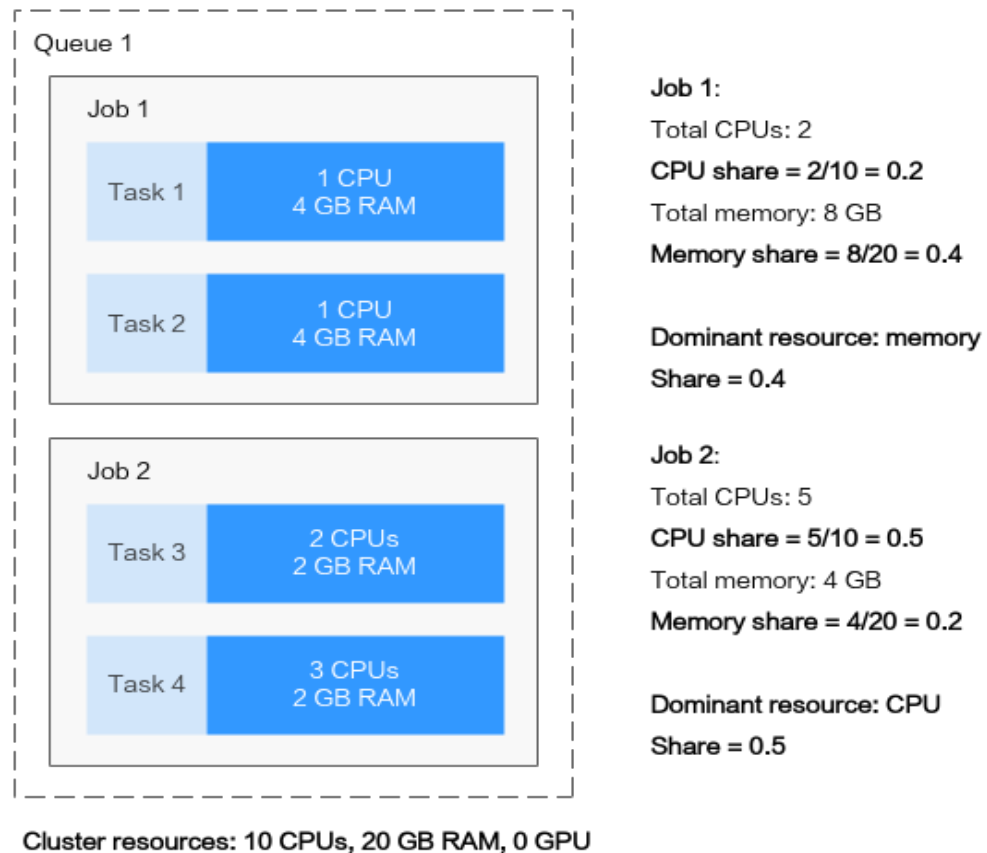
Share = Total requested resources/Cluster resources

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 10-4 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. In the right pane, 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

10.4.5.2 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 resource waiting or 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 [Creating 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. In the right pane, 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

10.4.6 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 most suitable 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: <ul style="list-style-type: none"> • none: schedulable • best-effort: schedulable • restricted: schedulable • single-numa-node: schedulable 	None
best-effort	Filter the nodes with the best-effort topology policy. <ul style="list-style-type: none"> • 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. <ul style="list-style-type: none"> • none: unschedulable • best-effort: unschedulable • restricted: schedulable • single-numa-node: unschedulable 	Restricted scheduling: <ul style="list-style-type: none"> • 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. <ul style="list-style-type: none"> • 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.

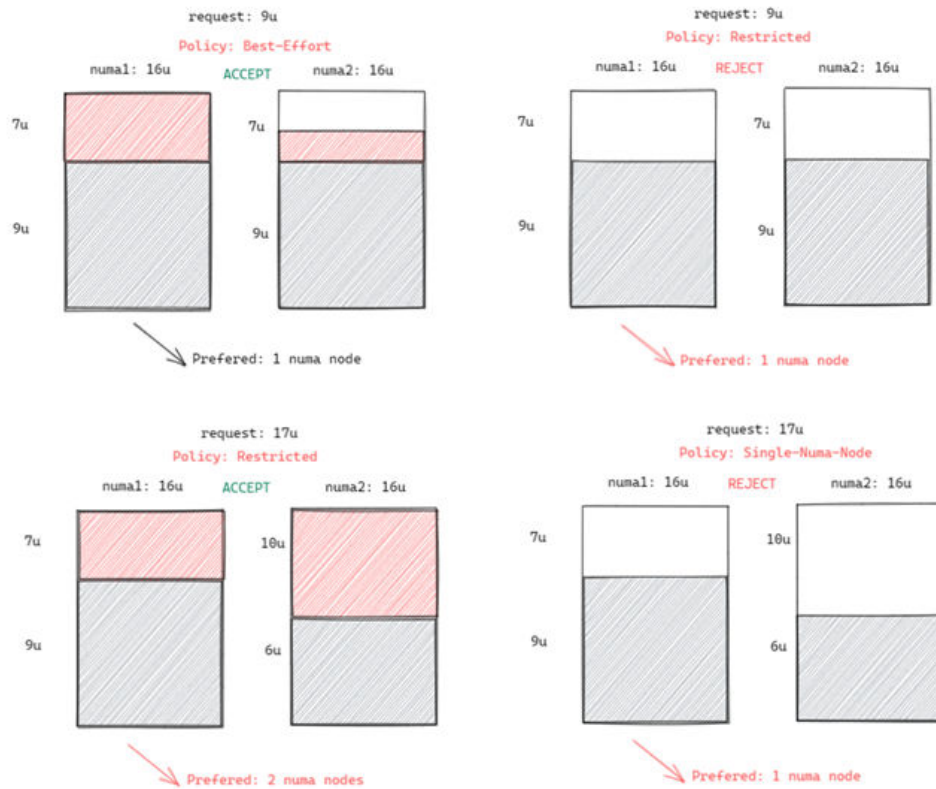
Worker Node	Node Topology Policy	Total CPU Cores on NUMA Node 1	Total CPU Cores on NUMA Node 2
Node 1	best-effort	16	16
Node 2	restricted	16	16
Node 3	restricted	16	16
Node 4	single-numa-node	16	16

Figure 10-5 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 both the 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 10-5 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:

$$\text{score} = \text{weight} \times (100 - 100 \times \text{numaNodeNum} / \text{maxNumaNodeNum})$$

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.

- $\text{score}(\text{Node A}) = 10 \times (100 - 100 \times 1/4) = 750$
- $\text{score}(\text{Node B}) = 10 \times (100 - 100 \times 2/4) = 500$
- $\text{score}(\text{Node C}) = 10 \times (100 - 100 \times 4/4) = 0$

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.

```
...
"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"
      }
    ]
  }
]
},
...

```

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-uma-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-uma-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.

10.5 Cloud Native Hybrid Deployment

10.5.1 Dynamic Resource Oversubscription

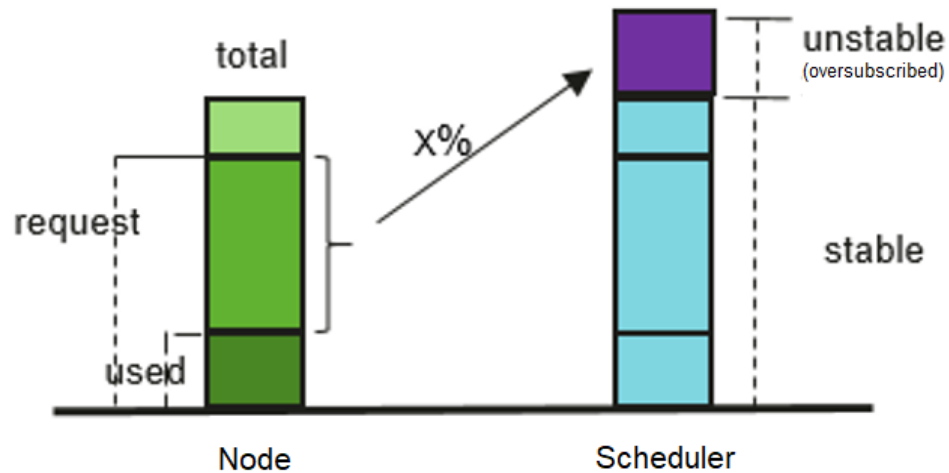
Many services see surges in traffic. To ensure performance and stability, resources are often requested at the maximum needed. However, the surges may ebb very shortly and resources, if not released, are wasted in non-peak hours. Especially for online jobs that request a large quantity of resources to ensure SLA, resource utilization can be as low as it gets.

Resource oversubscription is the process of making use of idle requested resources. Oversubscribed resources are suitable for deploying offline jobs, which focus on throughput but have low SLA requirements and can tolerate certain failures.

Hybrid deployment of online and offline jobs in a cluster can better utilize cluster resources.

Figure 10-6 Resource oversubscription

$$\text{Oversubscription} = (\text{request} - \text{used}) \times \text{Ratio}$$



Features

NOTE

After dynamic resource oversubscription and elastic scaling are enabled in a node pool, oversubscribed resources change rapidly because the resource usage of high-priority applications changes in real time. To prevent frequent node scale-ins and scale-outs, do not consider oversubscribed resources when evaluating node scale-ins.

Hybrid deployment is supported, and CPU and memory resources can be oversubscribed. The key features are as follows:

- Offline jobs preferentially run on oversubscribed nodes.
If both oversubscribed and non-oversubscribed nodes exist, the former will score higher than the latter and offline jobs are preferentially scheduled to oversubscribed nodes.
- Online jobs can use only non-oversubscribed resources if scheduled to an oversubscribed node.
Offline jobs can use both oversubscribed and non-oversubscribed resources of an oversubscribed node.
- In the same scheduling period, online jobs take precedence over offline jobs.
If both online and offline jobs exist, online jobs are scheduled first. When the node resource usage exceeds the upper limit and the node requests exceed 100%, offline jobs will be evicted.
- CPU/Memory resources can be isolation by kernel.
CPU isolation: Online jobs can quickly preempt CPU resources of offline jobs and suppress the CPU usage of the offline jobs.
Memory isolation: When system memory resources are used up and OOM Kill is triggered, the kernel evicts offline jobs first.
- kubelet offline jobs obey the following admission rules:

After the pod is scheduled to a node, kubelet starts the pod only when the node resources can meet the pod request (predicateAdmitHandler.Admit). kubelet starts the pod when both of the following conditions are met:

- The total request of pods to be started and online running jobs < allocatable nodes
- The total request of pods to be started and online/offline running job < allocatable nodes+oversubscribed nodes
- Resource oversubscription and hybrid deployment can be configured separately.

Enabling hybrid deployment of a node pool also enables oversubscription by default. Nodes are then labeled with both **volcano.sh/colocation="true"** and **volcano.sh/oversubscription="true"**. To use hybrid deployment for both online and offline jobs without oversubscription, simply disable oversubscription in hybrid deployment settings. This will remove the **volcano.sh/oversubscription="true"** label.

The following table lists the features that can be used after hybrid deployment or oversubscription is enabled.

Hybrid Deployment	Oversubscription	Oversubscription Resource	Scenario for Evicting Offline Pods
No	No	No	No
Yes	No	No	The actual resource usage of a node exceeds the upper limit.
No	Yes	Yes	The actual resource usage of a node exceeds the upper limit and the pod requests on the node exceed 100%.
Yes	Yes	Yes	The actual resource usage of a node exceeds the upper limit.

Compatible kubelet Oversubscription

NOTICE

Specifications

- Cluster version
 - v1.19: v1.19.16-r4 or later
 - v1.21: v1.21.7-r0 or later
 - v1.23: v1.23.5-r0 or later
 - v1.25 or later
- Cluster type: CCE standard
- Node OS: EulerOS 2.9 (kernel-4.18.0-147.5.1.6.h729.6.eulerosv2r9.x86_64)
- Node type: ECS
- Volcano version: 1.7.0 or later

Constraints

- Before enabling oversubscription, ensure that the overcommit add-on is not enabled on Volcano.
- Modifying the label of an oversubscribed node does not affect the running pods.
- Running pods cannot be converted between online and offline services. To convert services, rebuild pods.
- If the label **volcano.sh/oversubscription=true** is configured for a node in the cluster, the **oversubscription** configuration must be added to the Volcano add-on. Otherwise, the scheduling of oversold nodes will be abnormal. Ensure that you have correctly configured labels because the scheduler does not check the add-on and node configurations. For details, see [Table 10-8](#).
- To disable oversubscription, perform the following operations:
 - Remove the **volcano.sh/oversubscription** label from the oversubscribed node.
 - Set **over-subscription-resource** to **false**.
 - Modify the configmap of Volcano Scheduler named **volcano-scheduler-configmap** and remove the oversubscription add-on.
- If you have set **cpu-manager-policy** to statically bind CPU cores on a node, do not assign the QoS class of Guaranteed to offline pods. This is because offline pods may occupy the CPUs of online pods, leading to an online pod startup failure and offline pods failing to start even though they have been successfully scheduled. To prevent this, switch the pods to online pods if CPU core binding is required.
- If **cpu-manager-policy** is set to static CPU core binding on a node, do not bind CPU cores to all online pods. This is because doing so can cause online pods to occupy all available CPU or memory resources, leaving only a small number of oversubscribed resources.

If the label **volcano.sh/oversubscription=true** is configured for a node in the cluster, the **oversubscription** configuration must be added to the Volcano add-on.

Otherwise, the scheduling of oversold nodes will be abnormal. For details about the related configuration, see [Table 10-8](#).

Ensure that you have correctly configure labels because the scheduler does not check the add-on and node configurations.

Table 10-8 Configuring oversubscription labels for scheduling

Oversubscription in Add-on	Oversubscription Label on Node	Scheduling
Yes	Yes	Triggered by oversubscription
Yes	No	Triggered
No	No	Triggered
No	Yes	Not triggered or failed. Avoid this configuration.

Step 1 Use kubectl to access the cluster.

Step 2 Check the Volcano configuration.

```
kubectl edit cm volcano-scheduler-configmap -n kube-system
```

Check the oversubscription configuration in **volcano-scheduler-configmap**.

Ensure that the add-on configuration does not contain the overcommit add-on. If **- name: overcommit** exists, delete this configuration.

```
...
data:
  volcano-scheduler.conf: |
    actions: "allocate, backfill, preempt" # Configure a preemption action.
    tiers:
    - plugins:
      - name: gang
        enablePreemptable: false
        enableJobStarving: false
      - name: priority
      - name: conformance
      - name: oversubscription
    - plugins:
      - name: drf
      - name: predicates
      - name: nodeorder
      - name: binpack
    - plugins:
      - name: cce-gpu-topology-predicate
      - name: cce-gpu-topology-priority
      - name: cce-gpu
...

```

Step 3 Enable node oversubscription.

A label can be configured to use oversubscribed resources only after the oversubscription feature is enabled for a node. Related nodes can be created only in a node pool. To enable the oversubscription feature, perform the following steps:

1. Create a node pool.

2. Choose **Manage** in the **Operation** column of the created node pool.
3. On the **Manage Configurations** page, enable **Node oversubscription feature (over-subscription-resource)** and click **OK**.

Step 4 Set the node oversubscription label.

The **volcano.sh/oversubscription** label needs to be configured for an oversubscribed node. If this label is set for a node and the value is **true**, the node is an oversubscribed node. Otherwise, the node is not an oversubscribed node.

```
kubectl label node 192.168.0.0 volcano.sh/oversubscription=true
```

An oversubscribed node also supports the oversubscription thresholds, as listed in [Table 10-9](#). For example:

```
kubectl annotate node 192.168.0.0 volcano.sh/evicting-cpu-high-watermark=70
```

Querying the node information

```
# kubectl describe node 192.168.0.0
Name:          192.168.0.0
Roles:         <none>
Labels:        ...
               volcano.sh/oversubscription=true
Annotations:   ...
               volcano.sh/evicting-cpu-high-watermark: 70
```

Table 10-9 Node oversubscription annotations

Parameter	Description
volcano.sh/evicting-cpu-high-watermark	Upper limit for CPU usage. When the CPU usage of a node exceeds the specified value, offline job eviction is triggered and the node becomes unschedulable. The default value is 80 , indicating that offline job eviction is triggered when the CPU usage of a node exceeds 80%.
volcano.sh/evicting-cpu-low-watermark	Lower limit for CPU usage. When the CPU usage of a node is higher than the upper limit, offline jobs will be evicted. The node accepts the offline jobs again only when the CPU usage of the node is lower than the lower limit. The default value is 30 , indicating that offline jobs are accepted again when the CPU usage of a node is lower than 30%.
volcano.sh/evicting-memory-high-watermark	Upper limit for memory usage. When the memory usage of a node exceeds the specified value, offline job eviction is triggered and the node becomes unschedulable. The default value is 60 , indicating that offline job eviction is triggered when the memory usage of a node exceeds 60%.

Parameter	Description
volcano.sh/evicting-memory-low-watermark	Lower limit for memory usage. When the memory usage of a node is higher than the upper limit, offline jobs will be evicted. The node accepts the offline jobs again only when the memory usage of the node is lower than the lower limit. The default value is 30 , indicating that offline jobs are accepted again when the memory usage of a node is less than 30%.
volcano.sh/oversubscription-types	Oversubscribed resource type. Options: <ul style="list-style-type: none"> ● cpu: oversubscribed CPU ● memory: oversubscribed memory ● cpu,memory: oversubscribed CPU and memory The default value is cpu,memory .

Step 5 Create resources at a high- and low-priorityClass, respectively.

```
cat <<EOF | kubectl apply -f -
apiVersion: scheduling.k8s.io/v1
description: Used for high priority pods
kind: PriorityClass
metadata:
  name: volcano-production
preemptionPolicy: PreemptLowerPriority
value: 999999
---
apiVersion: scheduling.k8s.io/v1
description: Used for low priority pods
kind: PriorityClass
metadata:
  name: volcano-free
preemptionPolicy: PreemptLowerPriority
value: -90000
EOF
```

Step 6 Deploy online and offline jobs and configure priorityClasses for these jobs.

The **volcano.sh/qos-level** annotation needs to be added to distinguish offline jobs. The value is an integer ranging from -7 to 7. If the value is less than 0, the job is an offline job. If the value is greater than or equal to 0, the job is an online job. You do not need to set this annotation for online jobs. For both online and offline jobs, set **schedulerName** to **volcano** to enable Volcano.

 **NOTE**

The priorities between online jobs and between offline jobs are not differentiated, and the value validity is not verified. If the value of **volcano.sh/qos-level** of an offline job is not a negative integer ranging from -7 to 0, the job is processed as an online job.

For an offline job:

```
kind: Deployment
apiVersion: apps/v1
spec:
  replicas: 4
  template:
```

```

metadata:
  annotations:
    metrics.alpha.kubernetes.io/custom-endpoints: '[{"api":"","path":"","port":"","names":""}]'
    volcano.sh/qos-level: "-1" # Offline job annotation
  spec:
    schedulerName: volcano # Volcano is used.
    priorityClassName: volcano-free # volcano-free priorityClass
    ...

```

For an online job:

```

kind: Deployment
apiVersion: apps/v1
spec:
  replicas: 4
  template:
    metadata:
      annotations:
        metrics.alpha.kubernetes.io/custom-endpoints: '[{"api":"","path":"","port":"","names":""}]'
    spec:
      schedulerName: volcano # Volcano is used.
      priorityClassName: volcano-production # volcano-production priorityClass
      ...

```

Step 7 Run the following command to check the number of oversubscribed resources and the resource usage:

```
kubectl describe node <nodeIP>
```

```

# kubectl describe node 192.168.0.0
Name:          192.168.0.0
Roles:        <none>
Labels:       ...
              volcano.sh/oversubscription=true
Annotations:  ...
              volcano.sh/oversubscription-cpu: 2335
              volcano.sh/oversubscription-memory: 341753856
Allocatable:
  cpu:          3920m
  memory:       6263988Ki
Allocated resources:
(Total limits may be over 100 percent, i.e., overcommitted.)
Resource       Requests      Limits
-----
cpu            4950m (126%)  4950m (126%)
memory        1712Mi (27%) 1712Mi (27%)

```

In the preceding command, CPU and memory are in the unit of m CPU cores and MiB, respectively.

----End

Deployment Example

The following uses an example to describe how to deploy online and offline jobs in hybrid mode.

Step 1 Configure a cluster with two nodes, one oversubscribed and the other non-oversubscribed.

```

# kubectl get node
NAME          STATUS  ROLES  AGE  VERSION
192.168.0.173 Ready  <none> 4h58m v1.19.16-r2-CCE22.5.1
192.168.0.3   Ready  <none> 148m  v1.19.16-r2-CCE22.5.1

```

- 192.168.0.173 is an oversubscribed node (with the **volcano.sh/oversubscription=true** label).

- 192.168.0.3 is a non-oversubscribed node (without the **volcano.sh/oversubscription=true** label).

```
# kubectl describe node 192.168.0.173
Name:          192.168.0.173
Roles:        <none>
Labels:       beta.kubernetes.io/arch=amd64
              ...
              volcano.sh/oversubscription=true
```

- Step 2** Submit offline job creation requests. If resources are sufficient, all offline jobs will be scheduled to the oversubscribed node.

The offline job template is as follows:

```
apiVersion: apps/v1
kind: Deployment
metadata:
  name: offline
  namespace: default
spec:
  replicas: 2
  selector:
    matchLabels:
      app: offline
  template:
    metadata:
      labels:
        app: offline
      annotations:
        volcano.sh/qos-level: "-1" # Offline job label
    spec:
      schedulerName: volcano # Volcano is used.
      priorityClassName: volcano-free # volcano-free priorityClass
      containers:
        - name: container-1
          image: nginx:latest
          imagePullPolicy: IfNotPresent
          resources:
            requests:
              cpu: 500m
              memory: 512Mi
            limits:
              cpu: "1"
              memory: 512Mi
          imagePullSecrets:
            - name: default-secret
```

Offline jobs are scheduled to the oversubscribed node.

```
# kubectl get pod -o wide
NAME                READY STATUS RESTARTS AGE IP          NODE
offline-69cdd49bf4-pmjp8 1/1 Running 0      5s 192.168.10.178 192.168.0.173
offline-69cdd49bf4-z8kxh 1/1 Running 0      5s 192.168.10.131 192.168.0.173
```

- Step 3** Submit online job creation requests. If resources are sufficient, the online jobs will be scheduled to the non-oversubscribed node.

The online job template is as follows:

```
apiVersion: apps/v1
kind: Deployment
metadata:
  name: online
  namespace: default
spec:
  replicas: 2
  selector:
    matchLabels:
      app: online
  template:
    metadata:
```

```

labels:
  app: online
spec:
  schedulerName: volcano          # Volcano is used.
  priorityClassName: volcano-production # volcano-production priorityClass
  containers:
  - name: container-1
    image: resource_consumer:latest
    imagePullPolicy: IfNotPresent
    resources:
      requests:
        cpu: 1400m
        memory: 512Mi
      limits:
        cpu: "2"
        memory: 512Mi
    imagePullSecrets:
    - name: default-secret

```

Online jobs are scheduled to the non-oversubscribed node.

```

# kubectl get pod -o wide
NAME          READY STATUS RESTARTS AGE IP          NODE
online-ffb46f656-4mwr6 1/1   Running 0      5s 192.168.10.146 192.168.0.3
online-ffb46f656-dqdv2 1/1   Running 0      5s 192.168.10.67 192.168.0.3

```

Step 4 Improve the resource usage of the oversubscribed node and observe whether offline job eviction is triggered.

Deploy online jobs to the oversubscribed node (192.168.0.173).

```

apiVersion: apps/v1
kind: Deployment
metadata:
  name: online
  namespace: default
spec:
  replicas: 2
  selector:
    matchLabels:
      app: online
  template:
    metadata:
      labels:
        app: online
    spec:
      affinity:
        nodeAffinity:
          requiredDuringSchedulingIgnoredDuringExecution:
            nodeSelectorTerms:
            - matchExpressions:
              - key: kubernetes.io/hostname
                operator: In
                values:
                - 192.168.0.173
      schedulerName: volcano          # Volcano is used.
      priorityClassName: volcano-production # volcano-production priorityClass
      containers:
      - name: container-1
        image: resource_consumer:latest
        imagePullPolicy: IfNotPresent
        resources:
          requests:
            cpu: 700m
            memory: 512Mi
          limits:
            cpu: 700m
            memory: 512Mi
        imagePullSecrets:
        - name: default-secret

```

Submit the online or offline jobs to the oversubscribed node (192.168.0.173) at the same time.

```
# kubectl get pod -o wide
NAME                READY STATUS RESTARTS AGE IP          NODE
offline-69cdd49bf4-pmjp8 1/1 Running 0      13m 192.168.10.178 192.168.0.173
offline-69cdd49bf4-z8kxh 1/1 Running 0      13m 192.168.10.131 192.168.0.173
online-6f44bb68bd-b8z9p 1/1 Running 0      3m4s 192.168.10.18 192.168.0.173
online-6f44bb68bd-g6xk8 1/1 Running 0      3m12s 192.168.10.69 192.168.0.173
```

Check the oversubscribed node with IP address 192.168.0.173. It is found that resources are oversubscribed, where there are 2343m CPU cores and 3073653200 MiB of memory. Additionally, the CPU allocation rate exceeded 100%.

```
# kubectl describe node 192.168.0.173
Name:                192.168.0.173
Roles:               <none>
Labels:              ...
                    volcano.sh/oversubscription=true
Annotations:         ...
                    volcano.sh/oversubscription-cpu: 2343
                    volcano.sh/oversubscription-memory: 3073653200
                    ...
Allocated resources:
(Total limits may be over 100 percent, i.e., overcommitted.)
Resource            Requests    Limits
-----
cpu                  4750m (121%) 7350m (187%)
memory               3760Mi (61%) 4660Mi (76%)
...

```

Increase the CPU usage of online jobs on the node. Offline job eviction is triggered.

```
# kubectl get pod -o wide
NAME                READY STATUS RESTARTS AGE IP          NODE
offline-69cdd49bf4-bwdm7 1/1 Running 0      11m 192.168.10.208 192.168.0.3
offline-69cdd49bf4-pmjp8 0/1 Evicted 0      26m <none>         192.168.0.173
offline-69cdd49bf4-qpdss 1/1 Running 0      11m 192.168.10.174 192.168.0.3
offline-69cdd49bf4-z8kxh 0/1 Evicted 0      26m <none>         192.168.0.173
online-6f44bb68bd-b8z9p 1/1 Running 0      24m 192.168.10.18 192.168.0.173
online-6f44bb68bd-g6xk8 1/1 Running 0      24m 192.168.10.69 192.168.0.173
```

----End

Handling Suggestions

- After kubelet of the oversubscribed node is restarted, the resource view of Volcano Scheduler is not synchronized with that of kubelet. As a result, OutOfCPU occurs in some newly scheduled jobs, which is normal. After a period of time, Volcano Scheduler can properly schedule online and offline jobs.
- After online and offline jobs are submitted, you are not advised to dynamically change the job type (adding or deleting annotation volcano.sh/qos-level: "-1") because the current kernel does not support the change of an offline job to an online job.
- CCE collects the resource usage (CPU/memory) of all pods running on a node based on the status information in the cgroups system. The resource usage may be different from the monitored resource usage, for example, the resource statistics displayed by running the **top** command.
- You can add oversubscribed resources (such as CPU and memory) at any time. You can reduce the oversubscribed resource types only when the resource allocation rate does not exceed 100%.

- If an offline job is deployed on a node ahead of an online job and the online job cannot be scheduled due to insufficient resources, configure a higher `priorityClass` for the online job than that for the offline job.
- If there are only online jobs on a node and the eviction threshold is reached, the offline jobs that are scheduled to the current node will be evicted soon. This is normal.

11 Network

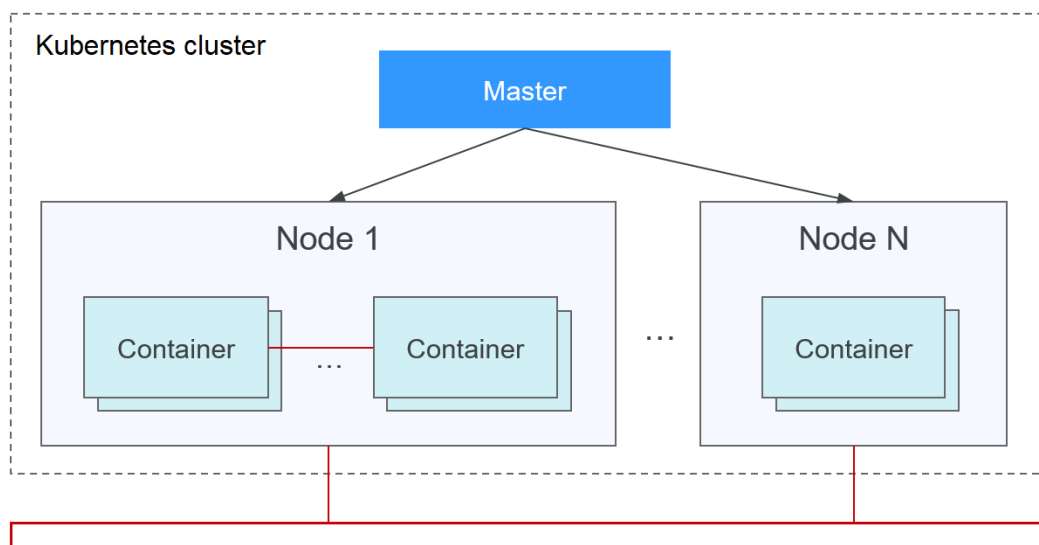
11.1 Overview

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 pods 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 model seamlessly combines VPC routing with the underlying network, making it ideal for high-performance scenarios. However, the maximum number of nodes allowed in a cluster is determined by the VPC route quota. Each node is assigned a CIDR block of a fixed size. The VPC network model outperforms the container tunnel network model in terms of performance because it does not have tunnel encapsulation overhead. 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](#).

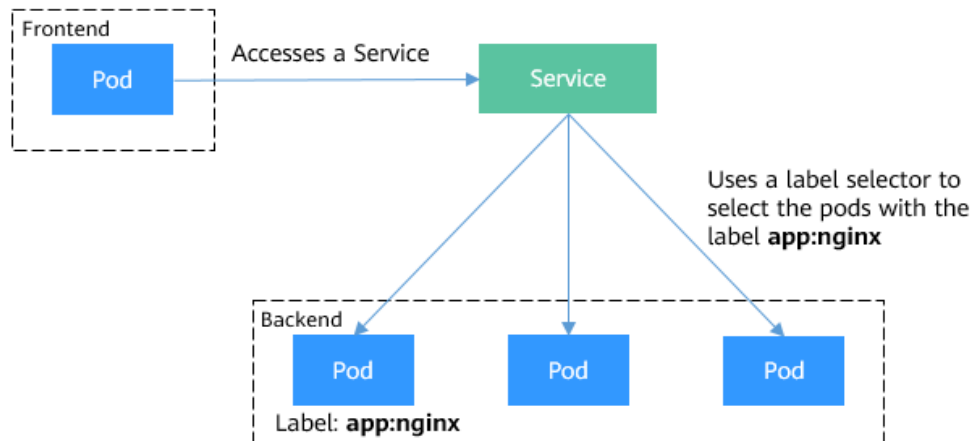
- **Service Network**

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 11-1 Accessing pods through a Service



You can configure the following types of Services:

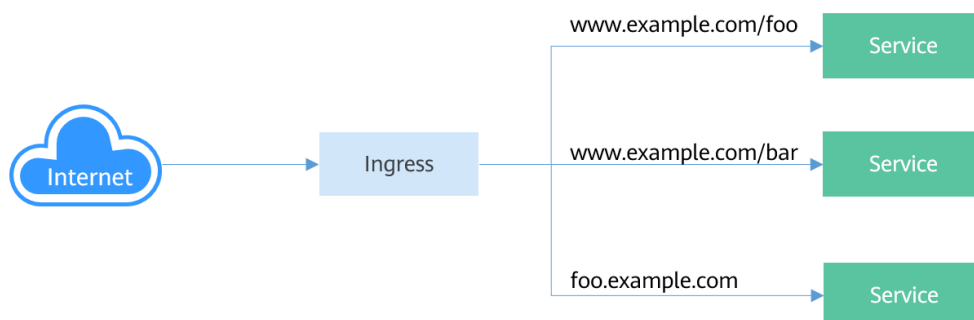
- ClusterIP: used to make the Service only reachable from within a cluster.
- NodePort: used for access from outside a cluster. A NodePort Service is accessed through the port on the node.
- LoadBalancer: used for access from outside a cluster. It is an extension of NodePort, to which a load balancer routes, and external systems only need to access the load balancer.

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 11-2 Ingress and Service



For details about the ingress, see [Overview](#).

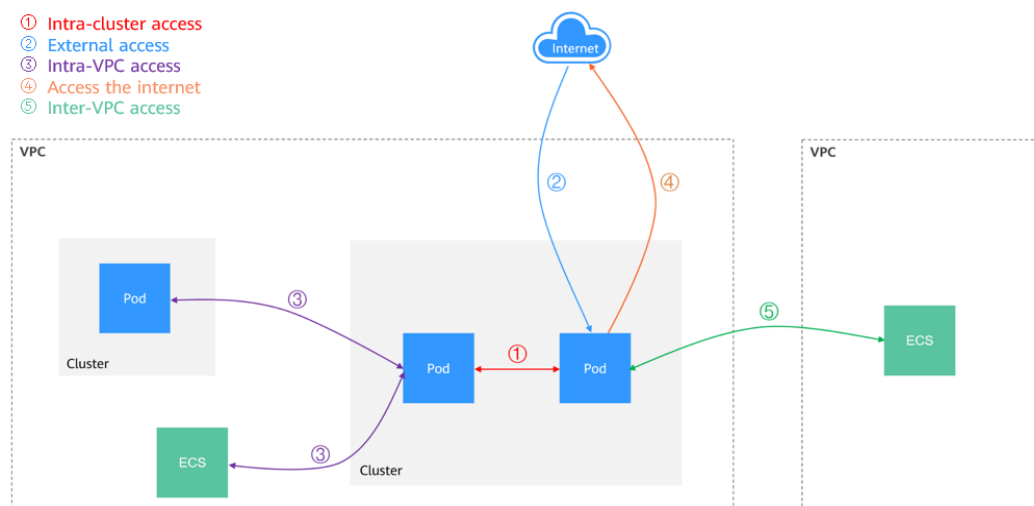
Access Scenarios

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 11-3 Network access diagram



11.2 Container Network

11.2.1 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:

- [VPC network](#)
- [Tunnel network](#)

Network Model Comparison

[Table 11-1](#) describes the differences of network models supported by CCE.

 CAUTION

After a cluster is created, the network model cannot be changed.

Table 11-1 Network model comparison

Dimension	Tunnel Network	VPC Network
Application scenarios	<ul style="list-style-type: none"> • 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. 	<ul style="list-style-type: none"> • 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.
Core technology	OVS	IPvlan and VPC route
Applicable clusters	CCE standard cluster	CCE standard cluster

Dimension	Tunnel Network	VPC Network
Container network isolation	Kubernetes native NetworkPolicy for pods	No
Interconnecting pods to a load balancer	Interconnected through a NodePort	Interconnected through a NodePort
Managing container IP addresses	<ul style="list-style-type: none"> Separate container CIDR blocks needed Container CIDR blocks divided by node and dynamically added after being allocated 	<ul style="list-style-type: none"> Separate container CIDR blocks needed Container CIDR blocks divided by node and statically allocated (the allocated CIDR blocks cannot be changed after a node is created)
Network performance	Performance loss due to VXLAN encapsulation	No tunnel encapsulation, and cross-node traffic forwarded through VPC routers (The performance is so good that is comparable to that of the host network, but there is a loss caused by NAT.)
Networking scale	A maximum of 2000 nodes are supported.	<p>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.</p> <p>Each time a node is added to the cluster, a route is added to the VPC routing tables. Evaluate the cluster scale that is limited by the VPC routing tables before creating the cluster.</p>

11.2.2 VPC Network Settings

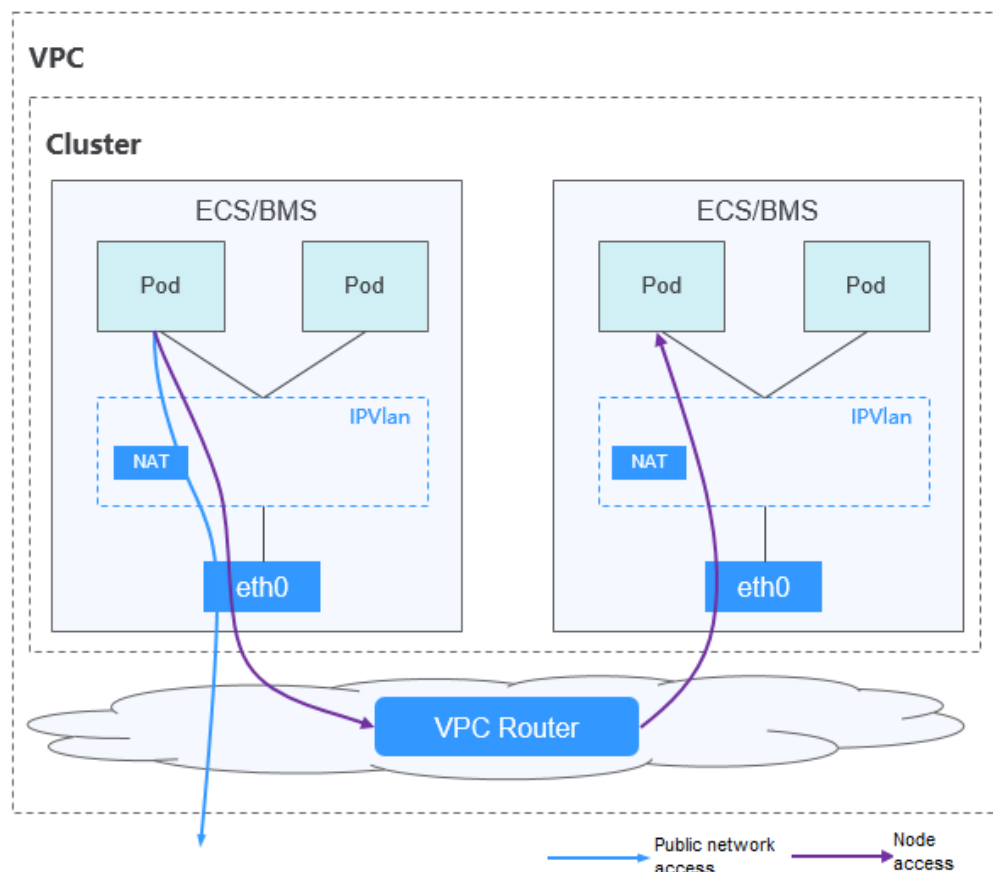
11.2.2.1 VPC Network Model

Model Definition

The VPC network model seamlessly combines VPC routing with the underlying network, making it ideal for high-performance scenarios. However, the maximum number of nodes allowed in a cluster is determined by the VPC route quota. In the

VPC network model, container CIDR blocks are separate from node CIDR blocks. To allocate IP addresses to containers running on a node in a cluster, each node in the cluster is allocated with a container CIDR block for a fixed number of IP addresses. The VPC network model outperforms the container tunnel network model in terms of performance because it does not have tunnel encapsulation overhead. When using the VPC network model in a cluster, the VPC routing table automatically configures the routes between container CIDR blocks and VPC CIDR blocks. This means that pods within the cluster can be accessed directly from cloud servers in the same VPC, even if they are outside the cluster.

Figure 11-4 VPC network model



In a cluster using the VPC network model, network communication paths are as follows:

- Inter-pod communication on the same node: Packets are directly forwarded through IPVlan.
- Inter-pod communication on different nodes: The traffic accesses the default gateway by following the route specified in the VPC routing table and then is forwarded to the target pod on another node using VPC routing.
- Pod communication outside a cluster: When a container in a cluster needs to access a network outside of the cluster, CCE uses NAT to translate the container's IP address into the node IP address so that the pod communicates externally using the node IP address.

Advantages and Disadvantages

Advantages

- High performance and simplified network fault locating are achieved by eliminating the need for tunnel encapsulation.
- A VPC routing table automatically configures routes between container CIDR blocks and VPC CIDR blocks. This enables resources in the VPC to directly communicate with containers in the cluster.

NOTE

Similarly, if the VPC is accessible to other VPCs or data centers and the VPC routing table includes routes to the container CIDR blocks, resources in other VPCs or data centers can directly communicate with containers in the cluster, provided there are no conflicts between the network CIDR blocks.

Disadvantages

- The number of nodes is limited by the VPC route quota.
- Each node is assigned a CIDR block with a fixed size, which results in IP address wastage in the container CIDR block.
- Pods cannot directly use features like EIPs and security groups.

Application Scenarios

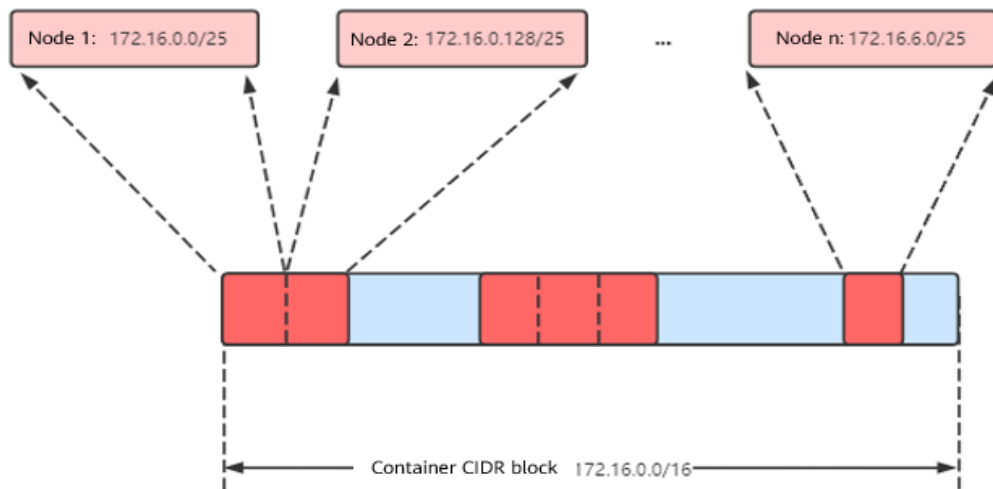
- High performance requirements: As no tunnel encapsulation is required, the VPC network model delivers the performance close to that of a VPC network when compared with the container tunnel network model. Therefore, the VPC network model applies to scenarios that have high requirements on performance, 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 model assigns container IP addresses based on the following guidelines:

- Container CIDR blocks are separate from node CIDR blocks.
- IP addresses are allocated by node. One CIDR block with a fixed size (configurable) is allocated to each node in a cluster from the container CIDR block.
- A container CIDR block assigns CIDR blocks to new nodes in a cyclical sequence.
- IP addresses from the CIDR blocks assigned to a node are allocated to pods scheduled to that node in a cyclical manner.

Figure 11-5 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 a 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. The number of nodes that can be added to a cluster is also determined by the available IP addresses in the node subnet and the scale of the cluster. For details, see [Recommendation for CIDR Block Planning](#).

Recommendation for CIDR Block Planning

As explained in [Cluster Network Structure](#), network addresses in a cluster are divided into the cluster network, container network, and service network. When planning network addresses, consider the following factors:

- **The three CIDR blocks cannot overlap.** Otherwise, a conflict occurs.
- Ensure that **each CIDR block has sufficient IP addresses.**
 - The IP addresses in the cluster 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 subnet must be greater than 200. Otherwise, nodes cannot be created due to insufficient IP addresses.

The container CIDR block is 172.16.0.0/16, 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 a 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.

Example of VPC Network Access

In this example, a cluster using the VPC network model is created, and the cluster contains one node.

On the VPC console, locate the VPC to which the cluster belongs and check the VPC routing table.

You can find that CCE has created a custom route in the routing table. This route has a destination address corresponding to the container CIDR block assigned to the node, and the next hop is directed towards the target node. In the example, the container CIDR block for the cluster is 172.16.0.0/16, with 128 container IP addresses assigned to each node. Therefore, the node's container CIDR block is 172.16.0.0/25, providing a total of 128 container IP addresses.

When a container IP address is accessed, the VPC route will forward the traffic to the next-hop node that corresponds to the destination address. The following is an example:

Step 1 Use `kubectl` to access the cluster. For details, see [Connecting to a Cluster Using kubectl](#).

Step 2 Create a Deployment in the cluster.

Create the `deployment.yaml` file. The following shows an example:

```
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
```

Create the workload.

```
kubectl apply -f deployment.yaml
```

Step 3 Check the running pods.

```
kubectl get pod -owide
```

Command output:

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-x8k5 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>
```

Step 4 Use a cloud server in the same VPC to directly access a pod's IP address from outside the cluster. You can also access a pod using its IP address within the pod or from a node in the cluster. In the following example, access a pod's IP address within the pod. *example-86b9779494-l8qrw* is the pod name, and *172.16.0.7* is the pod IP address.

```
kubectl exec -it example-86b9779494-l8qrw -- curl 172.16.0.7
```

If the following information is displayed, the workload can be properly accessed:

```
<!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

11.2.2.2 Adding a Container CIDR Block for a Cluster

Scenario

If the container CIDR block configured during CCE cluster creation cannot meet service expansion requirements, you can add a container CIDR block for the cluster.


Notes and Constraints

- This function is available only for clusters of v1.19 or later using a VPC network.
- An added container CIDR block cannot be deleted.

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

11.2.3 Tunnel Network Settings

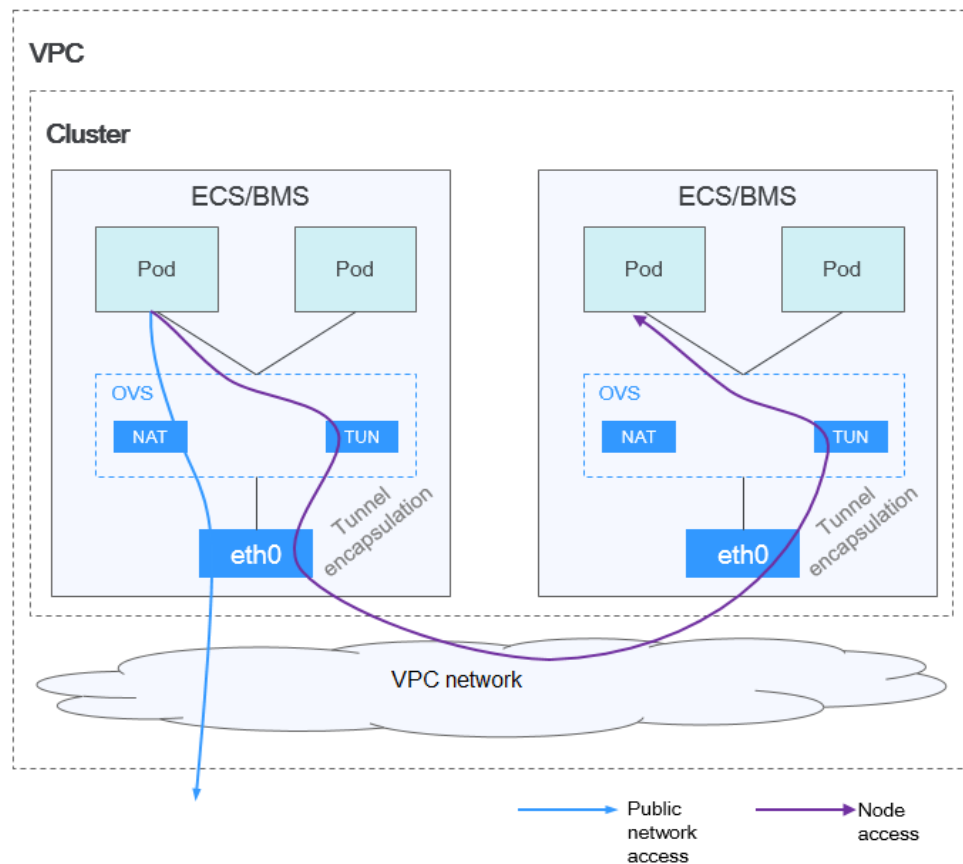
11.2.3.1 Tunnel Network Model

Model Definition

A container tunnel network creates a separate network plane for containers by using tunnel encapsulation on the host network plane. The container tunnel network of a CCE cluster uses VXLAN for tunnel encapsulation and Open vSwitch as the virtual switch backend. VXLAN is a protocol that encapsulates Ethernet packets into UDP packets to transmit them through tunnels. Open vSwitch is an open-source virtual switch software that provides functions such as network isolation and data forwarding.

While there may be some performance costs, packet encapsulation and tunnel transmission allow for greater interoperability and compatibility with advanced features, such as network policy-based isolation, in most common scenarios.

Figure 11-6 Container tunnel network



In a cluster using the container tunnel model, the communication paths between pods on the same node and between pods on different nodes are different.

- Inter-pod communication on the same node: Packets are directly forwarded via the OVS bridge on the node.
- Inter-pod communication on different nodes: Packets are encapsulated in the OVS bridge and then forwarded to the target pod on the peer node through the host NIC.

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 ENIs, and creation speed).
- Network isolation is supported. For details, see [Configuring Network Policies to Restrict Pod Access](#).
- Bandwidth limits are supported.
- Large-scale networking with a maximum of 2000 nodes is supported.

Disadvantages

- High encapsulation overhead results in poor performance and makes it difficult to locate network faults.

- Pods cannot directly use features like EIPs and security groups.
- Container IP addresses cannot be directly accessed by external networks.

Application Scenarios

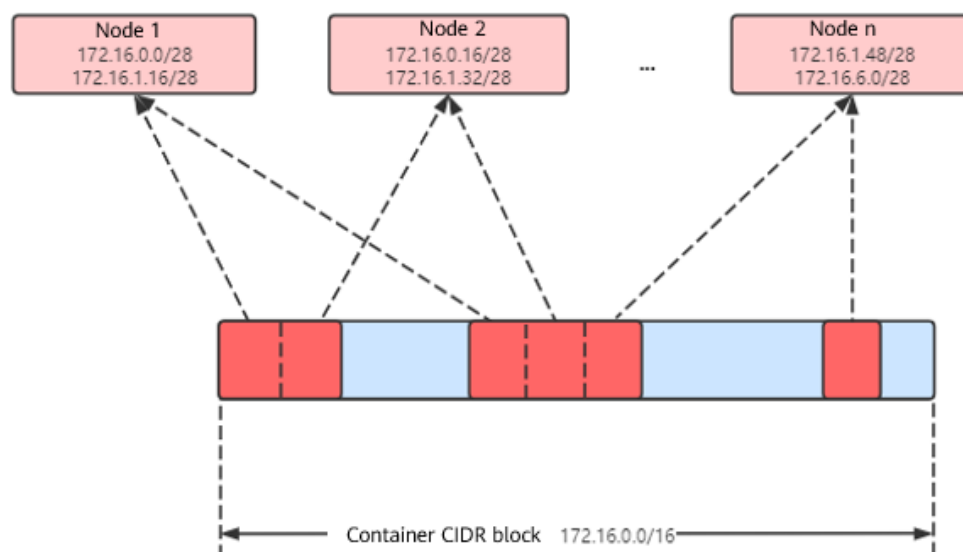
- Low requirements on performance: As the container tunnel network requires additional VXLAN tunnel encapsulation, it has about 5% to 15% of performance loss when compared with the other two container network models. Therefore, the container tunnel network applies to the scenarios that do not have high performance requirements, such as web applications, and middle-end and back-end services with a small number of access requests.
- Large-scale networking: Different from the VPC network that is limited by the VPC route quota, the container tunnel network does not have any restriction 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:

- Container CIDR blocks are separate from node CIDR blocks.
- 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.
- A container CIDR block assigns CIDR blocks to new nodes or existing nodes in a cyclical sequence.
- IP addresses from one or more CIDR blocks assigned to a node are allocated to pods scheduled to that node in a cyclical manner.

Figure 11-7 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. The mask of the container CIDR block allocated to a node is 28. That is, a total of 16 container IP addresses are allocated each time. Therefore, a maximum of 4096 (65536/16) nodes can be created. This is an extreme case. If 4096 nodes are created, a maximum of 16 pods can be created for each node because only a CIDR block with 16 IP addresses is allocated to each node. The number of nodes that can be added to a cluster is also determined by the available IP addresses in the node subnet and the scale of the cluster.

Recommendation for CIDR Block Planning

As explained in [Cluster Network Structure](#), network addresses in a cluster are divided into the cluster network, container network, and service network. When planning network addresses, consider the following factors:

- **The three CIDR blocks cannot overlap.** Otherwise, a conflict occurs.
- Ensure that **each CIDR block has sufficient IP addresses.**
 - The IP addresses in the cluster 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

The following is an example of creating a workload in a cluster using the container tunnel network model:

Step 1 Use `kubectl` to access the cluster. For details, see [Connecting to a Cluster Using kubectl](#).

Step 2 Create a Deployment in the cluster.

Create the `deployment.yaml` file. The following shows an example:

```
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
```

Create the workload.

```
kubectl apply -f deployment.yaml
```

Step 3 Check the running pods.

```
kubectl get pod -owide
```

Command output:

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>
example-5bdc5699b7-984j9	1/1	Running	0	3m28s	10.0.0.21	192.168.0.42	<none>
example-5bdc5699b7-lfxkm	1/1	Running	0	3m28s	10.0.0.22	192.168.0.42	<none>
example-5bdc5699b7-wjcmg	1/1	Running	0	3m28s	10.0.0.52	192.168.0.64	<none>

Step 4 Use a cloud server in the same VPC to directly access a pod's IP address from outside the cluster. The access failed.

You can access a pod using its IP address within the pod or from a node in the cluster. In the following example, access a pod's IP address within the pod.

example-5bdc5699b7-5rvq4 is the pod name, and *10.0.0.21* is the pod IP address.

```
kubectl exec -it example-5bdc5699b7-5rvq4 -- curl 10.0.0.21
```

If the following information is displayed, the workload can be properly accessed:

```
<!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

11.2.3.2 Configuring Network Policies to Restrict Pod Access

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. (Only egress rules support IP blocks.)

Notes and 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: Only the following OSs and cluster versions support egress rules.

OS	Cluster Version	Verified Kernel Version
CentOS	v1.23 or later	3.10.0-1062.18.1.el7.x86_64 3.10.0-1127.19.1.el7.x86_64 3.10.0-1160.25.1.el7.x86_64
EulerOS 2.5	v1.23 or later	3.10.0-862.14.1.5.h591.eulerosv2r7.x86_64 3.10.0-862.14.1.5.h687.eulerosv2r7.x86_64
EulerOS 2.9	v1.23 or later	4.18.0-147.5.1.6.h541.eulerosv2r9.x86_64 4.18.0-147.5.1.6.h766.eulerosv2r9.x86_64 4.18.0-147.5.1.6.h998.eulerosv2r9.x86_64 4.18.0-147.5.1.6.h1305.eulerosv2r9.x86_64

- Network isolation is not supported for IPv6 addresses.
- If upgrade to a cluster version that supports egress rules is performed in in-place mode, you cannot use egress rules because the node OS is not upgraded. In this case, reset the node.

Using Ingress Rules

- **Using podSelector to specify the access scope**

```
apiVersion: networking.k8s.io/v1
kind: NetworkPolicy
metadata:
  name: test-network-policy
```

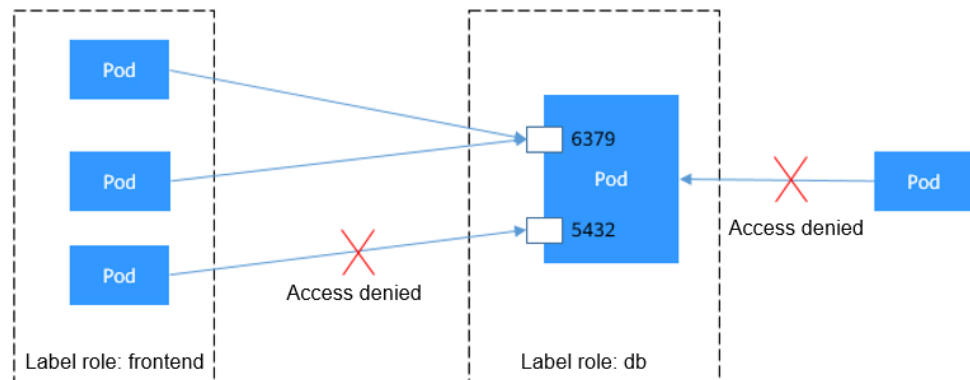


```

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 11-8 podSelector



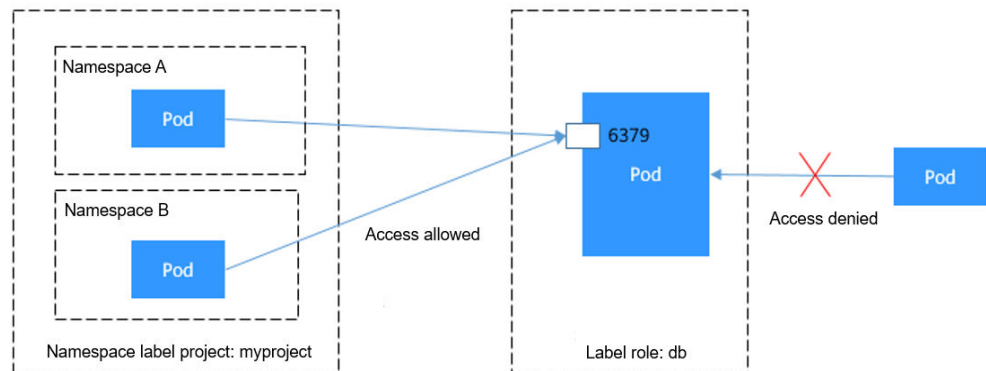
- **Using namespaceSelector to specify the access scope**

```

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 11-9 namespaceSelector



Using Egress Rules

Egress supports not only podSelector and namespaceSelector, but also ipBlock.

NOTE

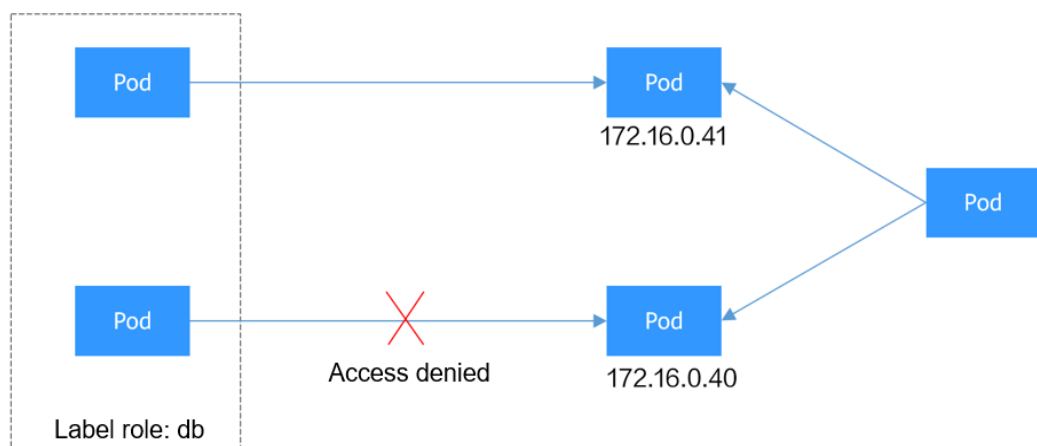
Only clusters of version 1.23 or later support Egress rules. Only nodes running EulerOS 2.5, EulerOS 2.9, or CentOS 7.X are supported.

```

apiVersion: networking.k8s.io/v1
kind: NetworkPolicy
metadata:
  name: deny-client-a-via-except-cidr-egress-rule
  namespace: default
spec:
  policyTypes:
    - Egress # Must be specified for an egress rule.
  podSelector:
    matchLabels:
      role: db # The rule takes effect for pods with the role=db label.
  egress:
    - to:
      - ipBlock:
          cidr: 172.16.0.16/16 # Allow access to this CIDR block.
          except:
            - 172.16.0.40/32 # This CIDR block cannot be accessed. This value must fall within the range specified by cidr.
    
```

The following figure shows how ipBlock works.

Figure 11-10 ipBlock



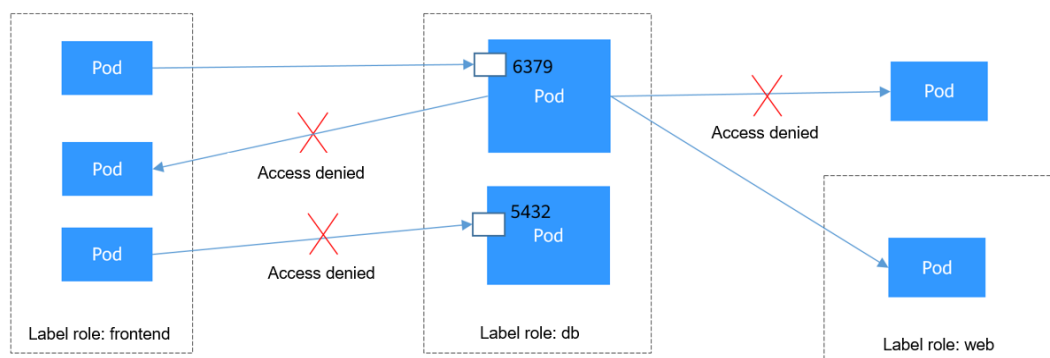
You can define ingress and egress in the same rule.

```

apiVersion: networking.k8s.io/v1
kind: NetworkPolicy
metadata:
  name: test-network-policy
  namespace: default
spec:
  policyTypes:
    - Ingress
    - Egress
  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
  egress:               # Egress rule
    - to:
      - podSelector:     # Only pods with the role=web label can be accessed.
        matchLabels:
          role: web
  
```

The following figure shows how to use ingress and egress together.

Figure 11-11 Using both ingress and egress



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 11-2](#).

Table 11-2 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 Click **OK**.

----End

11.2.4 Pod Network Settings

11.2.4.1 Configuring hostNetwork for Pods

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 a specific application must use a specific port on the host.

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()
```

11.2.4.2 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.

Notes and 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.

11.3 Service

11.3.1 Overview

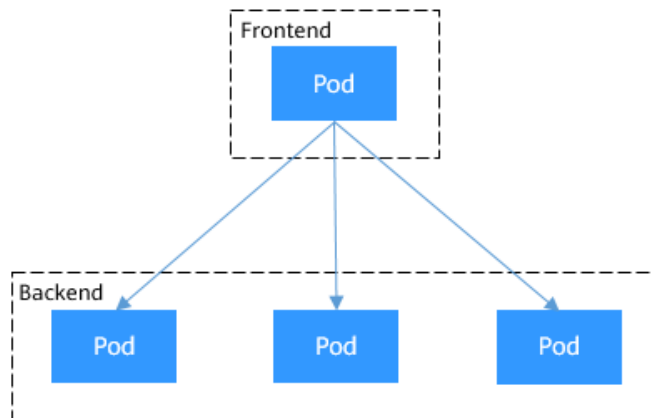
Direct Access to a Pod

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 11-12**. 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 11-12 Inter-pod access

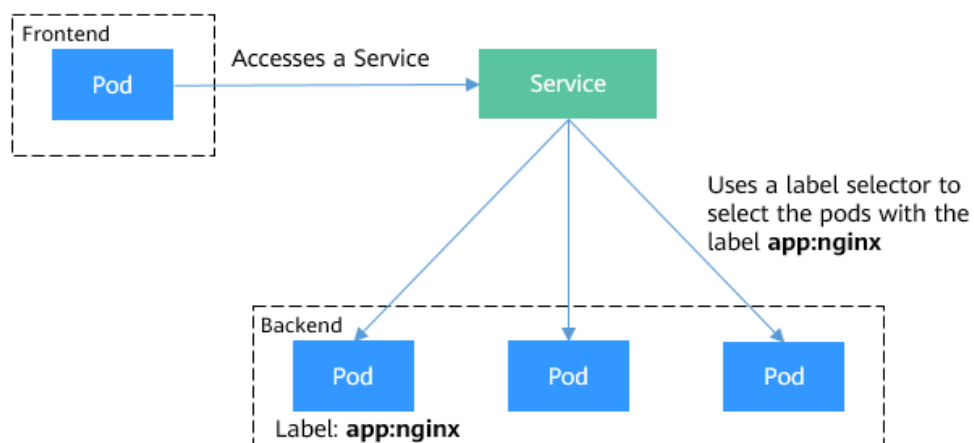


Using Services for Pod Access

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 11-13**.

Figure 11-13 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.

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 11-3 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 needs 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.
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	<p>Access the IP address and NodePort on the node where the server is located: The access is successful.</p> <p>Access the IP address and NodePort on a node other than the node where the server is located: The access failed.</p>	<p>Access the IP address and NodePort on the node where the server is located: The access is successful.</p> <p>Access the IP address and NodePort on a node other than the node where the server is located: The access failed.</p>	<p>Access the IP address and NodePort on the node where the server is located: The access is successful.</p> <p>Access the IP address and NodePort on a node other than the node where the server is located: The access failed.</p>	<p>Access the IP address and NodePort on the node where the server is located: The access is successful.</p> <p>Access the IP address and NodePort on a node other than the node where the server is located: The access failed.</p>

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	<p>Access the IP address and NodePort on the node where the server is located: The access is successful.</p> <p>Access the IP address and NodePort on a node other than the node where the server is located: The access failed.</p>	<p>Access the IP address and NodePort on the node where the server is located: The access is successful.</p> <p>Access the IP address and NodePort on a node other than the node where the server is located: The access failed.</p>	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	<p>Access the IP address and NodePort on the node where the server is located: The access is successful.</p> <p>Access the IP address and NodePort on a node other than the node where the server is located: The access failed.</p>	The access failed.	<p>Access the IP address and NodePort on the node where the server is located: The access is successful.</p> <p>Access the IP address and NodePort on a node other than the node where the server is located: The access failed.</p>	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.
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 [Configuring Passthrough Networking for a LoadBalancer Service](#).

NOTE

- In a CCE standard cluster, after passthrough networking is configured for a dedicated load balancer, the private IP address of the load balancer cannot be accessed from the node where the workload pod resides or other containers on the same node as the workload.
- Passthrough networking is not supported for clusters of v1.15 or earlier.
- In IPVS network mode, the passthrough settings of Services connected to the same load balancer must be the same.
- If node-level (local) service affinity is used, **kubernetes.io/elb.pass-through** is automatically set to **onlyLocal** to enable pass-through.

```
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
```

11.3.2 ClusterIP

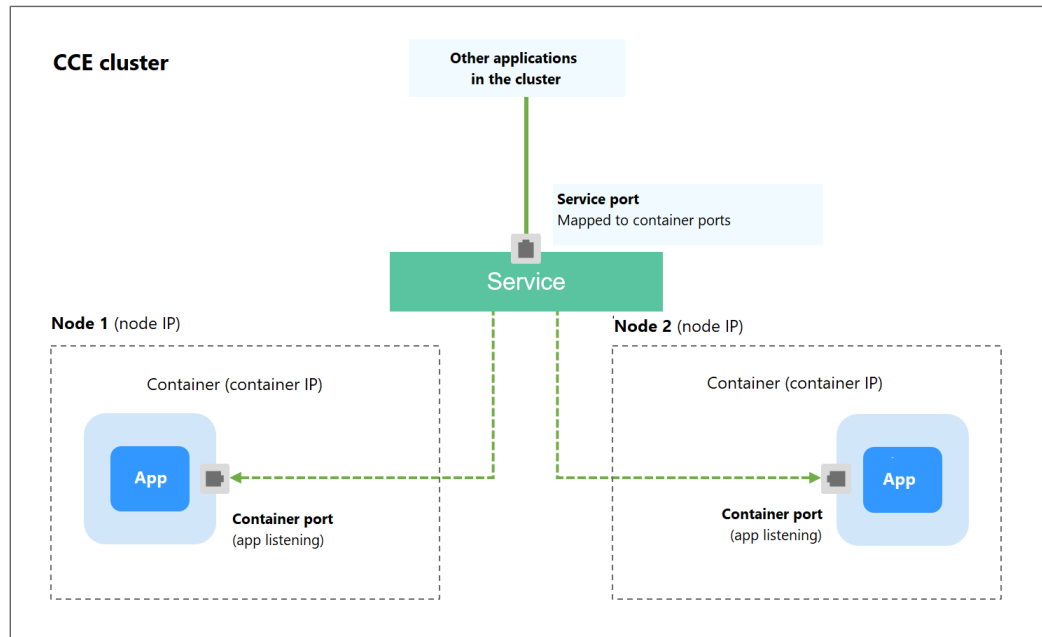
Scenario

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 11-14 shows the mapping relationships between access channels, container ports, and access ports.

Figure 11-14 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 that the workload belongs to.
- **Selector:** Add a label and click **Confirm**. The Service will use this label to select pods. 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**.
- **Ports**
 - **Protocol:** protocol used by the Service.
 - **Service Port:** port used by the Service. The port number ranges from 1 to 65535.
 - **Container Port:** listener port of the workload. For example, Nginx uses port 80 by default.

Step 4 Click **OK**.

----End

Setting the Access Type Using kubectl

You can configure Service access 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 access 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 the 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>
...

```

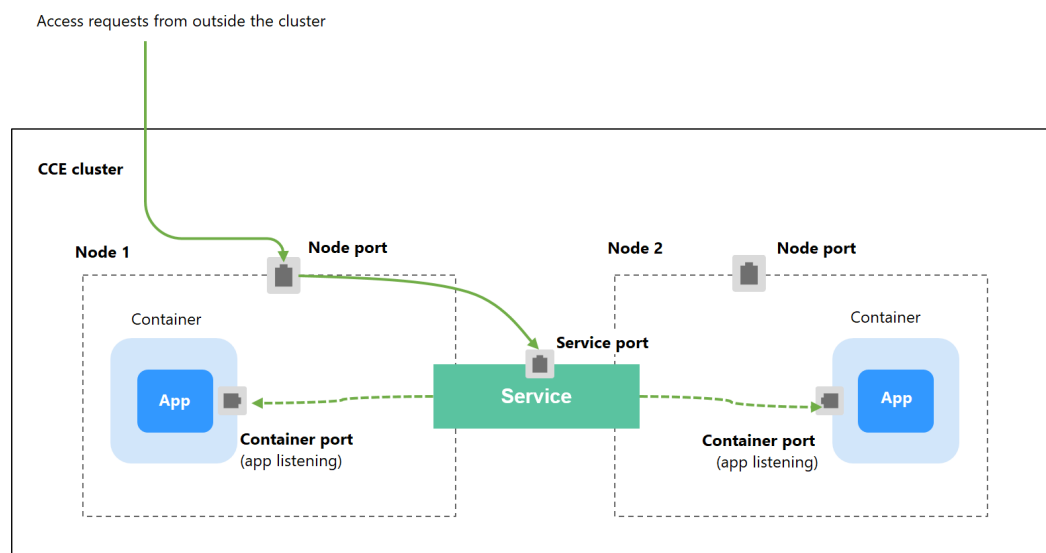
----End

11.3.3 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 11-15 NodePort access



Notes and 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 that the workload belongs to.
- **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**. The Service will use this label to select pods. 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**.
- **Ports**
 - **Protocol:** protocol used by the Service.
 - **Service Port:** port used by the Service. The port number ranges from 1 to 65535.
 - **Container Port:** listener port of the workload. 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 configure Service access using kubectl. This section uses an Nginx workload as an example to describe how to configure a NodePort Service using kubectl.

Step 1 Use kubectl to access 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

11.3.4 LoadBalancer

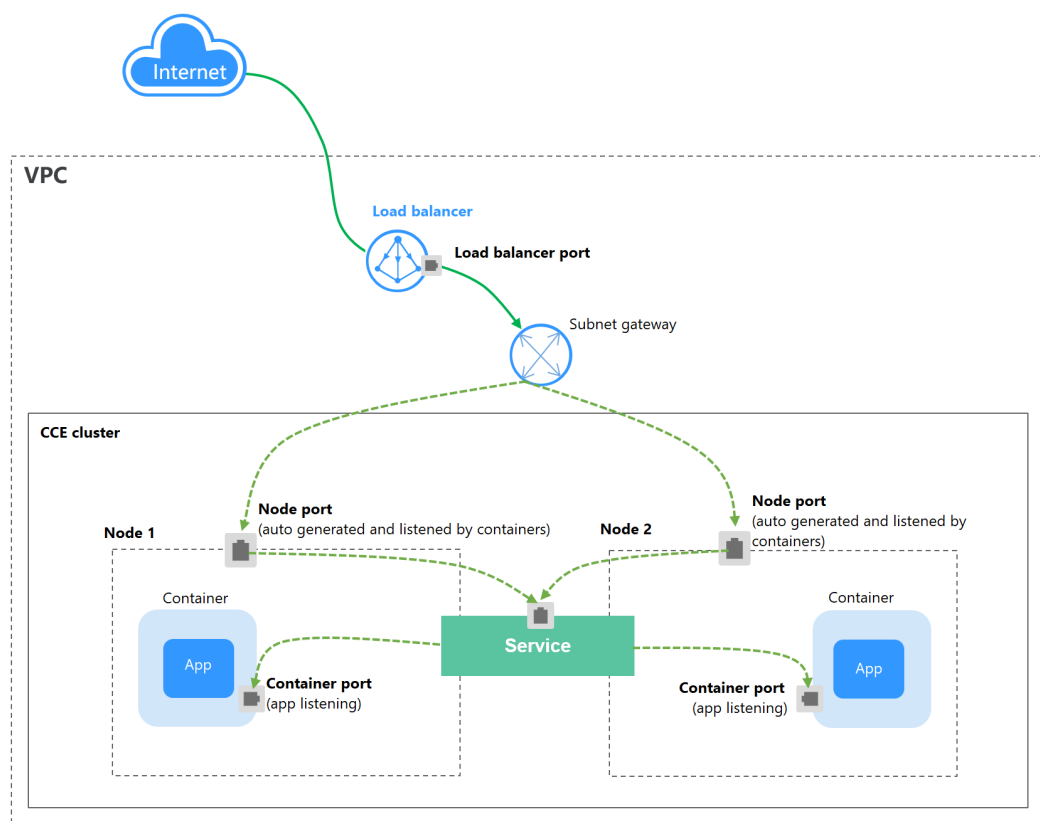
11.3.4.1 Creating a LoadBalancer Service

Scenario

LoadBalancer Services can access workloads from the public network through a load balancer, 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 11-16 LoadBalancer



Notes and 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. Do not modify the Service affinity setting after the Service is created. To modify it, create a Service again.

- If 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.
- A dedicated load balancer must be of the network type (TCP/UDP) and support private networks (with a private IP address). 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.
- 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 that the workload belongs to.
- **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**. The Service will use this label to select pods. 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.

You can select **Use existing** or **Auto create** to obtain a load balancer. For details about the configuration of different creation modes, see [Table 11-4](#).

Table 11-4 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	<ul style="list-style-type: none"> - Instance Name: Enter a load balancer name. - 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) <ul style="list-style-type: none"> ▪ 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. - 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.

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 configuration for custom health check, see [Configuring Health Check on Multiple Ports of a LoadBalancer Service](#).

Table 11-5 Health check parameters

Parameter	Description
Protocol	When the protocol of Port is set to TCP , the TCP and HTTP protocols are supported. When the protocol of Port is set to UDP , the UDP protocol is supported. <ul style="list-style-type: none"> - 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	<p>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.</p> <ul style="list-style-type: none"> - 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:** listener port of the workload. 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 11-5](#).

 **NOTE**

When a LoadBalancer Service is created, a random node port number (NodePort) is automatically generated.

- **Listener**

- **SSL Authentication:** Select this option if **HTTPS/TLS** is enabled on the listener port. This parameter is available only in clusters of v1.23.14-r0, v1.25.9-r0, v1.27.6-r0, v1.28.4-r0, or later versions.
 - **One-way authentication:** Only the backend server is authenticated. If you also need to authenticate the identity of the client, select mutual authentication.

- **Mutual authentication:** If you want the clients and the load balancer to authenticate each other, select this option. Only authenticated clients will be allowed to access the load balancer.
- **CA Certificate:** If **SSL Authentication** is set to **Mutual authentication**, add a CA certificate to authenticate the client. A CA certificate is issued by a certificate authority (CA) and used to verify the certificate issuer. If HTTPS mutual authentication is required, HTTPS connections can be established only when the client provides a certificate issued by a specific CA.
- **Server Certificate:** If **HTTPS/TLS** is enabled on the listener port, you must select a server certificate.
- **SNI:** If **HTTPS/TLS** is enabled on the listener port, you must determine whether to add an SNI certificate. Before adding an SNI certificate, ensure the certificate contains a domain name.
If an SNI certificate cannot be found based on the domain name requested by the client, the server certificate will be returned by default.
- **Security Policy:** If **HTTPS/TLS** is enabled on the listener port, you can select a security policy. This parameter is available only in clusters of v1.23.14-r0, v1.25.9-r0, v1.27.6-r0, v1.28.4-r0, or later versions.
- **Backend Protocol:** If **HTTPS** is enabled on the listener port, HTTP or HTTPS can be used to access the backend server. The default value is **HTTP**. If **TLS** is enabled on the listener port, TCP or TLS can be used to access the backend server. The default value is **TCP**. This parameter is available only in clusters of v1.23.14-r0, v1.25.9-r0, v1.27.6-r0, v1.28.4-r0, or later versions.
- **Access Control**
 - **Inherit ELB Configurations:** CCE does not modify the existing access control configurations on the ELB console.
 - **Allow all IP addresses:** No access control is configured.
 - **Trustlist:** Only the selected IP address group can access the load balancer.
 - **Blocklist:** The selected IP address group cannot access the load balancer.
- **Advanced Options**

Configuration	Description	Restrictions
Idle Timeout (s)	Timeout for an idle client connection. 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.	This configuration is not supported if the port of a shared load balancer uses UDP.

Configuration	Description	Restrictions
Request Timeout (s)	<p>Timeout for waiting for a request from a client. There are two cases:</p> <ul style="list-style-type: none"> ▪ 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. 	<p>This parameter is available only after HTTP/HTTPS is enabled on ports.</p>
Response Timeout (s)	<p>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 during the timeout duration, the load balancer will stop waiting and return HTTP 504 Gateway Timeout.</p>	<p>This parameter is available only after HTTP/HTTPS is enabled on ports.</p>
HTTP2	<p>Whether to use HTTP/2 for a client to communicate with a load balancer. 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.</p>	<p>This parameter is available only after HTTPS is enabled on ports.</p>

- **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 configure Service access using kubectl when creating a workload. This section uses an Nginx workload as an example to describe how to add a LoadBalancer Service using kubectl.

Step 1 Use kubectl to access the cluster. For details, see [Connecting to a Cluster Using kubectl](#).

Step 2 Create and edit the `nginx-deployment.yaml` and `nginx-elb-svc.yaml` files.

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

To enable sticky session, ensure anti-affinity is configured for the workload pods so that the pods are deployed onto 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> # Load balancer ID. Replace it with the actual
value.
    kubernetes.io/elb.class: union # 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 ELB health check.
    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 11-6](#).

For more annotations and examples related to advanced functions, see [Using Annotations to Balance Load](#).

Table 11-6 annotations parameters

Parameter	Mandatory	Type	Description
kubernetes.io/elb.id	Yes	String	<p>ID of a load balancer.</p> <p>Mandatory when an existing load balancer is to be associated.</p> <p>How to obtain:</p> <p>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.</p> <p>NOTE</p> <p>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).</p> <p>Do not use the spec.loadBalancerIP field to connect to the load balancer. This field will be discarded by Kubernetes. For details, see Deprecation.</p>
kubernetes.io/elb.class	Yes	String	<p>Select a proper load balancer type.</p> <p>The value can be:</p> <ul style="list-style-type: none"> ● union: shared load balancer ● performance: dedicated load balancer, which can be used only in clusters of v1.17 and later. <p>NOTE</p> <p>If a LoadBalancer Service accesses an existing dedicated load balancer, the dedicated load balancer must support TCP/UDP networking.</p>

Parameter	Mandatory	Type	Description
kubernetes.io/elb.lb-algorithm	No	String	<p>Specifies the load balancing algorithm of the backend server group. The default value is ROUND_ROBIN.</p> <p>Options:</p> <ul style="list-style-type: none"> ● ROUND_ROBIN: weighted round robin algorithm ● LEAST_CONNECTIONS: weighted least connections algorithm ● SOURCE_IP: source IP hash algorithm <p>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.</p>
kubernetes.io/elb.session-affinity-mode	No	String	<p>Source IP address-based sticky session means that access requests from the same IP address are forwarded to the same backend server.</p> <ul style="list-style-type: none"> ● 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. <p>NOTE When kubernetes.io/elb.lb-algorithm is set to SOURCE_IP (source IP hash), sticky session cannot be enabled.</p>
kubernetes.io/elb.session-affinity-option	No	Table 11-7 object	Sticky session timeout.
kubernetes.io/elb.health-check-flag	No	String	<p>Whether to enable the ELB health check.</p> <ul style="list-style-type: none"> ● Enabling health check: Leave blank this parameter or set it to on. ● Disabling health check: Set this parameter to off. <p>If this parameter is enabled, the kubernetes.io/elb.health-check-option field must also be specified at the same time.</p>

Parameter	Mandatory	Type	Description
kubernetes.io/elb.health-check-option	No	Table 11-8 object	ELB health check configuration items.

Table 11-7 elb.session-affinity-option data structure

Parameter	Mandatory	Type	Description
persistenc e_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 11-8 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_retriec s	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 11-17 Accessing Nginx through the LoadBalancer Service

Welcome to nginx!

If you see this page, the nginx web server is successfully installed and working. Further configuration is required.

For online documentation and support please refer to nginx.org. Commercial support is available at nginx.com.

Thank you for using nginx.

----End

Using kubectl to Create a Service (Automatically Creating a Load Balancer)

You can configure Service access using kubectl when creating a workload. This section uses an Nginx workload as an example to describe how to add a LoadBalancer Service using kubectl.

Step 1 Use kubectl to access the cluster. For details, see [Connecting to a Cluster Using kubectl](#).

Step 2 Create and edit the **nginx-deployment.yaml** and **nginx-elb-svc.yaml** files.

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

To enable sticky session, ensure anti-affinity is configured for the workload pods so that the pods are deployed onto different nodes. For details, see [Scheduling Policies \(Affinity/Anti-affinity\)](#).

Example of a Service using a public network shared load balancer:

```

apiVersion: v1
kind: Service
metadata:
  annotations:
    kubernetes.io/elb.class: union
    kubernetes.io/elb.autocreate: '{
      "type": "public",
      "bandwidth_name": "cce-bandwidth-1551163379627",
      "bandwidth_chargemode": "bandwidth",
      "bandwidth_size": 5,
      "bandwidth_sharetype": "PER",
      "vip_subnet_cidr_id": "*****",
      "vip_address": "***.***.***.***",
      "eip_type": "5_bgp"
    }'
    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 ELB health check.
    kubernetes.io/elb.health-check-option: '{
      "protocol": "TCP",
      "delay": "5",
      "timeout": "10",
      "max_retries": "3"
    }'
    kubernetes.io/elb.tags: key1=value1,key2=value2 # ELB resource tags
  labels:
    app: nginx
    name: nginx
spec:
  ports:
  - name: service0
    port: 80
    protocol: TCP
    targetPort: 80
  selector:
    app: nginx
  type: LoadBalancer

```

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.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 ELB health check.
    kubernetes.io/elb.health-check-option: '{
      "protocol": "TCP",
      "delay": "5",
      "timeout": "10",
      "max_retries": "3"
    }'
    kubernetes.io/elb.tags: key1=value1,key2=value2 # ELB resource tags
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 11-9](#).

For more annotations and examples related to advanced functions, see [Using Annotations to Balance Load](#).

Table 11-9 annotations parameters

Parameter	Mandatory	Type	Description
kubernetes.io/elb.class	Yes	String	Select a proper load balancer type. The value can be: <ul style="list-style-type: none"> • union: shared load balancer • 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 <ul style="list-style-type: none"> • If a public network load balancer will be automatically created, set this parameter to the following value: <pre>{ "type": "public", "bandwidth_name": "cce-bandwidth-1551163379627", "bandwidth_chargemode": "bandwidth", "bandwidth_size": 5, "bandwidth_sharetype": "PER", "eip_type": "5_bgp", "name": "james" }</pre> • If a private network load balancer will be automatically created, set this parameter to the following value: <pre>{ "type": "inner", "name": "A-location-d-test" }</pre>
kubernetes.io/elb.subnet-id	None	String	ID of the subnet where the cluster is located. The value can contain 1 to 100 characters. <ul style="list-style-type: none"> • 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.
kubernetes.io/elb.lb-algorithm	No	String	Specifies the load balancing algorithm of the backend server group. The default value is ROUND_ROBIN . Options: <ul style="list-style-type: none"> • 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.

Parameter	Mandatory	Type	Description
kubernetes.io/elb.session-affinity-mode	No	String	<p>Source IP address-based sticky session means that access requests from the same IP address are forwarded to the same backend server.</p> <ul style="list-style-type: none"> 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. <p>NOTE When kubernetes.io/elb.lb-algorithm is set to SOURCE_IP (source IP hash), sticky session cannot be enabled.</p>
kubernetes.io/elb.session-affinity-option	No	Table 11-7 object	Sticky session timeout.
kubernetes.io/elb.health-check-flag	No	String	<p>Whether to enable the ELB health check.</p> <ul style="list-style-type: none"> Enabling health check: Leave blank this parameter or set it to on. Disabling health check: Set this parameter to off. <p>If this parameter is enabled, the kubernetes.io/elb.health-check-option field must also be specified at the same time.</p>
kubernetes.io/elb.health-check-option	No	Table 11-8 object	ELB health check configuration items.
kubernetes.io/elb.tags	No	String	<p>Whether to add resource tags to a load balancer. This function is available only when the load balancer is automatically created, and the cluster is of v1.23.11-r0, v1.25.6-r0, v1.27.3-r0, or later.</p> <p>A tag is in the format of "key=value". Use commas (,) to separate multiple tags.</p>

Table 11-10 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. <ul style="list-style-type: none"> • 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. <ul style="list-style-type: none"> • bandwidth: billed by bandwidth • traffic: billed by traffic Default: bandwidth
bandwidth_size	Yes for public network load balancers	Integer	Bandwidth size. The value ranges from 1 Mbit/s to 2000 Mbit/s by default. Configure this parameter based on the bandwidth range allowed in your region. The minimum increment for bandwidth adjustment varies depending on the bandwidth range. <ul style="list-style-type: none"> • 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.

Parameter	Mandatory	Type	Description
bandwidth_sharetype	Yes for public network load balancers	String	Bandwidth sharing mode. <ul style="list-style-type: none"> • PER: dedicated bandwidth
eip_type	Yes for public network load balancers	String	EIP type. <ul style="list-style-type: none"> • 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.
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.

Parameter	Mandatory	Type	Description
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 11-18 Accessing Nginx through the LoadBalancer Service

Welcome to nginx!

If you see this page, the nginx web server is successfully installed and working. Further configuration is required.

For online documentation and support please refer to nginx.org. Commercial support is available at nginx.com.

Thank you for using nginx.

----End

11.3.4.2 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](#)
- [SNI](#)
- [Dynamic Adjustment of the Weight of the Backend ECS](#)
- [Passthrough Capability](#)
- [Blocklist/Trustlist](#)
- [Host Network](#)
- [Timeout](#)
- [Resource Tags](#)
- [HTTP/2](#)

Interconnection with ELB

Table 11-11 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: <ul style="list-style-type: none"> • union: shared load balancer • performance: dedicated load balancer, which can be used only in clusters of v1.17 and later. 	v1.9 or later

Parameter	Type	Description	Supported Cluster Version
kubernetes.io/elb.id	String	<p>Mandatory when an existing load balancer is to be associated.</p> <p>ID of a load balancer.</p> <p>How to obtain:</p> <p>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.</p> <p>NOTE</p> <p>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).</p> <p>Do not use the spec.loadBalancerIP field to connect to the load balancer. This field will be discarded by Kubernetes. For details, see Deprecation.</p>	v1.9 or later
kubernetes.io/elb.auto create	Table 11-23	<p>Mandatory when load balancers are automatically created.</p> <p>Example:</p> <ul style="list-style-type: none"> If a public network load balancer will be automatically created, set this parameter to the following value: <pre>{"type":"public","bandwidth_name":"cce-bandwidth-1551163379627","bandwidth_chargemode":"bandwidth","bandwidth_size":5,"bandwidth_sharetype":"PER","eip_type":"5_bgp","name":"james"}</pre> If a private network load balancer will be automatically created, set this parameter to the following value: <pre>{"type":"inner","name":"A-location-d-test"}</pre> 	v1.9 or later
kubernetes.io/elb.subnet-id	String	<p>Optional when load balancers are automatically created.</p> <p>ID of the subnet where the cluster is located. The value can contain 1 to 100 characters.</p> <ul style="list-style-type: none"> 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. 	<p>Mandatory for clusters earlier than v1.11.7-r0</p> <p>Discarded in clusters later than v1.11.7-r0</p>

Parameter	Type	Description	Supported Cluster Version
kubernetes.io/elb.algorithm	String	<p>Specifies the load balancing algorithm of the backend server group. The default value is ROUND_ROBIN.</p> <p>Options:</p> <ul style="list-style-type: none"> • ROUND_ROBIN: weighted round robin algorithm • LEAST_CONNECTIONS: weighted least connections algorithm • SOURCE_IP: source IP hash algorithm <p>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.</p>	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> # Load balancer 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 \(Automatically Creating a Load Balancer\)](#).

Shared load balancer:

```

apiVersion: v1
kind: Service
metadata:
  annotations:
    kubernetes.io/elb.class: union
    kubernetes.io/elb.autocreate: '{
      "type": "public",
      "bandwidth_name": "cce-bandwidth-1551163379627",
      "bandwidth_chargemode": "bandwidth",
      "bandwidth_size": 5,
      "bandwidth_sharetype": "PER",
      "eip_type": "5_bgp"
    }'
    kubernetes.io/elb.lb-algorithm: ROUND_ROBIN # Load balancer algorithm
  
```

```
labels:
  app: nginx
  name: nginx
spec:
  ports:
  - name: service0
    port: 80
    protocol: TCP
    targetPort: 80
  selector:
    app: nginx
  type: LoadBalancer
```

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.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 11-12 Annotations for sticky session

Parameter	Type	Description	Supported Cluster Version
kubernetes.io/elb.session-affinity-mode	String	<p>Source IP address-based sticky session means that access requests from the same IP address are forwarded to the same backend server.</p> <ul style="list-style-type: none"> 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. <p>NOTE When kubernetes.io/elb.lb-algorithm is set to SOURCE_IP (source IP hash), sticky session cannot be enabled.</p>	v1.9 or later
kubernetes.io/elb.session-affinity-option	Table 11-26	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> # Load balancer ID. Replace it with the actual value.
    kubernetes.io/elb.class: union # 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 11-13 Annotations for health check

Parameter	Type	Description	Supported Cluster Version
kubernetes.io/elb.health-check-flag	String	Whether to enable the ELB health check. <ul style="list-style-type: none"> 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 11-24	ELB health check configuration items.	v1.9 or later
kubernetes.io/elb.health-check-options	Table 11-25	ELB health check configuration items. Each Service port can be configured separately, and you can configure only some ports. NOTE Either kubernetes.io/elb.health-check-option or kubernetes.io/elb.health-check-options can be configured.	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>           # Load balancer ID. Replace it with the actual
value.
    kubernetes.io/elb.class: union               # Load balancer type
    kubernetes.io/elb.health-check-flag: 'on'    # Enable ELB health check.
    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 Ports of a LoadBalancer Service](#).

HTTP or HTTPS

Table 11-14 Annotations for using HTTP or HTTPS

Parameter	Type	Description	Supported Cluster Version
kubernetes.io/elb.protocol-port	String	<p>If a Service is HTTP/HTTPS-compliant, configure the protocol and port number in the format of "protocol:port".</p> <p>where,</p> <ul style="list-style-type: none"> • 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	<p>ID of an ELB certificate, which is used as the HTTPS server certificate.</p> <p>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.</p>	v1.19.16 or later

For details, see [Configuring HTTP/HTTPS for a LoadBalancer Service](#).

SNI

Table 11-15 Annotations for using SNIs

Parameter	Type	Description	Supported Cluster Version
kubernetes.io/elb.tls-certificate-ids	String	In ELB, the IDs of SNI certificates that must contain a domain name are separated by commas (,). 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.	v1.23.13-r0, v1.25.8-r0, v1.27.5-r0, v1.28.3-r0, or later

HTTPS must be enabled. For details, see [Configuring SNI for a LoadBalancer Service](#).

Dynamic Adjustment of the Weight of the Backend ECS

Table 11-16 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 load balancer backend server based on the number pods on the server. In this way, the requests received by each pod are more balanced. <ul style="list-style-type: none"> true: enabled false: disabled 	v1.21 or later

NOTE

This parameter is invalid in passthrough networking, where dedicated load balancers are used in a CCE Turbo cluster.

The following shows how to use the preceding annotations:

```
apiVersion: v1
kind: Service
metadata:
  name: nginx
annotations:
  kubernetes.io/elb.id: <your_elb_id> # Load balancer ID. Replace it with the actual value.
  kubernetes.io/elb.class: union # 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 11-17 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 [Configuring Passthrough Networking for a LoadBalancer Service](#).

Blocklist/Trustlist

Table 11-18 Annotations for ELB access control

Parameter	Type	Description	Supported Cluster Version
kubernetes.io/elb.acl-id	String	<ul style="list-style-type: none"> If this parameter is not specified, CCE does not modify access control on the ELB. If this parameter is left empty, all IP addresses are allowed to access the load balancer. If this parameter is set to the IP address group ID of the load balancer, access control is enabled and you need to configure an IP address blocklist or trustlist for the load balancer. Additionally, you need to configure both kubernetes.io/elb.acl-status and kubernetes.io/elb.acl-type. How to obtain: Log in to the console. In the Service List, choose Networking > Elastic Load Balance. On the Network Console, choose Elastic Load Balance > IP Address Groups and copy the ID of the target IP address group. 	v1.23.12-r0, v1.25.7-r0, v1.27.4-r0, v1.28.2-r0, or later
kubernetes.io/elb.acl-status	String	<p>This parameter is mandatory when you configure an IP address blocklist or trustlist for a load balancer. Options:</p> <ul style="list-style-type: none"> on: Access control is enabled. off: Access control is disabled. 	v1.23.12-r0, v1.25.7-r0, v1.27.4-r0, v1.28.2-r0, or later
kubernetes.io/elb.acl-type	String	<p>This parameter is mandatory when you configure an IP address blocklist or trustlist for a load balancer. Options:</p> <ul style="list-style-type: none"> black: indicates a blocklist. The selected IP address group cannot access the load balancer. white: indicates a trustlist. Only the selected IP address group can access the load balancer. 	v1.23.12-r0, v1.25.7-r0, v1.27.4-r0, v1.28.2-r0, 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>           # Load balancer ID. Replace it with the actual value.
  kubernetes.io/elb.class: performance         # Load balancer type
  kubernetes.io/elb.acl-id: <your_acl_id>      # ID of an IP address group for accessing a load
balancer
  kubernetes.io/elb.acl-status: 'on'          # Enable access control.
  kubernetes.io/elb.acl-type: 'white'         # Trustlist for access control
spec:
  selector:
    app: nginx
  ports:
  - name: service0
    port: 80
    protocol: TCP
    targetPort: 80
  type: LoadBalancer

```

Host Network

Table 11-19 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: <ul style="list-style-type: none"> 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>           # Load balancer ID. Replace it with the actual value.
  kubernetes.io/elb.class: union               # 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 11-20 Annotation for configuring timeout

Parameter	Type	Description	Supported Cluster Version
kubernetes.io/elb.keepalive_timeout	String	<p>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.</p> <p>Value:</p> <ul style="list-style-type: none"> 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. 	<p>Dedicated load balancers: v1.19.16-r30, v1.21.10-r10, v1.23.8-r10, v1.25.3-r10, or later</p> <p>Shared load balancers: v1.23.13-r0, v1.25.8-r0, v1.27.5-r0, v1.28.3-r0, or later</p>
kubernetes.io/elb.client_timeout	String	<p>Timeout for waiting for a request from a client. There are two cases:</p> <ul style="list-style-type: none"> 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. <p>The value ranges from 1 to 300 (in seconds). The default value is 60.</p>	<p>v1.23.13-r0, v1.25.8-r0, v1.27.5-r0, v1.28.3-r0, or later</p>
kubernetes.io/elb.member_timeout	String	<p>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.</p> <p>The value ranges from 1 to 300 (in seconds). The default value is 60.</p>	<p>v1.23.13-r0, v1.25.8-r0, v1.27.5-r0, v1.28.3-r0, or later</p>

For details, see [Configuring Timeout for a LoadBalancer Service](#).

Resource Tags

Table 11-21 Annotations

Parameter	Type	Description	Supported Cluster Version
kubernetes.io/elb.tags	String	Add resource tags to a load balancer. This parameter can be configured only when a load balancer is automatically created. A tag is in the format of "key=value". Use commas (,) to separate multiple tags.	v1.23.11-r0, v1.25.6-r0, v1.27.3-r0, or later

For details, see [Using kubectl to Create a Service \(Automatically Creating a Load Balancer\)](#).

HTTP/2

Table 11-22 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: <ul style="list-style-type: none"> 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 Service](#).

Parameters for Automatically Creating a Load Balancer

Table 11-23 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. <ul style="list-style-type: none"> 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. <ul style="list-style-type: none"> bandwidth: billed by bandwidth traffic: billed by traffic Default: bandwidth
bandwidth_size	Yes for public network load balancers	Integer	Bandwidth size. The value ranges from 1 Mbit/s to 2000 Mbit/s by default. Configure this parameter based on the bandwidth range allowed in your region. The minimum increment for bandwidth adjustment varies depending on the bandwidth range. <ul style="list-style-type: none"> 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.

Parameter	Mandatory	Type	Description
bandwidth_sharetype	Yes for public network load balancers	String	Bandwidth sharing mode. <ul style="list-style-type: none"> • PER: dedicated bandwidth
eip_type	Yes for public network load balancers	String	EIP type. <ul style="list-style-type: none"> • 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. <p>If this parameter is not specified, the ELB load balancer and the cluster are in the same subnet.</p> <p>This field can be specified only for clusters of v1.21 or later.</p>
vip_address	No	String	Private IP address of the load balancer. Only IPv4 addresses are supported. <p>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.</p> <p>This parameter is available only in clusters of v1.23.11-r0, v1.25.6-r0, v1.27.3-r0, or later versions.</p>
available_zone	Yes	Array of strings	AZ where the load balancer is located. <p>This parameter is available only for dedicated load balancers.</p>
l4_flavor_name	Yes	String	Flavor name of the layer-4 load balancer. <p>This parameter is available only for dedicated load balancers.</p>
l7_flavor_name	No	String	Flavor name of the layer-7 load balancer. <p>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.</p>

Parameter	Mandatory	Type	Description
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 11-24 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 11-25 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

Table 11-26 elb.session-affinity-option data structure

Parameter	Mandatory	Type	Description
persistenc e_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

11.3.4.3 Configuring HTTP/HTTPS for a LoadBalancer Service

Notes and Constraints

- Only clusters of v1.19.16 or later support HTTP or HTTPS.

Table 11-27 Scenarios where a load balancer supports HTTP or HTTPS

ELB Type	Application scenario	Whether to Support HTTP or HTTPS	Description
Shared load balancer	Interconnecting with an existing load balancer	Yes	None
	Automatically creating a load balancer	Yes	None
Dedicated load balancer	Interconnecting with an existing load balancer	Yes (A YAML file is required.)	<ul style="list-style-type: none"> 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.)	<ul style="list-style-type: none"> 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 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 **Services & Ingresses**. In the upper right corner, click **Create Service**.

Step 3 Configure Service parameters. In this example, only mandatory parameters required for using HTTP/HTTPS are listed. For details about how to configure other parameters, see [Creating a LoadBalancer Service](#).

- **Service Name:** Specify a Service name, which can be the same as the workload name.
- **Service Type:** Select **LoadBalancer**.
- **Selector:** Add a label and click **Confirm**. The Service will use this label to select pods. 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. To enable HTTP/HTTPS on the listener port of a dedicated load balancer, the type of the load balancer must be **Application (HTTP/HTTPS)** or **Network (TCP/UDP) & Application (HTTP/HTTPS)**.
 - This section uses an existing load balancer as an example. For details about the parameters for automatically creating a load balancer, see [Table 11-4](#).
- **Ports**
 - **Protocol:** Select **TCP**. If you select **UDP**, HTTP and HTTPS will be unavailable.
 - **Service Port:** port used by the Service. The port number ranges from 1 to 65535.
 - **Container Port:** listener port of the workload. For example, Nginx uses port 80 by default.
 - **Frontend Protocol:** specifies whether to enable HTTP/HTTPS on the listener port. For a [dedicated load balancer](#), to use HTTP/HTTPS, the type of the load balancer must be **Application (HTTP/HTTPS)**.
- **Listener**
 - **SSL Authentication:** Select this option if **HTTPS** is enabled on the listener port. This parameter is available only in clusters of v1.23.14-r0, v1.25.9-r0, v1.27.6-r0, v1.28.4-r0, or later versions.
 - **One-way authentication:** Only the backend server is authenticated. If you also need to authenticate the identity of the client, select mutual authentication.
 - **Mutual authentication:** If you want the clients and the load balancer to authenticate each other, select this option. Only authenticated clients will be allowed to access the load balancer.
 - **CA Certificate:** If **SSL Authentication** is set to **Mutual authentication**, add a CA certificate to authenticate the client. A CA certificate is issued by a certificate authority (CA) and used to verify the certificate issuer. If HTTPS mutual authentication is required, HTTPS connections can be established only when the client provides a certificate issued by a specific CA.
 - **Server Certificate:** If **HTTPS** is enabled on the listener port, you must select a server certificate.

- **SNI:** If **HTTPS** is enabled on the listener port, you must determine whether to add an SNI certificate. Before adding an SNI certificate, ensure the certificate contains a domain name.
- **Security Policy:** If **HTTPS** is enabled on the listener port, you can select a security policy. This parameter is available only in clusters of v1.23.14-r0, v1.25.9-r0, v1.27.6-r0, v1.28.4-r0, or later versions.
- **Backend Protocol:** If **HTTPS** is enabled on the listener port, HTTP or HTTPS can be used to access the backend server. The default value is **HTTP**. This parameter is available only in clusters of v1.23.14-r0, v1.25.9-r0, v1.27.6-r0, v1.28.4-r0, or later versions.

 **NOTE**

If multiple HTTPS Services are released, all listeners will use the same certificate configuration.

Step 4 Click **OK**.

----End

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 11-27](#).
- 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
  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.

11.3.4.4 Configuring SNI for a LoadBalancer Service

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

After SNI is configured, if you delete the SNI configuration on the CCE console or delete the target annotation from the YAML file, the configuration on the ELB will be retained.

Prerequisites

- A Kubernetes cluster is available and the cluster version meets the following requirements:
 - v1.23: v1.23.13-r0 or later
 - v1.25: v1.25.8-r0 or later
 - v1.27: v1.27.5-r0 or later

- v1.28: v1.28.3-r0 or later
- Other clusters of later versions
- You have created one or more SNI certificates in ELB and specified a domain name in these certificates.
- To create a cluster using commands, ensure kubectl is used. For details, see [Connecting to a Cluster Using kubectl](#).

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 **Services & Ingresses**. In the upper right corner, click **Create Service**.

Step 3 Configure Service parameters. In this example, only mandatory parameters required for using SNI are listed. For details about how to configure other parameters, see [Creating a LoadBalancer Service](#).

- **Service Name:** Specify a Service name, which can be the same as the workload name.
- **Service Type:** Select **LoadBalancer**.
- **Selector:** Add a label and click **Confirm**. The Service will use this label to select pods. 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. To enable HTTP/HTTPS on the listener port of a dedicated load balancer, the type of the load balancer must be **Application (HTTP/HTTPS)** or **Network (TCP/UDP) & Application (HTTP/HTTPS)**.
 - This section uses an existing load balancer as an example. For details about the parameters for automatically creating a load balancer, see [Table 11-4](#).
- **Ports**
 - **Protocol:** Select **TCP**. If you select **UDP**, HTTP and HTTPS will be unavailable.
 - **Service Port:** port used by the Service. The port number ranges from 1 to 65535.
 - **Container Port:** listener port of the workload. For example, Nginx uses port 80 by default.
 - **Frontend Protocol:** In this example, HTTPS must be enabled for the Service to use SNI. For a [dedicated load balancer](#), to use HTTP/HTTPS, the type of the load balancer must be **Application (HTTP/HTTPS)**.
- **Listener**
 - **SSL Authentication:** Select this option if **HTTPS** is enabled on the listener port. This parameter is available only in clusters of v1.23.14-r0, v1.25.9-r0, v1.27.6-r0, v1.28.4-r0, or later versions.
 - **One-way authentication:** Only the backend server is authenticated. If you also need to authenticate the identity of the client, select mutual authentication.

- **Mutual authentication:** If you want the clients and the load balancer to authenticate each other, select this option. Only authenticated clients will be allowed to access the load balancer.
- **CA Certificate:** If **SSL Authentication** is set to **Mutual authentication**, add a CA certificate to authenticate the client. A CA certificate is issued by a certificate authority (CA) and used to verify the certificate issuer. If HTTPS mutual authentication is required, HTTPS connections can be established only when the client provides a certificate issued by a specific CA.
- **Server Certificate:** Select a server certificate as the default certificate.
- **SNI:** Add an SNI certificate containing a domain name.
If an SNI certificate cannot be found based on the domain name requested by the client, the server certificate will be returned by default.
- **Security Policy:** If **HTTPS** is enabled on the listener port, you can select a security policy. This parameter is available only in clusters of v1.23.14-r0, v1.25.9-r0, v1.27.6-r0, v1.28.4-r0, or later versions.
- **Backend Protocol:** If **HTTPS** is enabled on the listener port, HTTP or HTTPS can be used to access the backend server. The default value is **HTTP**. This parameter is available only in clusters of v1.23.14-r0, v1.25.9-r0, v1.27.6-r0, v1.28.4-r0, or later versions.

Step 4 Click **OK**.

----End

Using kubectl

This section uses an existing load balancer as an example. An example YAML file of a SNI-compliant Service is as follows:

```
apiVersion: v1
kind: Service
metadata:
  name: test
  labels:
    app: test
  namespace: default
  annotations:
    kubernetes.io/elb.class: performance # Load balancer type
    kubernetes.io/elb.id: 65318265-4f01-4541-a654-fa74e439dfd3 # ID of an existing load balancer
    kubernetes.io/elb.protocol-port: https:80 # Port where SNI is to be enabled
    kubernetes.io/elb.cert-id: b64ab636f1614e1a960b5249c497a880 # HTTPS server certificate
    kubernetes.io/elb.tls-certificate-ids:
      5196aa70b0f143189e4cb54991ba2286,8125d71fcc124aabbbe007610cba42d60 # SNI certificate IDs
    kubernetes.io/elb.lb-algorithm: ROUND_ROBIN
spec:
  selector:
    app: test
  externalTrafficPolicy: Cluster
  ports:
    - name: cce-service-0
      targetPort: 80
      nodePort: 0
      port: 80
      protocol: TCP
  type: LoadBalancer
  loadBalancerIP: **.**.**.** # Private IP address of the load balancer
```

Table 11-28 Key parameters

Parameter	Type	Description
kubernetes.io/elb.protocol-port	String	<p>If a Service is HTTP/HTTPS-compliant, configure the protocol and port number in the format of "protocol:port".</p> <p>where,</p> <ul style="list-style-type: none"> • protocol: specifies the protocol used by the listener port. The value can be http or https. • ports: Service ports specified by spec.ports[].port. <p>For example, to use SNI, the Service protocol must be https and the Service port must be 80. Therefore, the parameter value is https:80.</p>
kubernetes.io/elb.cert-id	String	<p>ID of an ELB certificate, which is used as the HTTPS server certificate.</p> <p>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.</p>
kubernetes.io/elb.tls-certificate-ids	String	<p>In ELB, the IDs of SNI certificates that must contain a domain name are separated by commas (,).</p> <p>If an SNI certificate cannot be found based on the domain name requested by the client, the server certificate will be returned by default.</p> <p>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.</p>

11.3.4.5 Configuring HTTP/2 for a LoadBalancer Service

Services can be exposed via HTTP/2. By default, HTTP/1.x is used between clients and load balancers. HTTP/2 can improve access performance between clients and load balancers, but HTTP/1.x is still used between load balancers and backend servers.

 NOTE

- An HTTPS-compliant load balancer supports HTTP/2.
- After HTTP/2 is configured, if you delete the advanced configuration for enabling HTTP/2 on the CCE console or delete the target annotation from the YAML file, the configuration on the ELB will be retained.

Prerequisites

- A Kubernetes cluster is available and the cluster version meets the following requirements:
 - v1.23: v1.23.13-r0 or later
 - v1.25: v1.25.8-r0 or later
 - v1.27: v1.27.5-r0 or later
 - v1.28: v1.28.3-r0 or later
 - Other clusters of later versions
- To create a cluster using commands, ensure kubectl is used. For details, see [Connecting to a Cluster Using kubectl](#).

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 **Services & Ingresses**. In the upper right corner, click **Create Service**.

Step 3 Configure Service parameters. In this example, only mandatory parameters are listed. For details about how to configure other parameters, see [Creating a LoadBalancer Service](#).

- **Service Name:** Specify a Service name, which can be the same as the workload name.
- **Service Type:** Select **LoadBalancer**.
- **Selector:** Add a label and click **Confirm**. The Service will use this label to select pods. 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. To enable HTTP/HTTPS on the listener port of a dedicated load balancer, the type of the load balancer must be **Application (HTTP/HTTPS)** or **Network (TCP/UDP) & Application (HTTP/HTTPS)**.
 - This section uses an existing load balancer as an example. For details about the parameters for automatically creating a load balancer, see [Table 11-4](#).
- **Ports**
 - **Protocol:** Select **TCP**. If you select **UDP**, HTTP and HTTPS will be unavailable.
 - **Service Port:** port used by the Service. The port number ranges from 1 to 65535.

- **Container Port:** listener port of the workload. For example, Nginx uses port 80 by default.
- **Frontend Protocol:** In this example, HTTPS must be enabled for the Service to use HTTP/2. For a **dedicated load balancer**, to use HTTP/HTTPS, the type of the load balancer must be **Application (HTTP/HTTPS)**.
- **Listener**
 - SSL authentication is available only in clusters of v1.23.14-r0, v1.25.9-r0, v1.27.6-r0, v1.28.4-r0, or later versions.
 - **One-way authentication:** Only the backend server is authenticated. If you also need to authenticate the identity of the client, select mutual authentication.
 - **Mutual authentication:** If you want the clients and the load balancer to authenticate each other, select this option. Only authenticated clients will be allowed to access the load balancer.
 - **CA Certificate:** If **SSL Authentication** is set to **Mutual authentication**, add a CA certificate to authenticate the client. A CA certificate is issued by a certificate authority (CA) and used to verify the certificate issuer. If HTTPS mutual authentication is required, HTTPS connections can be established only when the client provides a certificate issued by a specific CA.
 - **Server Certificate:** Select a server certificate when HTTPS is used.
 - **SNI:** Add an SNI certificate containing a domain name.
 - **Advanced Options:** Click **Add custom container network settings** and enable HTTP/2.

Step 4 Click **OK**.

----End

Using kubectl

To enable HTTP/2, add the following annotation:

```
kubernetes.io/elb.http2-enable: 'true'
```

The following shows an example YAML file where an existing load balancer is associated:

```
apiVersion: v1
kind: Service
metadata:
  name: test
  labels:
    app: test
    version: v1
  namespace: default
  annotations:
    kubernetes.io/elb.class: performance
    kubernetes.io/elb.id: 35cb350b-23e6-4551-ac77-10d5298f5204
    kubernetes.io/elb.protocol-port: https:443
    kubernetes.io/elb.cert-id: b64ab636f1614e1a960b5249c497a880
    kubernetes.io/elb.http2-enable: 'true'
    kubernetes.io/elb.lb-algorithm: ROUND_ROBIN
spec:
  selector:
```

```

app: test
version: v1
externalTrafficPolicy: Cluster
ports:
- name: cce-service-0
  targetPort: 80
  nodePort: 0
  port: 443
  protocol: TCP
type: LoadBalancer
loadBalancerIP: *.*.*.*.
    
```

Table 11-29 HTTP/2 parameters

Parameter	Type	Description
kubernetes.io/elb.protocol-port	String	<p>If a Service is HTTP/HTTPS-compliant, configure the protocol and port number in the format of "protocol:port".</p> <p>where,</p> <ul style="list-style-type: none"> ● protocol: specifies the protocol used by the listener port. The value can be http or https. ● ports: Service ports specified by spec.ports[].port. <p>For example, to use HTTPS, the Service port must be 443. Therefore, the parameter value is https:443.</p>
kubernetes.io/elb.cert-id	String	<p>ID of an ELB certificate, which is used as the HTTPS server certificate.</p> <p>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.</p>
kubernetes.io/elb.http2-enable	String	<p>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.</p> <p>Options:</p> <ul style="list-style-type: none"> ● true: enabled ● false: disabled (default value) <p>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.</p>

11.3.4.6 Configuring Timeout for a LoadBalancer 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.

Notes and Constraints

- The following table lists the scenarios where timeout can be configured for a Service.

Timeout Type	Load Balancer Type	Restrictions	Supported Cluster Version
Idle timeout	Dedicated	None	<ul style="list-style-type: 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
Idle timeout	Shared	UDP is not supported.	<ul style="list-style-type: none"> v1.23: v1.23.13-r0 or later
Request timeout	Dedicated and shared	Only HTTP and HTTPS are supported.	<ul style="list-style-type: none"> v1.25: v1.25.8-r0 or later v1.27: v1.27.5-r0 or later v1.28: v1.28.3-r0 or later
Response timeout	Dedicated and shared	Only HTTP and HTTPS are supported.	<ul style="list-style-type: none"> Other clusters of later versions

- After timeout is configured, if you delete the timeout configuration on the CCE console or delete the target annotation from the YAML file, the configuration on the ELB will be retained.

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 **Services & Ingresses**. In the upper right corner, click **Create Service**.

Step 3 Configure Service parameters. In this example, only mandatory parameters required for configuring timeout are listed. For details about how to configure other parameters, see [Creating a LoadBalancer Service](#).

- Service Name:** Specify a Service name, which can be the same as the workload name.
- Service Type:** Select **LoadBalancer**.
- Selector:** Add a label and click **Confirm**. The Service will use this label to select pods. 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.
 - This section uses an existing load balancer as an example. For details about the parameters for automatically creating a load balancer, see [Table 11-4](#).
- **Ports**
 - **Protocol:** protocol that the load balancer complies. Timeout cannot be configured for a UDP-compliant shared load balancer.
 - **Service Port:** port used by the Service. The port number ranges from 1 to 65535.
 - **Container Port:** listener port of the workload. For example, Nginx uses port 80 by default.
 - **Frontend Protocol:** Select a protocol for the listener. If HTTP/HTTPS is not enabled, only the idle timeout can be configured.
- **Listener**
 - **Advanced Options:** Select a proper option.

Configuration	Description	Restrictions
Idle Timeout	Timeout for an idle client connection. 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.	This configuration is not supported if the port of a shared load balancer uses UDP.
Request Timeout	Timeout for waiting for a request from a client. There are two cases: <ul style="list-style-type: none"> ▪ 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. 	This parameter is available only after HTTP/HTTPS is enabled on ports.

Configuration	Description	Restrictions
Response Timeout	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 during the timeout duration, the load balancer will stop waiting and return HTTP 504 Gateway Timeout.	This parameter is available only after HTTP/HTTPS is enabled on ports.

Step 4 Click **OK**.

----End

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.
    kubernetes.io/elb.class: performance # Load balancer type
    kubernetes.io/elb.keepalive_timeout: '300' # Timeout setting for client connections
    kubernetes.io/elb.client_timeout: '60' # Timeout for waiting for a request from a client
name: nginx
spec:
  ports:
  - name: service0
    port: 80
    protocol: TCP
    targetPort: 80
  selector:
    app: nginx
  type: LoadBalancer
```

Table 11-30 Key annotation parameters

Parameter	Mandatory	Type	Description
kubernetes.io/elb.keepalive_timeout	No	String	<p>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.</p> <p>Value:</p> <ul style="list-style-type: none"> 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, the value ranges from 10 to 4000 (in seconds). The default value is 300.
kubernetes.io/elb.client_timeout	No	String	<p>Timeout for waiting for a request from a client. There are two cases:</p> <ul style="list-style-type: none"> 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. <p>The value ranges from 1 to 300 (in seconds). The default value is 60.</p>
kubernetes.io/elb.member_timeout	No	String	<p>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.</p> <p>The value ranges from 1 to 300 (in seconds). The default value is 60.</p>

11.3.4.7 Configuring a Blocklist/Trustlist Access Policy for a LoadBalancer Service

When using a LoadBalancer Service, you can configure a trustlist or blocklist to specify the IP addresses that are allowed or denied to access a load balancer listener.

- **Trustlist:** Only the IP addresses in the list can access the listener.
- **Blocklist:** The IP addresses in the list are not allowed to access the listener.

Prerequisites

- A Kubernetes cluster is available and the cluster version meets the following requirements:
 - v1.23: v1.23.12-r0 or later
 - v1.25: v1.25.7-r0 or later
 - v1.27: v1.27.4-r0 or later
 - v1.28: v1.28.2-r0 or later
 - Other clusters of later versions
- An IP address group has been created on the ELB console.

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 **Services & Ingresses** in the navigation pane, click the **Services** tab, and click **Create Service** in the upper right corner.

Step 3 Configure Service parameters.

- **Service Name:** Enter a service name, for example, **service-acl**.
- **Service Type:** Select **LoadBalancer**.
- **Service Affinity:** Select cluster level or node level as needed. For details about the differences, see [externalTrafficPolicy \(Service Affinity\)](#).
- **Selector:** Add a label and click **Confirm**. The Service will use this label to select pods. 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 to be accessed. Only load balancers in the same VPC as the cluster are supported. If no load balancer is available, click **Create Load Balancer** to create one on the ELB console. Alternatively, select **Auto create** to create a load balancer. For details about parameter settings, see [Table 11-4](#).
- **Health Check:** defaults to **Global health check**. You can configure this parameter as needed.
- **Ports**
 - **Protocol:** protocol used by the Service.
 - **Service Port:** port used by the Service. The port number ranges from 1 to 65535.
 - **Container Port:** listener port of the workload. For example, Nginx uses port 80 by default.
- **Access Control**
 - **Inherit ELB Configurations:** CCE does not modify the existing access control configurations on the ELB console.

- **Allow all IP addresses:** No access control is configured.
- **Trustlist:** Only the selected IP address group can access the load balancer.
- **Blocklist:** The selected IP address group cannot access the load balancer.

Step 4 Click **OK**.

----End

Using kubectl

An example YAML file of a Service created using an existing load balancer is as follows:

```
apiVersion: v1
kind: Service
metadata:
  name: nginx
  annotations:
    kubernetes.io/elb.id: <your_elb_id>           # Load balancer ID. Replace it with the actual value.
    kubernetes.io/elb.class: performance        # Load balancer type
    kubernetes.io/elb.acl-id: <your_acl_id>     # ID of an IP address group for accessing a load
balancer
  kubernetes.io/elb.acl-status: 'on'           # Enable access control.
  kubernetes.io/elb.acl-type: 'white'         # Trustlist for access control
spec:
  selector:
    app: nginx
  ports:
  - name: service0
    port: 80
    protocol: TCP
    targetPort: 80
  type: LoadBalancer
```

Table 11-31 Annotations for ELB access control

Parameter	Type	Description
kubernetes.io/elb.acl-id	String	<ul style="list-style-type: none"> If this parameter is not specified, CCE does not modify access control on the ELB. If this parameter is left empty, all IP addresses are allowed to access the load balancer. If this parameter is set to the IP address group ID of the load balancer, access control is enabled and you need to configure an IP address blocklist or trustlist for the load balancer. Additionally, you need to configure both kubernetes.io/elb.acl-status and kubernetes.io/elb.acl-type. How to obtain: Log in to the console. In the Service List, choose Networking > Elastic Load Balance. On the Network Console, choose Elastic Load Balance > IP Address Groups and copy the ID of the target IP address group.
kubernetes.io/elb.acl-status	String	<p>This parameter is mandatory when you configure an IP address blocklist or trustlist for a load balancer. Options:</p> <ul style="list-style-type: none"> on: Access control is enabled. off: Access control is disabled.
kubernetes.io/elb.acl-type	String	<p>This parameter is mandatory when you configure an IP address blocklist or trustlist for a load balancer. Options:</p> <ul style="list-style-type: none"> black: indicates a blocklist. The selected IP address group cannot access the load balancer. white: indicates a trustlist. Only the selected IP address group can access the load balancer.

11.3.4.8 Configuring Health Check on Multiple Ports of a LoadBalancer Service

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.

Notes and 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
- Either **kubernetes.io/elb.health-check-option** or **kubernetes.io/elb.health-check-options** can be configured.
- 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> # Load balancer 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 11-32 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
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

11.3.4.9 Configuring Passthrough Networking for a LoadBalancer Service

Background

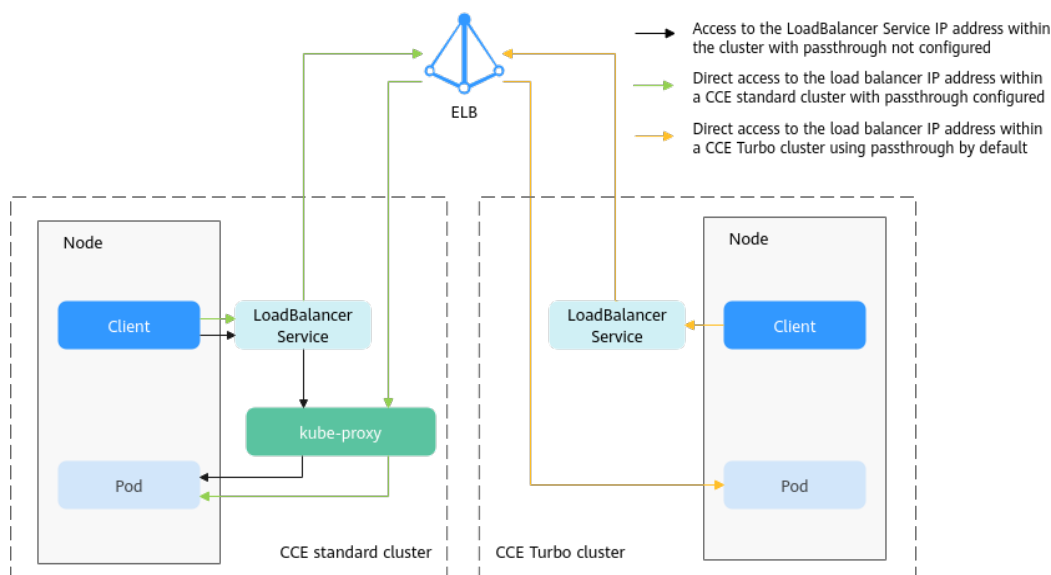
A Kubernetes cluster can publish applications running on a group of pods as Services, which provide unified layer-4 access entries. For a Loadbalancer Service, kube-proxy configures the LoadbalancerIP in **status** of the Service to the local forwarding rule of the node by default. When a pod accesses 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 11-19 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

- In a CCE standard cluster, after passthrough networking is configured for a dedicated load balancer, the private IP address of the load balancer cannot be accessed from the node where the workload pod resides or other containers on the same node as the workload.
- Passthrough networking is not supported for clusters of v1.15 or earlier.
- In IPVS network mode, the passthrough settings of Services connected to the same load balancer must be the same.
- If node-level (local) service affinity is used, **kubernetes.io/elb.pass-through** is automatically set to **onlyLocal** to enable pass-through.

Procedure

This section describes how to create a Deployment using an Nginx image and create a Service with passthrough networking enabled.

Step 1 Use the 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, 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_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
```

----End

Verification

Check the load balancer associated with the created Service. The load balancer name is **james**. The number of load balancer 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.

11.3.4.10 Enabling ICMP Security Group Rules

Scenario

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
	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

11.3.5 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
```

11.4 Ingresses

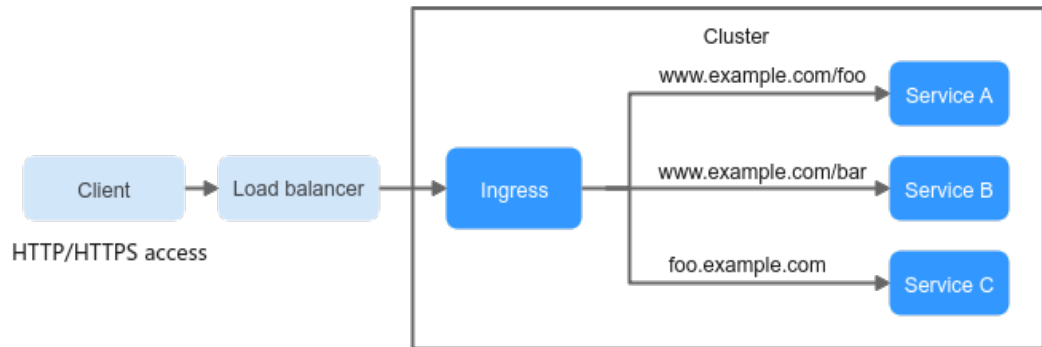
11.4.1 Overview

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 11-20](#), you can customize forwarding rules based on domain names and URLs to implement fine-grained distribution of access traffic.

Figure 11-20 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 11-33 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.

Feature	ELB Ingress Controller	Nginx Ingress Controller
	Dynamic loading is supported.	<ul style="list-style-type: none"> Processes must be reloaded for non-backend endpoint changes, which causes 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	Supported	Supported
SSL configuration	Supported	Supported
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.

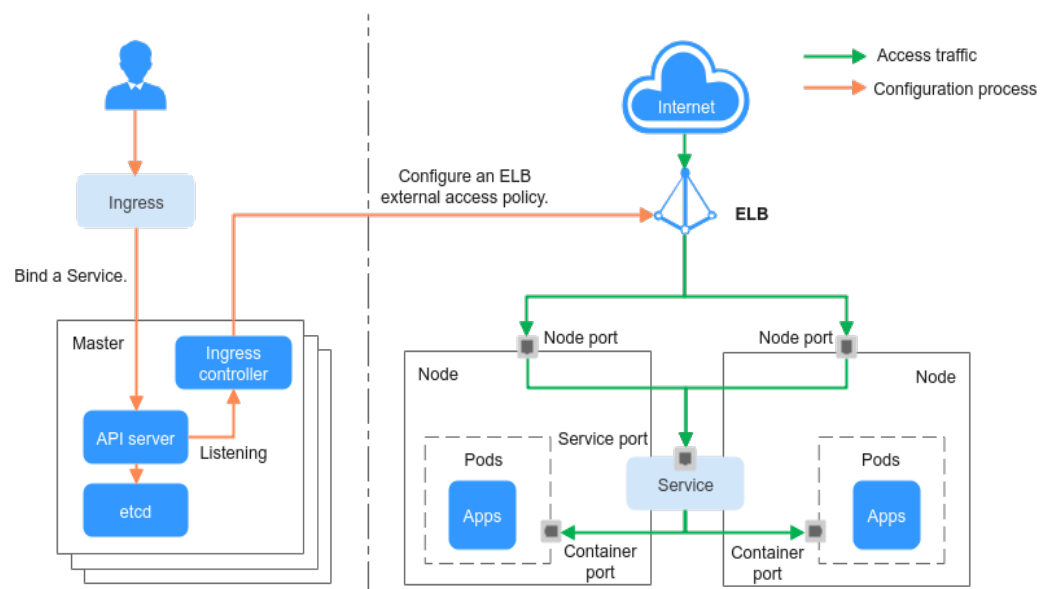
Working Rules of LoadBalancer Ingress Controller

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 11-21** 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 11-21 Working rules of shared LoadBalancer ingresses in CCE standard clusters



Working Rules of Nginx Ingress Controller

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

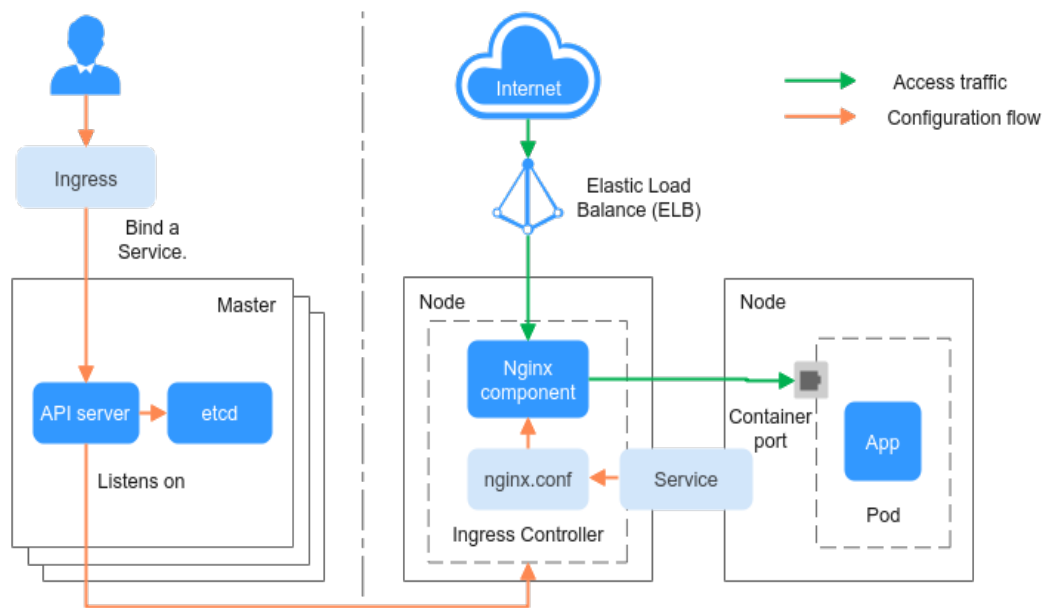
nginx-ingress uses the templates and images provided by the open-source community, and issues may occur during usage. CCE periodically synchronizes the community version to fix known vulnerabilities. Check whether your service requirements can be met.

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 11-22** 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 11-22 Working rules of Nginx Ingress Controller



Services Supported by Ingresses

Table 11-34 lists the Services supported by LoadBalancer ingresses.

Table 11-34 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 11-35 lists the Services supported by Nginx Ingress.

Table 11-35 Services supported by Nginx Ingress

Cluster Type	ELB Type	ClusterIP	NodePort
CCE standard cluster	Shared load balancer	Supported	Supported
	Dedicated load balancer	Supported	Supported

11.4.2 LoadBalancer Ingresses

11.4.2.1 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.

Notes and 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) and support private networks (with a private IP address).
- 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 HTTP/2 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:** Customize the 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 Controller 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 type (HTTP/HTTPS) 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 11-36](#).

Table 11-36 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.

How to Create	Configuration
Auto create	<ul style="list-style-type: none"> - Instance Name: Enter a load balancer name. - 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) <ul style="list-style-type: none"> ▪ 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. - 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.

- **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 and HTTPS are available.
 - **External Port:** port number that is open to the ELB service address. The port number is configurable.
 - **Access Control**
 - **Inherit ELB Configurations:** CCE does not modify the existing access control configurations on the ELB console.
 - **Allow all IP addresses:** No access control is configured.
 - **Trustlist:** Only the selected IP address group can access the load balancer.
 - **Blocklist:** The selected IP address group cannot access the load balancer.
 - **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:** 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.

 **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**.
 - **Advanced Options**

Configuration	Description	Restrictions
Idle Timeout	Timeout for an idle client connection. 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.	None
Request Timeout	Timeout for waiting for a request from a client. There are two cases: <ul style="list-style-type: none"> ▪ 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. 	None
Response Timeout	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 during the timeout duration, the load balancer will stop waiting and return HTTP 504 Gateway Timeout.	None
HTTP2	Whether to use HTTP/2 for a client to communicate with a load balancer. 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.	This function is available only when the listener is HTTPS-compliant.

- **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 1440 minutes.
 - **Application cookie:** This parameter is available only for shared load balancers. In addition, enter **Cookie Name**, which ranges from 1 to 64 characters.

 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. <ul style="list-style-type: none"> ○ 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	<p>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.</p> <ul style="list-style-type: none"> ○ 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 Click **OK**. After the ingress is created, it is displayed in the ingress list.

On the ELB console, you can check the load balancer automatically created through CCE. The default name is **cce-lb-<ingress.UID>**. Click the load balancer name to go to the details page. On the **Listeners** tab page, check the listener and forwarding policy of the target ingress.

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 11-23](#).

Figure 11-23 Accessing the **/healthz** interface of defaultbackend



----End

11.4.2.2 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.
- A dedicated load balancer must be of the application type (HTTP/HTTPS) and support private networks (with a private IP address).

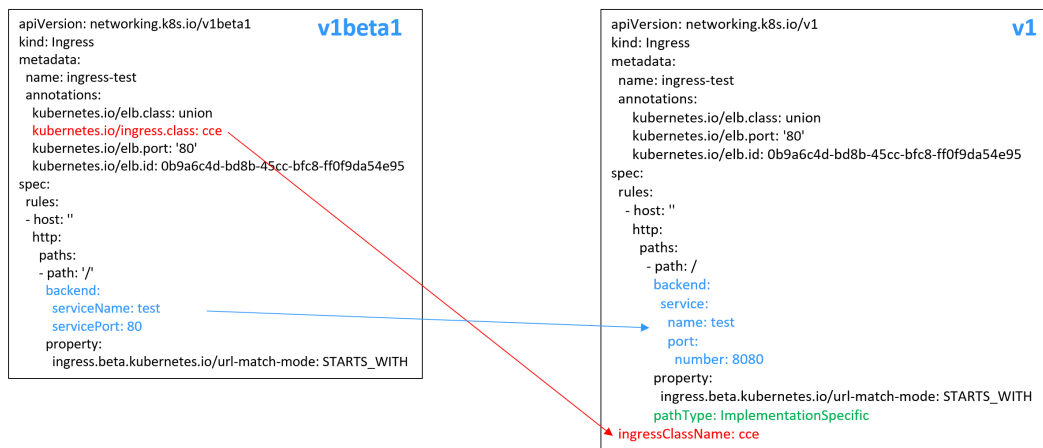
Ingress Description of networking.k8s.io/v1

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 access 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 shared load balancer (public network access) for clusters of v1.23 or later:

```
apiVersion: networking.k8s.io/v1
kind: Ingress
metadata:
  name: ingress-test
  annotations:
    kubernetes.io/elb.class: union
    kubernetes.io/elb.port: '80'
    kubernetes.io/elb.autocreate:
      '{
        "type": "public",
```

```

        "bandwidth_name": "cce-bandwidth-*****",
        "bandwidth_chargemode": "bandwidth",
        "bandwidth_size": 5,
        "bandwidth_sharetype": "PER",
        "vip_subnet_cidr_id": "*****",
        "vip_address": ".*.*.*.*",
        "eip_type": "5_bgp"
    }
    kubernetes.io/elb.tags: key1=value1,key2=value2      # ELB resource tags
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 # A LoadBalancer ingress is used.

```

Example of a shared load balancer (public network access) for clusters of v1.21 or earlier:

```

apiVersion: networking.k8s.io/v1beta1
kind: Ingress
metadata:
  name: ingress-test
  annotations:
    kubernetes.io/elb.class: union
    kubernetes.io/ingress.class: cce # A LoadBalancer ingress is used.
    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"
      }'
    kubernetes.io/elb.tags: key1=value1,key2=value2      # ELB resource tags
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

```

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": [
            "eu-west-0a"
        ],
        "l7_flavor_name": "L7_flavor.elb.s1.small"
    }
    kubernetes.io/elb.tags: key1=value1,key2=value2      # ELB resource tags
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 v1.21 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": [
            "eu-west-0a"
        ],
        "l7_flavor_name": "L7_flavor.elb.s1.small"
      }
    kubernetes.io/elb.tags: key1=value1,key2=value2      # ELB resource tags
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 11-37 Key parameters

Parameter	Mandatory	Type	Description
kubernetes.io/elb.class	Yes	String	Select a proper load balancer type. <ul style="list-style-type: none"> • union: shared load balancer • 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. The value ranges from 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. <ul style="list-style-type: none"> • 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.

Parameter	Mandatory	Type	Description
kubernetes.io/elb.autocreate	Yes	elb.autocreate object	<p>Whether to automatically create a load balancer associated with an ingress. For details about the field description, see Table 11-38.</p> <p>Example</p> <ul style="list-style-type: none"> If a public network load balancer will be automatically created, set this parameter to the following value: <code>{"type":"public","bandwidth_name":"cce-bandwidth-*****","bandwidth_chargemode":"bandwidth","bandwidth_size":5,"bandwidth_sharetype":"PER","eip_type":"5_bgp","name":"james"}</code> If a private network load balancer will be automatically created, set this parameter to the following value: <code>{"type":"inner","name":"A-location-d-test"}</code>
kubernetes.io/elb.tags	No	String	<p>Whether to add resource tags to a load balancer. This function is available only when the load balancer is automatically created, and the cluster is of v1.23.11-r0, v1.25.6-r0, v1.27.3-r0, or later.</p> <p>A tag is in the format of "key=value". Use commas (,) to separate multiple tags.</p>
host	No	String	<p>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.</p>
path	Yes	String	<p>User-defined route path. All external access requests must match host and path.</p> <p>NOTE</p> <p>The access path added here must exist in the backend application. Otherwise, the forwarding fails.</p> <p>For example, the default access URL of the Nginx application is <code>/usr/share/nginx/html</code>. When adding <code>/test</code> to the ingress forwarding policy, ensure the access URL of your Nginx application contains <code>/usr/share/nginx/html/test</code>. Otherwise, error 404 will be returned.</p>

Parameter	Mandatory	Type	Description
ingress.beta.kubernetes.io/url-match-mode	No	String	<p>Route matching policy.</p> <p>Default: STARTS_WITH (prefix match)</p> <p>Options:</p> <ul style="list-style-type: none"> • EQUAL_TO: exact match • STARTS_WITH: prefix match • REGEX: regular expression match
pathType	Yes	String	<p>Path type. This field is supported only by clusters of v1.23 or later.</p> <ul style="list-style-type: none"> • 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. <p>NOTE</p> <ul style="list-style-type: none"> - 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/. <p>See examples of ingress path matching.</p>

Table 11-38 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
type	No	String	Network type of the load balancer. <ul style="list-style-type: none"> • 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. <ul style="list-style-type: none"> • bandwidth: billed by bandwidth • traffic: billed by traffic Default: bandwidth
bandwidth_size	Yes for public network load balancers	Integer	Bandwidth size. The value ranges from 1 Mbit/s to 2000 Mbit/s by default. Configure this parameter based on the bandwidth range allowed in your region. The minimum increment for bandwidth adjustment varies depending on the bandwidth range. <ul style="list-style-type: none"> • 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.

Parameter	Mandatory	Type	Description
bandwidth_sharetype	Yes for public network load balancers	String	Bandwidth sharing mode. <ul style="list-style-type: none"> • PER: dedicated bandwidth
eip_type	Yes for public network load balancers	String	EIP type. <ul style="list-style-type: none"> • 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. <p>If this parameter is not specified, the ELB load balancer and the cluster are in the same subnet.</p> <p>This field can be specified only for clusters of v1.21 or later.</p>
vip_address	No	String	Private IP address of the load balancer. Only IPv4 addresses are supported. <p>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.</p> <p>This parameter is available only in clusters of v1.23.11-r0, v1.25.6-r0, v1.27.3-r0, or later versions.</p>
available_zone	Yes	Array of strings	AZ where the load balancer is located. <p>This parameter is available only for dedicated load balancers.</p>
l4_flavor_name	Yes	String	Flavor name of the layer-4 load balancer. <p>This parameter is available only for dedicated load balancers.</p>
l7_flavor_name	No	String	Flavor name of the layer-7 load balancer. <p>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.</p>

Parameter	Mandatory	Type	Description
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

- An existing dedicated load balancer must be of the application type (HTTP/HTTPS) and support private networks (with a private IP address).

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 11-39 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.

Parameter	Mandatory	Type	Description
kubernetes.io/elb.class	Yes	String	<p>Load balancer type.</p> <ul style="list-style-type: none"> • union: shared load balancer • performance: dedicated load balancer, which can be used only in clusters of v1.17 and later. <p>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.</p>

11.4.2.3 Configuring a LoadBalancer Ingress Using Annotations

You can add annotations to a YAML file for 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](#)
- [Adding Resource Tags](#)
- [Blocklist/Trustlist](#)
- [Configuring a Custom Listening Port](#)
- [Configuring a Custom Header Forwarding Policy](#)

Interconnection with ELB

Table 11-40 Annotations for interconnecting with ELB

Parameter	Type	Description	Supported Cluster Version
kubernetes.io/elb.class	String	<p>Select a proper load balancer type.</p> <ul style="list-style-type: none"> • union: shared load balancer • performance: dedicated load balancer, which can be used only in clusters of v1.17 and later. 	v1.9 or later

Parameter	Type	Description	Supported Cluster Version
kubernetes.io/ingress.class	String	<ul style="list-style-type: none"> ● cce: A proprietary LoadBalancer ingress is used. ● nginx: Nginx Ingress is used. <p>This parameter is mandatory when an ingress is created by calling the API.</p> <p>For clusters of v1.23 or later, use the parameter ingressClassName. For details, see Using kubectl to Create a LoadBalancer Ingress.</p>	Only clusters of v1.21 or earlier
kubernetes.io/elb.port	String	<p>This parameter indicates the external port registered with the address of the LoadBalancer Service.</p> <p>The value ranges from 1 to 65535.</p> <p>NOTE Some ports are high-risk ports and are blocked by default, for example, port 21.</p>	v1.9 or later
kubernetes.io/elb.id	String	<p>Mandatory when an existing load balancer is to be interconnected.</p> <p>ID of a load balancer.</p> <p>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.</p>	v1.9 or later
kubernetes.io/elb.ip	String	<p>Mandatory when an existing load balancer is to be interconnected.</p> <p>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.</p>	v1.9 or later

Parameter	Type	Description	Supported Cluster Version
kubernetes.io/elb.autocreate	Table 11-49 Object	<p>Mandatory when load balancers are automatically created.</p> <p>Example</p> <ul style="list-style-type: none"> If a public network load balancer will be automatically created, set this parameter to the following value: <pre>{"type":"public","bandwidth_name":"cce-bandwidth-1551163379627","bandwidth_chargemode":"bandwidth","bandwidth_size":5,"bandwidth_sharetype":"PER","eip_type":"5_bgp","name":"james"}</pre> If a private network load balancer will be automatically created, set this parameter to the following value: <pre>{"type":"inner","name":"A-location-d-test"}</pre> 	v1.9 or later
kubernetes.io/elb.subnet-id	String	<p>Optional when load balancers are automatically created.</p> <p>ID of the subnet where the cluster is located. The value can contain 1 to 100 characters.</p> <ul style="list-style-type: none"> 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. 	<p>Mandatory for clusters earlier than v1.11.7-r0</p> <p>Discarded in clusters later than v1.11.7-r0</p>

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 11-41 Annotations of using HTTP/2

Parameter	Type	Description	Supported Cluster Version
kubernetes.io/elb.http2-enable	String	<p>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.</p> <p>Options:</p> <ul style="list-style-type: none"> • true: enabled • false: disabled (default value) <p>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.</p>	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 11-42 ELB certificate annotations

Parameter	Type	Description	Supported Cluster Version
kubernetes.io/elb.tls-certificate-ids	String	<p>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.</p> <p>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.</p>	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 11-43 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 [Configuring HTTPS Backend Services for a LoadBalancer Ingress](#).

Configuring Timeout for an Ingress

Table 11-44 Annotations of configuring ingress redirection rules

Parameter	Type	Description	Supported Cluster Version
kubernetes.io/elb.keepalive_timeout	String	<p>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.</p> <p>Value:</p> <ul style="list-style-type: none"> 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. <p>For UDP listeners, this parameter does not take effect.</p>	<p>Dedicated load balancers: v1.19.16-r30, v1.21.10-r10, v1.23.8-r10, v1.25.3-r10, or later</p> <p>Shared load balancers: v1.23.13-r0, v1.25.8-r0, v1.27.5-r0, v1.28.3-r0, or later</p>

Parameter	Type	Description	Supported Cluster Version
kubernetes.io/elb.client_timeout	String	<p>Timeout for waiting for a request from a client. There are two cases:</p> <ul style="list-style-type: none"> • 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. <p>The value ranges from 1 to 300 (in seconds). The default value is 60.</p> <p>This parameter is available only for HTTP and HTTPS listeners.</p> <p>Minimum value: 1 Maximum value: 300 Default value: 60</p>	<p>Dedicated load balancers: v1.19.16-r30, v1.21.10-r10, v1.23.8-r10, v1.25.3-r10, or later</p> <p>Shared load balancers: v1.23.13-r0, v1.25.8-r0, v1.27.5-r0, v1.28.3-r0, or later</p>
kubernetes.io/elb.member_timeout	String	<p>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.</p> <p>The value ranges from 1 to 300 (in seconds). The default value is 60.</p> <p>This parameter is available only for HTTP and HTTPS listeners.</p> <p>Minimum value: 1 Maximum value: 300 Default value: 60</p>	<p>Dedicated load balancers: v1.19.16-r30, v1.21.10-r10, v1.23.8-r10, v1.25.3-r10, or later</p> <p>Shared load balancers: v1.23.13-r0, v1.25.8-r0, v1.27.5-r0, v1.28.3-r0, or later</p>

For details, see [Configuring Timeout for a LoadBalancer Ingress](#).

Adding Resource Tags

Table 11-45 Annotations

Parameter	Type	Description	Supported Cluster Version
kubernetes.io/elb.tags	String	Add resource tags to a load balancer. This parameter can be configured only when a load balancer is automatically created. A tag is in the format of "key=value". Use commas (,) to separate multiple tags.	v1.23.11-r0, v1.25.6-r0, v1.27.3-r0, or later

For details, see [Creating an Ingress - Automatically Creating a Load Balancer](#).

Blocklist/Trustlist

Table 11-46 Annotations for ELB access control

Parameter	Type	Description	Supported Cluster Version
kubernetes.io/elb.acl-id	String	<ul style="list-style-type: none"> If this parameter is not specified, CCE does not modify access control on the ELB. If this parameter is left empty, all IP addresses are allowed to access the load balancer. If this parameter is set to the IP address group ID of the load balancer, access control is enabled and you need to configure an IP address blocklist or trustlist for the load balancer. Additionally, you need to configure both kubernetes.io/elb.acl-status and kubernetes.io/elb.acl-type. <p>How to obtain:</p> <p>Log in to the console. In the Service List, choose Networking > Elastic Load Balance. On the Network Console, choose Elastic Load Balance > IP Address Groups and copy the ID of the target IP address group.</p>	v1.23.12-r0, v1.25.7-r0, v1.27.4-r0, v1.28.2-r0, or later

Parameter	Type	Description	Supported Cluster Version
kubernetes.io/elb.acl-status	String	Access control status. This parameter is mandatory when you configure an IP address blacklist or trustlist for a load balancer. Options: <ul style="list-style-type: none"> • on: Access control is enabled. • off: Access control is disabled. 	v1.23.12-r0, v1.25.7-r0, v1.27.4-r0, v1.28.2-r0, or later
kubernetes.io/elb.acl-type	String	IP address list type. This parameter is mandatory when you configure an IP address blacklist or trustlist for a load balancer. Options: <ul style="list-style-type: none"> • black: indicates a blacklist. The selected IP address group cannot access the load balancer. • white: indicates a trustlist. Only the selected IP address group can access the load balancer. 	v1.23.12-r0, v1.25.7-r0, v1.27.4-r0, v1.28.2-r0, or later

For details, see [Configuring a Blocklist/Trustlist Access Policy for a LoadBalancer Ingress](#).

Configuring a Custom Listening Port

A custom listening port can be configured for an ingress. In this way, both ports 80 and 443 can be exposed.

Table 11-47 Annotations for a custom listening port

Parameter	Type	Description	Supported Cluster Version
kubernetes.io/elb.listen-ports	String	<p>Create multiple listening ports for an ingress. The port number ranges from 1 to 65535.</p> <p>The following is an example for JSON characters: kubernetes.io/elb.listen-ports: '[{"HTTP":80},{"HTTPS":443}]'</p> <ul style="list-style-type: none"> • Only the listening ports that comply with both HTTP and HTTPS are allowed. • Only newly created ingresses are allowed. Additionally, after multiple listening ports are configured, annotations cannot be modified or deleted. • If both kubernetes.io/elb.listen-ports and kubernetes.io/elb.port are configured, kubernetes.io/elb.listen-ports takes a higher priority. • Ingress configuration items such as the blocklist, trustlist, and timeout concurrently take effect on multiple listening ports. • Advanced forwarding policies are not supported. 	v1.23.14-r0, v1.25.9-r0, v1.27.6-r0, v1.28.4-r0, or later

For example, if an existing ELB is used, the configuration is as follows:

```

apiVersion: networking.k8s.io/v1
kind: Ingress
metadata:
  annotations:
    kubernetes.io/elb.id: 2c623150-17bf-45f1-ae6f-384b036f547e # ID of an existing load balancer
    kubernetes.io/elb.class: performance # Load balancer type
    kubernetes.io/elb.listen-ports: '[{"HTTP": 80}, {"HTTPS": 443}]' # Multi-listener configuration
    kubernetes.io/elb.tls-certificate-ids: 6cfb43c9de1a41a18478b868e34b0a82,6cfb43c9de1a41a18478b868e34b0a82 # HTTPS certificate configuration
  name: test-https
  namespace: default
spec:
  ingressClassName: cce
  rules:
  - host: example.com
    http:
      paths:
      - backend:
          service:
            name: test
            port:
              number: 8888
        path: /
        pathType: ImplementationSpecific

```

property:
ingress.beta.kubernetes.io/url-match-mode: STARTS_WITH

Configuring a Custom Header Forwarding Policy

Table 11-48 Annotations for configuring a custom header forwarding policy

Parameter	Type	Description	Supported Cluster Version
kubernetes.io/elb.headers. <i>{svc_name}</i>	String	<p>Custom header of the Service associated with an ingress. <i>{svc_name}</i> is the Service name.</p> <p>Format: a JSON string, for example, {"key": "test", "values": ["value1", "value2"]}</p> <ul style="list-style-type: none"> • key/value indicates the key-value pair of the custom header. A maximum of eight values can be configured. Enter 1 to 40 characters for a key. Only letters, digits, hyphens (-), and underscores (_) are allowed. Enter 1 to 128 characters for a value. Asterisks (*) and question marks (?) are allowed, but spaces and double quotation marks are not allowed. An asterisk can match zero or more characters, and a question mark can match one character. • Either a custom header or grayscale release can be configured. • Enter 1 to 51 characters for <i>{svc_name}</i>. 	v1.23.16-r0, v1.25.11-r0, v1.27.8-r0, v1.28.6-r0, v1.29.2-r0, or later

For details, see [Configuring a Custom Header Forwarding Policy for a LoadBalancer Ingress](#).

Parameters for Automatically Creating a Load Balancer

Table 11-49 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. <ul style="list-style-type: none"> 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. <ul style="list-style-type: none"> bandwidth: billed by bandwidth traffic: billed by traffic Default: bandwidth
bandwidth_size	Yes for public network load balancers	Integer	Bandwidth size. The value ranges from 1 Mbit/s to 2000 Mbit/s by default. Configure this parameter based on the bandwidth range allowed in your region. The minimum increment for bandwidth adjustment varies depending on the bandwidth range. <ul style="list-style-type: none"> 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.

Parameter	Mandatory	Type	Description
bandwidth_sharetype	Yes for public network load balancers	String	Bandwidth sharing mode. <ul style="list-style-type: none"> • PER: dedicated bandwidth
eip_type	Yes for public network load balancers	String	EIP type. <ul style="list-style-type: none"> • 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. <p>If this parameter is not specified, the ELB load balancer and the cluster are in the same subnet.</p> <p>This field can be specified only for clusters of v1.21 or later.</p>
vip_address	No	String	Private IP address of the load balancer. Only IPv4 addresses are supported. <p>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.</p> <p>This parameter is available only in clusters of v1.23.11-r0, v1.25.6-r0, v1.27.3-r0, or later versions.</p>
available_zone	Yes	Array of strings	AZ where the load balancer is located. <p>This parameter is available only for dedicated load balancers.</p>
l4_flavor_name	Yes	String	Flavor name of the layer-4 load balancer. <p>This parameter is available only for dedicated load balancers.</p>
l7_flavor_name	No	String	Flavor name of the layer-7 load balancer. <p>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.</p>

Parameter	Mandatory	Type	Description
elb_virsubnet_ids	No	Array of strings	<p>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.</p> <p>Example:</p> <pre>"elb_virsubnet_ids": ["14567f27-8ae4-42b8-ae47-9f847a4690dd"]</pre>

11.4.2.4 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 access 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/v1 beta1
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": [
          "eu-west-0a"
        ],
        "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": [
          "eu-west-0a"
        ],
        "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 11-50 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: <ul style="list-style-type: none"> • tls-1-0 • tls-1-1 • tls-1-2 • tls-1-2-strict For details of cipher suites for each security policy, see Table 11-51 .
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 11-51 `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	ECDHE-RSA-AES256-GCM-SHA384:ECDHE-ECDSA-AES128-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-1-2	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:ECDHE-ECDSA-AES128-SHA:ECDHE-RSA-AES128-SHA:ECDHE-RSA-AES256-SHA:ECDHE-ECDSA-AES256-SHA:AES128-SHA:AES256-SHA

Security Policy	TLS Version	Cipher Suite
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/v1 beta1
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 11-52 Key parameters

Parameter	Type	Description
kubernetes.io/elb.tls-certificate-ids	String	<p>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.</p> <p>If an SNI certificate cannot be found based on the domain name requested by the client, the server certificate will be returned by default.</p> <p>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.</p>

11.4.2.5 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": [
        "eu-west-0a"
      ],
      "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": [
        "eu-west-0a"
      ],
      "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
```

11.4.2.6 Routing a LoadBalancer Ingress 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
```


11.4.2.7 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 HTTP/2 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.
- After HTTP/2 is configured, if you delete the advanced configuration for enabling HTTP/2 on the CCE console or delete the target annotation from the YAML file, the configuration on the ELB will be retained.

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 11-53 HTTP/2 parameters

Parameter	Man dato ry	Type	Description
kubernetes.io/ elb.http2-enable	No	String	<p>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.</p> <p>Options:</p> <ul style="list-style-type: none"> • true: enabled • false: disabled (default value) <p>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.</p>

11.4.2.8 Configuring HTTPS Backend Services for a LoadBalancer Ingress

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
```

Notes and 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
```

11.4.2.9 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.

Notes and 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	<ul style="list-style-type: 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
Request Timeout	Dedicated	
Response Timeout	Dedicated	
Idle Timeout	Shared	<ul style="list-style-type: none"> • v1.23: v1.23.13-r0 or later • v1.25: v1.25.8-r0 or later • v1.27: v1.27.5-r0 or later • v1.28: v1.28.3-r0 or later • Other clusters of later versions
Request Timeout	Shared	
Response Timeout	Shared	

- If you delete the timeout configuration during an ingress update, the timeout configuration on the existing listeners will be retained.

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 **Services & Ingresses**. Click the **Ingresses** tab and click **Create Ingress** in the upper right corner.

Step 3 Configure ingress parameters. In this example, only mandatory parameters are listed. For details about how to configure other parameters, see [Creating a LoadBalancer Ingress on the Console](#).

- **Name:** can be the same as the workload name.
- **Load Balancer:** Select a load balancer type and creation mode.
 - A load balancer can be dedicated or shared.
 - This section uses an existing load balancer as an example. For details about the parameters for automatically creating a load balancer, see [load balancers](#).
- **Listener**
 - **External Protocol:** **HTTP** and **HTTPS** are available. This section uses HTTP as an example.
 - **External Port:** port number that is open to the ELB service address. The port number is configurable.
 - **Advanced Options**

Configuration	Description
Idle Timeout	Timeout for an idle client connection. 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.
Request Timeout	Timeout for waiting for a request from a client. There are two cases: <ul style="list-style-type: none"> ▪ 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.
Response Timeout	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 during the timeout duration, the load balancer will stop waiting and return HTTP 504 Gateway Timeout.

- **Forwarding Policy:** Specify a domain name matching rule and the target Service to be accessed. 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 will be forwarded to the target Service for processing.

Step 4 Click **OK**.

----End

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 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 11-54 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 .

Parameter	Mandatory	Type	Description
kubernetes.io/elb.client_timeout	No	String	<p>Timeout for waiting for a request from a client. There are two cases:</p> <ul style="list-style-type: none"> • 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. <p>The value ranges from 1 to 300 (in seconds). The default value is 60.</p>
kubernetes.io/elb.member_timeout	No	String	<p>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.</p> <p>The value ranges from 1 to 300 (in seconds). The default value is 60.</p>

11.4.2.10 Configuring a Blocklist/Trustlist Access Policy for a LoadBalancer Ingress

You can add IP addresses to a trustlist or blocklist to control access to a listener of a LoadBalancer ingress.

- Trustlist: Only the IP addresses in the list can access the listener.
- Blocklist: The IP addresses in the list are not allowed to access the listener.

Prerequisites

- A Kubernetes cluster is available and the cluster version meets the following requirements:
 - v1.23: v1.23.12-r0 or later
 - v1.25: v1.25.7-r0 or later
 - v1.27: v1.27.4-r0 or later
 - v1.28: v1.28.2-r0 or later
 - Other clusters of later versions
- An IP address group has been created on the ELB console. For details, see .

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 **Services & Ingresses** in the navigation pane, click the **Ingresses** tab, and click **Create Ingress** in the upper right corner.

Step 3 Configure access control parameters for the ingress.

- **Inherit ELB Configurations:** CCE does not modify the existing access control configurations on the ELB console.
- **Allow all IP addresses:** No access control is configured.
- **Trustlist:** Only the selected IP address group can access the load balancer.
- **Blocklist:** The selected IP address group cannot access the load balancer.

For details about how to configure other parameters, see [Creating a LoadBalancer Ingress on the Console](#).

Step 4 Click **OK**.

----End

Using kubectl

An example YAML file of an ingress created using an existing load balancer is as follows:

```
apiVersion: networking.k8s.io/v1
kind: Ingress
metadata:
  name: ingress-test
  annotations:
    kubernetes.io/elb.id: <your_elb_id>           # Load balancer ID. Replace it with the actual value.
    kubernetes.io/elb.class: performance         # Load balancer type
    kubernetes.io/elb.port: 80                  # External port of the load balancer listener
    kubernetes.io/elb.acl-id: <your_acl_id>     # ID of an IP address group for accessing a load
balancer
    kubernetes.io/elb.acl-status: 'on'          # Enable access control.
    kubernetes.io/elb.acl-type: 'white'        # Trustlist for access control
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 11-55 Annotations for ELB access control

Parameter	Type	Description
kubernetes.io/elb.acl-id	String	<ul style="list-style-type: none"> If this parameter is not specified, CCE does not modify access control on the ELB. If this parameter is left empty, all IP addresses are allowed to access the load balancer. If this parameter is set to the IP address group ID of the load balancer, access control is enabled and you need to configure an IP address blacklist or trustlist for the load balancer. Additionally, you need to configure both kubernetes.io/elb.acl-status and kubernetes.io/elb.acl-type. How to obtain: Log in to the console. In the Service List, choose Networking > Elastic Load Balance. On the Network Console, choose Elastic Load Balance > IP Address Groups and copy the ID of the target IP address group.
kubernetes.io/elb.acl-status	String	<p>This parameter is mandatory when you configure an IP address blacklist or trustlist for a load balancer. Options:</p> <ul style="list-style-type: none"> on: Access control is enabled. off: Access control is disabled.
kubernetes.io/elb.acl-type	String	<p>This parameter is mandatory when you configure an IP address blacklist or trustlist for a load balancer. Options:</p> <ul style="list-style-type: none"> black: indicates a blacklist. The selected IP address group cannot access the load balancer. white: indicates a trustlist. Only the selected IP address group can access the load balancer.

11.4.2.11 Configuring a Custom Header Forwarding Policy for a LoadBalancer Ingress

Dedicated load balancer ingresses support custom header forwarding policies. You can configure different header key-value pairs to determine the backend Service to which data is forwarded.

Prerequisites

A cluster meeting the following requirements is available:

- v1.23: v1.23.16-r0 or later
- v1.25: v1.25.11-r0 or later
- v1.27: v1.27.8-r0 or later
- v1.28: v1.28.6-r0 or later
- v1.29: v1.29.2-r0 or later

Using kubectl

An example YAML file of an ingress created using an existing load balancer is as follows:

```
apiVersion: networking.k8s.io/v1
kind: Ingress
metadata:
  name: test-header
  namespace: default
  annotations:
    kubernetes.io/elb.port: '80'
    kubernetes.io/elb.id: 08eab934-1636-4d90-a4cd-cb3fa4330411
    kubernetes.io/elb.class: performance # A dedicated load balancer is required.
    # Path /a can be accessed only through Header key1=value1 or key1=value2. The accessed Service is
    svc-a:80.
    kubernetes.io/elb.headers.svc-a: |
      {
        "key": "key1",
        "values": [
          "value1",
          "value2"
        ]
      }
    # Path /b can be accessed only through Header key2=value1 or key2=value2. The accessed Service is
    svc-b:81.
    kubernetes.io/elb.headers.svc-b: |
      {
        "key": "key2",
        "values": [
          "value1",
          "value2"
        ]
      }
spec:
  rules:
    - host: ""
      http:
        paths:
          - path: /a
            backend:
              service:
                name: svc-a
                port:
                  number: 80
            property:
              ingress.beta.kubernetes.io/url-match-mode: STARTS_WITH
            pathType: ImplementationSpecific
          - path: /b
            backend:
              service:
                name: svc-b
                port:
                  number: 81
            property:
              ingress.beta.kubernetes.io/url-match-mode: STARTS_WITH
```

pathType: ImplementationSpecific
ingressClassName: cce

Table 11-56 Annotations for configuring a custom header forwarding policy

Parameter	Type	Description
kubernetes.io/elb.headers.\$ {svc_name}	String	<p>Custom header of the Service associated with an ingress. <i>{svc_name}</i> is the Service name.</p> <p>Format: a JSON string, for example, {"key": "test", "values": ["value1", "value2"]}</p> <ul style="list-style-type: none"> • key/value indicates the key-value pair of the custom header. A maximum of eight values can be configured. Enter 1 to 40 characters for a key. Only letters, digits, hyphens (-), and underscores (_) are allowed. Enter 1 to 128 characters for a value. Asterisks (*) and question marks (?) are allowed, but spaces and double quotation marks are not allowed. An asterisk can match zero or more characters, and a question mark can match one character. • Either a custom header or grayscale release can be configured. • Enter 1 to 51 characters for <i>{svc_name}</i>.

11.4.3 Nginx Ingresses

11.4.3.1 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 Nginx Ingress, ensure that the Nginx Ingress Controller add-on has been installed in the cluster. For details, see [Installing the Add-on](#).

Notes and 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:** Customize the 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.
 - **Ingress Class:** Select the name of the Nginx Ingress controller installed in the cluster. You can **install multiple Nginx Ingress controllers** and customize controller names as needed.
 - **External Protocol:** The options are **HTTP** and **HTTPS**. The default number of the listening port reserved when Nginx Ingress Controller is installed is 80 for HTTP and 443 for HTTPS. To use HTTPS, configure a certificate.
 - **Certificate Source:** source of a certificate for encrypting and authenticating HTTPS data transmission.
 - If you select a TLS key, you must create a key certificate of the IngressTLS or kubernetes.io/tls type beforehand. For details, see **Creating a Secret**.
 - If you select the default certificate, Nginx Ingress Controller will use its default certificate for encryption and authentication. You can configure the default certificate during **NGINX Ingress Controller** installation. If the default certificate is not configured, the certificate provided by Nginx Ingress Controller will be used.
 - **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.
 - **Path 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.
 - **Path:** 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 Click **OK**.

After the ingress is created, it is displayed in the ingress list.

----End

11.4.3.2 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

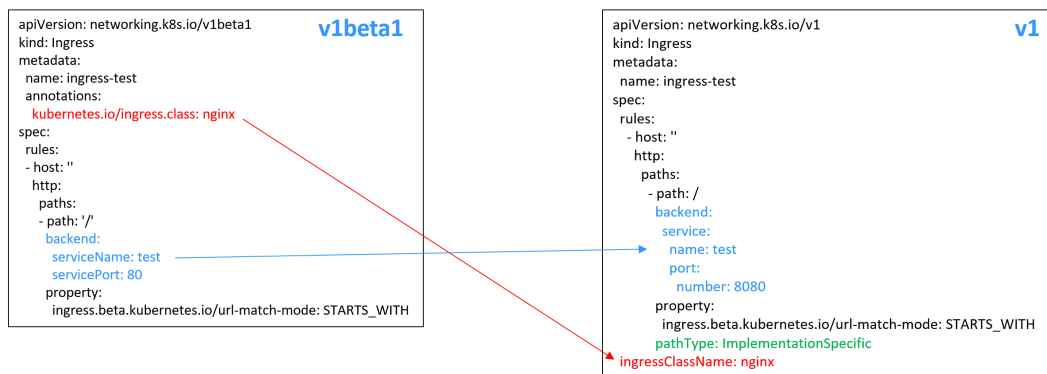
- The Nginx Ingress Controller add-on has been installed in a cluster. For details, see [Installing the Add-on](#).
- An ingress provides network access for backend workloads. Ensure that a workload is available in a cluster. If no workload is available, deploy a workload by referring to [Creating a 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 access 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 11-57 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 is available only after the NGINX Ingress Controller add-on is 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 is available only after the NGINX Ingress Controller add-on is 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	<p>User-defined route path. All external access requests must match host and path.</p> <p>NOTE</p> <ul style="list-style-type: none"> 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	<p>Route matching policy.</p> <p>Default: STARTS_WITH (prefix match)</p> <p>Options:</p> <ul style="list-style-type: none"> EQUAL_TO: exact match STARTS_WITH: prefix match

Parameter	Mandatory	Type	Description
pathType	Yes	String	<p>Path type. This field is supported only by clusters of v1.23 or later.</p> <ul style="list-style-type: none"> • 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. <p>NOTE</p> <ul style="list-style-type: none"> - 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/. <p>See examples of ingress path matching.</p>

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 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

11.4.3.3 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 Ingress supports native annotations of the community. For details, see [Annotations](#).
- [Ingress Type](#)
- [Interconnecting with HTTPS Backend Services](#)
- [Creating a Consistent Hashing Rule for Load Balancing](#)
- [Customized Timeout Interval](#)
- [Customizing a Body Size](#)
- [Two-Way HTTPS Authentication](#)
- [Domain Name Regularization](#)
- [Documentation](#)

Ingress Type

Table 11-58 Ingress type annotations

Parameter	Type	Description	Supported Cluster Version
kubernetes.io/ingress.class	String	<ul style="list-style-type: none"> nginx: Nginx Ingress is used. cce: A proprietary LoadBalancer ingress is used. <p>This parameter is mandatory when an ingress is created by calling the API.</p> <p>For clusters of v1.23 or later, use the parameter ingressClassName. For details, see Using kubectl to Create an Nginx Ingress.</p>	Only clusters of v1.21 or earlier

For details about how to use the preceding annotations, see [Using kubectl to Create an Nginx Ingress](#).

Interconnecting with HTTPS Backend Services

Table 11-59 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 [Configuring HTTPS Backend Services for an Nginx Ingress](#).

Creating a Consistent Hashing Rule for Load Balancing

Table 11-60 Annotation of consistent hashing for load balancing

Parameter	Type	Description
nginx.ingress.kubernetes.io/upstream-hash-by	String	<p>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:</p> <ul style="list-style-type: none"> • 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 [Configuring Consistent Hashing for Load Balancing of an Nginx Ingress](#).

Customized Timeout Interval

Table 11-61 Customized timeout interval annotations

Parameter	Type	Description
nginx.ingress.kubernetes.io/proxy-connect-timeout	String	<p>Customized connection timeout interval. You do not need to set the unit when setting the timeout interval. The default unit is second.</p> <p>Example: nginx.ingress.kubernetes.io/proxy-connect-timeout: '120'</p>

Customizing a Body Size

Table 11-62 Annotations of customizing a body size

Parameter	Type	Description
nginx.ingress.kubernetes.io/proxy-body-size	String	<p>When the body size in a request exceeds the upper limit, error 413 will be returned to the client. You can use this parameter to adjust the upper limit of the body size. The basic unit of the parameter value is byte. You can use units such as KB, MB, and GB. The unit conversion is as follows:</p> <p>1 KB = 1024 bytes, 1 MB = 1024 KB, 1 GB =1024 MB</p> <p>Example: nginx.ingress.kubernetes.io/proxy-body-size: 8m</p>

Two-Way HTTPS Authentication

Nginx Ingress supports two-way HTTPS authentication between the server and client to ensure secure connections.

Step 1 Use kubectl to access the cluster. For details, see [Connecting to a Cluster Using kubectl](#).

Step 2 Run the following command to create a self-signed CA certificate:

```
openssl req -x509 -sha256 -newkey rsa:4096 -keyout ca.key -out ca.crt -days 356 -nodes -subj '/CN=Ingress Cert Authority'
```

Expected output:

```
Generating a RSA private key
.....++++
.....++++
writing new private key to 'ca.key'
-----
```

Step 3 Create a server certificate.

1. Run the following command to create a request file for generating a server certificate:

```
openssl req -new -newkey rsa:4096 -keyout server.key -out server.csr -nodes -subj '/CN=foo.bar.com'
```

Expected output:

```
Generating a RSA private key
.....++++
.....++++
writing new private key to 'server.key'
-----
```

2. Run the following command to issue the server request file using the root certificate to generate the server certificate:

```
openssl x509 -req -sha256 -days 365 -in server.csr -CA ca.crt -CAkey ca.key -set_serial 01 -out server.crt
```

Expected output:

```
Signature ok
subject=CN = foo.bar.com
Getting CA Private Key
```

Step 4 Create a client certificate.

1. Run the following command to create a request file for generating a client certificate:

```
openssl req -new -newkey rsa:4096 -keyout client.key -out client.csr -nodes -subj '/CN=Ingress'
```

Expected output:

```
Generating a RSA private key
.....++++
.....++++
writing new private key to 'client.key'
-----
```

2. Run the following command to issue the client request file using the root certificate to generate the client certificate:

```
openssl x509 -req -sha256 -days 365 -in client.csr -CA ca.crt -CAkey ca.key -set_serial 02 -out client.crt
```

Expected output:

```
Signature ok
subject=CN = Ingress
Getting CA Private Key
```

Step 5 Run the **ls** command to check the created certificates.

Expected output:

```
ca.crt ca.key client.crt client.csr client.key server.crt server.csr server.key
```

Step 6 Run the following command to create a secret of the CA certificate:

```
kubectl create secret generic ca-secret --from-file=ca.crt=ca.crt
```

Expected output:

```
secret/ca-secret created
```

Step 7 Run the following command to create a secret of the server certificate:

```
kubectl create secret generic tls-secret --from-file=tls.crt=server.crt --from-file=tls.key=server.key
```

Expected output:

```
secret/tls-secret created
```

Step 8 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:
  annotations:
    nginx.ingress.kubernetes.io/auth-tls-verify-client: "on"
    nginx.ingress.kubernetes.io/auth-tls-secret: "default/ca-secret" # Replace it with your CA
certificate secret.
    nginx.ingress.kubernetes.io/auth-tls-verify-depth: "1"
    nginx.ingress.kubernetes.io/auth-tls-pass-certificate-to-upstream: "true"
  name: ingress-test
  namespace: default
spec:
  rules:
  - host: foo.bar.com
    http:
      paths:
      - backend:
          service:
            name: nginx-test # Replace it with the name of your target Service.
            port:
              number: 80 # Replace it with the port of your target Service.
```

```

path: /
pathType: ImplementationSpecific
tls:
- hosts:
- foo.bar.com
secretName: tls-secret # Replace it with your TLS certificate secret.
ingressClassName: nginx

```

- **For clusters of v1.21 or earlier:**

```

apiVersion: networking.k8s.io/v1beta1
kind: Ingress
metadata:
annotations:
kubernetes.io/ingress.class: nginx
nginx.ingress.kubernetes.io/auth-tls-verify-client: "on"
nginx.ingress.kubernetes.io/auth-tls-secret: "default/ca-secret" # Replace it with your CA
certificate secret.
nginx.ingress.kubernetes.io/auth-tls-verify-depth: "1"
nginx.ingress.kubernetes.io/auth-tls-pass-certificate-to-upstream: "true"
name: ingress-test
namespace: default
spec:
rules:
- host: foo.bar.com
http:
paths:
- path: '/'
backend:
serviceName: nginx-test # Replace it with the name of your target Service.
servicePort: 80 # Replace it with the port of your target Service.
tls:
- hosts:
- foo.bar.com
secretName: tls-secret # Replace it with your TLS key certificate.

```

Step 9 Run the following command to create an ingress:

```
kubectl create -f ingress-test.yaml
```

Expected output:

```
ingress.networking.k8s.io/ingress-test created
```

Step 10 Run the following command to obtain the IP address of the ingress:

```
kubectl get ingress
```

Expected output:

NAME	CLASS	HOSTS	ADDRESS	PORTS	AGE
nginx-test	nginx	foo.bar.com	10.3.xx.xx	80, 443	27m

Step 11 Run the following command to update the IP address of the ingress into the **hosts** file and replace the following IP address with the actual IP address of the ingress:

```
echo "10.3.xx.xx foo.bar.com" | sudo tee -a /etc/hosts
```

Expected output:

```
10.3.xx.xx foo.bar.com
```

Step 12 Verify the configuration.

- The client does not send the certificate for access.

```
curl --cacert ./ca.crt https://foo.bar.com
```

Expected output:

```

<html>
<head><title>400 No required SSL certificate was sent</title></head>
<body>
<center><h1>400 Bad Request</h1></center>
<center>No required SSL certificate was sent</center>

```

```
<hr><center>nginx</center>
</body>
</html>
```

- The client sends the certificate for access.

```
curl --cacert ./ca.crt --cert ./client.crt --key ./client.key https://foo.bar.com
```

Expected output:

```
<!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

Domain Name Regularization

Nginx Ingress allows you to configure the **nginx.ingress.kubernetes.io/server-alias** annotation to configure regular expressions for domain names.

Step 1 Use kubectl to access 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
```

For example, the regular expression **~^www\.\d+\.example\.com** **,\$abc.example.com** indicates that you can access the ingress using **www.{One or more digits}.example.com** and **abc.example.com**.

- **For clusters of v1.23 or later:**

```
apiVersion: networking.k8s.io/v1
kind: Ingress
metadata:
  annotations:
    nginx.ingress.kubernetes.io/server-alias: '~^www\.\d+\.example\.com,$abc.example.com'
  name: ingress-test
  namespace: default
spec:
  rules:
  - host: foo.bar.com
    http:
      paths:
      - backend:
          service:
```



```

name: nginx-93244 # Replace it with the name of your target Service.
port:
  number: 80 # Replace it with the port of your target Service.
path: /
pathType: ImplementationSpecific
ingressClassName: nginx

```

- **For clusters of v1.21 or earlier:**

```

apiVersion: networking.k8s.io/v1beta1
kind: Ingress
metadata:
  annotations:
    kubernetes.io/ingress.class: nginx
    nginx.ingress.kubernetes.io/server-alias: '~^www\.\d+\.example\.com$,abc.example.com'
  name: ingress-test
  namespace: default
spec:
  rules:
  - host: foo.bar.com
    http:
      paths:
      - path: '/'
        backend:
          serviceName: nginx-test # Replace it with the name of your target Service.
          servicePort: 80 # Replace it with the port of your target Service.

```

Step 3 Run the following command to create an ingress:

```
kubectl create -f ingress-test.yaml
```

Expected output:

```
ingress.networking.k8s.io/ingress-test created
```

Step 4 Check the Nginx Ingress Controller configuration.

1. Run the following command to check the Nginx Ingress Controller pods:

```
kubectl get pods -n kube-system | grep nginx-ingress-controller
```

Expected output:

```

cceaddon-nginx-ingress-controller-68d7bcc67-dxxxx    1/1    Running    0    18h
cceaddon-nginx-ingress-controller-68d7bcc67-cxxxx    1/1    Running    0    18h

```

2. Run the following command to check the Nginx Ingress Controller configuration:

```
kubectl exec -n kube-system cceaddon-nginx-ingress-controller-68d7bcc67-dxxxx cat /etc/nginx/nginx.conf | grep -C3 "foo.bar.com"
```

Expected output:

```

## start server foo.bar.com
server {
    server_name foo.bar.com abc.example.com ~^www\.\d+\.example\.com$ ;

    listen 80 ;
    listen [::]:80 ;
--
}
}
## end server foo.bar.com

```

Step 5 Run the following command to obtain the IP address of the ingress:

```
kubectl get ingress
```

Expected output:

NAME	CLASS	HOSTS	ADDRESS	PORTS	AGE
nginx-test	nginx	foo.bar.com	10.3.xx.xx	80	14m

Step 6 Use different rules to test service access.

- Run the following command to access the service through **Host: foo.bar.com:**

```
curl -H "Host: foo.bar.com" 10.3.xx.xx/
```

It is expected that the web page can be accessed properly.

- Run the following command to access the service through **Host: www.123.example.com:**

```
curl -H "Host: www.123.example.com" 10.3.xx.xx/
```

It is expected that the web page can be accessed properly.

- Run the following command to access the service through **Host: www.321.example.com:**

```
curl -H "Host: www.321.example.com" 10.3.xx.xx/
```

It is expected that the web page can be accessed properly.

----End

Documentation

For details about annotation parameters supported by Nginx Ingress, see [Annotations](#).

11.4.3.4 Configuring an HTTPS Certificate for an Nginx Ingress

HTTPS certificates can be configured for ingresses to provide security services.

- Step 1** Use `kubectl` to access 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

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 it 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

11.4.3.5 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 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 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 redirection 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.
```

11.4.3.6 Configuring URL Rewriting Rules for an Nginx Ingress

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 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/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 it 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.

NOTE

Snippet is not enabled by default when the Nginx Ingress Controller version is 2.4.6 or later (corresponding to the community version v1.9.3). For details, see [Changelog](#). If snippet is needed, enable it using [allow-snippet-annotations](#).

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`.

11.4.3.7 Configuring HTTPS Backend Services for an Nginx Ingress

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 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/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 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/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 it with the port number of your target Service.
```

11.4.3.8 Configuring Consistent Hashing for Load Balancing of an Nginx Ingress

The native Nginx supports multiple load balancing rules, including weighted round robin and IP hash. 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 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

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 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/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 it 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](#)

11.5 DNS

11.5.1 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.

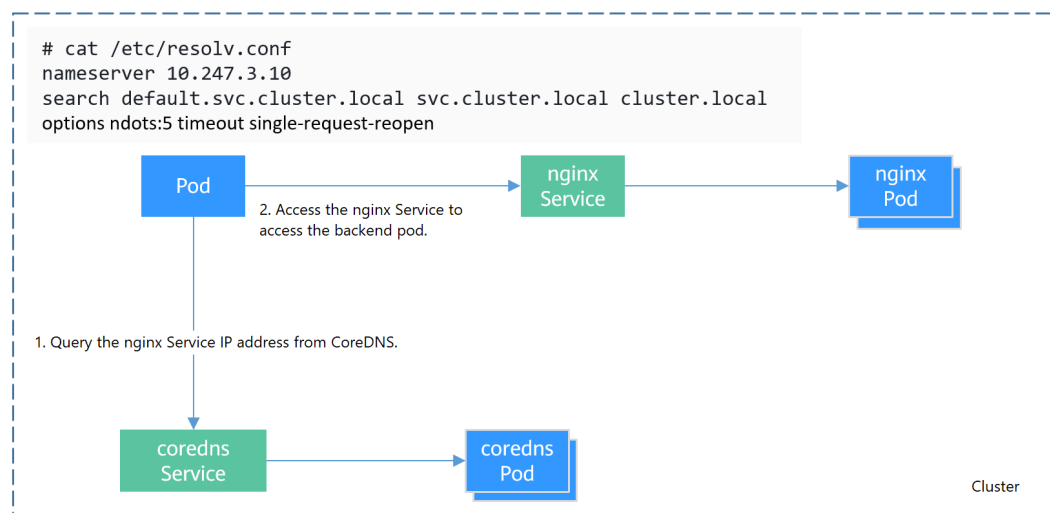
```
$ kubectl get svc -n kube-system
NAME      TYPE        CLUSTER-IP   EXTERNAL-IP   PORT(S)          AGE
coredns   ClusterIP   10.247.3.10  <none>        53/UDP,53/TCP,8080/TCP   13d
```

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 11-24 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.

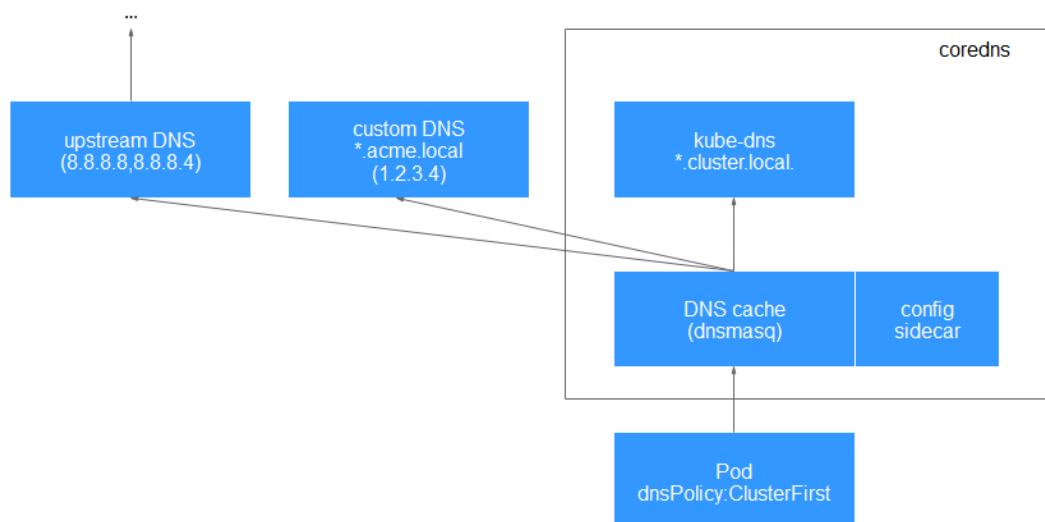
Routing

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 11-25 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](#).

11.5.2 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 11-63](#).
 - **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 of DNS Server:** **nameservers** in **dnsConfig**. You can configure a domain name server for a 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.

- **Host Alias:** Add the mapping between domain names and IP addresses to the local configuration file **/etc/hosts** of a pod for simplified local domain name resolution. For details, see [Adding entries to Pod /etc/hosts with HostAliases](#)

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 11-63 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.
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 11-64 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
```

11.5.3 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 {$POD_IP}
  cache 30 {
    servfail 5s
  }
  errors
  health {$POD_IP}:8080
  kubernetes cluster.local in-addr.arpa ip6.arpa {
    pods insecure
    fallthrough in-addr.arpa ip6.arpa
  }
  loadbalance round_robin
  prometheus {$POD_IP}:9153
  forward . /etc/resolv.conf {
    policy random
  }
  reload
  ready {$POD_IP}:8081
}
consul.local:5353 {
  bind {$POD_IP}
  errors
  cache 30
  forward . 10.150.0.1
}
```

----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

11.5.4 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:

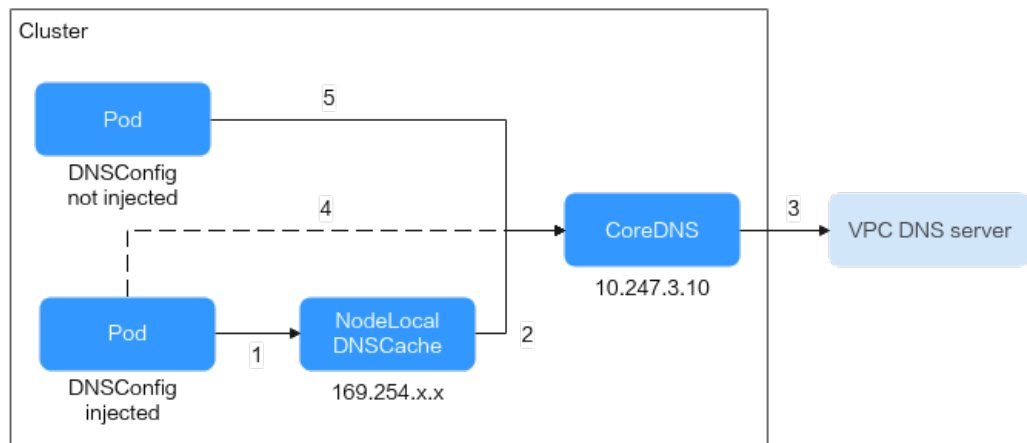
- Increased delay: CoreDNS needs to process more requests, which may slow down the DNS query and affect service performance.
- Increased resource usage: To ensure DNS performance, CoreDNS requires higher specifications.

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's load and improves the cluster DNS performance.

After NodeLocal DNSCache is enabled, a DNS query goes through the path as shown below.

Figure 11-26 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.

Notes and 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 modify the following content in 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.

- **DNSConfig Automatic Injection:** After this function is enabled, a DNSConfig admission controller will be created. The controller intercepts pod creation requests in the namespace labeled with **node-local-dns-injection=enabled** based on admission webhooks and automatically configures DNSConfig for pods. 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. (This function is not available for pods in 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
```

11.6 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.

```
kubectrl 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.

```
$ kubectrl 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 over the intranet include RDS, DCS, Kafka, and RabbitMQ.

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 trustlist. 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 trustlist.

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 trustlist is configured for the peer server. For example, the DCS Redis instance can be accessed only by the IP addresses in its trustlist. Add the container and node CIDR blocks to the trustlist.
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.

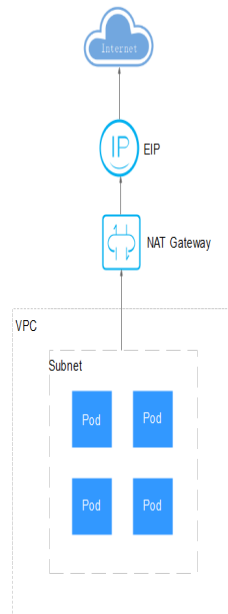
11.7 Accessing the Internet from a Container

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 11-27](#) 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 11-27 SNAT



To enable a container to access the Internet, perform the following steps:


Step 1 Obtain 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. Click  in the upper left corner and choose **Networking** > **NAT Gateway** in the expanded list.
2. On the **Public Network Gateways** page, click **Create Public NAT Gateway** in the upper right corner.
3. Configure parameters as required.

 **NOTE**

Select the same VPC.

Step 3 Configure an SNAT rule and bind the EIP to the subnet.

1. On the page displayed, click the name of the NAT gateway for which you want to add the SNAT rule.
2. On the **SNAT Rules** tab page, click **Add SNAT Rule**.
3. 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.
- Cloud Native Network 2.0: Select the subnet where the container is located, that is, the container subnet selected during cluster 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 container subnet (Cloud Native 2.0 network) or 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**

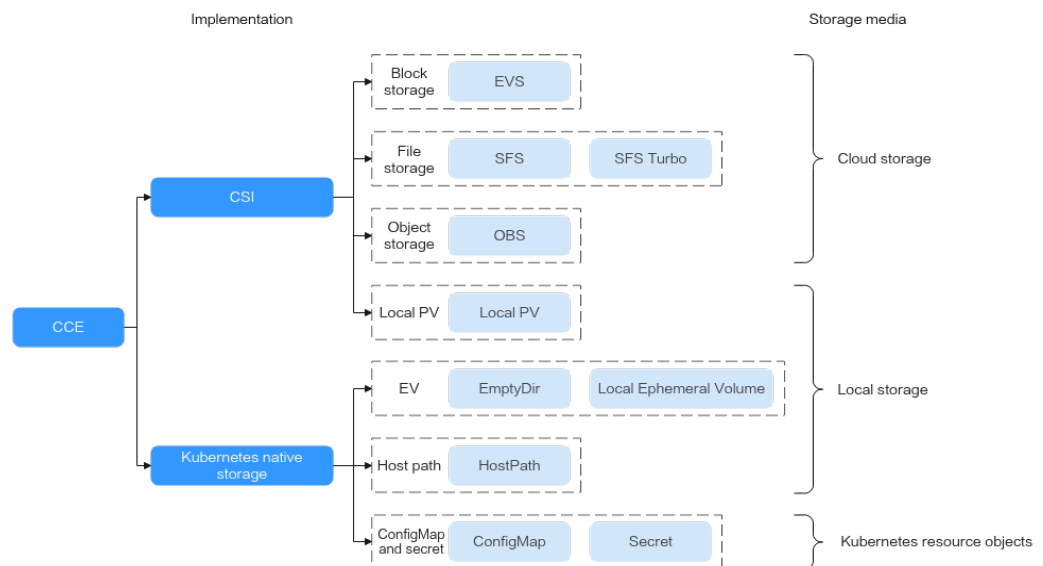
12 Storage

12.1 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.

Figure 12-1 Container storage types



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 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 PV 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	SFS Turbo	OBS	DSS
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 petabytes, SFS provides fully hosted shared file storage, highly available and stable to handle data- and bandwidth-intensive applications in HPC, media processing, file sharing, content management, and web services.	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.	Dedicated Distributed Storage Service (DSS) provides dedicated physical storage resources. With data redundancy and cache acceleration technologies, DSS delivers highly reliable, durable, low-latency, and stable storage resources.
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 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.	Stores binary data and cannot directly store files. To store files, format the file system first.

Item	EVS	SFS	SFS Turbo	OBS	DSS
Access mode	Accessible only after being attached to ECSs and initialized.	Mounted to ECSs using network protocols. A network address must be specified or mapped to a local directory for access.	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.	Accessible only after being mounted to ECSs and initialized.
Static storage volumes	Supported. For details, see Using an Existing EVS Disk Through a Static PV.	Supported. For details, see Using an Existing SFS File System 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.	Supported. For details, see Using DSS Through a Static PV.
Dynamic storage volumes	Supported. For details, see Using an EVS Disk Through a Dynamic PV.	Supported. For details, see Using an SFS File System Through a Dynamic PV.	Not supported	Supported. For details, see Using an OBS Bucket Through a Dynamic PV.	Supported. For details, see Using DSS Through a Dynamic PV.
Features	Non-shared storage. Each volume can be mounted to only one node.	Shared storage featuring high performance and throughput	Shared storage featuring high performance and bandwidth	Shared, user-mode file system	Non-shared storage. Each volume can be mounted to only one node.

Item	EVS	SFS	SFS Turbo	OBS	DSS
Application scenarios	<p>HPC, enterprise core cluster applications, enterprise application systems, and dev/test</p> <p>NOTE HPC apps here require high-speed and high-IOPS storage, such as industrial design and energy exploration.</p>	<p>HPC, media processing, content management, web services, big data, and analysis applications</p> <p>NOTE HPC apps here require high bandwidth and shared file storage, such as gene sequencing and image rendering.</p>	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)	<ul style="list-style-type: none"> Hybrid deployment of multiple applications, including HPC, database, email, office applications, and web applications HPC OLAP applications
Capacity	TB	SFS 1.0: PB	General-purpose: TB	EB	TB
Latency	1–2 ms	SFS 1.0: 3–20 ms	General-purpose: 1–5 ms	10 ms	1–3 ms
Max. IOPS	2200–256000, depending on flavors	SFS 1.0: 2000	General-purpose: up to 100,000	Tens of millions	1500–8000, depending on flavors
Bandwidth	MB/s	SFS 1.0: GB/s	General-purpose: up to GB/s	TB/s	MB/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 medium 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 medium. 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 PV. Storage volumes are non-shared storage and bound to nodes through labels. Therefore, storage volumes can be mounted only to a single pod.	Local ephemeral volume. The storage space is from local LVs.	Local ephemeral 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.	<ul style="list-style-type: none"> 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 	<ul style="list-style-type: none"> 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 	<p>Requiring a node file, for example, if Docker is used, you can use hostPath to mount the /var/lib/docker path of the node.</p> <p>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.</p>

Documentation

- [Storage Basics](#)
- [Elastic Volume Service](#)
- [Scalable File Service](#)
- [SFS Turbo](#)
- [Object Storage Service](#)

12.2 Storage Basics

Volumes

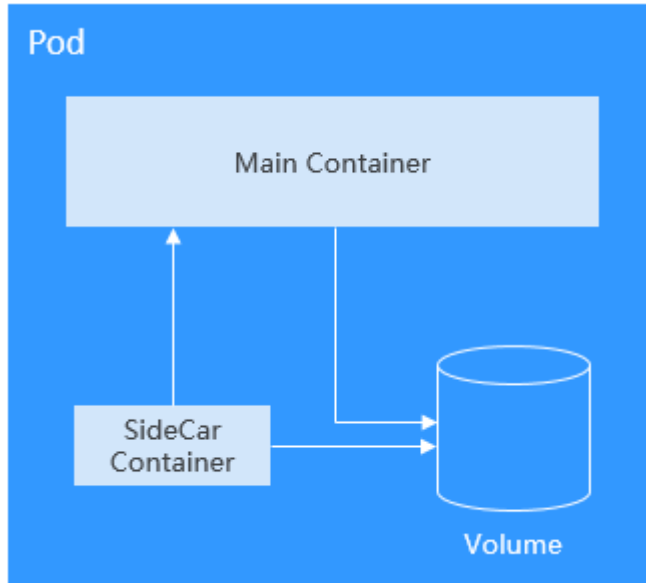
On-disk files in a container are ephemeral, which presents the following problems to important applications running in the container:

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	<p>Maintained through the Kubernetes code repository and built, edited, and released with Kubernetes binary files. Kubernetes does not accept this volume type anymore.</p> <p>Kubernetes-native volumes such as hostPath, emptyDir, Secret, and ConfigMap are all the in-tree type.</p> <p>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.</p>
Out-of-tree	<p>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.</p>

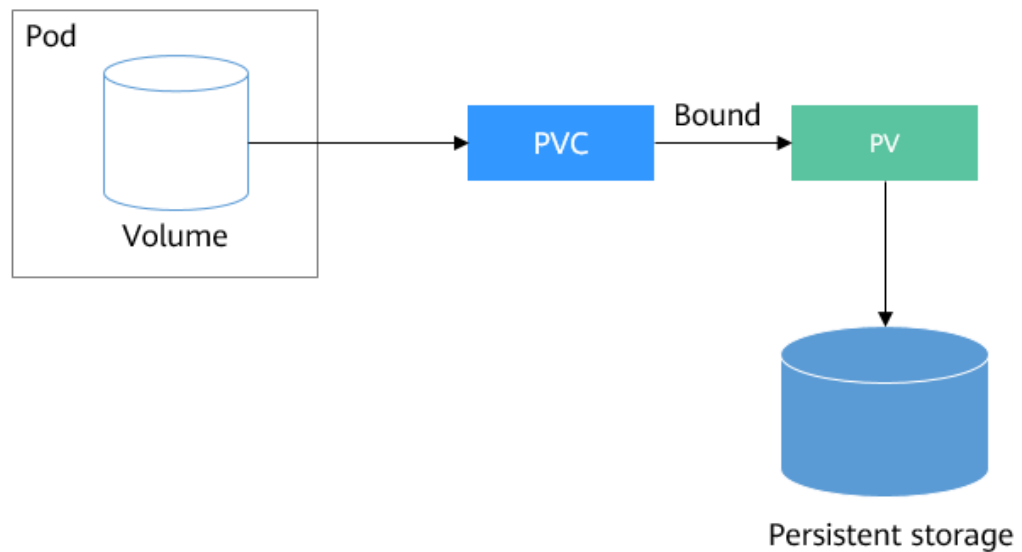
PV and PVC

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 12-2 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 12-1 Access modes supported by storage volumes

Volume Type	ReadWriteOnce	ReadWriteMany
EVS	√	x
SFS	x	√
OBS	x	√
SFS Turbo	x	√
Local PV	√	x
DSS	√	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 12-2 Modes of mounting volumes

Mount 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, DSS, 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, DSS, 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, and the associated underlying storage assets will also be removed from the external infrastructure.
- **Retain:** When a PVC is deleted, both the PV and underlying storage resources will be retained. You need to manually delete these resources. After the PVC is deleted, the PV is in the **Released** state and cannot be bound to a PVC again.

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](#).

12.3 Elastic Volume Service

12.3.1 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: the number of input/output operations performed by an EVS disk per second
- Throughput: the amount of data read from and written into an EVS disk per second
- I/O latency: the minimum interval between two consecutive I/O operations on an EVS disk

Table 12-3 EVS disk performance specifications

Parameter	General Purpose SSD	Ultra-high I/O	High I/O	Common I/O
Max. capacity (GiB)	<ul style="list-style-type: none"> • System disk: 1,024 • Data disk: 32,768 	<ul style="list-style-type: none"> • System disk: 1,024 • Data disk: 32,768 	<ul style="list-style-type: none"> • System disk: 1,024 • Data disk: 32,768 	<ul style="list-style-type: none"> • System disk: 1,024 • Data disk: 32,768
Max. IOPS	20,000	50,000	5000	2200
Max. throughput (MiB/s)	250	350	150	50
Burst IOPS limit	8000	16,000	5000	2200
Disk IOPS	Min. (20,000, 1800 + 12 x Capacity)	Min. (50,000, 1800 + 50 x Capacity)	Min. (5000, 1800 + 8 x Capacity)	Min. (2200, 500 + 2 x Capacity)

Parameter	General Purpose SSD	Ultra-high I/O	High I/O	Common I/O
Disk throughput (MiB/s)	Min. (250, 100 + 0.5 x Capacity)	Min. (350, 120 + 0.5 x Capacity)	Min. (150, 100 + 0.15 x Capacity)	50
Single-queue access latency (ms)	1	1	1-3	5-10
API name	GPSSD	SSD	SAS	SATA

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 if the underlying storage is available.
- **Using an EVS Disk Through a Dynamic PV:** dynamic creation mode, in which you do not need to create EVS volumes beforehand. Instead, specify a StorageClass when creating a PVC. Then, an EVS volume and PV will be created automatically. This mode applies to scenarios where no underlying storage is available.
- **Dynamically Mounting an EVS Disk to a StatefulSet:** available only for StatefulSets. 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. This mode applies to StatefulSets with multiple pods.

12.3.2 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 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 create 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.

- EVS disks that have been partitioned are not supported.
- To create a cluster using commands, ensure kubectl is used. For details, see [Connecting to a Cluster Using kubectl](#).

Notes and 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 attached to multiple nodes, I/O conflicts and data cache conflicts may occur. Therefore, select 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. In the right pane, click the **PVCs** tab. Click **Create PVC** in the upper right corner. In the dialog box displayed, configure PVC parameters.

Parameter	Description
PVC Type	In this example, select EVS .
PVC Name	Enter the PVC name, which must be unique in a namespace.
Creation Method	<ul style="list-style-type: none"> - If underlying storage is available, create a PV or use an existing PV to statically create a PVC. - If no underlying storage is available, select Dynamically provision. For details, see Using an EVS Disk Through a Dynamic PV. <p>In this example, select Create new to create both a PV and PVC on the console.</p>
PV ^a	<p>Select an existing PV in the cluster. For details about how to create a PV, see "Creating a storage volume" in Related Operations.</p> <p>You do not need to specify this parameter in this example.</p>
EVS ^b	Click Select EVS . On the displayed page, select the EVS volume that meets your requirements and click OK .
PV Name ^b	Enter the PV name, which must be unique in the same cluster.

Parameter	Description
Access Mode ^b	EVS volumes 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. Choose **Workloads** in the navigation pane. 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 12-4](#). For details about other parameters, see [Workloads](#).

Table 12-4 Mounting a storage volume

Parameter	Description
PVC	Select an existing EVS volume. An EVS volume can be mounted to only one workload.
Mount Path	Enter a mount path, for example, /tmp . This parameter specifies a 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, leading to 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 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	<ul style="list-style-type: none"> - 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 can be attached to only one workload pod. If there are multiple pods, extra pods cannot start properly. Ensure that the number of workload pods is 1 if an EVS disk is attached.

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

Using an Existing EVS Disk Through kubectl

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 underlying volume is retained
when the PV is deleted.
  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, which 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> # EVS volume ID
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.
persistentVolumeReclaimPolicy: Delete # Reclaim policy
storageClassName: csi-disk # StorageClass name. The value must be csi-disk for EVS disks.

```

Table 12-5 Key parameters

Parameter	Mandatory	Description
everest.io/reclaim-policy: retain-volume-only	No	Optional. Only retain-volume-only is supported. This parameter 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. For details about the value of region , see Regions and Endpoints .
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. For details about the value of zone , see Regions and Endpoints .
fsType	Yes	File system type, which defaults to ext4 . The value can be ext4 or xfs . The restrictions on using xfs are as follows: – The nodes must run CentOS 7 or Ubuntu 22.04, and the Everest version in the cluster must be 2.3.2 or later. – Only common containers are supported.
volumeHandle	Yes	Volume ID of the EVS disk. To obtain a 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 .

Parameter	Mandatory	Description
everest.io/ disk-volume- type	Yes	EVS disk type. All letters are in uppercase. <ul style="list-style-type: none"> - SATA: common I/O - SAS: high I/O - SSD: ultra-high I/O - GPSSD: general-purpose SSD
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 an 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.
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: <ul style="list-style-type: none"> - If everest.io/reclaim-policy is not specified, both the PV and EVS disk will be deleted when a PVC is deleted. - If everest.io/reclaim-policy is set to retain-volume-only, when a PVC is deleted, the PV will be deleted but the EVS disk will be retained. Retain: When a PVC is deleted, both the PV and underlying storage resources will be retained. You need to manually delete these resources. After the PVC is deleted, the PV is in the Released state and cannot be bound to a 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.
  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 # StorageClass is EVS.
      volumeName: pv-evs # PV name
  
```

Table 12-6 Key parameters

Parameter	Mandatory	Description
failure-domain.beta.kubernetes.io/region	Yes	Region where the cluster is located. For details about the value of region , see Regions and Endpoints .
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. For details about the value of zone , see Regions and Endpoints .
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-eps-0 -- df | grep data
```

Expected output:

```
/dev/sdc      10255636   36888 10202364   0% /data
```

3. Run the following command to check the files in the **/data** path:

```
kubectl exec web-eps-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-eps-0 -- touch /data/static
```

- Step 3** Run the following command to check the files in the **/data** path:

```
kubectl exec web-eps-0 -- ls /data
```

Expected output:

```
lost+found  
static
```

- Step 4** Run the following command to delete the pod named **web-eps-0**:

```
kubectl delete pod web-eps-0
```

Expected output:

```
pod "web-eps-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-eps-0 -- ls /data
```

Expected output:

```
lost+found  
static
```

The **static** file is retained, indicating that the data in the EVS volume can be stored persistently.

----End

Related Operations

You can also perform the operations listed in [Table 12-7](#).

Table 12-7 Related operations

Operation	Description	Procedure
Creating a storage volume (PV)	Create a PV on the CCE console.	<ol style="list-style-type: none"> Choose Storage in the navigation pane. In the right pane, click the PVs tab. Click Create PersistentVolume in the upper right corner. In the dialog box displayed, configure parameters. <ul style="list-style-type: none"> Volume Type: Select EVS. EVS: Click Select EVS. On the displayed page, select the EVS volume that meets your requirements and click OK. PV Name: Enter the PV name, which must be unique in a cluster. Access Mode: EVS volumes 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. Click Create.
Expanding the capacity of an EVS disk	Quickly expand the capacity of an attached EVS disk on the CCE console.	<ol style="list-style-type: none"> Choose Storage in the navigation pane. In the right pane, click the PVCs tab. Click More in the Operation column of the target PVC and select Scale-out. Enter the capacity to be added and click OK.
Viewing events	View event names, event types, number of occurrences, Kubernetes events, first occurrence time, and last occurrence time of the PVC or PV.	<ol style="list-style-type: none"> Choose Storage in the navigation pane. In the right pane, click the PVCs or PVs tab. Click View Events in the Operation column of the target PVC or PV to view events generated within one hour (events are retained for one hour).
Viewing a YAML file	View, copy, or download the YAML file of a PVC or PV.	<ol style="list-style-type: none"> Choose Storage in the navigation pane. In the right pane, click the PVCs or PVs tab. Click View YAML in the Operation column of the target PVC or PV to view or download the YAML.

12.3.3 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.
- To create a cluster using commands, ensure kubectl is used. For details, see [Connecting to a Cluster Using kubectl](#).

Notes and 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 attached to multiple nodes, I/O conflicts and data cache conflicts may occur. Therefore, select 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. In the right pane, click the **PVCs** tab. Click **Create PVC** in the upper right corner. In the dialog box displayed, configure PVC parameters.

Parameter	Description
PVC Type	In this example, select EVS .
PVC Name	Enter the PVC name, which must be unique in a namespace.

Parameter	Description
Creation Method	<ul style="list-style-type: none"> 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 PV or use an existing PV to statically create a PVC. 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 .
(Optional) Storage Volume Name Prefix	<p>Available only when the cluster version is v1.23.14-r0, v1.25.9-r0, v1.27.6-r0, v1.28.4-r0, or later, and Everest of v2.4.15 or later is installed in the cluster.</p> <p>This parameter specifies the name of the underlying storage that is automatically created. The actual underlying storage name is in the format of "PV name prefix + PVC UID". If this parameter is left blank, the default prefix pvc will be used.</p> <p>For example, if the PV name prefix is set to test, the actual underlying storage name is test-<i>{UID}</i>.</p>
AZ	<p>Select the AZ of the EVS disk. The AZ must be the same as that of the cluster node.</p> <p>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.</p>
Disk Type	Select an EVS disk type. EVS disk types vary depending on regions. Obtain the available EVS types on the console.
Capacity (GiB)	Capacity of the requested storage volume.
Access Mode	EVS volumes support only ReadWriteOnce , indicating that a storage volume can be mounted to one node in read/write mode. For details, see Volume Access Modes .
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.

Parameter	Description
Resource Tag	<p>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.</p> <p>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.</p> <p>CCE automatically creates system tags CCE-Cluster-ID=<i>{Cluster ID}</i>, CCE-Cluster-Name=<i>{Cluster name}</i>, and CCE-Namespace=<i>{Namespace name}</i>. These tags cannot be modified.</p> <p>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.</p>

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. Choose **Workloads** in the navigation pane. 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 12-8](#). For details about other parameters, see [Workloads](#).

Table 12-8 Mounting a storage volume

Parameter	Description
PVC	<p>Select an existing EVS volume.</p> <p>An EVS volume can be mounted to only one workload.</p>

Parameter	Description
Mount Path	<p>Enter a mount path, for example, /tmp.</p> <p>This parameter specifies a 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, leading to container startup failures or workload creation failures.</p> <p>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 may be damaged.</p>
Subpath	<p>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.</p>
Permission	<ul style="list-style-type: none"> - 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 can be attached to only one workload pod. If there are multiple pods, extra pods cannot start properly. Ensure that the number of workload pods is 1 if an EVS disk is attached.

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

Automatically Creating an EVS Volume Through kubectl

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/disk-volume-tags: '{"key1":"value1","key2":"value2"}' # (Optional) Custom resource tags
    csi.storage.k8s.io/fstype: xfs # (Optional) The file system is of the xfs type. If it is left blank, ext4
    will be used by default.
    everest.io/csi.volume-name-prefix: test # (Optional) PV name prefix of the automatically created
    underlying storage
  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 # StorageClass is EVS.
  
```

Table 12-9 Key parameters

Parameter	Mandatory	Description
failure-domain.beta.kubernetes.io/region	Yes	Region where the cluster is located. For details about the value of region , see Regions and Endpoints .
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. For details about the value of zone , see Regions and Endpoints .
everest.io/disk-volume-type	Yes	EVS disk type. All letters are in uppercase. <ul style="list-style-type: none"> - SATA: common I/O - SAS: high I/O - SSD: ultra-high I/O - GPSSD: general-purpose SSD
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/disk-volume-tags	No	<p>This field is optional. It is supported when the Everest version in the cluster is 2.1.39 or later.</p> <p>You can add resource tags to classify resources.</p> <p>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.</p> <p>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.</p>
csi.storage.k8s.io/fstype	No	<p>This field is optional. It specifies the file system type, which defaults to ext4.</p> <p>The value can be ext4 or xfs. The restrictions on using xfs are as follows:</p> <ul style="list-style-type: none"> - The nodes must run CentOS 7 or Ubuntu 22.04, and the Everest version in the cluster must be 2.3.2 or later. - Only common containers are supported.
everest.io/csi.volume-name-prefix	No	<p>(Optional) This parameter is available only when the cluster version is v1.23.14-r0, v1.25.9-r0, v1.27.6-r0, v1.28.4-r0, or later, and Everest of v2.4.15 or later is installed in the cluster.</p> <p>This parameter specifies the name of the underlying storage that is automatically created. The actual underlying storage name is in the format of "PV name prefix + PVC UID". If this parameter is left blank, the default prefix pvc will be used.</p> <p>Enter 1 to 26 characters that cannot start or end with a hyphen (-). Only lowercase letters, digits, and hyphens (-) are allowed.</p> <p>For example, if the PV name prefix is set to test, the actual underlying storage name is test-{UID}.</p>
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:
kubectrl 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:

```
kubectrl 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 check 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 check 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
```

The **static** file is retained, indicating that the data in the EVS volume can be stored persistently.

----End

Related Operations

You can also perform the operations listed in [Table 12-10](#).

Table 12-10 Related operations

Operation	Description	Procedure
Expanding the capacity of an EVS disk	Quickly expand the capacity of an attached EVS disk on the CCE console.	<ol style="list-style-type: none"> 1. Choose Storage in the navigation pane. In the right pane, click the PVCs tab. Click More in the Operation column of the target PVC and select Scale-out. 2. Enter the capacity to be added and click OK.
Viewing events	View event names, event types, number of occurrences, Kubernetes events, first occurrence time, and last occurrence time of the PVC or PV.	<ol style="list-style-type: none"> 1. Choose Storage in the navigation pane. In the right pane, 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 (events are retained for one hour).
Viewing a YAML file	View, copy, or download the YAML file of a PVC or PV.	<ol style="list-style-type: none"> 1. Choose Storage in the navigation pane. In the right pane, 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.

12.3.4 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 dynamic creation of PVs through StorageClass. 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.
- To create a cluster using commands, ensure kubectl is used. For details, see [Connecting to a Cluster Using kubectl](#).

Dynamically Mounting an 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** Choose **Workloads** in the navigation pane. 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 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 <i><Custom PVC name>-<Serial number></i> , for example, <i>example-0</i> .
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 .
(Optional) Storage Volume Name Prefix	Available only when the cluster version is v1.23.14-r0, v1.25.9-r0, v1.27.6-r0, v1.28.4-r0, or later, and Everest of v2.4.15 or later is installed in the cluster. This parameter specifies the name of the underlying storage that is automatically created. The actual underlying storage name is in the format of "PV name prefix + PVC UID". If this parameter is left blank, the default prefix pvc will be used. For example, if the PV name prefix is set to test , the actual underlying storage name is test-<i>{UID}</i> .
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.
Capacity (GiB)	Capacity of the requested storage volume.
Access Mode	EVS volumes support only ReadWriteOnce , indicating that a storage volume can be mounted to one node in read/write mode. For details, see Volume Access Modes .

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.
Resource Tag	<p>You can add resource tags to classify resources. This option is supported only when the Everest version in the cluster is 2.1.39 or later.</p> <p>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.</p> <p>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.</p> <p>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.</p>

Step 5 Enter the path to which the volume is mounted.

Table 12-11 Mounting a storage volume

Parameter	Description
Mount Path	<p>Enter a mount path, for example, /tmp.</p> <p>This parameter specifies a 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, leading to container startup failures or workload creation failures.</p> <p>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 may be damaged.</p>
Subpath	<p>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.</p>

Parameter	Description
Permission	<ul style="list-style-type: none"> • 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 Through 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/disk-volume-tags: '{"key1":"value1","key2":"value2"}' # (Optional) Custom resource tags
    csi.storage.k8s.io/fstype: xfs # (Optional) The file system is of the xfs type. If it is left blank, ext4
will be used by default.
    everest.io/csi.volume-name-prefix: test # (Optional) PV name prefix of the automatically created
underlying storage
    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 # StorageClass 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 12-12 Key parameters

Parameter	Mandatory	Description
failure-domain.beta.kubernetes.io/region	Yes	Region where the cluster is located. For details about the value of region , see Regions and Endpoints .
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. For details about the value of zone , see Regions and Endpoints .
everest.io/disk-volume-type	Yes	EVS disk type. All letters are in uppercase. <ul style="list-style-type: none"> ● SATA: common I/O ● SAS: high I/O ● SSD: ultra-high I/O ● GPSSD: general-purpose SSD

Parameter	Mandatory	Description
everest.io/crypt-key-id	No	<p>Mandatory when the EVS disk is encrypted. Enter the encryption key ID selected during EVS disk creation.</p> <p>To obtain an 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.</p>
everest.io/disk-volume-tags	No	<p>This field is optional. It is supported when the Everest version in the cluster is 2.1.39 or later.</p> <p>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.</p> <p>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.</p>
csi.storage.k8s.io/fstype	No	<p>This field is optional. It specifies the file system type, which defaults to ext4.</p> <p>The value can be ext4 or xfs. The restrictions on using xfs are as follows:</p> <ul style="list-style-type: none"> • The nodes must run CentOS 7 or Ubuntu 22.04, and the Everest version in the cluster must be 2.3.2 or later. • Only common containers are supported.

Parameter	Mandatory	Description
everest.io/csi.volume-name-prefix	No	<p>(Optional) This parameter is available only when the cluster version is v1.23.14-r0, v1.25.9-r0, v1.27.6-r0, v1.28.4-r0, or later, and Everest of v2.4.15 or later is installed in the cluster.</p> <p>This parameter specifies the name of the underlying storage that is automatically created. The actual underlying storage name is in the format of "PV name prefix + PVC UID". If this parameter is left blank, the default prefix pvc will be used.</p> <p>Enter 1 to 26 characters that cannot start or end with a hyphen (-). Only lowercase letters, digits, and hyphens (-) are allowed.</p> <p>For example, if the PV name prefix is set to test, the actual underlying storage name is test-<i>{UID}</i>.</p>
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 check 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 check 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
```

The **static** file is retained, indicating that the data in the EVS volume can be stored persistently.

----End

Related Operations

You can also perform the operations listed in [Table 12-13](#).

Table 12-13 Related operations

Operation	Description	Procedure
Expanding the capacity of an EVS disk	Quickly expand the capacity of an attached EVS disk on the CCE console.	<ol style="list-style-type: none"> 1. Choose Storage in the navigation pane. In the right pane, click the PVCs tab. Click More in the Operation column of the target PVC and select Scale-out. 2. Enter the capacity to be added and click OK.
Viewing events	View event names, event types, number of occurrences, Kubernetes events, first occurrence time, and last occurrence time of the PVC or PV.	<ol style="list-style-type: none"> 1. Choose Storage in the navigation pane. In the right pane, 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 (events are retained for one hour).

Operation	Description	Procedure
Viewing a YAML file	View, copy, or download the YAML file of a PVC or PV.	<ol style="list-style-type: none">1. Choose Storage in the navigation pane. In the right pane, 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.

12.3.5 Encrypting EVS Disks

Encrypting cloud disks ensures data privacy and control, making it ideal for scenarios that demand high security or compliance standards. This section describes how to use the keys managed by Data Encryption Workshop (DEW) to encrypt EVS disks.

Prerequisites

- You have created a cluster and installed the [CCE Container Storage \(Everest\)](#) add-on in the cluster.
- An available key has been created in DEW.
- To create a cluster using commands, ensure kubectl is used. For details, see [Connecting to a Cluster Using kubectl](#).

Using 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 **PersistentVolumeClaims (PVCs)** tab. Click **Create PVC** in the upper right corner. In the dialog box displayed, configure PVC parameters.
2. Select EVS for the storage type, enable encryption, and choose a key. Configure other parameters based on service requirements. For details, see [Using an EVS Disk Through a Dynamic PV](#).
3. Click **Create**.

Step 3 Go to the **PersistentVolumeClaims (PVCs)** tab and check whether the PVC of the encrypted EVS disk is created and whether the disk is encrypted.

Step 4 The method of using an encrypted PVC is the same as that of using a regular PVC.

----End

Automatically Creating an Encrypted EVS Disk Using kubectl

Step 1 Use kubectl to access the cluster.

Step 2 Create the `pvc-evs-auto.yaml` file. For details, see [Automatically Creating an EVS Volume Through kubectl](#).

```
apiVersion: v1
kind: PersistentVolumeClaim
metadata:
  name: pvc-evs-auto
  namespace: default
  annotations:
    everest.io/disk-volume-type: SAS # EVS disk
    everest.io/crypt-key-id: 37f202db-a970-4ac1-a506-e5c4f2d7ce69 # Encryption key ID, which can be
    obtained from DEW
  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.
```

Step 3 Run the following command to create a PVC:

```
kubectl apply -f pvc-evs-auto.yaml
```

Step 4 Go to the **PersistentVolumeClaims (PVCs)** tab and check whether the PVC of the encrypted EVS disk is created and whether the disk is encrypted.

----End

12.3.6 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 checked or configured.
- 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.
- A PVC of the `xfs` file system type can generate snapshots. The file system of the disk associated with the PVC created using these snapshots remains `xfs`.

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. In the right pane, 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. In the right pane, 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.
    csi.storage.k8s.io/fstype: xfs # (Optional) Configure this field when the snapshot file system is of the
    xfs type.
  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
```

12.4 Scalable File Service

12.4.1 Overview

Introduction

CCE allows you to mount a volume created from a Scalable File Service (SFS) file system to a container to store data persistently. SFS volumes are commonly used in ReadWriteMany scenarios for large-capacity expansion and cost-sensitive services, such as media processing, content management, big data analysis, and workload process analysis. For services with massive volume of small files, SFS Turbo file systems are recommended.

Expandable to petabytes, SFS provides fully hosted shared file storage, highly available and stable to handle data- and bandwidth-intensive applications

- **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.
- **Capacity and performance:** The capacity of a single file system is high (PB level) and the performance is excellent (ms-level I/O latency).
- **Use cases:** Deployments/StatefulSets in the ReadWriteMany mode and jobs created for high-performance computing (HPC), media processing, content management, web services, big data analysis, and workload process analysis

Application Scenarios

SFS supports the following mounting modes based on application scenarios:

- **Using an Existing SFS 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. This mode applies if the underlying storage is available.
- **Using an SFS File System Through a Dynamic PV:** dynamic creation mode, in which you do not need to create SFS file systems beforehand. Instead, specify a StorageClass when creating a PVC. Then, a file system and PV will be created automatically. This mode applies to scenarios where no underlying storage is available.

12.4.2 Using an Existing SFS File System Through a Static PV

SFS is a network-attached storage (NAS) that provides shared, scalable, and high-performance file storage. It applies to large-capacity expansion and cost-sensitive services. This section describes how to use an existing SFS 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.
- To create a cluster using commands, ensure kubectl is used. For details, see [Connecting to a Cluster Using kubectl](#).

- You have created an SFS file system that is in the same VPC as the cluster.

Notes and Constraints

- Multiple PVs can use the same SFS or SFS Turbo file system with the following restrictions:
 - Do not mount the PVCs/PVs that use the same underlying SFS or SFS Turbo volume to one pod. This will lead to a pod startup failure because not all PVCs can be mounted to the pod due to the same **volumeHandle** value.
 - 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.

Using an Existing SFS File System Through kubectl

Step 1 Use kubectl to access the cluster.

Step 2 Create a PV.

1. Create the **pv-sfs.yaml** file.

SFS Capacity-Oriented:

```
apiVersion: v1
kind: PersistentVolume
metadata:
  annotations:
    pv.kubernetes.io/provisioned-by: everest-csi-provisioner
    everest.io/reclaim-policy: retain-volume-only # (Optional) The underlying volume is retained
    when the PV is deleted.
  name: pv-sfs # PV name
spec:
  accessModes:
    - ReadWriteMany # Access mode. The value must be ReadWriteMany for SFS.
  capacity:
    storage: 1Gi # SFS volume capacity
  csi:
    driver: nas.csi.everest.io # Dependent storage driver for the mounting
    fsType: nfs
    volumeHandle: <your_volume_id> # SFS Capacity-Oriented volume ID
  volumeAttributes:
    everest.io/share-export-location: <your_location> # Shared path of the SFS volume
    storage.kubernetes.io/csiProvisionerIdentity: everest-csi-provisioner
  persistentVolumeReclaimPolicy: Retain # Reclaim policy
  storageClassName: csi-nas # StorageClass name. csi-nas indicates that SFS Capacity-
  Oriented is used.
  mountOptions: [] # Mount options
```

Table 12-14 Key parameters

Parameter	Mandatory	Description
everest.io/reclaim-policy	No	Only retain-volume-only is supported. This parameter 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.
volumeHandle	Yes	<ul style="list-style-type: none"> If an SFS Capacity-Oriented volume is used, enter the volume ID. Log in to the CCE console, choose Service List > Storage > Scalable File Service , and select SFS Capacity-Oriented . In the list, click the name of the target SFS file system. On the details page, copy the content following ID .
everest.io/share-export-location	Yes	Shared path of the file system. <ul style="list-style-type: none"> For an SFS Capacity-Oriented file system, log in to the CCE console, choose Service List > Storage > Scalable File Service, and obtain the shared path from the Mount Address column.
mountOptions	Yes	Mount options. If not specified, the following configurations are used by default. For details, see Configuring SFS Volume Mount Options . mountOptions: - vers=3 - timeo=600 - nolock - hard

Parameter	Mandatory	Description
persistentVolumeReclaimPolicy	Yes	<p>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.</p> <p>The Delete and Retain reclaim policies are supported. For details, see PV Reclaim Policy. If multiple PVs use the same SFS volume, use Retain to prevent the underlying volume from being deleted with a PV.</p> <p>Retain: When a PVC is deleted, both the PV and underlying storage resources will be retained. You need to manually delete these resources. After the PVC is deleted, the PV is in the Released state and cannot be bound to a PVC again.</p> <p>Delete: When a PVC is deleted, its PV will also be deleted.</p>
storage	Yes	<p>Requested capacity in the PVC, in Gi.</p> <p>For SFS, 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 SFS file systems.</p>

- Run the following command to create a PV:

```
kubectl apply -f pv-sfs.yaml
```

Step 3 Create a PVC.

- Create the **pvc-sfs.yaml** file.

```
apiVersion: v1
kind: PersistentVolumeClaim
metadata:
  name: pvc-sfs
  namespace: default
  annotations:
    volume.beta.kubernetes.io/storage-provisioner: everest-csi-provisioner
spec:
  accessModes:
    - ReadWriteMany # The value must be ReadWriteMany for SFS.
  resources:
    requests:
      storage: 1Gi # SFS volume capacity.
      storageClassName: csi-nas # Storage class name, which must be the same as the PV's storage class.
      volumeName: pv-sfs # PV name
```

Table 12-15 Key parameters

Parameter	Mandatory	Description
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 .

- Run the following command to create a PVC:

```
kubectl apply -f pvc-sfs.yaml
```

Step 4 Create an application.

- Create a file named **web-demo.yaml**. In this example, the SFS 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-sfs-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-sfs-volume # Volume name, which can be customized
              persistentVolumeClaim:
                claimName: pvc-sfs # Name of the created PVC
```

- Run the following command to create a workload to which the SFS volume is mounted:

```
kubectl apply -f web-demo.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 and Sharing](#).

----End

Verifying Data Persistence and Sharing

Step 1 View the deployed application and files.

- 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 check 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
```

The **static** file is retained, indicating that the data in the file system 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 12-16](#).

Table 12-16 Related operations

Operation	Description	Procedure
Viewing events	View event names, event types, number of occurrences, Kubernetes events, first occurrence time, and last occurrence time of the PVC or PV.	<ol style="list-style-type: none"> 1. Choose Storage in the navigation pane. In the right pane, 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 (events are retained for one hour).
Viewing a YAML file	View, copy, or download the YAML file of a PVC or PV.	<ol style="list-style-type: none"> 1. Choose Storage in the navigation pane. In the right pane, 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.

12.4.3 Using an SFS File System Through a Dynamic PV

This section describes how to use storage classes to dynamically 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.
- To create a cluster using commands, ensure kubectl is used. For details, see [Connecting to a Cluster Using kubectl](#).
- You have created an SFS file system that is in the same VPC as the cluster.

Automatically Creating an SFS File System Through kubectl

Step 1 Use kubectl to access the cluster.

Step 2 Use **StorageClass** to dynamically create a PVC and PV.

1. Create the **pvc-sfs-auto.yaml** file.

```

apiVersion: v1
kind: PersistentVolumeClaim
metadata:
  name: pvc-sfs-auto
  namespace: default
  annotations:
    everest.io/crypt-key-id: <your_key_id> # (Optional) ID of the key for encrypting file systems

    everest.io/crypt-alias: sfs/default # (Optional) Key name. Mandatory for encrypting volumes.

    everest.io/crypt-domain-id: <your_domain_id> # (Optional) ID of the tenant to which an
    encrypted volume belongs. Mandatory for encrypting volumes.

spec:
  accessModes:
    - ReadWriteMany # The value must be ReadWriteMany for SFS.
  resources:
    requests:
      storage: 1Gi # SFS volume capacity
      storageClassName: csi-nas # StorageClass is SFS.
  
```

Table 12-17 Key parameters

Parameter	Mandatory	Description
storage	Yes	Requested capacity in the PVC, in Gi. For SFS, 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 SFS file systems.
everest.io/crypt-key-id	No	This parameter is mandatory when an SFS system is encrypted. Enter the encryption key ID selected during SFS system creation. You can use a custom key or the default key named sfs/default . To obtain a key ID, log in to the DEW console, locate the key to be encrypted, and copy the key ID.
everest.io/crypt-alias	No	Key name, which is mandatory when you create an encrypted volume. To obtain a key name, log in to the DEW console, locate the key to be encrypted, and copy the key name.

Parameter	Mandatory	Description
everest.io/crypt-domain-id	No	ID of the tenant to which the encrypted volume belongs. This parameter is mandatory for creating an encrypted volume. To obtain a tenant ID, hover the cursor over the username in the upper right corner of the ECS console, choose My Credentials , and copy the account ID.

2. Run the following command to create a PVC:

```
kubectl apply -f pvc-sfs-auto.yaml
```

Step 3 Create an application.

1. Create a file named **web-demo.yaml**. In this example, the SFS 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-sfs-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-sfs-volume # Volume name, which can be customized
              persistentVolumeClaim:
                claimName: pvc-sfs-auto # Name of the created PVC
```

2. Run the following command to create a workload to which the SFS volume is mounted:

```
kubectl apply -f web-demo.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 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 check 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
```

The **static** file is retained, indicating that the data in the file system 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 12-18](#).

Table 12-18 Related operations

Operation	Description	Procedure
Viewing events	View event names, event types, number of occurrences, Kubernetes events, first occurrence time, and last occurrence time of the PVC or PV.	<ol style="list-style-type: none"> 1. Choose Storage in the navigation pane. In the right pane, 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 (events are retained for one hour).
Viewing a YAML file	View, copy, or download the YAML file of a PVC or PV.	<ol style="list-style-type: none"> 1. Choose Storage in the navigation pane. In the right pane, 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.

12.4.4 Configuring SFS Volume Mount Options

This section describes how to configure SFS 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 \(Everest\)](#) 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.

Notes and 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 Volume Mount Options

The Everest add-on in CCE presets the options described in [Table 12-19](#) for mounting SFS volumes.

Table 12-19 SFS volume mount options

Parameter	Value	Description
keep-original-ownership	Blank	Whether to retain the ownership of the file mount point. If this option is used, the Everest add-on must be v1.2.63 or v2.1.2 or later. <ul style="list-style-type: none"> • By default, this option is not added, and the mount point ownership is root:root when SFS is mounted. • If this option is added, the original ownership of the file system is retained when SFS is mounted.
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
hard/soft	Blank	Mount mode. <ul style="list-style-type: none"> • 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 .

Parameter	Value	Description
sharecache/ nosharecache	Blank	<p>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 between the mountings. 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.</p> <p>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.</p>

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 Volume Mount Options](#).

Step 1 Use kubectl to access 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 underlying volume is retained when
the PV is deleted.
  name: pv-sfs
spec:
  accessModes:
    - ReadWriteMany # Access mode. The value must be ReadWriteMany for SFS.
  capacity:
    storage: 1Gi # SFS volume capacity
  csi:
    driver: nas.csi.everest.io # Dependent storage driver for the mounting
    fsType: nfs
    volumeHandle: <your_volume_id> # ID of the SFS Capacity-Oriented volume
  volumeAttributes:
    everest.io/share-export-location: <your_location> # Shared path of the SFS volume
    storage.kubernetes.io/csiProvisionerIdentity: everest-csi-provisioner
  persistentVolumeReclaimPolicy: Retain # Reclaim policy
  storageClassName: csi-nas # StorageClass 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 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 volume has been mounted. In this example, the workload name is **web-sfs**.

```
kubectl get pod | grep web-sfs
```

Command output:

```
web-sfs-*** 1/1 Running 0 23m
```

2. Run the following command to check the mount options (**web-sfs-***** is an example pod):

```
kubectl exec -it web-sfs-*** -- 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 shared 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=2050,mountproto=tcp,local_lock=all,addr=*.**.*.**)

```

----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 [SFS Volume Mount Options](#).

Step 1 Use kubectl to access the cluster. For details, see [Connecting to a Cluster Using kubectl](#).

Step 2 Create a custom StorageClass. Example:

```
apiVersion: storage.k8s.io/v1
kind: StorageClass
metadata:
  name: csi-sfs-mount-option
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-to: <your_vpc_id> # VPC ID of the cluster
reclaimPolicy: Delete
volumeBindingMode: Immediate
mountOptions: # Mount options
- vers=3
- nolock
- timeo=600
- hard
```

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 SFS File System 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 run the **mount -l** command to check whether the mount options take effect.

1. View the pod to which the SFS volume has been mounted. In this example, the workload name is **web-sfs**.

```
kubectrl get pod | grep web-sfs
```

Command output:

```
web-sfs-*** 1/1 Running 0 23m
```

2. Run the following command to check the mount options (**web-sfs-***** is an example pod):

```
kubectrl exec -it web-sfs-*** -- 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 shared 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=2050,mountproto=tcp,local_lock=all,addr=*.**.**) 
```

----End

12.5 SFS Turbo

12.5.1 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 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.
- **Dynamically Creating an SFS Turbo Subdirectory Using StorageClass:** 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.

12.5.2 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.
- To create a cluster using commands, ensure kubectl is used. 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.

Notes and Constraints

- Multiple PVs can use the same SFS or SFS Turbo file system with the following restrictions:
 - Do not mount the PVCs/PVs that use the same underlying SFS or SFS Turbo volume to one pod. This will lead to a pod startup failure because not all PVCs can be mounted to the pod due to the same **volumeHandle** value.
 - 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.

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. In the right pane, click the **PVCs** tab. Click **Create PVC** in the upper right corner. In the dialog box displayed, configure PVC parameters.

Parameter	Description
PVC Type	In this example, select SFS Turbo .
PVC Name	Enter the PVC name, which must be unique in a 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 both a PV and PVC on the console.
PV ^a	Select an existing PV in the cluster. For details about how to create a PV, 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 .
Subdirectory ^b	Determine whether to use subdirectories to create PVs. Enter the absolute path of a subdirectory, for example, /a/b . Ensure that the subdirectory is available.
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 if you do not use subdirectories to create PVs. This indicates that the PV is not deleted when the PVC is deleted. For details, see PV Reclaim Policy . If you choose to use a subdirectory to create a PV, the value of this parameter can be Delete .
Subdirectory Reclaim Policy ^b	Determine whether to retain subdirectories when a PVC is deleted. This parameter must be used with PV Reclaim Policy and can be configured when PV Reclaim Policy is set to Delete . <ul style="list-style-type: none"> – Retain: If a PVC is deleted, the PV will be deleted, but the subdirectories associated with the PV will be retained. – Delete: After a PVC is deleted, the PV and its associated subdirectories will also be deleted.
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. Choose **Workloads** in the navigation pane. 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 12-20](#). For details about other parameters, see [Workloads](#).

Table 12-20 Mounting a storage volume

Parameter	Description
PVC	Select an existing SFS Turbo volume.
Mount Path	<p>Enter a mount path, for example, /tmp.</p> <p>This parameter specifies a 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, leading to container startup failures or workload creation failures.</p> <p>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 may be damaged.</p>
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	<ul style="list-style-type: none"> - 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

Using an Existing SFS File System Through kubectl

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
    everest.io/reclaim-policy: retain-volume-only # Used for a subdirectory when the reclaim policy is
Delete. This parameter indicates that when a PVC is deleted, the PV will be deleted but the
subdirectory associated with the PV will be retained.
  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
    storage.kubernetes.io/csiProvisionerIdentity: everest-csi-provisioner
    everest.io/share-export-location: /a # (Optional) This parameter indicates an automatically
    created subdirectory, which must be an absolute path.
    everest.io/volume-as: absolute-path # (Optional) An SFS Turbo subdirectory is used.
    persistentVolumeReclaimPolicy: Retain # Reclaim policy, which can be set to Delete when
    subdirectories are automatically created
    storageClassName: csi-sfsturbo # Storage class name of the SFS Turbo file system
    mountOptions: [] # Mount options
```

Table 12-21 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 file system. On the details page, copy the content following ID .

Parameter	Mandatory	Description
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.
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
persistentVolume ReclaimPolicy	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. For details, see PV Reclaim Policy . Retain: When a PVC is deleted, both the PV and underlying storage resources will be retained. You need to manually delete these resources. After the PVC is deleted, the PV is in the Released state and cannot be bound to a PVC again.
everest.io/reclaim-policy	No	Whether to retain subdirectories when deleting a PVC. This parameter must be used with PV Reclaim Policy . This parameter is available only when the PV reclaim policy is Delete . Options: - retain-volume-only: If a PVC is deleted, the PV will be deleted, but the subdirectories associated with the PV will be retained . - delete: After a PVC is deleted, the PV and its associated subdirectories will also be deleted . NOTE When a subdirectory is deleted, only the absolute path of the subdirectory configured in the PVC will be deleted. The upper-layer directory will not be deleted.

Parameter	Mandatory	Description
everest.io/ volume-as	No	The value is fixed at absolute-path , indicating that a dynamically created SFS Turbo subdirectory is used. Ensure Everest of v2.3.23 or later has been installed in the cluster.
everest.io/path	No	Subdirectory that is automatically created, which must be an absolute path.
storage	Yes	Requested capacity in the PVC, in Gi.
storageClassName	Yes	The storage class name of SFS Turbo volumes is csi-sfsturbo .

- Run the following command to create a PV:
kubectl apply -f pv-sfsturbo.yaml

Step 3 Create a PVC.

- 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
spec:
  accessModes:
    - ReadWriteMany # The value must be ReadWriteMany for SFS Turbo.
  resources:
    requests:
      storage: 500Gi # SFS Turbo volume capacity.
  storageClassName: csi-sfsturbo # Storage class name of the SFS Turbo file system, which must
  be the same as that of the PV
  volumeName: pv-sfsturbo # PV name
```

Table 12-22 Key parameters

Parameter	Mandatory	Description
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 check 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
```

The **static** file is retained, indicating that the data in the file system 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 12-23](#).

Table 12-23 Related operations

Operation	Description	Procedure
Creating a storage volume (PV)	Create a PV on the CCE console.	<p>1. Choose Storage in the navigation pane. In the right pane, click the PVs tab. Click Create PersistentVolume in the upper right corner. In the dialog box displayed, configure parameters.</p> <ul style="list-style-type: none"> ● Volume Type: Select SFS Turbo. ● SFS Turbo: Click Select SFS Turbo. On the page displayed, select the SFS Turbo file system that meets your requirements and click OK. ● Subdirectory: Determine whether to use subdirectories to create PVs. Enter the absolute path of a subdirectory, for example, /a/b. Ensure that the subdirectory is available. ● PV Name: Enter the PV name, which must be unique in a 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 if you do not use subdirectories to create PVs. For details, see PV Reclaim Policy. If you choose to use a subdirectory to create a PV, the value of this parameter can be Delete. ● Subdirectory Reclaim Policy: Determine whether to retain subdirectories when a PVC is deleted. This parameter must be used with PV Reclaim Policy and can be configured when PV Reclaim Policy is set to Delete. Retain: If a PVC is deleted, the PV will be deleted, but the subdirectories associated with the PV will be retained. Delete: After a PVC is deleted, the PV and its associated subdirectories will also be deleted. ● Mount Options: Enter the mounting parameter key-value pairs. For details,

Operation	Description	Procedure
		<p>see Configuring SFS Turbo Mount Options.</p> <p>2. Click Create.</p>
Expanding the capacity of an SFS Turbo volume	Quickly expand the capacity of a mounted SFS Turbo volume on the CCE console.	<ol style="list-style-type: none"> 1. Choose Storage in the navigation pane. In the right pane, click the PVCs tab. Click More in the Operation column of the target PVC and select Scale-out. 2. Enter the capacity to be added and click OK.
Viewing events	View event names, event types, number of occurrences, Kubernetes events, first occurrence time, and last occurrence time of the PVC or PV.	<ol style="list-style-type: none"> 1. Choose Storage in the navigation pane. In the right pane, 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 (events are retained for one hour).
Viewing a YAML file	View, copy, or download the YAML file of a PVC or PV.	<ol style="list-style-type: none"> 1. Choose Storage in the navigation pane. In the right pane, 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.

12.5.3 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 \(Everest\)](#) 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.

Notes and 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 12-24](#) for mounting SFS Turbo volumes.

Table 12-24 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
hard/soft	Blank	Mount mode. <ul style="list-style-type: none"> • 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 between the mountings. 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 . <p>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.</p>

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 access 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 # Storage class name of the SFS Turbo file system
  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,wsiz=1048576,namlen=255,hard,nolock,noresvport,proto=tcp,timeo=600,retrans=2,sec=sys,mountaddr=*.*.**,mountvers=3,mountport=20048,mountproto=tcp,local_lock=all,addr=*.**.**)

----End
```

12.5.4 (Recommended) Creating an SFS Turbo Subdirectory Using a Dynamic PV

When an SFS Turbo volume is mounted to a workload container, the root directory is mounted to the container by default. However, the minimum capacity of an SFS Turbo volume is 500 GiB, which exceeds the capacity required by most workloads, leading to a waste of storage resources. To properly use the storage capacity, CCE allows you to dynamically create an SFS Turbo subdirectory when creating a PVC so that different workloads can share one SFS Turbo volume.

Prerequisites

- You have created a cluster and installed the [CCE Container Storage \(Everest\)](#) add-on of v2.3.23 or later in the cluster.
- To create a cluster using commands, ensure `kubectl` is used. 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.

Dynamically Creating an SFS Turbo Subdirectory on the Console

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

Step 2 Choose **Storage** in the navigation pane. In the right pane, click the **PVCs** tab. Click **Create PVC** in the upper right corner. In the dialog box displayed, configure PVC parameters.

Parameter	Description
PVC Type	In this example, select SFS Turbo .
PVC Name	Enter the PVC name, which must be unique in a namespace.
Creation Method	Select New subdirectory .
Storage Classes	Choose csi-sfsturbo .
Access Mode	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 .
SFS Turbo	Click Select SFS Turbo . On the displayed page, select the SFS Turbo file system that meets your requirements and click OK .
Subdirectory	Enter the absolute path of a subdirectory, for example, /a/b .

Parameter	Description
Subdirectory Reclaim Policy	<p>Whether to retain subdirectories when a PVC is deleted.</p> <ul style="list-style-type: none"> • Retain: If a PVC is deleted, the PV will be deleted, but the subdirectories associated with the PV will be retained. • Delete: After a PVC is deleted, the PV and its associated subdirectories will also be deleted. <p>NOTE When a subdirectory is deleted, only the absolute path of the subdirectory configured in the PVC will be deleted. The upper-layer directory will not be deleted.</p>

Step 3 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.

----End

Dynamically Creating an SFS Turbo Subdirectory Using kubectl

Step 1 Use kubectl to access the cluster.

Step 2 Create the **pvc-sfsturbo-subpath.yaml** file.

```

apiVersion: v1
kind: PersistentVolumeClaim
metadata:
  name: pvc-sfsturbo-subpath # PVC name
  namespace: default
  annotations:
    everest.io/volume-as: absolute-path # An SFS Turbo subdirectory is used.
    everest.io/sfsturbo-share-id: <sfsturbo_id> # SFS Turbo ID
    everest.io/path: /a # Subdirectory that is automatically created, which must be an
    absolute path
    everest.io/reclaim-policy: retain-volume-only # When a PVC is deleted, the PV will be deleted, but the
subdirectories associated with the PV will be retained.
spec:
  accessModes:
    - ReadWriteMany # ReadWriteMany must be selected for SFS Turbo.
  resources:
    requests:
      storage: 10Gi # This parameter is only used for verification for the PVCs of the SFS Turbo
      subdirectory type. The value cannot be empty or 0.
      storageClassName: csi-sfsturbo # Storage class name of the SFS Turbo file system
  
```

Table 12-25 Key parameters

Parameter	Mandator y	Description
everest.io/volume-as	No	The value is fixed at absolute-path , indicating that a dynamically created SFS Turbo subdirectory is used.

Parameter	Mandatory	Description
everest.io/sfsturbo-share-id	No	SFS Turbo 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 file system. On the details page, copy the content following ID .
everest.io/path	No	Subdirectory that is automatically created, which must be an absolute path.
everest.io/reclaim-policy	No	Whether to retain subdirectories when deleting a PVC. This parameter must be used with PV Reclaim Policy . This parameter is available only when the PV reclaim policy is Delete . Options: <ul style="list-style-type: none"> retain-volume-only: If a PVC is deleted, the PV will be deleted, but the subdirectories associated with the PV will be retained. delete: After a PVC is deleted, the PV and its associated subdirectories will also be deleted. NOTE When a subdirectory is deleted, only the absolute path of the subdirectory configured in the PVC will be deleted. The upper-layer directory will not be deleted.
storage	Yes	Requested capacity in the PVC, in Gi. This parameter is only used for verification for the PVCs of the SFS Turbo subdirectory type. The value cannot be empty or 0 , and can be fixed at 10 because any value you set does not take effect.

Step 3 Run the following command to create a PVC:

```
kubectl apply -f pvc-sfsturbo-subpath.yaml
```

----End

12.5.5 Dynamically Creating an SFS Turbo Subdirectory Using StorageClass

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: wwwwww
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
```

12.6 Object Storage Service

12.6.1 Overview

Introduction

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.

- **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 (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): an optimized high-performance file system provided by OBS for speedy processing of HPC workloads. PFS boasts millisecond-level access latency, TB/s-level bandwidth, and million-level IOPS, making it a reliable choice for those seeking top-notch performance. PFS outperforms OBS buckets.
- Object bucket
 - 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.

Performance

Every time an OBS volume is mounted to a container workload, a resident process is created in the backend. When a workload uses too many OBS volumes or reads and writes a large number of object storage files, resident processes will consume a significant amount of memory. The amount of memory required in these scenarios is listed [Table 12-26](#). To ensure stable running of the workload, make sure that the number of OBS volumes used does not exceed the requested memory. For example, if the workload requests for 4 GiB of memory, the number of OBS volumes should be **no more than 4**.

Table 12-26 Memory required by a single object storage resident process

Test Item	Memory Usage
Long-term stable running	About 50 MiB
Concurrent write to a 10 MB file from two processes	About 110 MiB
Concurrent write to a 10 MB file from four processes	About 220 MiB
Write to a 100 GB file from a single process	About 300 MiB

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 if the underlying storage is available.
- **Using an OBS Bucket Through a Dynamic PV:** dynamic creation mode, in which you do not need to create OBS volumes beforehand. Instead, specify a StorageClass when creating a PVC. Then, an OBS volume and PV will be created automatically. This mode applies to scenarios where no underlying storage is available.

12.6.2 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 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.
- To create a cluster using commands, ensure kubectl is used. For details, see **Connecting to a Cluster Using kubectl**.

Notes and Constraints

- If OBS volumes are used, the owner group and permission of the mount point cannot be modified.
- Every time an OBS volume is mounted to a workload through a PVC, a resident process is created in the backend. When a workload uses too many OBS volumes or reads and writes a large number of object storage files, resident processes will consume a significant amount of memory. To ensure stable running of the workload, make sure that the number of OBS volumes used does not exceed the requested memory. For example, if the workload requests for 4 GiB of memory, the number of OBS volumes should be **no more than 4**.
- Hard links are not supported when common buckets are mounted.
- Multiple PVs can use the same OBS storage volume with the following restrictions:
 - Do not mount the PVCs/PVs that use the same underlying OBS volume to one pod. This will lead to a pod startup failure because not all PVCs can be mounted to the pod due to the same **volumeHandle** value.
 - 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. In the right pane, click the **PVCs** tab. Click **Create PVC** in the upper right corner. In the dialog box displayed, configure PVC parameters.

Parameter	Description
PVC Type	In this example, select OBS .
PVC Name	Enter the PVC name, which must be unique in a namespace.
Creation Method	<ul style="list-style-type: none"> - If underlying storage is available, create a PV or use an existing PV to statically create a PVC. - If no underlying storage is available, select Dynamically provision. For details, see Using an OBS Bucket Through a Dynamic PV. <p>In this example, select Create new to create both a PV and PVC on the console.</p>
PV ^a	Select an existing PV in the cluster. For details about how to create a PV, see "Creating a storage volume" in Related Operations . You do not need to specify this parameter in this example.
OBS ^b	Click Select OBS . On the displayed page, select the OBS volume 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 prevent the underlying volume from being deleted with a PV.

Parameter	Description
Access Key (AK/SK) ^b	<p>Custom (Recommended): 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.</p> <p>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.</p> <ul style="list-style-type: none"> - 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. Choose **Workloads** in the navigation pane. 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 12-27](#). For details about other parameters, see [Workloads](#).

Table 12-27 Mounting a storage volume

Parameter	Description
PVC	Select an existing OBS volume.

Parameter	Description
Mount Path	<p>Enter a mount path, for example, /tmp.</p> <p>This parameter specifies a 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, leading to container startup failures or workload creation failures.</p> <p>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 may be damaged.</p>
Subpath	<p>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.</p>
Permission	<ul style="list-style-type: none"> - 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

Using an Existing OBS Bucket Through kubectl

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 underlying volume is retained
when the PV is deleted.
```

```

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
    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 12-28 Key parameters

Parameter	Mandatory	Description
everest.io/reclaim-policy: retain-volume-only	No	Optional. Only retain-volume-only is supported. This parameter 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 . <ul style="list-style-type: none"> - obsfs: a parallel file system - s3fs: object bucket
volumeHandle	Yes	OBS volume name.
everest.io/obs-volume-type	Yes	OBS storage class. <ul style="list-style-type: none"> - 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. For details about the value of region , see Regions and Endpoints .

Parameter	Mandatory	Description
nodePublishSecretRef	No	<p>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.</p> <p>An example is as follows:</p> <pre>nodePublishSecretRef: name: secret-demo namespace: default</pre>
mountOptions	No	Mount options. For details, see Configuring OBS Mount Options .
persistentVolumeReclaimPolicy	Yes	<p>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.</p> <p>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 prevent the underlying volume from being deleted with a PV.</p> <p>Delete:</p> <ul style="list-style-type: none"> - If everest.io/reclaim-policy is not specified, both the PV and storage resources will be deleted when a PVC is deleted. - If everest.io/reclaim-policy is set to retain-volume-only, when a PVC is deleted, the PV will be deleted but the storage resources will be retained. <p>Retain: When a PVC is deleted, both the PV and underlying storage resources will be retained. You need to manually delete these resources. After the PVC is deleted, the PV is in the Released state and cannot be bound to a PVC again.</p>
storage	Yes	<p>Storage capacity, in Gi.</p> <p>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.</p>
storageClassName	Yes	StorageClass name, which is csi-obs for an OBS volume.

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.
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 12-29 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.
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 . StorageClass name, which is csi-obs for an OBS volume.
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 check 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
```

The **static** file is retained, indicating that the data in the file system 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 12-30](#).

Table 12-30 Related operations

Operation	Description	Procedure
<p>Creating a storage volume (PV)</p>	<p>Create a PV on the CCE console.</p>	<ol style="list-style-type: none"> Choose Storage in the navigation pane. In the right pane, click the PVs tab. Click Create PersistentVolume in the upper right corner. In the dialog box displayed, configure parameters. <ul style="list-style-type: none"> Volume Type: Select OBS. OBS: Click Select OBS. On the displayed page, select the OBS volume that meets your requirements and click OK. PV Name: Enter the PV name, which must be unique in a 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. <p>NOTE If multiple PVs use the same underlying storage volume, use Retain to prevent the underlying volume from being deleted with a PV.</p> <ul style="list-style-type: none"> Custom (Recommended): 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. Click Create.

Operation	Description	Procedure
Updating an access key	Update the access key of object storage on the CCE console.	<ol style="list-style-type: none"> 1. Choose Storage in the navigation pane. In the right pane, click the PVCs tab. Click More in the Operation column of the target PVC and select Update Access Key. 2. Upload a key file in .csv format. For details, see Obtaining an Access Key. Click OK. <p>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.</p>
Viewing events	View event names, event types, number of occurrences, Kubernetes events, first occurrence time, and last occurrence time of the PVC or PV.	<ol style="list-style-type: none"> 1. Choose Storage in the navigation pane. In the right pane, 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 (events are retained for one hour).
Viewing a YAML file	View, copy, or download the YAML file of a PVC or PV.	<ol style="list-style-type: none"> 1. Choose Storage in the navigation pane. In the right pane, 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.

12.6.3 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.

Notes and Constraints

- If OBS volumes are used, the owner group and permission of the mount point cannot be modified.
- Every time an OBS volume is mounted to a workload through a PVC, a resident process is created in the backend. When a workload uses too many OBS volumes or reads and writes a large number of object storage files, resident processes will consume a significant amount of memory. To ensure stable running of the workload, make sure that the number of OBS volumes used does not exceed the requested memory. For example, if the workload requests for 4 GiB of memory, the number of OBS volumes should be **no more than 4**.
- Hard links are not supported when common buckets are mounted.

- 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. In the right pane, click the **PVCs** tab. Click **Create PVC** in the upper right corner. In the dialog box displayed, configure PVC parameters.

Parameter	Description
PVC Type	In this example, select OBS .
PVC Name	Enter the PVC name, which must be unique in a namespace.
Creation Method	<ul style="list-style-type: none"> – 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 PV or use an existing PV to statically create a PVC. For details, see Using an Existing OBS Bucket Through a Static PV. In this example, select Dynamically provision .
Storage Classes	StorageClass name, which is csi-obs for an OBS volume.
(Optional) Storage Volume Name Prefix	Available only when the cluster version is v1.23.14-r0, v1.25.9-r0, v1.27.6-r0, v1.28.4-r0, or later, and Everest of v2.4.15 or later is installed in the cluster. This parameter specifies the name of the underlying storage that is automatically created. The actual underlying storage name is in the format of "PV name prefix + PVC UID". If this parameter is left blank, the default prefix pvc will be used. For example, if the PV name prefix is set to test , the actual underlying storage name is test-<i>{UID}</i> .
Instance Type	<ul style="list-style-type: none"> – 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: <ul style="list-style-type: none"> – 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 (Recommended): 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. <ul style="list-style-type: none"> – 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.

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. Choose **Workloads** in the navigation pane. 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 12-31](#). For details about other parameters, see [Workloads](#).

Table 12-31 Mounting a storage volume

Parameter	Description
PVC	Select an existing OBS volume.

Parameter	Description
Mount Path	<p>Enter a mount path, for example, /tmp.</p> <p>This parameter specifies a 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, leading to container startup failures or workload creation failures.</p> <p>NOTICE</p> <p>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 may be damaged.</p>
Subpath	<p>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.</p>
Permission	<ul style="list-style-type: none"> - 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

Automatically Creating an OBS Volume Through kubectl

Step 1 Use kubectl to access 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 # OBS
```



```

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/csi.volume-name-prefix: test # (Optional) PV name prefix of the automatically created
underlying storage
spec:
  accessModes:
    - ReadWriteMany # The value must be ReadWriteMany for OBS.
  resources:
    requests:
      storage: 1Gi # OBS volume capacity
      storageClassName: csi-obs # StorageClass is OBS.

```

Table 12-32 Key parameters

Parameter	Mandatory	Description
everest.io/obs-volume-type	Yes	OBS storage class. <ul style="list-style-type: none"> 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 . <ul style="list-style-type: none"> obsfs: a parallel file system s3fs: object bucket
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.

Parameter	Mandatory	Description
everest.io/csi.volume-name-prefix	No	<p>(Optional) This parameter is available only when the cluster version is v1.23.14-r0, v1.25.9-r0, v1.27.6-r0, v1.28.4-r0, or later, and Everest of v2.4.15 or later is installed in the cluster.</p> <p>This parameter specifies the name of the underlying storage that is automatically created. The actual underlying storage name is in the format of "PV name prefix + PVC UID". If this parameter is left blank, the default prefix pvc will be used.</p> <p>Enter 1 to 26 characters that cannot start or end with a hyphen (-). Only lowercase letters, digits, and hyphens (-) are allowed.</p> <p>For example, if the PV name prefix is set to test, the actual underlying storage name is test-<i>{UID}</i>.</p>
storage	Yes	<p>Requested capacity in the PVC, in Gi.</p> <p>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.</p>
storageClassName	Yes	<p>StorageClass name, which is csi-obs for an OBS volume.</p>

- Run the following command to create a PVC:

```
kubectl apply -f pvc-obs-auto.yaml
```

Step 3 Create an application.

- 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 check 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
```

The **static** file is retained, indicating that the data in the file system 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 12-33](#).

Table 12-33 Related operations

Operation	Description	Procedure
Updating an access key	Update the access key of object storage on the CCE console.	<ol style="list-style-type: none"> 1. Choose Storage in the navigation pane. In the right pane, click the PVCs tab. Click More in the Operation column of the target PVC and select Update Access Key. 2. Upload a key file in .csv format. For details, see Obtaining an Access Key. Click OK. <p>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.</p>

Operation	Description	Procedure
Viewing events	View event names, event types, number of occurrences, Kubernetes events, first occurrence time, and last occurrence time of the PVC or PV.	<ol style="list-style-type: none"> 1. Choose Storage in the navigation pane. In the right pane, 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 (events are retained for one hour).
Viewing a YAML file	View, copy, or download the YAML file of a PVC or PV.	<ol style="list-style-type: none"> 1. Choose Storage in the navigation pane. In the right pane, 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.

12.6.4 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 \(Everest\)](#) 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 12-34](#) and [Table 12-35](#) by default. The options in [Table 12-34](#) are mandatory.

Table 12-34 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.

Parameter	Value	Description
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 12-35 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	0	Mask of the configuration file permission. For example, if the umask value is 022 , the directory permission (the maximum permission is 777) is 755 ($777 - 022 = 755$, $rw\!-\!xr\!-\!x$).

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 access 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 underlying volume is retained when
the PV is deleted.
    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
  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 access 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:
- umask=027 # Mount options
```

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

12.6.5 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)** version must be 1.2.8 or later.
- The cluster version must be 1.15.11 or later.

Notes and 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

On the earlier version's console, you need to upload the AK/SK, which is then used by default for mounting an OBS volume. As a result, all IAM users within your account will use the same key to mount OBS buckets, and they will have identical permissions on the buckets. However, this setting does not allow you to set different permissions for individual 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**.

```
- /bin/sh
- -c
- /var/paas/everest-csi-driver/everest-csi-driver --call-mode=kubelet --drivers=*.local.csi.everest.io
--aksk-secret-name=paas.aks-k --iam-endpoint=https://iam.192.168.1.1:443 --evs-endpoint=https://evs.192.168.1.1:443
--ecs-endpoint=https://ecs.192.168.1.1:443 --sfs-endpoint=https://sfs.192.168.1.1:443
--obs-endpoint=https://obs.192.168.1.1:443 --sfs-turbo-endpoint=https://sfs-turbo.192.168.1.1:443
--bms-endpoint=https://bms.192.168.1.1:443 --ims-endpoint=https://ims.192.168.1.1:443
--feature-gates=supportHcs=fake --project-id=b6315dd3d0ff4be5b31a963256794989
--cluster-id=827dced9-c2ad-11e6-bfce-0255ac1036e0 --default-vpc-id=0f090290-2b77-48ae-a601-0e746f350265
--disable-auto-mount-secret=true --cluster-version=v1.19.10-r0 --v=2 1>/var/paas/sys/log/everest-csi-driver/everest-csi-driver-standalone.log
2>&1
env:
```

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.
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 cfesecureopaque . 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: eu-west-0
    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. <ul style="list-style-type: none"> ● name: name of the secret ● namespace: namespace of the secret
fsType	File type, which can be s3fs or obsfs . If the value is s3fs , an OBS bucket is created. If the value is obsfs , an OBS parallel file system is created.
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

Parameter	Description
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
```

12.7 DSS

12.7.1 Overview

Dedicated Distributed Storage Service (DSS) provides dedicated physical storage resources. With data redundancy and cache acceleration technologies, DSS delivers highly reliable, durable, low-latency, and stable storage resources. CCE allows you to mount DSS storage volumes to containers.

DSS Performance

The key indicators to measure the performance of DSS storage pools include IOPS, throughput, and I/O latency.

- IOPS: the number of input/output operations per second
- Throughput: the amount of data read from and written into a storage pool per second
- I/O latency: the minimum interval between two consecutive I/O operations

Table 12-36 DSS performance specifications

Parameter	High I/O	Ultra-high I/O
IOPS	1500 IOPS/TB	8000 IOPS/TB
I/O latency (single queue, 4 KiB data blocks)	1 ms to 3 ms	1 ms
Typical application scenarios	Common development and testing	<ul style="list-style-type: none"> • Transcoding services • I/O-intensive services <ul style="list-style-type: none"> - NoSQL - SQL Server - PostgreSQL • Latency-sensitive services <ul style="list-style-type: none"> - Redis - Memcache

Application Scenarios

DSS supports the following mounting modes based on application scenarios:

- **Using DSS Through a Static PV:** static creation mode, where you use an existing volume to create a PV and then mount storage to the workload through a PVC. This mode applies to scenarios where disks are available.
- **Using DSS Through a Dynamic PV:** dynamic creation mode, in which you do not need to create disks beforehand. Instead, specify a StorageClass when creating a PVC. Then, a disk and PV will be created automatically. This mode applies to scenarios where no disk is available.
- **Dynamically Mounting a DSS Disk to a StatefulSet:** available only for StatefulSets. 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. This mode applies to StatefulSets with multiple pods.

12.7.2 Using DSS Through a Static PV

CCE allows you to create a PV using an existing DSS disk. After the PV is created, you can create a PVC and bind it to the PV. This mode applies to scenarios where underlying storage is available.

Prerequisites

- You have created a cluster of version v1.21.15-r0, v1.23.14-r0, v1.25.9-r0, v1.27.6-r0, v1.28.4-r0, or later, and **CCE Container Storage (Everest)** of v2.4.5 or later has been installed in the cluster.
- To create a cluster using commands, ensure kubectl is used. For details, see **Connecting to a Cluster Using kubectl**.

- You have created a DSS disk that meets the following requirements:
 - The DSS disk cannot be a system disk or shared disk.
 - The DSS disk must be of the **SCSI** type (the default disk type is **VBD** when you create a DSS disk).
 - The DSS disk must be available and not used by other resources.
 - If the DSS disk is encrypted, the key must be available.

Notes and Constraints

- DSS 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 a DSS disk is attached to multiple nodes, I/O conflicts and data cache conflicts may occur. Therefore, select only one pod when creating a Deployment that uses DSS.
- If an HPA policy is used to expand the capacity of a workload with a DSS disk attached, new pods cannot be started because the DSS disk cannot attach to them.

Using an Existing DSS 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. In the right pane, click the **PVCs** tab. Click **Create PVC** in the upper right corner. In the dialog box displayed, configure PVC parameters.

Parameter	Description
PVC Type	In this example, select DSS .
PVC Name	Enter the PVC name, which must be unique in a namespace.
Creation Method	<ul style="list-style-type: none"> – If underlying storage is available, create a PV or use an existing PV to statically create a PVC. – If no underlying storage is available, select Dynamically provision. For details, see Using DSS Through a Dynamic PV. <p>In this example, select Create new to create both a PV and PVC on the console.</p>
PV ^a	<p>Select an existing PV in the cluster. For details about how to create a PV, see "Creating a storage volume" in Related Operations.</p> <p>You do not need to specify this parameter in this example.</p>
DSS ^b	Click Select DSS . On the displayed page, select the DSS volume that meets your requirements and click OK .

Parameter	Description
PV Name ^b	Enter the PV name, which must be unique in the same cluster.
Access Mode ^b	DSS volumes support only ReadWriteOnce , indicating that a storage volume can be mounted to one node in read/write mode.
Reclaim Policy ^b	You can select Delete or Retain to specify the reclaim policy of the underlying storage when the PVC is deleted.

 **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. Choose **Workloads** in the navigation pane. 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 12-37](#). For details about other parameters, see [Workloads](#).

Table 12-37 Mounting a storage volume

Parameter	Description
PVC	Select an existing DSS volume. A DSS volume can be mounted to only one workload.
Mount Path	Enter a mount path, for example, /tmp . This parameter specifies a 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, leading to 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 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	<ul style="list-style-type: none"> - 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 DSS disk.

 **NOTE**

A non-shared DSS disk can be attached to only one workload pod. If there are multiple pods, extra pods cannot start properly. Ensure that the number of workload pods is 1 if a DSS disk is attached.

If multiple workload pods are needed, create a StatefulSet and dynamically mount a PV to each pod. For details, see [Dynamically Mounting a DSS Disk to a StatefulSet](#).

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

Using an Existing DSS Disk Through kubectl

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-dss.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 underlying volume is retained
when the PV is deleted.
  name: pv-dss # 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, which must be ReadWriteOnce for DSS
capacity:
  storage: 10Gi # 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.
  volumeAttributes:
    everest.io/disk-mode: SCSI # Device type of the DSS disk. Only SCSI is supported.
    everest.io/disk-volume-type: SAS # Disk type
    everest.io/csi.dedicated-storage-id: <dss_id> # ID of the DSS storage pool
    storage.kubernetes.io/csiProvisionerIdentity: everest-csi-provisioner
    everest.io/crypt-key-id: <your_key_id> # (Optional) Encryption key ID. Mandatory for an
    encrypted disk.
  persistentVolumeReclaimPolicy: Delete # Reclaim policy
  storageClassName: csi-disk-dss # Storage class name of the DSS disk

```

Table 12-38 Key parameters

Parameter	Mandatory	Description
everest.io/reclaim-policy: retain-volume-only	No	Optional. Only retain-volume-only is supported. This parameter 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. For details about the value of region , see Regions and Endpoints .
failure-domain.beta.kubernetes.io/zone	Yes	AZ where the DSS volume is created. It must be the same as the AZ planned for the workload. For details about the value of zone , see Regions and Endpoints .
fsType	Yes	File system type, which defaults to ext4 .
everest.io/disk-volume-type	Yes	Disk type. All letters are in uppercase. - SAS : high I/O - SSD : ultra-high I/O
everest.io/csi.dedicated-storage-id	Yes	ID of the DSS storage pool where the DSS disk resides. To obtain a DSS storage pool ID, log in to the Cloud Server Console . In the navigation pane, choose Dedicated Distributed Storage Service > Storage Pools and click the name of the target storage pool. On the resource pool details page, copy the pool ID.

Parameter	Mandatory	Description
everest.io/crypt-key-id	No	Mandatory when the disk is encrypted. Enter the encryption key ID selected during disk creation. To obtain an encryption key ID, log in to the Cloud Server Console . In the navigation pane, choose Dedicated Distributed Storage Service > Disks . Click the name of the target disk to go to its details page. On the Summary tab page, copy the value of KMS Key ID in the Configuration Information area.
persistentVolumeReclaimPolicy	Yes	The Delete and Retain reclaim policies are supported. If high data security is required, select Retain to prevent data from being deleted by mistake. Delete: <ul style="list-style-type: none"> If everest.io/reclaim-policy is not specified, both the PV and DSS disk will be deleted when a PVC is deleted. If everest.io/reclaim-policy is set to retain-volume-only, when a PVC is deleted, the PV will be deleted but the DSS disk will be retained. Retain: When a PVC is deleted, both the PV and underlying storage resources will be retained. You need to manually delete these resources. After the PVC is deleted, the PV is in the Released state and cannot be bound to a PVC again.
storageClassName	Yes	The storage class for DSS disks is csi-disk-dss .

- Run the following command to create a PV:

```
kubectl apply -f pv-dss.yaml
```

Step 3 Create a PVC.

- Create the **pvc-dss.yaml** file.

```
apiVersion: v1
kind: PersistentVolumeClaim
metadata:
  name: pvc-dss
  namespace: default
annotations:
  everest.io/disk-volume-type: SAS # Disk type
  everest.io/csi.dedicated-storage-id: <dss_id> # ID of the DSS storage pool
  everest.io/crypt-key-id: <your_key_id> # (Optional) Encryption key ID. Mandatory for an encrypted disk.
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 DSS.
  resources:
  requests:
    storage: 10Gi # Disk capacity, ranging from 1 to 32768. The value must be the same as
the storage size of the existing PV.
  storageClassName: csi-disk-dss # StorageClass is DSS.
  volumeName: pv-dss # PV name

```

Table 12-39 Key parameters

Parameter	Mandatory	Description
failure-domain.beta.kubernetes.io/region	Yes	Region where the cluster is located. For details about the value of region , see Regions and Endpoints .
failure-domain.beta.kubernetes.io/zone	Yes	AZ where the disk is created. It must be the same as the AZ planned for the workload. For details about the value of zone , see Regions and Endpoints .
everest.io/csi.dedicated-storage-id	Yes	ID of the DSS storage pool where the DSS disk resides. To obtain a DSS storage pool ID, log in to the Cloud Server Console . In the navigation pane, choose Dedicated Distributed Storage Service > Storage Pools and click the name of the target storage pool. On the resource pool details page, copy the pool ID.
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 DSS disks is csi-disk-dss .

- Run the following command to create a PVC:
kubect apply -f pvc-dss.yaml

Step 4 Create an application.

- Create a file named **web-dss.yaml**. In this example, the disk is mounted to the **/data** path.
apiVersion: apps/v1
kind: StatefulSet

```

metadata:
  name: web-dss
  namespace: default
spec:
  replicas: 1
  selector:
    matchLabels:
      app: web-dss
  serviceName: web-dss # Headless Service name
  template:
    metadata:
      labels:
        app: web-dss
    spec:
      containers:
        - name: container-1
          image: nginx:latest
          volumeMounts:
            - name: pvc-disk-dss # 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-dss # Volume name, which can be customized
              persistentVolumeClaim:
                claimName: pvc-dss # Name of the created PVC
---
apiVersion: v1
kind: Service
metadata:
  name: web-dss # Headless Service name
  namespace: default
  labels:
    app: web-dss
spec:
  selector:
    app: web-dss
  clusterIP: None
  ports:
    - name: web-dss
      targetPort: 80
      nodePort: 0
      port: 80
      protocol: TCP
  type: ClusterIP

```

2. Run the following command to create a workload to which the DSS volume is mounted:

```
kubectl apply -f web-dss.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 DSS volume files.

1. Run the following command to view the created pod:

```
kubectl get pod | grep web-dss
```

Expected output:

```
web-dss-0          1/1    Running    0          38s
```

2. Run the following command to check whether the DSS volume has been mounted to the **/data** path:

```
kubectl exec web-dss-0 -- df | grep data
```

Expected output:

```
/dev/sdc      10255636   36888 10202364   0% /data
```

3. Run the following command to check the files in the **/data** path:

```
kubectl exec web-dss-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-dss-0 -- touch /data/static
```

- Step 3** Run the following command to check the files in the **/data** path:

```
kubectl exec web-dss-0 -- ls /data
```

Expected output:

```
lost+found  
static
```

- Step 4** Run the following command to delete the pod named **web-dss-0**:

```
kubectl delete pod web-dss-0
```

Expected output:

```
pod "web-dss-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-dss-0 -- ls /data
```

Expected output:

```
lost+found  
static
```

The **static** file is retained, indicating that the data in the DSS volume can be stored persistently.

----End

Related Operations

You can also perform the operations listed in [Table 12-40](#).

Table 12-40 Related operations

Operation	Description	Procedure
Creating a storage volume (PV)	Create a PV on the CCE console.	<ol style="list-style-type: none"> 1. Choose Storage in the navigation pane. In the right pane, click the PVs tab. Click Create PersistentVolume in the upper right corner. In the dialog box displayed, configure parameters. <ul style="list-style-type: none"> • Volume Type: Select DSS. • DSS: Click Select DSS. On the displayed page, select the disk that meets your requirements and click OK. • PV Name: Enter the PV name, which must be unique in a cluster. • Access Mode: DSS volumes support only ReadWriteOnce, indicating that a storage volume can be mounted to one node in read/write mode. • Reclaim Policy: Delete or Retain is supported. 2. Click Create.
Expanding the capacity of DSS storage	Quickly expand the capacity of an attached DSS disk on the CCE console.	<ol style="list-style-type: none"> 1. Choose Storage in the navigation pane. In the right pane, click the PVCs tab. Click More in the Operation column of the target PVC and select Scale-out. 2. Enter the capacity to be added and click OK.
Viewing events	View event names, event types, number of occurrences, Kubernetes events, first occurrence time, and last occurrence time of the PVC or PV.	<ol style="list-style-type: none"> 1. Choose Storage in the navigation pane. In the right pane, 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 (events are retained for one hour).
Viewing a YAML file	View, copy, or download the YAML file of a PVC or PV.	<ol style="list-style-type: none"> 1. Choose Storage in the navigation pane. In the right pane, 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.

12.7.3 Using DSS Through a Dynamic PV

CCE allows you to specify a StorageClass to automatically create a DSS disk and the corresponding PV. This function is applicable when no underlying storage volume is available.

Prerequisites

- You have created a cluster of version v1.21.15-r0, v1.23.14-r0, v1.25.9-r0, v1.27.6-r0, v1.28.4-r0, or later, and **CCE Container Storage (Everest)** of v2.4.5 or later has been installed in the cluster.
- To create a cluster using commands, ensure kubectl is used. For details, see [Connecting to a Cluster Using kubectl](#).

Notes and Constraints

- DSS 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 a DSS disk is attached to multiple nodes, I/O conflicts and data cache conflicts may occur. Therefore, select only one pod when creating a Deployment that uses DSS.
- If an HPA policy is used to expand the capacity of a workload with a DSS disk attached, new pods cannot be started because the DSS disk cannot attach to them.

Automatically Creating a DSS 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.

- Choose **Storage** in the navigation pane. In the right pane, click the **PVCs** tab. Click **Create PVC** in the upper right corner. In the dialog box displayed, configure PVC parameters.

Parameter	Description
PVC Type	In this example, select DSS .
PVC Name	Enter the PVC name, which must be unique in a namespace.
Creation Method	<ul style="list-style-type: none">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 PV or use an existing PV to statically create a PVC. For details, see Using DSS Through a Static PV. In this example, select Dynamically provision .
Storage Classes	The storage class for DSS disks is csi-disk-dss .

Parameter	Description
(Optional) Storage Volume Name Prefix	<p>Available only when the cluster version is v1.23.14-r0, v1.25.9-r0, v1.27.6-r0, v1.28.4-r0, or later, and Everest of v2.4.15 or later is installed in the cluster.</p> <p>This parameter specifies the name of the underlying storage that is automatically created. The actual underlying storage name is in the format of "PV name prefix + PVC UID". If this parameter is left blank, the default prefix pvc will be used.</p> <p>For example, if the PV name prefix is set to test, the actual underlying storage name is test-<i>{UID}</i>.</p>
DSS Pool	Select an existing DSS pool.
Capacity (GiB)	Capacity of the requested storage volume.
Access Mode	DSS volumes support only ReadWriteOnce , indicating that a storage volume can be mounted to one node in read/write mode.
Encryption	Configure whether to encrypt underlying storage. If you select Enabled (key) , an encryption key must be configured.
Resource Tag	<p>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.</p> <p>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.</p> <p>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.</p> <p>NOTE</p> <p>After a dynamic PV of the DSS type is created, the resource tags cannot be updated on the CCE console. To update DSS resource tags, go to the DSS console.</p>

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. Choose **Workloads** in the navigation pane. 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 12-41](#). For details about other parameters, see [Workloads](#).

Table 12-41 Mounting a storage volume

Parameter	Description
PVC	Select an existing DSS volume. A DSS volume can be mounted to only one workload.
Mount Path	Enter a mount path, for example, /tmp . This parameter specifies a 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, leading to 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 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	<ul style="list-style-type: none"> - 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 DSS disk.

 **NOTE**

A non-shared DSS disk can be attached to only one workload pod. If there are multiple pods, extra pods cannot start properly. Ensure that the number of workload pods is 1 if a DSS disk is attached.

If multiple workload pods are needed, create a StatefulSet and dynamically mount a PV to each pod. For details, see [Dynamically Mounting a DSS Disk to a StatefulSet](#).

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

Automatically Creating a DSS Volume Through kubectl

Step 1 Use kubectl to access the cluster.

Step 2 Use StorageClass to dynamically create a PVC and PV.

1. Create the **pvc-dss-auto.yaml** file.

```
apiVersion: v1
kind: PersistentVolumeClaim
metadata:
  name: pvc-dss-auto
  namespace: default
  annotations:
    everest.io/disk-volume-type: SAS # Disk type
    everest.io/csi.dedicated-storage-id: <dss_id> # ID of the DSS storage pool
    everest.io/crypt-key-id: <your_key_id> # (Optional) Encryption key ID. Mandatory for an
    encrypted disk.
    everest.io/disk-volume-tags: '{"key1":"value1","key2":"value2"}' # (Optional) Custom resource tags
    everest.io/csi.volume-name-prefix: test # (Optional) PV name prefix of the automatically created
    underlying storage
  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 DSS.
  resources:
    requests:
      storage: 10Gi # Disk capacity, ranging from 1 to 32768
    storageClassName: csi-disk-dss # StorageClass is DSS.
```

Table 12-42 Key parameters

Parameter	Mandatory	Description
failure-domain.beta.kubernetes.io/region	Yes	Region where the cluster is located. For details about the value of region , see Regions and Endpoints .
failure-domain.beta.kubernetes.io/zone	Yes	AZ where the disk is created. It must be the same as the AZ planned for the workload. For details about the value of zone , see Regions and Endpoints .
everest.io/disk-volume-type	Yes	Disk type. All letters are in uppercase. - SAS : high I/O - SSD : ultra-high I/O

Parameter	Mandatory	Description
everest.io/csi.dedicated-storage-id	Yes	<p>ID of the DSS storage pool where the DSS disk resides.</p> <p>To obtain a DSS storage pool ID, log in to the Cloud Server Console. In the navigation pane, choose Dedicated Distributed Storage Service > Storage Pools and click the name of the target storage pool. On the resource pool details page, copy the pool ID.</p>
everest.io/crypt-key-id	No	<p>Mandatory when the DSS disk is encrypted. Enter the encryption key ID selected during disk creation.</p> <p>To obtain a key ID, log in to the DEW console, locate the key to be encrypted, and copy the key ID.</p>
everest.io/disk-volume-tags	No	<p>This field is optional. It is supported when the Everest version in the cluster is 2.1.39 or later.</p> <p>You can add resource tags to classify resources.</p> <p>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.</p> <p>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.</p>

Parameter	Mandatory	Description
everest.io/csi.volume-name-prefix	No	<p>(Optional) This parameter is available only when the cluster version is v1.23.14-r0, v1.25.9-r0, v1.27.6-r0, v1.28.4-r0, or later, and Everest of v2.4.15 or later is installed in the cluster.</p> <p>This parameter specifies the name of the underlying storage that is automatically created. The actual underlying storage name is in the format of "PV name prefix + PVC UID". If this parameter is left blank, the default prefix pvc will be used.</p> <p>Enter 1 to 26 characters that cannot start or end with a hyphen (-). Only lowercase letters, digits, and hyphens (-) are allowed.</p> <p>For example, if the PV name prefix is set to test, the actual underlying storage name is test-<i>{UID}</i>.</p>
storage	Yes	Requested PVC capacity, in Gi. The value ranges from 1 to 32768 .
storageClassName	Yes	The storage class for DSS disks is csi-disk-dss .

- Run the following command to create a PVC:

```
kubectl apply -f pvc-dss-auto.yaml
```

Step 3 Create an application.

- Create a file named **web-dss-auto.yaml**. In this example, the disk is mounted to the **/data** path.

```

apiVersion: apps/v1
kind: StatefulSet
metadata:
  name: web-dss-auto
  namespace: default
spec:
  replicas: 1
  selector:
    matchLabels:
      app: web-dss-auto
  serviceName: web-dss-auto # Headless Service name
  template:
    metadata:
      labels:
        app: web-dss-auto
    spec:
      containers:
        - name: container-1
          image: nginx:latest
          volumeMounts:
            - name: pvc-disk-dss # 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-dss # Volume name, which can be customized
    persistentVolumeClaim:
      claimName: pvc-dss-auto # Name of the created PVC
---
apiVersion: v1
kind: Service
metadata:
  name: web-dss-auto # Headless Service name
  namespace: default
  labels:
    app: web-dss-auto
spec:
  selector:
    app: web-dss-auto
  clusterIP: None
  ports:
    - name: web-dss-auto
      targetPort: 80
      nodePort: 0
      port: 80
      protocol: TCP
  type: ClusterIP
```

2. Run the following command to create a workload to which the DSS volume is mounted:

```
kubectl apply -f web-dss-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 DSS volume files.

1. Run the following command to view the created pod:

```
kubectl get pod | grep web-dss-auto
```

Expected output:

```
web-dss-auto-0          1/1    Running    0          38s
```

2. Run the following command to check whether the DSS volume has been mounted to the **/data** path:

```
kubectl exec web-dss-auto-0 -- df | grep data
```

Expected output:

```
/dev/sdc          10255636   36888 10202364   0% /data
```

3. Run the following command to check the files in the **/data** path:

```
kubectl exec web-dss-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-dss-auto-0 -- touch /data/static
```

Step 3 Run the following command to check the files in the **/data** path:

```
kubectl exec web-dss-auto-0 -- ls /data
```

Expected output:

```
lost+found
static
```

Step 4 Run the following command to delete the pod named **web-dss-auto-0**:

```
kubectl delete pod web-dss-auto-0
```

Expected output:

```
pod "web-dss-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-dss-auto-0 -- ls /data
```

Expected output:

```
lost+found  
static
```

The **static** file is retained, indicating that the data in the DSS volume can be stored persistently.

----End

Related Operations

You can also perform the operations listed in [Table 12-43](#).

Table 12-43 Related operations

Operation	Description	Procedure
Expanding the capacity of DSS storage	Quickly expand the capacity of an attached DSS disk on the CCE console.	<ol style="list-style-type: none"> 1. Choose Storage in the navigation pane. In the right pane, click the PVCs tab. Click More in the Operation column of the target PVC and select Scale-out. 2. Enter the capacity to be added and click OK.
Viewing events	View event names, event types, number of occurrences, Kubernetes events, first occurrence time, and last occurrence time of the PVC or PV.	<ol style="list-style-type: none"> 1. Choose Storage in the navigation pane. In the right pane, 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 (events are retained for one hour).
Viewing a YAML file	View, copy, or download the YAML file of a PVC or PV.	<ol style="list-style-type: none"> 1. Choose Storage in the navigation pane. In the right pane, 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.

12.7.4 Dynamically Mounting a DSS 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 dynamic creation of PVs through StorageClass. 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 of version v1.21.15-r0, v1.23.14-r0, v1.25.9-r0, v1.27.6-r0, v1.28.4-r0, or later, and [CCE Container Storage \(Everest\)](#) of v2.4.5 or later has been installed in the cluster.
- To create a cluster using commands, ensure kubectl is used. For details, see [Connecting to a Cluster Using kubectl](#).

Dynamically Mounting a DSS Disk on the 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. 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 PVC parameters.

Click **Create**.

Parameter	Description
PVC Type	In this example, select DSS .
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 <i><Custom PVC name>-<Serial number></i> , for example, example-0.
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 DSS disks is csi-disk-dss .

Parameter	Description
(Optional) Storage Volume Name Prefix	Available only when the cluster version is v1.23.14-r0, v1.25.9-r0, v1.27.6-r0, v1.28.4-r0, or later, and Everest of v2.4.15 or later is installed in the cluster. This parameter specifies the name of the underlying storage that is automatically created. The actual underlying storage name is in the format of "PV name prefix + PVC UID". If this parameter is left blank, the default prefix pvc will be used. For example, if the PV name prefix is set to test , the actual underlying storage name is test-<i>{UID}</i> .
DSS Pool	Select an existing DSS pool.
Capacity (GiB)	Capacity of the requested storage volume.
Access Mode	DSS volumes support only ReadWriteOnce , indicating that a storage volume can be mounted to one node in read/write mode.
Encryption	Configure whether to encrypt underlying storage. If you select Enabled (key) , an encryption key must be configured.
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. For details, see . 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 DSS type is created, the resource tags cannot be updated on the CCE console. To update DSS resource tags, go to the DSS console.

Step 5 Enter the path to which the volume is mounted.

Table 12-44 Mounting a storage volume

Parameter	Description
Mount Path	<p>Enter a mount path, for example, /tmp.</p> <p>This parameter specifies a 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, leading to container startup failures or workload creation failures.</p> <p>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 may be damaged.</p>
Subpath	<p>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.</p>
Permission	<ul style="list-style-type: none"> ● 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 DSS 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 a DSS Volume Through kubectl

Step 1 Use kubectl to access the cluster.

Step 2 Create a file named **statefulset-dss.yaml**. In this example, the disk is mounted to the **/data** path.

```
apiVersion: apps/v1
kind: StatefulSet
metadata:
  name: statefulset-dss
  namespace: default
```

```

spec:
  selector:
    matchLabels:
      app: statefulset-dss
  template:
    metadata:
      labels:
        app: statefulset-dss
    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-dss  # Headless Service name
      replicas: 2
      volumeClaimTemplates:
        - apiVersion: v1
          kind: PersistentVolumeClaim
          metadata:
            name: pvc-disk
            namespace: default
            annotations:
              everest.io/disk-volume-type: SAS # Disk type
              everest.io/csi.dedicated-storage-id: <dss_id> # ID of the DSS storage pool
              everest.io/crypt-key-id: <your_key_id> # (Optional) Encryption key ID. Mandatory for an encrypted
disk.
          everest.io/disk-volume-tags: '{"key1":"value1","key2":"value2"}' # (Optional) Custom resource tags
          everest.io/csi.volume-name-prefix: test # (Optional) PV name prefix of the automatically created
underlying storage
          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 DSS.
            resources:
              requests:
                storage: 10Gi # Disk capacity, ranging from 1 to 32768
                storageClassName: csi-disk # StorageClass is DSS.
---
apiVersion: v1
kind: Service
metadata:
  name: statefulset-dss # Headless Service name
  namespace: default
  labels:
    app: statefulset-dss
spec:
  selector:
    app: statefulset-dss
  clusterIP: None
  ports:
    - name: statefulset-dss
      targetPort: 80
      nodePort: 0
      port: 80
      protocol: TCP
  type: ClusterIP

```

Table 12-45 Key parameters

Parameter	Mandatory	Description
failure-domain.beta.kubernetes.io/region	Yes	Region where the cluster is located. For details about the value of region , see Regions and Endpoints .
failure-domain.beta.kubernetes.io/zone	Yes	AZ where the DSS volume is created. It must be the same as the AZ planned for the workload. For details about the value of zone , see Regions and Endpoints .
everest.io/disk-volume-type	Yes	Disk type. All letters are in uppercase. <ul style="list-style-type: none"> • SAS: high I/O • SSD: ultra-high I/O
everest.io/csi.dedicated-storage-id	Yes	ID of the DSS storage pool where the DSS disk resides. To obtain a DSS storage pool ID, log in to the Cloud Server Console . In the navigation pane, choose Dedicated Distributed Storage Service > Storage Pools and click the name of the target storage pool. On the resource pool details page, copy the pool ID.
everest.io/crypt-key-id	No	Mandatory when the DSS disk is encrypted. Enter the encryption key ID selected during disk creation. To obtain a key ID, log in to the DEW console, locate the key to be encrypted, and copy the key 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.

Parameter	Mandatory	Description
everest.io/csi.volume-name-prefix	No	<p>(Optional) This parameter is available only when the cluster version is v1.23.14-r0, v1.25.9-r0, v1.27.6-r0, v1.28.4-r0, or later, and Everest of v2.4.15 or later is installed in the cluster.</p> <p>This parameter specifies the name of the underlying storage that is automatically created. The actual underlying storage name is in the format of "PV name prefix + PVC UID". If this parameter is left blank, the default prefix pvc will be used.</p> <p>Enter 1 to 26 characters that cannot start or end with a hyphen (-). Only lowercase letters, digits, and hyphens (-) are allowed.</p> <p>For example, if the PV name prefix is set to test, the actual underlying storage name is test-<i>{UID}</i>.</p>
storage	Yes	Requested PVC capacity, in Gi. The value ranges from 1 to 32768 .
storageClassName	Yes	The storage class for DSS disks is csi-disk-dss .

Step 3 Run the following command to create a workload to which the DSS volume is mounted:

```
kubectl apply -f statefulset-dss.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 DSS volume files.

1. Run the following command to view the created pod:

```
kubectl get pod | grep statefulset-dss
```

Expected output:

```
statefulset-dss-0    1/1    Running    0        45s
statefulset-dss-1    1/1    Running    0        28s
```

2. Run the following command to check whether the DSS volume has been mounted to the **/data** path:

```
kubectl exec statefulset-dss-0 -- df | grep data
```

Expected output:

```
/dev/sdd    10255636    36888    10202364    0% /data
```

3. Run the following command to check the files in the **/data** path:

```
kubectl exec statefulset-dss-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-dss-0 -- touch /data/static
```

Step 3 Run the following command to check the files in the **/data** path:

```
kubectl exec statefulset-dss-0 -- ls /data
```

Expected output:

```
lost+found
static
```

Step 4 Run the following command to delete the pod named **web-dss-auto-0**:

```
kubectl delete pod statefulset-dss-0
```

Expected output:

```
pod "statefulset-dss-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-dss-0 -- ls /data
```

Expected output:

```
lost+found
static
```

The **static** file is retained, indicating that the data in the DSS volume can be stored persistently.

----End

Related Operations

You can also perform the operations listed in [Table 12-46](#).

Table 12-46 Related operations

Operation	Description	Procedure
Expanding the capacity of DSS storage	Quickly expand the capacity of an attached DSS disk on the CCE console.	<ol style="list-style-type: none"> 1. Choose Storage in the navigation pane. In the right pane, click the PVCs tab. Click More in the Operation column of the target PVC and select Scale-out. 2. Enter the capacity to be added and click OK.
Viewing events	View event names, event types, number of occurrences, Kubernetes events, first occurrence time, and last occurrence time of the PVC or PV.	<ol style="list-style-type: none"> 1. Choose Storage in the navigation pane. In the right pane, 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 (events are retained for one hour).

Operation	Description	Procedure
Viewing a YAML file	View, copy, or download the YAML file of a PVC or PV.	<ol style="list-style-type: none">1. Choose Storage in the navigation pane. In the right pane, 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.

12.8 Local PVs

12.8.1 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.

Mount Modes

Local PVs can be mounted only in the following modes:

- **Using a Local PV Through a Dynamic PV:** dynamic creation mode, in which you specify a StorageClass when creating a PVC. Then, an OBS volume and PV will be created automatically.
- **Dynamically Mounting a Local PV to a StatefulSet:** available only for StatefulSets. 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. 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.

Notes and 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** a node will cause the loss of the PVC/PV data of the local PV associated with the node. The lost data cannot be restored, and the affected PVC/PV cannot be 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.
- 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.

12.8.2 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.

Notes and 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 PV is insufficient, you can manually import a PV.

- 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. In the right pane, 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

12.8.3 Using a Local PV Through a Dynamic PV

Prerequisites

- You have created a cluster and installed the CSI add-on ([Everest](#)) in the cluster.
- To create a cluster using commands, ensure kubectl is used. 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](#).

Notes and 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](#) a node will cause the loss of the PVC/PV data of the local PV associated with the node. The lost data cannot be restored, and the affected PVC/PV cannot be 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.
- 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. In the right pane, click the **PVCs** tab. Click **Create PVC** in the upper right corner. In the dialog box displayed, configure PVC parameters.

Parameter	Description
PVC Type	In this section, select Local PV .
PVC Name	Enter the PVC name, which must be unique in a 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 .
(Optional) Storage Volume Name Prefix	Available only when the cluster version is v1.23.14-r0, v1.25.9-r0, v1.27.6-r0, v1.28.4-r0, or later, and Everest of v2.4.15 or later is installed in the cluster. This parameter specifies the name of the underlying storage that is automatically created. The actual underlying storage name is in the format of "PV name prefix + PVC UID". If this parameter is left blank, the default prefix pvc will be used. For example, if the PV name prefix is set to test , the actual underlying storage name is test-<i>{UID}</i> .
Capacity (GiB)	Capacity of the requested storage volume.
Access Mode	Local PVs support only ReadWriteOnce , indicating that a PV 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 .

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. Choose **Workloads** in the navigation pane. 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 12-47](#). For details about other parameters, see [Workloads](#).

Table 12-47 Mounting a storage volume

Parameter	Description
PVC	Select an existing local PV. A local PV can be mounted to only one workload.
Mount Path	Enter a mount path, for example, /tmp . This parameter specifies a 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, leading to 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 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	<ul style="list-style-type: none"> - 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

Automatically Creating a Local PV Through kubectl

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
  annotations:
    everest.io/csi.volume-name-prefix: test # (Optional) PV name prefix of the automatically created
    underlying storage
spec:
  accessModes:
    - ReadWriteOnce # The value must be ReadWriteOnce for local PVs.
  resources:
    requests:
      storage: 10Gi # Local PV capacity
  storageClassName: csi-local-topology # StorageClass is local PV.

```

Table 12-48 Key parameters

Parameter	Mandatory	Description
everest.io/csi.volume-name-prefix	No	<p>(Optional) This parameter is available only when the cluster version is v1.23.14-r0, v1.25.9-r0, v1.27.6-r0, v1.28.4-r0, or later, and Everest of v2.4.15 or later is installed in the cluster.</p> <p>This parameter specifies the name of the underlying storage that is automatically created. The actual underlying storage name is in the format of "PV name prefix + PVC UID". If this parameter is left blank, the default prefix pvc will be used.</p> <p>Enter 1 to 26 characters that cannot start or end with a hyphen (-). Only lowercase letters, digits, and hyphens (-) are allowed.</p> <p>For example, if the PV name prefix is set to test, the actual underlying storage name is test-<i>{UID}</i>.</p>
storage	Yes	Requested capacity in the PVC, in Gi.
storageClassName	Yes	StorageClass name, which is csi-local-topology for a local PV.

- Run the following command to create a PVC:

```
kubectl apply -f pvc-local.yaml
```

Step 3 Create an application.

- Create a file named **web-local.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 check 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 check 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
```

The **static** file is retained, indicating that the data in the local PV can be stored persistently.

----End

Related Operations

You can also perform the operations listed in [Table 12-49](#).

Table 12-49 Related operations

Operation	Description	Procedure
Viewing events	View event names, event types, number of occurrences, Kubernetes events, first occurrence time, and last occurrence time of the PVC or PV.	<ol style="list-style-type: none"> 1. Choose Storage in the navigation pane. In the right pane, 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 (events are retained for one hour).

Operation	Description	Procedure
Viewing a YAML file	View, copy, or download the YAML file of a PVC or PV.	<ol style="list-style-type: none"> 1. Choose Storage in the navigation pane. In the right pane, 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.

12.8.4 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 dynamic creation of PVs through StorageClass. 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.
- To create a cluster using commands, ensure kubectl is used. 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** Choose **Workloads** in the navigation pane. 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 .

Parameter	Description
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 <i><Custom PVC name>-<Serial number></i> , for example, <i>example-0</i> .
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 .
(Optional) Storage Volume Name Prefix	Available only when the cluster version is v1.23.14-r0, v1.25.9-r0, v1.27.6-r0, v1.28.4-r0, or later, and Everest of v2.4.15 or later is installed in the cluster. This parameter specifies the name of the underlying storage that is automatically created. The actual underlying storage name is in the format of "PV name prefix + PVC UID". If this parameter is left blank, the default prefix pvc will be used. For example, if the PV name prefix is set to test , the actual underlying storage name is test-<i>{UID}</i> .
Capacity (GiB)	Capacity of the requested storage volume.
Access Mode	Local PVs support only ReadWriteOnce , indicating that a PV 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 .

Step 5 Enter the path to which the volume is mounted.

Table 12-50 Mounting a storage volume

Parameter	Description
Mount Path	Enter a mount path, for example, /tmp . This parameter specifies a 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 malfunctioning. 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, leading to 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 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	<ul style="list-style-type: none"> • 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 Through 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
    annotations:
      everest.io/csi.volume-name-prefix: test # (Optional) PV name prefix of the automatically created
underlying storage
  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 12-51 Key parameters

Parameter	Mandatory	Description
everest.io/ csi.volume- name-prefix	No	(Optional) This parameter is available only when the cluster version is v1.23.14-r0, v1.25.9-r0, v1.27.6-r0, v1.28.4-r0, or later, and Everest of v2.4.15 or later is installed in the cluster. This parameter specifies the name of the underlying storage that is automatically created. The actual underlying storage name is in the format of "PV name prefix + PVC UID". If this parameter is left blank, the default prefix pvc will be used. Enter 1 to 26 characters that cannot start or end with a hyphen (-). Only lowercase letters, digits, and hyphens (-) are allowed. For example, if the PV name prefix is set to test , the actual underlying storage name is test-<i>{UID}</i> .
storage	Yes	Requested capacity in the PVC, in Gi.
storageClassNa me	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 check 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 check 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
```

The **static** file is retained, indicating that the data in the local PV can be stored persistently.

----End

Related Operations

You can also perform the operations listed in [Table 12-52](#).

Table 12-52 Related operations

Operation	Description	Procedure
Viewing events	View event names, event types, number of occurrences, Kubernetes events, first occurrence time, and last occurrence time of the PVC or PV.	<ol style="list-style-type: none"> 1. Choose Storage in the navigation pane. In the right pane, 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 (events are retained for one hour).
Viewing a YAML file	View, copy, or download the YAML file of a PVC or PV.	<ol style="list-style-type: none"> 1. Choose Storage in the navigation pane. In the right pane, 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.

12.9 Ephemeral Volumes

12.9.1 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 pods. LVs deliver better performance than the default storage medium of emptyDir.

Notes and 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.

12.9.2 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.

Notes and 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 an EV.

- 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. In the right pane, 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

12.9.3 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.
- To create a cluster using commands, ensure kubectl is used. 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](#).

Notes and 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** Choose **Workloads** in the navigation pane. In the right pane, click the **Deployments** 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 **Local Ephemeral Volume (emptyDir)**.
- Step 4** Mount and use storage volumes, as shown in [Table 12-53](#). For details about other parameters, see [Workloads](#).

Table 12-53 Mounting a local EV

Parameter	Description
Capacity	Capacity of the requested storage volume.
Mount Path	<p>Enter a mount path, for example, /tmp.</p> <p>This parameter specifies a 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, leading to container startup failures or workload creation failures.</p> <p>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 may be damaged.</p>
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	<ul style="list-style-type: none"> • 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

Mounting a Local EV Through kubectl

- Step 1** Use kubectl to access 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        # Location where the emptyDir 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

12.9.4 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 a Temporary Path on the 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. In the right pane, click the **Deployments** 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 **EmptyDir**.

Step 4 Mount and use storage volumes, as shown in [Table 12-54](#). For details about other parameters, see [Workloads](#).

Table 12-54 Mounting an EV

Parameter	Description
Storage Medium	<p>Memory:</p> <ul style="list-style-type: none"> 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. <p>NOTE</p> <ul style="list-style-type: none"> 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	<p>Enter a mount path, for example, /tmp.</p> <p>This parameter specifies a 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, leading to container startup failures or workload creation failures.</p> <p>NOTICE</p> <p>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 may be damaged.</p>
Subpath	<p>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.</p>
Permission	<ul style="list-style-type: none"> 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 a Temporary Path Through kubectl

Step 1 Use kubectl to access 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 # Location where the emptyDir 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

12.10 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 directories 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 12-55](#).

Table 12-55 Setting parameters for mounting a hostPath volume

Parameter	Description
Volume Type	Select HostPath .
HostPath	<p>Path of the host to which the local volume is to be mounted, for example, /etc/hosts.</p> <p>NOTE HostPath cannot be set to the root directory /. Otherwise, the mounting fails. Mount paths can be as follows:</p> <ul style="list-style-type: none"> • /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.) <p>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.</p>

Parameter	Description
Mount Path	<p>Enter a mount path, for example, /tmp.</p> <p>This parameter specifies a 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, leading to container startup failures or workload creation failures.</p> <p>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 may be damaged.</p>
Subpath	<p>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.</p>
Permission	<ul style="list-style-type: none"> • 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 Through kubectl

Step 1 Use kubectl to access 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          # Location where the storage volume is mounted
    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
```

12.11 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](#)

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 delay
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 # (Optional) Set the file system type to xfs or ext4. If it is left blank, ext4
  will be used by default.
  everest.io/disk-volume-type: SAS
  everest.io/passthrough: 'true'
reclaimPolicy: Delete
allowVolumeExpansion: true
volumeBindingMode: Immediate
```

Table 12-56 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 12-57 .
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 . <ul style="list-style-type: none"> • Delete: indicates that a dynamically created PV will be automatically deleted when the PVC is deleted. • Retain: indicates that a dynamically created PV will be retained when the PVC is deleted.
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 . <ul style="list-style-type: none"> • 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 12-57 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 or xfs . The restrictions on using xfs are as follows: <ul style="list-style-type: none"> The nodes must run CentOS 7 or Ubuntu 22.04, and the Everest version in the cluster must be 2.3.2 or later. Only common containers are supported.
	everest.io/disk-volume-type	Yes	EVS disk type. All letters are in uppercase. <ul style="list-style-type: none"> SATA: common I/O SAS: high I/O SSD: ultra-high I/O GPSSD: general-purpose SSD
	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	csi.storage.k8s.io/csi-driver-name	Yes	Driver type. If SFS is used, the parameter value is fixed at nas.csi.everest.io .
	csi.storage.k8s.io/fstype	Yes	If SFS is used, the value can be nfs .
	everest.io/share-access-level	Yes	The parameter value is fixed at rw , indicating that the SFS data is readable and writable.
	everest.io/share-access-to	Yes	VPC ID of the cluster.
	everest.io/share-is-public	No	The parameter value is fixed at false , indicating that the file is shared to private. You do not need to configure this parameter when SFS 3.0 is used.

Volume Type	Parameter	Mandatory	Description
	everest.io/sfs-version	No	This parameter is mandatory only when SFS 3.0 is used. The value is fixed at sfs3.0 .
SFS Turbo	csi.storage.k8s.io/csi-driver-name	Yes	Driver type. If SFS Turbo is used, the parameter value is fixed at sfsturbo.csi.everest.io .
	csi.storage.k8s.io/fstype	Yes	If SFS Turbo is used, the value can be nfs .
	everest.io/share-access-to	Yes	VPC ID of the cluster.
	everest.io/share-expand-type	No	Extension type. The default value is bandwidth , indicating an enhanced file system. This parameter does not take effect.
	everest.io/share-source	Yes	The parameter value is fixed at sfs-turbo .
	everest.io/share-volume-type	No	SFS Turbo 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 . <ul style="list-style-type: none"> • obsfs: a parallel file system • s3fs: object bucket
	everest.io/obs-volume-type	Yes	OBS storage class. <ul style="list-style-type: none"> • 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.

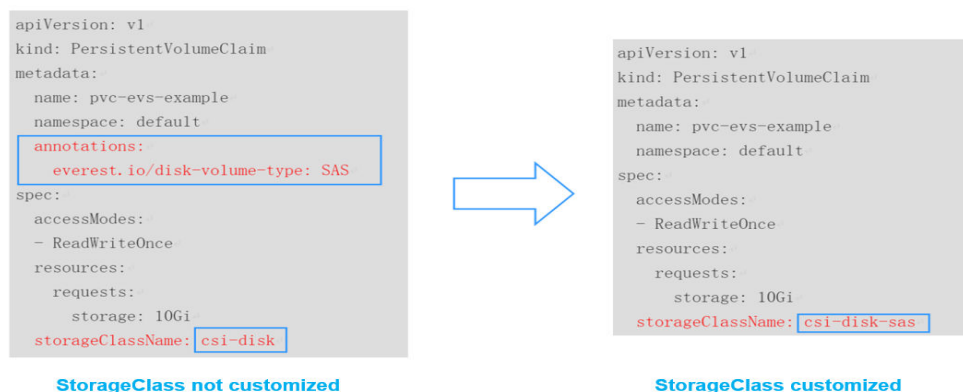
The preceding is a basic method of using StorageClass. In real-world scenarios, you can use StorageClass to perform other operations.

Application Scenario	Solution	Procedure
<p>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.</p>	<p>Define PVC annotations in the parameters field of StorageClass. When compiling a YAML file, you only need to specify storageClassName.</p> <p>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.</p>	<p>Custom Storage Class</p>
<p>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.</p>	<p>Create a storage class with the same name as that in the original application YAML file in the CCE cluster. After the migration, you do not need to modify the storageClassName in the application YAML file.</p> <p>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.</p>	

Application Scenario	Solution	Procedure
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**.



- 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 # (Optional) Set the file system type to xfs or ext4. If it is left blank, ext4 will be used by default.
  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 # (Optional) Set the file system type to xfs or ext4. If it is left blank,
ext4 will be used by default.
  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, both the PV and underlying storage resources will be retained. You need to manually delete these resources. After the PVC is deleted, the PV is in the **Released** state and cannot be bound to a 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
```

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.

13 Observability

13.1 Logging

13.1.1 Overview

Kubernetes logs allow you to locate and rectify faults. This section describes how you can manage Kubernetes logs generated for CCE.

- Connect CCE to AOM. For details, see [Collecting Container Logs Using ICAgent](#).

13.1.2 Collecting Container Logs

13.1.2.1 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 13-1 Configuring log policies

Parameter	Description
Volume Type	<ul style="list-style-type: none"> ● 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	<p>Container path (for example, /tmp) to which the storage resources will be mounted.</p> <p>NOTICE</p> <ul style="list-style-type: none"> ● 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	<p>This parameter is mandatory only if Volume Type is set to HostPath.</p> <p>Extended host paths contain pod IDs or container names to distinguish different containers into which the host path is mounted.</p> <p>A level-3 directory is added to the original volume directory/subdirectory. You can easily obtain the files output by a single Pod.</p> <ul style="list-style-type: none"> ● 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	<p>A collection path narrows down the scope of collection to specified logs.</p> <ul style="list-style-type: none"> 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. <p>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.</p> <p>CAUTION Ensure that ICAgent is of v5.12.22 or later.</p>
Log Dump	<p>Log dump refers to rotating log files on a local host.</p> <ul style="list-style-type: none"> 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. <p>NOTE</p> <ul style="list-style-type: none"> 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 collect 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 13-2 Parameter description

Parameter	Description	Description
extendPath Mode	Extended host path	<p>Extended host paths contain pod IDs or container names to distinguish different containers into which the host path is mounted.</p> <p>A level-3 directory is added to the original volume directory/subdirectory. You can easily obtain the files output by a single Pod.</p> <ul style="list-style-type: none"> • 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	<p>Log dump refers to rotating log files on a local host.</p> <ul style="list-style-type: none"> • 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. <p>NOTE</p> <ul style="list-style-type: none"> • 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	<p>A collection path narrows down the scope of collection to specified logs.</p> <ul style="list-style-type: none"> 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. <p>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.</p> <p>CAUTION Ensure that ICAgent is of version 5.12.22 or later.</p>

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 container stdout.

```
# 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)
```

13.2 Log Auditing

13.2.1 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 13-3 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
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

Operation	Resource Type	Event Name
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
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

Operation	Resource Type	Event Name
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
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

Operation	Resource Type	Event Name
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
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


Operation	Resource Type	Event Name
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
Deleting a template application	Kubernetes resource	deleteRelease



13.2.2 Viewing CTS Traces in the Trace List

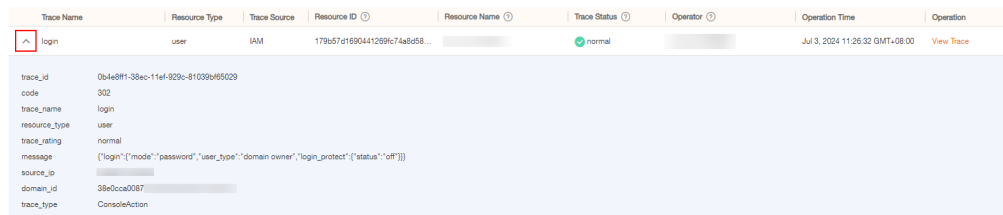
Scenarios

After you enable CTS and the management tracker is created, CTS starts recording operations on cloud resources. Cloud Trace Service (CTS) stores operation records (traces) generated in the last seven days.

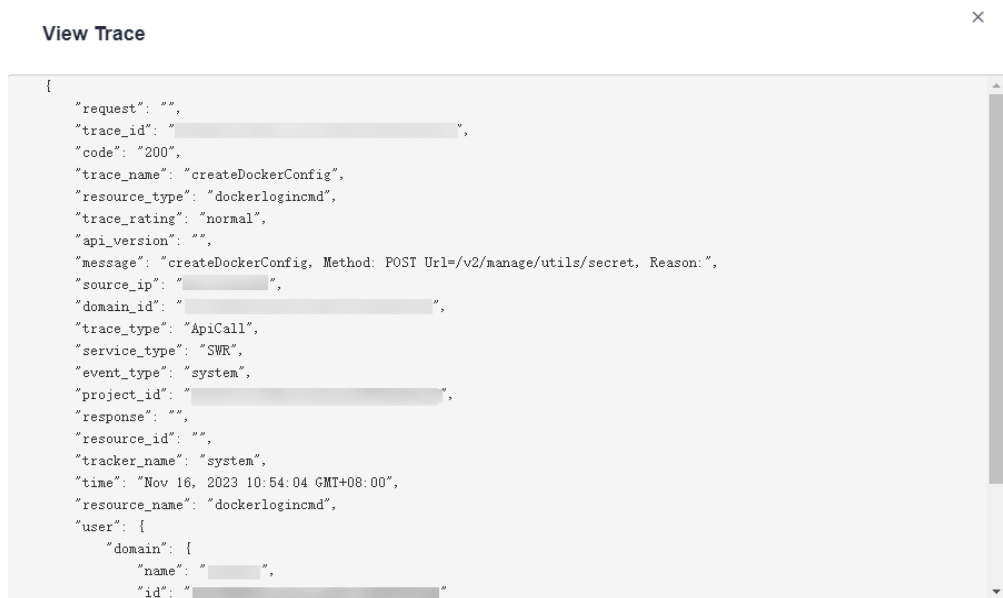
Viewing Real-Time Traces in the Trace List

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. 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:** Select **Last 1 hour, Last 1 day, or Last 1 week**, or specify a custom time range within the last seven days.
5. Click **Query**.
6. 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 5,000 records.

- Click  to view the latest information about traces.
- 7. Click  on the left of a trace to expand its details.



- 8. Click **View Trace** in the **Operation** column. The trace details are displayed.



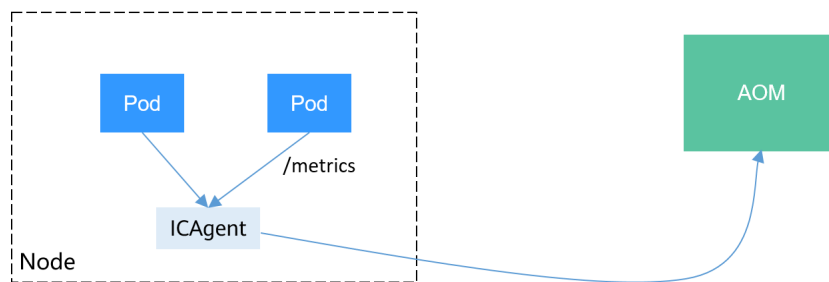
- 9. For details about key fields in the trace structure, see section "Trace References" > "Trace Structure" and section "Trace References" > "Example Traces" in the *CTS User Guide*.

13.3 Best Practices

13.3.1 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 13-1 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.

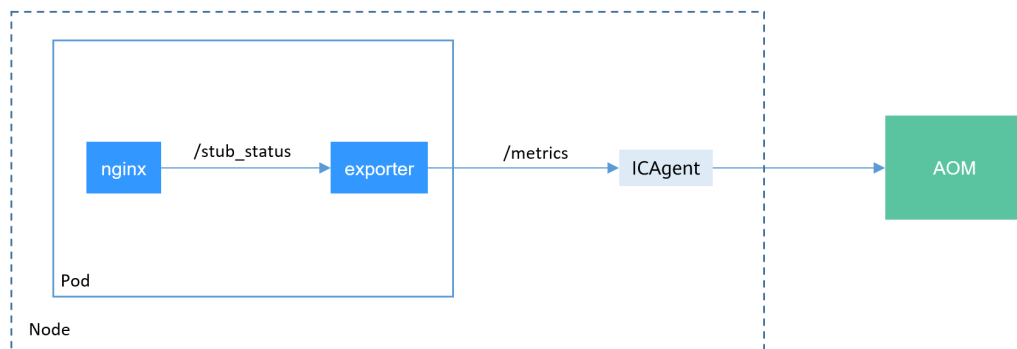
```
# curl http://127.0.0.1:8080/stub_status
Active connections: 3
server accepts handled requests
146269 146269 212
Reading: 0 Writing: 1 Waiting: 2
```

----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 13-2 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

14 Auto Scaling

14.1 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 Types

Table 14-1 Workload scaling types

Type	Component	Component Description	Reference
HPA	HorizontalPodAutoscaler (built-in Kubernetes component)	HorizontalPodAutoscaler is a built-in component of Kubernetes for Horizontal Pod Autoscaling (HPA). CCE incorporates the application-level cooldown time window and scaling threshold functions into Kubernetes HPA.	Creating an HPA Policy
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.	Creating a Scheduled CronHPA Policy

Node Scaling Types

Table 14-2 Node scaling types

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

14.2 Scaling a Workload

14.2.1 Workload Scaling Rules

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 have built-in monitoring capabilities, but you can use extensions like **Metrics Server** to monitor and collect data.

- **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.

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, 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:

$$\text{desiredReplicas} = \text{ceil}[\text{currentReplicas} \times (\text{currentMetricValue} / \text{desiredMetricValue})]$$

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: $\text{ratio} = \text{currentMetricValue} / \text{desiredMetricValue}$

When $|\text{ratio} - 1.0| \leq \text{tolerance}$, scaling will not be performed.

When $|\text{ratio} - 1.0| > \text{tolerance}$, 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.

14.2.2 Creating an HPA Policy

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.

Notes and 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 volumes mounted, a new pod cannot be started because EVS disks cannot be attached.

Procedure

- 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 [Creating a Scheduled CronHPA Policy](#).

Table 14-3 HPA policy

Parameter	Description
Pod Range	<p>Minimum and maximum numbers of pods.</p> <p>When a policy is triggered, the workload pods are scaled within this range.</p>
Cooldown Period	<p>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.</p> <p>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.</p>
Scaling Behavior	<p>This parameter is supported only in clusters of v1.25 or later.</p> <ul style="list-style-type: none"> • 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. <ul style="list-style-type: none"> – 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.

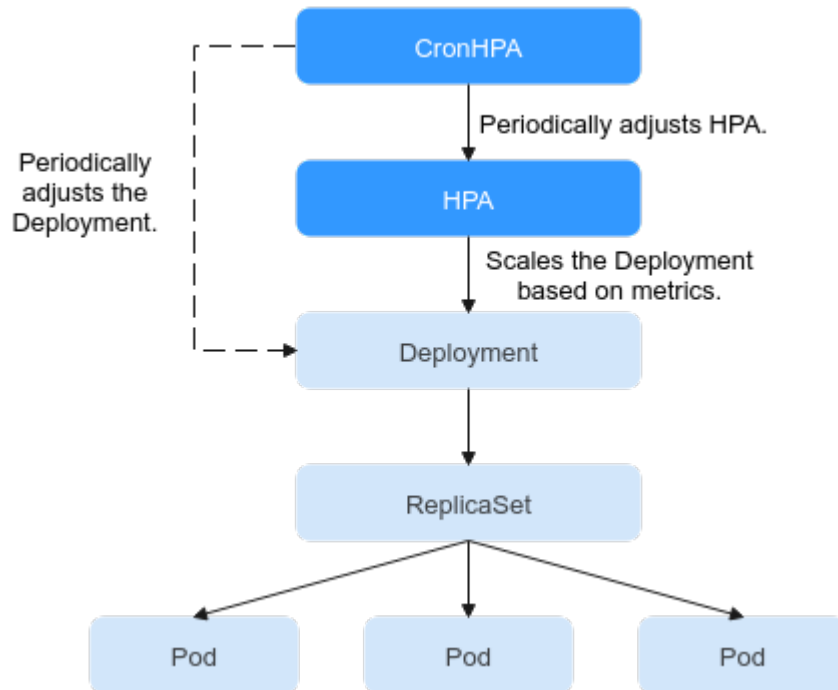
Parameter	Description
System Policy	<ul style="list-style-type: none"> • Metric: You can select CPU usage or Memory usage. <p>NOTE Usage = CPUs or memory used by pods/Requested CPUs or memory.</p> <ul style="list-style-type: none"> • Desired Value: Enter the desired average resource usage. This parameter 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 <p>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.</p> <ul style="list-style-type: none"> • 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)	<p>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.</p> <ul style="list-style-type: none"> • 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 <p>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.</p> <ul style="list-style-type: none"> • 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

14.2.3 Creating a Scheduled CronHPA Policy

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.

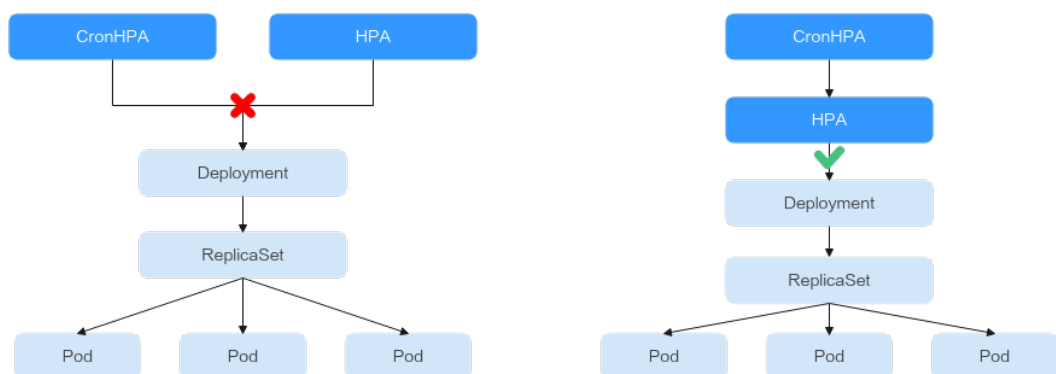
Prerequisites

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 14-1 CronHPA scaling scenarios

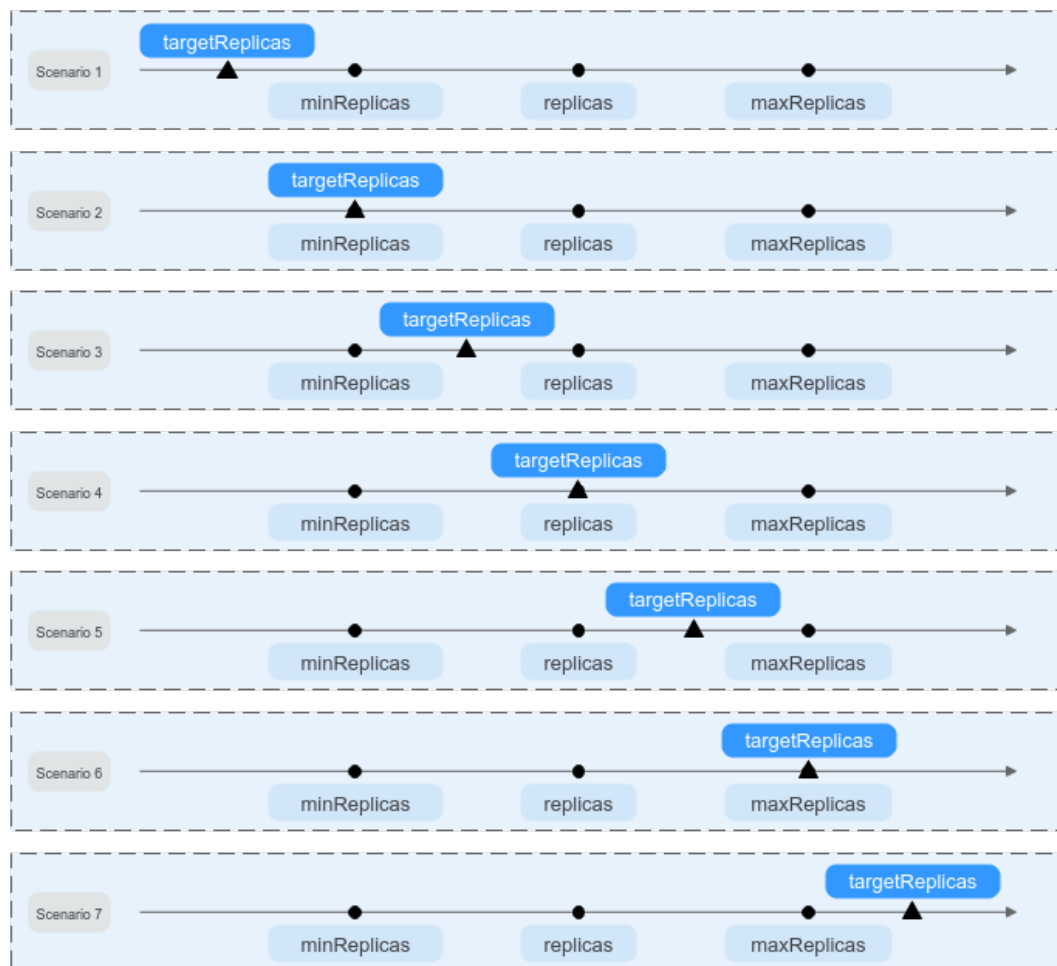


Figure 14-1 shows possible scaling scenarios. The following examples detail how CronHPA modifies the number of pods in HPAs.

Table 14-4 CronHPA scaling parameters

Scenario	Scenario Description	CronHPA (target Replicas)	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 : <ul style="list-style-type: none"> • 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 : <ul style="list-style-type: none"> • 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 replicas : <ul style="list-style-type: none"> • Change the value of minReplicas. • The value of replicas requires no change.

Scenario	Scenario Description	CronHPA (target Replicas)	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 replicas : <ul style="list-style-type: none"> • 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 replicas and less than that of maxReplicas : <ul style="list-style-type: none"> • 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 replicas and equal to that of maxReplicas : <ul style="list-style-type: none"> • Change the value of minReplicas. • Change the value of replicas.

Scenario	Scenario Description	CronHPA (target Replicas)	Deployment (replicas)	HPA (minReplicas / maxReplicas)	Result	Operation Description
7	minReplicas ≤ replicas ≤ maxReplicas < targetReplicas	11	5	5/10	HPA: 11/11 Deployments: 11	<p>When the value of targetReplicas is greater than that of maxReplicas:</p> <ul style="list-style-type: none"> • 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 [Creating an HPA Policy](#).

Table 14-5 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	<p>Interval between a scale-in and a scale-out. The unit is minute. The interval cannot be shorter than 1 minute.</p> <p>This parameter is supported only in clusters of v1.15 to v1.23.</p> <p>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.</p>
Scaling Behavior	<p>This parameter is supported only in clusters of v1.25 or later.</p> <ul style="list-style-type: none"> ● 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. <ul style="list-style-type: none"> – 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	<ul style="list-style-type: none"> ● 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)	<p>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.</p> <ul style="list-style-type: none"> • 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 <p>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.</p> <ul style="list-style-type: none"> • 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 14-6 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 14-4 .
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 kubectl

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 14-7 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	<p>Specifies the scaling object of CronHPA. The following fields can be configured:</p> <ul style="list-style-type: none"> • apiVersion: API version of the CronHPA scaling object. • kind: API type of the CronHPA scaling object. • name: Name of the CronHPA scaling object. <p>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.</p>
spec.rules	<p>CronHPA policy rule. Multiple rules can be added. The following fields can be configured for each rule:</p> <ul style="list-style-type: none"> • 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. <p>NOTE This time indicates the local time of where the node is deployed.</p> <ul style="list-style-type: none"> • 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 14-8 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 kubectl

```
apiVersion: autoscaling.cce.io/v2alpha1
kind: CronHorizontalPodAutoscaler
metadata:
  name: cctest
  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
```

14.2.4 Managing Workload Scaling Policies

Scenario

After a workload scaling policy is created, you can update and delete the policy, as well as edit the YAML file.

Procedure

You can view the rules, status, and events of a workload scaling 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 displayed page, click the **HPA/CronHPA Policies** tab page based on the scaling policy type.

Step 3 Check the status, rules, and associated workloads of a scaling policy.

 **NOTE**

You can also check a created scaling 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 obtain the scaling policies. You can also obtain the scaling policies you configured on the **Policies** page.

Step 4 Manage scaling policies.

Scaling Policy Type	Operation
HPA	<ul style="list-style-type: none"> • View Events: Check HPA policy events. If an error occurred, locate and rectify the fault based on the error message displayed on the page. • Edit YAML: In the dialog box displayed, edit, copy, or download the YAML file. • Edit: On the Edit HPA Policy page, configure policy parameters listed in Table 14-3. • Clone: Duplicate an existing auto scaling policy and modify the parameter settings as required. • Delete: In the dialog box displayed, click Yes.
CronHPA	<ul style="list-style-type: none"> • View YAML: In the dialog box displayed, copy or download the YAML file but you are not allowed to modify it. • Delete: In the dialog box displayed, click Yes.

----End

14.3 Scaling a Node

14.3.1 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 custom scale-in threshold (in percentage), Autoscaler will check whether pods on the current node can be migrated to other nodes.

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)

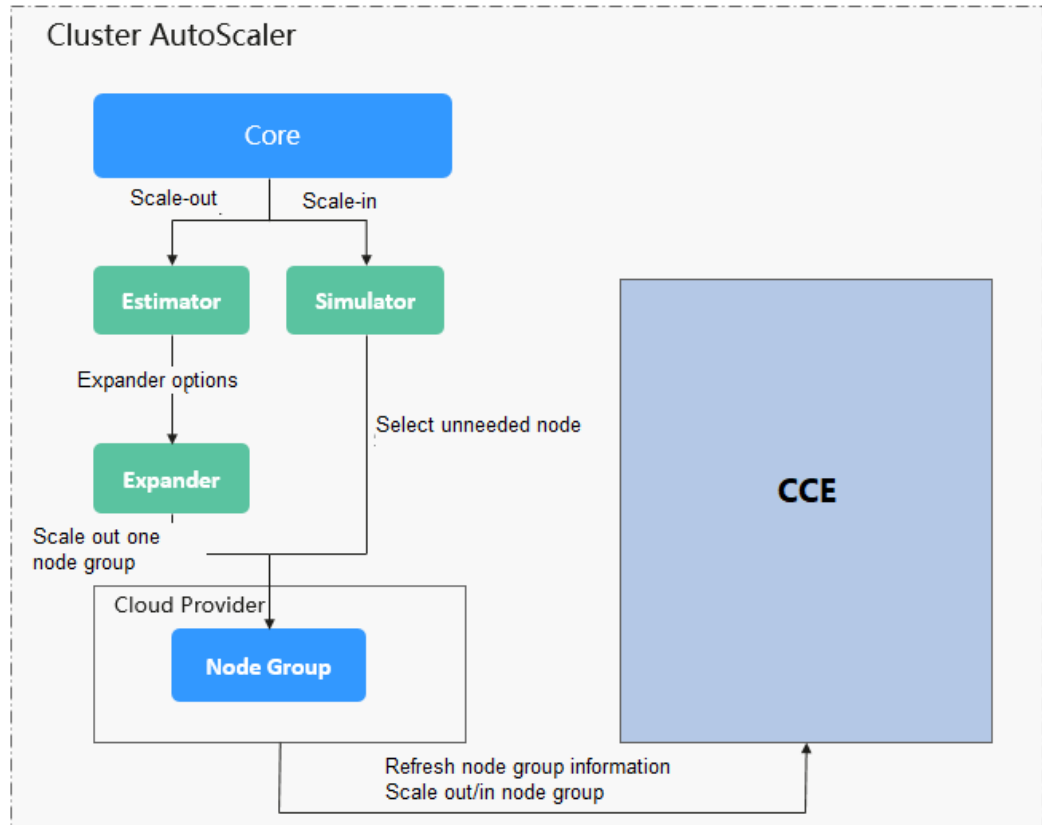
NOTE

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 14-2](#) shows the Cluster Autoscaler architecture and its core modules.

Figure 14-2 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. [Table 14-9](#) lists the Expander policies.

Table 14-9 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.	<p>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:</p> <ol style="list-style-type: none"> 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	<p>A combined policy. It takes precedence over the random policy.</p> <p>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.</p>	<p>This policy is based on the maximum number of pods that can be scheduled.</p>	<p>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:</p> <ol style="list-style-type: none"> 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	<p>A combined policy. It takes precedence over the random policy.</p> <p>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.</p>	<p>This policy uses the minimum waste score of CPU or memory resources as the selection criteria.</p> <p>The formula for calculating the minimum waste score (wastedScore) is as follows:</p> <ul style="list-style-type: none"> • $\text{wastedCPU} = (\text{Total number of CPUs of the nodes to be scaled out} - \text{Total number of CPUs of the pods to be scheduled}) / \text{Total number of CPUs of the nodes to be scaled out}$ • $\text{wastedMemory} = (\text{Total memory size of nodes to be scaled out} - \text{Total memory size of pods to be scheduled}) / \text{Total memory size of nodes to be scaled out}$ • $\text{wastedScore} = \text{wastedCPU} + \text{wastedMemory}$ 	<p>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:</p> <ol style="list-style-type: none"> 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	<p>A combined policy. The priorities for the policies are as follows: priority > least-waste > random.</p> <p>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.</p>	<p>This policy allows you to configure the priorities of node pools or scaling groups through the console or API, while the least-waste policy can effectively minimize resource waste in various scenarios. The priority policy is used as the default preferred policy thanks to its good universality.</p>	<p>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:</p> <ol style="list-style-type: none"> 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	<p>A combined policy. The priorities for the policies are as follows: priority > priority-ratio > least-waste > random.</p> <p>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.</p>	<p>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.</p>	<p>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:</p> <ol style="list-style-type: none"> 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.

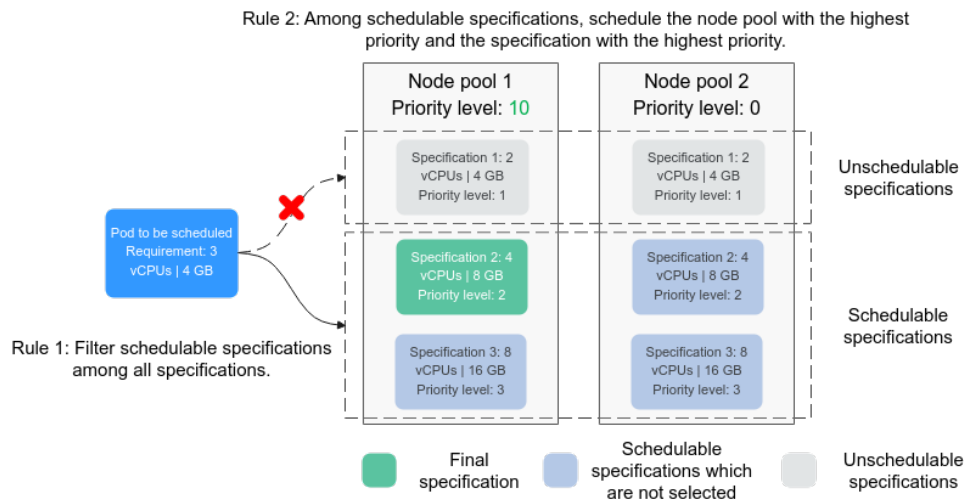
14.3.2 Priorities for Scaling Node Pools

Prerequisites

To use node flavor priorities, the Autoscaler version must be 1.19.35, 1.21.28, 1.23.30, 1.25.20, or later. To balance load among AZs, the version must be 1.23.122, 1.25.117, 1.27.85, 1.28.52, or later.

Elastic Capacity Expansion Policies

Node pools are scaled according to their priorities and flavor priorities.



1. Predictive flavor filtering:

- The predictive algorithm chooses proper flavors that meet the scheduling needs of pending pods from all node pools.
- To schedule pods, various factors are considered, including whether the node resources meet the requested resources of the pods, and if the nodeSelector, nodeAffinity, and taints satisfy the conditions for pod scheduling.
- Additionally, if certain node pool flavors experience scale-out failures, such as insufficient resources, and enter a 5-minute cooldown period, the scale-out algorithm will automatically exclude them from consideration during that time.

2. Node pool sorting by priority

Node pools are assigned priorities and sorted accordingly. The node pool with the highest priority is preferentially selected.

3. Flavor selection by priority

When multiple node pools have the same highest priority, the flavor with the highest priority is selected according to the following rules:

- The flavor with the highest priority in each node pool is selected.
- If multiple flavors have the same priority, choose the one that requires the least volume of resources to meet the pod scheduling requirements.
- If multiple flavors require the minimum volume of resources, choose one based on a balanced distribution among AZs.

4. Troubleshooting if resources are insufficient or a creation failed
If the preferred flavor is unavailable due to insufficient quota in the AZ, CCE will try to use the next priority flavor in the node pool, and the original instance will enter a 5-minute cooldown period.
If none of the flavors in a node pool can be used to create instances, CCE will try to use the next priority node pool to create instances.

Manual Capacity Expansion Policies

When manually scaling out a node pool, you can select a specified flavor. If the resources of the selected flavor are insufficient or the quota is insufficient, the scale-out will fail.

Configuring Priorities

For details about how to configure the priorities of node pool flavors, see [Configuring an Auto Scaling Policy for a Cluster](#).

14.3.3 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 Autoscaler 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 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.

Notes and 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 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.
- 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 affect 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 Autoscaler 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 Autoscaler 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 14-10 Custom rules

Rule Type	Configuration
Metric-based	<p>– Trigger: Select CPU allocation rate or Memory allocation rate and enter a value. The percentage must be greater than the value specified in the node resource requirements for a node scale-in when you configure a scaling policy (Configuring an Auto Scaling Policy for a Cluster).</p> <p>NOTE</p> <ul style="list-style-type: none"> ▪ 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 is configured based on the CPU allocation rate and a periodic rule and both the rules meet the scale-out conditions, the periodic rule executed early changes the node pool to the scaling state. As a result, the metric-based rule cannot be executed. After the periodic rule is executed and the node pool status becomes normal, the metric-based rule will not be executed. If the metric-based rule is executed early, the periodic rule will be executed after the metric-based rule is executed. ▪ If a rule is configured based on the CPU allocation rate and memory allocation rate, 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. ▪ If the number of nodes reaches the upper limit of the cluster scale, the upper limit of the nodes supported in a node pool, or the upper limit of the nodes of a specific flavor, a metric-based scale-out will not be triggered. ▪ If the number of nodes, CPUs, or memory resources reaches the upper limit for a node scale-out, a metric-based scale-out will not be triggered. <p>– Action: Configure an action to be performed when the triggering condition is met.</p> <ul style="list-style-type: none"> ▪ 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

Rule Type	Configuration
Periodic	<ul style="list-style-type: none"> - 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

- **Specifications:** Configure whether to enable auto scaling for node flavors in a node pool.

NOTE

If multiple flavors are configured for a node pool, you can specify the upper limit for the number of nodes and the priority for each flavor separately.

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.

- If Autoscaler 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 Autoscaler has been installed, directly configure scaling policies.

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 pod has been scheduled to a node, the node will not be involved in an automatic scale-out. 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, [custom scaling rules](#) are the only option for performing a scale-out.

- **Upper limit of resources to be expanded:** the upper limit for the cluster's resources, such as the number of nodes, CPU cores, and memory. Once this limit is reached, no new nodes will be automatically added.
- **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 Period**

- **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 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 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 14-11 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.

Parameter	Type	Description
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.
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	Threshold of the metric rule. The value can be an integer ranging from 1 to 100 and must be a character. If the value is set to -1 , the threshold is automatically calculated.
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.

14.3.4 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.

NOTE

You can obtain created auto scaling policies on the **Policies** page.

1. Log in to the CCE console and click the cluster name to access the cluster console.
2. In the navigation pane, choose **Policies**. On the page displayed, click the **Node Scaling Policies** tab.
3. Check the configuration of the auto scaling policies. Choose **More > Scaling History** for the target policy to check the scaling records of the policy.

----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 14-11](#).
- 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 **Create 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

14.4 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 deploying applications in pods, you can configure requested resources and resource limits for the pods to prevent unlimited usage of resources during peak hours. However, after the upper limit is reached, an application error may occur. Pod scaling can effectively resolve this issue. If the resource usage on the node increases to a certain extent, newly added pods cannot be scheduled to this node. In this case, CCE will add nodes accordingly.

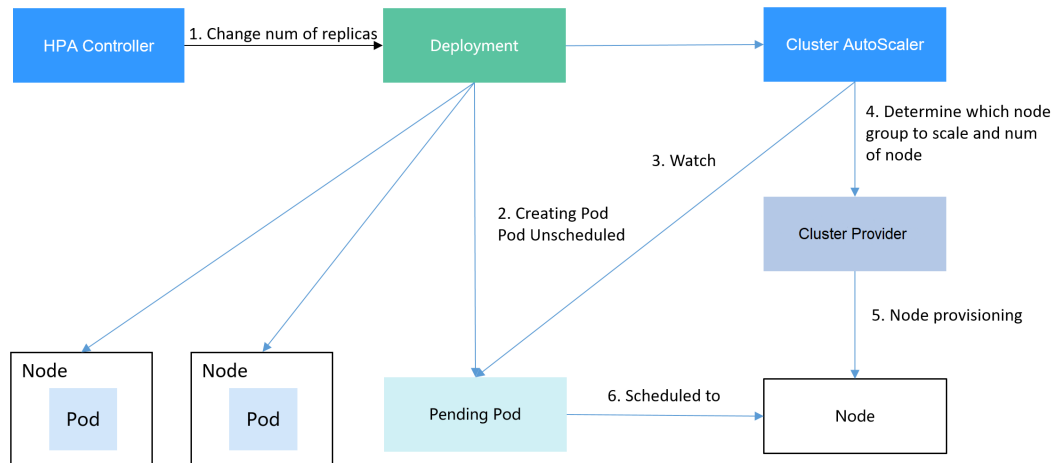
Solution

Two major auto scaling policies are HPA (Horizontal Pod Autoscaling) and CA (Cluster AutoScaling). HPA is for workload auto scaling and CA is for node auto scaling.

HPA and CA work with each other. HPA requires sufficient cluster resources for successful scaling. When the cluster resources are insufficient, CA is needed to add nodes. If HPA reduces workloads, the cluster will have a large number of idle resources. In this case, CA needs to release nodes to avoid resource waste.

As shown in **Figure 14-3**, 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 14-3 HPA and CA working flows



Using HPA and CA enables auto scaling for most scenarios while also providing monitoring capabilities.

This section uses an example to describe the auto scaling process using HPA and CA policies together.

Preparations

Step 1 Create a cluster with one node. The node should have 2 cores of vCPUs and 4 GiB of memory, or a higher specification, as well as an EIP to allow external access. If no EIP is bound to the node during node creation, you can manually bind one on the ECS console after creating the node.

Step 2 Install add-ons for the cluster.

- autoscaler: node scaling add-on
- metrics-server: an aggregator of resource usage data in a Kubernetes cluster. It can collect measurement data of major Kubernetes resources, such as pods, nodes, containers, and Services.

Step 3 Log in to the cluster node and run a computing-intensive application. When a user sends a request, the result needs to be calculated before being returned to the user.

1. Create a PHP file named **index.php** to calculate the square root of the request for 1,000,000 times before returning **OK!**.

```
vi index.php
```

The file content is as follows:

```
<?php
$x = 0.0001;
for ($i = 0; $i <= 1000000; $i++) {
    $x += sqrt($x);
}
```

```
echo "OK!";  
?>
```

2. Compile a **Dockerfile** file to build an image.


```
vi Dockerfile
```

The content is as follows:

```
FROM php:5-apache  
COPY index.php /var/www/html/index.php  
RUN chmod a+rx index.php
```

3. Run the following command to build an image named **hpa-example** with the tag **latest**.

```
docker build -t hpa-example:latest .
```

4. (Optional) Log in to the SWR console, choose **Organizations** in the navigation pane, and click **Create Organization** in the upper right corner. Skip this step if you already have an organization.
5. In the navigation pane, choose **My Images** and then click **Upload Through Client**. On the page displayed, click **Generate a temporary login command** and click  to copy the command.
6. Run the login command copied in the previous step on the cluster node. If the login is successful, the message "Login Succeeded" is displayed.
7. Tag the hpa-example image.

```
docker tag {Image name 1:Tag 1}{Image repository address}{Organization name}{Image name 2:Tag 2}
```

- *{Image name 1:Tag 1}*: name and tag of the local image to be uploaded.
- *{Image repository address}*: the domain name at the end of the login command in **login command**. It can be obtained on the SWR console.
- *{Organization name}*: name of the **created organization**.
- *{Image name 2:Tag 2}*: desired image name and tag to be displayed on the SWR console.

The following is an example:

```
docker tag hpa-example:latest {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 default values 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

Conclusion

By using HPA and CA, auto scaling can be effortlessly implemented in various scenarios. Additionally, the scaling process of nodes and pods can be conveniently tracked.

15 Namespaces

15.1 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.

Notes and 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 automatically or manually.

- 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) so that some resources in the cluster can be readable in the entire cluster. This is a reserved Kubernetes namespace. Its common attributes are only conventions but not requirements.

- **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 15-1](#).

Table 15-1 Parameters for creating a namespace

Parameter	Description
Name	Unique name of the created namespace.
Description	Description about the namespace.
Quota Management	<p>Resource quotas can limit the amount of resources available in namespaces, achieving resource allocation by namespace.</p> <p>NOTICE You are advised to set resource quotas in the namespace as required to prevent cluster or node exceptions caused by resource overload.</p> <p>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.</p> <p>Enter an integer. If the quota of a resource is not specified, no limit is posed on the resource.</p> <p>If you want to limit the CPU or memory quota, you must specify the CPU or memory request value when creating a workload.</p>

- 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
```

15.2 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.

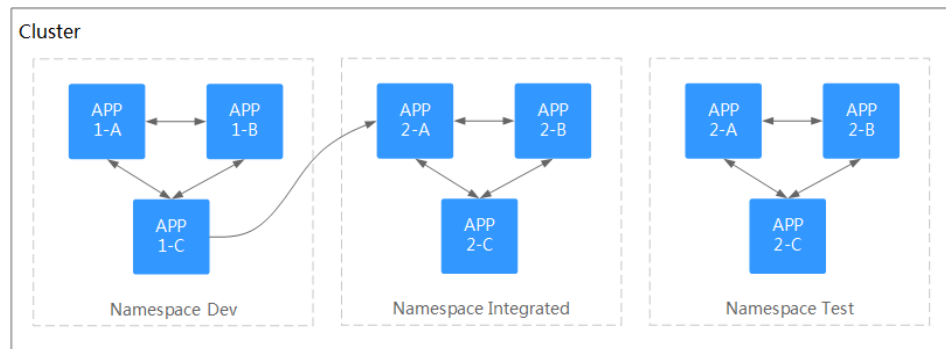
Resources cannot be shared among different clusters. In addition, services in different environments can access each other only through load balancing.

- 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.

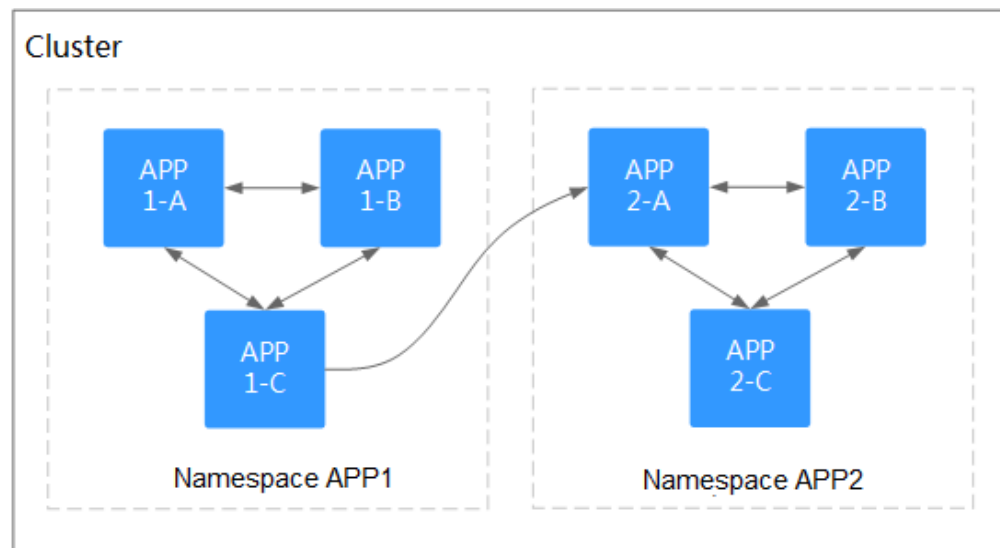
Figure 15-1 One namespace for one environment



- **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 15-2 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 **cidc**, indicating that the namespace is used to deploy CIDC.

- 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 **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

15.3 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 15-2](#) lists the resource quotas based on cluster specifications. You can modify them according to your service requirements.

Table 15-2 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

Notes and 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

16 ConfigMaps and Secrets

16.1 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.


Notes and 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 16-1 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 access 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 16-2 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 16-3](#).

Table 16-3 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	<ol style="list-style-type: none"> 1. Select the name of the ConfigMap to be updated and click Update. 2. Modify the secret data. For more information, see Table 16-1. 3. Click OK.
Deleting a ConfigMap	Select the configuration you want to delete and click Delete . Follow the prompts to delete the ConfigMap.

16.2 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 access 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 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:

```
cat /usr/share/nginx/html/index.html
```

The example output is as follows:

```
Hello CCE
```

----End

Using kubectl

Step 1 Use kubectl to access 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 16-4](#).

Table 16-4 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 specifies a 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. <ul style="list-style-type: none"> • 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 access 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 will be 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

16.3 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.

Notes and 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 16-5 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	<p>Type of the secret you create.</p> <ul style="list-style-type: none"> • Opaque: common secret. • <code>kubernetes.io/dockerconfigjson</code>: a secret that stores the authentication information required for pulling images from a private repository. • <code>kubernetes.io/tls</code>: Kubernetes TLS secret, which is used to store the certificate required by layer-7 load balancing Services. For details about examples of the <code>kubernetes.io/tls</code> 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	<p>Workload secret data can be used in containers.</p> <ul style="list-style-type: none"> • 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 <code>kubernetes.io/dockerconfigjson</code>, enter the account and password for logging in to the private image repository. • If Secret Type is <code>kubernetes.io/tls</code> or IngressTLS, upload the certificate file and private key file. <p>NOTE</p> <ul style="list-style-type: none"> - 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	<p>Label of the secret. Enter a key-value pair and click Confirm.</p>

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:

- 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.
- 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=
```

- Use Base64 to encode the following JSON content:

```
echo -n '{"auths":{"address":
{"username":"username","password":"password","auth":"dXNlcm5hbWU6cGFzc3dvcmQ="}}}'
| base64
```

Command output:

```
eyJhdXRocyl6eyJhZGRyZXNzIjp7InVzZXJhZG90eS5hbWU6cGFzc3dvcmQ="}
kIiwiaXV0aCI6ImRYTmxbTVoYldVNmNHRnpjM2R2Y21RPSJ9fX0=
```

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*****FURStLS0t # 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*****FUR50tLS0t # 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 access 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 16-6](#).

NOTE

The secret list contains system secret resources that can be queried only. The system secret resources cannot be updated or deleted.

Table 16-6 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	<ol style="list-style-type: none"> 1. Select the name of the secret to be updated and click Update. 2. Modify the secret data. For more information, see Table 16-5. 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	<ol style="list-style-type: none"> 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
*****
```

16.4 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 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 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 access 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
              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:

```
kubectrl 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:

```
kubectrl 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** Choose **Workloads** in the navigation pane. 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 16-7](#).

Table 16-7 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 specifies a 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	<p>Enter a subpath of the mount path.</p> <ul style="list-style-type: none"> • 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 access 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

16.5 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>
```

17 Add-ons

17.1 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
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.

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.

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.
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.

Add-on Lifecycle

An add-on lifecycle involves all the statuses of the add-on from installation to uninstallation.

Table 17-1 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.

Status	Attribute	Description
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 add-on 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 17-2](#) on the **Add-ons** page.

Table 17-2 Related operations

Operation	Description	Procedure
Install	Install a specified add-on.	<ol style="list-style-type: none"> 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.	<ol style="list-style-type: none"> 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.	<ol style="list-style-type: none"> 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.	<ol style="list-style-type: none"> 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	<p>Roll back an add-on to the source version.</p> <p>NOTE</p> <ul style="list-style-type: none"> 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. 	<ol style="list-style-type: none"> Log in to the CCE console and click the cluster name to access the cluster console. In the navigation pane, choose Add-ons. If an add-on can be rolled back, the Roll Back button is displayed under it. Click Roll Back. 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

17.2 Scheduling and Elasticity Add-ons

17.2.1 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 17-3 Add-on 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. 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.

Parameter	Description
Containers	<p>CPU and memory quotas of the container allowed for the selected add-on specifications.</p> <p>If you select Custom, the recommended values for volcano-controller and volcano-scheduler are as follows:</p> <ul style="list-style-type: none"> • 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. <p>NOTE</p> <p>Recommended formula for calculating the requested value:</p> <ul style="list-style-type: none"> - 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 17-4, 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 17-4. 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 17-4 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.

- **Application Scaling Priority Policy:** After this function is enabled, application scale-in is performed based on the default priority policy and customized policies. If application scale-out is required, you need to set the default scheduler of the cluster to volcano.
- **Advanced Settings:** You can configure the default scheduler parameters. For details, see [Table 17-6](#).

Example:

```

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 17-5 Advanced Volcano configuration parameters

Plugin	Function	Description	Demonstration
colocation_enable	Whether to enable hybrid deployment.	Value: <ul style="list-style-type: none"> ● 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. <ul style="list-style-type: none"> ● 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	<p>Actions to be executed in each scheduling phase. The configured action sequence is the scheduler execution sequence. For details, see Actions.</p> <p>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.</p>	<p>The following options are supported:</p> <ul style="list-style-type: none"> • 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. 	<p>actions: 'allocate, backfill, preempt'</p> <p>NOTE When configuring actions, use either preempt or enqueue.</p>
plugins	<p>Implementation details of algorithms in actions based on different scenarios. For details, see Plugins.</p>	<p>For details, see Table 17-6.</p>	<p>None</p>
tolerations	<p>Tolerance of the add-on to node taints.</p>	<p>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.</p>	<p>tolerations:</p> <ul style="list-style-type: none"> - effect: NoExecute key: node.kubernetes.io/not-ready operator: Exists tolerationSeconds: 60 - effect: NoExecute key: node.kubernetes.io/unreachable operator: Exists tolerationSeconds: 60

Table 17-6 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.	<p>arguments:</p> <ul style="list-style-type: none"> • 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. <i><your_resource></i> indicates the resource type defined in binpack.resources, for example, binpack.resources.nvidia.com/gpu. 	<pre>- 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.co m/foo: 3</pre>
conformance	Prevent key pods, such as the pods in the kube-system namespace from being preempted.	None	<pre>- plugins: - name: 'priority' - name: 'gang' enablePreemptable: false - name: 'conformance'</pre>

Plugin	Function	Description	Demonstration
lifecycle	<p>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.</p> <ol style="list-style-type: none"> 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. 	<p>arguments:</p> <ul style="list-style-type: none"> • 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. 	<pre>- plugins: - name: priority - name: gang enablePreemptable: false - name: conformance - name: lifecycle arguments: lifecycle.MaxGrade: 3 lifecycle.MaxScore: 200.0 lifecycle.SaturatedTresh: 0.8 lifecycle.WindowSize: 10</pre> <p>NOTE</p> <ul style="list-style-type: none"> • 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
		<p>Maximum score (equivalent to the weight) of the lifecycle plugin.</p> <ul style="list-style-type: none"> 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	<p>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.</p> <p>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.</p>	<ul style="list-style-type: none"> ● enablePreemptable: <ul style="list-style-type: none"> - true: Preemption enabled - false: Preemption not enabled ● enableJobStarving: <ul style="list-style-type: none"> - true: Resources are preempted based on the minAvailable setting of jobs. - false: Resources are preempted based on job replicas. <p>NOTE</p> <ul style="list-style-type: none"> - 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. 	<ul style="list-style-type: none"> - plugins: <ul style="list-style-type: none"> - name: priority - name: gang - enablePreemptable: false - enableJobStarving: false - name: conformance
priority	Schedule based on custom load priorities.	None	<ul style="list-style-type: none"> - plugins: <ul style="list-style-type: none"> - name: priority - name: gang - enablePreemptable: false - name: conformance

Plugin	Function	Description	Demonstration
overcommit	<p>Resources in a cluster are scheduled after being accumulated in a certain multiple to improve the workload enqueueing efficiency. If all workloads are Deployments, remove this plugin or set the raising factor to 2.0.</p> <p>NOTE This plugin is supported in Volcano 1.6.5 and later versions.</p>	<p>arguments:</p> <ul style="list-style-type: none"> • overcommit-factor: inflation factor, which defaults to 1.2. 	<pre>- plugins: - name: overcommit arguments: overcommit-factor: 2.0</pre>
drf	<p>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.</p>	-	<pre>- plugins: - name: 'drf' - name: 'predicates' - name: 'nodeorder'</pre>

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	<ul style="list-style-type: 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.	<p>Scoring parameters:</p> <ul style="list-style-type: none"> ● 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. ● podtopologyspread.weight: Pods are 	<pre>- plugins: - name: nodeorder arguments: leastrequested.weight: 1 mostrequested.weight: 0 nodeaffinity.weight: 2 podaffinity.weight: 2 balancedresource.weight: 1 1 tainttoleration.weight: 3 imagelocality.weight: 1 podtopologyspread.weight: 2</pre>

Plugin	Function	Description	Demonstration
		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: <ul style="list-style-type: none"> 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
networkresource	The ENI requirement node can be preselected and filtered. The parameters are transferred by CCE and do not need to be manually configured.	arguments: <ul style="list-style-type: none"> NetworkType: network type (eni or vpc-router) 	- plugins: - name: 'nodelocalvolume' - name: 'nodeemptydirvolume' - name: 'nodeCSIScheduling' - name: ' networkresource ' arguments: NetworkType: vpc-router
nodelocalvolume	Filter out nodes that do not meet local volume requirements.	None	- plugins: - name: ' nodelocalvolume ' - name: 'nodeemptydirvolume' - name: 'nodeCSIScheduling' - name: 'networkresource'

Plugin	Function	Description	Demonstration
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 17-7 Configurations for add-on scheduling

Parameter	Description
Multi AZ	<ul style="list-style-type: none"> • 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.
Node Affinity	<ul style="list-style-type: none"> • 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	<p>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.</p> <p>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.</p> <p>For details, see Configuring Tolerance Policies.</p>

Step 5 Click **Install**.

----End

Components

Table 17-8 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
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**:

```
...
"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"
        }
    ]
}
],
},
...
```

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.

```
...
"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"
        }
      ]
    }
  ]
},
...

```

 **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 17-9 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"]
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

Metric	Type	Description	Label
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 17-10) 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 17-10 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
Queue	scheduling.volcano.sh	v1beta1	Cluster

17.2.2 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.

Notes and 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](#).
- 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, a pod that uses the local PV will be evicted from the node. A new pod will be created, but it remains in a pending state because the label of the PVC bound to it conflicts with the node label.
- 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 affect 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 17-11 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 17-12 .

Table 17-12 Recommended Autoscaler quotas

Nodes	Pods	Requested vCPUs	vCPU Limit	Requested Memory	Memory Limit
50	2	1000m	1000m	1000 MiB	1000 MiB

Nodes	Pods	Requested vCPUs	vCPU Limit	Requested Memory	Memory Limit
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 17-13 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 (GiB)	Maximum sum of memory of all nodes in a cluster, within which cluster scale-out is performed.

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 17-14 Configurations for add-on scheduling

Parameter	Description
Multi AZ	<ul style="list-style-type: none"> ● 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	<ul style="list-style-type: none"> ● 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	<p>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.</p> <p>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.</p> <p>For details, see Configuring Tolerance Policies.</p>

Step 5 After the configuration is complete, click **Install**.

----End

Components

Table 17-15 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 cannot be deleted. This setting takes effect in the entire node pool.

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 a scale-out (due to the unschedulable pods, metrics, and scaling policies). This setting 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 auto scaling 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 scale-in. This interval takes effect at the cluster level.

17.2.3 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.

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.

Notes and Constraints

- This add-on can be installed only in clusters of v1.15 or later.
- If the add-on version is 1.2.11 or later, the add-ons that can provide metrics API must be installed.
 - **Kubernetes Metrics Server**: provides basic resource usage metrics, such as container CPU and memory usage. It is supported by all cluster versions.

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 17-16 Add-on configuration

Parameter	Description
Add-on Specifications	Select Single or Custom for Add-on Specifications . NOTE A single instance is solely for verification purposes. For commercial situations, you need to choose Custom based on the cluster specifications. The add-on specifications are influenced by the total number of containers in clusters and the number of scaling policies. For typical situations, it is recommended that you configure 500m CPU cores and 1,000 MiB of memory for every 5,000 containers. As for scaling policies, 100m CPU cores and 500 MiB of memory should be configured for every 1,000 of them.
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. 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	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 17-17 Configurations for add-on scheduling

Parameter	Description
Multi AZ	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • 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	<p>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.</p> <p>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.</p> <p>For details, see Configuring Tolerance Policies.</p>

Step 4 Click **Install**.

----End

Components

Table 17-18 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

17.3 Cloud Native Observability Add-ons

17.3.1 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](#).

Notes and Constraints

- When using this add-on, do not format or partition node disks.
- Each NPD process occupies 30m CPUs and 100 MiB of 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 17-19 Add-on 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. 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	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 17-20 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 an individual 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 17-21 Configurations for add-on scheduling

Parameter	Description
Multi AZ	<ul style="list-style-type: none"> ● 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	<ul style="list-style-type: none"> ● 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	<p>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.</p> <p>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.</p> <p>For details, see Configuring Tolerance Policies.</p>

Step 5 Click **Install**.

----End

Components

Table 17-22 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 17-23 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	<p>Check whether the Remount root filesystem read-only error occurs in the system kernel by listening to the kernel logs.</p> <p>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.</p> <p>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.</p>	<p>Warning event</p> <p>Listening object: /dev/kmsg</p> <p>Matching rule: Remounting filesystem read-only</p>

- 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 17-24 Checking system components

Check Item	Function	Description
Container network component error CNIPProblem	Check the status of the CNI components (container network components).	None
Container runtime component error CRIPProblem	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.	<ul style="list-style-type: none"> • 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 17-25 Checking system metrics

Check Item	Function	Description
Conntrack table full ConntrackFullProblem	Check whether the conntrack table is full.	<ul style="list-style-type: none"> • 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.	<ul style="list-style-type: none"> • Default threshold: 90% • Source: <code>df -h</code> <p>Currently, additional data disks are not supported.</p>
Insufficient file handles FDProblem	Check if the FD file handles are used up.	<ul style="list-style-type: none"> • 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.	<ul style="list-style-type: none"> • 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.	<ul style="list-style-type: none"> • 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 17-26 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.	<p>Detection paths:</p> <ul style="list-style-type: none"> • /mnt/paas/kubernetes/kubelet/ • /var/lib/docker/ • /var/lib/containerd/ • /var/paas/sys/log/cceaddon-npd/ <p>The temporary file npd-disk-write-ping is generated in the detection path.</p> <p>Currently, additional data disks are not supported.</p>

Check Item	Function	Description
emptyDir storage pool error EmptyDirVolumeGroupStatusError	<p>Check whether the ephemeral volume group on the node is normal.</p> <p>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.</p> <p>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.</p>	<ul style="list-style-type: none"> • 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	<p>Check the PV group on the node.</p> <p>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.</p> <p>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.</p>	

Check Item	Function	Description
<p>Mount point error</p> <p>MountPointProblem</p>	<p>Check the mount point on the node.</p> <p>Exceptional definition: You cannot access the mount point by running the cd command.</p> <p>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.</p>	<p>Alternatively, you can run the following command:</p> <pre>for dir in `df -h grep -v "Mounted on" awk '{print \\\$NF}'`;do cd \$dir; done && echo "ok"</pre>
<p>Suspended disk I/O</p> <p>DiskHung</p>	<p>Check whether I/O suspension occurs on all disks on the node, that is, whether I/O read and write operations are not responded.</p> <p>Definition of I/O suspension: The system does not respond to disk I/O requests, and some processes are in the D state.</p> <p>Typical scenario: Disks cannot respond due to abnormal OS hard disk drivers or severe faults on the underlying network.</p>	<ul style="list-style-type: none"> • Check object: all data disks • Source: /proc/diskstat <p>Alternatively, you can run the following command:</p> <pre>iostat -xmt 1</pre> <ul style="list-style-type: none"> • Threshold: <ul style="list-style-type: none"> - 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 <p>NOTE</p> <p>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.</p>

Check Item	Function	Description
Slow disk I/O DiskSlow	<p>Check whether all disks on the node have slow I/Os, that is, whether I/Os respond slowly.</p> <p>Typical scenario: EVS disks have slow I/Os due to network fluctuation.</p>	<ul style="list-style-type: none"> • 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 <p>NOTE If I/O requests are not responded and the await data is not updated, this check item is invalid.</p>

Table 17-27 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: <ul style="list-style-type: none"> • /proc/{PID}/stat • Alternately, you can run the ps aux command.
Process Z error ProcessZ	Check whether the node has processes in Z state.	
ResolvConf error ResolvConfFileProblem	<p>Check whether the ResolvConf file is lost.</p> <p>Check whether the ResolvConf file is normal.</p> <p>Exceptional definition: No upstream domain name resolution server (nameserver) is included.</p>	Object: /etc/resolv.conf

Check Item	Function	Description
Existing scheduled event ScheduledEvent	<p>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.</p> <p>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.</p>	<p>Source:</p> <ul style="list-style-type: none"> • http://169.254.169.254/meta-data/latest/events/scheduled <p>This check item is an Alpha feature and is disabled by default.</p>

The kubelet component has the following default check items, which have bugs or defects. You can fix them by upgrading the cluster or using NPDP.

Table 17-28 Default kubelet check items

Check Item	Function	Description
Insufficient PID resources PIDPressure	<p>Check whether PIDs are sufficient.</p>	<ul style="list-style-type: none"> • 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.	<ul style="list-style-type: none"> 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.	<ul style="list-style-type: none"> 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 17-29 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: <ul style="list-style-type: none"> 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

Viewing NPD Events

Events reported by the NPD add-on can be queried on the **Nodes** page.

- 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.
- Step 3** Locate the row that contains the target node, and click **View Events**.

----End

17.3.2 CCE Network Metrics Exporter

Introduction

CCE Network Metrics Exporter (dolphin) is an add-on for monitoring and managing container network traffic. The current version of CCE Network Metrics Exporter controls traffic statistics of containers that do not use the host network in CCE Turbo clusters and performs node-wide container connectivity checks.

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 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, check 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 17-30 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 17-31 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_recv_pkt	Pod	runc/kata	v1.19 or later	1.1.2	EulerOS 2.9 on x86 EulerOS 2.10 on x86
Number of received IPv4 bytes	dolphin_ip4_recv_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

Monitoring Metric	Monitoring Item	Granularity	Supported Runtime	Supported Cluster Version	Supported Add-on Version	Supported OS
Health status of the latest health check	dolphin_health_check_statuses	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
Number of received IP packets	dolphin_ip_received_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_received_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_sent_pkt	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 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
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

Monitoring Metric	Monitoring Item	Granularity	Supported Runtime	Supported Cluster Version	Supported Add-on Version	Supported OS
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
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

Monitoring Metric	Monitoring Item	Granularity	Supported Runtime	Supported Cluster Version	Supported Add-on Version	Supported OS
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
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
```

17.3.3 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 [Creating an HPA Policy](#).

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 17-32 Add-on 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. 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	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 17-33 Configurations for add-on scheduling

Parameter	Description
Multi AZ	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • 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	<p>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.</p> <p>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.</p> <p>For details, see Configuring Tolerance Policies.</p>

Step 4 Click **Install**.

----End

Components

Table 17-34 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

17.4 Cloud Native Heterogeneous Computing Add-ons

17.4.1 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.

Notes and 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 CUDA library version of your application. You need to check the compatibility by yourself.
- If a custom OS image has had 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.

```

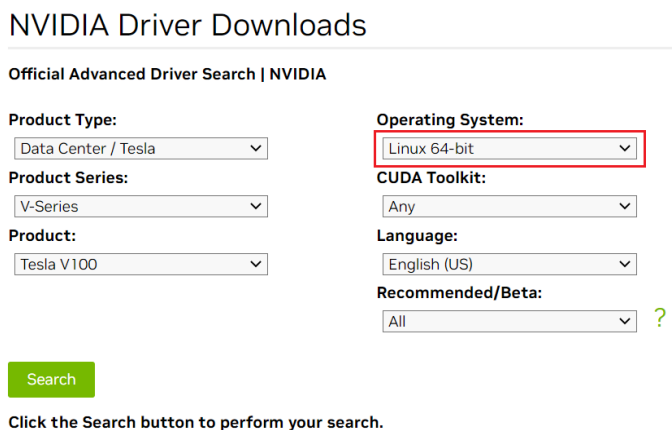
+-----+
| NVIDIA-SMI 440.118.02   Driver Version: 440.118.02   CUDA Version: 10.2   |
+-----+-----+
| GPU  Name                Persistence-M| Bus-Id        Disp.A | Volatile Uncorr. ECC |
| Fan  Temp  Perf    Pwr:Usage/Cap|      Memory-Usage | GPU-Util  Compute M. |
+-----+-----+-----+
|   0   Tesla 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 17-1**. **Operating System** must be **Linux 64-bit**.

Figure 17-1 Setting parameters



- Step 5** After confirming the driver information, click **SEARCH**. A page is displayed, showing the driver information, as shown in **Figure 17-2**. Click **DOWNLOAD**.

Figure 17-2 Driver information

Data Center Driver For Linux X64

Version: 470.103.01
 Release Date: 2022.1.31
 Operating System: Linux 64-bit
 CUDA Toolkit: 11.4
 Language: English (US)
 File Size: 259.86 MB

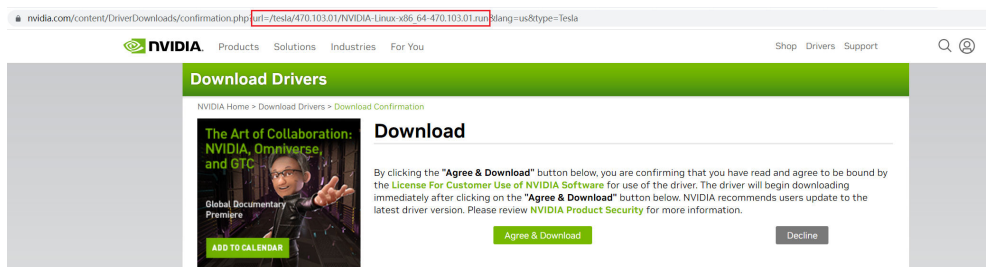
Download

Release Highlights	Supported Products	Additional Information
Release notes, supported GPUs and other documentation can be found at: https://docs.nvidia.com/datacenter/tesla/index.html		

Step 6 Obtain the driver link in either of the following ways:

- Method 1: As shown in Figure 17-3, 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 17-3, 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 17-3 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 17-35 Add-on components

Component	Description	Resource Type
nvidia-driver-installer	Used for installing an NVIDIA driver on GPU nodes.	DaemonSet

17.4.2 CCE AI Suite (Ascend NPU)

Introduction

CCE AI Suite (Ascend NPU) supports and manages NPUs in containers.

After this add-on is installed, you can create Ascend-accelerated nodes to quickly and efficiently process inference and image recognition.

Notes and 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 17-36 Add-on components

Component	Description	Resource Type
npu-driver-installer	Used for installing an NPU driver on NPU nodes.	DaemonSet

17.5 Container Network Add-ons

17.5.1 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](#).

Notes and 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 17-37 Add-on 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	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 17-38 .

Table 17-38 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
2000	20000	4	2000m	2000m	2048 MiB	2048 MiB

Step 3 Configure the add-on parameters.

Table 17-39 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	<ul style="list-style-type: none"> ● parameterSyncStrategy: indicates whether to configure consistency check when the add-on is upgraded. <ul style="list-style-type: none"> – 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, the value of parameterSyncStrategy is automatically restored to ensureConsistent to enable the configuration consistency check again. ● servers: nameservers, which are available in CoreDNS v1.23.1 and later versions. You can customize nameservers. For details, see dns-custom-nameservers. <p>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:</p> <pre>\$name \$parameters { \$configBlock }</pre> <p>Table 17-40 describes common plugins. For details, see Plugins.</p> <ul style="list-style-type: none"> ● upstream_nameservers: specifies the IP address of the upstream DNS server. <p>Example of advanced configurations:</p> <pre>{ "annotations": {}, "parameterSyncStrategy": "ensureConsistent", "servers": [{ "plugins": [{ "name": "bind", "parameters": "\${POD_IP}" }, { "name": "cache", "parameters": 30 }, { "name": "errors" }, { "name": "health",</pre>

Parameter	Description
	<pre> "parameters": "{\$POD_IP}:8080" }, { "name": "ready", "parameters": "{\$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": "." }] }, "upstream_nameservers": ["8.8.8.8", "8.8.4.4"] } </pre>

Table 17-40 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 .
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 .

Plugin Name	Description
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: <pre>{ "name": "log" }</pre>
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: <pre>{ "configBlock": "rcode NXDOMAIN", "name": "template", "parameters": "ANY AAAA" }</pre>

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 17-41 Configurations for add-on scheduling

Parameter	Description
Multi AZ	<ul style="list-style-type: none"> ● 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	<ul style="list-style-type: none"> ● 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	<p>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.</p> <p>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.</p> <p>For details, see Configuring Tolerance Policies.</p>

Step 5 Click **Install**.

----End

Components

Table 17-42 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

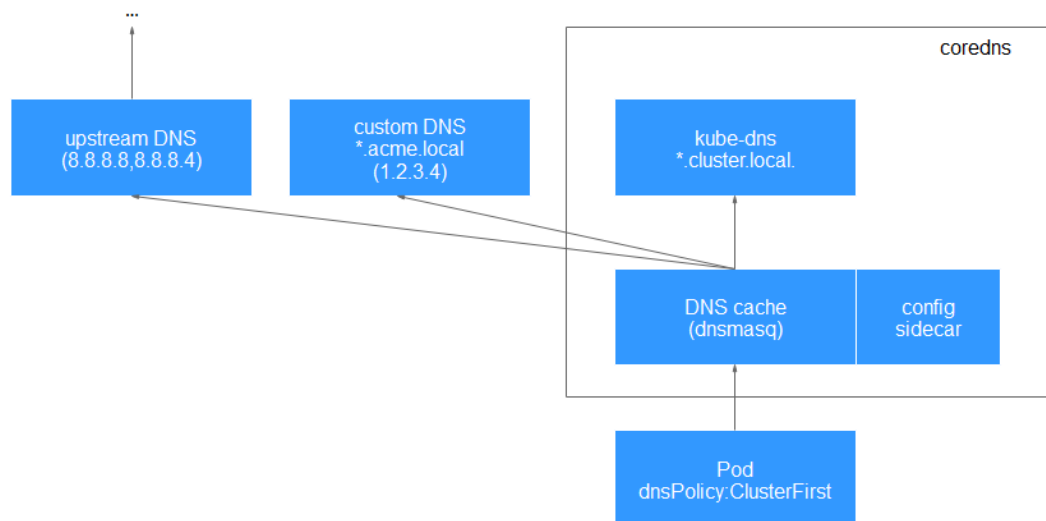
Without stub domain configurations: Any query that does not match the configured cluster domain suffix, such as **www.kubernetes.io**, is forwarded to the upstream DNS server inherited from the node.

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 17-4 Routing



17.5.2 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 the Add-on Works](#).

You can visit the [open source community](#) for more information.

NOTE

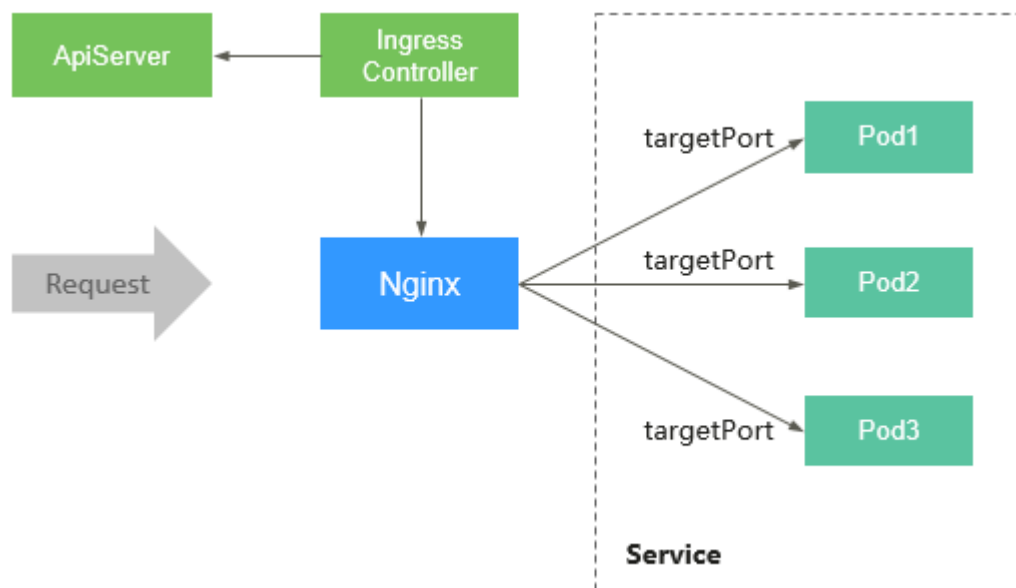
- Starting from version 2.3.3, NGINX Ingress Controller only supports TLS v1.2 and v1.3 by default. If the TLS version is earlier than v1.2, an error will occur during the negotiation process between the client and Nginx Ingress. If more versions of TLS are needed, see [TLS/HTTPS](#).
- When installing 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 the Add-on Works

NGINX Ingress Controller 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 17-5](#) shows how this add-on 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 17-5 Working principles of NGINX Ingress Controller



Precautions

- 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).
- If the node where NGINX Ingress Controller runs and containers on this node cannot access Nginx ingress, you need to configure anti-affinity for the workload pods and Nginx Ingress Controller. For details, see [Configuring Anti-affinity Between a Workload and Nginx Ingress Controller](#).
- During the NGINX Ingress Controller pod upgrade, 10s are reserved for deleting the NGINX Ingress Controller at the ELB backend.
- The timeout duration for the graceful exit of the NGINX Ingress Controller is 300s. If the timeout duration is longer than 300s during the upgrade of the NGINX Ingress Controller, persistent connections will be disconnected, and connectivity will be interrupted for a short period of time.

Prerequisites

Before installing this add-on, you have one available cluster and there is a node running properly. If no cluster is available, create one according to [Creating 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 17-43 Add-on 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. 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	You can adjust the container specifications of an add-on instance as required.

- Step 3** Configure the add-on parameters.
- **Ingress Class:** Enter a custom controller name, which uniquely identifies an Ingress controller. The name of each controller in the same cluster must be unique and cannot be set to **cce**. (**cce** is the unique identifier of the ELB Ingress Controller.) When creating an Ingress, you can specify the controller name to declare which controller should manage this Ingress.

- **Namespace:** Select a namespace where the ingress controller is in.
- **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"  
}
```

- **Enabling Indicator Collection:** If the add-on version is 2.4.12 or later, Prometheus monitoring metrics can be collected.
- **Default server certificate:** Select an IngressTLS or kubernetes.io/tls key to configure the default certificate when an Nginx Ingress Controller is started. If no secret is available, click **Create TLS Secret**. For details, see [Creating a Secret](#). For details about the default server certificate, see [Default SSL Certificate](#).
- **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.
- **Adding a TCP/UDP Service:** By default, Nginx Ingress Controller can forward only external HTTP and HTTPS traffic. You can add TCP/UDP port mapping to forward external TCP/UDP traffic to services in the cluster. For more information about adding TCP/UDP services, see [Exposing TCP and UDP services](#).
 - **Protocol:** Select **TCP** or **UDP**.
 - **Service Port:** specifies the port used by the ELB listener. The port number ranges from 1 to 65535.
 - **Target Service Namespace:** Select the namespace where the Service is in.
 - **Destination Service:** Select an existing Service. Any services that do not match the search criteria will be filtered out automatically.
 - **Destination Service Port:** Select the access port of the destination Service.

 **NOTE**

- If the cluster version is v1.19.16-r5, v1.21.8-r0, v1.23.6-r0, or later, the TCP/UDP hybrid protocols can be configured.
- If the cluster version is v1.19.16-r5, v1.21.8-r0, v1.23.6-r0, v1.25.2-r0, or later, you can configure the TCP/UDP hybrid protocols to use the same external port.

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 17-44 Configurations for add-on scheduling

Parameter	Description
Multi AZ	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • 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	<p>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.</p> <p>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.</p> <p>For details, see Configuring Tolerance Policies.</p>

Step 5 Click **Install**.

----End

Installing Multiple Nginx Ingress Controllers

Step 1 Log in to the CCE console and click the cluster name to access the cluster console. In the navigation pane, choose **Add-ons**, locate the installed Nginx Ingress Controller, and click **New**.

Step 2 On the page displayed, reconfigure the add-on parameters. For details, see [Installing the Add-on](#).

Step 3 Click **Install**.

Step 4 Wait until the installation instruction is delivered. Go back to Add-ons, click **Manage**, and view the installed add-on instance on the add-on details page.

----End

Components

Table 17-45 Add-on components

Component	Description	Resource Type
cceaddon-nginx-ingress- <Controller name>-controller (The controller name in versions earlier than 2.5.4 is cceaddon-nginx-ingress-controller .)	Nginx Ingress controller, which provides flexible routing and forwarding for clusters	Deployment
cceaddon-nginx-ingress- <Controller name>-backend (The controller name in versions earlier than 2.5.4 is cceaddon-nginx-ingress-default-backend .)	Default backend of Nginx Ingress. The message "default backend - 404" is returned.	Deployment

Configuring Anti-affinity Between a Workload and Nginx Ingress Controller

To avoid a situation where the node running NGINX Ingress Controller and its containers cannot access the Nginx Ingress Controller, you should set up anti-affinity between the workload and Nginx Ingress Controller. This means that the workload pods cannot be scheduled to the same node as the Nginx Ingress Controller.

```
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:alpine
          imagePullPolicy: IfNotPresent
          name: nginx
      imagePullSecrets:
        - name: default-secret
      affinity:
        podAntiAffinity:
          requiredDuringSchedulingIgnoredDuringExecution:
            - labelSelector:
                matchExpressions: # Implement anti-affinity through the label of the NGINX Ingress
                  Controller pods.
                  - key: app
                    operator: In
                    values:
                      - nginx-ingress #If multiple NGINX Ingress Controllers are installed in the cluster, the label
value is nginx-ingress-<Controller name>.
            - key: component
              operator: In
              values:
                - controller
      namespaces:
        - kube-system
      topologyKey: kubernetes.io/hostname
```

17.5.3 NodeLocal DNSCache

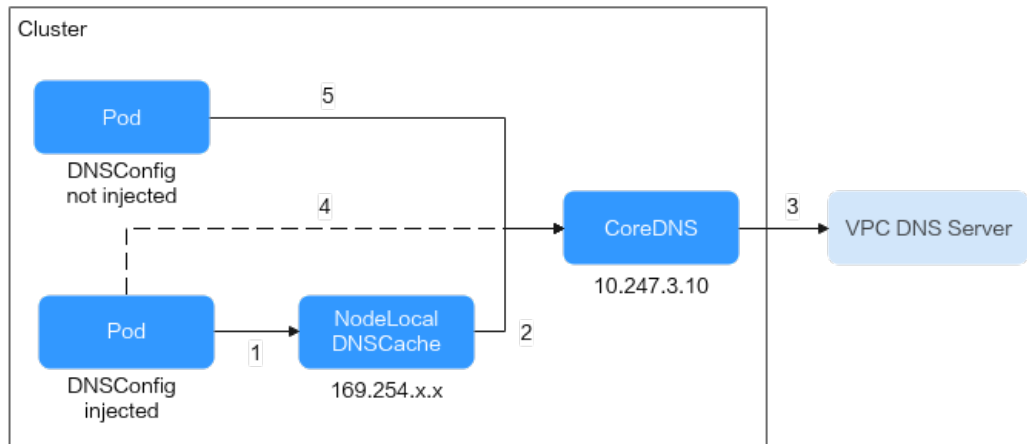
Introduction

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 17-6 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.

Notes and 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 17-46 Add-on configuration

Parameter	Description
Add-on Specifications	Select Standalone , HA , or Custom for Add-on Specifications .

Parameter	Description
Pods	<p>Number of pods that will be created to match the selected add-on specifications.</p> <p>If you select Custom, you can adjust the number of pods as required.</p> <p>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.</p>
Containers	<p>CPU and memory quotas of the container allowed for the selected add-on specifications.</p> <p>If you select Custom, you can adjust the container specifications as required.</p>

Step 3 Configure the add-on parameters.

- **DNSConfig Automatic Injection:** After this function is enabled, a DNSConfig admission controller will be created. The controller intercepts pod creation requests in the namespace labeled with **node-local-dns-injection=enabled** based on admission webhooks and automatically configures DNSConfig for pods. 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 17-47 Configurations for add-on scheduling

Parameter	Description
Multi AZ	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • 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	<p>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.</p> <p>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.</p> <p>For details, see Configuring Tolerance Policies.</p>

Step 5 Click **Install**.

----End

Components

Table 17-48 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. (This function is not available for pods in 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 `kubect` 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:

```
kubect get pod -n default -o yam
```

- 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](#)

17.6 Container Storage Add-ons

17.6.1 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.

Notes and Constraints

- If your cluster is upgraded from v1.13 to v1.15, **storage-driver** will be replaced by Everest (v1.1.6 or later) for container storage. The takeover does not affect the original storage functions.
- 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.
- By default, this add-on is installed in **clusters of v1.15 and later**. For clusters of v1.13 and earlier, the **storage-driver** add-on is installed by default.

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 17-49 Add-on 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	<p>The Everest add-on contains the Everest-csi-controller and everest-csi-driver components. For details, see Components.</p> <p>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 17-50.</p> <p>In non-typical scenarios, the formulas for estimating the limit values are as follows:</p> <ul style="list-style-type: none"> • everest-csi-controller <ul style="list-style-type: none"> - 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 <ul style="list-style-type: none"> - 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 17-50 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

Step 3 Configure the add-on parameters.

Table 17-51 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_attachment_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.
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.

Parameter	Description
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 17-52 Configurations for add-on scheduling

Parameter	Description
Multi AZ	<ul style="list-style-type: none"> • 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.

Parameter	Description
Node Affinity	<ul style="list-style-type: none"> • 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	<p>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.</p> <p>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.</p> <p>For details, see Configuring Tolerance Policies.</p>

Step 5 Click **Install**.

----End

Components

Table 17-53 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

Component	Description	Resource Type
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

17.6.2 FlexVolume (Discarded)

Introduction

CCE Container Storage (FlexVolume), also called storage-driver, functions as a standard Kubernetes FlexVolume plugin to allow containers to use EVS, SFS, OBS, and SFS Turbo storage resources. By installing and upgrading storage-driver, you can quickly install and update cloud storage capabilities.

FlexVolume is a system resource add-on. It is installed by default when a cluster of Kubernetes v1.13 or earlier is created.

Notes and Constraints

- For clusters created in CCE, Kubernetes v1.15.11 is a transitional version in which the FlexVolume add-on is compatible with the CSI add-on ([Everest](#)). Clusters of v1.17 and later versions do not support FlexVolume anymore. Use the Everest add-on.
- The FlexVolume add-on will be maintained by Kubernetes developers, but new functionality will only be added to [Everest](#). Do not create CCE storage that uses the FlexVolume add-on (storage-driver) anymore. Otherwise, storage may malfunction.
- This add-on can be installed only in **clusters of v1.13 or earlier**. By default, the [Everest](#) add-on is installed when clusters of v1.15 or later are created.

NOTE

In a cluster of v1.13 or earlier, when an upgrade or bug fix is available for storage functionalities, you only need to install or upgrade the storage-driver add-on. Upgrading the cluster or creating a cluster is not required.

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:

If storage-driver is not installed in a cluster, perform the following steps to install it:

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 Container Storage (FlexVolume)** on the right, and click **Install**.

Step 2 Click **Install** to install the add-on. Note that the storage-driver has no configurable parameters and can be directly installed.

----End

17.7 Container Security Add-ons

17.7.1 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.

Notes and 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 CCE Secrets Manager for DEW add-on can be installed only on clusters v1.19 or later.
- The CCE Secrets Manager for DEW 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 17-54 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 SecretProviderClass-PodStatus (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. 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.
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 <ul style="list-style-type: none"> 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).

- Run the following command to create a SecretProviderClass object:

```
kubectl apply -f secretproviderclass.yaml
```

- 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.

- 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

Mounting a Credential Using a Secret

NOTE

CCE Secrets Manager for DEW must be 1.1.1 or later.

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. 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. Create the **secretproviderclass.yaml** file using the template below.

```
apiVersion: secrets-store.csi.x-k8s.io/v1
kind: SecretProviderClass
metadata:
  name: nginx-deployment-spc-k8s-secrets
spec:
  provider: cce
  parameters:
    # Reference a secret in CSMS.
    objects: |
      - objectName: "secret_1"
        objectType: "csms"
        objectVersion: "latest"
        jmesPath:
          - path: username
            objectAlias: dbusername
          - path: password
            objectAlias: dbpassword
    # Create a CCE secret based on the CSMS secret and mount the secret to a pod.
  secretObjects:
    - secretName: my-secret-01
      type: Opaque
      data:
```

```
- objectName: dbusername
  key: db_username_01
- objectName: dbpassword
  key: db_password_01
```

Table 17-55 objects parameter

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.
objectType	String	Yes	Secret type. Only csms is supported. A value other than csms is invalid.
objectVersion	String	Yes	Secret version. <ul style="list-style-type: none"> - 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).
jmesPath	Array of Object	Yes	jmesPath is used to extract key-value pairs from objects in JSON format. CCE Secrets Manager for DEW uses this tool to support Secret mounting. <ul style="list-style-type: none"> - path: Enter the key in a DEW secret. The key cannot contain special characters such as +, -, {}, and (). - objectAlias: name of the file mounted to a pod. The value must be the same as the value of objectName defined in secretObjects.

Table 17-56 secretObjects parameter

Parameter	Type	Mandatory	Description
secretName	String	Yes	Secret name
type	String	Yes	Secret type

Parameter	Type	Mandatory	Description
data	Array of Object	Yes	<ul style="list-style-type: none"> - objectName: name of the file mounted to the pod. The value must be the same as the value of objectAlias specified in objects. - key: key in a secret. The value can be used to reference the encrypted content in a pod.

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
nginx-deployment-spc-k8s-secrets 20h
```

Step 3 Create a pod. The following describes how to create an Nginx application.

```
apiVersion: apps/v1
kind: Deployment
metadata:
  name: nginx-deployment-k8s-secrets
  labels:
    app: nginx-k8s-secrets
spec:
  replicas: 1
  selector:
    matchLabels:
      app: nginx-k8s-secrets
  template:
    metadata:
      labels:
        app: nginx-k8s-secrets
    spec:
      serviceAccountName: nginx-spc-sa # Reference the created ServiceAccount.
      containers:
      - name: nginx-deployment-k8s-secrets
        image: nginx
        volumeMounts: # Mount the secret to a container.
        - name: secrets-store-inline # Name of the volume to be mounted
          mountPath: "/mnt/secrets" # Path of the container to be mounted
          readOnly: true
        env: # Reference the secret in environment variables.
        - name: DB_USERNAME_01 # Environment variable name in the workload
          valueFrom:
            secretKeyRef:
              name: my-secret-01 # Secret name specified in the SPC
              key: db_username_01 # The value of the key specified in the SPC
        - name: DB_PASSWORD_01
          valueFrom:
            secretKeyRef:
              name: my-secret-01
              key: db_password_01
      imagePullSecrets:
      - name: default-secret
      volumes: # Use the secret specified in the SPC to create a volume.
      - name: secrets-store-inline # Custom volume name
        csi:
          driver: secrets-store.csi.k8s.io
          readOnly: true
          volumeAttributes:
```

```
secretProviderClass: nginx-deployment-spc-k8s-secrets # Name of the SPC created in the
previous step
```

Step 4 Verify the result.

```
$ kubectl get secrets
NAME          TYPE          DATA  AGE
default-secret  kubernetes.io/dockerconfigjson  1    33d
my-secret-01   Opaque        2     1h
```

The output shows that a secret named **my-secret-01** has been created using **secret_1** specified in the SPC object.

----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...
...
```

17.8 Other Add-ons

17.8.1 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 (Supported by 3.0.2 and later versions) In the window that slides out from the right, configure **Specifications**.

Table 17-57 Add-on configuration

Parameter	Description
Add-on Specifications	Select Single or custom-resources for Add-on Specifications .
Containers	If you select custom-resources , you can adjust the container specifications as required.

Step 3 In the **Parameters** area, configure the following parameters:

- **Access Mode:** NodePort is supported. This add-on can be accessed through the EIP bound to the node. If the cluster node does not have an EIP bound to it, then this function will not be available.
- **Certificate:** Configure a certificate for the dashboard.
 - Use a custom certification.
You need to fill in the **Certificate File** and **Certificate Private Key** in PEM format by referring to the example.
 - Use the 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 4 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, see <https://kubernetes.io/docs/reference/access-authn-authz/rbac/>.

Components

Table 17-58 Add-on components (for versions earlier than 3.0.2)

Component	Description	Resource Type
Dashboard	Visualized monitoring UI	Deployment

Table 17-59 Add-on components (for 3.0.2 or later)

Component	Description	Resource Type
dashboard-api	Back-end API of Dashboard, which provides a RESTful API for communicating with the Kubernetes API server. This component obtains cluster information from the Kubernetes API server and reports the information to the web component.	Deployment
dashboard-auth	Authentication module of Dashboard, which provides a token-based authentication mechanism. When a user logs in to the Dashboard, this component checks whether the token provided by the user is valid. If the token is valid, the user can access the Dashboard.	Deployment
dashboard-web	Front-end UI of Dashboard, which provides a user-friendly UI for viewing and managing Kubernetes clusters. This component is a single-page application based on the React framework and can be accessed through HTTPS.	Deployment

Component	Description	Resource Type
metrics-scraper	Metric collection module of Dashboard, which collects metric data from Kubernetes clusters and reports the data to the web component. Metrics-scraper uses Heapster or Metrics Server to get metric data, and it stores the data in the Kubernetes API server.	Deployment
dashboard-kong	Open-source API gateway component on which Dashboard depends, which helps manage APIs and implement authentication and authorization.	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 17-7 Error message displayed on Google Chrome



Your connection is not private

Attackers might be trying to steal your information from **www.illaskme.com** (for example, passwords, messages, or credit cards). [Learn more](#)

NET::ERR_CERT_COMMON_NAME_INVALID

Help improve Safe Browsing by sending some [system information and page content](#) to Google. [Privacy policy](#)

Advanced

Back to safety

- 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.

18 Helm Chart

18.1 Overview

CCE provides a console for managing Helm charts, helping you easily deploy applications using the charts and manage applications on the console.

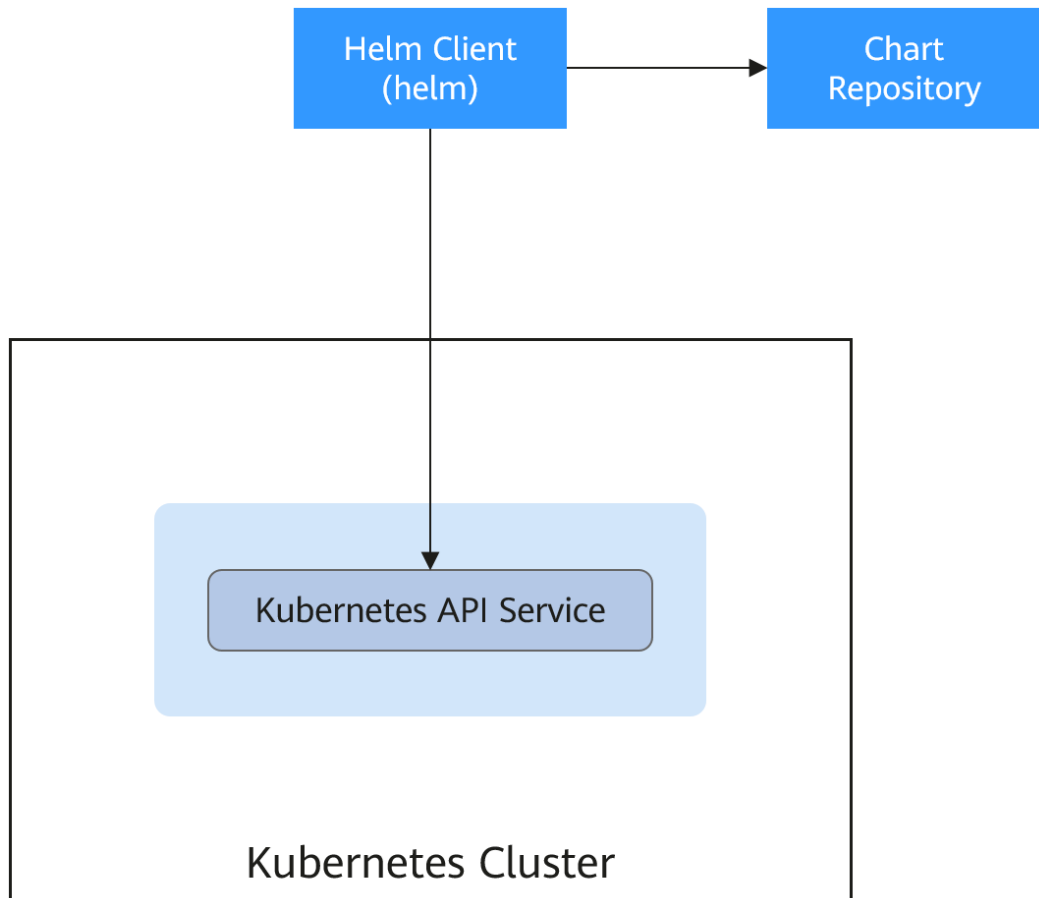
Helm

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 releasors 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.

18.2 Deploying an Application from a Chart

On the CCE console, you can upload a Helm chart package, deploy it, and manage the deployed pods.

Notes and 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 18-1](#), the parameters marked with * are mandatory.

Table 18-1 Parameters in the directory structure of a chart

Parameter	Description
* templates	Stores all templates.
* values.yaml	<p>Describes configuration parameters required by templates.</p> <p>NOTICE</p> <p>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.</p> <p>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.</p>

Parameter	Description
README.md	A markdown file, including: <ul style="list-style-type: none"> 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 18-2](#).

Table 18-2 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	<p>You can import and replace the values.yaml file or directly edit the chart parameters online.</p> <p>NOTE</p> <p>An imported values.yaml file must comply with YAML specifications, that is, KEY:VALUE format. The fields in the file are not restricted.</p> <p>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.</p> <ol style="list-style-type: none"> 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. In the right pane, 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. In the right pane, 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. In the right pane, 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

18.3 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 original manifest, its live state, and the new manifest when generating a patch. Helm compares the current live state with the live state of the original 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

18.4 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 -xzf 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:"a690bad98af45b015bd3da1a41f6218b1a451d8e", 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 you run the **yum install socat -y** command on a node running EulerOS 2.9, the following error message is displayed:

```
No match for argument: socat
Error: Unable to find a match: socat
```

The image does not contain socat. In this case, manually download the RPM chart and run the following command to install it (replace the RPM chart name with the actual one):

```
rpm -i socat-1.7.3.2-8.oe1.x86_64.rpm
```

- 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](#).

18.5 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 you run the **yum install socat -y** command on a node running EulerOS 2.9, the following error message is displayed:

```
No match for argument: socat
Error: Unable to find a match: socat
```

The node image does not contain socat. In this case, manually download the RPM chart and run the following command to install it (replace the RPM chart name with the actual one):

```
rpm -i socat-1.7.3.2-8.oe1.x86_64.rpm
```

- 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](#).

18.6 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 -xzf 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

19 Permissions

19.1 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.

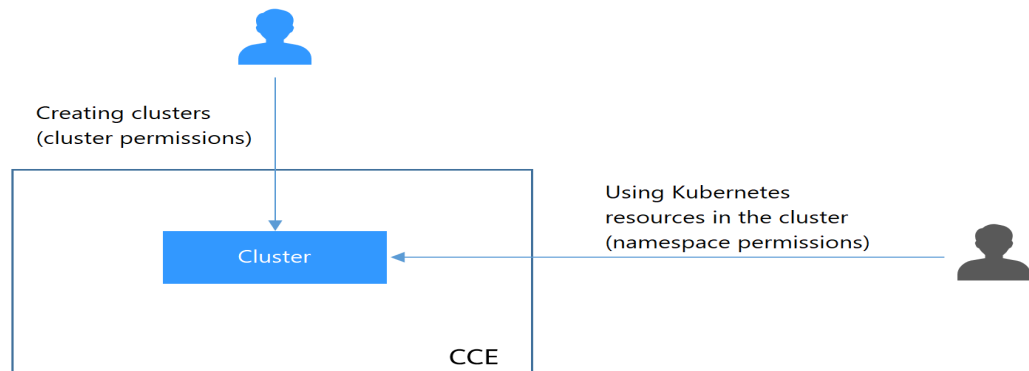
- **Namespace-level permissions:** You can regulate users' or user groups' access to Kubernetes resources in a single namespace based on their Kubernetes RBAC roles. CCE has also been enhanced based on open-source capabilities. It supports RBAC authorization based on IAM user or user group, and RBAC 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 19-1 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 19-1](#) lists the namespace permissions of different users.

Table 19-1 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 19-1](#).

19.2 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 to users for operating 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

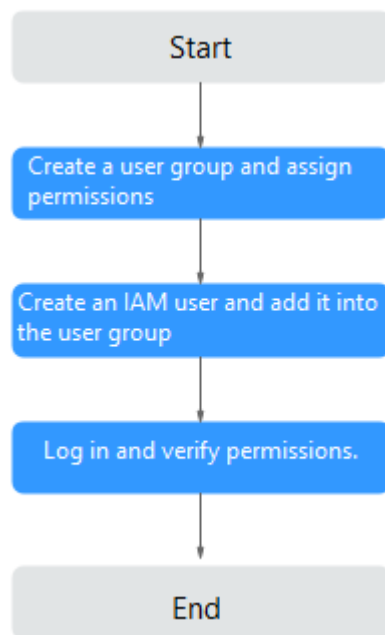
- A user with the Security Administrator role (for example, your account) has all IAM permissions except role switching. Only these users can view user groups and their permissions on the **Permissions** page on the CCE console.

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 19-2 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 create 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 with other policies. 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 IAM RBAC

CCE is compatible with IAM system roles for permissions management. 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

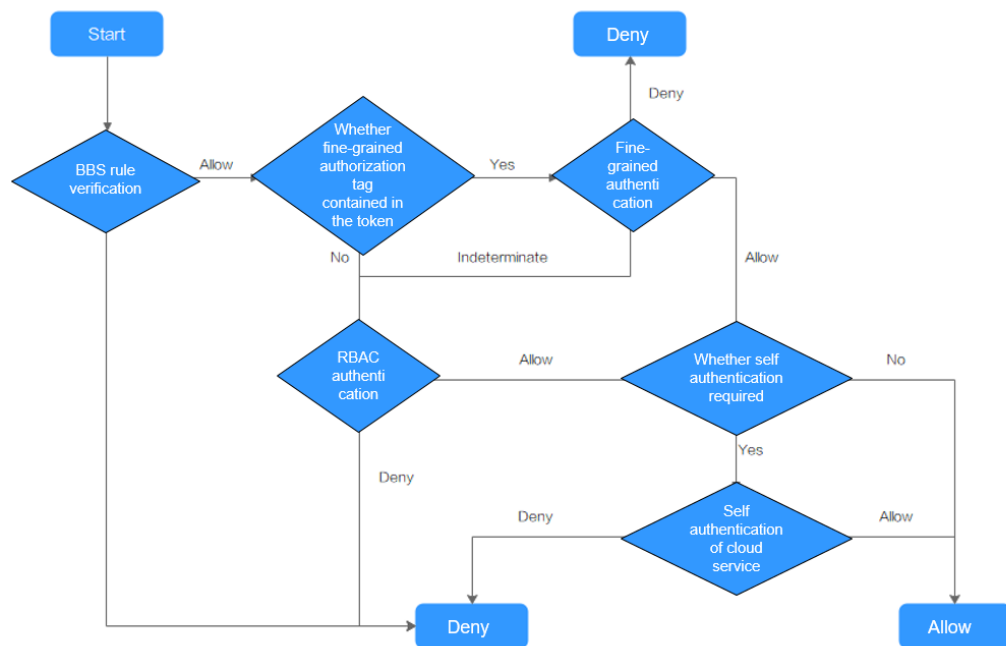
NOTE

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** in 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.



19.3 Namespace Permissions (Kubernetes RBAC-based)

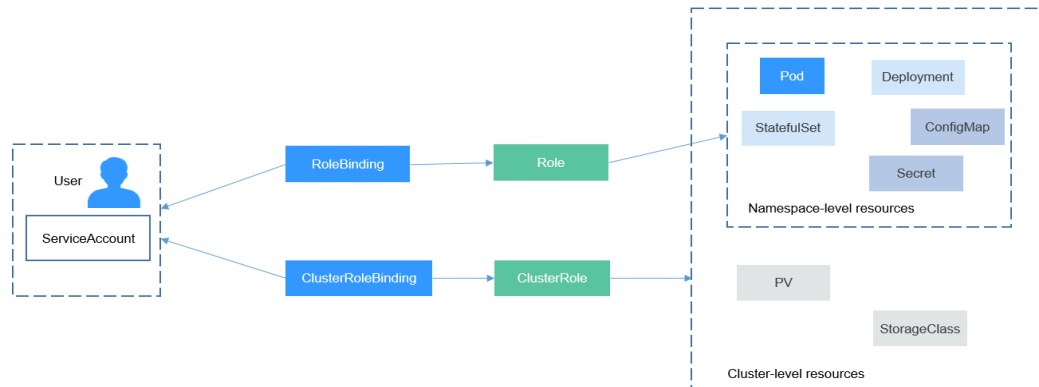
Namespace Permissions (Kubernetes RBAC-based)

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 19-3 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.
- drainage-editor: drain a node.
- drainage-viewer: view the nodal drainage status but cannot drain a node.

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 19-2](#) lists the namespace permissions of different users.

Table 19-2 Differences in namespace permissions

User	Clusters of v1.13 and Later
User with the Tenant Administrator permissions	All namespace permissions

User	Clusters of v1.13 and Later
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.

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.

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**.

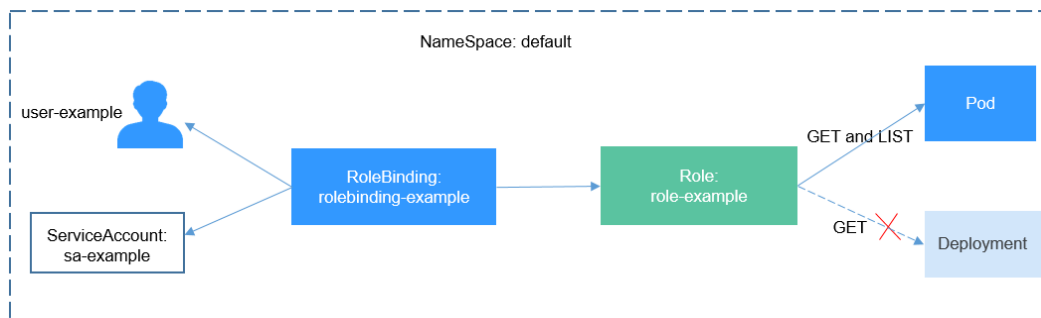
For details, see [Using RBAC Authorization](#).

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 19-4 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-twvnpn 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 the admin role is bound 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](#).

19.4 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.

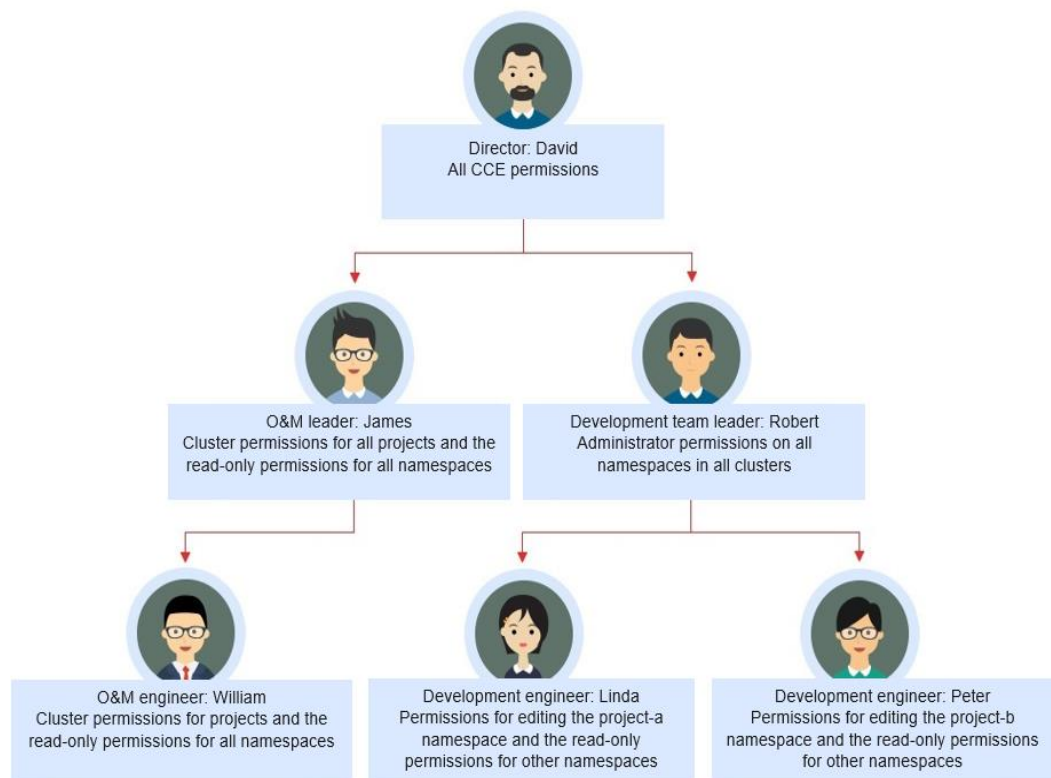
Cluster permissions and namespace permissions are independent of each other but must be used together. The permissions set for a user group apply to all users in the user group. When multiple permissions are added to a user or user group, they take effect at the same time (the union set is used).

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.

19.5 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 19-3](#) to the user. These dependency policies will allow the IAM user to access resources of other cloud services.

 **NOTE**

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 19-3 Dependency policies

Console Function	Dependent Service	Role or Policy Required
Cluster overview	Application Operations Management (AOM)	<ul style="list-style-type: none"> • 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) Scalable File Service (SFS)	Except in the following cases, the user does not require any additional role to create workloads. <ul style="list-style-type: none"> • 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. <p>NOTE Because of the cache, it takes about 13 minutes for the RBAC policy to take effect after being granted to users and user groups. After an OBS-related system policy is granted, it takes about 5 minutes for the policy to take effect.</p> <ul style="list-style-type: none"> • To use SFS, you must have the SFS FullAccess permission assigned.
Cluster management	Application Operations Management (AOM)	<ul style="list-style-type: none"> • Auto scale-out or scale-up requires the AOM FullAccess policy.

Console Function	Dependent Service	Role or Policy Required
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.
Service	Elastic Load Balance (ELB) NAT Gateway	<p>Except in the following cases, the user does not require any additional role to create a Service.</p> <ul style="list-style-type: none"> 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) Scalable File Service (SFS) SFS Turbo	<ul style="list-style-type: none"> To use OBS, you must have the OBS Administrator permission globally assigned. <p>NOTE Because of the cache, it takes about 13 minutes for the RBAC policy to take effect after being granted to users and user groups. After an OBS-related system policy is granted, it takes about 5 minutes for the policy to take effect.</p> <ul style="list-style-type: none"> To use SFS, you must have the SFS FullAccess permission assigned. To use SFS Turbo, you must have the SFS Turbo FullAccess permission. <p>The CCE Administrator role is required for importing storage devices.</p>
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	/	<ul style="list-style-type: none"> 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	/	<ul style="list-style-type: none"> 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.

19.6 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: \geq v0.15.7
- Python: \geq v12.0.0
- Java: \geq v9.0.0
- Javascript: \geq v0.10.3
- Ruby: master branch
- Haskell: v0.3.0.0
- C#: \geq 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 access 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.

```
[root@ ~]# kubectl get --raw "/metrics" | grep stale
# HELP serviceaccount_stale_tokens_total [ALPHA] Cumulative stale projected service account tokens used
# TYPE serviceaccount_stale_tokens_total counter
serviceaccount_stale_tokens_total 52
```

20 Settings

20.1 Dashboard

Settings offers you an entry to check and modify the basic settings of clusters. It includes information from dimension like [Cluster Information](#), [Cluster Settings](#), [Master Node AZs](#), and [Installed Add-ons](#).

Accessing the Settings


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

Step 2 In the navigation pane, choose **Settings** and click the **Dashboard** tab.

----End

Cluster Information

It includes:

- **ID:** uniquely identifies a cluster resource. It is automatically generated after a cluster is created and can be used in scenarios such as API calling.
- **Current Name:** After a cluster is created, you can click  to change its name.
- **Original Name:** specifies a cluster's original name after its current name is changed. The current name of a cluster must be unique.
- **Status:** specifies the status of a cluster. For details, see [Cluster Lifecycle](#).
- **Created On:** specifies the time when a cluster was created. You will be billed based on the creation time of clusters.

Cluster Settings

After a cluster is created, you can modify the following items for it:

- **Cluster Scale:** specifies how many nodes a cluster can manage at most. You can change the cluster scale as needed. For details, see [Changing Cluster Scale](#).

- **Cluster Version | Patch Version:** specifies the Kubernetes version and CCE patch version of a cluster.
- **Network Model:** specifies the network model of a cluster, which cannot be changed. For details about network models, see [Container Network](#).
- **Billing Mode:** specifies the billing mode of a cluster.
- **Resource Tag:** You can add resource tags to classify resources.
- **Cluster Description:** specifies the description that you entered for a cluster. A maximum of 200 characters are allowed.

Master Node AZs

You can check how many master nodes are supported in a cluster.

Installed Add-ons

You can check the installed add-ons in a cluster. If there is an add-on to be upgraded in the cluster, click **Go to Upgrade** to go to the **Add-ons** page and see more details.

20.2 Cluster Access

Access Mode

- **kubectl:** You need to download and configure the kubectl and kubeconfig configuration files first, and then use kubectl to access a Kubernetes cluster. For details, see [Connecting to a Cluster Using kubectl](#).
- **EIP:** You can bind an EIP to the cluster API server. Then, the cluster API server can access the public network.

NOTE

- Binding an EIP to a cluster could bring the cluster potential access risks from the public network. You are advised to harden the inbound rule of port 5443 for the master node security group.
- This operation will restart kube-apiserver and update the cluster access certificate (kubeconfig). Do not perform any operations on the cluster during this time.
- **Custom SAN:** The Subject Alternative Name (SAN) allows multiple values (including IP addresses and domain names) to be associated with certificates. After the custom SAN is configured in the cluster access certificate, the cluster can be accessed using the domain names or IP addresses specified by the SAN. For details, see [Accessing a Cluster Using a Custom Domain Name](#).

NOTE

This operation will restart kube-apiserver and update the cluster access certificate (kubeconfig). Do not perform any operations on the cluster during this time.

Authentication

CCE allows you to download the X509 certificate, which contains the **client.key**, **client.crt**, and **ca.crt** files. Keep your certificate secure.

For details about how to use certificates to access clusters, see [Accessing a Cluster Using an X.509 Certificate](#).

Server Request Settings

Table 20-1 Parameters

Item	Parameter	Description	Value
Maximum Number of Concurrent Modification API Calls	max-mutating-requests-inflight	<p>Maximum number of concurrent modification API calls. Any requests that exceeding the specified value will be rejected by the server.</p> <p>The value 0 specifies that there is no limitation on the maximum number of concurrent modification calls. This parameter is related to the cluster scale. You are advised not to change the value.</p>	<p>Manual configuration is no longer supported since clusters of v1.21. The value is automatically specified based on the cluster scale:</p> <ul style="list-style-type: none"> • 200 for clusters with 50 or 200 worker nodes • 500 for clusters with 1,000 worker nodes • 1000 for clusters with 2,000 worker nodes

Item	Parameter	Description	Value
Maximum Number of Concurrent Non-Modification API Calls	max-requests-inflight	<p>Maximum number of concurrent non-modification API calls. Any requests that exceeding the specified value will be rejected by the server.</p> <p>The value 0 specifies that there is no limitation on the maximum number of concurrent non-modification calls. This parameter is related to the cluster scale. You are advised not to change the value.</p>	<p>Manual configuration is no longer supported since clusters of v1.21. The value is automatically specified based on the cluster scale:</p> <ul style="list-style-type: none"> • 400 for clusters with 50 or 200 worker nodes • 1000 for clusters with 1,000 worker nodes • 2000 for clusters with 2,000 worker nodes
Request Timeout	request-timeout	<p>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.</p> <p>This parameter is available only in clusters of v1.19.16-r30, v1.21.10-r10, v1.23.8-r10, v1.25.3-r10, and later versions.</p>	<p>Default: 1m0s</p> <p>Options: Min ≥ 1s Max ≤ 1 hour</p>

Item	Parameter	Description	Value
Overload Control	support-overload	<p>Cluster overload control. If 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 Enabling Overload Control for a Cluster.</p> <p>This parameter is available only in clusters of v1.23 or later.</p> <p>NOTE In particular scenarios, such as request burst over a short period of time, a cluster could still be overloaded even though overload control is enabled for it. In such cases, you are advised to manage and control access to the cluster in a timely manner.</p>	-

20.3 Network

You can configure a default security group and secondary CIDR block for your clusters.

Cluster Network

Table 20-2 Parameters

Parameter	Description
VPC	<p>VPC where a cluster resides</p> <p>VPC enables you to provision logically isolated, configurable, manageable virtual networks for cloud servers, cloud containers, and cloud databases. The VPC gives you complete control over your virtual network, allowing you to select your own IP address range, create subnets, configure security groups, and even assign EIPs and allocate bandwidth in your network, enabling secure and easy access to your business system.</p>
VPC CIDR Block	VPC CIDR Block of a cluster

Parameter	Description
Default Node Subnet	<p>Node subnet of a cluster</p> <p>A subnet is a network that manages ECS network planes. It supports IP address management and DNS. ECSs in a subnet are assigned with its IP addresses.</p> <p>By default, ECSs in all subnets of the same VPC can communicate with one another, but ECSs in different VPCs cannot.</p> <p>You can create a VPC peering connection to enable ECSs in different VPCs to communicate with each other.</p>
Default Node Subnet IPv4 CIDR Block	<p>Node subnet CIDR block of a cluster</p>
Network Model	<p>Network model of a cluster</p> <p>After a cluster is created, its network model cannot be changed.</p>
<p>Retain the non-spoofed CIDR block of the original pod IP address. (available only in clusters using the VPC network model)</p>	<p>In a cluster using a VPC network, 10.0.0.0/8, 172.16.0.0/12, and 192.168.0.0/16 are regarded as private CIDR blocks of the cluster by default. If the VPC to which the cluster resides uses a secondary CIDR block, operations such as creating or resetting a node will also add the secondary CIDR block to the private CIDR blocks.</p> <p>If a pod tries to access a private CIDR block, the source node will not perform NAT on the pod IP address. Instead, the upper-layer VPC can directly send the pod data packet to the destination, which means, the pod IP address is directly used to communicate with the private CIDR block in the cluster.</p> <p>This function is available only in clusters of v1.23.14-r0, v1.25.9-r0, v1.27.6-r0, v1.28.4-r0, or later versions.</p> <p>NOTE</p> <p>To enable a node to access a pod in another node, the node CIDR block must be added to this parameter.</p> <p>Similarly, to enable an ECS to access the IP address of a pod in a cluster that is in the same VPC as the ECS, the ECS CIDR block must be added to this parameter.</p>

Service Settings

Table 20-3 Parameters

Parameter	Description
Request Forwarding	Forwarding mode of a cluster After a cluster is created, the service forwarding mode cannot be changed. IPVS and iptables are supported. For details, see Comparing iptables and IPVS .
Service CIDR Block	Each Service in a cluster has its own IP address. When creating a CCE cluster, you can specify the Service CIDR block. The Service CIDR block cannot overlap with the subnet or the container CIDR block. The Service CIDR block can be used only within a cluster.
Service Port Range	NodePort port range The default port range is 30000 to 32767. The port range can be changed to 20106 to 32767. 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 from external networks. NOTE If the port number is smaller than 20106, a conflict may occur between the port and the system 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 random port of the OS, which may further affect the performance.

Container CIDR Blocks (Available only in Clusters Using the VPC Network Model)

If a container CIDR block configured during cluster creation cannot meet service expansion requirements, you can add more container CIDR blocks. For details, see [Adding a Container CIDR Block for a Cluster](#).

 **NOTE**

- This function is available only for clusters of v1.19 or later using a VPC network.
- An added container CIDR block cannot be deleted.

20.4 Scheduling

Basic kube-scheduler configurations and Volcano-backed advanced scheduling are available. You can enable advanced scheduling functions such as bin packing, priority-based scheduling and preemption, AI task performance enhancement, and heterogeneous resource management for improved cluster resource utilization at low costs.

Scheduler Configuration

 NOTE

Only kube-scheduler supports this configuration.

Table 20-4 Parameters

Item	Parameter	Description	Value
QPS for communicating with kube-apiserver	kube-api-qps	QPS for communication with kube-apiserver	<ul style="list-style-type: none"> If the number of nodes in a cluster is less than 1,000, the default value is 100. If the number of nodes in a cluster is 1,000 or more, the default value is 200.
Burst for communicating with kube-apiserver	kube-api-burst	Burst for communication with kube-apiserver	<ul style="list-style-type: none"> If the number of nodes in a cluster is less than 1,000, the default value is 100. If the number of nodes in a cluster is 1,000 or more, the default value is 200.

Business Priority Scheduling

Scheduling based on priority

This is a basic scheduling capability and cannot be disabled. The scheduler preferentially guarantees the running of high-priority pods, and will not evict low-priority pods that are running. For details, see [Priority-based Scheduling and Preemption](#).

Resource Utilization Optimization Scheduling (Supported by the Volcano Scheduler)

Enable boxing strategy (binpack)

With this option enabled, the cluster scheduler schedules pods to nodes that have the most requested resources. This reduces resource fragments on each node and improves the resource utilization of the cluster. For details, see [Bin Packing](#).

For details about the bin packing weight and weights for each resource to score nodes, see [Table 20-5](#).

Table 20-5 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
Add 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.	-

AI Task Performance Enhancement Scheduling (Supported by the Volcano Scheduler)

Fair Scheduling Policy (drf)

Dominant Resource Fairness (DRF) is a scheduling algorithm based on the dominant resource of a container group. It supports fair allocation of multiple types of resources and is suitable for batch AI training and big data jobs. DRF is suitable for batch process small scale services like single AI model training and single big data computing and query, because it preferentially considers the throughput of services in clusters.

DRF helps you enhance the service throughput of clusters and improve service performance. For details, see [DRF](#).

Workload Group Scheduling Policy (Gang)

Gang scheduling meets the scheduling requirements of "All or nothing" in the scheduling process and avoids the waste of cluster resources caused by arbitrary scheduling of pods. It is mainly used in scenarios that require multi-process collaboration, such as AI and big data scenarios.

Gang scheduling effectively resolves pain points such as resource waiting or deadlocks in distributed training jobs, thereby significantly improving the utilization of cluster resources. For details, see [Gang](#).

Heterogeneous Resource Scheduling (Supported by the Volcano Scheduler)

Support GPU resource scheduling

To use this feature, install the [CCE AI Suite \(NVIDIA GPU\)](#) add-on in the cluster first. With this option enabled, GPUs can be used for AI training jobs, and the

scheduler provides full GPU dispatch and GPU sharing to improve resource utilization.

20.5 Auto Scaling

Auto Scale-out Configuration

CCE Cluster Autoscaler comprehensively checks the resource statuses of an entire cluster. When the load of a microservice is high (for example, the CPU or memory usage is too high), it will add more pods to reduce the load.

Node Capacity Expansion Conditions

- Auto scale-out when the workload cannot be scheduled: If a workload pod cannot be scheduled, the system automatically scales out the node pool with auto scaling enabled. If the pod has been configured to be affinity for a node, the system will not automatically add more nodes.

This function can be used together with HPA policies. For details, see [Using HPA and CA for Auto Scaling of Workloads and Nodes](#).

- User-defined policy switch: specifies whether to automatically scale out a node pool based on the [node scaling policies](#). This function is enabled by default.

Upper limit of resources to be expanded

- **Total Nodes:** specifies how many nodes can be present in a cluster during scale-out. If there are more nodes in the cluster than the specified value, the cluster will not add nodes. The default value is determined by how many nodes a cluster can manage at most.
- **Total Cores:** specifies how many cores on all nodes can be present in a cluster during scale-out. If there are more cores in the cluster than the specified value, the cluster will not add nodes. By default, the number is not limited.
- **Total Memory (GiB):** specifies the upper limit of the total memory of all nodes in a cluster during scale-out. If the total memory exceeds the specified value, the cluster will not add nodes. By default, the number is not limited.

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 node pools in the list to adjust their scale-out priorities.

Auto Scale-in Configuration

CCE Cluster Autoscaler comprehensively checks the resource statuses of an entire cluster. Once it confirms that workload pods can be scheduled and run properly, it automatically obtains nodes for scale-in.

Node Scale-in Conditions

- **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

Table 20-6 Node scale-in policy configurations

Item	Description	Default Value
Number of Concurrent Scale-In Requests	Maximum number of idle nodes that can be deleted concurrently. 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.	10
Node Recheck Timeout	Interval for rechecking a node that could not be removed	5 minutes

Item	Description	Default Value
Cooldown Time	Cooldown period for starting scale-in evaluation again after auto scale-in is triggered in a cluster NOTE If both auto scale-out and scale-in exist in a cluster, set this parameter 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.	10 minutes
	Cooldown period for starting scale-in evaluation again after auto scale-out is triggered in a cluster	10 minutes
	Cooldown period for starting scale-in evaluation again after auto scale-in triggered in a cluster failed	3 minutes

20.6 Kubernetes

Typical native configuration items are provided. You can configure native community management components such as kube-apiserver and kube-controller for the best cloud native experience.

API Server Configuration (kube-apiserver)

Container eviction configuration

By default, the default tolerance time applies to all containers in a cluster. You can also configure different tolerance times for pods. In this case, your custom settings take effect.

NOTE

It is recommended that you properly configure the tolerance times for pods, or certain problems may occur.

- If the parameter is set to a low value, containers may be moved frequently during brief fault scenarios like network jitter, which can impact services.
- If the parameter is set to a high value, containers may not be moved for a long period of time in the event of a node failure, which can impact services.

Table 20-7 Parameters

Item	Parameter	Description	Value
Toleration time for nodes in NotReady state	default-not-ready-toleration-seconds	Tolerance time when a node is not ready. If a node becomes unavailable, pods running on the node are evicted automatically after the tolerance time elapses. The default value is 300s .	Default: 300s
Toleration time for nodes in unreachable state	default-unreachable-toleration-seconds	Tolerance time when a node is unreachable. If the environment is abnormal, for example, a node cannot be accessed (due to reasons such as abnormal node network), pods running on the node are evicted automatically after the tolerance time elapses. The default value is 300s .	Default: 300s

Admission Controller Add-on Configurations

With Kubernetes, you can enable admission add-ons to limit and manage Kubernetes API objects (like pods, Services, and Deployments) prior to modifying them within a cluster.

 **NOTE**

This parameter is available only in clusters of v1.23.14-r0, v1.25.9-r0, v1.27.6-r0, v1.28.4-r0, or later versions.

Table 20-8 Parameters

Item	Parameter	Description	Value
Node Restriction Add-on	enable-admission-plugin-node-restriction	This add-on allows the kubelet of a node to operate only the objects of the current node for enhanced isolation in multi-tenant scenarios or the scenarios with high security requirements. For details, see the official documentation .	Enable/Disable

Item	Parameter	Description	Value
Pod Node Selector Add-on	enable-admission-plugin-pod-node-selector	This add-on allows cluster administrators to configure the default node selector through namespace annotations. In this way, pods run only on specific nodes and configurations are simplified.	Enable/Disable
Pod Toleration Limit Add-on	enable-admission-plugin-pod-toleration-restriction	This add-on allows cluster administrators to configure the default value and limits of pod tolerations through namespaces for fine-grained control over pod scheduling and key resource protection.	Enable/Disable

Service Account Token Volume Projection

Kubelet can project a service account token into a pod. You can specify the desired properties of the token, such as the API audiences. The token will become invalid against the API when either the pod or the service account is deleted. For details, see the [official document](#).

NOTE

This parameter is available only in clusters of v1.23.16-r0, v1.25.11-r0, v1.27.8-r0, v1.28.6-r0, v1.29.2-r0, or later versions.

Table 20-9 Parameters

Item	Parameter	Description	Value
API Audience Settings	api-audiences	<p>Audiences for a service account token. The Kubernetes component for authenticating service account tokens checks whether the token used in an API request specifies authorized audiences.</p> <p>Configuration suggestion: Accurately configure audiences according to the communication needs among cluster services. By doing so, the service account token is used for authentication only between authorized services, which enhances security.</p> <p>NOTE An incorrect configuration may lead to an authentication communication failure between services or an error during token verification.</p>	<p>Default value: "https://kubernetes.default.svc.cluster.local"</p> <p>Multiple values can be configured, which are separated by commas (,).</p>
Service Account Token Issuer Identity	service-account-issuer	<p>Entity identifier for issuing a service account token, which is the value identified by the iss field in the payload of the service account token.</p> <p>Configuration suggestion: Ensure the configured issuer URL can be accessed in the cluster and trusted by the authentication system in the cluster.</p> <p>NOTE If your specified issuer URL is untrusted or inaccessible, the authentication process based on the service account may fail.</p>	<p>Default value: "https://kubernetes.default.svc.cluster.local"</p> <p>Multiple values can be configured, which are separated by commas (,).</p>

Controller Configuration (kube-controller-manager)

Common Configurations of the Controller

- **Controller performance configuration:** used to configure performance parameters for the controller to access kube-apiserver.

 **NOTE**

It is recommended that you properly configure the controller performance settings, or certain problems may occur.

- If a parameter is set to a small value, client traffic limiting may be triggered, affecting controller performance.
- If a parameter is set to a large value, kube-apiserver may be overloaded.

Table 20-10 Parameters

Item	Parameter	Description	Value
QPS for communicating with kube-apiserver	kube-api-qps	QPS for communication with kube-apiserver	<ul style="list-style-type: none"> • If the number of nodes in a cluster is less than 1,000, the default value is 100. • If the number of nodes in a cluster is 1,000 or more, the default value is 200.
Burst for communicating with kube-apiserver	kube-api-burst	Burst for communication with kube-apiserver	<ul style="list-style-type: none"> • If the number of nodes in a cluster is less than 1,000, the default value is 100. • If the number of nodes in a cluster is 1,000 or more, the default value is 200.

- **Cluster controller concurrent configuration:** specifies the number of resource objects that are allowed to synchronize simultaneously. A larger value indicates a quicker response and higher CPU (and network) load.

 **NOTE**

It is recommended that you properly configure the controller concurrency, or certain problems may occur.

- If a parameter is set to a small value, the controller may respond slowly.
- If a parameter is set to a large value, the cluster management plane will be overloaded.

Table 20-11 Parameters

Item	Parameter	Description	Value
Number of concurrent processing of deployment	concurrent-deployment-syncs	Number of deployment objects that can be synchronized concurrently. A larger value indicates a quicker response to Deployments and higher CPU (and network bandwidth) pressure.	Default: 5
Concurrent processing number of endpoint	concurrent-endpoint-syncs	Number of endpoints that can be concurrently synchronized. A larger value indicates faster update of endpoints and higher CPU (and network) pressure.	Default: 5
Concurrent number of garbage collectors	concurrent-gc-syncs	Number of garbage collector workers that are allowed to synchronize concurrently.	Default: 20
Number of job objects allowed to sync simultaneously	concurrent-job-syncs	Number of job objects that can be synchronized concurrently. A larger value indicates a quicker response to jobs and higher CPU (and network) usage.	Default: 5
Number of CronJob objects allowed to sync simultaneously	concurrent-cron-job-syncs	Number of CronJob objects that can be synchronized concurrently. A larger value indicates a quicker response to CronJobs and higher CPU (and network) usage.	Default: 5

Item	Parameter	Description	Value
Number of concurrent processing of namespace	concurrent-namespace-syncs	Number of namespace objects that can be synchronized concurrently. A larger value indicates a quicker response to namespaces and higher CPU (and network) usage.	Default: 10
Concurrent processing number of replicaset	concurrent-replicaset-syncs	Number of ReplicaSet objects that can be synchronized concurrently. A larger value indicates a quicker response to ReplicaSet management and higher CPU (and network) usage.	Default: 5
Number of concurrent processing of resource quota	concurrent-resource-quota-syncs	Number of ResourceQuota objects that can be synchronized concurrently. A larger value indicates a faster response to quota management and higher CPU (and network) usage.	Default: 5
Servicepace	concurrent-service-syncs	Number of Service objects that can be synchronized concurrently. A larger value indicates a faster response to Service management and higher CPU (and network) usage.	Default: 10
Concurrent processing number of serviceaccount-token	concurrent-serviceaccount-token-syncs	Number of service account token objects that can be synchronized concurrently. A larger value indicates faster token generation and higher CPU (and network) usage.	Default: 5
Concurrent processing of ttl-after-finished	concurrent-ttl-after-finished-syncs	Number of ttl-after-finished-controller workers that can be synchronized concurrently.	Default: 5

Item	Parameter	Description	Value
RC	concurrent_rc_syncs	Number of replication controllers that can be synchronized concurrently. A larger value indicates faster replica management operations and higher CPU (and network) usage. NOTE This parameter is used only in clusters of v1.19 or earlier.	Default: 5
RC	concurrent-rc-syncs	Number of replication controllers that can be synchronized concurrently. A larger value indicates faster replica management operations and higher CPU (and network) usage. 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
HPA	concurrent-horizontal-pod-autoscaler-syncs	Maximum number of HPA auto scaling requests that can be processed concurrently. A larger value indicates a faster HPA auto scaling and higher CPU (and network) usage. This parameter is available only in clusters of v1.27 or later.	Default: 5 Value range: 1 to 50

Node lifecycle controller (node-lifecycle-controller) configuration

 **NOTE**

This parameter is available only in clusters of v1.23.14-r0, v1.25.9-r0, v1.27.6-r0, v1.28.4-r0, or later versions.

Table 20-12 Parameters

Item	Parameter	Description	Value
Unhealthy AZ Threshold	unhealthy-zone-threshold	<p>When more than a certain proportion of pods in an AZ are unhealthy, the AZ itself will be considered unhealthy, and scheduling pods to nodes in that AZ will be restricted to limit the impacts of the unhealthy AZ.</p> <p>NOTE If the parameter is set to a large value, pods in unhealthy AZs will be migrated in a large scale, which may lead to risks such as overloaded clusters.</p>	Default: 0.55
Node Eviction Rate	node-eviction-rate	<p>This parameter specifies the number of nodes that pods are deleted from per second in a cluster when the AZ is healthy. The default value is 0.1, indicating that pods can be evicted from at most one node every 10 seconds.</p> <p>NOTE Configure this parameter based on the size of the cluster. The number of pods to be evicted in each batch should not exceed 300.</p> <p>If the parameter is set to a large value, the cluster may be overloaded. Additionally, if too many pods are evicted, they cannot be rescheduled, which will slow down fault recovery.</p>	Default: 0.1

Item	Parameter	Description	Value
Secondary Node Eviction Rate	secondary-node-eviction-rate	<p>This parameter specifies the number of nodes that pods are deleted from per second in a cluster when the AZ is unhealthy. The default value is 0.01, indicating that pods can be evicted from at most one node every 100 seconds.</p> <p>NOTE Configure this parameter with node-eviction-rate and set it to one-tenth of node-eviction-rate.</p> <p>There is no need to set the parameter to a large value for nodes in an unhealthy AZ, and this configuration may result in overloaded clusters.</p>	Default: 0.01
Large Cluster Threshold	large-cluster-size-threshold	<p>If the number of nodes in a cluster is greater than the value of this parameter, this is a large cluster.</p> <p>Configuration suggestion: For the clusters with a large number of nodes, configure a relatively larger value than the default one for higher performance and faster responses of controllers. Retain the default value for small clusters. Before adjusting the value of this parameter in a production environment, check the impact of the change on cluster performance in a test environment.</p> <p>NOTE kube-controller-manager automatically adjusts configurations for large clusters to optimize the cluster performance. Therefore, an excessively small threshold for small clusters will deteriorate the cluster performance.</p>	Default: 50

Load elastic scaling synchronization cycle

Table 20-13 Parameters

Item	Parameter	Description	Value
Cluster elastic computing period	horizontal-pod-autoscaler-sync-period	<p>Period for the horizontal pod autoscaler to perform elastic scaling on pods. A smaller value will result in a faster auto scaling response and higher CPU load.</p> <p>NOTE Make sure to configure this parameter properly as a lengthy period can cause the controller to respond slowly, while a short period may overload the cluster management plane.</p>	Default: 15s
Horizontal Pod Scaling Tolerance	horizontal-pod-autoscaler-tolerance	<p>The configuration determines how quickly HPA will act to auto scaling policies. If the parameter is set to 0, auto scaling will be triggered immediately when the related metrics are met.</p> <p>Configuration suggestion: If the service resource usage increases sharply over time, retain a certain tolerance to prevent auto scaling which is beyond expectation in high resource usage scenarios.</p>	Default: 0.1

Item	Parameter	Description	Value
HPA CPU Initialization Period	horizontal-pod-autoscaler-cpu-initialization-period	<p>During the period specified by this parameter, the CPU usage data used in HPA calculation is limited to pods that are both ready and have recently had their metrics collected. You can use this parameter to filter out unstable CPU usage data during the early stage of pod startup. This helps prevent incorrect scaling decisions based on momentary peak values.</p> <p>Configuration suggestion: If you find that HPA is making incorrect scaling decisions due to CPU usage fluctuations during pod startup, increase the value of this parameter to allow for a buffer period of stable CPU usage.</p> <p>NOTE</p> <p>Make sure to configure this parameter properly as a small value may trigger unnecessary scaling based on peak CPU usage, while a large value may cause scaling to be delayed.</p> <p>This parameter is available only in clusters of v1.23.16-r0, v1.25.11-r0, v1.27.8-r0, v1.28.6-r0, v1.29.2-r0, or later versions.</p>	Default: 5 minutes

Item	Parameter	Description	Value
HPA Initial Readiness Delay	horizontal-pod-autoscaler-initial-readiness-delay	<p>After CPU initialization, this period allows HPA to use a less strict criterion for getting CPU metrics. During this period, HPA will gather data on the CPU usage of the pod for scaling, regardless of any changes in the pod's readiness status. This parameter ensures continuous tracking of CPU usage, even when the pod status changes frequently.</p> <p>Configuration suggestion: If the readiness status of pods fluctuates after startup and you want to prevent HPA misjudgment caused by the fluctuation, increase the value of this parameter to allow HPA to gather more comprehensive CPU usage data.</p> <p>NOTE</p> <p>Configure this parameter properly. If it is set to a small value, an unnecessary scale-out may occur due to CPU data fluctuations when the pod is just ready. If it is set to a large value, HPA may not be able to make a quick decision when a rapid response is needed.</p> <p>This parameter is available only in clusters of v1.23.16-r0, v1.25.11-r0, v1.27.8-r0, v1.28.6-r0, v1.29.2-r0, or later versions.</p>	Default: 30s

Threshold configuration of the number of terminal state pods that trigger recycling

Table 20-14 Parameters

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 before the terminated pod garbage collector starts deleting terminated pods NOTE It is recommended that you properly configure this parameter. If the value is too large, there may be a large number of terminated pods in the cluster, which will further affect the performance of list queries and result in an overloaded cluster.	Default: 1000 Value range: 10 to 12500

Resource quota controller (resource-quota-controller) configuration

 **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.

Table 20-15 Parameters

Item	Parameter	Description	Value
Enable resource quota management	enable-resource-quota	With resource quota management, you are allowed to control the number of workloads (such as Deployments and pods) and the upper limits of resources (such as CPUs and memory) in namespaces or related dimensions. Namespaces control quotas through the ResourceQuota objects. <ul style="list-style-type: none"> false: Auto creation is disabled. true: Auto creation is enabled. For details about the default values of resource quota, see Configuring Resource Quotas. 	Default: false

20.7 Heterogeneous Resources

GPU Settings

GPU Driver

- **Default Cluster Driver:** specifies the default GPU driver version used by the GPU nodes in a cluster. To use a custom driver, enter the download link of the NVIDIA driver.
- **Custom Node Pool Driver:** 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. After you customize a GPU driver for a node pool, nodes in the node pool will preferentially use the custom driver. Nodes for which no driver is specified will use the cluster's default driver.

NOTE

- The system installs the driver of the version specified for the node pool. The driver applies only to new nodes in the node pool.
- After the driver version of new nodes is updated, you need to restart the nodes for the update to take effect. The driver version can be updated only for new nodes.

21 FAQs

21.1 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?](#)

21.2 Billing

21.2.1 How Is CCE Billed/Charged?

Billing Items

CCE is free of charge. You only pay for the resources (such as nodes) created when you are using CCE. There are two types of billing items:

1. **Clusters:** the cost of resources used by master nodes, varying depending on the cluster type and size. Cluster types include VM cluster and BMS cluster (the number of master nodes determines whether a cluster is highly available). Cluster size (also called management scale) indicates the maximum number of nodes allowed in a cluster.

NOTE

The management scale indicates the number of ECSs or BMSs in a cluster.

2. **IaaS resource costs** are incurred from the IaaS resources you use to run worker nodes in your cluster. These resources, created either manually or automatically, include ECSs, EVS disks, EIPs, bandwidth, and load balancers.

Billing Modes

CCE is billed on a pay-per-use basis.

- **Pay-per-use:** It is a pay-after-use mode. Billing starts when a resource is provisioned and stops when the resource is deleted. You can use cloud resources as required and stop paying for them when you no longer need them. There is no upfront payment for excess capacity.

NOTE

The following are pricing principles in the case of CCE cluster hibernation or node shutdown. Note that there are many types of cluster nodes and ECS is used as an example.

- **Cluster hibernation:** For a hibernated cluster, you will not be billed for resources on the master nodes, but the resources used by or bound to the cluster, such as the EVS disks, EIPs, and bandwidth, will be billed in their own ways such as pay-per-use.
- **Node shutdown:** Hibernating a cluster will not stop worker nodes in the cluster. You can select **Stop all nodes in the cluster** to do so. You can also stop a node on the ECS console after hibernating a cluster..

NOTICE

- Clusters follow a tiered pricing plan. Pricing for each tier varies with cluster size and type.
 - Once a pay-per-use resource becomes in arrears, provides a grace period and a retention period during which you can top up your account or renew resources. Within the grace period, you can still access and use your cloud service.
-

21.2.2 Will I Be Notified When My Balance Is Insufficient?

In Billing Center, on the overview page, click **Settings** in the **Available Credit** area. Then, you can enable or disable **Balance Alert**. Click **Modify** and configure a desired threshold.

- After the function is enabled, if your total balance (including cash balance, credit balance, common vouchers, and flexi-purchase coupons) is lower than the alert threshold, the system sends you SMS and email notifications every day for a maximum of three consecutive days.
- In Message Center, choose **Message Receiving Management > SMS & Email Settings** in the navigation pane, select **Account balance** under **Finance** to change contacts that receive the balance alerts.

21.2.3 Will I Be Notified When My Account Balance Changes?

Question

Will I be notified when my account balance changes?

Answer

The system will notify you via email or SMS message of your account balance changes, including whether your online topping up is successful.

21.3 Cluster

21.3.1 Cluster Creation

21.3.1.1 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

21.3.1.2 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.

21.3.1.3 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 ECS or EVS disks that can be created.

If the existing resource quota cannot meet your service requirements, you can apply for a higher quota.

21.3.2 Cluster Running

21.3.2.1 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

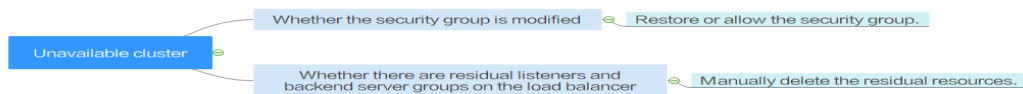
The issues here are described in order of how likely they are to occur.

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, contact the customer service to help you locate the fault.

Figure 21-1 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

21.3.2.2 How Do I Retrieve Data After a CCE Cluster Is Deleted?

Question

How do I retrieve data after a CCE cluster is deleted?

Answer:

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.

21.3.3 Cluster Deletion

21.3.3.1 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

21.3.3.2 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

21.3.4 Cluster Upgrade

21.3.4.1 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

21.4 Node

21.4.1 Node Creation

21.4.1.1 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.

21.4.1.2 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

- ECSs can be managed.

Prerequisites

The cloud servers to be managed must meet the following requirements:

- 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.
- Only cloud servers with the same data disk configurations can be added in batches.
- 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.

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.

21.4.1.3 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 Causes

Log in to the node and check the `/var/paas/sys/log/baseagent/baseagent.log` installation log. The following error information is displayed:

```
net_core.somaxconn=32768
net.ipv4.tcp_max_syn_backlog=8096
PEERDNS=on
failed because of no tenant.conf
10310 10:17:41.075997 6872 baseagent.go:338] install failed
E0310 10:17:41.076379 6872 install.go:181] Install failed: Install Version(v1.13.7-rc) failed: Exec component plugins/config-prepare Install failed: exit status 1
output: [ Tue Mar 10 10:17:35 CST 2020 ] start install plugins/config-prepare
net.ipv4.ip_forward = 1
net.ipv4.neigh.default.gc_thresh1 = 2048
net.ipv4.neigh.default.gc_thresh2 = 4096
net.ipv4.neigh.default.gc_thresh3 = 8192
net.ipv4.ip_forward=1
```

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.

21.4.2 Node Running

21.4.2.1 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 and **-cce-control-**.

Check whether the security group rules have been modified. For details about security groups, 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 groups, 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.

```
root@bms-ccc-00406059-11044:~# systemctl status kubelet
● kubelet.service - Cloud Container Engine Kubelet Service
   Loaded: loaded (/usr/lib/systemd/system/kubelet.service; enabled; vendor preset: disabled)
   Active: active (running) since Mon 2019-08-05 14:38:22 CST; 3 days ago
     Main PID: 17029 (sudo)
        Memory: 139.6M
     CGroup: /system.slice/system-hostos.slice/kubelet.service
             └─17029 sudo /var/paas/kubernetes/kubelet/srvkubelet start
                 └─17030 /bin/sh /var/paas/kubernetes/kubelet/srvkubelet start
                     └─17422 /usr/local/bin/kubelet --bootstrap-kubeconfig=/var/paas/kubernetes/kubelet/boot.conf --cert-dir=/var/paas/kubernetes/kubelet/pki --rotate-certificates=true ...

Aug 05 14:38:22 bms-ccc-00406059-11044:~# systemctl status kubelet
systemd[1]: Started Cloud Container Engine Kubelet Service.
Aug 05 14:38:22 bms-ccc-00406059-11044:~# systemctl status kubelet
systemd[1]: Starting Cloud Container Engine Kubelet Service.
Aug 05 14:38:22 bms-ccc-00406059-11044:~# sudo[17029]:    paa : TTY=unknown ; PWD=/ ; USER=root ; COMMAND=/var/paas/kubernetes/kubelet/srvkubelet start
Aug 05 14:38:22 bms-ccc-00406059-11044:~# sudo[17051]:    paa : TTY=unknown ; PWD=/ ; USER=root ; COMMAND=/bin/sh -c cat > /etc/resolv.conf <<EOF
nameserver 100.79.1.250
options timeout:2 attempts:3 single-request-reopen...
Aug 05 14:38:28 bms-ccc-00406059-11044 sh[17029]: 5 Aug 14:38:28 ntpdate[17054]: adjust time server 100.79.0.250 offset 0.014749 sec
hint: Some lines were ellipsized, use -l to show in full.
```


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

21.4.2.2 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

21.4.2.3 How Do I Collect Logs of Nodes in a CCE Cluster?

The following tables list log files of CCE nodes.

Table 21-1 Node logs

Name	Path
kubelet log	<ul style="list-style-type: none"> For clusters of v1.21 or later: <code>/var/log/cce/kubernetes/kubelet.log</code> For clusters of v1.19 or earlier: <code>/var/paas/sys/log/kubernetes/kubelet.log</code>
kube-proxy log	<ul style="list-style-type: none"> For clusters of v1.21 or later: <code>/var/log/cce/kubernetes/kube-proxy.log</code> For clusters of v1.19 or earlier: <code>/var/paas/sys/log/kubernetes/kube-proxy.log</code>
yangtse log (networking)	<ul style="list-style-type: none"> For clusters of v1.21 or later: <code>/var/log/cce/yangtse</code> For clusters of v1.19 or earlier: <code>/var/paas/sys/log/yangtse</code>
canal log	<ul style="list-style-type: none"> For clusters of v1.21 or later: <code>/var/log/cce/canal</code> For clusters of v1.19 or earlier: <code>/var/paas/sys/log/canal</code>
System logs	<code>/var/log/messages</code>
Container engine Logs	<ul style="list-style-type: none"> For Docker nodes: <code>/var/lib/docker</code> For containerd nodes: <code>/var/log/cce/containerd</code>

Table 21-2 Add-on logs

Name	Path
everest log	<ul style="list-style-type: none"> For v2.1.41 or later: <ul style="list-style-type: none"> everest-csi-driver: <code>/var/log/cce/kubernetes</code> everest-csi-controller: <code>/var/paas/sys/log/kubernetes</code> For version earlier than v2.1.41: <ul style="list-style-type: none"> everest-csi-driver: <code>/var/log/cce/everest-csi-driver</code> everest-csi-controller: <code>/var/paas/sys/log/everest-csi-controller</code>
npd log	<ul style="list-style-type: none"> For v1.18.16 or later: <code>/var/paas/sys/log/kubernetes</code> For versions earlier than v1.18.16: <code>/var/paas/sys/log/cceaddon-npd</code>
cce-hpa-controller log	<ul style="list-style-type: none"> For v1.3.12 or later: <code>/var/paas/sys/log/kubernetes</code> For versions earlier than v1.3.12: <code>/var/paas/sys/log/ccehpa-controller</code>

21.4.2.4 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.

```
vgcreate VG_new PV ...
create volume group error
, skip pause's work in case of failed dependency docker, skip fuxi's work in case of failed dependency docker, sk
work in case of failed dependency kubelet, skip kube-proxy's work in case of failed dependency config-prepare, sk
ork in case of failed dependency config-prepare, skip canal-agent's work in case of failed dependency fuxi, skip c
work in case of failed dependency config-prepare, skip docker's work in case of failed dependency config-prepare,
s work in case of failed dependency config-prepare]
18525 17:22:55.835685 7116 install.go:36] install failed
Install Failed: [Install config-prepare failed: exit status 1, output: [ Mon May 25 17:22:53 CST 2020 ] start inst
pare
success download the file
success download the file
success download the file
success download the file
success download the file
success download the file
success download the file
success download the file
Checking device: /dev/vda
Raw disk /dev/vda has been partition, will skip this device
Checking device: /dev/vdb
Detected paas disk: /dev/vdb
Use to config lv(eg. docker(direct-lvm),kubelet,user)
No command with matching syntax recognised. Run 'vgcreate --help' for more information.
Correct command syntax is:
vgcreate VG_new PV ...

create volume group error
, skip pause's work in case of failed dependency docker, skip fuxi's work in case of failed dependency docker, sk
work in case of failed dependency kubelet, skip kube-proxy's work in case of failed dependency config-prepare, sk
ork in case of failed dependency config-prepare, skip canal-agent's work in case of failed dependency fuxi, skip c
work in case of failed dependency config-prepare, skip docker's work in case of failed dependency config-prepare,
s work in case of failed dependency config-prepare]
```

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

21.4.2.5 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:

```
1128103.173120] sd 2:0:0:0: [sda] write Protect IS 011
1128163.173457] sd 2:0:0:0: [sda] Mode Sense: 69 00 00 08
1128163.173573] sd 2:0:0:0: [sda] Write cache: disabled, read cache: enabled, doesn't support DPO or FUA
1128163.176426] sd 2:0:0:0: [sda] Attached SCSI disk
1128350.437941] INFO: task jbd2/dm-1-8:1604 blocked for more than 120 seconds.
1128350.438267] "echo 0 > /proc/sys/kernel/hung_task_timeout_secs" disables this message.
1128350.438564] jbd2/dm-1-8 D ffff9ede7f8420e0 0 1604 2 0x00000000
1128350.438829] Call Trace:
1128350.439120] [<ffffffffffaab5a585>] ? blk_mq_dispatch_rq_list+0x325/0x620
1128350.439394] [<ffffffffffaaf7f229>] schedule+0x29/0x70
```

Possible Causes

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**.

21.4.2.6 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.

```
Storage Driver: devicemapper
Pool Name: vgpaas-thinpool
Pool Blocksize: 524.3kB
Base Device Size: 10.74GB
Backing Filesystem: ext4
Udev Sync Supported: true
Data Space Used: 7.794GB
Data Space Total: 71.94GB
Data Space Available: 64.15GB
Metadata Space Used: 3.076MB
Metadata Space Total: 3.221GB
Metadata Space Available: 3.218GB
Thin Pool Minimum Free Space: 7.194GB
Deferred Removal Enabled: true
Deferred Deletion Enabled: true
Deferred Deleted Device Count: 0
Library Version: 1.02.146-BHEL7 (2018-01-22)
```

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 a data disk on the EVS console.

Only the storage capacity of the EVS disk is expanded. You also need to perform the following steps to expand the capacity of the logical volume and file system.

Step 2 Log in to the CCE console and click the cluster. In the navigation pane, choose **Nodes**. Click **More > Sync Server Data** in the row containing the target node.

Step 3 Log in to the target node.

Step 4 Run the **lsblk** command to check the block device information of the node.

A data disk is divided depending on the container storage **Rootfs**:

Overlaysfs: No independent thin pool is allocated. Image data is stored in **dockersys**.

1. Check the disk and partition sizes of the device.

```
# lsblk
NAME                MAJ:MIN RM  SIZE RO TYPE MOUNTPOINT
vda                  8:0   0  50G  0 disk
└─vda1                8:1   0  50G  0 part /
vdb                  8:16   0 200G  0 disk  # Data disk has been expanded but not allocated
├─vgpaas-dockersys 253:0   0  90G  0 lvm  /var/lib/containerd # Space used by the
container engine
└─vgpaas-kubernetes 253:1   0  10G  0 lvm  /mnt/paas/kubernetes/kubelet # Space used by
Kubernetes
```

2. Expand the disk capacity.

Add the new disk capacity to the **dockersys** logical volume used by the container engine.

a. Expand the PV capacity so that LVM can identify the new EVS capacity. **/dev/vdb** specifies the physical volume where dockersys is located.

```
pvresize /dev/vdb
```

Information similar to the following is displayed:

```
Physical volume "/dev/vdb" changed
1 physical volume(s) resized or updated / 0 physical volume(s) not resized
```

- b. Expand 100% of the free capacity to the logical volume. *vgpaas/dockersys* specifies the logical volume used by the container engine.
`lvextend -l+100%FREE -n vgpaas/dockersys`

Information similar to the following is displayed:

Size of logical volume vgpaas/dockersys changed from <90.00 GiB (23039 extents) to <190.00 GiB (48639 extents).

Logical volume vgpaas/dockersys successfully resized.

- c. Adjust the size of the file system. */dev/vgpaas/dockersys* specifies the file system path of the container engine.
`resize2fs /dev/vgpaas/dockersys`

Information similar to the following is displayed:

Filesystem at /dev/vgpaas/dockersys is mounted on /var/lib/containerd; on-line resizing required old_desc_blocks = 12, new_desc_blocks = 24

The filesystem on /dev/vgpaas/dockersys is now 49807360 (4k) blocks long.

Devicemapper: A thin pool is allocated to store image data.

1. Check the disk and partition sizes of the device.

```
# lsblk
NAME                MAJ:MIN RM  SIZE RO TYPE MOUNTPOINT
vda                  8:0    0  50G  0 disk
├─vda1                8:1    0  50G  0 part /
└─vgdb                 8:16   0 200G  0 disk
   └─vgpaas-dockersys 253:0   0  18G  0 lvm  /var/lib/docker
      └─vgpaas-thinpool_tmeta 253:1   0   3G  0 lvm
         └─vgpaas-thinpool 253:3   0  67G  0 lvm          # Space used by thinpool
            ...
      └─vgpaas-thinpool_tdata 253:2   0  67G  0 lvm
         └─vgpaas-thinpool 253:3   0  67G  0 lvm
            ...
   └─vgpaas-kubernetes 253:4   0  10G  0 lvm  /mnt/paas/kubernetes/kubelet
```

2. Expand the disk capacity.

Option 1: Add the new disk capacity to the thin pool disk.

- a. Expand the PV capacity so that LVM can identify the new EVS capacity. */dev/vdb* specifies the physical volume where thinpool is located.
`pvresize /dev/vdb`

Information similar to the following is displayed:

Physical volume "/dev/vdb" changed

1 physical volume(s) resized or updated / 0 physical volume(s) not resized

- b. Expand 100% of the free capacity to the logical volume. *vgpaas/thinpool* specifies the logical volume used by the container engine.
`lvextend -l+100%FREE -n vgpaas/thinpool`

Information similar to the following is displayed:

Size of logical volume vgpaas/thinpool changed from <67.00 GiB (23039 extents) to <167.00 GiB (48639 extents).

Logical volume vgpaas/thinpool successfully resized.

- c. Do not need to adjust the size of the file system, because the thin pool is not mounted to any devices.

Option 2: Add the new disk capacity to the **dockersys** disk.

- a. Expand the PV capacity so that LVM can identify the new EVS capacity. */dev/vdb* specifies the physical volume where dockersys is located.

`pvresize /dev/vdb`

Information similar to the following is displayed:

Physical volume "/dev/vdb" changed

1 physical volume(s) resized or updated / 0 physical volume(s) not resized

- b. Expand 100% of the free capacity to the logical volume. `vgpaas/dockersys` specifies the logical volume used by the container engine.
- ```
lvextend -l+100%FREE -n vgpaas/dockersys
```

Information similar to the following is displayed:

```
Size of logical volume vgpaas/dockersys changed from <18.00 GiB (7679 extents) to <118.00 GiB (33279 extents).
Logical volume vgpaas/dockersys successfully resized.
```

- c. Adjust the size of the file system. `/dev/vgpaas/dockersys` specifies the file system path of the container engine.
- ```
resize2fs /dev/vgpaas/dockersys
```

Information similar to the following is displayed:

```
Filesystem at /dev/vgpaas/dockersys is mounted on /var/lib/docker; on-line resizing required
old_desc_blocks = 4, new_desc_blocks = 16
The filesystem on /dev/vgpaas/dockersys is now 49807360 (4k) blocks long.
```

----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.

21.4.2.7 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.

```
unknown flag: --show-labels
root@chengyindu-test-98835 ~]# kubectl get node --show-labels
NAME                STATUS    ROLES    AGE    VERSION    LABELS
172.16.0.188        Ready    <none>   6h26m v1.13.10-r1-CCE2.0.20.B001  accelerator=nvidia-p100, beta.kubernetes.io/arch=amd64, beta.kubernetes.io/os=linux, failure-domain.beta.kubernetes.io/is-baremetal=false, failure-domain.beta.kubernetes.io/region=cn-east-2, failure-domain.beta.kubernetes.io/zone=cn-east-2b, kubernetes.io/availablezone=cn-east-2b, kubernetes.io/eniquota=12, kubernetes.io/hostname=172.16.0.188, node.kubernetes.io/subnetid=4883a3c2-f09f-412d-bd3a-5a2892c5833a, os.architecture=amd64, os.name=EulerOS_2.0_SP5, os.version=3.10.0-862.14.1.2.h249.eulerosv2r7.x86_64
root@chengyindu-test-98835 ~]#
```

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?](#)

21.4.3 Specification Change

21.4.3.1 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.

21.4.3.2 What Are the Impacts of Changing the Flavor of a Node in a CCE Node Pool?

Context

After you change the flavor of a node in a CCE node pool on the ECS console and then synchronize the ECS status on the CCE console, the node flavor no longer matches the configurations in the node pool.

Impact

When you change the node flavor, it also changes the node parameters such as CPU, memory, and ENI quota (available IP addresses). This can cause the auto scaling settings of the node pool where the node is located to not function as expected.

Assume that the CPU and memory of a node are increased from 2 vCPUs and 4 GiB of memory to 4 vCPUs and 8 GiB of memory.

- During node pool scale-out, the total number of resources in the node pool may exceed the upper limit of the CPU or memory. Expanding a node pool involves calculating resources based on the node template. However, changing the node flavor on the ECS console can cause inconsistencies with the configurations in the node pool, resulting in inaccurate CPU and memory usage for the cluster.
- During node pool scale-in, too many CPU or memory resources may be scaled down. If the node with changed flavor is removed, the actual number of CPUs or memory to be scaled down (4 vCPUs and 8 GiB of memory) may be greater than the expected 2 vCPUs and 4 GiB of memory.

Solution

You are not advised to change the flavor of a node in a node pool. Instead, you can update the node pool and add nodes of other flavors to it. The original node will be removed after services are scheduled to the new nodes.

- Step 1** Log in to the CCE console and click the cluster name to access the cluster console. In the navigation pane, choose **Nodes**.
- Step 2** Locate the row containing the target node pool and click **Update**.
- Step 3** In the **Specifications** area, select new flavors, click **Next: Confirm**, and submit the request.
- Step 4** After the node pool configurations are updated, locate the row containing the target node pool and click **Scaling**.
- Step 5** In the window that slides out from the right, select the node flavors to be expanded, configure the number of nodes to be added, and click **OK**.
- Step 6** Click the **Nodes** tab, locate the row containing the target node, and choose **More > Nodal Drainage** to safely evict the service pods on the node.

Step 7 After the service pods are scheduled to a new node, locate the row containing the target node pool, click **Scaling**, select the flavor of the node to be reduced, configure the number of nodes to be removed, and click **OK**.

----End

21.4.3.3 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

21.4.4 OSs

21.4.4.1 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.contrack** 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	<p>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.</p> <ul style="list-style-type: none"> 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. <p>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.</p>	<p>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.</p> <ul style="list-style-type: none"> For a node running EulerOS 2.5, 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 EulerOS 2.9, if the kernel version is too early, kube-proxy will set net.ipv4.vs.conn_reuse_mode to 0. This results in Problem 1. To resolve this problem, upgrade the kernel version. For details, see Rectification Plan. 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, HCE OS 2.0 or Ubuntu 22.04. The newly created nodes which run EulerOS 2.9 are not affected by the preceding issues. Upgrade the earlier kernel versions used by existing nodes to the fixed version. For details, see [Rectification Plan](#).
2. Use a cluster whose forwarding mode is iptables.

Rectification Plan

If you use a node running EulerOS 2.9, check whether the kernel version meets the requirements. If the kernel version of the node is too early, reset the node or create a new one.

The following kernel versions are recommended:

- x86: 4.18.0-147.5.1.6.h686.eulerosv2r9.x86_64
- Arm: 4.19.90-vhulk2103.1.0.h584.eulerosv2r9.aarch64

Kubernetes community issue: <https://github.com/kubernetes/kubernetes/issues/81775>

21.5 Node Pool

21.5.1 What Should I Do If a Node Pool Is Abnormal?

Fault Locating

Locate the fault based on the status of the abnormal node pool, as shown in [Table 21-3](#).

Table 21-3 Node pool exceptions

Abnormal Node Pool Status	Description	Solution
Error	The node pool cannot be deleted.	Delete the node pool again. If the node pool still cannot be deleted, submit a service ticket and delete the node pool.
QuotaInsufficient	The node pool cannot be scaled out due to insufficient quota.	Submit a service ticket and increase the quota.
SoldOut	The underlying resources are insufficient.	Update the node pool configuration and select other available resources.
ConfigurationInvalid	The ECS group does not exist (ServerGroupNotExists). The ECS group to which the node pool belongs is not present. This may be because you manually deleted the ECS group.	<ol style="list-style-type: none"> 1. Log in to the CCE console. In the navigation pane, choose Nodes, click the Node Pools tab, and click the name of the target node pool. Click the Overview tab, click Expand, and check the ECS group to which the node pool belongs. 2. Log in to the ECS console. In the navigation pane, choose Elastic Cloud Server > ECS Group and see if the target ECS group is present. 3. If the ECS group is not present, log in to the CCE console. In the navigation pane, choose Nodes, click the Node Pools tab, locate the row containing the target node pool, and click Update. In the Advanced Settings area, unbind or change the ECS group.

Abnormal Node Pool Status	Description	Solution
InstanceAboveServerGroup	The number of ECSs in the ECS group exceeds the upper limit.	<ol style="list-style-type: none"> 1. Log in to the CCE console. In the navigation pane, choose Nodes, click the Node Pools tab, and click the name of the target node pool. Click the Overview tab, click Expand, and check the ECS group to which the node pool belongs. 2. Log in to the ECS console, choose Elastic Cloud Server > ECS Group in the navigation pane, and check the quota of the target ECS group. 3. If the quota is insufficient, log in to the CCE console. In the navigation pane, choose Nodes, click the Node Pools tab, locate the row containing the target node pool, and click Update. In the Advanced Settings area, unbind or change the ECS group.

21.5.2 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.

21.5.3 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 21-4](#).

Table 21-4 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 *** ...	<p>The possible causes are as follows:</p> <ul style="list-style-type: none"> 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
{ "error": { "message": "encrypted key id [***] is invalid.", "code": "Ecs.0912" } }	<p>The possible causes are as follows:</p> <ul style="list-style-type: none"> The KMS key ID entered during node pool creation does not exist. The KMS key ID entered during node pool creation is the key of another user, but the user has not authorized you. 	Invalid KMS Key ID

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.

Invalid KMS Key ID

When a node pool fails to be expanded, the reported event contains **Ecs.0912**.

```
{"error":{"message":"encrypted key id [***] is invalid.,"code":"Ecs.0912"}}
```

The possible causes are as follows:

- The KMS key ID entered during node pool creation does not exist.
- The KMS key ID entered during node pool creation is the key of another user, but the user has not authorized you.

Solution:

- If the scale-out fails due to the first cause, ensure that the entered key ID exists.
- If the scale-out fails due to second cause, use the ID of the shared key that has been authorized to you.

21.5.4 How Do I Modify ECS Configurations When an ECS Cannot Be Managed by a Node Pool?

If an ECS cannot be managed by a node pool due to the reasons listed in this section, you can modify the configuration to manage the ECS.

Cause	Solution	Reference
Inconsistent flavors	Change the ECS flavor to that contained in the node pool.	Modifying the Flavor of an ECS
Inconsistent VPC and subnet	Change the VPC and subnet where the ECS resides to the same VPC and subnet as the node pool.	Changing the VPC and Subnet of an ECS
Different data disk configuration	Change the data disk configuration of the ECS to be the same as that of the node pool.	Changing Data Disk Configuration of an ECS
Different ECS groups	Change the ECS group of the ECS to be the same as that of the node pool.	Change the ECS Group of an ECS

Modifying the Flavor of an ECS

NOTE

The flavor of the ECS to be managed must be changed to that contained in the target node pool.

- Step 1** Log in to the ECS console.
- Step 2** Click the name of the target ECS. On the page displayed, click **Stop** in the upper right corner. After the ECS is stopped, choose **More > Modify Specifications** in the **Operation** column.
- Step 3** On the **Modify ECS Specifications** page, select the needed flavor and submit the application.
- Step 4** Go back to the ECS list page and start the ECS.

----End

Changing the VPC and Subnet of an ECS

NOTE

The VPC and subnet to which the ECS to be managed belongs must be changed to the same VPC and subnet as the target node pool.

- Step 1** Log in to the ECS console.
- Step 2** Locate the row containing the target ECS and choose **More > Manage Network > Change VPC** in the **Operation** column.
- Step 3** Configure the parameters for changing the VPC.
 - **VPC:** Select the target VPC.
 - **Subnet:** Select the target subnet.
 - **Private IP Address:** Select **Assign new** or **Use existing** as required.
- Step 4** Click **OK**.

----End

Changing Data Disk Configuration of an ECS

NOTE

The number, space, and type of data disks of the ECS to be managed must be the same as those of data disks in the node pool.

Data Disk Number

- Step 1** Log in to the ECS console.
- Step 2** Click the name of the target ECS to access the ECS details page.
- Step 3** Click the **Disks** tab.
 - If there are fewer data disks on the node to be managed than the number of data disks configured for the target node pool, you need to add more disks.

- If there are more data disks on the node to be managed than the number of data disks configured for the target node pool, you need to remove some disks.

Click **Detach** on the right of the EVS disk to be removed.

----End

Data Disk Space

Step 1 Log in to the ECS console.

Step 2 Click the name of the target ECS to access the ECS details page.

Step 3 Click the **Disks** tab and click **Expand Capacity** on the right of the EVS disk to be expanded.

Step 4 Configure **New Capacity** following instructions.

Step 5 Click **Next** and submit the order following instructions.

----End

Change the ECS Group of an ECS

NOTE

The ECS group of the ECS to be managed must be the same as that of the target node pool.

Step 1 Log in to the ECS console.

Step 2 In the navigation pane, choose **Elastic Cloud Server > ECS Group**.

Step 3 Locate the row containing the target ECS group and click **Add ECS** in the **Operation** column.

Step 4 In the dialog box displayed, select the ECS to be added.

Step 5 Click **OK** to add the ECS to the ECS group.

----End

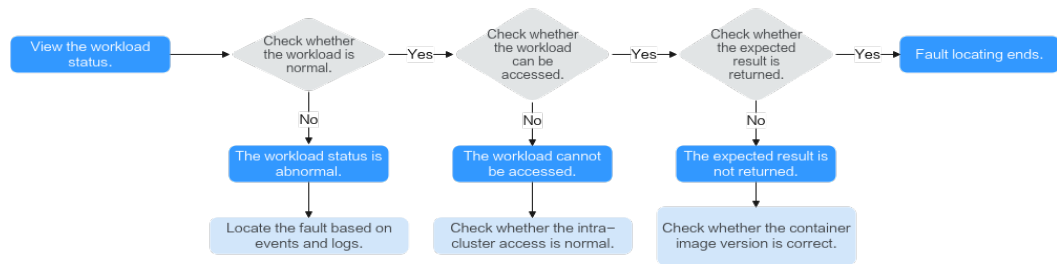
21.6 Workload

21.6.1 Workload Abnormalities

21.6.1.1 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 21-5 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?
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?

21.6.1.2 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 21-6](#).

Table 21-6 Pod scheduling failure

Event	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
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:

```
$ kubectrl 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 a data disk on the EVS console.

Only the storage capacity of the EVS disk is expanded. You also need to perform the following steps to expand the capacity of the logical volume and file system.

Step 2 Log in to the CCE console and click the cluster. In the navigation pane, choose **Nodes**. Click **More > Sync Server Data** in the row containing the target node.

Step 3 Log in to the target node.

Step 4 Run the **lsblk** command to check the block device information of the node.

A data disk is divided depending on the container storage **Rootfs**:

Overlaysfs: No independent thin pool is allocated. Image data is stored in **dockersys**.

1. Check the disk and partition sizes of the device.

```
# lsblk
NAME                MAJ:MIN RM  SIZE RO TYPE MOUNTPOINT
vda                  8:0    0  50G  0 disk
└─vda1                8:1    0  50G  0 part /
vdb                   8:16    0 200G  0 disk # Data disk has been expanded but not allocated
└─vgpaas-dockersys 253:0    0  90G  0 lvm  /var/lib/containerd # Space used by the
   container engine
└─vgpaas-kubernetes 253:1    0  10G  0 lvm  /mnt/paas/kubernetes/kubelet # Space used by
   Kubernetes
```

2. Expand the disk capacity.

Add the new disk capacity to the **dockersys** logical volume used by the container engine.

- a. Expand the PV capacity so that LVM can identify the new EVS capacity. `/dev/vdb` specifies the physical volume where dockersys is located.

```
pvresize /dev/vdb
```

Information similar to the following is displayed:

```
Physical volume "/dev/vdb" changed
1 physical volume(s) resized or updated / 0 physical volume(s) not resized
```

- b. Expand 100% of the free capacity to the logical volume. *vgpaas/dockersys* specifies the logical volume used by the container engine.
`lvextend -l+100%FREE -n vgpaas/dockersys`

Information similar to the following is displayed:

```
Size of logical volume vgpaas/dockersys changed from <90.00 GiB (23039 extents) to <190.00 GiB (48639 extents).
Logical volume vgpaas/dockersys successfully resized.
```

- c. Adjust the size of the file system. */dev/vgpaas/dockersys* specifies the file system path of the container engine.
`resize2fs /dev/vgpaas/dockersys`

Information similar to the following is displayed:

```
Filesystem at /dev/vgpaas/dockersys is mounted on /var/lib/containerd; on-line resizing required
old_desc_blocks = 12, new_desc_blocks = 24
The filesystem on /dev/vgpaas/dockersys is now 49807360 (4k) blocks long.
```

Devicemapper: A thin pool is allocated to store image data.

1. Check the disk and partition sizes of the device.

```
# lsblk
NAME                                MAJ:MIN RM  SIZE RO TYPE MOUNTPOINT
vda                                  8:0    0  50G  0 disk
├─vda1                               8:1    0  50G  0 part /
└─vgdb
   └─vgpaas-dockersys                 253:0    0  18G  0 lvm  /var/lib/docker
      └─vgpaas-thinpool_tmeta          253:1    0   3G  0 lvm
         └─vgpaas-thinpool             253:3    0  67G  0 lvm          # Space used by thinpool
            ...
      └─vgpaas-thinpool_tdata          253:2    0  67G  0 lvm
         └─vgpaas-thinpool             253:3    0  67G  0 lvm
            ...
      └─vgpaas-kubernetes             253:4    0  10G  0 lvm  /mnt/paas/kubernetes/kubelet
```

2. Expand the disk capacity.

Option 1: Add the new disk capacity to the thin pool disk.

- a. Expand the PV capacity so that LVM can identify the new EVS capacity. */dev/vdb* specifies the physical volume where thinpool is located.
`pvresize /dev/vdb`

Information similar to the following is displayed:

```
Physical volume "/dev/vdb" changed
1 physical volume(s) resized or updated / 0 physical volume(s) not resized
```

- b. Expand 100% of the free capacity to the logical volume. *vgpaas/thinpool* specifies the logical volume used by the container engine.
`lvextend -l+100%FREE -n vgpaas/thinpool`

Information similar to the following is displayed:

```
Size of logical volume vgpaas/thinpool changed from <67.00 GiB (23039 extents) to <167.00 GiB (48639 extents).
Logical volume vgpaas/thinpool successfully resized.
```

- c. Do not need to adjust the size of the file system, because the thin pool is not mounted to any devices.

Option 2: Add the new disk capacity to the **dockersys** disk.

- a. Expand the PV capacity so that LVM can identify the new EVS capacity. */dev/vdb* specifies the physical volume where dockersys is located.
`pvresize /dev/vdb`

Information similar to the following is displayed:

```
Physical volume "/dev/vdb" changed  
1 physical volume(s) resized or updated / 0 physical volume(s) not resized
```

- b. Expand 100% of the free capacity to the logical volume. *vgpaas/dockersys* specifies the logical volume used by the container engine.

```
lvextend -l+100%FREE -n vgpaas/dockersys
```

Information similar to the following is displayed:

```
Size of logical volume vgpaas/dockersys changed from <18.00 GiB (7679 extents) to <118.00  
GiB (33279 extents).  
Logical volume vgpaas/dockersys successfully resized.
```

- c. Adjust the size of the file system. */dev/vgpaas/dockersys* specifies the file system path of the container engine.

```
resize2fs /dev/vgpaas/dockersys
```

Information similar to the following is displayed:

```
Filesystem at /dev/vgpaas/dockersys is mounted on /var/lib/docker; on-line resizing required  
old_desc_blocks = 4, new_desc_blocks = 16  
The filesystem on /dev/vgpaas/dockersys is now 49807360 (4k) blocks long.
```

----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**.

21.6.1.3 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 21-7](#).

Table 21-7 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	<p>You have not logged in to the image repository.</p> <p>Check Item 1: Whether imagePullSecret Is Specified When You Use kubectl to Create a Workload</p>
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	<p>The image address is incorrectly configured.</p> <p>Check Item 2: Whether the Image Address Is Correct When a Third-Party Image Is Used</p> <p>Check Item 3: Whether an Incorrect Secret Is Used When a Third-Party Image Is Used</p>
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	<p>The disk space is insufficient.</p> <p>Check Item 4: Whether the Node Disk Space Is Insufficient</p>
Failed to pull image "xxx": rpc error: code = Unknown desc = error pulling image configuration: xxx x509: certificate signed by unknown authority	<p>An unknown or insecure certificate is used by the third-party image repository from which the image is pulled.</p> <p>Check Item 5: Whether the Remote Image Repository Uses an Unknown or Insecure Certificate</p>
Failed to pull image "xxx": rpc error: code = Unknown desc = context canceled	<p>The image size is too large.</p> <p>Check Item 6: Whether the Image Size Is Too Large</p>
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)	<p>Check Item 7: Connection to the Image Repository</p>

Event Information	Cause and Solution
<p>ERROR: toomanyrequests: Too Many Requests.</p> <p>Or</p> <p>you have reached your pull rate limit, you may increase the limit by authenticating an upgrading</p>	<p>The rate is limited because the number of image pull times reaches the upper limit.</p> <p>Check Item 8: Whether the Number of Public Image Pull Times Reaches the Upper Limit</p>

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
```

```
[root@zhouxu-20650 ~]# lvs
LV          VG      Attr      LSize  Pool Origin  Data%  Meta%  Move Log Cpy%Sync  Convert
kubernetes  vgpaas -wi-ao--- <10.00g
thinpool   vgpaas twi-aot--- 84.00g
5.05      0.07
```

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 a data disk on the EVS console.

Only the storage capacity of the EVS disk is expanded. You also need to perform the following steps to expand the capacity of the logical volume and file system.

**Step 2** Log in to the CCE console and click the cluster. In the navigation pane, choose **Nodes**. Click **More > Sync Server Data** in the row containing the target node.

**Step 3** Log in to the target node.

**Step 4** Run the **lsblk** command to check the block device information of the node.

A data disk is divided depending on the container storage **Rootfs**:

Overlaysfs: No independent thin pool is allocated. Image data is stored in **dockersys**.

1. Check the disk and partition sizes of the device.

```
lsblk
NAME MAJ:MIN RM SIZE RO TYPE MOUNTPOINT
vda 8:0 0 50G 0 disk
└─vda1 8:1 0 50G 0 part /
vdb 8:16 0 200G 0 disk # Data disk has been expanded but not allocated
├─vgpaas-dockersys 253:0 0 90G 0 lvm /var/lib/containerd # Space used by the
 container engine
└─vgpaas-kubernetes 253:1 0 10G 0 lvm /mnt/paas/kubernetes/kubelet # Space used by
 Kubernetes
```

2. Expand the disk capacity.

Add the new disk capacity to the **dockersys** logical volume used by the container engine.

a. Expand the PV capacity so that LVM can identify the new EVS capacity. */dev/vdb* specifies the physical volume where dockersys is located.

```
pvresize /dev/vdb
```

Information similar to the following is displayed:

```
Physical volume "/dev/vdb" changed
1 physical volume(s) resized or updated / 0 physical volume(s) not resized
```

b. Expand 100% of the free capacity to the logical volume. *vgpaas/dockersys* specifies the logical volume used by the container engine.

```
lvextend -l+100%FREE -n vgpaas/dockersys
```

Information similar to the following is displayed:

```
Size of logical volume vgpaas/dockersys changed from <90.00 GiB (23039 extents) to <190.00 GiB (48639 extents).
Logical volume vgpaas/dockersys successfully resized.
```

- c. Adjust the size of the file system. `/dev/vgpaas/dockersys` specifies the file system path of the container engine.

```
resize2fs /dev/vgpaas/dockersys
```

Information similar to the following is displayed:

```
Filesystem at /dev/vgpaas/dockersys is mounted on /var/lib/containerd; on-line resizing required
old_desc_blocks = 12, new_desc_blocks = 24
The filesystem on /dev/vgpaas/dockersys is now 49807360 (4k) blocks long.
```

Devicemapper: A thin pool is allocated to store image data.

1. Check the disk and partition sizes of the device.

```
lsblk
NAME MAJ:MIN RM SIZE RO TYPE MOUNTPOINT
vda 8:0 0 50G 0 disk
├─vda1 8:1 0 50G 0 part /
└─vgdb 8:16 0 200G 0 disk
 └─vgpaas-dockersys 253:0 0 18G 0 lvm /var/lib/docker
 └─vgpaas-thinpool_tmeta 253:1 0 3G 0 lvm
 └─vgpaas-thinpool 253:3 0 67G 0 lvm # Space used by thinpool
 ...
 └─vgpaas-thinpool_tdata 253:2 0 67G 0 lvm
 └─vgpaas-thinpool 253:3 0 67G 0 lvm
 ...
 └─vgpaas-kubernetes 253:4 0 10G 0 lvm /mnt/paas/kubernetes/kubelet
```

2. Expand the disk capacity.

Option 1: Add the new disk capacity to the thin pool disk.

- a. Expand the PV capacity so that LVM can identify the new EVS capacity. `/dev/vdb` specifies the physical volume where thinpool is located.
 

```
pvresize /dev/vdb
```

Information similar to the following is displayed:

```
Physical volume "/dev/vdb" changed
1 physical volume(s) resized or updated / 0 physical volume(s) not resized
```

- b. Expand 100% of the free capacity to the logical volume. `vgpaas/thinpool` specifies the logical volume used by the container engine.
 

```
lvextend -l+100%FREE -n vgpaas/thinpool
```

Information similar to the following is displayed:

```
Size of logical volume vgpaas/thinpool changed from <67.00 GiB (23039 extents) to <167.00 GiB (48639 extents).
Logical volume vgpaas/thinpool successfully resized.
```

- c. Do not need to adjust the size of the file system, because the thin pool is not mounted to any devices.

Option 2: Add the new disk capacity to the **dockersys** disk.

- a. Expand the PV capacity so that LVM can identify the new EVS capacity. `/dev/vdb` specifies the physical volume where dockersys is located.
 

```
pvresize /dev/vdb
```

Information similar to the following is displayed:

```
Physical volume "/dev/vdb" changed
1 physical volume(s) resized or updated / 0 physical volume(s) not resized
```

- b. Expand 100% of the free capacity to the logical volume. `vgpaas/dockersys` specifies the logical volume used by the container engine.

```
lvextend -l+100%FREE -n vgpaas/dockersys
```

Information similar to the following is displayed:

```
Size of logical volume vgpaas/dockersys changed from <18.00 GiB (7679 extents) to <118.00 GiB (33279 extents).
Logical volume vgpaas/dockersys successfully resized.
```

- c. Adjust the size of the file system. `/dev/vgpaas/dockersys` specifies the file system path of the container engine.

```
resize2fs /dev/vgpaas/dockersys
```

Information similar to the following is displayed:

```
Filesystem at /dev/vgpaas/dockersys is mounted on /var/lib/docker; on-line resizing required
old_desc_blocks = 4, new_desc_blocks = 16
The filesystem on /dev/vgpaas/dockersys is now 49807360 (4k) blocks long.
```

----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 on 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-AQbl5RActnudzV%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 [Docker Hub pull usage and limits](#).

### Solution

Push the frequently used image to SWR and then pull the image from SWR.

## 21.6.1.4 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 21-8](#).

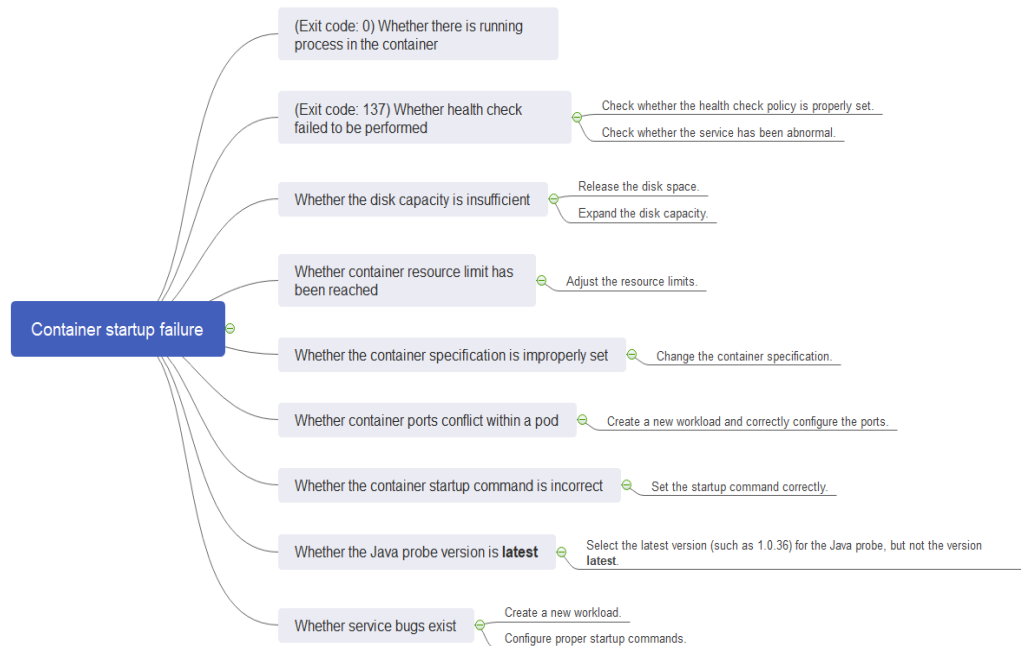
**Table 21-8** Container startup failure

| Log or Event                                                                                                                                                                                                                                     | Cause and Solution                                                                                                                                                                                                  |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| The log contains <b>exit(0)</b> .                                                                                                                                                                                                                | No process exists in the container.<br>Check whether the container is running properly.<br><b>Check Item 1: Whether There Are Processes that Keep Running in the Container (Exit Code: 0)</b>                       |
| Event information: <b>Liveness probe failed: Get http...</b><br>The log contains <b>exit(137)</b> .                                                                                                                                              | Health check fails.<br><b>Check Item 2: Whether Health Check Fails to Be Performed (Exit Code: 137)</b>                                                                                                             |
| Event information:<br>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.<br><b>Check Item 3: Whether the Container Disk Space Is Insufficient</b>                                                                                      |
| The keyword OOM exists in the log.                                                                                                                                                                                                               | The memory is insufficient.<br><b>Check Item 4: Whether the Upper Limit of Container Resources Has Been Reached</b><br><b>Check Item 5: Whether the Resource Limits Are Improperly Configured for the Container</b> |
| Address already in use                                                                                                                                                                                                                           | A conflict occurs between container ports in the pod.<br><b>Check Item 6: Whether the Container Ports in the Same Pod Conflict with Each Other</b>                                                                  |
| 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.<br><b>Check Item 7: Whether the Value of the Secret Mounted to the Workload Meets Requirements</b>                  |

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 21-2 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 61385f81959 "/bin/bash" 10 seconds ago Exited (0) 10 seconds ago
k8s_container-0_test-66b79cddb7-htcjf_default_5c388617-ac32-11e9-9168-fa163ec28742_1 2c73ac8717cc cce-pause:2.0 12 seconds ago Up 12 seconds
k8s_POD_test-66b79cddb7-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

```
lvs
LV VG Attr LSize Pool Origin Data% Meta% Move Log Cpy%Sync Convert
dockersys vgpaas -wi-ao--- <18.00g
kubernetes vgpaas -wi-ao--- <18.00g
thinpool vgpaas twi-aot--- 67.00g 98.04 1.32
```

### 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 a data disk on the EVS console.

Only the storage capacity of the EVS disk is expanded. You also need to perform the following steps to expand the capacity of the logical volume and file system.

**Step 2** Log in to the CCE console and click the cluster. In the navigation pane, choose **Nodes**. Click **More > Sync Server Data** in the row containing the target node.

**Step 3** Log in to the target node.

**Step 4** Run the **lsblk** command to check the block device information of the node.

A data disk is divided depending on the container storage **Rootfs**:

Overlayfs: No independent thin pool is allocated. Image data is stored in **dockersys**.

1. Check the disk and partition sizes of the device.

```
lsblk
NAME MAJ:MIN RM SIZE RO TYPE MOUNTPOINT
vda 8:0 0 50G 0 disk
├─vda1 8:1 0 50G 0 part /
└─vdb 8:16 0 200G 0 disk # Data disk has been expanded but not allocated
 └─vgpaas-dockersys 253:0 0 90G 0 lvm /var/lib/containerd # Space used by the
 container engine
 └─vgpaas-kubernetes 253:1 0 10G 0 lvm /mnt/paas/kubernetes/kubelet # Space used by
 Kubernetes
```

2. Expand the disk capacity.

Add the new disk capacity to the **dockersys** logical volume used by the container engine.

a. Expand the PV capacity so that LVM can identify the new EVS capacity. */dev/vdb* specifies the physical volume where dockersys is located.

```
pvresize /dev/vdb
```

Information similar to the following is displayed:

```
Physical volume "/dev/vdb" changed
1 physical volume(s) resized or updated / 0 physical volume(s) not resized
```

b. Expand 100% of the free capacity to the logical volume. *vgpaas/dockersys* specifies the logical volume used by the container engine.

```
lvextend -l+100%FREE -n vgpaas/dockersys
```

Information similar to the following is displayed:

```
Size of logical volume vgpaas/dockersys changed from <90.00 GiB (23039 extents) to <190.00 GiB (48639 extents).
Logical volume vgpaas/dockersys successfully resized.
```

c. Adjust the size of the file system. */dev/vgpaas/dockersys* specifies the file system path of the container engine.

```
resize2fs /dev/vgpaas/dockersys
```

Information similar to the following is displayed:

```
Filesystem at /dev/vgpaas/dockersys is mounted on /var/lib/containerd; on-line resizing required
old_desc_blocks = 12, new_desc_blocks = 24
The filesystem on /dev/vgpaas/dockersys is now 49807360 (4k) blocks long.
```

Devicemapper: A thin pool is allocated to store image data.

1. Check the disk and partition sizes of the device.

```
lsblk
NAME MAJ:MIN RM SIZE RO TYPE MOUNTPOINT
vda 8:0 0 50G 0 disk
├─vda1 8:1 0 50G 0 part /
└─vdb 8:16 0 200G 0 disk
 └─vgpaas-dockersys 253:0 0 18G 0 lvm /var/lib/docker
 └─vgpaas-thinpool_tmeta 253:1 0 3G 0 lvm
 └─vgpaas-thinpool 253:3 0 67G 0 lvm # Space used by thinpool
 ...
 └─vgpaas-thinpool_tdata 253:2 0 67G 0 lvm
 └─vgpaas-thinpool 253:3 0 67G 0 lvm
 ...
 └─vgpaas-kubernetes 253:4 0 10G 0 lvm /mnt/paas/kubernetes/kubelet
```

## 2. Expand the disk capacity.

Option 1: Add the new disk capacity to the thin pool disk.

- a. Expand the PV capacity so that LVM can identify the new EVS capacity. `/dev/vdb` specifies the physical volume where thinpool is located.  
`pvresize /dev/vdb`

Information similar to the following is displayed:

```
Physical volume "/dev/vdb" changed
1 physical volume(s) resized or updated / 0 physical volume(s) not resized
```

- b. Expand 100% of the free capacity to the logical volume. `vgpaas/thinpool` specifies the logical volume used by the container engine.  
`lvextend -l+100%FREE -n vgpaas/thinpool`

Information similar to the following is displayed:

```
Size of logical volume vgpaas/thinpool changed from <67.00 GiB (23039 extents) to <167.00
GiB (48639 extents).
Logical volume vgpaas/thinpool successfully resized.
```

- c. Do not need to adjust the size of the file system, because the thin pool is not mounted to any devices.

Option 2: Add the new disk capacity to the **dockersys** disk.

- a. Expand the PV capacity so that LVM can identify the new EVS capacity. `/dev/vdb` specifies the physical volume where dockersys is located.  
`pvresize /dev/vdb`

Information similar to the following is displayed:

```
Physical volume "/dev/vdb" changed
1 physical volume(s) resized or updated / 0 physical volume(s) not resized
```

- b. Expand 100% of the free capacity to the logical volume. `vgpaas/dockersys` specifies the logical volume used by the container engine.  
`lvextend -l+100%FREE -n vgpaas/dockersys`

Information similar to the following is displayed:

```
Size of logical volume vgpaas/dockersys changed from <18.00 GiB (7679 extents) to <118.00
GiB (33279 extents).
Logical volume vgpaas/dockersys successfully resized.
```

- c. Adjust the size of the file system. `/dev/vgpaas/dockersys` specifies the file system path of the container engine.  
`resize2fs /dev/vgpaas/dockersys`

Information similar to the following is displayed:

```
Filesystem at /dev/vgpaas/dockersys is mounted on /var/lib/docker; on-line resizing required
old_desc_blocks = 4, new_desc_blocks = 16
The filesystem on /dev/vgpaas/dockersys is now 49807360 (4k) blocks long.
```

----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
```

```
[root@xxx ~]# cat /var/log/messages | grep 96feb0a425d6 | grep oom
2019-07-22T11:57:49.441756+08:00 xxx dockerd: time="2019-07-22T11:57:49.440755329+08:00" level=info msg=event OOMKilled=true containerID=96feb0a425d6669f8f062cf3a6096868617a10711334fd5bce4a6ee6eadc82d module=libcontainerd namespace=moby topic=/tasks/oom
2019-07-22T11:59:55.828162+08:00 xxx [/bin/bash]: [2019-07-22T11:57:49.441756+08:00 xxx dockerd: time="2019-07-22T11:57:49.440755329+08:00" level=info msg=event OOMKilled=true containerID=96feb0a425d6669f8f062cf3a6096868617a10711334fd5bce4a6ee6eadc82d module=libcontainerd namespace=moby topic=/tasks/oom] return code=[127], execute failed by [root(uid=0)] from [pts/0 (192.168.0.7)]
2019-07-22T12:01:47.621029+08:00 xxx [/bin/bash]: [cat /var/log/messages | grep 96feb0a425d6 | grep oom] return code=[0], execute success by [root(uid=0)] from [pts/0 (192.168.0.7)]
[root@xxx ~]#
```

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.

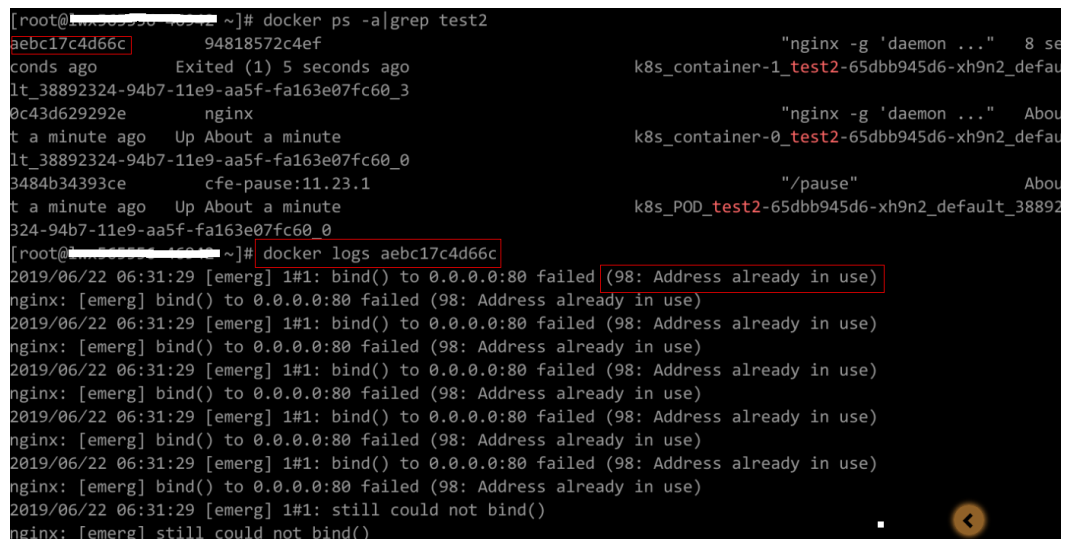
```
docker ps -a | grep $podName
```

**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 21-3 Container restart failure due to a container port conflict



```
[root@k8s-03-00-00-00 ~]# docker ps -a|grep test2
aebc17c4d66c 94818572c4def "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@k8s-03-00-00-00 ~]# 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: 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@k8s-POD-test1-19f0d2a0-94ba-11e9-aa5f-fa163e07fc60_0 ~]# 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@k8s-POD-test1-19f0d2a0-94ba-11e9-aa5f-fa163e07fc60_0 ~]# 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 21-4** Incorrect startup command of the container

```
[root@dcb-ha-11638 ~]# docker ps -a |grep nginx
cf0357f617f9 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.

## 21.6.1.5 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/log/cce/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 21-9** 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.                                                          |
| 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](#)

## 21.6.1.6 What Should I Do If a Storage Volume Cannot Be Mounted or the Mounting Times Out?

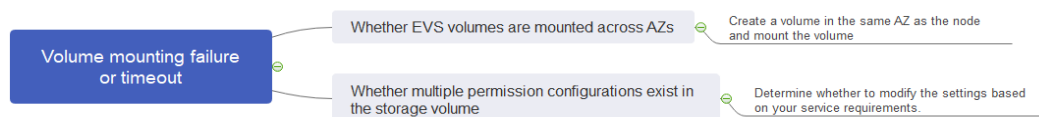
### Troubleshooting Process

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 21-5** 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}
```

## 21.6.1.7 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 -xvzf /opt/cloud/cce/package/node-package/pause-*.tgz
```

**Step 3** Import the image.

- Docker nodes:

```
docker load -i ./pause/package/image/cce-pause-*.tar
```

- containerd nodes:  

```
ctr -n k8s.io images import --all-platforms ./pause/package/image/cce-pause-*.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

### 21.6.1.8 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-789bf5b497-6rwrq 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
```

### 21.6.1.9 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**.

### 21.6.1.10 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?](#)

## 21.6.2 Container Configuration

### 21.6.2.1 When Is Pre-stop Processing Used?

#### Question

When is pre-stop processing used?

### Answer

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.

## 21.6.2.2 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.

## 21.6.2.3 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.

## 21.6.2.4 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. 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
```

### 21.6.2.5 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.

## 21.6.3 Scheduling Policies

### 21.6.3.1 How Do I Evenly Distribute Multiple Pods to Each Node?

The kube-scheduler component in Kubernetes is responsible for 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:
 - weight: 100 # Priority that can be configured when the best-effort policy is used. The value
 # ranges from 1 to 100. A larger value indicates a higher priority.
 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
```

### 21.6.3.2 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 a pod is killed because of excessive resource usage (while the node resources are still sufficient), the system tends to restart the pod on the same node.
- 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).

### 21.6.3.3 Why Are Pods Not Evenly Distributed on Nodes?

#### Pod Scheduling Principles in Kubernetes

The kube-scheduler component in Kubernetes is responsible for 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](#).

## Possible Causes of Why Pods Are Not Evenly Distributed on Nodes

- Resource configurations may vary between nodes, including differences in CPU and memory size. This can result in the pods' defined requests not being met, even if a node's actual load is low. As a result, the pod cannot be scheduled to the node.
- Custom scheduling policies can be used to schedule pods based on affinity and anti-affinity rules, resulting in uneven distribution of pods across nodes.
- Nodes can have taints that prevent unscheduled pods from being assigned to them if tolerations are not set.
- Certain workloads may have unique distribution constraints. For instance, if an EVS disk is attached to a workload, the workload pods can only be scheduled to nodes within the same AZ as the disk.
- Certain pods may require specific resources, such as GPUs. In such cases, the scheduler can only assign those pods to GPU nodes.
- The health and status of a node can impact scheduling decisions. If a node is unhealthy, it may not be able to accept new pods.

## Possible Causes of Why Pod Loads Are Unevenly Distributed on Nodes

When allocating pods, kube-scheduler does not take into account the actual load of applications. This can result in some nodes being heavily loaded while others are lightly loaded, especially if the application load is uneven.

### 21.6.3.4 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            |
|---------------|-----------------------------------------|--------|---------|----------|-------|---------------|
| 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 exists on the node, the message "error: unable to drain node "192.168.0.160" due to error: cannot delete DaemonSet-managed Pods..." 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](#).

### 21.6.3.5 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

## 21.6.4 Others

### 21.6.4.1 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.

### 21.6.4.2 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.

### 21.6.4.3 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: "{\n \"errors\": [\n {\n \"code\": 400,\n \"message\": \"Auth is empty, only accept X-Auth-Token or Authorization.\\\"}\n]\n}"
```

## 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
```

### 21.6.4.4 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 **IfNotPresent**:
  - 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.

### 21.6.4.5 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.

```
events:
Type Reason Age From Message
---- -
Normal Scheduled 44s default-scheduler Successfully assigned cattle-prometheus/prometheus-server-6c69469cf4-nfs7f1 to 10.14.11.139
Normal SuccessfulMountVolume 55s kubelet Successfully mounted volumes for pod "prometheus-server-6c69469cf4-nfs7f1_cattle-prometheus(48ac202a-649a-429c-91ca-573dbaacb72)"
Normal SuccessfulUpdateSecurityGroup 52s yamete-controller Successfully updated security group to "eb87f99-8fde-431a-8901-e6072ba3398c"
Normal Pulled 8s (x6 over 51s) kubelet Container image "100.125.0.29:20202/prometheus/busybox:1.29.2" already present on machine
Warning FailedCreate 7s (x6 over 50s) kubelet Error: failed to create containerd container: error unpacking image: failed to extract layer sha256:f9f9e4e62f0689cd752390e14ade48b0ec6f2485a9a15a2f6ccaf54c229d: failed to get reader from content store: content digest sha256:8ca37a1a1bc60205f2c2e645743eccc1f320c3e39e9a98772b705a185: not found
```



## Possible Causes

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.

# 21.7 Networking

## 21.7.1 Network Planning

### 21.7.1.1 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.

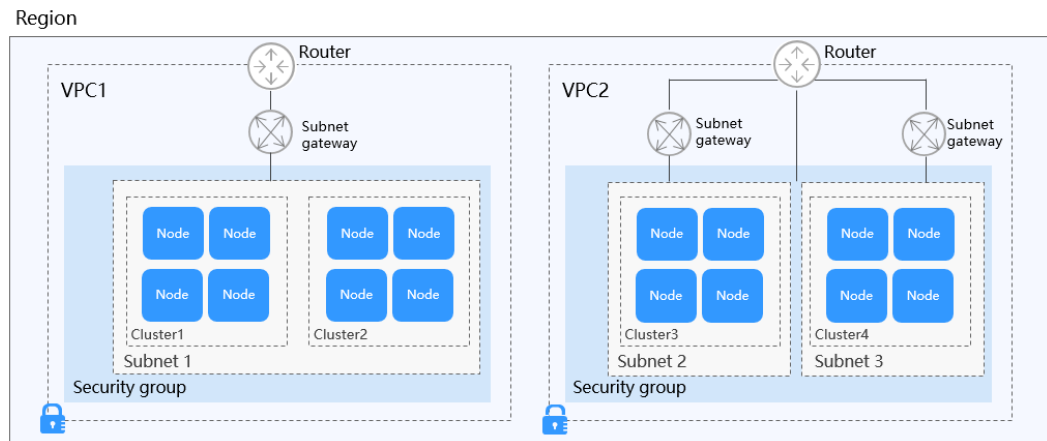
A VPC can be divided into multiple subnets. Security groups are configured to determine whether these subnets can communicate with each other. This ensures that subnets can be isolated from each other, so that you can deploy different services on different subnets.

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 21-6](#), 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 21-6** Relationship between clusters, VPCs, and subnets



### 21.7.1.2 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 nodes and worker nodes, separately. The security group name of the master nodes is *{Cluster name}-cce-control-{Random ID}*, and the security group name of the worker nodes is *{Cluster name}-cce-node-{Random ID}*.

You can modify the security group rules on the VPC console as required. (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 corresponding security groups, and modify their rules.)

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

### Node security group

A security group named *{Cluster name}-cce-node-{Random ID}* is automatically created for the worker nodes in a cluster. For details about the default ports, see [Table 21-10](#).

**Table 21-10** Default ports in the security group for the worker nodes that use a VPC network

| Dir<br>ecti<br>on            | Port                                    | Default<br>Source<br>Address                 | Description                                                                                                                                                                                      | Modif<br>iable               | Modification<br>Suggestion                                                             |
|------------------------------|-----------------------------------------|----------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------|----------------------------------------------------------------------------------------|
| Inb<br>oun<br>d<br>rule<br>s | All UDP<br>ports                        | VPC CIDR<br>block                            | Allow access<br>between worker<br>nodes and<br>between worker<br>nodes and the<br>master nodes.                                                                                                  | No                           | N/A                                                                                    |
|                              | All TCP<br>ports                        |                                              |                                                                                                                                                                                                  |                              |                                                                                        |
|                              | All ICMP<br>ports                       | Security<br>group of<br>master<br>nodes      | Allow master<br>nodes to access<br>worker nodes.                                                                                                                                                 | No                           | N/A                                                                                    |
|                              | TCP port<br>range:<br>30000 to<br>32767 | All IP<br>addresses<br>:<br><b>0.0.0.0/0</b> | Allow access from<br>NodePort.                                                                                                                                                                   | Yes                          | These ports must<br>permit requests<br>from VPC,<br>container, and<br>ELB CIDR blocks. |
|                              | UDP port<br>range:<br>30000 to<br>32767 |                                              |                                                                                                                                                                                                  |                              |                                                                                        |
|                              | All                                     | Containe<br>r CIDR<br>block                  | Allow containers<br>in a cluster to<br>access nodes.                                                                                                                                             | No                           | N/A                                                                                    |
|                              | All                                     | Node<br>security<br>group                    | Access outside the<br>security group of<br>the worker nodes<br>is restricted, but<br>mutual access<br>between instances<br>in the security<br>group of the<br>worker nodes is<br>not restricted. | No                           | N/A                                                                                    |
|                              | TCP port 22                             | All IP<br>addresses<br>:<br><b>0.0.0.0/0</b> | Allow SSH access<br>to EC2s.                                                                                                                                                                     | <b>Reco<br/>mme<br/>nded</b> | N/A                                                                                    |

| Direction     | Port | Default Source Address              | Description                                                                    | Modifiable | Modification Suggestion                                                                                                                                              |
|---------------|------|-------------------------------------|--------------------------------------------------------------------------------|------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Outbound rule | All  | All IP addresses : <b>0.0.0.0/0</b> | 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 <a href="#">Hardening Outbound Rules</a> . |

### Security group of master nodes

A security group named *{Cluster name}-cce-control-{Random ID}* is automatically created for the master nodes in a cluster. For details about the default ports, see [Table 21-11](#).

**Table 21-11** Default ports in the security group for the master nodes that use 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 the worker nodes to access master nodes.                            | No                 | N/A                                                                                                                          |
|               | TCP port 5443 | All IP addresses : <b>0.0.0.0/0</b> | Allow kube-apiserver of the master nodes to listen to the worker nodes.                         | <b>Recommended</b> | The port must allow traffic from the CIDR blocks of the VPC, container, and the management plane of the hosted service mesh. |

| Direction     | Port          | Default Source Address              | Description                                                                                                                                                           | Modifiable | Modification Suggestion |
|---------------|---------------|-------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|-------------------------|
|               | TCP port 8445 | VPC CIDR block                      | Allow the storage add-on of worker nodes to access master nodes.                                                                                                      | No         | N/A                     |
|               | All           | Security group of master nodes      | Access outside the security group of the master nodes is restricted, but mutual access between instances in the security group of the master nodes is not restricted. | No         | N/A                     |
| Outbound rule | All           | All IP addresses : <b>0.0.0.0/0</b> | Allow traffic on all ports by default.                                                                                                                                | No         | N/A                     |

## Security Group Rules of a Cluster Using the Tunnel Network

### Node security group

A security group named *{Cluster name}-cce-node-{Random ID}* is automatically created for the worker nodes in a cluster. For details about the default ports, see [Table 21-12](#).

**Table 21-12** Default ports in the security group for the worker nodes that use a tunnel network

| Direction     | Port           | Default Source Address              | Description                                                                                              | Modifiable | Modification Suggestion |
|---------------|----------------|-------------------------------------|----------------------------------------------------------------------------------------------------------|------------|-------------------------|
| Inbound rules | UDP port 4789  | All IP addresses : <b>0.0.0.0/0</b> | Allow access between containers.                                                                         | No         | N/A                     |
|               | TCP port 10250 | CIDR block of master nodes          | Allow master nodes to access kubelet on worker nodes, for example, by running <b>kubect exec {pod}</b> . | No         | N/A                     |

| Direction     | Port                           | Default Source Address              | Description                                                                                                                                                           | Modifiable         | Modification Suggestion                                                                                                                                              |
|---------------|--------------------------------|-------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|               | TCP port range: 30000 to 32767 | All IP addresses : <b>0.0.0.0/0</b> | 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 : <b>0.0.0.0/0</b> | Allow SSH access to ECSs.                                                                                                                                             | <b>Recommended</b> | N/A                                                                                                                                                                  |
|               | All                            | Node security group                 | Access outside the security group of the worker nodes is restricted, but mutual access between instances in the security group of the worker nodes is not restricted. | No                 | N/A                                                                                                                                                                  |
| Outbound rule | All                            | All IP addresses : <b>0.0.0.0/0</b> | 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 <a href="#">Hardening Outbound Rules</a> . |

### Security group of master nodes

A security group named *{Cluster name}-cce-control-{Random ID}* is automatically created for the master nodes in a cluster. For details about the default ports, see [Table 21-13](#).

**Table 21-13** Default ports in the security group for the master nodes that use a tunnel network

| Direction     | Port          | Default Source Address              | Description                                                                                                                                                           | Modifiable         | Modification Suggestion                                                                                                      |
|---------------|---------------|-------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------|------------------------------------------------------------------------------------------------------------------------------|
| Inbound rules | UDP port 4789 | All IP addresses : <b>0.0.0.0/0</b> | 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 the worker nodes to access master nodes.                                                                                                  | No                 | N/A                                                                                                                          |
|               | TCP port 5443 | All IP addresses : <b>0.0.0.0/0</b> | Allow kube-apiserver of the master nodes to listen to the worker nodes.                                                                                               | <b>Recommended</b> | The port must allow traffic from the CIDR blocks of the VPC, container, and the management plane of the hosted service mesh. |
|               | TCP port 8445 | VPC CIDR block                      | Allow the storage add-on of worker nodes to access master nodes.                                                                                                      | No                 | N/A                                                                                                                          |
|               | All           | Security group of master nodes      | Access outside the security group of the master nodes is restricted, but mutual access between instances in the security group of the master nodes is not restricted. | No                 | N/A                                                                                                                          |

| Direction     | Port | Default Source Address              | Description                            | Modifiable | Modification Suggestion |
|---------------|------|-------------------------------------|----------------------------------------|------------|-------------------------|
| Outbound rule | All  | All IP addresses : <b>0.0.0.0/0</b> | 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 21-14** Minimum configurations of outbound security group rules for worker nodes

| 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 master nodes           | Allow kube-apiserver of the master nodes 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 master nodes           | None                                                                                            |
| TCP port 8445                                                           | VPC CIDR block                       | Allow the storage add-on of worker nodes to access master nodes.                                |
| TCP port 9443                                                           | VPC CIDR block                       | Allow the network add-on of the worker nodes to access master nodes.                            |
| All ports                                                               | 198.19.128.0/17                      | Allow worker nodes to access the VPC Endpoint (VPCEP) service.                                  |
| UDP port 123                                                            | 100.126.0.0/16                       | Allow worker nodes to access the internal NTP server.                                           |



| Port          | Allowed CIDR   | Description                                                                               |
|---------------|----------------|-------------------------------------------------------------------------------------------|
| TCP port 443  | 100.126.0.0/16 | Allow worker nodes to access OBS over internal networks to pull the installation package. |
| TCP port 6443 | 100.126.0.0/16 | Allow worker nodes to report that the worker nodes are installed.                         |

## 21.7.2 Network Fault

### 21.7.2.1 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 disabled. Enable it if necessary.
- 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?](#)


## 21.7.2.2 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 21-7 404:ALB



# 404 Not Found

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 21-8 404:nginx/1.\*\*.\*

# 404 Not Found

nginx/1.14.0

## 21.7.2.3 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.

## 21.7.2.4 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.

## 21.7.2.5 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**.

```
[root@192-168-0-31 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@xxxxxxxxx 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=[] newV
alue={{IPs:+++++ Hostname: Ports:[]}} {IP:+++++ Hostname: Ports:[]}}
```

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: {}
```

## 21.7.3 Security Hardening

### 21.7.3.1 How Do I Prevent Cluster Nodes from Being Exposed to Public Networks?

#### Question

How do I prevent cluster nodes from being exposed to public networks?

#### Solution

- 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.

### 21.7.3.2 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 management plane of the hosted service mesh to ensure that the API Server can be accessed from within the cluster.

- Step 7** Click **Confirm**.

----End

### 21.7.3.3 How Do I Obtain a TLS Key Certificate?

#### Scenario

If your ingress needs to use HTTPS, you must configure a secret of the IngressTLS or kubernetes.io/tls type when creating an ingress.

The certificate file uploaded in the secret data must match the private key file. Otherwise, the certificate file becomes invalid.

#### Solution

Generally, you need to obtain a valid certificate from the certificate provider. If you want to use it in the test environment, you can create a certificate and private key by performing the following steps.

##### NOTE

Self-created certificates apply only to test scenarios. Such certificates are invalid and will affect browser access. Manually upload a valid one to ensure secure connections.

1. Generate a `tls.key`.

```
openssl genrsa -out tls.key 2048
```

The command will generate a private `tls.key` in the directory where the command is executed.

2. Generate a certificate using the private `tls.key`.

```
openssl req -new -x509 -key tls.key -out tls.crt -subj /C=CN/ST=*****/O=Devops/CN=example.com -days 3650
```

The generated key must be in the following format:

```
-----BEGIN RSA PRIVATE KEY-----
.....
-----END RSA PRIVATE KEY-----
```

The generated certificate must be in the following format:

```
-----BEGIN CERTIFICATE-----
.....
-----END CERTIFICATE-----
```

3. Import the certificate.

When creating a TLS secret, import the certificate and private key file to the corresponding location.

#### Verification

The ingress address can be accessed through a browser. However, the certificate and secret are not issued by the CA, so the CA does not recognize them and shows a message saying they are insecure.

### 21.7.4 Network Configuration



## 21.7.4.1 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.

## 21.8 Storage

### 21.8.1 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**

```
df -h
Filesystem Size Used Avail Use% Mounted on
/dev/mapper/docker-253:1-787293-631c1bde2cbe82e39f32253b216ba914cb183b168b54700b3e5b9a54ee40aed1 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

## 21.8.2 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 21-15** 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           | Supported          | Supported                           | Supported. This type of volumes can be shared among multiple nodes or workloads. |

| Storage Class | Persistent Storage | Automatic Migration with Containers | Multi-node Mounting                                                              |
|---------------|--------------------|-------------------------------------|----------------------------------------------------------------------------------|
| 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.
- **SFS volumes:** Create SFS volumes and mount them to a container path. The file system volumes created by the underlying SFS service can also be used. SFS volumes are applicable to persistent storage for frequent read/write in multiple workload scenarios, including media processing, content management, big data analysis, and workload analysis.
- **OBS volumes:** Create OBS volumes and mount them to a container path. OBS volumes are applicable to scenarios such as cloud workload, data analysis, content analysis, and hotspot objects.
- **SFS Turbo volumes:** Create SFS Turbo volumes and mount them to a container path. SFS Turbo volumes are fast, on-demand, and scalable, which makes them suitable for DevOps, containerized microservices, and enterprise office applications.

### 21.8.3 Can I Create a CCE Node Without Adding a Data Disk to the Node?

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.

## 21.8.4 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.

## 21.8.5 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 21-16** Descriptions of key parameters

| Parameter     | Type   | Description          |
|---------------|--------|----------------------|
| containername | String | Name of a container. |
| name          | String | Name of a volume.    |
| mountpath     | String | Mount path.          |

| Parameter      | Type   | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
|----------------|--------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| extendpathmode | String | <p>A third-level directory is added to the created volume directory/subdirectory to facilitate the obtaining of a single pod output file.</p> <p>The following types are supported.</p> <ul style="list-style-type: none"> <li>● <b>None</b>: The extended path is not configured.</li> <li>● <b>PodUID</b>: ID of a pod.</li> <li>● <b>PodName</b>: Name of a pod.</li> <li>● <b>PodUID/ContainerName</b>: ID of a pod or name of a container.</li> <li>● <b>PodName/ContainerName</b>: Name of a pod or container.</li> </ul> |

## 21.8.6 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.

## 21.9 Namespace

### 21.9.1 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.

```

75 - kube:metas
76 status:
77 phase: Terminating
78 conditions:
79 - type: NamespaceDeletionDiscoveryFailure
80 status: 'True'
81 lastTransitionTime: '2022-07-04T13:44:55Z'
82 reason: DiscoveryFailed
83 message: 'Discovery failed for some groups, 1 failing: unable to retrieve the complete list of server
84 APIs: metrics.k8s.io/v1beta1: the server is currently unable to handle the request'
85 - type: NamespaceDeletionGroupVersionParsingFailure
86 status: 'False'

```

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.

## 21.10 Chart and Add-on

### 21.10.1 What Should I Do If Installation of an Add-on Fails and "The release name is already exist" Is Displayed?

#### Symptom

When an add-on fails to be installed, the error message "The release name is already exist" is returned.

#### Possible Causes

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**

During the initial installation of the add-on, it is possible to encounter abnormal behavior caused by residual resources from a previous add-on release. This is a normal occurrence. In such cases, you can resolve the issue by uninstalling the add-on from the console. This will ensure that any remaining resources are cleared, allowing for a proper installation of the add-on again.

----End

## 21.10.2 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 21-17** 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 21-18](#).

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 21-18** 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                    |

## 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 21-19** 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 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 CPU by 500m and the requested memory by 1000 MiB each time 100 nodes (10,000 pods) are added. Increase the CPU limit by 1500m 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 21-20](#), 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 4000m and the limit to 5500m.

- 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 21-20](#). 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 21-20** 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.

### 21.10.3 How Can I Clean Up Residual Resources After the NGINX Ingress Controller Add-on in the Unknown State Is Deleted?

#### Symptom

The NGINX Ingress Controller add-on is in the unknown state, and after this add-on is uninstalled, residual components still remain.

Involved Kubernetes resources include:

- Namespace-level resources: secret, ConfigMap, Deployment, Service, Role, RoleBinding, lease, ServiceAccount, and job
- Cluster-level resources: ClusterRole, ClusterRoleBinding, IngressClass, and ValidatingWebhookConfiguration

#### Solution

**Step 1** Use kubectl to access a cluster.

**Step 2** Search for related resources.

```
className="nginx"
namespace="kube-system"
className=`if [[${className} == "nginx"]]; then echo ""; else echo "-${className}";fi`
kubectl get -n ${namespace} secret sh.helm.release.v1.cceaddon-nginx-ingress${className}.v1 cceaddon-
nginx-ingress${className}-admission
kubectl get -n ${namespace} cm cceaddon-nginx-ingress${className}-controller
kubectl get -n ${namespace} deploy cceaddon-nginx-ingress${className}-controller cceaddon-nginx-ingress
${className}-default-backend
kubectl get -n ${namespace} svc cceaddon-nginx-ingress${className}-controller-admission cceaddon-nginx-
ingress${className}-default-backend cceaddon-nginx-ingress${className}-controller
kubectl get -n ${namespace} role cceaddon-nginx-ingress${className}
kubectl get -n ${namespace} rolebinding cceaddon-nginx-ingress${className}
kubectl get -n ${namespace} lease ingress-controller-leader${className}
kubectl get -n ${namespace} serviceAccount cceaddon-nginx-ingress${className}
kubectl get clusterRole cceaddon-nginx-ingress${className}
kubectl get clusterRoleBinding cceaddon-nginx-ingress${className}
kubectl get ingressClass ${className}
kubectl get ValidatingWebhookConfiguration cceaddon-nginx-ingress${className}-admission
```

**className** specifies the name of a controller. **namespace** specifies the namespace where NGINX Ingress Controller was installed.

**Step 3** Manually delete the residual resources if the preceding resources are present.

----End

## 21.10.4 Why TLS v1.0 and v1.1 Cannot Be Used After the NGINX Ingress Controller Add-on Is Upgraded?

### Symptom

After the NGINX Ingress Controller add-on is upgraded to 2.3.3 or later, if the TLS version of the client is earlier than v1.2, an error is reported during the negotiation between the client and NGINX Ingress Controller.

```
[root@~]# curl -I --tls-max 1.1 -kv https://192.168.0.141:443
* Trying 192.168.0.141:443...
* Connected to 192.168.0.141 (192.168.0.141) port 443 (#0)
* ALPN, offering h2
* ALPN, offering http/1.1
* successfully set certificate verify locations:
* CAfile: /etc/pki/tls/certs/ca-bundle.crt
* CApath: none
* TLSv1.1 (OUT), TLS handshake, Client hello (1):
* TLSv1.1 (IN), TLS alert, protocol version (582):
* error:1409442E:SSL routines:ssl3_read_bytes:tlsv1 alert protocol version
* Closing connection 0
curl: (35) error:1409442E:SSL routines:ssl3_read_bytes:tlsv1 alert protocol version
```

### Solution

NGINX Ingress Controller 2.3.3 and later versions support only TLS v1.2 and v1.3 by default. If additional TLS versions are needed, you can add the `@SECLEVEL=0` field to the `ssl-ciphers` parameter configured for the NGINX Ingress Controller add-on. For details, see [TLS/HTTPS](#).

- Step 1** Log in to the CCE console and click the cluster name to access the cluster console. In the navigation pane, choose **Add-ons**. Choose **Installed** from the drop-down list, click **Manage** under **NGINX Ingress Controller**.
- Step 2** Click **Edit** of the corresponding instance.
- Step 3** Add the following configuration to the **Nginx Parameters**:

```
{
 "ssl-ciphers": "@SECLEVEL=0 ECDHE-ECDSA-AES128-GCM-SHA256:ECDHE-RSA-AES128-GCM-SHA256:ECDHE-ECDSA-AES256-GCM-SHA384:ECDHE-RSA-AES256-GCM-SHA384:ECDHE-ECDSA-CHACHA20-POLY1305:ECDHE-RSA-CHACHA20-POLY1305:DHE-RSA-AES128-GCM-SHA256:DHE-RSA-AES256-GCM-SHA384:DHE-RSA-CHACHA20-POLY1305:ECDHE-ECDSA-AES128-SHA256:ECDHE-RSA-AES128-SHA256:ECDHE-ECDSA-AES128-SHA:ECDHE-RSA-AES128-SHA:ECDHE-ECDSA-AES256-SHA384:ECDHE-RSA-AES256-SHA384:ECDHE-ECDSA-AES256-SHA:ECDHE-RSA-AES256-SHA:DHE-RSA-AES128-SHA256:DHE-RSA-AES256-SHA256:AES128-GCM-SHA256:AES256-GCM-SHA384:AES128-SHA256:AES256-SHA256:AES128-SHA:AES256-SHA:DES-CBC3-SHA",
 "ssl-protocols": "TLSv1 TLSv1.1 TLSv1.2 TLSv1.3"
}
```

- Step 4** Click **OK**.
- Step 5** Use TLS v1.1 for access again. The response is normal.

```
[root@...]# curl -I --tls-max 1.1 -kv https://192.168.0.141:443
* Trying 192.168.0.141:443...
* Connected to 192.168.0.141 (192.168.0.141) port 443 (#0)
* ALPN, offering h2
* ALPN, offering http/1.1
* successfully set certificate verify locations:
* CAfile: /etc/pki/tls/certs/ca-bundle.crt
* CApath: none
* TLSv1.1 (OUT), TLS handshake, Client hello (1):
* TLSv1.1 (IN), TLS handshake, Server hello (2):
* TLSv1.1 (IN), TLS handshake, Certificate (11):
* TLSv1.1 (IN), TLS handshake, Server key exchange (12):
* TLSv1.1 (IN), TLS handshake, Server finished (14):
* TLSv1.1 (OUT), TLS handshake, Client key exchange (16):
* TLSv1.1 (OUT), TLS change cipher, Change cipher spec (1):
* TLSv1.1 (OUT), TLS handshake, Finished (20):
* TLSv1.1 (IN), TLS handshake, Finished (20):
```

----End

## 21.11 API & kubectl FAQs

### 21.11.1 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 token 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.

### 21.11.2 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 least one label of the workload uses **app** as its key.
- b. The label of a Service is the same as that of the workload.

### 21.11.3 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

### 21.11.4 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?](#).

### 21.11.5 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

## 21.12 DNS FAQs

### 21.12.1 What Should I Do If Domain Name Resolution Fails in a CCE Cluster?

#### 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 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 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}'
```

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-8f57-09b62bd24ea6/6aa98c323f43d689ac47190bc84cf4fadd23bd8dd25307f773df2
5003ef0eef0/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.

## 21.12.2 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.

```
bash-4.4# exit
exit
[root@global-skyworth1-vpn ~]# ping [REDACTED]
PING [REDACTED] (10.247.11.29) 56(84) bytes of data.

^C
--- ota.skyworth.web ping statistics ---
```

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.

```
[root@global-skyworth1-vpn ~]#
[root@global-skyworth1-vpn ~]# docker exec -it 86cf062a5ba3 bash
bash-4.4# ping [REDACTED]
ping: bad address '[REDACTED]'
bash-4.4#
```

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.

## 21.12.3 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:

```
root@test-5dffddd95-vpt4m:/# cat /etc/resolv.conf
nameserver 10.247.3.10
search istio.svc.cluster.local svc.cluster.local cluster.local
options ndots:5 single-request-reopen timeout:2
```

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.

## 21.12.4 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.

## 21.13 Image Repository FAQs

### 21.13.1 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](#)

## 21.14 Permissions

### 21.14.1 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.

### 21.14.2 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.

### 21.14.3 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.



# 22 Best Practices

## 22.1 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 22-1 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 <b>3</b> 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. <ul style="list-style-type: none"> <li>• Select <b>VPC network</b> or <b>Tunnel network</b> for your CCE standard cluster.</li> </ul> | Deployment       | After a cluster is created, the network model cannot be changed.                                                                                                                                                                                                  |

| 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 <b>liveness probe</b> and <b>readiness probe</b> .                             | 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 ( <b>Lifecycle &gt; Pre-Stop</b> ) 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 22-2** 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 22-3** 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 <b>cce</b> .                                                                                                                                                                                                                                                                                                                                                                                                                            | Deployment | CCE cluster functions may be abnormal.                                                                                                                                                                 |
| Proactive O&M | <p>CCE provides multi-dimensional monitoring and alarm reporting functions, allowing users to locate and rectify faults as soon as possible.</p> <ul style="list-style-type: none"> <li>• Application Operations Management (AOM): The default basic resource monitoring of CCE covers detailed container-related metrics and provides alarm reporting functions.</li> <li>• 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.</li> </ul> | 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. |

## 22.2 Containerization

## 22.2.1 Containerizing an Enterprise Application (ERP)

### 22.2.1.1 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 22-4** lists the advantages and disadvantages of the three modes.

**Table 22-4** Containerization modes

| Containerization Mode                                              | Advantage                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | Disadvantage                                                                                                                                                                                                                                                                            |
|--------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p>Method 1:<br/>Containerize a single application as a whole.</p> | <ul style="list-style-type: none"> <li>• Zero modification on services: The application architecture and code require no change.</li> <li>• The deployment and upgrade efficiency is improved. Applications can be packed as container images to ensure application environment consistency and improve deployment efficiency.</li> <li>• Reduce resource costs: Containers use system resources more efficiently. Compared with a VM with the same configurations, a container can run more applications.</li> </ul> | <ul style="list-style-type: none"> <li>• Difficult to expand the entire architecture of an application. As the code size increases, code update and maintenance would be complicated.</li> <li>• Difficult to launch new functions, languages, frameworks, and technologies.</li> </ul> |



| Containerization Mode                                                                                                                     | Advantage                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | Disadvantage                           |
|-------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------|
| <p>Method 2:<br/>Containerize first the application components that are frequently updated or have high requirements on auto scaling.</p> | <ul style="list-style-type: none"> <li>• 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.</li> <li>• 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.</li> <li>• 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.</li> </ul> | <p>Need to decouple some services.</p> |

| Containerization Mode                                                                                              | Advantage                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | Disadvantage                                                                                         |
|--------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------|
| <p>Method 3:<br/>Transform an application to microservices and then containerize the microservices one by one.</p> | <ul style="list-style-type: none"> <li>● Independent scaling: After an application is split into microservices, you can independently increase or decrease the number of instances for each microservice.</li> <li>● Increased development speed: Microservices are decoupled from one another. Code development of a microservice does not affect other microservices.</li> <li>● 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.</li> <li>● Breakdown isolation: If one microservice breaks down, other microservices can still run properly.</li> </ul> | <p>Need to transform the application to microservices, which involves a large number of changes.</p> |

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

## 22.2.1.2 Procedure

### 22.2.1.2.1 Containerizing an Entire Application

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

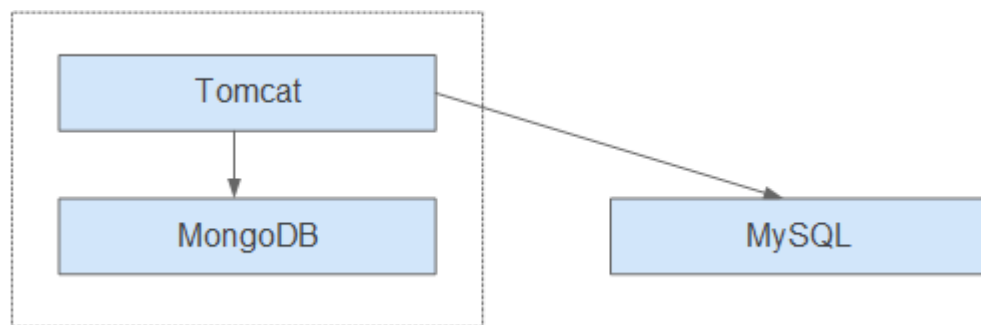
No recoding or re-architecting is required. You only need to pack the entire application into a container image and deploy the container image on CCE.

## 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 22-1** Application architecture



As shown in [Figure 22-1](#), 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 22-5** Comparison between the two deployment modes

| Category                        | Before: Application Deployment on VM                                                                                                                                                             | After: Application Deployment Using Containers                                                                                                                                                       |
|---------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Deployment                      | High deployment cost.<br>A VM is required for deploying a system for a customer.                                                                                                                 | More than 50% cost reduced.<br>Container services achieve multi-tenant isolation, which allows you to deploy systems for different enterprises on the same VM.                                       |
| Upgrade                         | Low upgrade efficiency.<br>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.<br>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.<br>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<br>Enterprises can focus on service development without paying attention to VM maintenance.                                                                                            |

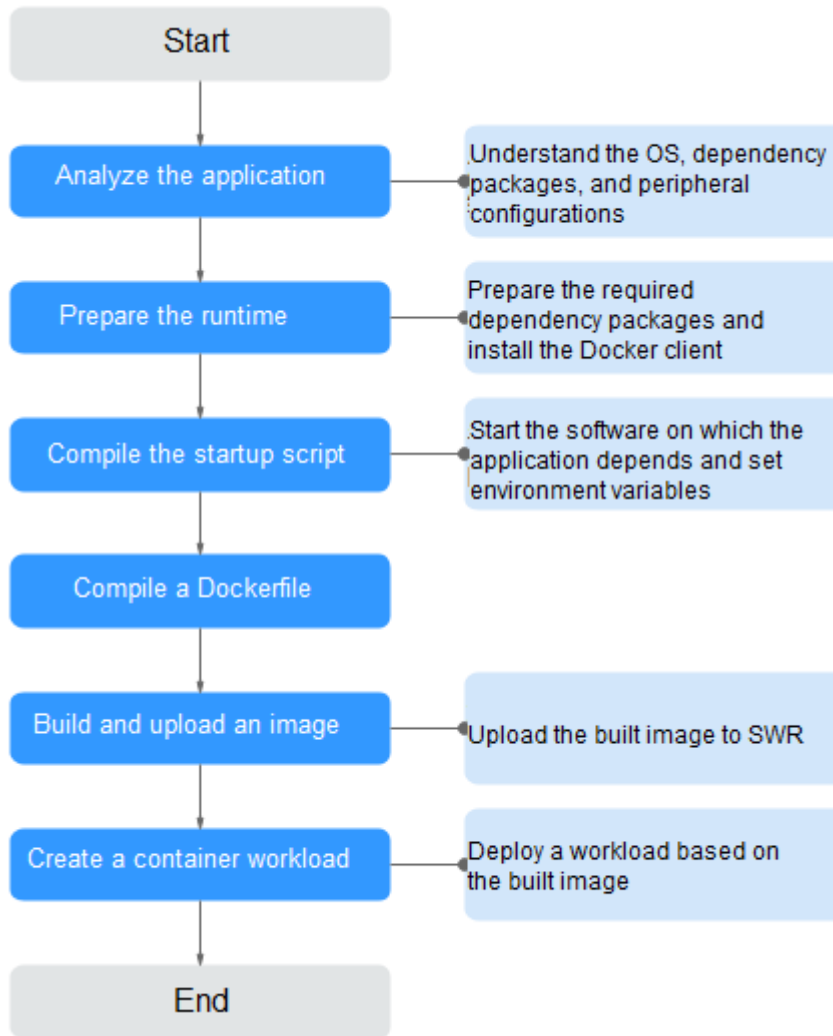
### 22.2.1.2.2 Containerization Process

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

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

For details about each step of the containerization, see [Figure 22-2](#).

**Figure 22-2** Process of containerizing an application



### 22.2.1.2.3 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 22-6](#).

**Table 22-6** Application environment

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

| Category        | Sub-category              | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
|-----------------|---------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                 | Runtime environment       | <p>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.</p> <p>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.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                  |
|                 | Dependency package        | <p>Understand required dependency packages, such as OpenSSL and other system software, and their version numbers.</p> <p>In this example, no dependency package is required.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| Deployment mode | Peripheral configurations | <p>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.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
|                 |                           | <p>External services with which the application needs to interconnect, such as databases and file systems.</p> <p>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.</p> <p>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.</p> <pre>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</pre> |

| Category | Sub-category               | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
|----------|----------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|          | Application configurations | <p>Sort out the configuration parameters, such as configurations that need to be modified frequently and those remain unchanged during the running of the application.</p> <p>In this example, no application configurations need to be extracted.</p> <p><b>NOTE</b><br/>To avoid frequent image replacement, you are advised to classify configurations of the application.</p> <ul style="list-style-type: none"> <li>For the configurations (such as peripheral interconnection information and log levels) that are frequently changed, you are advised to configure them as environment variables.</li> <li>For the configurations that remain unchanged, directly write them into images.</li> </ul> |

### 22.2.1.2.4 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.

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

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

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

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

```
sh get-docker.sh
```

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

### **docker version**

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

**Version** indicates the version number.

----End

## **Obtaining the 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 22-3 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](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 appstest
```

```
cd appstest
```

**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 appstest.war apache-tomcat-7.0.82/webapps/apptest
```

```
cd apache-tomcat-7.0.82/webapps/apptest
```

```
./.././../jdk1.8.0_151/bin/jar -xf appstest.war
```

```
rm -rf appstest.war
```

```
----End
```

### 22.2.1.2.5 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
```

### 22.2.1.2.6 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

### 22.2.1.2.7 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

### 22.2.1.2.8 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 22-7](#).

**Table 22-7** Preparing the environment

| No. | Category       | Procedure                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
|-----|----------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1   | Creating a VPC | <p>Create a VPC before you create a cluster. A VPC provides an isolated, configurable, and manageable virtual network environment for CCE clusters.</p> <p>If you have a VPC already, skip to the next task.</p> <ol style="list-style-type: none"> <li>1. Log in to the management console.</li> <li>2. In the service list, choose <b>Networking &gt; Virtual Private Cloud</b>.</li> <li>3. On the <b>Dashboard</b> page, click <b>Create VPC</b>.</li> <li>4. Follow the instructions to create a VPC. Retain default settings for parameters unless otherwise specified.</li> </ol> |

| No. | Category            | Procedure                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
|-----|---------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 2   | Creating a key pair | <p>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.</p> <ol style="list-style-type: none"> <li>1. Log in to the management console.</li> <li>2. In the service list, choose <b>Data Encryption Workshop</b> under <b>Security &amp; Compliance</b>.</li> <li>3. In the navigation pane, choose <b>Key Pair Service</b>. On the <b>Private Key Pairs</b> tab, click <b>Create Key Pair</b>.</li> <li>4. Enter a key pair name, select <b>I agree to host the private key of the key pair.</b> and <b>I have read and agree to the Key Pair Service Disclaimer</b>, and click <b>OK</b>.</li> <li>5. In the dialog box displayed, click <b>OK</b>.<br/>View and save the key pair. For security purposes, a key pair can be downloaded only once. Keep it secure to ensure successful login.</li> </ol> |

**Step 2** Create a cluster and a node.

1. Log in to the CCE console. On the **Clusters** page, click **Create Cluster** and select the type for the cluster to be created.  
Configure cluster parameters and select the VPC created in [Step 1](#).
2. Create 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 22-8** 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.                     |

- 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`.

- 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.

## 22.3 Disaster Recovery

### 22.3.1 Recommended Configurations for HA CCE Clusters

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

| Item                     | Description                                                                                                                                                                                            | Recommended Operations                                                                                                                                                                                                                                                                                                                                  |
|--------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Cluster management plane | CCE is a hosted Kubernetes cluster service. You do not need to perform O&M on the management plane (master nodes). You can use some settings to improve the stability and reliability of your cluster. | <ul style="list-style-type: none"> <li>• <a href="#">Deploying the Master Nodes in Different AZs</a></li> <li>• <a href="#">Selecting a Network Model</a></li> <li>• <a href="#">Selecting a Service Forwarding Mode</a></li> <li>• <a href="#">Configuring Quotas and Limits for the Cloud Service Resources and Resources in a Cluster</a></li> </ul> |

| Item               | Description                                                                                                                                                                                                                                                                                                                                          | Recommended Operations                                                                                                                                                                                                                                                                                                                                                                                                                              |
|--------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Cluster data plane | 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. | <ul style="list-style-type: none"> <li>• <a href="#">Partitioning Data Disks Attached to a Node</a></li> <li>• <a href="#">Running npd</a></li> <li>• <a href="#">Configuring the DNS Cache</a></li> <li>• <a href="#">Properly Deploying CoreDNS</a></li> </ul>                                                                                                                                                                                    |
| 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.                                                                                                                                                                           | <ul style="list-style-type: none"> <li>• <a href="#">Running Multiple Pods</a></li> <li>• <a href="#">Configuring Resource Quotas for a Workload</a></li> <li>• <a href="#">Deploying an Application in Multiple AZs</a></li> <li>• <a href="#">Deploying the System Add-ons in Multiple AZs</a></li> <li>• <a href="#">Configuring Auto Scaling</a></li> <li>• <a href="#">Viewing Logs, Monitoring Metrics, and Adding Alarm Rules</a></li> </ul> |

## 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 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](#).

## 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 data 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.

## 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 the System Add-ons in Multiple AZs

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

**Table 22-9** Deployment description

| Mode      | Configuration Description                                                                                                                                                                              | Usage Description                                                                                                                                                                                                                                                                               | Recommended Configuration Scenario                                                                                            |
|-----------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------|
| Preferred | Add-on pods will have labels with the key <b>topology.kubernetes.io/zone</b> for soft anti-affinity deployment, and the anti-affinity type is <b>preferredDuringSchedulingIgnoredDuringExecution</b> . | 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 <b>topology.kubernetes.io/zone</b> for hard anti-affinity deployment, and the anti-affinity type is <b>requiredDuringSchedulingIgnoredDuringExecution</b> .  | 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 <b>topology.kubernetes.io/zone</b> 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 deploying applications in pods, you can configure requested resources and resource limits for the pods to prevent unlimited usage of resources during peak hours. However, this approach may encounter a resource bottleneck as an application exception may occur once the upper

limit of resource usage is reached. To address this problem, you can scale the pods in or out to distribute the workload.

- 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 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.

## 22.3.2 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
```

## 22.3.3 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.

### Deployment Solution

An add-on typically runs as Deployments or DaemonSets. By default, DaemonSet pods are deployed on all nodes. To ensure HA of the add-on, there are multiple pods, AZ affinity policies, and specified node scheduling configured for Deployments.

Pod-level HA solution:

- **Increasing the Number of Pods:** Multi-pod deployment can effectively prevent service unavailability caused by a single point of failure (SPOF).

Node-level HA solutions:

- **Deploying the Add-on Pods on Dedicated Nodes:** To prevent resource preemption between service applications and core add-ons, it is best to deploy the core add-on pods on dedicated nodes. This ensures that the add-on resources are isolated and restricted on the node level.
- **Deploying the Add-on in Multiple AZs:** Multi-AZ deployment can effectively prevent service unavailability caused by the failure of a single AZ.

Take the CoreDNS add-on as an example. This add-on is deployed as two pods by default in the preferred mode, and the scheduling policies are hard anti-affinity for nodes and soft anti-affinity for AZs. In this case, two nodes are needed to ensure that all add-on pods in the cluster can run properly, and Deployment pods of the add-on can be preferentially scheduled to nodes in different AZs.

The following sections describe how to further improve the add-on SLA.

## Increasing the Number of Pods

You can adjust the number of CoreDNS pods ensure high performance and HA.

- Step 1** Log in to the CCE console and click the cluster name to access the cluster console. In the navigation pane, choose **Add-ons**, locate **CoreDNS** on the right, and click **Edit**.
  - Step 2** Increase the number of pods.
  - Step 3** Click **OK**.
- End

## Deploying the Add-on Pods on Dedicated Nodes

You can adjust the node affinity policy of CoreDNS and make the CoreDNS pods run on dedicated nodes. This can prevent the CoreDNS resources from being preempted by service applications.

A custom policy is used as an example.

- Step 1** Log in to the CCE console and click the cluster name to access the cluster console. In the navigation pane, choose **Nodes**.
- Step 2** Click the **Nodes** tab, select the node dedicated for CoreDNS, and click **Labels and Taints** above the node list.

Add the following labels:

- Key: **node-role.kubernetes.io/coredns**
- Value: **true**

Add the following taints:

- Key: **node-role.kubernetes.io/coredns**
- Value: **true**

- Effect: **NoSchedule**

**Step 3** In the navigation pane, choose **Add-ons**, locate **CoreDNS**, and click **Edit**.

**Step 4** Select Custom Policies for **Node Affinity** and add the preceding node label.  
Add tolerations for the preceding taint.

**Step 5** Click **OK**.

----End

## Deploying the Add-on in Multiple AZs

By default, the add-on scheduling policy can handle single-node faults. However, if your services require a higher SLA, you can create nodes with different AZ specifications on the node pool page and set the multi-AZ deployment mode of the add-on to the required mode.

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

**Step 2** Create nodes in different AZs.

To create nodes in different AZs, you can simply repeat these steps. Alternatively, you can create multiple node pools, associate them with different AZ specifications, and increase the number of nodes in each pool to achieve the same result.

1. In the navigation pane, choose **Nodes**, click the **Nodes** tab, and click **Create Node** in the upper right corner.
2. On the page displayed, select an AZ for the node.
3. Configure other mandatory parameters following instructions to complete the creation.

**Step 3** In the navigation tree, choose **Add-ons**. In the right pane, locate **CoreDNS** and click **Edit**.

**Step 4** In the window that slides out from the right, set **Multi AZ** to **Required** and click **Install**.

**Step 5** Choose **Workload**, click the **Deployments** tab, and view the CoreDNS pods. Select the **kube-system** namespace to view the pod distribution of the add-on.

**Step 6** View that the Deployment pods of the add-on has been allocated to nodes in two AZs.

----End

## 22.4 Security

### 22.4.1 Configuration Suggestions on CCE Cluster Security

To ensure security, it is recommended that you configure a cluster in the following manner.

## 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-mode=Webhook**).

**Step 1** Run the following command to create a 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.

## 22.4.2 Configuration Suggestions on CCE Node Security

### 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

## 22.4.3 Configuration Suggestions on CCE Container Security

### Controlling the Pod Scheduling Scope

The nodeSelector or nodeAffinity is used to limit the range of nodes to which applications can be scheduled, preventing the entire cluster from being threatened due to the exceptions of a single application.

To achieve strong isolation, like in logical multi-tenancy situations, it is important to have system add-ons run on separate nodes or node pools. This helps keep them separated from service pods and reduces the risk of privilege escalation within a cluster. To do this, you can set the node affinity policy to either **Node Affinity** or **Specified Node Pool Scheduling** on the add-on installation page.

## Suggestions on Container Security Configuration

- Set the computing resource limits (**request** and **limit**) of a container. This prevents the container from occupying too many resources and affecting the stability of the host and other containers on the same node.
- Unless necessary, do not mount sensitive host directories to containers, such as `/`, `/boot`, `/dev`, `/etc`, `/lib`, `/proc`, `/sys`, and `/usr`.
- Do not run the `sshd` process in containers unless necessary.
- Unless necessary, it is not recommended that containers and hosts share the network namespace.
- Unless necessary, it is not recommended that containers and hosts share the process namespace.
- Unless necessary, it is not recommended that containers and hosts share the IPC namespace.
- Unless necessary, it is not recommended that containers and hosts share the UTS namespace.
- Unless necessary, do not mount the sock file of Docker to any container.

## Container Permission Access Control

When using a containerized application, comply with the minimum privilege principle and properly set `securityContext` of `Deployments` or `StatefulSets`.

- Configure `runAsUser` to specify a non-root user to run a container.
- Configure `privileged` to prevent containers being used in scenarios where privilege is not required.
- Configure `capabilities` to accurately control the privileged access permission of containers.
- Configure `allowPrivilegeEscalation` to disable privilege escape in scenarios where privilege escalation is not required for container processes.
- Configure `seccomp` to restrict the container syscalls. For details, see [Restrict a Container's Syscalls with seccomp](#) in the official Kubernetes documentation.
- Configure `ReadOnlyRootFilesystem` to protect the root file system of a container.

Example YAML for a Deployment:

```
apiVersion: apps/v1
kind: Deployment
metadata:
 name: security-context-example
 namespace: security-example
spec:
 replicas: 1
 selector:
 matchLabels:
 app: security-context-example
```

```
 label: security-context-example
strategy:
 rollingUpdate:
 maxSurge: 25%
 maxUnavailable: 25%
 type: RollingUpdate
template:
 metadata:
 annotations:
 seccomp.security.alpha.kubernetes.io/pod: runtime/default
 labels:
 app: security-context-example
 label: security-context-example
 spec:
 containers:
 - image: ...
 imagePullPolicy: Always
 name: security-context-example
 securityContext:
 allowPrivilegeEscalation: false
 readOnlyRootFilesystem: true
 runAsUser: 1000
 capabilities:
 add:
 - NET_BIND_SERVICE
 drop:
 - all
 volumeMounts:
 - mountPath: /etc/localtime
 name: localtime
 readOnly: true
 - mountPath: /opt/write-file-dir
 name: tmpfs-example-001
 securityContext:
 seccompProfile:
 type: RuntimeDefault
 volumes:
 - hostPath:
 path: /etc/localtime
 type: ""
 name: localtime
 - emptyDir: {}
 name: tmpfs-example-001
```

## Restricting the Access of Service Containers to the Management Plane

To avoid unnecessary service interruption when restricting the service containers on a node from accessing the Kubernetes management plane, consider the following:

- **Check whether any containers on the node require access to the cluster management plane.**

Once you have restricted the service containers on the node from accessing the management plane, all containers on that node will be unable to access the kube-apiserver of the cluster. Before making the configuration, make sure that none of the containers on the node need to access the kube-apiserver of the cluster.

Keep in mind that certain CCE add-ons, like CCE Advanced HPA, still require access to kube-apiserver. It is not recommended that you configure the access restriction on a node where such add-ons are running.

- **Configure taints and affinity for the node.**

If the service containers on the node do not need to access kube-apiserver, it is recommended that you configure labels and taints for the node.

Additionally, configure **taints**, **tolerations**, and **node affinity** for the containers on the node. This will prevent other containers from being scheduled to that node, thus avoiding service exceptions.

To restrict the service containers on a node from accessing the management plane, take the following steps:

**Step 1** Obtain the container CIDR block and private API server address.

On the **Clusters** page of the CCE console, click the name of the cluster to find the information on the details page.

**Step 2** Configure access rules.

- CCE cluster: Log in to each node in the cluster as user **root** and run the following command:

- VPC network

```
iptables -I OUTPUT -s {container_cidr} -d {Private API server IP} -j REJECT
```

- Container tunnel network

```
iptables -I FORWARD -s {container_cidr} -d {Private API server IP} -j REJECT
```

*{container\_cidr}* indicates the container CIDR of the cluster, for example, 10.0.0.0/16.

To ensure configuration persistence, write the command to the **/etc/rc.local** script.

**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

## 22.4.4 Configuration Suggestions on CCE Secret Security

Currently, CCE has configured static encryption for secret resources. The secrets created by users will be encrypted and stored in etcd of the CCE cluster. Secrets can be used in two modes: environment variable and file mounting. No matter which mode is used, CCE still transfers the configured data to users. Therefore, it is recommended that:

1. Do not record sensitive information in logs.
2. For the secret that uses the file mounting mode, the default file permission mapped in the container is 0644. Configure stricter permissions for the file.

For example:

```
apiversion: v1
kind: Pod
metadata:
 name: mypod
spec:
 containers:
 - name: mypod
 image: redis
 volumeMounts:
 - name: foo
 mountPath: "/etc/foo"
 volumes:
 - name: foo
 secret:
 secretName: mysecret
 defaultMode: 256
```

In **defaultMode: 256, 256** is a decimal number, which corresponds to the octal number **0400**.

3. When the file mounting mode is used, configure the secret file name to hide the file in the container.

```
apiVersion: v1
kind: Secret
metadata:
 name: dotfile-secret
data:
 .secret-file: dmFsdWUtMg0KDQo=

apiVersion: v1
kind: Pod
metadata:
 name: secret-dotfiles-pod
spec:
 volumes:
 - name: secret-volume
 secret:
 secretName: dotfile-secret
 containers:
 - name: dotfile-test-container
 image: k8s.gcr.io/busybox
 command:
 - ls
 - "-1"
 - "/etc/secret-volume"
 volumeMounts:
 - name: secret-volume
 readOnly: true
 mountPath: "/etc/secret-volume"
```

In this way, **.secret-file** cannot be seen by running **ls -l** in the **/etc/secret-volume/** directory, but can be viewed by running **ls -al**.

4. Encrypt sensitive information before creating a secret and decrypt the information when using it.

## Using a Bound ServiceAccount Token to Access a Cluster

The secret-based ServiceAccount token does not support expiration time or auto update. In addition, after the mounting pod is deleted, the token is still stored in the secret. Token leakage may incur security risks. A bound ServiceAccount token is recommended for CCE clusters of version 1.23 or later. In this mode, the expiration time can be set and is the same as the pod lifecycle, reducing token leakage risks. An example is as follows:

```
apiVersion: apps/v1
kind: Deployment
metadata:
 name: security-token-example
 namespace: security-example
spec:
 replicas: 1
 selector:
 matchLabels:
 app: security-token-example
 label: security-token-example
 template:
 metadata:
 annotations:
 seccomp.security.alpha.kubernetes.io/pod: runtime/default
 labels:
 app: security-token-example
 label: security-token-example
 spec:
```

```
serviceAccountName: test-sa
containers:
- image: ...
 imagePullPolicy: Always
 name: security-token-example
volumes:
- name: test-projected
 projected:
 defaultMode: 420
 sources:
 - serviceAccountToken:
 expirationSeconds: 1800
 path: token
 - configMap:
 items:
 - key: ca.crt
 path: ca.crt
 name: kube-root-ca.crt
 - downwardAPI:
 items:
 - fieldRef:
 apiVersion: v1
 fieldPath: metadata.namespace
 path: namespace
```

For details, see [Managing Service Accounts](#).

## 22.5 Auto Scaling

### 22.5.1 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 deploying applications in pods, you can configure requested resources and resource limits for the pods to prevent unlimited usage of resources during peak hours. However, after the upper limit is reached, an application error may occur. Pod scaling can effectively resolve this issue. If the resource usage on the node increases to a certain extent, newly added pods cannot be scheduled to this node. In this case, CCE will add nodes accordingly.

#### Solution

Two major auto scaling policies are HPA (Horizontal Pod Autoscaling) and CA (Cluster AutoScaling). HPA is for workload auto scaling and CA is for node auto scaling.

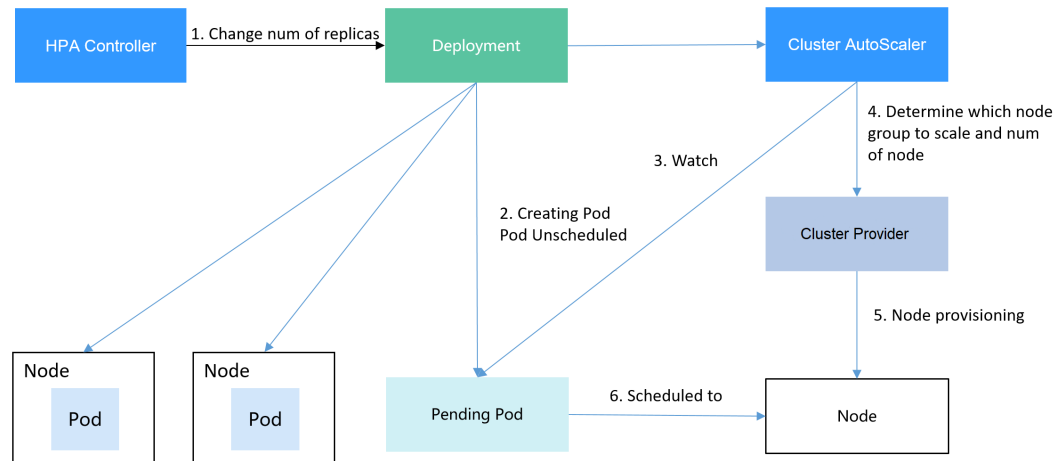
HPA and CA work with each other. HPA requires sufficient cluster resources for successful scaling. When the cluster resources are insufficient, CA is needed to add nodes. If HPA reduces workloads, the cluster will have a large number of idle resources. In this case, CA needs to release nodes to avoid resource waste.

As shown in [Figure 22-4](#), 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 22-4** HPA and CA working flows



Using HPA and CA enables auto scaling for most scenarios while also providing monitoring capabilities.

This section uses an example to describe the auto scaling process using HPA and CA policies together.

## Preparations

**Step 1** Create a cluster with one node. The node should have 2 cores of vCPUs and 4 GiB of memory, or a higher specification, as well as an EIP to allow external access. If no EIP is bound to the node during node creation, you can manually bind one on the ECS console after creating the node.

**Step 2** Install add-ons for the cluster.

- autoscaler: node scaling add-on
- metrics-server: an aggregator of resource usage data in a Kubernetes cluster. It can collect measurement data of major Kubernetes resources, such as pods, nodes, containers, and Services.

**Step 3** Log in to the cluster node and run a computing-intensive application. When a user sends a request, the result needs to be calculated before being returned to the user.

1. Create a PHP file named **index.php** to calculate the square root of the request for 1,000,000 times before returning **OK!**.

```
vi index.php
```

The file content is as follows:

```
<?php
$x = 0.0001;
for ($i = 0; $i <= 1000000; $i++) {
 $x += sqrt($x);
}
echo "OK!";
?>
```

2. Compile a **Dockerfile** file to build an image.


```
vi Dockerfile
```

The content is as follows:

```
FROM php:5-apache
COPY index.php /var/www/html/index.php
RUN chmod a+rx index.php
```

3. Run the following command to build an image named **hpa-example** with the tag **latest**.

```
docker build -t hpa-example:latest .
```

4. (Optional) Log in to the SWR console, choose **Organizations** in the navigation pane, and click **Create Organization** in the upper right corner. Skip this step if you already have an organization.
5. In the navigation pane, choose **My Images** and then click **Upload Through Client**. On the page displayed, click **Generate a temporary login command** and click  to copy the command.
6. Run the login command copied in the previous step on the cluster node. If the login is successful, the message "Login Succeeded" is displayed.
7. Tag the hpa-example image.

```
docker tag {Image name 1:Tag 1}{Image repository address}{Organization name}{Image name 2:Tag 2}
```

- *{Image name 1:Tag 1}*: name and tag of the local image to be uploaded.
- *{Image repository address}*: the domain name at the end of the login command in **login command**. It can be obtained on the SWR console.
- *{Organization name}*: name of the **created organization**.
- *{Image name 2:Tag 2}*: desired image name and tag to be displayed on the SWR console.

The following is an example:

```
docker tag hpa-example:latest {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 default values 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 Step 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

## Conclusion

By using HPA and CA, auto scaling can be effortlessly implemented in various scenarios. Additionally, the scaling process of nodes and pods can be conveniently tracked.

## 22.6 Monitoring

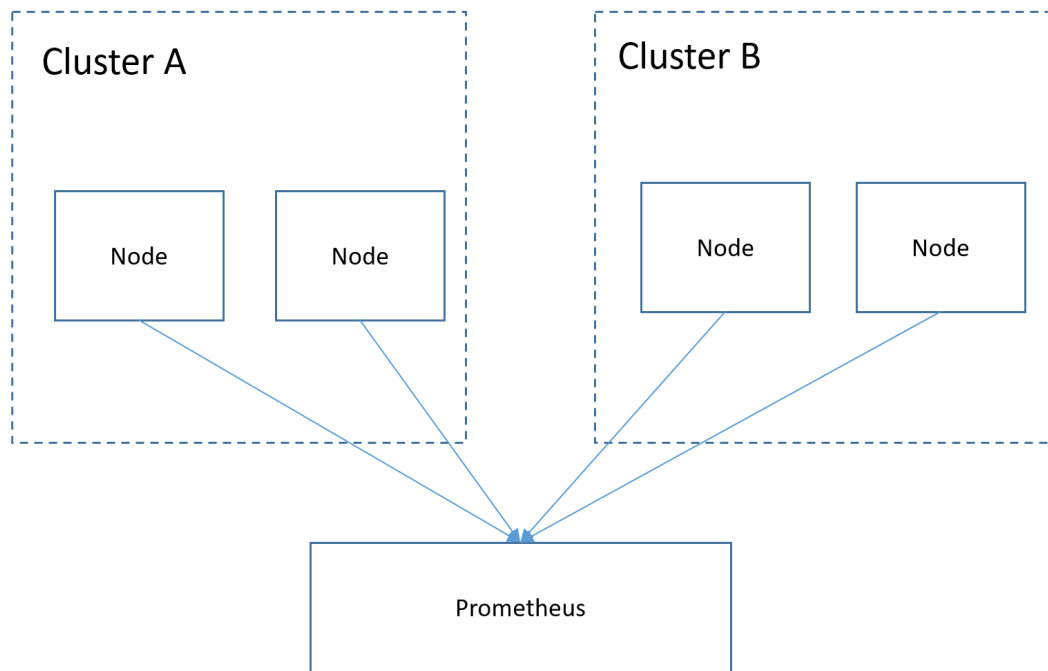
### 22.6.1 Monitoring Multiple Clusters Using Prometheus

#### Application Scenarios

Generally, a user has different clusters for different purposes, such as production, testing, and development. To monitor, collect, and view metrics of these clusters, you can deploy a set of Prometheus.

#### Solution Architecture

Multiple clusters are connected to the same Prometheus monitoring system, as shown in the following figure. This reduces maintenance and resource costs and facilitates monitoring information aggregation.



## Prerequisites

- The target cluster has been created.
- Prometheus has been properly connected to the target cluster.
- Prometheus has been installed on a Linux host using a binary file. For details, see [Installation](#).

## Procedure

**Step 1** Obtain the **bearer\_token** information of the target cluster.

1. Create the RBAC permission in the target cluster.

Log in to the background node of the target cluster and create the **prometheus\_rbac.yaml** file.

```
apiVersion: v1
kind: ServiceAccount
metadata:
 name: prometheus-test
 namespace: kube-system

apiVersion: rbac.authorization.k8s.io/v1
kind: ClusterRole
metadata:
 name: prometheus-test
rules:
- apiGroups:
 - ""
 resources:
 - nodes
 - services
 - endpoints
 - pods
 - nodes/proxy
verbs:
- get
- list
```



```

- watch
- apiGroups:
 - "extensions"
 resources:
 - ingresses
 verbs:
 - get
 - list
 - watch
- apiGroups:
 - ""
 resources:
 - configmaps
 - nodes/metrics
 verbs:
 - get
- nonResourceURLs:
 - /metrics
 verbs:
 - get

apiVersion: rbac.authorization.k8s.io/v1
kind: ClusterRoleBinding
metadata:
 name: prometheus-test
roleRef:
 apiGroup: rbac.authorization.k8s.io
 kind: ClusterRole
 name: prometheus-test
subjects:
- kind: ServiceAccount
 name: prometheus-test
 namespace: kube-system

```

Run the following command to create the RBAC permission:

**kubectl apply -f prometheus\_rbac.yaml**

2. Obtain the **bearer\_token** information of the target cluster.

**NOTE**

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

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

- 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**



```

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.

#### Targets

All Unhealthy

k8s02\_cAdvisor (2/2 up) show less

| Endpoint                                                                           | State | Labels                                                        | Last Scrape | Scrape Duration | Error |
|------------------------------------------------------------------------------------|-------|---------------------------------------------------------------|-------------|-----------------|-------|
| https://192.168.0.223:5443/api/v1/nodes/192.168.0.110:10250/proxy/metrics/cadvisor | UP    | cluster="k8s02" instance="192.168.0.110" job="k8s02_cAdvisor" | 1.689s      | 47.677ms        |       |
| https://192.168.0.223:5443/api/v1/nodes/192.168.0.162:10250/proxy/metrics/cadvisor | UP    | cluster="k8s02" instance="192.168.0.162" job="k8s02_cAdvisor" | 7.279s      | 65.193ms        |       |

k8s\_cAdvisor (4/4 up) show less

| Endpoint                                                                           | State | Labels                                                    | Last Scrape | Scrape Duration | Error |
|------------------------------------------------------------------------------------|-------|-----------------------------------------------------------|-------------|-----------------|-------|
| https://192.168.0.153:5443/api/v1/nodes/192.168.0.65:10250/proxy/metrics/cadvisor  | UP    | cluster="k8s" instance="192.168.0.65" job="k8s_cAdvisor"  | 12.365s     | 37.925ms        |       |
| https://192.168.0.153:5443/api/v1/nodes/192.168.0.250:10250/proxy/metrics/cadvisor | UP    | cluster="k8s" instance="192.168.0.250" job="k8s_cAdvisor" | 2.390s      | 29.235ms        |       |
| https://192.168.0.153:5443/api/v1/nodes/192.168.0.109:10250/proxy/metrics/cadvisor | UP    | cluster="k8s" instance="192.168.0.109" job="k8s_cAdvisor" | 1.578s      | 102.146ms       |       |
| https://192.168.0.153:5443/api/v1/nodes/192.168.0.228:10250/proxy/metrics/cadvisor | UP    | cluster="k8s" instance="192.168.0.228" job="k8s_cAdvisor" | 416.000ms   | 21.256ms        |       |

Enable query history Use local time Enable autocomplete

container\_cpu\_load\_average\_10s(namespace="default")

Execute

Table Graph

Evaluation time

Monitoring task of cluster 2

Monitoring task of cluster 1

----End

## 22.7 Cluster

## 22.7.1 Suggestions on CCE Cluster Selection

When you use CCE to create a Kubernetes cluster, there are multiple configuration options and terms. This section compares the key configurations for CCE clusters and provides recommendations to help you create a cluster that better suits your needs.

### Cluster 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 a cluster is created, the network model cannot be changed.

---

**Table 22-10** Network model comparison

| Dimension                               | Tunnel Network                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | VPC Network                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
|-----------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Application scenarios                   | <ul style="list-style-type: none"> <li>● 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.</li> <li>● 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.</li> </ul> | <ul style="list-style-type: none"> <li>● 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.</li> <li>● 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.</li> </ul> |
| Core technology                         | OVS                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | IPvlan and VPC route                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| Applicable clusters                     | CCE standard cluster                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | CCE standard cluster                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| Container network isolation             | Kubernetes native NetworkPolicy for pods                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | No                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| Interconnecting pods to a load balancer | Interconnected through a NodePort                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Interconnected through a NodePort                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |

| Dimension                       | Tunnel Network                                                                                                                                                                         | VPC Network                                                                                                                                                                                                                                                                                                                                                                |
|---------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Managing container IP addresses | <ul style="list-style-type: none"> <li>• Separate container CIDR blocks needed</li> <li>• Container CIDR blocks divided by node and dynamically added after being allocated</li> </ul> | <ul style="list-style-type: none"> <li>• Separate container CIDR blocks needed</li> <li>• Container CIDR blocks divided by node and statically allocated (the allocated CIDR blocks cannot be changed after a node is created)</li> </ul>                                                                                                                                  |
| Network performance             | Performance loss due to VXLAN encapsulation                                                                                                                                            | No tunnel encapsulation, and cross-node traffic forwarded through VPC routers (The performance is so good that is comparable to that of the host network, but there is a loss caused by NAT.)                                                                                                                                                                              |
| Networking scale                | A maximum of 2000 nodes are supported.                                                                                                                                                 | <p>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.</p> <p>Each time a node is added to the cluster, a route is added to the VPC routing tables. Evaluate the cluster scale that is limited by the VPC routing tables before creating the cluster.</p> |

## 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.

## 22.7.2 Executing the Pre- or Post-installation Commands During Node Creation

### Background

When creating a node, use the pre- or -installation commands to install tools or perform security hardening on the node. This section provides guidance for you to correctly use the pre- or post-installation scripts.

### Precautions

- Do not use pre- or post-installation scripts that take a long time to execute. The pre-installation script has a 15-minute time limit, while the post-installation script has a 30-minute time limit. If the node is not available within the designated time, the node reclaim process will be initiated. Therefore, do not use pre- or post-installation scripts that take a long time to execute.
- Do not directly use **reboot** in the script. CCE executes the post-installation command after installing mandatory components on a node. The node will be available only after the post-installation command is executed. If you run **reboot** directly, the node may be restarted before its status is reported. As a result, it cannot reach the running state within 30 minutes, and a rollback due to timeout will be triggered. Therefore, do not use **reboot**.

If you need to restart a node, perform the following operations:

- Run **shutdown -r <time >** in the script to delay the restart. For example, you can run **shutdown -r 1** to delay the restart for 1 minute.
- After the node is available, manually restart it.

### Procedure

- Step 1** Log in to the CCE console. In the navigation pane, choose **Clusters**. Click the target cluster name to access the cluster console.
- Step 2** Choose **Nodes** in the navigation pane, click the **Nodes** tab, click **Create Node** in the right corner, and configure the parameters.
- Step 3** In the **Advanced Settings** area, enter pre- or post-installation commands.



For example, you can create iptables rules by running a post-installation command to allow a maximum of 25 TCP data packets to be addressed to port 80 per minute and allow a maximum of 100 data packets to be addressed to the port when the limit is exceeded to prevent DDoS attacks.

```
iptables -A INPUT -p tcp --dport 80 -m limit --limit 25/minute --limit-burst 100 -j ACCEPT
```

#### NOTE

The command example here is for reference only.

**Step 4** After the configuration, enter the number of nodes to be created and click **Next: Confirm**.

**Step 5** Click **Submit**.

----End

## 22.7.3 Connecting to Multiple Clusters Using kubectl

### Background

The kubectl command line tool relies on the kubeconfig configuration file to locate the necessary authentication information to select a cluster and communicate with its API server. By default, kubectl uses the **\$HOME/.kube/config** file as the credential for accessing the cluster.

When working with CCE clusters on a daily basis, it is common to manage multiple clusters simultaneously. However, this can make using the kubectl command line tool to connect to clusters cumbersome, as it requires frequent switching of the kubeconfig file during routine O&M. This section introduces how to connect to multiple clusters using the same kubectl client.

#### NOTE

The file used to configure cluster access is called the kubeconfig file, but it does not mean that the file name is **kubeconfig**.

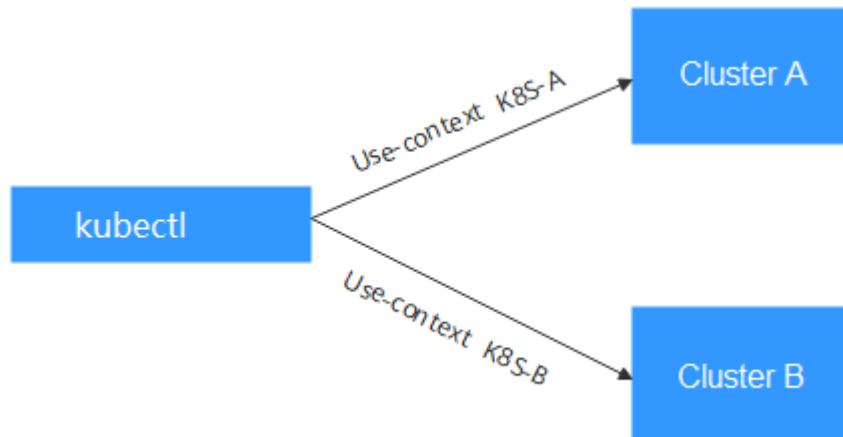
### Solution

When performing O&M on Kubernetes clusters, it is often necessary to switch between multiple clusters. The following shows some typical solutions for cluster switchover:

- **Solution 1:** Specify **--kubeconfig** of kubectl to select the kubeconfig file used by each cluster and use aliases to simplify commands.
- **Solution 2:** Combine clusters, users, and credentials in multiple kubeconfig files into one configuration file and run **kubectl config use-context** to switch clusters.

Compared with solution 1, this solution requires manual configuration of the kubeconfig file, which is relatively complex.

Figure 22-5 Using kubectl to connect to multiple clusters



## Prerequisites

- You have a Linux VM with the kubectl command line tool installed. The kubectl version must match the cluster version. For details, see [Install Tools](#).
- The VM where kubectl is installed must be able to access the network of each cluster.

## kubeconfig File Structure

kubeconfig is the configuration file of kubectl. You can download it on the cluster details page.

The content of the kubeconfig file is as follows:

```
{
 "kind": "Config",
 "apiVersion": "v1",
 "preferences": {},
 "clusters": [{
 "name": "internalCluster",
 "cluster": {
 "server": "https://192.168.0.85:5443",
 "certificate-authority-data": "LS0tLS1CRUULIE..."
 }
 }, {
 "name": "externalCluster",
 "cluster": {
 "server": "https://xxx.xxx.xxx.xxx:5443",
 "insecure-skip-tls-verify": true
 }
 }
],
 "users": [{
 "name": "user",
 "user": {
 "client-certificate-data": "LS0tLS1CRUdJTjBDRVJ...",
 "client-key-data": "LS0tLS1CRUdJTjBS..."
 }
 }
],
 "contexts": [{
 "name": "internal",
 "context": {
 "cluster": "internalCluster",
 "user": "user"
 }
 }
]
```

```

 }
 }, {
 "name": "external",
 "context": {
 "cluster": "externalCluster",
 "user": "user"
 }
 }
}],
"current-context": "external"
}

```

It mainly consists of three sections.

- **clusters**: describes the cluster information, mainly the access address of the cluster.
- **users**: describes information about the users who access the cluster. It includes the **client-certificate-data** and **client-key-data** certificate files.
- **contexts**: describes the configuration contexts. You switch between contexts to access different clusters. A context is associated with **user** and **cluster**, that is, it defines which user accesses which cluster.

The preceding kubeconfig defines the private network address and public network address of the cluster as two clusters with two different contexts. You can switch the context to use different addresses to access the cluster.

## Solution 1: Specify Different kubeconfig Files in Commands

**Step 1** Log in to the VM where kubectl is installed.

**Step 2** Download the kubeconfig files of the two clusters to the **/home** directory on the kubectl client. The following names are taken as examples.

| Cluster Name | kubeconfig File Name |
|--------------|----------------------|
| Cluster A    | kubeconfig-a.json    |
| Cluster B    | kubeconfig-b.json    |

**Step 3** Make kubectl access cluster A by default and move the **kubeconfig-a.json** file to **\$HOME/.kube/config**.

```

cd /home
mkdir -p $HOME/.kube
mv -f kubeconfig-a.json $HOME/.kube/config

```

**Step 4** Move the **kubeconfig-b.json** file of cluster B to **\$HOME/.kube/config-test**.

```

mv -f kubeconfig-b.json $HOME/.kube/config-test

```

The name of the **config-test** file can be customized.

**Step 5** Add **--kubeconfig** to specify the credential used by the kubectl commands when accessing cluster B. (There is no need to add **--kubeconfig** when running kubectl commands to access cluster A, because kubectl can access cluster A by default.) For example, run the following command to check the nodes in cluster B:

```

kubectl --kubeconfig=$HOME/.kube/config-test get node

```

If you frequently use a long command, the preceding method can be inconvenient. To simplify the command, you can use aliases. For example:

```

alias ka='kubectl --kubeconfig=$HOME/.kube/config'
alias kb='kubectl --kubeconfig=$HOME/.kube/config-test'

```

In the preceding information, **ka** and **kb** can be custom aliases. When running the `kubectl` command, you can directly enter **ka** or **kb** to replace **kubectl**. The `--kubeconfig` parameter is automatically added. For example, the command for checking nodes in cluster B can be simplified as follows:

```
kb get node
```

----End

## Solution 2: Combine the kubeconfig Files of the Two Clusters Together

The following steps walk you through the procedure of modifying the kubeconfig files and accessing multiple clusters.

This example configures only the public network access to the clusters. If you want to access multiple clusters over private networks, retain the **clusters** field and ensure that the clusters can be accessed over private networks. Its configuration is similar to that described in this example.

**Step 1** Download the kubeconfig files of the two clusters and delete the lines related to private network access, as shown in the following figure.

- Cluster A:

```
{
 "kind": "Config",
 "apiVersion": "v1",
 "preferences": {},
 "clusters": [{
 "name": "externalCluster",
 "cluster": {
 "server": "https://119.xxx.xxx.xxx:5443",
 "insecure-skip-tls-verify": true
 }
 }
],
 "users": [{
 "name": "user",
 "user": {
 "client-certificate-data": "LS0tLS1CRUdJTzM...",
 "client-key-data": "LS0tLS1CRUdJTjB..."
 }
 }
],
 "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": "LS0rTUideUdJTjB...."
 }
]],
 "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": "LS0tLS1CRUdJTjB...."
 }
 }
]],
 "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": "LS0rTUideUdJTjB...."
 }
 }
]],
 "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": "LS0tLS1CRUdJTzM...",
 "client-key-data": "LS0tLS1CRUdJTjB..."
 }
 },
 {
 "name": "Cluster-B-user",
 "user": {
 "client-certificate-data": "LS0tLS1CRUdJTzM...",
 "client-key-data": "LS0rTUideUdJTjB..."
 }
 }
],
 "contexts": [{
 "name": "Cluster-A-Context",
 "context": {
 "cluster": "Cluster-A",
 "user": "Cluster-A-user"
 }
 },
 {
 "name": "Cluster-B-Context",
 "context": {
 "cluster": "Cluster-B",
 "user": "Cluster-B-user"
 }
 }
],
 "current-context": "Cluster-A-Context"
}
```

**Step 4** Run the following command to copy the combined file to the kubect configuration path:

```
mkdir -p $HOME/.kube
```

```
mv -f kubeconfig.json $HOME/.kube/config
```

**Step 5** Run the `kubectl` command to check whether the two clusters can be accessed.

```
kubectl config use-context Cluster-A-Context
Switched to context "Cluster-A-Context".
kubectl cluster-info
Kubernetes control plane is running at https://119.xxx.xxx.xxx:5443
CoreDNS is running at https://119.xxx.xxx.xxx:5443/api/v1/namespaces/kube-system/services/coresdns/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/coresdns/dns/proxy
```

To further debug and diagnose cluster problems, use 'kubectl cluster-info dump'.

If you frequently use a long command, the preceding method can be inconvenient. To simplify the command, you can use aliases. For example:

```
alias ka='kubectl config use-context Cluster-A-Context;kubectl'
alias kb='kubectl config use-context Cluster-B-Context;kubectl'
```

In the preceding information, **ka** and **kb** can be custom aliases. When running the `kubectl` command, you can directly enter **ka** or **kb** to replace **kubectl**. You need to switch the context and then run the `kubectl` command. For example:

```
ka cluster-info
Switched to context "Cluster-A-Context".
Kubernetes control plane is running at https://119.xxx.xxx.xxx:5443
CoreDNS is running at https://119.xxx.xxx.xxx:5443/api/v1/namespaces/kube-system/services/coresdns/dns/proxy
```

To further debug and diagnose cluster problems, use 'kubectl cluster-info dump'.

----End

## 22.7.4 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 for the thinpool volume requires 80% of the container engine and container image storage capacity.
- Capacity for storing temporary kubelet and emptyDir requires 10% of the data disk capacity.

On a node using the Device Mapper storage driver, when an image is pulled, the .tar package is temporarily stored in the dockersys volume. After the .tar package is decompressed, the image file is stored in the thinpool volume, and the package in the dockersys volume will be deleted. Therefore, during image pull, ensure that the 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 a data disk on the EVS console.

Only the storage capacity of the EVS disk is expanded. You also need to perform the following steps to expand the capacity of the logical volume and file system.

**Step 2** Log in to the CCE console and click the cluster. In the navigation pane, choose **Nodes**. Click **More > Sync Server Data** in the row containing the target node.

**Step 3** Log in to the target node.

**Step 4** Run the **lsblk** command to check the block device information of the node.

A data disk is divided depending on the container storage **Rootfs**:

Overlayfs: No independent thin pool is allocated. Image data is stored in **dockersys**.

1. Check the disk and partition sizes of the device.

```
lsblk
NAME MAJ:MIN RM SIZE RO TYPE MOUNTPOINT
vda 8:0 0 50G 0 disk
└─vda1 8:1 0 50G 0 part /
vdb 8:16 0 200G 0 disk # Data disk has been expanded but not allocated
└─vgpaas-dockersys 253:0 0 90G 0 lvm /var/lib/containerd # Space used by the
 container engine
└─vgpaas-kubernetes 253:1 0 10G 0 lvm /mnt/paas/kubernetes/kubelet # Space used by
 Kubernetes
```

2. Expand the disk capacity.

Add the new disk capacity to the **dockersys** logical volume used by the container engine.

- a. Expand the PV capacity so that LVM can identify the new EVS capacity. `/dev/vdb` specifies the physical volume where dockersys is located.

```
pvresize /dev/vdb
```

Information similar to the following is displayed:

```
Physical volume "/dev/vdb" changed
1 physical volume(s) resized or updated / 0 physical volume(s) not resized
```

- b. Expand 100% of the free capacity to the logical volume. `vgpaas/dockersys` specifies the logical volume used by the container engine.

```
lvextend -l+100%FREE -n vgpaas/dockersys
```

Information similar to the following is displayed:

```
Size of logical volume vgpaas/dockersys changed from <90.00 GiB (23039 extents) to <190.00
GiB (48639 extents).
Logical volume vgpaas/dockersys successfully resized.
```

- c. Adjust the size of the file system. `/dev/vgpaas/dockersys` specifies the file system path of the container engine.

```
resize2fs /dev/vgpaas/dockersys
```

Information similar to the following is displayed:

```
Filesystem at /dev/vgpaas/dockersys is mounted on /var/lib/containerd; on-line resizing required
old_desc_blocks = 12, new_desc_blocks = 24
The filesystem on /dev/vgpaas/dockersys is now 49807360 (4k) blocks long.
```

Devicemapper: A thin pool is allocated to store image data.

1. Check the disk and partition sizes of the device.

```
lsblk
NAME MAJ:MIN RM SIZE RO TYPE MOUNTPOINT
vda 8:0 0 50G 0 disk
├─vda1 8:1 0 50G 0 part /
└─vgdb 8:16 0 200G 0 disk
 └─vgpaas-dockersys 253:0 0 18G 0 lvm /var/lib/docker
 └─vgpaas-thinpool_tmeta 253:1 0 3G 0 lvm
 └─vgpaas-thinpool 253:3 0 67G 0 lvm # Space used by thinpool
 ...
 └─vgpaas-thinpool_tdata 253:2 0 67G 0 lvm
 └─vgpaas-thinpool 253:3 0 67G 0 lvm
 ...
 └─vgpaas-kubernetes 253:4 0 10G 0 lvm /mnt/paas/kubernetes/kubelet
```

2. Expand the disk capacity.

Option 1: Add the new disk capacity to the thin pool disk.

- a. Expand the PV capacity so that LVM can identify the new EVS capacity. `/dev/vdb` specifies the physical volume where thinpool is located.  
`pvresize /dev/vdb`

Information similar to the following is displayed:

```
Physical volume "/dev/vdb" changed
1 physical volume(s) resized or updated / 0 physical volume(s) not resized
```

- b. Expand 100% of the free capacity to the logical volume. `vgpaas/thinpool` specifies the logical volume used by the container engine.  
`lvextend -l+100%FREE -n vgpaas/thinpool`

Information similar to the following is displayed:

```
Size of logical volume vgpaas/thinpool changed from <67.00 GiB (23039 extents) to <167.00 GiB (48639 extents).
Logical volume vgpaas/thinpool successfully resized.
```

- c. Do not need to adjust the size of the file system, because the thin pool is not mounted to any devices.

Option 2: Add the new disk capacity to the **dockersys** disk.

- a. Expand the PV capacity so that LVM can identify the new EVS capacity. `/dev/vdb` specifies the physical volume where dockersys is located.  
`pvresize /dev/vdb`

Information similar to the following is displayed:

```
Physical volume "/dev/vdb" changed
1 physical volume(s) resized or updated / 0 physical volume(s) not resized
```

- b. Expand 100% of the free capacity to the logical volume. `vgpaas/dockersys` specifies the logical volume used by the container engine.  
`lvextend -l+100%FREE -n vgpaas/dockersys`

Information similar to the following is displayed:

```
Size of logical volume vgpaas/dockersys changed from <18.00 GiB (7679 extents) to <118.00 GiB (33279 extents).
Logical volume vgpaas/dockersys successfully resized.
```

- c. Adjust the size of the file system. `/dev/vgpaas/dockersys` specifies the file system path of the container engine.  
`resize2fs /dev/vgpaas/dockersys`

Information similar to the following is displayed:

```
Filesystem at /dev/vgpaas/dockersys is mounted on /var/lib/docker; on-line resizing required
old_desc_blocks = 4, new_desc_blocks = 16
The filesystem on /dev/vgpaas/dockersys is now 49807360 (4k) blocks long.
```

----End

## 22.7.5 Protecting a CCE Cluster Against Overload

As services grow, the Kubernetes cluster scales up, putting more pressure on the control plane. If the control plane cannot handle the load, clusters may fail to provide services. This section explains the symptoms, impact, and causes of cluster overload, as well as how CCE clusters can protect against overload. It also provides recommended measures for protecting against overload.

### What Is Cluster Overload?

An overloaded cluster can cause delays in Kubernetes API responses and increase the resource usage on master nodes. In severe cases, the APIs may fail to respond, master nodes may become unusable, and the entire cluster may malfunction.

When a cluster is overloaded, both the control plane and the services that rely on it are impacted. The following lists some scenarios that may be affected:

- Kubernetes resource management: Creating, deleting, updating, or obtaining Kubernetes resources may fail.
- Kubernetes distributed leader selection: In distributed applications based on Kubernetes Leases, leaders may restart due to lease renewal request timeout.

#### NOTE

For example, if the lease renewal of the controller component of the NPD add-on fails, an active/standby switchover is triggered. This means that the active instance will restart, and the standby instance will take over services, ensuring that there is no impact on services.

- Cluster management: When a cluster is severely overloaded, it may become unavailable. In this case, cluster management operations, such as creating or deleting nodes, cannot be performed.

Common causes of cluster overload are as follows:

- The cluster resource data volume is too large.  
etcd and kube-apiserver are two core components of the cluster control plane. etcd serves as the background database that stores all cluster data, while kube-apiserver acts as the entry point for processing requests. kube-apiserver caches cluster data to lessen the burden on etcd, and other core components in the cluster also cache various resources and monitor changes to these resources.  
However, if the cluster resource data volume is too large, the control plane resource usage remains high, leading to overload when the resource data volume exceeds the bearing capability.
- A large amount of data is obtained from a client. For example, a large number of LIST requests are initiated or a single LIST request is sent to obtain a large amount of data.

Assume that a client uses field selectors to obtain pod data in a cluster and needs to obtain data from etcd (although the client can also get data from the kube-apiserver cache). Data in etcd cannot be obtained by field, so kube-apiserver must get all pod data from etcd, replicate, and serialize structured pod data, and then respond to the client request.

When the client sends a LIST request, it may need to be processed by multiple control plane components, resulting in a larger amount of data to be processed and a more complex data type. As a result, when the client gets a large amount of data, resource usages on etcd and API server remain high. If the bearing capability is exceeded, the cluster becomes overloaded.

## CCE Overload Control

- **Overload control:** CCE clusters have supported overload control since v1.23, which reduces the number of LIST requests outside the system when the control plane experiences high resource usage pressure. To use this function, enable overload control for your clusters. For details, see [Cluster Overload Control](#).
- **Optimized processes on LIST requests:** Starting from CCE clusters of v1.23.8-r0 and v1.25.3-r0, processes on LIST requests have been optimized. Even if a client does not specify the **resourceVersion** parameter, kube-apiserver responds to requests based on its cache to avoid additional etcd queries and ensure that the response data is up to date. Additionally, namespace indexes are now added to the kube-apiserver cache. This means that when a client requests a specified resource in a specified namespace, it no longer needs to obtain resources belonging to the namespace based on full data. This effectively reduces the response delay and control plane memory overhead.
- **Refined traffic limiting policy on the server:** The API Priority and Fairness (APF) feature is used to implement fine-grained control on concurrent requests. For details, see [API Priority and Fairness](#).

## Suggestions

The following provides measures and suggestions you can take to prevent clusters from being overloaded.

## Upgrading the Cluster Version

As the CCE cluster version evolves, new overload protection features and optimizations are regularly introduced. It is recommended that you promptly upgrade your clusters to the latest version. For details, see [Upgrading a Cluster](#).

## Enabling Overload Control

After overload control is enabled, concurrent LIST requests outside the system will be dynamically controlled based on the resource demands received by master nodes to ensure the stable running of the master nodes and the cluster.

For details, see [Cluster Overload Control](#).

## Enabling Observability

Observability is crucial for maintaining the reliability and stability of clusters. By using monitoring, alarms, and logs, administrators can gain a better

understanding of the clusters' performance, promptly identify any issues, and take corrective action in a timely manner.

### Monitoring configurations

- You can check the monitoring information about master nodes on the **Overview** page of the CCE cluster console.

## Controlling Data Volume of Resources

When the resource data volume in a cluster is too large, it can negatively impact etcd performance, including data read and write latency. Additionally, if the data volume of a single type of resource is too large, the control plane consumes a significant number of resources when a client requests all the resources. To avoid these issues, it is recommended that you keep both the etcd data volume and the data volume of a single type of resources under control.

**Table 22-11** Recommended maximum etcd data volume for different cluster scales

| Cluster Scale                                  | 50 Nodes | 200 Nodes | 1,000 Nodes | 2,000 Nodes |
|------------------------------------------------|----------|-----------|-------------|-------------|
| Total etcd data capacity                       | 500Mi    | 1Gi       | 4Gi         | 8Gi         |
| etcd data volume of a single type of resources | 50Mi     | 100Mi     | 400Mi       | 800Mi       |

## Clearing Up Unused Resources

To prevent a large number of pending pods from consuming extra resources on the control plane, it is recommended that you promptly clear up Kubernetes resources that are no longer in use, such as ConfigMaps, Secrets, and PVCs.

## Optimizing the Client Access Mode

- To avoid frequent LIST queries, it is best to use the client cache mechanism when retrieving cluster resource data multiple times. It is recommended that you communicate with clusters using informers and listers. For details, see [client-go documentation](#).

If a LIST query must be used, you can:

- Obtain needed data from the kube-apiserver cache first and avoid making additional queries on etcd data. For clusters earlier than v1.23.8-r0 and v1.25.3-r0, you can set **resourceVersion** to **0**. In clusters of v1.23.8-r0, v1.25.3-r0, and later versions, CCE has improved the way data is retrieved and ensured that the cached data is up to date. By default, you can access the required data from the cache.
- Accurately define the query scope to avoid retrieving irrelevant data and using unnecessary resources. For example:

```
client-go Code example for obtaining pods in a specified namespace
k8sClient.CoreV1().Pods("<your-namespace>").List(metav1.ListOptions{}
```

```
kubectl Command example for obtaining pods in a specified namespace
kubectl get pods -n <your-namespace>
```

- Use the more efficient Protobuf format instead of the JSON format. By default, Kubernetes returns objects serialized to JSON with content type **application/json**. This is the default serialization format for the API. However, clients may request the more efficient Protobuf representation of these objects for better performance. For details, see [Alternate representations of resources](#).

## Changing the Cluster Scale

If the resource usage on the master nodes in a cluster remains high for a long time, for example, the memory usage is greater than 85%, it is recommended that you promptly increase the cluster management scale. This will prevent the cluster from becoming overloaded during sudden traffic surges. For details, see [Changing Cluster Scale](#).

### NOTE

- The performance of the master nodes improves and their specifications become higher as the management scale of a cluster increases.
- The CCE cluster management scale is the maximum number of nodes that a cluster can manage. It is used as a reference during service deployment planning, and the actual quantity of nodes in use may not reach the maximum number of nodes selected. The actual scale depends on various factors, including the type, quantity, and size of resource objects in the cluster, as well as the number of external accesses to the cluster control plane.

## Splitting the Cluster

The Kubernetes architecture has a performance bottleneck, meaning that the scale of a single cluster cannot be expanded indefinitely. If your cluster has 2,000 worker nodes, it is necessary to split the services and deploy them across multiple clusters. If you encounter any issues with splitting a cluster, submit a service ticket for technical support.

## Conclusion

When running services on Kubernetes clusters, their performance and availability are influenced by various factors, including the cluster scale, number and size of resources, and resource access. CCE has optimized cluster performance and availability based on cloud native practices and has developed measures to protect against cluster overload. You can use these measures to ensure that your services run stably and reliably over the long term.

# 22.8 Networking

## 22.8.1 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.

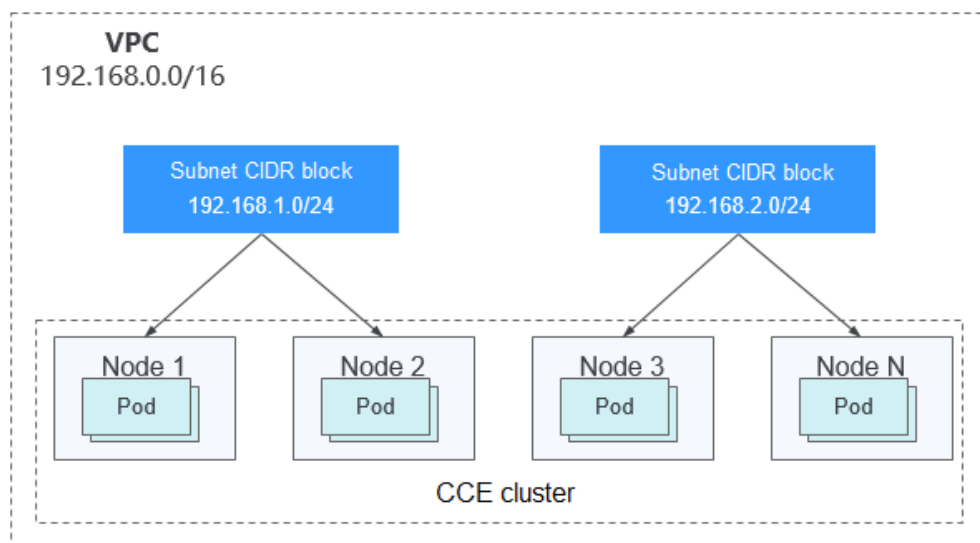
## Constraints

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 22-6** 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.

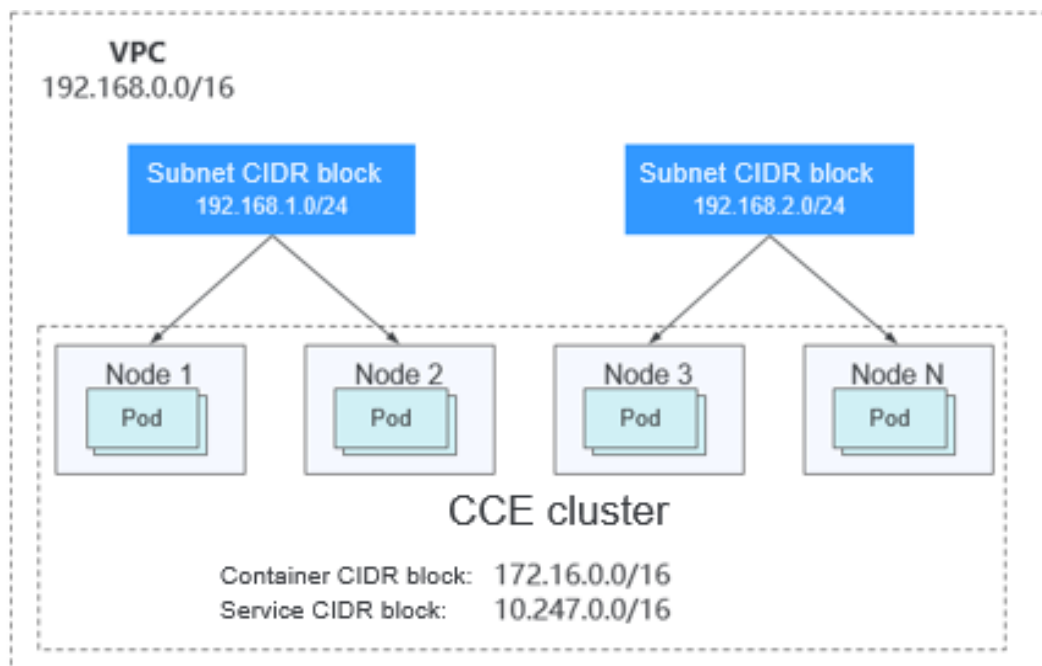
- Service CIDR Block**  
 Service is also a Kubernetes concept. Each Service has an address. When creating a cluster on CCE, you can specify the Service CIDR block. Similarly, the Service CIDR block cannot overlap with the subnet CIDR block or the container CIDR block. The Service CIDR block can be used only within a cluster.

## Single-VPC Single-Cluster Scenarios

**CCE Clusters:** include clusters in VPC network model and container tunnel network model. **Figure 22-7** 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 22-7** Network CIDR block planning in single-VPC single-cluster scenarios (CCE cluster)



## Single-VPC Multi-Cluster Scenarios

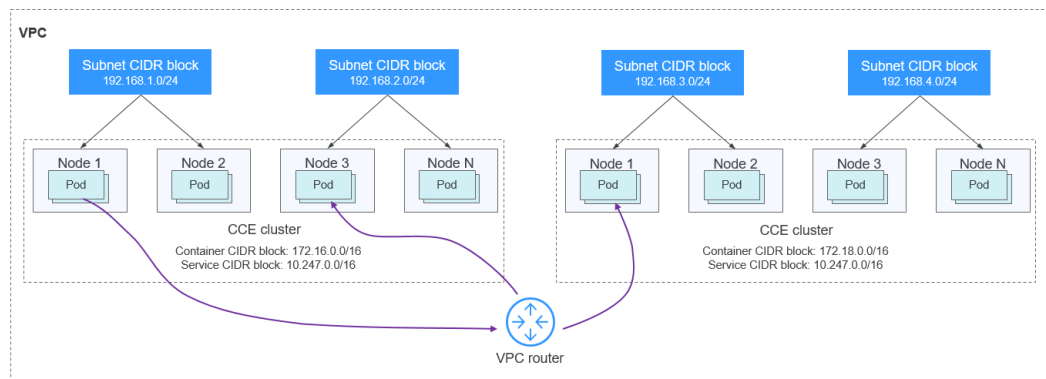
### VPC network model

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 22-8** 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 22-8** VPC network - multi-cluster scenario

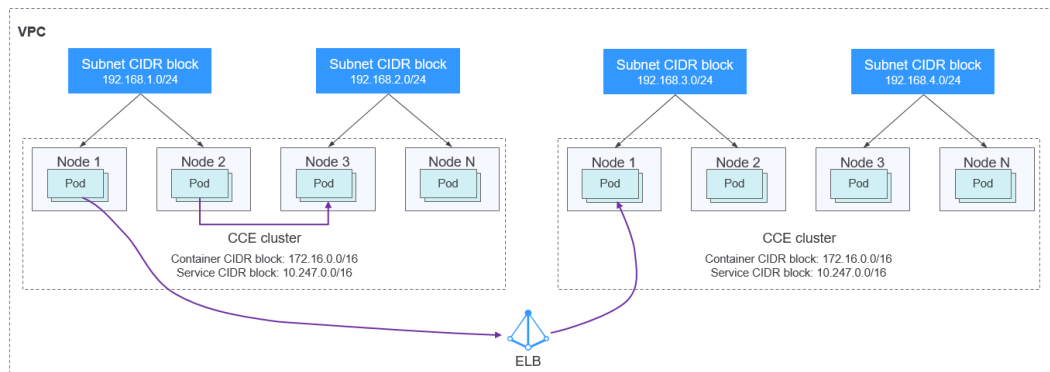


### Tunnel network model

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 22-9** 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 22-9 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.

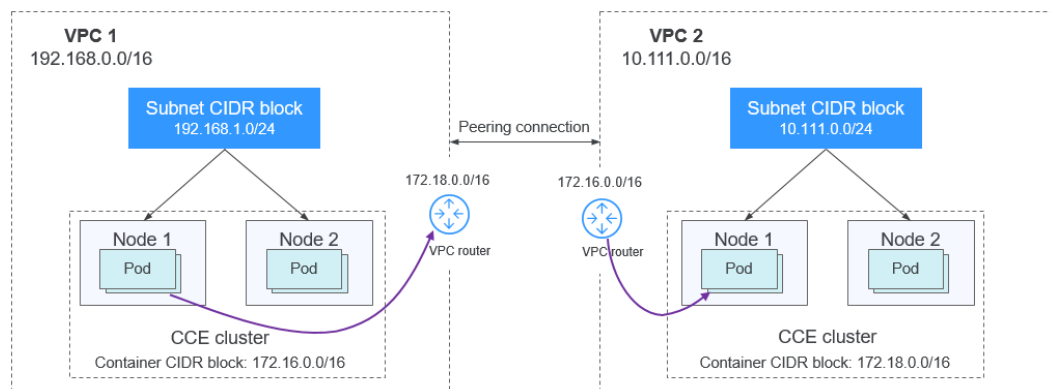
### Cross-VPC Cluster Interconnection

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 22-10 VPC network - VPC interconnection scenario**



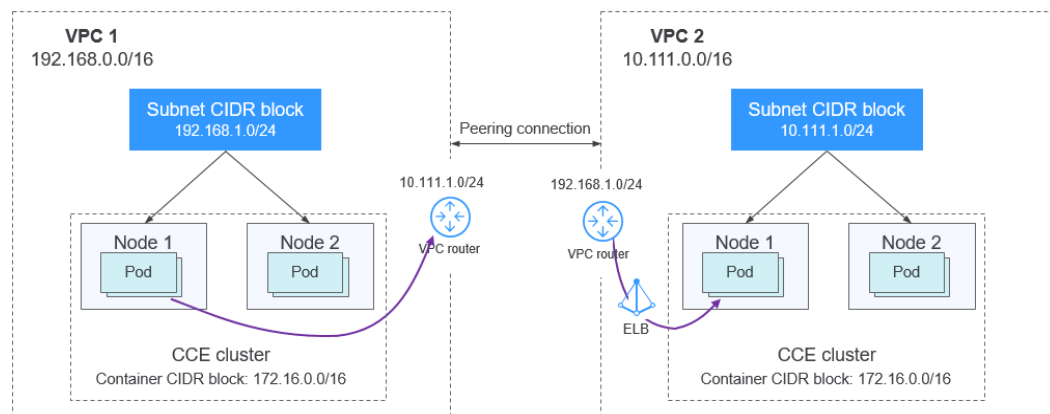
When creating a VPC peering connection between containers across VPCs, pay attention to the following points:

- 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 addresses. 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 22-11** 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 LoadBalancer 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, the pod can access 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, the pod can access 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 route of the container CIDR block 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.

## 22.8.2 Selecting a Network Model

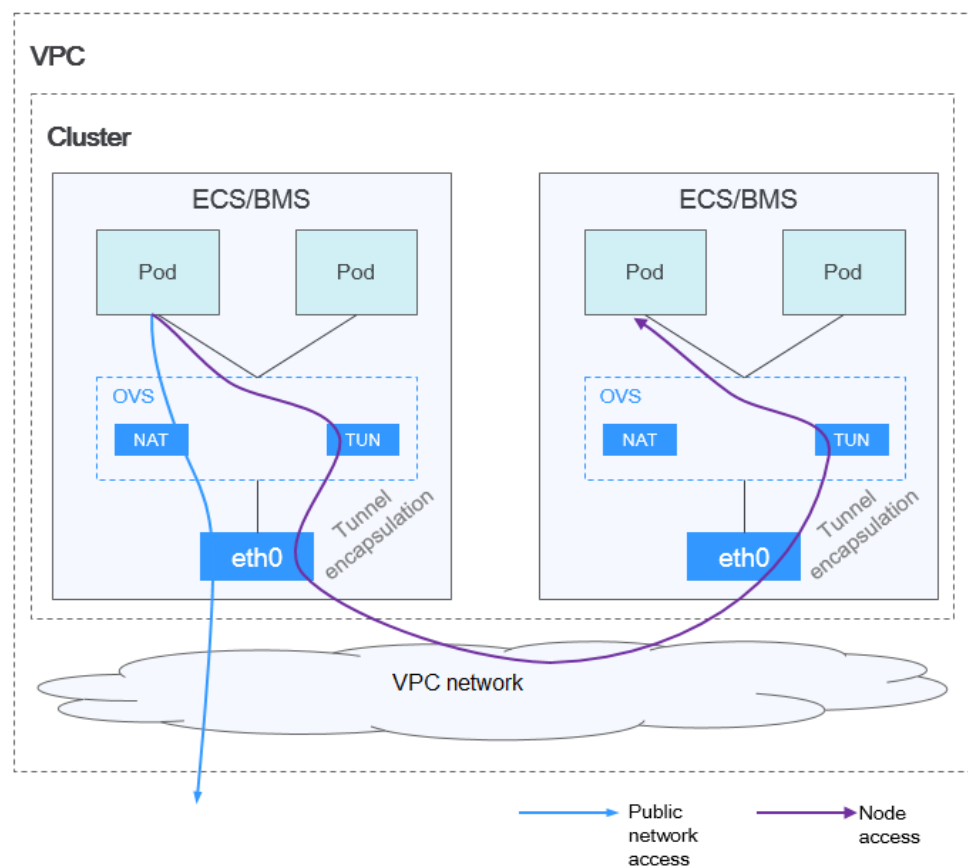
CCE uses proprietary, high-performance container networking add-ons to support the tunnel and VPC network models.

**CAUTION**

After a cluster is created, the network model cannot be changed.

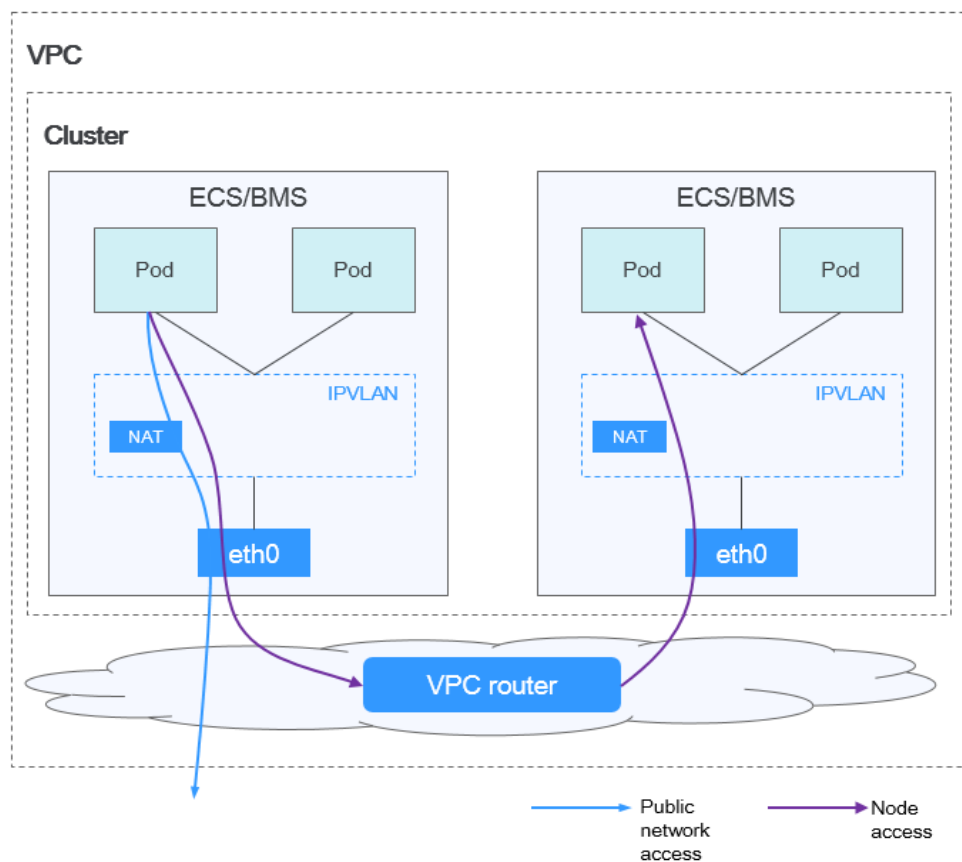
- Tunnel network:** The container network is an overlay tunnel network on top of a VPC network and uses the VXLAN technology. This network model is applicable when there is no high requirements on performance. VXLAN encapsulates Ethernet packets as UDP packets for tunnel transmission. Though at some 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 22-12** 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 22-13 VPC network



The following table lists the differences between the network models.



**Table 22-12** Network model comparison

| Dimension                               | Tunnel Network                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | VPC Network                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
|-----------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Application scenarios                   | <ul style="list-style-type: none"> <li>● 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.</li> <li>● 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.</li> </ul> | <ul style="list-style-type: none"> <li>● 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.</li> <li>● 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.</li> </ul> |
| Core technology                         | OVS                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | IPvlan and VPC route                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| Applicable clusters                     | CCE standard cluster                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | CCE standard cluster                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| Container network isolation             | Kubernetes native NetworkPolicy for pods                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | No                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| Interconnecting pods to a load balancer | Interconnected through a NodePort                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Interconnected through a NodePort                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |

| Dimension                       | Tunnel Network                                                                                                                                                                         | VPC Network                                                                                                                                                                                                                                                                                                                                                                |
|---------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Managing container IP addresses | <ul style="list-style-type: none"> <li>• Separate container CIDR blocks needed</li> <li>• Container CIDR blocks divided by node and dynamically added after being allocated</li> </ul> | <ul style="list-style-type: none"> <li>• Separate container CIDR blocks needed</li> <li>• Container CIDR blocks divided by node and statically allocated (the allocated CIDR blocks cannot be changed after a node is created)</li> </ul>                                                                                                                                  |
| Network performance             | Performance loss due to VXLAN encapsulation                                                                                                                                            | No tunnel encapsulation, and cross-node traffic forwarded through VPC routers (The performance is so good that is comparable to that of the host network, but there is a loss caused by NAT.)                                                                                                                                                                              |
| Networking scale                | A maximum of 2000 nodes are supported.                                                                                                                                                 | <p>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.</p> <p>Each time a node is added to the cluster, a route is added to the VPC routing tables. Evaluate the cluster scale that is limited by the VPC routing tables before creating the cluster.</p> |

**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.

## 22.8.3 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 22-13** 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   | <b>Source IP address:</b><br>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. | <ul style="list-style-type: none"> <li>• Default: 20 minutes</li> <li>• Maximum: 60 minutes</li> <li>• Range: 1 minute to 60 minutes</li> </ul> | <ul style="list-style-type: none"> <li>• Source IP addresses of the clients have changed.</li> <li>• Requests from the clients exceed the session stickiness duration.</li> </ul> |

| OSI Layer | Listener Protocol and Networking   | Sticky Session Type                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | Stickiness Duration                                                                                                                                 | Scenarios Where Sticky Sessions Become Invalid                                                                                                                                                                                  |
|-----------|------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Layer 7   | HTTP- or HTTPS-compliant ingresses | <ul style="list-style-type: none"> <li>• <b>Load balancer cookie:</b> 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.</li> <li>• <b>Application cookie:</b> 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.</li> </ul> | <ul style="list-style-type: none"> <li>• Default: 20 minutes</li> <li>• Maximum: 1440 minutes</li> <li>• Range: 1 minute to 1440 minutes</li> </ul> | <ul style="list-style-type: none"> <li>• If requests sent by the clients do not contain a cookie, sticky sessions will not take effect.</li> <li>• Requests from the clients exceed the session stickiness duration.</li> </ul> |

 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

## 22.8.4 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

#### 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.



## Ngix Ingress

- For an Ngix Ingress that uses a dedicated load balancer, transparent transmission of source IP addresses is enabled by default. This means that you can easily obtain the source IP address of the client without any additional configurations.
- For an Ngix Ingress that uses a shared load balancer, perform the following steps to obtain the source IP address of the client:

**Step 1** Take the Ngix workload as an example. Before configuring the source IP address, obtain the access logs. `nginx-c99fd67bb-ghv4q` indicates the pod name.


```
kubectl logs nginx-c99fd67bb-ghv4q
```

Information similar to the following is displayed:

```
...
10.0.0.7 - - [17/Aug/2023:01:30:11 +0000] "GET / HTTP/1.1" 200 19 "http://114.114.114.114:9421/"
"Mozilla/5.0 (Windows NT 10.0; Win64; x64) AppleWebKit/537.36 (KHTML, like Gecko) Chrome/115.0.0.0
Safari/537.36 Edg/115.0.1901.203" "100.125.**.***"
```

`100.125.**.***` specifies the CIDR block of the load balancer, indicating that the traffic is forwarded through the load balancer.

**Step 2** Enable the function of transferring the client IP address. **This operation is required only when shared load balancers are used. For dedicated load balancers, source IP address-based transparent transmission is enabled by default.**

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** Access the workload again and view the new access log.

```
...
10.0.0.7 - - [17/Aug/2023:02:43:11 +0000] "GET / HTTP/1.1" 304 0 "http://114.114.114.114:9421/"
"Mozilla/5.0 (Windows NT 10.0; Win64; x64) AppleWebKit/537.36 (KHTML, like Gecko) Chrome/115.0.0.0
Safari/537.36 Edg/115.0.1901.203" "124.**.***"
```

The source IP address of the client is obtained.

----End

 NOTE

You can enable WAF for the load balancers used by Nginx Ingress Controllers in clusters, but different WAF modes will affect how Nginx Ingress Controllers obtain the real client IP addresses.

- **Load balancer access in WAF cloud CNAME access mode**

When using the cloud CNAME access mode, requests go through WAF and are checked for protection before being sent to the load balancer. This means that even if the load balancer has transparent transmission of source IP addresses enabled, the client will receive the back-to-source IP address of WAF. Consequently, the Nginx Ingress Controller is unable to obtain the real client IP address by default. In this case, you can edit the NGINX Ingress Controller add-on and add the following configuration to the add-on parameters:

```
{
 "enable-real-ip": "true",
 "forwarded-for-header": "true",
 "proxy-real-ip-cidr": <Back-to-source IP address you obtained from WAF>
}
```

- **Load balancer access in the cloud WAF mode**


This mode is transparent access (non-inline deployment) and supports only dedicated load balancers. In this mode, Nginx Ingress Controllers can obtain the real client IP address by default.

## LoadBalancer

For a LoadBalancer Service, different types of clusters obtain source IP addresses in different scenarios. In some scenarios, source IP addresses cannot be obtained currently.

### VPC and Container Tunnel Network Models

To enable the function of obtaining the source IP address on the console, perform the following steps:

- Step 1** When creating a LoadBalancer Service on the CCE console, set **Service Affinity** to **Node-level** instead of **Cluster-level**.
- Step 2** Go to the ELB console and enable the function of obtaining the client IP address of the listener corresponding to the load balancer. **Transparent transmission of source IP addresses is enabled for dedicated load balancers by default. You do not need to manually enable this function.**
  1. 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**.

## 22.8.5 CoreDNS Configuration Optimization

### 22.8.5.1 Overview

#### Application Scenarios

DNS is one of the important basic services in Kubernetes. When the container DNS policy is not properly configured and the cluster scale is large, DNS resolution may time out or fail. In extreme cases, a large number of services in the cluster may fail to be resolved. This section describes the best practices of CoreDNS configuration optimization in Kubernetes clusters to help you avoid such problems.

#### Solution

CoreDNS configuration optimization includes clients and servers.

On the client, you can optimize domain name resolution requests to reduce resolution latency, and use proper container images and NodeLocal DNSCache to reduce resolution exceptions.

- [Optimizing Domain Name Resolution Requests](#)
- [Selecting a Proper Image](#)
- [Avoiding Occasional DNS Resolution Timeout Caused by IPVS Defects](#)
- [Using NodeLocal DNSCache](#)
- [Upgrading the CoreDNS in the Cluster Timely](#)
- [Adjusting the DNS Configuration of the VPC and VM](#)

On the server, you can adjust the CoreDNS deployment status or CoreDNS configuration to improve the availability and throughput of CoreDNS in the cluster.

- [Monitoring the coredns Add-on](#)
- [Adjusting the CoreDNS Deployment Status](#)
- [Configuring CoreDNS](#)

For more information about CoreDNS configurations, see <https://coredns.io/>.

CoreDNS open source community: <https://github.com/coredns/coredns>

#### Prerequisites

- A CCE cluster has been created.
- You can access the cluster using `kubectl`.
- The CoreDNS add-on is installed in the cluster. The latest version of CoreDNS is recommended.

## 22.8.5.2 Client

### 22.8.5.2.1 Optimizing Domain Name Resolution Requests

DNS resolution is frequently used in Kubernetes clusters. Based on the characteristics of DNS resolution in Kubernetes, you can optimize domain name resolution requests in the following ways.

#### Using a Connection Pool

When a containerized application needs to frequently request another service, you are advised to use a connection pool. The connection pool can cache the link information of the upstream service to avoid the overhead of DNS resolution and TCP link reestablishment for each access.

#### Optimizing the `resolve.conf` File in the Container

The `ndots` and `search` parameters in the `resolve.conf` file determine the domain name resolution efficiency. For details about the two parameters, see [DNS Configuration](#).

#### Optimizing the Domain Name Configuration

When a container needs to access a domain name, configure the domain name based on the following rules to improve the domain name resolution efficiency.

1. When a pod accesses a Service in the same namespace, use `<service-name>`, which indicates the Service name.
2. When a pod accesses a Service across namespaces, use `<service-name>.<namespace-name>`. `namespace-name` indicates the namespace where the Service is located.
3. When a pod accesses an external domain name of a cluster, it uses the FQDN domain name. This type of domain name is specified by adding a period (.) at the end of a common domain name to avoid multiple invalid search attempts caused by search domain combination.

#### Using Local Cache

If the cluster specifications are large and the number of DNS resolution requests is large, you can cache the DNS resolution result on the node. You are advised to use the node DNS to cache NodeLocal DNSCache. For details, see [Using NodeLocal DNSCache to Improve DNS Performance](#).

### 22.8.5.2.2 Selecting a Proper Image

The `musl` library of the Alpine container image differs from the standard `glibc` library in the following aspects:

- Alpine 3.3 and earlier versions do not support the `search` parameter. As a result, search domains cannot be specified for discovering Services.
- Multiple DNS servers configured in `/etc/resolve.conf` are concurrently requested. As a result, NodeLocal DNSCache cannot improve the DNS performance.

- When the same Socket is used to request A and AAAA records concurrently, the Conntrack source port conflict is triggered in the kernel of an earlier version. As a result, packet loss occurs.
- If the domain name cannot be resolved when Alpine is used as the base container image, update the base container image for testing.

For details about the functional differences from glibc, see [Functional differences from glibc](#).

### 22.8.5.2.3 Avoiding Occasional DNS Resolution Timeout Caused by IPVS Defects

#### Description

When kube-proxy uses IPVS load balancing, you may encounter DNS resolution timeout occasionally during CoreDNS scale-in or restart.

This problem is caused by a Linux kernel defect. For details, see <https://github.com/torvalds/linux/commit/35dfb013149f74c2be1ff9c78f14e6a3cd1539d1>.

#### Solution

You can use NodeLocal DNSCache to minimize the impact of IPVS defects. For details, see [Using NodeLocal DNSCache to Improve DNS Performance](#).

### 22.8.5.2.4 Using NodeLocal DNSCache

#### Challenges

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

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

#### Solution

NodeLocal DNSCache can improve the performance of service discovery. For details about NodeLocal DNSCache and how to deploy it in a cluster, see [Using NodeLocal DNSCache to Improve DNS Performance](#).

### 22.8.5.2.5 Upgrading the CoreDNS in the Cluster Timely

CoreDNS provides simple functions and is compatible with different Kubernetes versions. CCE periodically synchronizes bugs from the community and upgrades the coredns add-on. You are advised to periodically upgrade the CoreDNS. The CCE add-on management center supports the CoreDNS installation and upgrade. You can define the CoreDNS version in the cluster. If the version can be upgraded, upgrade the CoreDNS component in the cluster as soon as possible.

You can upgrade CoreDNS in a cluster by performing the following procedure:

**Step 1** Log in to the CCE console, select a cluster, and click **Add-ons** in the navigation pane.

**Step 2** In the **Add-on Installed**, locate the coredns add-on and click **Upgrade**.

**Step 3** Set parameters.

----End

### 22.8.5.2.6 Adjusting the DNS Configuration of the VPC and VM

When the coredns add-on is started, it obtains the DNS configuration in the **resolve.conf** file from the deployed instance by default and uses the configuration as the upstream resolution server address. Before the coredns add-on is restarted, the **resolve.conf** configuration on the node is not reloaded. Suggestions:

- Ensure that the **resolve.conf** configuration of each node in the cluster is the same. In this way, the coredns add-on can schedule requests to any node in the cluster.
- When modifying the **resolve.conf** file, if the node has a coredns add-on, restart the coredns add-on timely to ensure status consistency.

## 22.8.5.3 Server

### 22.8.5.3.1 Monitoring the coredns Add-on

- CoreDNS exposes health metrics such as resolution results through the standard Prometheus API to detect exceptions on the CoreDNS server or even upstream DNS server.
- Port for obtaining coredns metrics. The default zone listening IP address is **{*\$POD\_IP*}:9153**. Retain the default value. Otherwise, Prometheus cannot collect the metrics.
- If you use on-premises Prometheus to monitor Kubernetes clusters, you can observe related metrics on Prometheus and configure alarms for the key metrics. For details, see [prometheus](#).

### 22.8.5.3.2 Adjusting the CoreDNS Deployment Status

In CCE clusters, the CoreDNS add-on is installed by default, and it can run on the same cluster nodes as your service containers. You need to pay attention to the following points when deploying CoreDNS:

- [Properly Changing the Number of CoreDNS Replicas](#)
- [Properly Deploying the CoreDNS Pods](#)
- [Deploying CoreDNS Separately Using Custom Parameters](#)
- [Automatically Expanding the CoreDNS Capacity Based on the HPA](#)

## Properly Changing the Number of CoreDNS Replicas

You are advised to set the number of CoreDNS replicas to at least 2 in any case and keep the number of replicas within a proper range to support the resolution of the entire cluster. The default number of pods for installing the add-on in a CCE cluster is 2.

- Modifying the number of CoreDNS replicas, CPUs, and memory size will change CoreDNS' parsing capability. Therefore, evaluate the impact before the operation.
- By default, podAntiAffinity (pod anti-affinity) is configured for the add-on. If a node already has a CoreDNS pod, no new pod can be added. That is, only one CoreDNS pod can run on a node. If there are more configured CoreDNS replicas than cluster nodes, the excess pods cannot be scheduled. Therefore, keep the number of replicas less than or equal to the number of nodes.

## Properly Deploying the CoreDNS Pods

- By default, podAntiAffinity (pod anti-affinity) is configured for CoreDNS, so CoreDNS pods are forcibly deployed on different nodes in a cluster. It is recommended that you deploy CoreDNS pods on nodes in different AZs to prevent the add-on from being interrupted by faults in a single AZ.
- The CPU and memory of the cluster node where the coredns add-on runs must not be used up. Otherwise, the QPS and response of domain name resolution will be affected. It is recommended that you use the custom parameters to [deploy CoreDNS separately](#).

## Deploying CoreDNS Separately Using Custom Parameters

It is recommended that CoreDNS be deployed separately from resource-intensive workloads to prevent CoreDNS performance deterioration or unavailability due to service fluctuation. You can customize parameters to deploy CoreDNS on a dedicated node.

### NOTE

There should be more nodes than CoreDNS pods. You need to avoid deploying multiple CoreDNS pods on a single node.

**Step 1** Log in to the CCE console and click the cluster name to access the cluster console. In the navigation pane, choose **Nodes**.

**Step 2** Click the **Nodes** tab, select the node dedicated for CoreDNS, and click **Labels and Taints** above the node list.

Add the following labels:

- Key: **node-role.kubernetes.io/coredns**
- Value: **true**

Add the following taints:

- Key: **node-role.kubernetes.io/coredns**
- Value: **true**
- Effect: **NoSchedule**

**Step 3** In the navigation pane, choose **Add-ons**, locate **CoreDNS**, and click **Edit**.

**Step 4** Select Custom Policies for **Node Affinity** and add the preceding node label.

Add tolerations for the preceding taint.

**Step 5** Click **OK**.

----End

## Automatically Expanding the CoreDNS Capacity Based on the HPA

HPA frequently scales down the number of the coredns add-on replicas. Therefore, you are advised not to use HPA. If HPA is required, you can configure HPA auto scaling policies using the CCE Advanced HPA add-on. The process is as follows:

**Step 1** Log in to the CCE console and click the name of the target cluster to access the cluster console. In the navigation pane, choose **Add-ons**, locate the **CCE Advanced HPA** add-on on the right, and click **Install**.

**Step 2** Configure the add-on parameters and click **Install**.

**Step 3** In the navigation pane, choose **Workloads**, select the **kube-system** namespace, locate the row containing the CoreDNS pod, and click **Auto Scaling** in the **Operation** column.

In the **HPA Policies** area, you can customize HPA policies based on metrics such as CPU usage and memory usage to automatically scale out the CoreDNS pods.

**Step 4** Click **Create**. If the latest status is **Started**, the policy has taken effect.

----End

### 22.8.5.3.3 Configuring CoreDNS

On the console, the CoreDNS add-on can only be configured with the preset specifications, which can satisfy most of the service requirements. In some scenarios where there are requirements on the CoreDNS resource usage, you may need to customize the add-on specifications.

CoreDNS official document: <https://coredns.io/plugins/>

## Configuring CoreDNS Specifications

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

**Step 2** In the navigation pane, choose **Add-ons**. On the displayed page, click **Edit** under **CoreDNS**. The add-on details page is displayed.

**Step 3** In the **Specifications** area, configure coredns specifications.

**Step 4** Change the number of pods, CPU quotas, and memory quotas as needed to adjust the domain name resolution QPS provided by CoreDNS.

**Step 5** Click **OK**.

----End

## Properly Configuring the Stub Domain for DNS

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

**Step 2** In the navigation pane, choose **Add-ons**. Then, click **Edit** under **CoreDNS**.



- Step 3** Add a stub domain in the **Parameters** area. The format is a key-value pair. The key is a DNS suffix domain name, and the value is a DNS IP address or a group of DNS IP addresses, for example, **consul.local -- 10.150.0.1**.
- 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 {$POD_IP}
 cache 30 {
 servfail 5s
 }
 errors
 health {$POD_IP}:8080
 kubernetes cluster.local in-addr.arpa ip6.arpa {
 pods insecure
 fallthrough in-addr.arpa ip6.arpa
 }
 loadbalance round_robin
 prometheus {$POD_IP}:9153
 forward . /etc/resolv.conf {
 policy random
 }
 reload
 ready {$POD_IP}:8081
}
consul.local:5353 {
 bind {$POD_IP}
 errors
 cache 30
 forward . 10.150.0.1
}

----End
```

## Properly Configuring the Host

To specify hosts for a specific domain name, you can use the hosts add-on. An example is as follows:

- Step 1** Log in to the CCE console and click the cluster name to access the cluster console.
- Step 2** In the navigation pane, choose **Add-ons**. Then, click **Edit** under **CoreDNS**.
- Step 3** Edit 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

## Configuring the Default Protocol Between the forward Plug-in and the Upstream DNS Service

**Step 1** The NodeLocal DNSCache uses TCP to communicate with the CoreDNS. The CoreDNS communicates with the upstream DNS server based on the protocol used by the request source. By default, external domain name resolution requests from service containers pass through NodeLocal DNSCache and CoreDNS in sequence, and finally request the DNS server in the VPC using TCP.

**Step 2** However, the cloud server does not support TCP. To use NodeLocal DNSCache, modify the CoreDNS configuration so that UDP is preferentially used to communicate with the upstream DNS server, preventing resolution exceptions. You are advised to use the following method to modify the CoreDNS configuration file:

The forward plug-in is used to set the upstream Nameservers DNS server. The following parameters are included:

**prefer\_udp**: Even if a request is received through TCP, UDP must be used first.

If you want CoreDNS to preferentially use UDP to communicate with upstream systems, set the protocol in the forward plug-in to **prefer\_udp**. For details about the forward plug-in, see <https://coredns.io/plugins/forward/>.

1. Log in to the CCE console and click the cluster name to access the cluster console.
2. In the navigation pane, choose **Add-ons**. Then, click **Edit** under **CoreDNS**.
3. Edit the advanced configuration under **Parameters** and modify the following content in the **plugins** field:

```
{
 "configBlock": "prefer_udp",
 "name": "forward",
 "parameters": ". /etc/resolv.conf"
}
```

----End

## Properly Configuring Cache Policies

If you configure CoreDNS with an upstream DNS server, you can implement a cache policy that enables CoreDNS to use the expired local cache when it is unable to access the upstream DNS server.

- Step 1** Log in to the CCE console and click the cluster name to access the cluster console.
- Step 2** In the navigation pane, choose **Add-ons**. On the displayed page, click **Edit** under **CoreDNS**.
- Step 3** In the window that slides out from the right, in the **Parameters** area, modify the cache content in the **plugins** field for **Advance Config**. For details about how to configure the cache, see <https://coredns.io/plugins/cache/>.

```
{
 "configBlock": "servfail 5s\nserve_stale 60s immediate",
 "name": "cache",
 "parameters": 30
}
```

```
{
 "annotations": {},
 "parameterSyncStrategy": "ensureConsistent",
 "servers": [
 {
 "plugins": [
 {
 "name": "bind",
 "parameters": "${POD_IP}"
 },
 {
 "configBlock": "servfail 5s\nserve_stale 60s immediate",
 "name": "cache",
 "parameters": 30
 },
 {
 "name": "errors"
 }
],
 "name": "health",
 "parameters": "${POD_IP}:8080"
 }
]
}
```

**Step 4** Click **OK**.

**Step 5** In the navigation pane, choose **ConfigMaps and Secrets**. Select the **kube-system** namespace, view the data of the ConfigMap named **coredns** to check whether the update is successful.

Corresponding Corefile content:

```
.:5353 {
 bind {${POD_IP}
 cache 30 {
 servfail 5s
 serve_stale 60s immediate
 }
 errors
 health {${POD_IP}:8080
 kubernetes cluster.local in-addr.arpa ip6.arpa {
 pods insecure
 fallthrough in-addr.arpa ip6.arpa
 }
 loadbalance round_robin
 prometheus {${POD_IP}:9153
 forward . /etc/resolv.conf {
 policy random
 }
 reload
 ready {${POD_IP}:8081
}
```

----End

## 22.8.6 Retaining the Original IP Address of a Pod

### SNAT Overview

In a CCE cluster that uses a VPC network, to enable pods to communicate with external systems, the system automatically translates the source IP addresses of the pods into the IP addresses of the nodes that are running them. This allows pods to communicate with external systems using the node IP addresses. This process is known as pod IP address masquerading or Source Network Address Translation (SNAT).

### Prerequisites

You have a cluster that uses the VPC network and whose version is v1.23.14-r0, v1.25.9-r0, v1.27.6-r0, v1.28.4-r0, or later.

### Default Non-Masqueraded CIDR Block Settings in a CCE Cluster

By default, CCE uses the following well-known private CIDR blocks as non-masqueraded CIDR blocks in each cluster:

- **10.0.0.0/8**
- **172.16.0.0/12**
- **192.168.0.0/16**

Additionally, in a CCE cluster that uses a secondary VPC CIDR block, adding or resetting a node will automatically include the secondary CIDR block in the non-masqueraded CIDR blocks.

This means that when a pod initiates communication from these CIDR blocks with external resources, its source IP address of the data packet remains unchanged, and it will not be replaced with the IP address of the node running the pod.

## Scenarios Where the Default Non-Masqueraded CIDR Blocks Does Not Fit

The default non-masqueraded CIDR block settings in CCE clusters apply to typical scenarios, but in certain specific scenarios, these default settings may not be sufficient to meet user requirements. The following shows typical examples:

- Cross-node access to pods in a cluster

When a node in a Kubernetes cluster needs to access a pod on another node, the response data packet sent from the pod is automatically subject to SNAT. This changes the source IP address from the pod IP address to the IP address of the node that runs the pod. However, this automatic IP address translation can sometimes lead to communication issues, making cross-node access impossible.

To enable a node to access pods on other nodes, you can add the CIDR block of the subnet where the node is located to the **nonMasqueradeCIDRs** parameter. This will skip SNAT and allow the original IP addresses of pods on these nodes to be retained.

- Access from other resources in the same VPC as a cluster to pods in the cluster

In certain scenarios, it may be necessary to access the original IP addresses of pods on different nodes in a CCE cluster directly from other resources (such as ECSs) in the same VPC as the cluster. However, with SNAT enabled by default, the source IP addresses of the data packets are replaced with the IP addresses of the nodes that run these pods when the data packets pass through the nodes. This makes it difficult for these resources to access pods directly.

To enable direct access from resources in the same VPC as the cluster to pods, you can add the CIDR blocks of the subnets where these resources are located to the **nonMasqueradeCIDRs** parameter. This will skip SNAT and ensure that the source IP addresses of the data packets remain the same as the original IP addresses of pods.

## Precautions

If you have set up a security group or ACL for a cloud service that only allows access from IP addresses of nodes running pods, there is no need to perform pod IP address masquerading and configure the **nonMasqueradeCIDRs** parameter.

The default setting of pod IP address masquerading (SNAT) is usually sufficient. However, if you need to retain the original IP addresses of pods in specific scenarios, you can configure the **nonMasqueradeCIDRs** parameter.

Before doing so, make sure you have evaluated your application scenario and understood the potential risks of improper configuration, because it may block access within clusters. If you are unsure whether to configure this parameter, it is recommended that you keep the default settings and adjust the configuration later once the requirement is clarified.

## Procedure

To reserve the source IP address of a pod when the pod accesses a CIDR block, you can configure **nonMasqueradeCIDRs** to specify the CIDR block that does not need to be masqueraded.

- Step 1** Log in to the CCE console and click the name of the target cluster to access the cluster console.
- Step 2** In the navigation pane, choose **Settings** and click the **Network** tab.
- Step 3** Modify the parameters under **Retain the non-spoofed CIDR block of the original pod IP address**. Make sure the parameter configuration complies with the following rules:
- Each CIDR block must comply with the CIDR format and must be a valid IPv4 CIDR block.  
Example of a correct CIDR block: **192.168.1.0/24**  
Example of an incorrect CIDR block: **192.168.1.1/24** (incompliant with the CIDR format)
  - The CIDR blocks you configured do not overlap with each other.  
Example of correct CIDR blocks: **192.168.1.0/24** and **192.168.2.0/24**  
Example of incorrect CIDR blocks: **192.168.1.0/24** and **192.168.1.128/25** (The two CIDR blocks overlap.)
  - The **nonMasqueradeCIDRs** parameter must contain all destination CIDR blocks that you want them to use the original pod IP addresses for communications.
- Step 4** After the modification, click **Confirm configuration**. The setting takes effect within 1 minute.

----End

## 22.9 Storage

### 22.9.1 Expanding the Storage Space

The storage classes that can be expanded for CCE nodes are as follows:

**Table 22-14** Capacity expansion methods

| Type      | Name        | Purpose                                                                 | Capacity Expansion Method                      |
|-----------|-------------|-------------------------------------------------------------------------|------------------------------------------------|
| Node disk | System disk | A disk attached to a node for installing the operating system           | <a href="#">Expanding System Disk Capacity</a> |
|           | Data disk   | The first data disk attached to a node for container engine and kubelet | <a href="#">Expanding Data Disk Capacity</a>   |

| Type              | Name                | Purpose                                                                                                                                                   | Capacity Expansion Method                                                    |
|-------------------|---------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------|
| 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) | <a href="#">Expanding the Capacity of a Data Disk Used by Pod (basesize)</a> |
|                   | PVC                 | Storage resources mounted to the containers                                                                                                               | <a href="#">Expanding a PVC</a>                                              |

## Expanding System Disk Capacity

EulerOS 2.9 is used as the sample OS. There is only one partition (**/dev/vda1**) with a capacity of 50 GiB in the system disk **/dev/vda**, and then 50 GiB is added to the system disk. In this example, the additional 50 GiB is allocated to the existing **/dev/vda1** partition.

**Step 1** Expand the system disk capacity on the EVS console.

Only the storage capacity of the EVS disk is expanded. You also need to perform the following steps to expand the partition and file system.

**Step 2** Log in to the node and run the **growpart** command to check whether growpart has been installed.

If the tool operation guide is displayed, the growpart has been installed. Otherwise, run the following command to install growpart:

```
yum install cloud-utils-growpart
```

**Step 3** Run the following command to view the total capacity of the system disk **/dev/vda**:

```
fdisk -l
```

If the following information is displayed, the total capacity of **/dev/vda** is 100 GiB.

```
[root@test-48162 ~]# fdisk -l
Disk /dev/vda: 100 GiB, 107374182400 bytes, 209715200 sectors
Units: sectors of 1 * 512 = 512 bytes
Sector size (logical/physical): 512 bytes / 512 bytes
I/O size (minimum/optimal): 512 bytes / 512 bytes
Disklabel type: dos
Disk identifier: 0x78d88f0b

Device Boot Start End Sectors Size Id Type
/dev/vda1 * 2048 104857566 104855519 50G 83 Linux

Disk /dev/vdb: 100 GiB, 107374182400 bytes, 209715200 sectors
Units: sectors of 1 * 512 = 512 bytes
Sector size (logical/physical): 512 bytes / 512 bytes
I/O size (minimum/optimal): 512 bytes / 512 bytes

Disk /dev/mapper/vgpaas-dockersys: 90 GiB, 96632569856 bytes, 188735488 sectors
Units: sectors of 1 * 512 = 512 bytes
Sector size (logical/physical): 512 bytes / 512 bytes
I/O size (minimum/optimal): 512 bytes / 512 bytes
```

```
Disk /dev/mapper/vgpaas-kubernetes: 10 GiB, 10733223936 bytes, 20963328 sectors
Units: sectors of 1 * 512 = 512 bytes
Sector size (logical/physical): 512 bytes / 512 bytes
I/O size (minimum/optimal): 512 bytes / 512 bytes
```

**Step 4** Run the following command to check the capacity of the system disk partition **/dev/vda1**:

```
df -TH
```

Information similar to the following is displayed:

```
[root@test-48162 ~]# df -TH
Filesystem Type Size Used Avail Use% Mounted on
devtmpfs devtmpfs 1.8G 0 1.8G 0% /dev
tmpfs tmpfs 1.8G 0 1.8G 0% /dev/shm
tmpfs tmpfs 1.8G 13M 1.8G 1% /run
tmpfs tmpfs 1.8G 0 1.8G 0% /sys/fs/cgroup
/dev/vda1 ext4 53G 3.3G 47G 7% /
tmpfs tmpfs 1.8G 75M 1.8G 5% /tmp
/dev/mapper/vgpaas-dockersys ext4 95G 1.3G 89G 2% /var/lib/docker
/dev/mapper/vgpaas-kubernetes ext4 11G 39M 10G 1% /mnt/paas/kubernetes/kubelet
...
```

**Step 5** Run the following command to extend the partition using growpart:

```
growpart System disk Partition number
```

The partition number is **1** because there is only one **/dev/vda1** partition in the system disk, as shown in the following command:

```
growpart /dev/vda 1
```

Information similar to the following is displayed:

```
CHANGED: partition=1 start=2048 old: size=104855519 end=104857567 new: size=209713119
end=209715167
```

**Step 6** Run the following command to extend the file system:

```
resize2fs Disk partition
```

An example command is as follows:

```
resize2fs /dev/vda1
```

Information similar to the following is displayed:

```
resize2fs 1.45.6 (20-Mar-2020)
Filesystem at /dev/vda1 is mounted on /; on-line resizing required
old_desc_blocks = 7, new_desc_blocks = 13
The filesystem on /dev/vda1 is now 26214139 (4k) blocks long.
```

**Step 7** Run the following command to view the new capacity of the **/dev/vda1** partition:

```
df -TH
```

Information similar to the following is displayed:

```
[root@test-48162 ~]# df -TH
Filesystem Type Size Used Avail Use% Mounted on
devtmpfs devtmpfs 1.8G 0 1.8G 0% /dev
tmpfs tmpfs 1.8G 0 1.8G 0% /dev/shm
tmpfs tmpfs 1.8G 13M 1.8G 1% /run
tmpfs tmpfs 1.8G 0 1.8G 0% /sys/fs/cgroup
/dev/vda1 ext4 106G 3.3G 98G 4% /
tmpfs tmpfs 1.8G 75M 1.8G 5% /tmp
/dev/mapper/vgpaas-dockersys ext4 95G 1.3G 89G 2% /var/lib/docker
/dev/mapper/vgpaas-kubernetes ext4 11G 39M 10G 1% /mnt/paas/kubernetes/kubelet
...
```



**Step 8** Log in to the CCE console and click the cluster. In the navigation pane, choose **Nodes**. Click **More > Sync Server Data** in the row containing the target node.

----End

## Expanding Data Disk Capacity

The first data disk of a CCE node is composed of container engine and kubelet space by default. If either of them reaches full capacity, you can expand the disk space as needed.

In clusters of v1.21.10-r0, v1.23.8-r0, v1.25.3-r0, and later, CCE enables container engine (Docker/containerd) and kubelet to share the space of the first data disk. If the shared disk space is insufficient, you can expand it.

## Expanding the Container Engine Capacity

The available container engine space affects image pulls and container startup and running. This section uses containerd as an example to describe how to expand the container engine capacity.

**Step 1** Expand the capacity of a data disk on the EVS console.

Only the storage capacity of the EVS disk is expanded. You also need to perform the following steps to expand the capacity of the logical volume and file system.

**Step 2** Log in to the CCE console and click the cluster. In the navigation pane, choose **Nodes**. Click **More > Sync Server Data** in the row containing the target node.

**Step 3** Log in to the target node.

**Step 4** Run the **lsblk** command to check the block device information of the node.

A data disk is divided depending on the container storage **Rootfs**:

Overlaysfs: No independent thin pool is allocated. Image data is stored in **dockersys**.

1. Check the disk and partition sizes of the device.

```
lsblk
NAME MAJ:MIN RM SIZE RO TYPE MOUNTPOINT
vda 8:0 0 50G 0 disk
└─vda1 8:1 0 50G 0 part /
vdb 8:16 0 200G 0 disk # Data disk has been expanded but not allocated
├─vgpaas-dockersys 253:0 0 90G 0 lvm /var/lib/containerd # Space used by the
container engine
└─vgpaas-kubernetes 253:1 0 10G 0 lvm /mnt/paas/kubernetes/kubelet # Space used by
Kubernetes
```

2. Expand the disk capacity.

Add the new disk capacity to the **dockersys** logical volume used by the container engine.

a. Expand the PV capacity so that LVM can identify the new EVS capacity. `/dev/vdb` specifies the physical volume where dockersys is located.

```
pvresize /dev/vdb
```

Information similar to the following is displayed:

```
Physical volume "/dev/vdb" changed
1 physical volume(s) resized or updated / 0 physical volume(s) not resized
```

- b. Expand 100% of the free capacity to the logical volume. *vgpaas/dockersys* specifies the logical volume used by the container engine.

```
lvextend -l+100%FREE -n vgpaas/dockersys
```

Information similar to the following is displayed:

```
Size of logical volume vgpaas/dockersys changed from <90.00 GiB (23039 extents) to <190.00 GiB (48639 extents).
```

```
Logical volume vgpaas/dockersys successfully resized.
```

- c. Adjust the size of the file system. */dev/vgpaas/dockersys* specifies the file system path of the container engine.

```
resize2fs /dev/vgpaas/dockersys
```

Information similar to the following is displayed:

```
Filesystem at /dev/vgpaas/dockersys is mounted on /var/lib/containerd; on-line resizing required old_desc_blocks = 12, new_desc_blocks = 24
```

```
The filesystem on /dev/vgpaas/dockersys is now 49807360 (4k) blocks long.
```

Devicemapper: A thin pool is allocated to store image data.

1. Check the disk and partition sizes of the device.

```
lsblk
NAME MAJ:MIN RM SIZE RO TYPE MOUNTPOINT
vda 8:0 0 50G 0 disk
├─vda1 8:1 0 50G 0 part /
└─vgdb 8:16 0 200G 0 disk
 └─vgpaas-dockersys 253:0 0 18G 0 lvm /var/lib/docker
 └─vgpaas-thinpool_tmeta 253:1 0 3G 0 lvm
 └─vgpaas-thinpool 253:3 0 67G 0 lvm # Space used by thinpool
 ...
 └─vgpaas-thinpool_tdata 253:2 0 67G 0 lvm
 └─vgpaas-thinpool 253:3 0 67G 0 lvm
 ...
 └─vgpaas-kubernetes 253:4 0 10G 0 lvm /mnt/paas/kubernetes/kubelet
```

2. Expand the disk capacity.

Option 1: Add the new disk capacity to the thin pool disk.

- a. Expand the PV capacity so that LVM can identify the new EVS capacity. */dev/vdb* specifies the physical volume where thinpool is located.

```
pvresize /dev/vdb
```

Information similar to the following is displayed:

```
Physical volume "/dev/vdb" changed
```

```
1 physical volume(s) resized or updated / 0 physical volume(s) not resized
```

- b. Expand 100% of the free capacity to the logical volume. *vgpaas/thinpool* specifies the logical volume used by the container engine.

```
lvextend -l+100%FREE -n vgpaas/thinpool
```

Information similar to the following is displayed:

```
Size of logical volume vgpaas/thinpool changed from <67.00 GiB (23039 extents) to <167.00 GiB (48639 extents).
```

```
Logical volume vgpaas/thinpool successfully resized.
```

- c. Do not need to adjust the size of the file system, because the thin pool is not mounted to any devices.

Option 2: Add the new disk capacity to the **dockersys** disk.

- a. Expand the PV capacity so that LVM can identify the new EVS capacity. */dev/vdb* specifies the physical volume where dockersys is located.

```
pvresize /dev/vdb
```

Information similar to the following is displayed:

```
Physical volume "/dev/vdb" changed
```

```
1 physical volume(s) resized or updated / 0 physical volume(s) not resized
```

- b. Expand 100% of the free capacity to the logical volume. *vgpaas/dockersys* specifies the logical volume used by the container engine.  
`lvextend -l+100%FREE -n vgpaas/dockersys`

Information similar to the following is displayed:

```
Size of logical volume vgpaas/dockersys changed from <18.00 GiB (7679 extents) to <118.00 GiB (33279 extents).
Logical volume vgpaas/dockersys successfully resized.
```

- c. Adjust the size of the file system. */dev/vgpaas/dockersys* specifies the file system path of the container engine.  
`resize2fs /dev/vgpaas/dockersys`

Information similar to the following is displayed:

```
Filesystem at /dev/vgpaas/dockersys is mounted on /var/lib/docker; on-line resizing required
old_desc_blocks = 4, new_desc_blocks = 16
The filesystem on /dev/vgpaas/dockersys is now 49807360 (4k) blocks long.
```

----End

## Expanding the kubelet Capacity

The kubelet space serves as a temporary storage location for kubelet components and EmptyDir. You can follow the following steps to increase the kubelet capacity:

- Step 1** Expand the capacity of a data disk on the EVS console.

Only the storage capacity of the EVS disk is expanded. You also need to perform the following steps to expand the capacity of the logical volume and file system.

- Step 2** Log in to the CCE console and click the cluster. In the navigation pane, choose **Nodes**. Click **More > Sync Server Data** in the row containing the target node.

- Step 3** Log in to the target node.

- Step 4** Run **lsblk** to view the block device information of the node.

```
lsblk
NAME MAJ:MIN RM SIZE RO TYPE MOUNTPOINT
vda 8:0 0 50G 0 disk
└─vda1 8:1 0 50G 0 part /
vdb 8:16 0 200G 0 disk # Data disk has been expanded but not allocated
├─vgpaas-dockersys 253:0 0 90G 0 lvm /var/lib/containerd # Space used by the container engine
└─vgpaas-kubernetes 253:1 0 10G 0 lvm /mnt/paas/kubernetes/kubelet # Space used by Kubernetes
```

- Step 5** Perform the following operations on the node to add the new disk capacity to the kubelet space:

1. Expand the PV capacity so that LVM can identify the new EVS capacity. */dev/vdb* specifies the physical volume where kubelet is located.  
`pvresize /dev/vdb`

Information similar to the following is displayed:

```
Physical volume "/dev/vdb" changed
1 physical volume(s) resized or updated / 0 physical volume(s) not resized
```

2. Expand 100% of the free capacity to the logical volume. *vgpaas/kubernetes* specifies the logical volume used by kubelet.  
`lvextend -l+100%FREE -n vgpaas/kubernetes`

Information similar to the following is displayed:

```
Size of logical volume vgpaas/kubernetes changed from <10.00 GiB (2559 extents) to <110.00 GiB (28159 extents).
Logical volume vgpaas/kubernetes successfully resized.
```

- Adjust the size of the file system. `/dev/vgpaas/kubernetes` specifies the file system path of the container engine.

```
resize2fs /dev/vgpaas/kubernetes
```

Information similar to the following is displayed:

```
Filesystem at /dev/vgpaas/kubernetes is mounted on /mnt/paas/kubernetes/kubelet; on-line resizing required
old_desc_blocks = 2, new_desc_blocks = 14
The filesystem on /dev/vgpaas/kubernetes is now 28834816 (4k) blocks long.
```

----End

## Expanding Capacity of the Disk Shared by Container Engine and kubelet

To expand the capacity of the disk shared by container engine and kubelet, perform the following steps:

- Step 1** Expand the capacity of a data disk on the EVS console.

Only the storage capacity of the EVS disk is expanded. You also need to perform the following steps to expand the capacity of the logical volume and file system.

- Step 2** Log in to the CCE console and click the cluster. In the navigation pane, choose **Nodes**. Click **More > Sync Server Data** in the row containing the target node.

- Step 3** Log in to the target node.

- Step 4** Run `lsblk` to view the block device information of the node.

```
lsblk
NAME MAJ:MIN RM SIZE RO TYPE MOUNTPOINTS
vda 253:0 0 50G 0 disk
└─vda1 253:1 0 50G 0 part /
vdb 253:16 0 200G 0 disk # Data disk has been expanded but not allocated
└─vgpaas-share 252:0 0 100G 0 lvm /mnt/paas # Space used by the container engine and the kubelet component
```

- Step 5** Run the following commands on the node to add the new disk capacity to the shared disk:

- Expand the PV capacity so that LVM can identify the new EVS capacity. `/dev/vdb` specifies the physical volume where the shared disk is located.

```
pvresize /dev/vdb
```

Information similar to the following is displayed:

```
Physical volume "/dev/vdb" changed
1 physical volume(s) resized or updated / 0 physical volume(s) not resized
```

- Expand 100% of the free capacity to the logical volume. `vgpaas/share` specifies the logical volume shared by the container engine and the kubelet component.

```
lvextend -l+100%FREE -n vgpaas/share
```

Information similar to the following is displayed:

```
Size of logical volume vgpaas/share changed from <100.00 GiB (25599 extents) to <200.00 GiB (51199 extents).
Logical volume vgpaas/share successfully resized.
```

- Adjust the size of the file system. `/dev/vgpaas/share` specifies the file system path of the shared disk.

```
resize2fs /dev/vgpaas/share
```

Information similar to the following is displayed:

```
Filesystem at /dev/vgpaas/share is mounted on /mnt/paas; on-line resizing required
old_desc_blocks = 13, new_desc_blocks = 25
The filesystem on /dev/vgpaas/share is now 52427776 (4k) blocks long.
```

----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 roots 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-253:1-787293-631c1bde2cbe82e39f32253b216ba914cb183b168b54708b3e5b9a54ae40a8d1 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 48G 5.2G 43G 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. In the right pane, click the **PVCs** tab. Click **More** in the **Operation** column of the target PVC and select **Scale-out**.
    - ii. Enter the capacity to be added and click **OK**.
- For SFS Turbo, expand the capacity on the SFS console and then change the capacity in the PVC.

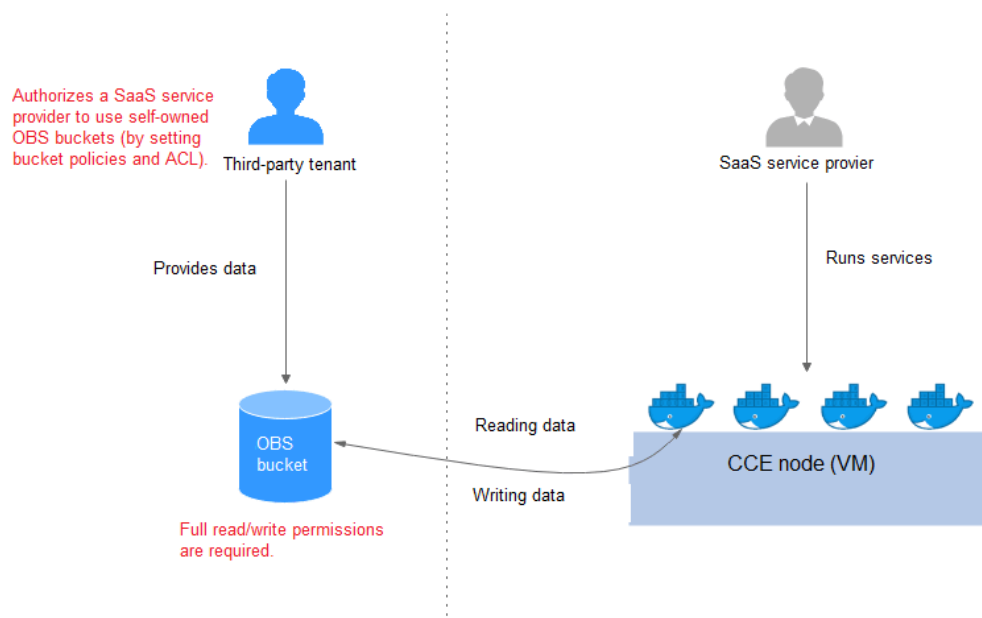
## 22.9.2 Mounting an Object Storage Bucket of a Third-Party Tenant

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 22-14](#).

**Figure 22-14** 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 the name of the target bucket 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 resource that can be operated.
- **Actions:** Select the action 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.

## 22.9.3 Dynamically Creating an SFS Turbo Subdirectory Using StorageClass

### 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: www
 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

## 22.9.4 Changing the Storage Class Used by a Cluster of v1.15 from FlexVolume to CSI Everest

In clusters later than v1.15.11-r1, CSI (the everest add-on) has taken over all functions of fuxi FlexVolume (the storage-driver add-on) for managing container storage. You are advised to use CSI Everest.

To migrate your storage volumes, create a static PV to associate with the original underlying storage, and then create a PVC to associate with this static PV. When you upgrade your application, mount the new PVC to the original mounting path to migrate the storage volumes.

---

**WARNING**

Services will be interrupted during the migration. Therefore, properly plan the migration and back up data.

---

### Procedure

**Step 1** (Optional) Back up data to prevent data loss in case of exceptions.

**Step 2** Configure a YAML file of the PV in the CSI format according to the PV in the FlexVolume format and associate the PV with the existing storage.

To be specific, run the following commands to configure the pv-example.yaml file, which is used to create a PV.

```
touch pv-example.yaml
```

```
vi pv-example.yaml
```

Configuration example of a PV for an EVS volume:

```
apiVersion: v1
kind: PersistentVolume
metadata:
 labels:
 failure-domain.beta.kubernetes.io/region: eu-west-0
 failure-domain.beta.kubernetes.io/zone: <zone name>
 annotations:
 pv.kubernetes.io/provisioned-by: everest-csi-provisioner
name: pv-evs-example
spec:
 accessModes:
 - ReadWriteOnce
 capacity:
 storage: 10Gi
 csi:
 driver: disk.csi.everest.io
 fsType: ext4
 volumeAttributes:
 everest.io/disk-mode: SCSI
 everest.io/disk-volume-type: SAS
 storage.kubernetes.io/csiProvisionerIdentity: everest-csi-provisioner
 volumeHandle: 0992dbda-6340-470e-a74e-4f0db288ed82
 persistentVolumeReclaimPolicy: Delete
 storageClassName: csi-disk
```

Pay attention to the fields in bold and red. The parameters are described as follows:

**Table 22-15** EVS volume configuration parameters

| Parameter                                | Description                                                                                                                                              |
|------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------|
| failure-domain.beta.kubernetes.io/region | Region where the EVS disk is located. Use the same value as that of the FlexVolume PV.                                                                   |
| failure-domain.beta.kubernetes.io/zone   | AZ where the EVS disk is located. Use the same value as that of the FlexVolume PV.                                                                       |
| name                                     | Name of the PV, which must be unique in the cluster.                                                                                                     |
| storage                                  | EVS volume capacity in the unit of Gi. Use the value of <b>spec.capacity.storage</b> of the FlexVolume PV.                                               |
| driver                                   | Storage driver used to attach the volume. Set the driver to <b>disk.csi.everest.io</b> for the EVS volume.                                               |
| volumeHandle                             | Volume ID of the EVS disk. Use the value of <b>spec.flexVolume.options.volumeID</b> of the FlexVolume PV.                                                |
| everest.io/disk-mode                     | EVS disk mode. Use the value of <b>spec.flexVolume.options.disk-mode</b> of the FlexVolume PV.                                                           |
| everest.io/disk-volume-type              | EVS disk type. Use the value of <b>kubernetes.io/volumetype</b> in the storage class corresponding to <b>spec.storageClassName</b> of the FlexVolume PV. |
| storageClassName                         | Name of the Kubernetes storage class associated with the storage volume. Set this field to <b>csi-disk</b> for EVS disks.                                |

Configuration example of a PV for an SFS volume:

```

apiVersion: v1
kind: PersistentVolume
metadata:
 name: pv-sfs-example
 annotations:
 pv.kubernetes.io/provisioned-by: everest-csi-provisioner
spec:
 accessModes:
 - ReadWriteMany
 capacity:
 storage: 10Gi
 csi:
 driver: nas.csi.everest.io
 fsType: nfs
 volumeAttributes:
 everest.io/share-export-location: # Shared path of the file storage
 storage.kubernetes.io/csiProvisionerIdentity: everest-csi-provisioner
 volumeHandle: 682f00bb-ace0-41d8-9b3e-913c9aa6b695
 persistentVolumeReclaimPolicy: Delete
 storageClassName: csi-nas

```

Pay attention to the fields in bold and red. The parameters are described as follows:



**Table 22-16** SFS volume configuration parameters

| Parameter                        | Description                                                                                                           |
|----------------------------------|-----------------------------------------------------------------------------------------------------------------------|
| name                             | Name of the PV, which must be unique in the cluster.                                                                  |
| storage                          | File storage size in the unit of Gi. Use the value of <b>spec.capacity.storage</b> of the FlexVolume PV.              |
| driver                           | Storage driver used to attach the volume. Set the driver to <b>nas.csi.everest.io</b> for the file system.            |
| everest.io/share-export-location | Shared path of the file system. Use the value of <b>spec.flexVolume.options.deviceMountPath</b> of the FlexVolume PV. |
| volumeHandle                     | File system ID. Use the value of <b>spec.flexVolume.options.volumeID</b> of the FlexVolume PV.                        |
| storageClassName                 | Name of the Kubernetes storage class. Set this field to <b>csi-nas</b> .                                              |

Configuration example of a PV for an OBS volume:

```

apiVersion: v1
kind: PersistentVolume
metadata:
 name: pv-obs-example
 annotations:
 pv.kubernetes.io/provisioned-by: everest-csi-provisioner
spec:
 accessModes:
 - ReadWriteMany
 capacity:
 storage: 1Gi
 csi:
 driver: obs.csi.everest.io
 fsType: s3fs
 volumeAttributes:
 everest.io/obs-volume-type: STANDARD
 everest.io/region: eu-west-0
 storage.kubernetes.io/csiProvisionerIdentity: everest-csi-provisioner
 volumeHandle: obs-normal-static-pv
 persistentVolumeReclaimPolicy: Delete
 storageClassName: csi-obs

```

Pay attention to the fields in bold and red. The parameters are described as follows:

**Table 22-17** OBS volume configuration parameters

| Parameter | Description                                                                             |
|-----------|-----------------------------------------------------------------------------------------|
| name      | Name of the PV, which must be unique in the cluster.                                    |
| storage   | Storage capacity, in the unit of Gi. Set this parameter to the fixed value <b>1Gi</b> . |

| Parameter                  | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
|----------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| driver                     | Storage driver used to attach the volume. Set the driver to <b>obs.csi.everest.io</b> for the OBS volume.                                                                                                                                                                                                                                                                                                                                                                                                                      |
| fsType                     | File type. Value options are <b>obsfs</b> or <b>s3fs</b> . If the value is <b>s3fs</b> , an OBS bucket is created and mounted using s3fs. If the value is <b>obsfs</b> , an OBS parallel file system is created and mounted using obsfs. Set this parameter according to the value of <b>spec.flexVolume.options.posix</b> of the FlexVolume PV. If the value of <b>spec.flexVolume.options.posix</b> is <b>true</b> , set this parameter to <b>obsfs</b> . If the value is <b>false</b> , set this parameter to <b>s3fs</b> . |
| everest.io/obs-volume-type | Storage class, including <b>STANDARD</b> (standard bucket) and <b>WARM</b> (infrequent access bucket). Set this parameter according to the value of <b>spec.flexVolume.options.storage_class</b> of the FlexVolume PV. If the value of <b>spec.flexVolume.options.storage_class</b> is <b>standard</b> , set this parameter to <b>STANDARD</b> . If the value is <b>standard_ia</b> , set this parameter to <b>WARM</b> .                                                                                                      |
| everest.io/region          | Region where the OBS bucket is located. Use the value of <b>spec.flexVolume.options.region</b> of the FlexVolume PV.                                                                                                                                                                                                                                                                                                                                                                                                           |
| volumeHandle               | OBS bucket name. Use the value of <b>spec.flexVolume.options.volumeID</b> of the FlexVolume PV.                                                                                                                                                                                                                                                                                                                                                                                                                                |
| storageClassName           | Name of the Kubernetes storage class. Set this field to <b>csi-obs</b> .                                                                                                                                                                                                                                                                                                                                                                                                                                                       |

Configuration example of a PV for an SFS Turbo volume:

```

apiVersion: v1
kind: PersistentVolume
metadata:
 name: pv-efs-example
 annotations:
 pv.kubernetes.io/provisioned-by: everest-csi-provisioner
spec:
 accessModes:
 - ReadWriteMany
 capacity:
 storage: 10Gi
 csi:
 driver: sfsturbo.csi.everest.io
 fsType: nfs
 volumeAttributes:
 everest.io/share-export-location: 192.168.0.169:/
 storage.kubernetes.io/csiProvisionerIdentity: everest-csi-provisioner
 volumeHandle: 8962a2a2-a583-4b7f-bb74-fe76712d8414
 persistentVolumeReclaimPolicy: Delete
 storageClassName: csi-sfsturbo

```

Pay attention to the fields in bold and red. The parameters are described as follows:

**Table 22-18** SFS Turbo volume configuration parameters

| Parameter                        | Description                                                                                                                |
|----------------------------------|----------------------------------------------------------------------------------------------------------------------------|
| name                             | Name of the PV, which must be unique in the cluster.                                                                       |
| storage                          | File system size. Use the value of <b>spec.capacity.storage</b> of the FlexVolume PV.                                      |
| driver                           | Storage driver used to attach the volume. Set it to <b>sfsturbo.csi.everest.io</b> .                                       |
| everest.io/share-export-location | Shared path of the SFS Turbo volume. Use the value of <b>spec.flexVolume.options.deviceMountPath</b> of the FlexVolume PV. |
| volumeHandle                     | SFS Turbo volume ID. Use the value of <b>spec.flexVolume.options.volumeID</b> of the FlexVolume PV.                        |
| storageClassName                 | Name of the Kubernetes storage class. Set this field to <b>csi-sfsturbo</b> for SFS Turbo volumes.                         |

**Step 3** Configure a YAML file of the PVC in the CSI format according to the PVC in the FlexVolume format and associate the PVC with the PV created in [Step 2](#).

To be specific, run the following commands to configure the `pvc-example.yaml` file, which is used to create a PVC.

```
touch pvc-example.yaml
```

```
vi pvc-example.yaml
```

Configuration example of a PVC for an EVS volume:

```
apiVersion: v1
kind: PersistentVolumeClaim
metadata:
 labels:
 failure-domain.beta.kubernetes.io/region: eu-west-0
 failure-domain.beta.kubernetes.io/zone: <zone name>
 annotations:
 everest.io/disk-volume-type: SAS
 volume.beta.kubernetes.io/storage-provisioner: everest-csi-provisioner
 name: pvc-evs-example
 namespace: default
spec:
 accessModes:
 - ReadWriteOnce
 resources:
 requests:
 storage: 10Gi
 volumeName: pv-evs-example
 storageClassName: csi-disk
```

Pay attention to the fields in bold and red. The parameters are described as follows:

**Table 22-19** PVC configuration parameters for an EVS volume

| Parameter                                | Description                                                                                                                                                                                                                                |
|------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| failure-domain.beta.kubernetes.io/region | Region where the cluster is located. Use the same value as that of the FlexVolume PVC.                                                                                                                                                     |
| failure-domain.beta.kubernetes.io/zone   | AZ where the EVS disk is deployed. Use the same value as that of the FlexVolume PVC.                                                                                                                                                       |
| everest.io/disk-volume-type              | Storage class of the EVS disk. The value can be <b>SAS</b> or <b>SSD</b> . Set this parameter to the same value as that of the PV created in <a href="#">Step 2</a> .                                                                      |
| name                                     | PVC name, which must be unique in the namespace. The value must be unique in the namespace. (If the PVC is dynamically created by a stateful application, the value of this parameter must be the same as the name of the FlexVolume PVC.) |
| namespace                                | Namespace to which the PVC belongs. Use the same value as that of the FlexVolume PVC.                                                                                                                                                      |
| storage                                  | Requested capacity of the PVC, which must be the same as the storage size of the existing PV.                                                                                                                                              |
| volumeName                               | Name of the PV. Set this parameter to the name of the static PV in <a href="#">Step 2</a> .                                                                                                                                                |
| storageClassName                         | Name of the Kubernetes storage class. Set this field to <b>csi-disk</b> for EVS disks.                                                                                                                                                     |

**Configuration example of a PVC for an SFS volume:**

```

apiVersion: v1
kind: PersistentVolumeClaim
metadata:
 annotations:
 volume.beta.kubernetes.io/storage-provisioner: everest-csi-provisioner
 name: pvc-sfs-example
 namespace: default
spec:
 accessModes:
 - ReadWriteMany
 resources:
 requests:
 storage: 10Gi
 storageClassName: csi-nas
 volumeName: pv-sfs-example

```

Pay attention to the fields in bold and red. The parameters are described as follows:

**Table 22-20** PVC configuration parameters for an SFS volume

| Parameter        | Description                                                                                                                                                                                                                                |
|------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| name             | PVC name, which must be unique in the namespace. The value must be unique in the namespace. (If the PVC is dynamically created by a stateful application, the value of this parameter must be the same as the name of the FlexVolume PVC.) |
| namespace        | Namespace to which the PVC belongs. Use the same value as that of the FlexVolume PVC.                                                                                                                                                      |
| storage          | Storage capacity, in the unit of Gi. The value must be the same as the storage size of the existing PV.                                                                                                                                    |
| storageClassName | Set this field to <b>csi-nas</b> .                                                                                                                                                                                                         |
| volumeName       | Name of the PV. Set this parameter to the name of the static PV in <a href="#">Step 2</a> .                                                                                                                                                |

Configuration example of a PVC for an OBS volume:

```

apiVersion: v1
kind: PersistentVolumeClaim
metadata:
 annotations:
 volume.beta.kubernetes.io/storage-provisioner: everest-csi-provisioner
 everest.io/obs-volume-type: STANDARD
 csi.storage.k8s.io/fstype: s3fs
 name: pvc-obs-example
 namespace: default
spec:
 accessModes:
 - ReadWriteMany
 resources:
 requests:
 storage: 1Gi
 storageClassName: csi-obs
 volumeName: pv-obs-example

```

Pay attention to the fields in bold and red. The parameters are described as follows:

**Table 22-21** PVC configuration parameters for an OBS volume

| Parameter                  | Description                                                                                                                                                                                            |
|----------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| everest.io/obs-volume-type | OBS volume type, which can be <b>STANDARD</b> (standard bucket) and <b>WARM</b> (infrequent access bucket). Set this parameter to the same value as that of the PV created in <a href="#">Step 2</a> . |
| csi.storage.k8s.io/fstype  | File type, which can be <b>obsfs</b> or <b>s3fs</b> . The value must be the same as that of <b>fsType</b> of the static OBS volume PV.                                                                 |

| Parameter        | Description                                                                                                                                                                                                                                |
|------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| name             | PVC name, which must be unique in the namespace. The value must be unique in the namespace. (If the PVC is dynamically created by a stateful application, the value of this parameter must be the same as the name of the FlexVolume PVC.) |
| namespace        | Namespace to which the PVC belongs. Use the same value as that of the FlexVolume PVC.                                                                                                                                                      |
| storage          | Storage capacity, in the unit of Gi. Set this parameter to the fixed value <b>1Gi</b> .                                                                                                                                                    |
| storageClassName | Name of the Kubernetes storage class. Set this field to <b>csi-obs</b> .                                                                                                                                                                   |
| volumeName       | Name of the PV. Set this parameter to the name of the static PV created in <a href="#">Step 2</a> .                                                                                                                                        |

Configuration example of a PVC for an SFS Turbo volume:

```

apiVersion: v1
kind: PersistentVolumeClaim
metadata:
 annotations:
 volume.beta.kubernetes.io/storage-provisioner: everest-csi-provisioner
 name: pvc-efs-example
 namespace: default
spec:
 accessModes:
 - ReadWriteMany
 resources:
 requests:
 storage: 10Gi
 storageClassName: csi-sfsturbo
 volumeName: pv-efs-example

```

Pay attention to the fields in bold and red. The parameters are described as follows:

**Table 22-22** PVC configuration parameters for an SFS Turbo volume

| Parameter        | Description                                                                                                                                                                                                                                |
|------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| name             | PVC name, which must be unique in the namespace. The value must be unique in the namespace. (If the PVC is dynamically created by a stateful application, the value of this parameter must be the same as the name of the FlexVolume PVC.) |
| namespace        | Namespace to which the PVC belongs. Use the same value as that of the FlexVolume PVC.                                                                                                                                                      |
| storageClassName | Name of the Kubernetes storage class. Set this field to <b>csi-sfsturbo</b> .                                                                                                                                                              |

| Parameter  | Description                                                                                             |
|------------|---------------------------------------------------------------------------------------------------------|
| storage    | Storage capacity, in the unit of Gi. The value must be the same as the storage size of the existing PV. |
| volumeName | Name of the PV. Set this parameter to the name of the static PV created in <a href="#">Step 2</a> .     |

**Step 4** Upgrade the workload to use a new PVC.

### For Deployments

1. Run the **kubectl create -f** commands to create a PV and PVC.

```
kubectl create -f pv-example.yaml
kubectl create -f pvc-example.yaml
```

#### NOTE

Replace the example file name **pvc-example.yaml** in the preceding commands with the names of the YAML files configured in [Step 2](#) and [Step 3](#).

2. Go to the CCE console. On the workload upgrade page, click **Upgrade > Advanced Settings > Data Storage > Cloud Storage**.
3. Uninstall the old storage and add the PVC in the CSI format. Retain the original mounting path in the container.
4. Click **Submit**.
5. Wait until the pods are running.

### For StatefulSets that use existing storage

1. Run the **kubectl create -f** commands to create a PV and PVC.

```
kubectl create -f pv-example.yaml
kubectl create -f pvc-example.yaml
```

#### NOTE

Replace the example file name **pvc-example.yaml** in the preceding commands with the names of the YAML files configured in [Step 2](#) and [Step 3](#).

2. Run the **kubectl edit** command to edit the StatefulSet and use the newly created PVC.

```
kubectl edit sts sts-example -n xxx
```

```
30 pod.alpha.kubernetes.io/initialized: true
31 spec:
32 volumes:
33 - name: cce-efs-import-kjxmtzqn-z65j
34 persistentVolumeClaim:
35 claimName: pvc-csi-sfsturbo-f2ed93a7-408c-49c3-9a8b-9ded5c6e1533-1
36 containers:
```

#### NOTE

Replace **sts-example** in the preceding command with the actual name of the StatefulSet to upgrade. **xxx** indicates the namespace to which the StatefulSet belongs.

3. Wait until the pods are running.

 NOTE

The current console does not support the operation of adding new cloud storage for StatefulSets. Use the `kubectl` commands to replace the storage with the newly created PVC.

**For StatefulSets that use dynamically allocated storage**

1. Back up the PV and PVC in the flexVolume format used by the StatefulSet.  
**`kubectl get pvc xxx -n {namespaces} -oyaml > pvc-backup.yaml`**  
**`kubectl get pv xxx -n {namespaces} -oyaml > pv-backup.yaml`**
2. Change the number of pods to **0**.
3. On the storage page, disassociate the flexVolume PVC used by the StatefulSet.
4. Run the **`kubectl create -f`** commands to create a PV and PVC.  
**`kubectl create -f pv-example.yaml`**  
**`kubectl create -f pvc-example.yaml`**

 NOTE

Replace the example file name **`pvc-example.yaml`** in the preceding commands with the names of the YAML files configured in [Step 2](#) and [Step 3](#).

5. Change the number of pods back to the original value and wait until the pods are running.

 NOTE

The dynamic allocation of storage for StatefulSets is achieved by using **`volumeClaimTemplates`**. This field cannot be modified by Kubernetes. Therefore, data cannot be migrated by using a new PVC.

The PVC naming rule of the **`volumeClaimTemplates`** is fixed. When a PVC that meets the naming rule exists, this PVC is used.

Therefore, disassociate the original PVC first, and then create a PVC with the same name in the CSI format.

6. (Optional) Recreate the stateful application to ensure that a CSI PVC is used when the application is scaled out. Otherwise, FlexVolume PVCs are used in scaling out.

- Run the following command to obtain the YAML file of the StatefulSet:

```
kubectl get sts xxx -n {namespaces} -oyaml > sts.yaml
```

- Run the following command to back up the YAML file of the StatefulSet:

```
cp sts.yaml sts-backup.yaml
```

- Modify the definition of **`volumeClaimTemplates`** in the YAML file of the StatefulSet.

```
vi sts.yaml
```

Configuration example of **`volumeClaimTemplates`** for an EVS volume:

```
volumeClaimTemplates:
- metadata:
 name: pvc-161070049798261342
 namespace: default
 creationTimestamp: null
 annotations:
```



```

 everest.io/disk-volume-type: SAS
 spec:
 accessModes:
 - ReadWriteOnce
 resources:
 requests:
 storage: 10Gi
 storageClassName: csi-disk

```

The parameter value must be the same as the PVC of the EVS volume created in [Step 3](#).

Configuration example of **volumeClaimTemplates** for an SFS volume:

```

volumeClaimTemplates:
 - metadata:
 name: pvc-161063441560279697
 namespace: default
 creationTimestamp: null
 spec:
 accessModes:
 - ReadWriteMany
 resources:
 requests:
 storage: 10Gi
 storageClassName: csi-nas

```

The parameter value must be the same as the PVC of the SFS volume created in [Step 3](#).

Configuration example of **volumeClaimTemplates** for an OBS volume:

```

volumeClaimTemplates:
 - metadata:
 name: pvc-161070100417416148
 namespace: default
 creationTimestamp: null
 annotations:
 csi.storage.k8s.io/fstype: s3fs
 everest.io/obs-volume-type: STANDARD
 spec:
 accessModes:
 - ReadWriteMany
 resources:
 requests:
 storage: 1Gi
 storageClassName: csi-obs

```

The parameter value must be the same as the PVC of the OBS volume created in [Step 3](#).

- Delete the StatefulSet.

**kubectl delete sts xxx -n {namespace}**

- Create the StatefulSet.

**kubectl create -f sts.yaml**

**Step 5** Check service functions.

1. Check whether the application is running properly.
2. Checking whether the data storage is normal.

 NOTE

If a rollback is required, perform [Step 4](#). Select the PVC in FlexVolume format and upgrade the application.

**Step 6** Uninstall the PVC in the FlexVolume format.

If the application functions normally, unbind the PVC in the FlexVolume format on the storage management page.

You can also run the kubectl command to delete the PVC and PV of the FlexVolume format.

 CAUTION

Before deleting a PV, change the persistentVolumeReclaimPolicy of the PV to **Retain**. Otherwise, the underlying storage will be reclaimed after the PV is deleted.

If the cluster has been upgraded before the storage migration, PVs may fail to be deleted. You can remove the PV protection field **finalizers** to delete PVs.

```
kubectl patch pv {pv_name} -p '{"metadata":{"finalizers":null}}'
```

----End

## 22.9.5 Using Custom Storage Classes

### Background

When using storage resources in CCE, the most common method is to specify **storageClassName** to define the type of storage resources to be created when creating a PVC. The following configuration shows how to use a PVC to apply for an SAS (high I/O) EVS disk (block storage).

```
apiVersion: v1
kind: PersistentVolumeClaim
metadata:
 name: pvc-evs-example
 namespace: default
 annotations:
 everest.io/disk-volume-type: SAS
spec:
 accessModes:
 - ReadWriteOnce
 resources:
 requests:
 storage: 10Gi
 storageClassName: csi-disk
```

To specify the EVS disk type, you can configure the **everest.io/disk-volume-type** field. The value **SAS** is used as an example here, indicating the high I/O EVS disk type. Or you can choose **SATA** (common I/O) and **SSD** (ultra-high I/O).

This configuration method may not work if you want to:

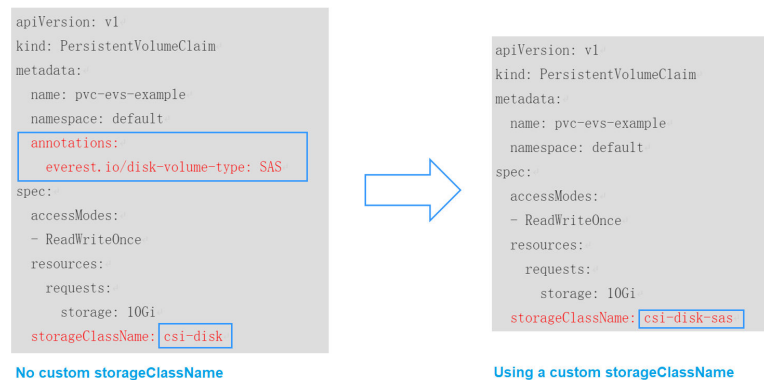
- Set **storageClassName** only, which is simpler than specifying the EVS disk type by using **everest.io/disk-volume-type**.

- 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 # EVS disk
csi-disk everest-csi-provisioner 17d # EVS disks created with delay
csi-disk-topology everest-csi-provisioner 17d # SFS 1.0
csi-nas everest-csi-provisioner 17d # OBS
csi-obs everest-csi-provisioner 17d # SFS Turbo
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 # (Optional) Set the file system type to xfs or ext4. If it is left blank, ext4
 will be used by default.
 everest.io/disk-volume-type: SAS
 everest.io/passthrough: 'true'
reclaimPolicy: Delete
allowVolumeExpansion: true
volumeBindingMode: Immediate
```

Table 22-23 Key parameters

| Parameter            | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
|----------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| provisioner          | Specifies the storage resource provider, which is the Everest add-on for CCE. Set this parameter to <b>everest-csi-provisioner</b> .                                                                                                                                                                                                                                                                                                                                                                                                 |
| parameters           | Specifies the storage parameters, which vary with storage types. For details, see <a href="#">Table 22-24</a> .                                                                                                                                                                                                                                                                                                                                                                                                                      |
| reclaimPolicy        | Specifies the value of <b>persistentVolumeReclaimPolicy</b> for creating a PV. The value can be <b>Delete</b> or <b>Retain</b> . If <b>reclaimPolicy</b> is not specified when a StorageClass object is created, the value defaults to <b>Delete</b> . <ul style="list-style-type: none"> <li>• <b>Delete</b>: indicates that a dynamically created PV will be automatically deleted when the PVC is deleted.</li> <li>• <b>Retain</b>: indicates that a dynamically created PV will be retained when the PVC is deleted.</li> </ul> |
| allowVolumeExpansion | Specifies whether the PV of this storage class supports dynamic capacity expansion. The default value is <b>false</b> . Dynamic capacity expansion is implemented by the underlying storage add-on. This is only a switch.                                                                                                                                                                                                                                                                                                           |

| Parameter         | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
|-------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| volumeBindingMode | <p>Specifies the volume binding mode, that is, the time when a PV is dynamically created. The value can be <b>Immediate</b> or <b>WaitForFirstConsumer</b>.</p> <ul style="list-style-type: none"> <li>• <b>Immediate</b>: PV binding and dynamic creation are completed when a PVC is created.</li> <li>• <b>WaitForFirstConsumer</b>: PV binding and creation are delayed. The PV creation and binding processes are executed only when the PVC is used in the workload.</li> </ul> |
| 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 22-24** 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 <b>disk.csi.everest.io</b> .                                                                                                                                                                                                                                                                 |
|             | csi.storage.k8s.io/fstype          | Yes       | <p>If an EVS disk is used, the parameter value can be <b>ext4</b> or <b>xfs</b>.</p> <p>The restrictions on using <b>xfs</b> are as follows:</p> <ul style="list-style-type: none"> <li>• The nodes must run CentOS 7 or Ubuntu 22.04, and the Everest version in the cluster must be 2.3.2 or later.</li> <li>• Only common containers are supported.</li> </ul> |
|             | everest.io/disk-volume-type        | Yes       | <p>EVS disk type. All letters are in uppercase.</p> <ul style="list-style-type: none"> <li>• <b>SATA</b>: common I/O</li> <li>• <b>SAS</b>: high I/O</li> <li>• <b>SSD</b>: ultra-high I/O</li> <li>• <b>GPSSD</b>: general-purpose SSD</li> </ul>                                                                                                                |
|             | everest.io/passthrough             | Yes       | The parameter value is fixed at <b>true</b> , which indicates that the EVS device type is <b>SCSI</b> . Other parameter values are not allowed.                                                                                                                                                                                                                   |
| SFS         | csi.storage.k8s.io/csi-driver-name | Yes       | Driver type. If SFS is used, the parameter value is fixed at <b>nas.csi.everest.io</b> .                                                                                                                                                                                                                                                                          |

| Volume Type | Parameter                          | Mandatory | Description                                                                                                                                                        |
|-------------|------------------------------------|-----------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|             | csi.storage.k8s.io/fstype          | Yes       | If SFS is used, the value can be <b>nfs</b> .                                                                                                                      |
|             | everest.io/share-access-level      | Yes       | The parameter value is fixed at <b>rw</b> , indicating that the SFS data is readable and writable.                                                                 |
|             | everest.io/share-access-to         | Yes       | VPC ID of the cluster.                                                                                                                                             |
|             | everest.io/share-is-public         | No        | The parameter value is fixed at <b>false</b> , indicating that the file is shared to private.<br>You do not need to configure this parameter when SFS 3.0 is used. |
|             | everest.io/sfs-version             | No        | This parameter is mandatory only when SFS 3.0 is used. The value is fixed at <b>sfs3.0</b> .                                                                       |
| SFS Turbo   | csi.storage.k8s.io/csi-driver-name | Yes       | Driver type. If SFS Turbo is used, the parameter value is fixed at <b>sfsturbo.csi.everest.io</b> .                                                                |
|             | csi.storage.k8s.io/fstype          | Yes       | If SFS Turbo is used, the value can be <b>nfs</b> .                                                                                                                |
|             | everest.io/share-access-to         | Yes       | VPC ID of the cluster.                                                                                                                                             |
|             | everest.io/share-expand-type       | No        | Extension type. The default value is <b>bandwidth</b> , indicating an enhanced file system. This parameter does not take effect.                                   |
|             | everest.io/share-source            | Yes       | The parameter value is fixed at <b>sfs-turbo</b> .                                                                                                                 |
|             | everest.io/share-volume-type       | No        | SFS Turbo storage class. The default value is <b>STANDARD</b> , 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 <b>obs.csi.everest.io</b> .                                                                           |

| Volume Type | Parameter                  | Mandatory | Description                                                                                                                                                                                                                                                                            |
|-------------|----------------------------|-----------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|             | csi.storage.k8s.io/fstype  | Yes       | Instance type, which can be <b>obsfs</b> or <b>s3fs</b> . <ul style="list-style-type: none"> <li><b>obsfs</b>: a parallel file system</li> <li><b>s3fs</b>: object bucket</li> </ul>                                                                                                   |
|             | everest.io/obs-volume-type | Yes       | OBS storage class. <ul style="list-style-type: none"> <li>If <b>fsType</b> is set to <b>s3fs</b>, <b>STANDARD</b> (standard bucket) and <b>WARM</b> (infrequent access bucket) are supported.</li> <li>This parameter is invalid when <b>fsType</b> is set to <b>obsfs</b>.</li> </ul> |

## 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 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 pv
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

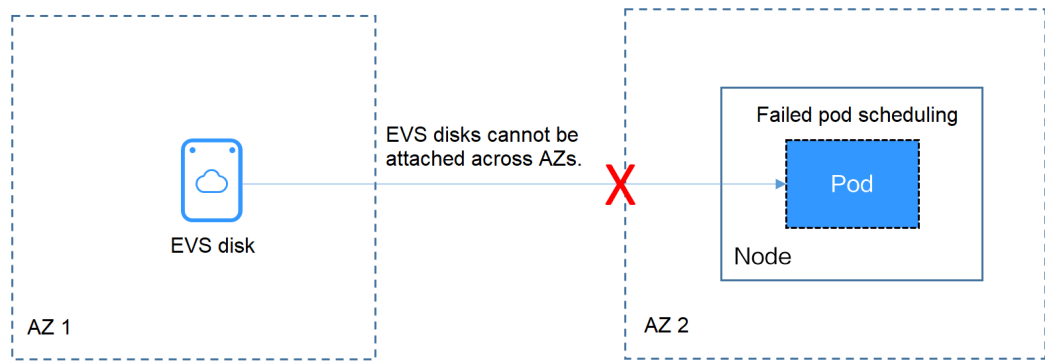
```

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.

## 22.9.6 Scheduling EVS Disks Across AZs Using `csi-disk-topology`

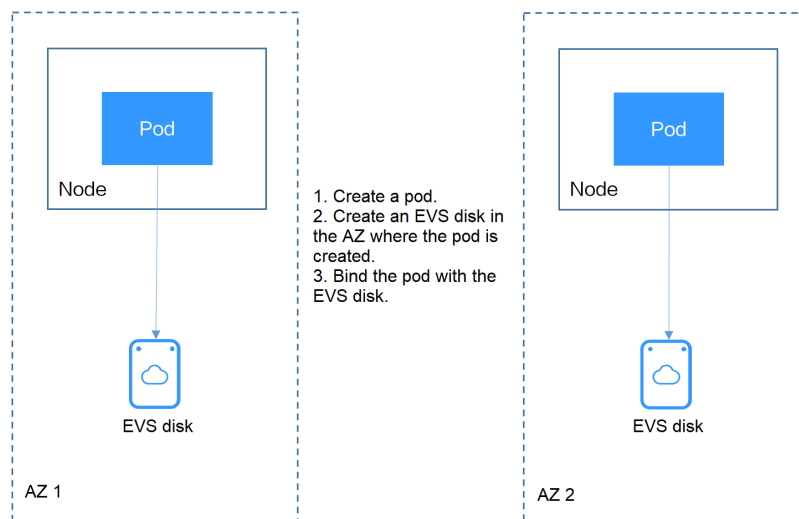
### Background

EVS disks cannot be attached to a node deployed in another AZ. For example, the EVS disks in AZ 1 cannot be attached to a node in AZ 2. If the storage class `csi-disk` is used for StatefulSets, when a StatefulSet is scheduled, a PVC and a PV are created immediately (an EVS disk is created along with the PV), and then the PVC is bound to the PV. However, when the cluster nodes are located in multiple AZs, the EVS disk created by the PVC and the node to which the pods are scheduled may be in different AZs. As a result, the pods fail to be scheduled.



## Solution

CCE provides a storage class named **csi-disk-topology**, which is a late-binding EVS disk type. When you use this storage class to create a PVC, no PV will be created in pace with the PVC. Instead, the PV is created in the AZ of the node where the pod will be scheduled. An EVS disk is then created in the same AZ to ensure that the EVS disk can be attached and the pod can be successfully scheduled.



## Failed Pod Scheduling Due to csi-disk Used in Cross-AZ Node Deployment

Create a cluster with three nodes in different AZs.

Use the csi-disk storage class to create a StatefulSet and check whether the workload is successfully created.

```
apiVersion: apps/v1
kind: StatefulSet
metadata:
 name: nginx
spec:
 serviceName: nginx # Name of the headless Service
 replicas: 4
 selector:
 matchLabels:
 app: nginx
 template:
 metadata:
 labels:
```

```

 app: nginx
 spec:
 containers:
 - name: container-0
 image: nginx:alpine
 resources:
 limits:
 cpu: 600m
 memory: 200Mi
 requests:
 cpu: 600m
 memory: 200Mi
 volumeMounts:
 - 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      |
|----------|----------------|------------------------------------------|----------|-------------------|
| disk     | <b>Bound</b>   | pvc-88d96508-d246-422e-91f0-8caf414001fc | 10Gi     | RWO               |
| topology | <b>Pending</b> |                                          |          | csi-disk-topology |

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 | <b>WaitForFirstConsumer</b> | 5s (x3 over 30s) | persistentvolume-controller | <b>waiting for first consumer to be created before binding</b> |

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 Message
 ---- -
 Normal WaitForFirstConsumer 84s (x26 over 7m34s) persistentvolume-controller
binding waiting for first consumer to be created before
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- 55s Filesystem
topology
data-nginx-1 Bound pvc-fc942a73-45d3-476b-95d4-1eb94bf19f1f 1Gi RWO csi-disk- 39s Filesystem
topology
data-nginx-2 Bound pvc-d219f4b7-e7cb-4832-a3ae-01ad689e364e 1Gi RWO csi-disk- 22s Filesystem
topology
data-nginx-3 Bound pvc-b54a61e1-1c0f-42b1-9951-410ebd326a4d 1Gi RWO csi-disk- 9s Filesystem
topology

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>
```

## 22.10 Container

### 22.10.1 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
```

## 22.10.2 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          | <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:

|                     |                                             |                       |                |       |
|---------------------|---------------------------------------------|-----------------------|----------------|-------|
| <b>897b99faa9ce</b> | 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

## 22.10.3 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.

```

9dc822969e3f percona "docker-entrypoint..." 34 seconds ago Up 33 seconds
pl_mysql-76598b8c64-mm9w9_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-mm9w9_default_522566ea-bda5-11e9-a219-fa163e8b288b_0
915db9e60a80 cfe-pause:11.23.1 "/pause" About a minute ago Up About a minute
mysql-76598b8c64-mm9w9_default_522566ea-bda5-11e9-a219-fa163e8b288b_0

```

----End

## 22.10.4 Configuring the /etc/hosts File of a Pod Using hostAliases

### Application Scenarios

If DNS or other related settings are inappropriate, you can use **hostAliases** to overwrite the resolution of the hostname at the pod level when adding entries to the **/etc/hosts** file of the pod.

### Procedure

**Step 1** Use kubectl to connect to the cluster.

**Step 2** Create the **hostaliases-pod.yaml** file.

**vi hostaliases-pod.yaml**

The field in bold in the YAML file indicates the image name and tag. You can replace the example value as required.

```

apiVersion: v1
kind: Pod
metadata:

```

```

name: hostaliases-pod
spec:
 hostAliases:
 - ip: 127.0.0.1
 hostnames:
 - foo.local
 - bar.local
 - ip: 10.1.2.3
 hostnames:
 - foo.remote
 - bar.remote
 containers:
 - name: cat-hosts
 image: tomcat:9-jre11-slim
 lifecycle:
 postStart:
 exec:
 command:
 - cat
 - /etc/hosts
 imagePullSecrets:
 - name: default-secret

```

**Table 22-25** 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 <a href="#">Table 22-26</a> . |

**Table 22-26** spec field description

| Parameter   | Mandatory | Description                                    |
|-------------|-----------|------------------------------------------------|
| hostAliases | Yes       | Host alias                                     |
| containers  | Yes       | For details, see <a href="#">Table 22-27</a> . |

**Table 22-27** 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

## 22.10.5 Locating Container Faults Using the Core Dump File

### Application Scenarios

Linux allows you to create a core dump file if an application crashes, which contains the data the application had in memory at the time of the crash. You can analyze the file to locate the fault.

Generally, when a service application crashes, its container exits and is reclaimed and destroyed. Therefore, container core files need to be permanently stored on the host or cloud storage. This topic describes how to configure container core dumps.

### Constraints

When a container core dump is persistently stored to OBS (parallel file system or object bucket), the default mount option **umask=0** is used. As a result, although

the core dump file is generated, the core dump information cannot be written to the core file.

## 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
```

## 22.11 Permission

### 22.11.1 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 **base64 -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-12q92 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 group "" 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 delete 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](#).

# 22.12 Release

## 22.12.1 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.

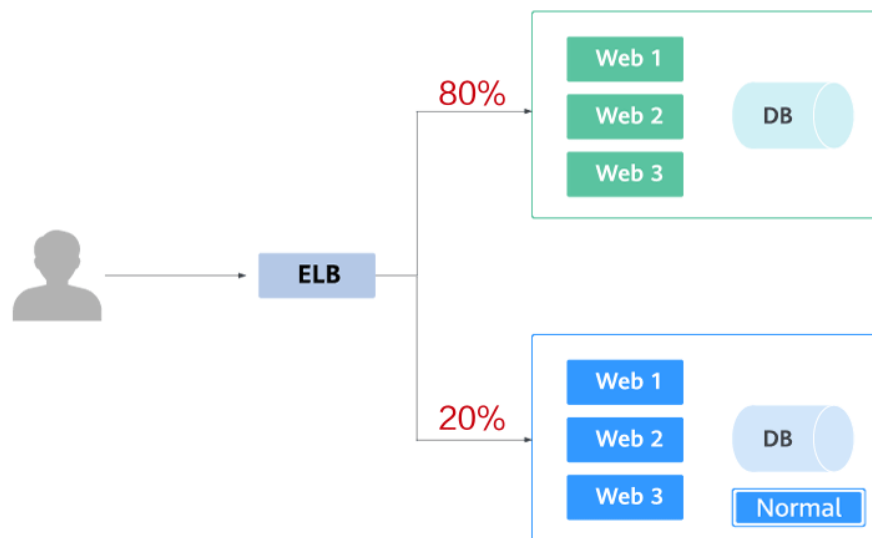
### Solution

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.

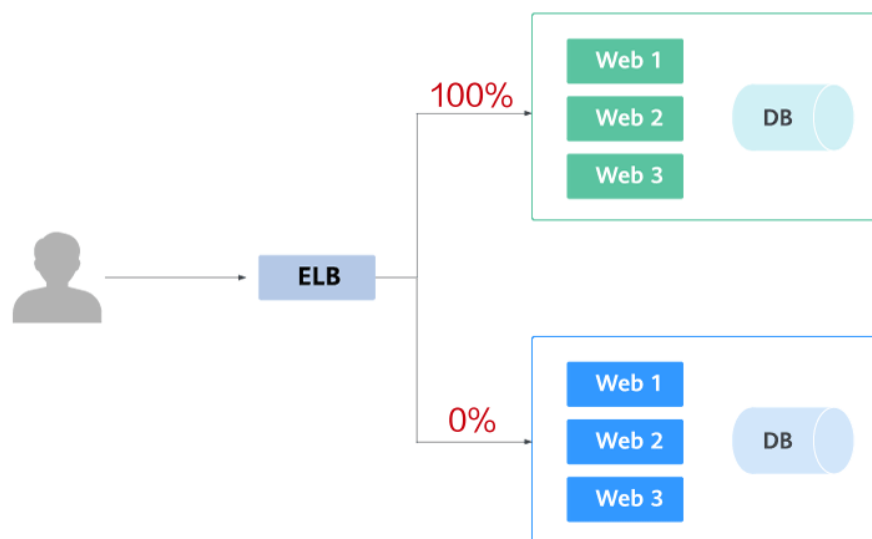
This document describes the principles and practices of grayscale release and blue-green deployment.

- 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.

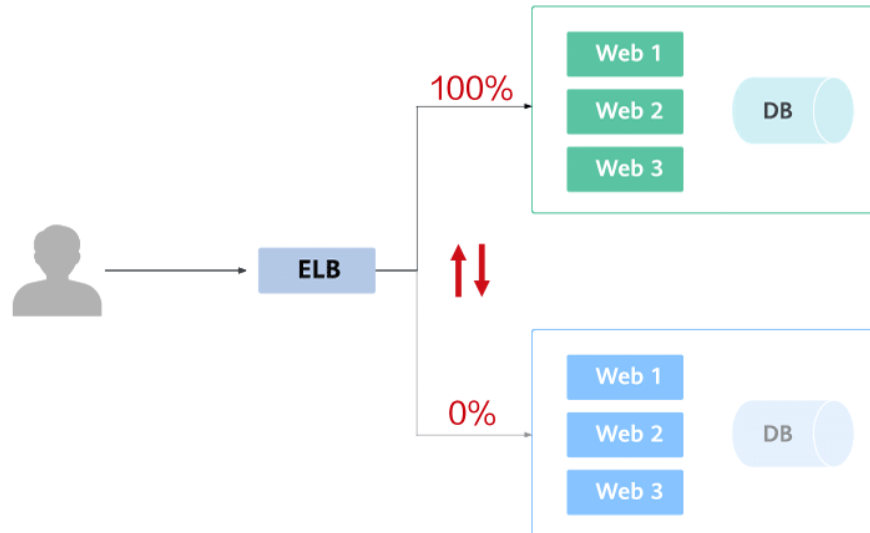


If an exception occurs in the new version when 20% of the traffic goes to the new version, you can quickly switch back to the old version.



- 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.

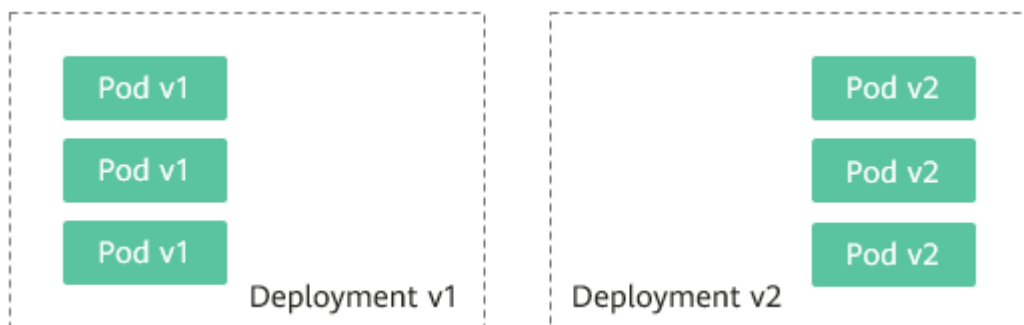


## 22.12.2 Using Services to Implement Simple Grayscale Release and Blue-Green Deployment

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.

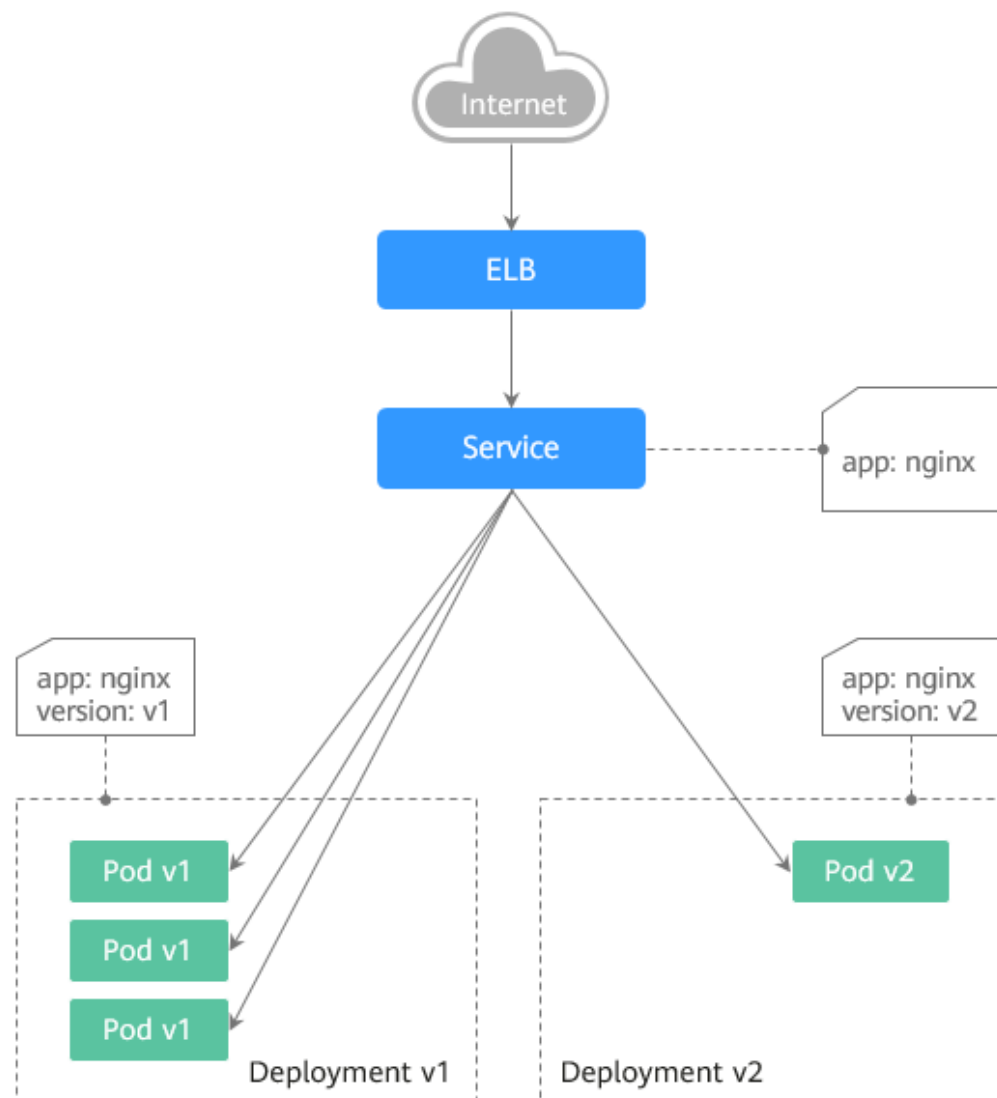


Generally, a Service is created for each workload. The Service uses the selector to match the backend pod. Other Services or objects outside the cluster can access

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**

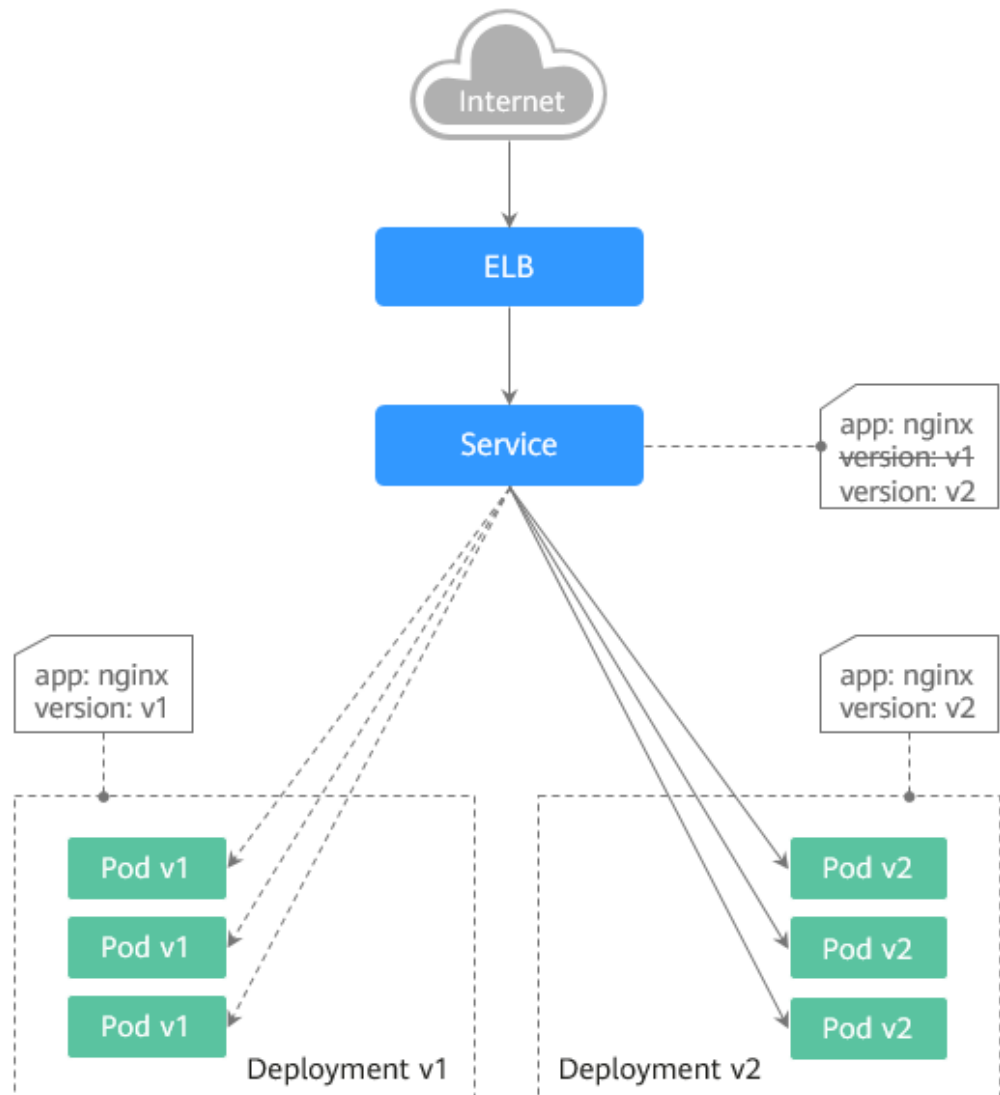
Take a Deployment as an example. A Service, in most cases, will be created for each Deployment. However, Kubernetes does not require that Services and Deployments correspond to each other. A Service uses a selector to match backend pods. If pods of different Deployments are selected by the same selector, 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 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**

# 23 Migrating Data from CCE 1.0 to CCE 2.0

---

Perform the following operations to migrate data from CCE 1.0 to CCE 2.0:

1. **Migrating Images:** Pull images from the image repository of CCE 1.0, and push them to the image repository of CCE 2.0.
2. **Migrating clusters:** Create VM clusters in CCE 2.0 for application deployment.
3. **Migrating applications:** Move applications deployed in CCE 1.0 to the new clusters of CCE 2.0.

## 23.1 Differences Between CCE 1.0 and CCE 2.0

CCE 2.0 inherits and modifies the features of CCE 1.0, and release new features.

- Modified features:
  - Clusters in CCE 1.0 are equivalent to VM clusters in CCE 2.0.
  - CCE 2.0 does not have the concept of component template. In CCE 1.0, you can set parameters in the component template when creating an application.
  - Applications in CCE 1.0 are equivalent to Deployments in CCE 2.0. In addition, the concept of StatefulSet is added in CCE 2.0.
- New Features:
  - EVS disks and file storage can be created and directly mounted during workload creation on the CCE console.
  - Auto scaling for cluster nodes.
  - Docker upgraded to the 1706 version.
  - Customized helm charts for orchestrating workloads.
- In CCE 2.0, before uploading an image, you must create an image repository.

The following table compares the two versions.

**Table 23-1** Comparison between CCE 1.0 and CCE 2.0

| CCE 1.0            | CCE 2.0                          |
|--------------------|----------------------------------|
| Container registry | Image repository                 |
| Cluster            | Resource Management > VM Cluster |
| Component template | -                                |
| App Designer       | -                                |
| App Manager        | Deployment                       |

## 23.2 Migrating Images

Migrate the images stored in the image repository of CCE 1.0 to CCE 2.0.

This section takes the Apache image as an example to show how to migrate images step by step.

### Procedure

Before pushing container images, ensure that the local Docker client can access your private container registry.

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

**Step 2** Create an organization. Organizations are used to isolate images and assign access permissions (read, edit, and manage) to different users.

1. Log in to the CCE console. In the navigation pane, choose **Image Repository**.
2. On the Image Repository dashboard page, click **Create Organization**.
3. Enter an organization name, that is, the domain name. When the configuration is complete, click **OK**.

**Step 3** Log in to the Docker client as the **root** user.

**Step 4** Pull the images stored in the image repository of CCE 1.0 to a local directory.

 **NOTE**


To pull images, log in to the CCE 1.0 console. In the navigation pane, choose **Image Repository**. Click the name of the target images. On the image details pages, you can find corresponding image pull command.

Example:

**docker pull 10.154.57.150:443/test/apache-php:latest**

**Step 5** Connect to CCE 2.0.

1. Log in to the CCE 2.0 console. In the navigation pane, click **Image Repository**.
2. On the page displayed, click **Upload Through Docker Client**. Click **Generate a temporary Docker login command**.

3. Click  to copy the command.

**Step 6** Log in to the server where Docker is installed. Run the Docker login command copied in [Step 5](#).

After you log in to the Docker client, the system displays the message "login succeeded".

**Step 7** Run the following command to tag the nginx:1.10 image:

```
docker tag {imageid} {image address}:tag
```

{image address} is the image repository address. If you push an image from an external network, enter the external image address. If you push an image from an internal network, enter the internal image address.

Example:

```
docker tag 2e233ad9329b 10.125.1.15:20202/test/apache-php:latest
```

**Step 8** Run the following command to push the image to the image repository:

```
docker push {image address}:tag
```

Example:

```
docker push 10.125.1.15:20202/test/apache-php:latest
```

If the following information is displayed, the push is successful:

```
6d6b9812c8ae: Pushed
695da0025de6: Pushed
fe4c16cbf7a4: Pushed
1.10: digest: sha256:eb7e3bbd8e3040efa71d9c2cacfa12a8e39c6b2ccd15eac12bdc49e0b66cee63 size: 948
```

On the **SWR** console, choose **My Images**. The pushed images are displayed in the image list.

----End

## 23.3 Migrating Clusters

Create VM clusters on the CCE 2.0 console. These new VM clusters should have the same specifications with those created on CCE 1.0.

To create clusters using APIs, see *Cloud Container Engine API Reference 2.0*.

### Procedure

**Step 1** Log in to the CCE console. In the navigation pane, choose **Resource Management** > **Clusters**. Click **Create VM Cluster**.

**Step 2** Set cluster parameters. Parameters with \* are mandatory.

**Table 23-2** Parameters for creating a cluster

| Parameter in CCE 2.0 | Parameter in CCE 1.0                                                                     | Configuration                                                                                                                                                                                                                                                                                                                                      |
|----------------------|------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| * Cluster Name       | Name                                                                                     | Name of the cluster to be created.                                                                                                                                                                                                                                                                                                                 |
| *Version             | This parameter does not exist in CCE 1.0. Retain the default value.                      | Cluster version, namely, corresponding Kubernetes baseline version.                                                                                                                                                                                                                                                                                |
| *Management Scale    | This parameter does not exist in CCE 1.0. Set this parameter based on your requirements. | Maximum number of nodes that can be managed by the cluster.                                                                                                                                                                                                                                                                                        |
| * High Availability  | Cluster type                                                                             | <ul style="list-style-type: none"> <li>● <b>Yes:</b> The cluster has three master nodes. The cluster is still available even when two master nodes are down.</li> <li>● <b>No:</b> The cluster has only one master node. If the master node is down, the whole cluster becomes unavailable, but existing applications are not affected.</li> </ul> |
| * VPC                | VPCs created in CCE 1.0 can be used in CCE 2.0.                                          | VPC where the cluster will be located.<br>If no VPCs are available, click <b>Create a VPC</b> .                                                                                                                                                                                                                                                    |
| * Subnet             | Subnets created in CCE 1.0 can be used in CCE 2.0.                                       | Subnet in which the cluster will run.                                                                                                                                                                                                                                                                                                              |



| Parameter in CCE 2.0 | Parameter in CCE 1.0                                                                     | Configuration                                                                                                                                                                                                                                                                                                                                                                 |
|----------------------|------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| *Network Model       | This parameter does not exist in CCE 1.0. Set this parameter based on your requirements. | <ul style="list-style-type: none"> <li>● Container tunnel network: indicates a network built on top of a VPC network and can be applied to common scenarios.</li> <li>● VPC network: delivers better performance and applies to high-performance and intensive interaction scenarios. Only one cluster using the VPC network model can be created in a single VPC.</li> </ul> |

| Parameter in CCE 2.0      | Parameter in CCE 1.0                                                                     | Configuration                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
|---------------------------|------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Container Network Segment | This parameter does not exist in CCE 1.0. Set this parameter based on your requirements. | <p>An IP address range that can be allocated to container pods.</p> <ul style="list-style-type: none"> <li>• If <b>Automatically select</b> is deselected, enter a CIDR block manually. If the CIDR block you specify conflicts with a subnet CIDR block, the system prompts you to select another CIDR block. The recommended CIDR blocks are 10.0.0.0/12-19, 172.16.0.0/16-19, and 192.168.0.0/16-19. If different clusters share a container CIDR block, an IP address conflict will occur and access to the applications in the clusters may fail.</li> <li>• If <b>Automatically select</b> is selected, the system automatically assigns a CIDR block that does not conflict with any subnet CIDR block.</li> </ul> <p>The mask of the container CIDR block must be appropriate. It determines the number of available nodes in a cluster. A too small mask value will cause the cluster to soon fall short of nodes. After the mask is set, the estimated maximum number of nodes supported by the current CIDR block will be displayed.</p> |

| Parameter in CCE 2.0    | Parameter in CCE 1.0                                                                     | Configuration                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
|-------------------------|------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Service Network Segment | This parameter does not exist in CCE 1.0. Set this parameter based on your requirements. | <p>This parameter is left unspecified, by default. This parameter applies only to clusters of v1.11.7 and later versions.</p> <p>This parameter indicates a CIDR block of Kubernetes services. The mask of the service CIDR block must be appropriate. It determines the number of available nodes in a cluster.</p>                                                                                                                                                                                              |
| Open EIP                | This parameter does not exist in CCE 1.0. Set this parameter based on your requirements. | <p>An independent public IP address that is reachable from public networks. Select an EIP that has not been bound to any node. A cluster's EIP is preset in the cluster's certificate. Do not delete the EIP after the cluster has been created. Otherwise, two-way authentication will fail.</p> <ul style="list-style-type: none"> <li>• <b>Do not configure:</b> The cluster's master node will not have an EIP.</li> <li>• <b>Configure now:</b> If no EIP is available for selection, create one.</li> </ul> |
| Authorization Mode      | This parameter does not exist in CCE 1.0. Set this parameter based on your requirements. | <p>By default, <b>RBAC</b> is selected. Read <a href="#">CCE Role Management Instructions</a> and select <b>I am aware of the above limitations and read the CCE Role Management Instructions</b>.</p> <p>After RBAC is enabled, users access resources in the cluster according to fine-grained permissions policies.</p>                                                                                                                                                                                        |

| Parameter in CCE 2.0 | Parameter in CCE 1.0                                                                     | Configuration                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
|----------------------|------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Authentication Mode  | This parameter does not exist in CCE 1.0. Set this parameter based on your requirements. | <p>Permission control on resources in a cluster. For example, you can configure user A to read and write application data in a namespace, while user B to only read resource data in a cluster.</p> <ul style="list-style-type: none"> <li>• By default, X.509 authentication instead of <b>Enhanced authentication</b> is enabled. X.509 is a standard defining the format of public key certificates. X.509 certificates are used in many Internet protocols.</li> <li>• If permission control on a cluster is required, select <b>Enhanced authentication</b> and then <b>Authenticating Proxy</b>. Click <b>Upload</b> next to <b>CA Root Certificate</b> to upload a valid certificate. Select the check box to confirm that the uploaded certificate is valid. If the certificate is invalid, the cluster cannot be created. The uploaded certificate file must be smaller than 1 MB and in .crt or .cer format.</li> </ul> |
| Cluster Description  | Description                                                                              | Description of the cluster.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |

**Step 3** After the configuration is complete, click **Next** to add a node.

**Step 4** Continue to add a node.

**Step 5** Set the parameters based on [Table 23-3](#).

**Table 23-3** Parameters for adding a node

| Parameter in CCE 2.0 | Parameter in CCE 1.0 | Configuration                                                                                                                                            |
|----------------------|----------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------|
| Scope                |                      |                                                                                                                                                          |
| Current Region       | Scope                | Physical location of the node.                                                                                                                           |
| AZ.                  |                      | Physical region where resources use independent power supplies and networks. AZs are physically isolated but interconnected through an internal network. |
| Specifications       |                      |                                                                                                                                                          |
| Node Name            | Specifications       | Name of the node.                                                                                                                                        |

| Parameter in CCE 2.0 | Parameter in CCE 1.0 | Configuration                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
|----------------------|----------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Node specifications. |                      | <ul style="list-style-type: none"> <li>• <b>General-purpose:</b> provides general computing, storage, and network configurations for the majority of application scenarios. General-purpose instances can be used in web servers, development and test environments, and small database applications.</li> <li>• <b>Memory-optimized:</b> provides higher memory capacity than general-purpose nodes and is suitable for relational databases, NoSQL, and other workloads that are both memory-intensive and data-intensive.</li> <li>• <b>General computing-plus:</b> provides stable performance and exclusive resources to enterprise-class workloads with high and stable computing performance.</li> <li>• <b>GPU-accelerated:</b> provides powerful floating-point computing and is suitable for real-time, highly concurrent massive computing.<br/>Calculation scenario. Graphical processing units (GPUs) of P series are suitable for deep learning, scientific computing, and CAE. GPUs of G series are suitable for 3D animation rendering and CAD.<br/>Currently, only clusters of v1.11 support GPU-accelerated nodes. If the cluster version is v1.13 or later, <b>GPU-accelerated</b> is not displayed on the page.</li> <li>• <b>Ultra-high I/O:</b> provides ultra-low SSD access latency and ultra-high IOPS performance.<br/>This type of specifications is suitable for high-performance relational databases, NoSQL databases (such as Cassandra and MongoDB), and Elasticsearch.</li> </ul> |
| OS                   |                      | <p>Select an operating system for the node pool.</p> <p>Reinstalling OSs or modifying OS configurations could make nodes unavailable. Exercise caution when performing these operations. For details, see <a href="#">Risky Operations on Cluster Nodes</a>.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |

| Parameter in CCE 2.0                                                                                                                                                                                                                                                                     | Parameter in CCE 1.0                                                                     | Configuration                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Virtual Private Cloud                                                                                                                                                                                                                                                                    | This parameter does not exist in CCE 1.0. Set this parameter based on your requirements. | The node pool inherits VPC settings from the cluster to which it belongs. This parameter is supported only in v1.13.10-r0 and later versions of clusters. It is not displayed in versions earlier than v1.13.10-r0.                                                                                                                                                                                                                                                                                                                                                                                                                       |
| Subnet                                                                                                                                                                                                                                                                                   | This parameter does not exist in CCE 1.0. Set this parameter based on your requirements. | A subnet provides dedicated network resources that are logically isolated from other networks for network security.<br><br>You can select any subnet in the cluster VPC. Cluster nodes can belong to different subnets. This parameter is supported only in v1.13.10-r0 and later versions of clusters. It is not displayed in versions earlier than v1.13.10-r0.                                                                                                                                                                                                                                                                         |
| Nodes                                                                                                                                                                                                                                                                                    | Quantity                                                                                 | Number of nodes to be created.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| <p>Network</p> <p><b>NOTE</b><br/>If the nodes to be created require public network access, select <b>Automatically assign</b> or <b>Use existing</b> for <b>EIP</b>. If an EIP is not bound to a node, applications running on the node cannot be accessed by the external network.</p> |                                                                                          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| EIP                                                                                                                                                                                                                                                                                      | EIP                                                                                      | <p>A public IP address that is reachable from public networks.</p> <ul style="list-style-type: none"> <li>• <b>Do Not Use:</b> A node without an EIP cannot access the Internet. It can be used only as a cloud server for deploying services or clusters on a private network.</li> <li>• <b>Automatically assign:</b> An EIP with exclusive bandwidth is automatically assigned to each ECS. When creating an ECS, ensure that the EIP quota is sufficient. Set the specifications, required quantity, billing mode, and bandwidth as required.</li> <li>• <b>Use Existing EIP:</b> An existing EIP is assigned to the node.</li> </ul> |

| Parameter in CCE 2.0  | Parameter in CCE 1.0                                                                     | Configuration                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
|-----------------------|------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Disks                 | Storage                                                                                  | <p>Disk type, which can be <b>System Disk</b> or <b>Data Disk</b>.</p> <ul style="list-style-type: none"> <li>The system disk capacity ranges from 40 to 1024 GB. The default value is 40 GB.</li> <li>The data disk capacity ranges from 100 to 32678 GB. The default value is 100 GB.</li> </ul> <p>Data disks deliver three levels of I/O performance:</p> <ul style="list-style-type: none"> <li><b>Common I/O:</b> SATA drives are used to store data. EVS disks of this level provide reliable block storage and a maximum IOPS of 1,000 per disk. They are suitable for key applications.</li> <li><b>High I/O:</b> SAS drives are used to store data. EVS disks of this level provide a maximum IOPS of 3,000 and a minimum read/write latency of 1 ms. They are suitable for RDS, NoSQL, data warehouse, and file system applications.</li> <li><b>Ultra-high I/O:</b> SSD drives are used to store data. EVS disks of this level provide a maximum IOPS of 20,000 and a minimum read/write latency of 1 ms. They are suitable for RDS, NoSQL, and data warehouse applications.</li> </ul> |
| Login information     |                                                                                          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| Key pair              | Key pair                                                                                 | A key pair is used for identity authentication when you remotely log in to a node. If no key pair is available, click <b>Create a key pair</b> and create one.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| Advanced ECS Settings |                                                                                          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| ECS Group             | This parameter does not exist in CCE 1.0. Set this parameter based on your requirements. | <p>Select an existing ECS group, or click <b>Create ECS Group</b> to create one. After the ECS group is created, click the refresh icon.</p> <p>An ECS group allows you to create ECSs on different hosts, thereby improving service reliability.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |



| Parameter in CCE 2.0                     | Parameter in CCE 1.0 | Configuration                                                                                                                                                                                                                                                                                                                                                                                                                                      |
|------------------------------------------|----------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Resource tag.                            |                      | <p>By adding tags to resources, you can classify resources.</p> <p>You can create <b>predefined tags</b> in Tag Management Service (TMS). Predefined tags are visible to all service resources that support the tagging function. You can use predefined tags to improve tag creation and migration efficiency.</p> <p>CCE will automatically create the "CCE-Dynamic-Provisioning-Node=<i>Node ID</i>" tag. A maximum of 5 tags can be added.</p> |
| Agency Management                        |                      | <p>The 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. To authorize ECS or BMS to call cloud services, select <b>Cloud service</b> as the agency type, click <b>Select</b>, and then select <b>ECS BMS</b>.</p>                                                  |
| Script required before the installation. |                      | <p>Script commands. Enter 0 to 1000 characters.</p> <p>The script will be executed before Kubernetes software is installed. Note that if the script is incorrect, Kubernetes software may not be installed successfully. The script is usually used to format data disks.</p>                                                                                                                                                                      |
| Script required after the installation.  |                      | <p>Script commands. Enter 0 to 1000 characters.</p> <p>The script will be executed after Kubernetes software is installed and will not affect the installation. The script is usually used to modify Docker parameters.</p>                                                                                                                                                                                                                        |
| Add Data Disk                            |                      | <p>Click <b>Add Data Disk</b> to add a data disk and set the capacity of the data disk. Enter a disk formatting command in the input box of <b>Pre-installation Script</b>.</p>                                                                                                                                                                                                                                                                    |
| Subnet IP Address                        |                      | <p>Select <b>Automatically assign IP address</b> (recommended) or <b>Manually assigning IP addresses</b>.</p>                                                                                                                                                                                                                                                                                                                                      |
| Advanced Kubernetes Settings             |                      |                                                                                                                                                                                                                                                                                                                                                                                                                                                    |

| Parameter in CCE 2.0             | Parameter in CCE 1.0                                                                     | Configuration                                                                                                                                                                                                                                                                                                                                                                                                                                          |
|----------------------------------|------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Maximum Instances                | This parameter does not exist in CCE 1.0. Set this parameter based on your requirements. | The maximum number of pods that can be created on a node, including the system's default pods. Value range: 16 to 250. This limit prevents the node from being overloaded by managing too many pods.                                                                                                                                                                                                                                                   |
| insecure-registries              | This parameter does not exist in CCE 1.0. Set this parameter based on your requirements. | Click <b>Add insecure-registry</b> and enter a repository address. Add the address of the custom image repository with no valid SSL certificate to the docker startup option to avoid unsuccessful image pulling from the personal image repository. The address is in the format of IP address:Port number (or domain name). Post-installation script and insecure-registries cannot be used together.                                                |
| Maximum Data Space per Container | This parameter does not exist in CCE 1.0. Set this parameter based on your requirements. | The maximum data space that can be used by a container. Value range: 10 GB to 80 GB. If the value of this field is larger than the data disk space allocated to Docker resources, the latter will override the value specified here. Typically, 90% of the data disk space is allocated to Docker resources. This parameter is supported only in v1.13.10-r0 and later versions of clusters. It is not displayed in versions earlier than v1.13.10-r0. |

**Step 6** Click **Next** to install cluster add-ons.

System resource add-ons must be installed. Advanced functional add-ons are optional.

You can also install optional add-ons after the cluster is created. To do so, choose **Add-ons** in the navigation pane of the CCE console and select the add-on you will install. For details, see [Add-on Management](#).

**Step 7** Click **Create Now**. Check all the configurations, and click **Submit**.

It takes about 6 to 10 minutes to create a cluster. Information indicating the progress of the creation process will be displayed.

----End

## 23.4 Migrating Applications

This section describes how to create a Deployment with the same specifications as that in CCE 1.0 on the CCE 2.0 console.

It is advised to delete the applications on CCE 1.0 only after you have successfully created these applications on CCE 2.0.

## 23.4.1 Applications Created Through APIs or kubectl

If the application in CCE 1.0 is created using APIs or kubectl, use the same method to create applications of the same specifications on the cluster created in CCE 2.0. For details, see *Cloud Container Engine API Reference 2.0* or [Connecting to a Cluster Through kubectl](#).

- If you connect to the cluster through kubectl, you are advised to perform the operation in CCE 2.0. While in CCE 1.0, you need to download three certificate files and manually perform multiple steps on the client. In CCE 2.0, you only need to perform the following steps to connect to the cluster.
  - a. Download the kubectl CLI configuration file. (All authentication information and cluster addresses are in the same file.)
  - b. Install and configure the kubectl CLI tool. (Run the required Linux commands to complete the interconnection.)For details, see [Connecting to a Cluster Through kubectl](#).
- If you access the CCE console through APIs, the cluster management APIs need to be updated. The native Kubernetes interface does not change, so you can use Kubernetes APIs in the same way. For details, see *Cloud Container Engine API Reference 2.0*.

## 23.4.2 Applications Created Through Component Templates

If the application in CCE 1.0 is created using a component template, follow the steps this section to migrate the application to CCE 2.0.

### Migration Method

Create workloads in the CCE 2.0 console. Delete applications from in CCE 1.0 only after applications are successfully run in CCE 2.0.

### Procedure

- Step 1** In the navigation pane, choose **Workloads > Deployments**. Click **Create Deployment**.
- Step 2** Set basic workload parameters as described in [Table 23-4](#). The parameters marked with an asterisk (\*) are mandatory.

**Table 23-4** Basic parameters

| Name            | Configuration                                                                                      |
|-----------------|----------------------------------------------------------------------------------------------------|
| * Workload Name | Name of a workload, which must be unique.                                                          |
| * Cluster Name  | Cluster to which the workload belongs.                                                             |
| * Namespace     | Namespace to which the new workload belongs. By default, this parameter is set to <b>default</b> . |

| Name                      | Configuration                                                                                                                                                                                                                                                                                                                                                  |
|---------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| * Instances               | <p>Number of instances in the workload. Each workload has at least one instance. You can specify the number of instances as required.</p> <p>Each workload pod consists of the same containers. You can configure multiple pods for a workload to ensure high reliability. For such a workload, if one pod is faulty, the workload can still run properly.</p> |
| Time Zone Synchronization | <p>If this parameter is enabled, the container and the node use the same time zone.</p> <p><b>NOTICE</b><br/>After time zone synchronization is enabled, disks of the hostPath type will be automatically added and listed in the <b>Data Storage &gt; Local Volume</b> area. Do not modify or delete the disks.</p>                                           |
| Description               | Description of the workload.                                                                                                                                                                                                                                                                                                                                   |

**Step 3** Click **Next** to add a container.

1. Click **Add Container** and select the image to be deployed.
2. Set image parameters according to [Table 23-5](#).

**Table 23-5** Setting image parameters

| Parameter in CCE 2.0 | Parameter in CCE 1.0 | Configuration                                                                                                                                                                                                                                                                            |
|----------------------|----------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Image Name           | Container Images     | Name of the image. You can click <b>Change Image</b> to select another image.                                                                                                                                                                                                            |
| Image Version        |                      | Version of the image to be deployed.                                                                                                                                                                                                                                                     |
| Container name.      |                      | Container name, which is modifiable.                                                                                                                                                                                                                                                     |
| Privileged Container |                      | <p>Programs in a privileged container have certain privileges.</p> <p>If <b>Privileged Container</b> is enabled, the container is granted superuser permissions. For example, privileged containers can manipulate network devices on the host machine and modify kernel parameters.</p> |

| Parameter in CCE 2.0     | Parameter in CCE 1.0 | Configuration                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
|--------------------------|----------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Container Specifications | Memory and CPU       | <p><b>CPU Quota:</b></p> <ul style="list-style-type: none"> <li>- <b>Request:</b> minimum number of CPU cores required by a container. The default value is 0.25 cores.</li> <li>- <b>Limit:</b> maximum number of CPU cores available for a container. Do not leave <b>Limit</b> unspecified. Otherwise, intensive use of container resources will occur and your workload may exhibit unexpected behavior.</li> </ul> <p><b>Memory Quota:</b></p> <ul style="list-style-type: none"> <li>- <b>Request:</b> minimum amount of memory required by a container. The default value is 512 MiB.</li> <li>- <b>Limit:</b> maximum amount of memory available for a container. When memory usage exceeds the specified memory limit, the container will be terminated.</li> </ul> <p>For details, see <a href="#">Setting Container Specifications</a>.</p> <p><b>GPU:</b> configurable only when the cluster contains GPU nodes.</p> <ul style="list-style-type: none"> <li>- <b>GPU:</b> the percentage of GPU resources reserved for a container. Select <b>Use</b> and set the percentage. For example, if this parameter is set to 10%, the container is allowed to use 10% of GPU resources. If you do not select <b>Use</b> or set this parameter to <b>0</b>, no GPU resources can be used.</li> </ul> |

| Parameter in CCE 2.0 | Parameter in CCE 1.0 | Configuration                                                                                                                                                                                                                                                                                                   |
|----------------------|----------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                      |                      | <ul style="list-style-type: none"> <li>- <b>GPU/Graphics Card:</b> The workload's pods will be scheduled to the node with the specified GPU. If <b>Any GPU type</b> is selected, the container uses a random GPU in the node. If you select a specific GPU, the container uses that GPU accordingly.</li> </ul> |

3. Set the environment variables, data storage, and user-defined log.

**Table 23-6** Configuring advanced settings

| Parameter in CCE 2.0 | Parameter in CCE 1.0                                                                                        | Configuration                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
|----------------------|-------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Lifecycle            | This parameter does not exist in CCE 1.0. For migrated applications, you do not need to set this parameter. | <p>Set the commands for starting and running containers.</p> <ul style="list-style-type: none"> <li>- <b>Startup Command:</b> Executed to start a container. For details, see <a href="#">Setting Container Startup Commands</a>.</li> <li>- <b>Post-Start:</b> Executed after a container runs successfully. For details, see <a href="#">Setting Container Lifecycle Parameters</a>.</li> <li>- <b>Pre-Stop:</b> Executed to delete logs or temporary files before a container is stopped. For details, see <a href="#">Setting Container Lifecycle Parameters</a>.</li> </ul> |

| Parameter in CCE 2.0         | Parameter in CCE 1.0                                                                                        | Configuration                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
|------------------------------|-------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Health check                 | This parameter does not exist in CCE 1.0. For migrated applications, you do not need to set this parameter. | <p>Configure the health check function to check whether containers and services are running properly. Two types of probes are provided: liveness probes and readiness probes. For details, see <a href="#">Setting Health Check for a Container</a>.</p> <ul style="list-style-type: none"> <li>- <b>Liveness Probe:</b> used to restart the unhealthy container.</li> <li>- <b>Readiness Probe:</b> used to change the container to the unready state when detecting that the container is unhealthy. In this way, service traffic will not be directed to the container.</li> </ul>                                                                                                                                              |
| Adding environment variables | Adding environment variables                                                                                | <p>In the <b>Environment Variables</b> area, click <b>Add Environment Variable</b>. Currently, environment variables can be added using any of the following methods:</p> <ul style="list-style-type: none"> <li>- <b>Added manually:</b> Set <b>Variable Name</b> and <b>Variable Value</b>.</li> <li>- <b>Added from Secret:</b> Set <b>Variable Name</b> and select the desired secret name and data. You need to create a secret in advance. For details, see <a href="#">Creating a Secret</a>.</li> <li>- <b>Added from ConfigMap:</b> Set <b>Variable Name</b> and select the desired ConfigMap name and data. You need to create a ConfigMap in advance. For details, see <a href="#">Creating a ConfigMap</a>.</li> </ul> |

| Parameter in CCE 2.0 | Parameter in CCE 1.0                                                                                        | Configuration                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
|----------------------|-------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Data Storage         | Volume                                                                                                      | <p>For the applications using the old component template, perform the following operations:</p> <ol style="list-style-type: none"> <li>1. Choose <b>Data Storage</b> &gt; <b>Local Volume</b>. Click <b>Add Local Volume</b>.</li> <li>2. Select <b>HostPath</b>.</li> <li>3. Set the following parameters: <ul style="list-style-type: none"> <li>▪ <b>Host Path:</b> Path of the host to which the local volume is to be mounted, corresponding to <b>/tmp</b> of volumes.</li> <li>▪ Click <b>Add Container Path</b>, enter the container path to which the data volume is mounted. It corresponds to <b>/test</b> of <b>Volumes</b>.</li> <li>▪ <b>Permission: Read/Write</b>.</li> </ul> </li> <li>4. When the configuration is complete, click <b>OK</b>.</li> </ol> |
| Security Settings    | This parameter does not exist in CCE 1.0. For migrated applications, you do not need to set this parameter. | Set container permissions to protect the system and other containers from being affected. Enter the user ID to set container permissions and prevent systems and other containers from being affected.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| Container Logs       | This parameter does not exist in CCE 1.0. For migrated applications, you do not need to set this parameter. | Set a policy and log directory for collecting application logs and preventing logs from being over-sized. For details, see <a href="#">Collecting Container Logs from Specified Paths</a> .                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |



**Step 4** Click **Next**. Click **Add Service** and set the workload access type.

If your workload will be reachable to other workloads or public networks, add a Service to define the workload access type.

The workload access type determines the network attributes of the workload. Workloads with different access types can provide different network capabilities. For details, see [Network Management](#).


- **Access Type:** Select **LoadBalancer (ELB)**.
- **Service Name:** Specify a service name. You can use the workload name as the service name.
- **Service Affinity:**
  - **Cluster level:** External traffic is routed to all nodes in the cluster while masking clients' source IP addresses.
  - **Node level:** External traffic is routed to the node where the load balancer used by the service is located, without masking clients' source IP addresses.
- **Elastic Load Balancer:** A load balancer automatically distributes Internet access traffic to multiple nodes running the workload. 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).
  - **Public network:** You can select an existing public network load balancer or have the system automatically create a new public network load balancer.

If you have the system automatically create a public network load balancer, you can click **Change Configuration** to modify its name, EIP type, billing mode, and bandwidth.
  - **Private network:** You can select an existing private network load balancer or have the system automatically create a new private network load balancer.
- **Port Settings**
  - **Protocol:** protocol used by the Service.
  - **Container Port:** a port that is defined in the container image and on which the workload listens. The Nginx application listens on port 80.
  - **Access Port:** a port mapped to the container port at the load balancer's IP address. The workload can be accessed at <load balancer's IP address>:<access port>. The port number range is 1–65535.

**Step 5** Click **OK**, and then click **Next**. Skip advanced settings.

**Step 6** Click **Create** after the configuration is complete. Click **Back to Deployment List**.

If the deployment is in the **Running** state, the deployment is successfully created.

Workload status is not updated in real time. Click  in the upper right corner or press **F5** to refresh the page.

**Step 7** To access the workload in a browser, copy the workload's **External Access Address** and paste it into the address box in the browser.

 NOTE

External access addresses are available only if the Deployment access type is set to **NodePort** and an EIP is assigned to any node in the cluster, or if the Deployment access type is set to **LoadBalancer (ELB)**.

----End

## 23.4.3 Applications Created Through App Designer

If the application in CCE 1.0 version is created through App Designer, follow the steps in this section to migrate the application to CCE 2.0. In CCE 2.0, use the custom Helm chart to create applications. For more information, see [Chart Management](#).

### Procedure

- Step 1** Log in to the console of CCE 1.0. In the navigation pane, click **App Manager**. Then, click the name of the application to be migrated to go to the details page. Obtain **Component Name** and **Service Name**.
- Step 2** Connect to a cluster. For details, see [Connecting to a Cluster Through kubectl](#).
- Step 3** Run the following commands on the kubectl client to obtain the YAML files related to the application.

```
kubectl get rc new-appcomponent-1-11d3 -o yaml > new-appcomponent-1-11d3.yaml
```

```
kubectl get svc new-port-3 -o yaml > new-port-3.yaml
```

In the preceding commands, replace *new-appcomponent-1-11d3* and *new-port-3* with the values obtained in [Step 1](#).

- Step 4** Edit the *new-appcomponent-1-11d3.yaml* file by deleting the lines in bold and modifying the lines in Italic.

```
apiVersion: v1
kind: ReplicationController
metadata:
 annotations:
 cce/app-createTimestamp: 2018-04-19-11-39-27
 cce/app-description: ""
 cce/app-updateTimestamp: 2018-04-19-11-39-27
creationTimestamp: 2018-04-19T11:37:17Z
generation: 1
 labels:
 cce/appgroup: app-design
 name: new-appcomponent-1-11d3
 rollingupdate: "false"
 name: new-appcomponent-1-11d3
 namespace: default
resourceVersion: "8325781"
selfLink: /api/v1/namespaces/default/replicationcontrollers/new-appcomponent-1-11d3
uid: 039ada96-43c6-11e8-8f34-fa163e738aa3
spec:
 replicas: 1
 selector:
 cce/appgroup: app-design
 name: new-appcomponent-1-11d3
 rollingupdate: "false"
 template:
 metadata:
```

```

annotations:
 scheduler.alpha.kubernetes.io/affinity: '{"nodeAffinity":
{"requiredDuringSchedulingIgnoredDuringExecution":{"nodeSelectorTerms":[{"matchExpressions":
[{"key":"failure-domain.beta.kubernetes.io/zone","operator":"NotIn","values":[""]}]}]}}'
 creationTimestamp: null
labels:
 cce/appgroup: app-design
 name: new-appcomponent-1-11d3
 rollingupdate: "false"
spec:
 affinity:
 nodeAffinity:
 requiredDuringSchedulingIgnoredDuringExecution:
 nodeSelectorTerms:
 - matchExpressions:
 - key: failure-domain.beta.kubernetes.io/zone
 operator: NotIn
 values:
 - ""
 containers:
 - image: 10.125.1.108:6443/test/apache-php:latest -->Change it to the image address of the later
CCE version
 imagePullPolicy: Always
 name: new-container-2-11d3f16
 ports:
 - containerPort: 3333
 protocol: TCP
 resources: {}
 securityContext:
 privileged: true
 terminationMessagePath: /dev/termination-log
 terminationMessagePolicy: File
 dnsPolicy: ClusterFirst
 imagePullSecrets:
 - name: myregistry -----> Change it to default-secret
 restartPolicy: Always
 schedulerName: default-scheduler
 securityContext: {}
 terminationGracePeriodSeconds: 30
status:
availableReplicas: 1
fullyLabeledReplicas: 1
observedGeneration: 1
readyReplicas: 1
replicas: 1

```

**Step 5** Open the **new-port-3.yaml** file, and delete the lines in bold.

```

apiVersion: v1
kind: Service
metadata:
 creationTimestamp: 2018-04-19T11:37:17Z
 labels:
 cce/appgroup: app-design
 name: new-appcomponent-1-11d3
 name: new-port-3
 namespace: default
 resourceVersion: "8325766"
 selfLink: /api/v1/namespaces/default/services/new-port-3
 uid: 039c918f-43c6-11e8-8f34-fa163e738aa3
spec:
 clusterIP: 10.247.145.136
 externalTrafficPolicy: Cluster
 ports:
 - name: new-port-30
 nodePort: 31471
 port: 3333
 protocol: TCP
 targetPort: 3333
 selector:

```

```
cce/appgroup: app-design
name: new-appcomponent-1-11d3
sessionAffinity: None
type: NodePort
status:
loadBalancer: {}
```

**Step 6** Connect the kubectl client to the CCE cluster of the latest version. For details, see [Connecting to a Cluster Through kubectl](#).

**Step 7** Run the following commands to create the application again:

```
kubectl create -f new-appcomponent-1-11d3.yaml
```

```
kubectl create -f new-port-3.yaml
```

```
----End
```