# Storage

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# Introduction

**Alauda Build of Rook-Ceph** is a hyper-converged storage solution provided by the platform within the cluster. Based on the open-source Rook + Ceph storage solution, distributed storage achieves automatic management, automatic scaling, and automatic repair capabilities, fulfilling the block storage, file storage, and object storage needs of small to medium-sized applications.

> **NOTE**
>
> In this document, **distributed storage** refers to the Ceph storage within this cluster, while **external storage** refers to Ceph storage outside of this cluster.

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## Feature Overview

- **Easy Deployment**: Provides graphical automatic deployment and management services for storage clusters; supports both integrated and decoupled deployment modes for compute and storage.

- **Professional Operations**: Offers persistent volume snapshot backup and clone new volume functionalities; visual monitoring of capacity, performance, and component levels; equipped with built-in alert policies to meet the needs of most storage operation scenarios.
- **Secure and Reliable**: Distributed and multi-replica mechanisms ensure data security and reliability; simple and reliable automated management supports online expansion of storage resources.
- **Excellent Performance**: Provides elastic and high-performance storage services; supports the deployment of hybrid disk devices to enhance storage system performance and efficiency.

# Storage Solution Comparison

The platform supports the following two types of storage solutions; you can choose one or the other.

## Creating a Storage Cluster

| Requirement | Advantages |
| --- | --- |
| **You can choose to create either a** standard type cluster **or an** extended type cluster | No need for additional storage solution preparation; configuration can be completed on the business cluster, saving costs. |

## Accessing External Storage

Option 1: Access the distributed storage resources of other business clusters within the platform to ensure storage and business are isolated for easier management and maintenance.

Option 2: Integrate external Ceph storage resources as distributed storage.

| Requirement (choose one) | Advantages |
| --- | --- |
| **Option 1: Distributed storage already deployed in** | Can fully utilize storage resources across clusters and avoid interference from business changes. Ensures data security |

| Requirement (choose one) | Advantages |
| --- | --- |
| **other business clusters.** | and stability while reducing operational complexity.<br><br>**Note**: If the storage to be accessed is distributed storage from different platforms, such as a primary/backup platform in a disaster recovery environment, please use the method of integrating external Ceph. |
| **Option 2: External Ceph storage outside the platform, version ≥ 14.2.3.** | Compared to directly creating a storage class, this method is more convenient for using the platform's interface for volume snapshots, scaling, and other functions. |

**Note**: If you need to maintain the storage pool, storage device, and other configurations of external storage, operations must be performed in the management interface of the storage cluster.

# Planning Your Deployment

This topic provides a planning checklist for deploying Ceph distributed storage on Alauda Container Platform (ACP). It summarizes architecture choices, security options, infrastructure sizing, network constraints, and disaster recovery considerations so that you can decide on a deployment model before performing the actual installation.

For product background, see Introduction and Architecture. For deployment procedures, see the documents under Install and How To.

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# Deployment Architecture

ACP distributed storage is based on Ceph and Rook. At a high level, the platform combines the following layers:

- Ceph daemons such as MON, MGR, OSD, MDS, and RGW to provide block, file, and object storage capabilities
- Rook and CSI components to automate deployment, provisioning, expansion, and lifecycle management
- ACP platform integration to expose storage pools, observability, and operational entry points

Before deployment, decide whether your environment should use storage services from the local cluster or consume storage from an external Ceph environment.

## Internal and External Deployment Models

You can plan ACP distributed storage in one of the following ways:

| Deployment pattern | Where storage services run | Who manages the storage cluster | Best fit | Key tradeoff |
| --- | --- | --- | --- | --- |
| Internal, co-resident | Ceph components run on the same ACP worker nodes that also run business workloads | The ACP platform team or cluster admin | Early-stage environments, bare metal clusters, or situations where storage requirements are not fully clear yet | Simpler rollout, but resource contention between apps and storage is more likely |
| Internal, dedicated nodes | Ceph components run on dedicated storage or infrastructure nodes inside the same ACP cluster | The ACP platform team or cluster admin | Production environments with predictable storage demand and stricter isolation requirements | Better operational isolation and sizing control, but requires more reserved nodes and capacity planning |
| External | ACP consumes storage classes from an external Ceph environment | A separate storage team, SRE team, or an existing external storage owner | Large-scale environments, multiple consumer clusters, or organizations that already operate a separate Ceph cluster | Clear ownership boundary, but more cross-cluster networking, authentication, and dependency management |

Internal deployment is easier to roll out and manage because storage services and the consuming workloads are planned within the same ACP environment. Within internal deployment, the first design choice is whether storage should share nodes with business workloads or use dedicated nodes. External deployment is better when you need stronger

separation between storage and application clusters or when multiple business clusters need to share the same storage backend.

The main planning decision points are:

- Choose co-resident deployment when you want faster rollout and can tolerate storage and application workloads sharing the same worker pool.
- Choose dedicated-node deployment when storage demand is known and you want clearer capacity control, fault isolation, and maintenance boundaries.
- Choose external deployment when storage is already managed elsewhere or when a single external cluster must serve multiple ACP clusters.

## Node Roles

When planning node placement, separate the responsibilities of control plane nodes, infrastructure nodes, and worker nodes:

- Control plane nodes maintain cluster management functions and should not be treated as general-purpose storage nodes unless the deployment model explicitly supports it.
- Infrastructure nodes are suitable when you want to isolate storage platform components from business workloads.
- Worker nodes can host storage services in co-resident deployments, but this increases resource contention between applications and storage daemons.

For production use, plan at least three failure domains for highly available storage services. Spread storage nodes across racks, zones, or host groups wherever possible.

# Security Considerations

Before deployment, confirm whether encryption in transit is required for the storage design and validate the operational impact before enabling it.

## Encryption in Transit

ACP currently supports encryption in transit for Ceph distributed storage. This feature protects traffic between Ceph components and clients and is typically planned around Ceph `msgr2` and the cluster networking model.

Before enabling in-transit encryption, verify:

- Kernel and operating system support on storage and client nodes
- Expected CPU overhead on busy storage nodes
- Throughput and latency impact on the target hardware

For implementation details, see Configure in-transit encryption.

# Infrastructure Requirements

## Minimum and Recommended Configuration

Plan node count, storage devices, and available resources before creating the cluster.

| Item | Minimum configuration | Recommended configuration |
| --- | --- | --- |
| Storage nodes | 3 nodes | 3 or more nodes distributed across failure domains |
| Storage devices | 1 available storage device per node | Multiple dedicated devices per node, with consistent type and size |
| Node distribution | 3 nodes available to host Ceph services | 3 failure domains such as racks or zones |
| Device usage | Separate system disk and storage disk | Dedicated raw disks for Ceph data and future expansion headroom |

At minimum, the cluster should have three nodes and one usable storage device on each node. For production use, deploy the cluster across at least three failure domains and reserve enough free resources to absorb rebalance, repair, and future growth.

## Resource Sizing

Ceph storage services consume CPU, memory, and device capacity continuously. Plan resources for storage daemons first, then reserve additional headroom for recovery, rebalance, upgrades, and background tasks.

As a baseline:

- Start with at least three storage nodes for a highly available cluster
- Reserve enough CPU and memory for MON, MGR, OSD, and any enabled MDS or RGW services
- Keep growth headroom for new pools, additional devices, and cluster recovery events
- Avoid planning a cluster that is already near saturation at day one

If your design uses dedicated storage nodes, resource planning is more predictable. If storage runs together with business workloads, reserve extra headroom to absorb contention during peak load and node failures.

## Aggregate Cluster Planning Budget

For early sizing, start from an aggregate cluster budget rather than from per-component values alone. The following table is intended as a planning reference for a three-node highly available cluster before workload-specific tuning:

| Deployment pattern | Aggregate CPU to reserve for storage | Aggregate memory to reserve for storage | Notes |
|---|---|---|---|
| Internal, minimum baseline | 24 logical CPUs | 72 GiB | Entry-level three-node planning baseline when only the minimum deployment target is being met |
| Internal, standard baseline | 30 logical CPUs | 72 GiB | Better starting point for general production planning and future expansion |

| Deployment pattern | Aggregate CPU to reserve for storage | Aggregate memory to reserve for storage | Notes |
| --- | --- | --- | --- |
| Internal, performance-oriented baseline | 45 logical CPUs | 96 GiB | Suitable when higher throughput or lower latency is required from the beginning |
| External consumer cluster | Size for connectivity and client access only | Size for connectivity and client access only | Storage daemons run outside the ACP cluster, so the ACP cluster mainly needs network reachability, credentials, and client-side capacity |

These values should be treated as cluster-level planning targets, not exact scheduler reservations. To estimate per-node budget for a three-node cluster, divide the aggregate numbers evenly across the participating storage nodes.

The following recommendations are suitable for early planning:

| Component | Recommended CPU | Recommended memory |
| --- | --- | --- |
| MON | 2 cores | 3 GiB |
| MGR | 3 cores | 4 GiB |
| MDS | 3 cores | 8 GiB |
| RGW | 2 cores | 4 GiB |
| OSD | 4 cores | 8 GiB |

These values are planning references rather than hard scheduling guarantees. Actual requirements depend on the number of devices, enabled services, and workload intensity.

## How to Estimate Cluster Size

Use the following order when sizing a cluster:

1. Choose the deployment pattern: co-resident, dedicated-node, or external.
2. Determine the minimum node count and failure-domain layout.
3. Decide whether block, file, object, or mixed storage services are required.
4. Start from the aggregate cluster planning budget.
5. Add headroom for additional device sets, recovery, monitoring, and expected growth.

If file and object services are both required, or if the cluster will host heavy business workloads at the same time, size above the minimum baseline rather than directly at it.

## Pod Placement

Pod placement rules directly affect resilience. Plan the cluster so that:

- Highly available components can be spread across different failure domains
- Every failure domain has accessible storage devices and enough allocatable resources
- New device sets or future expansion can still follow the same placement pattern

In practice, this means that simply having three nodes is not enough. The nodes also need to be distributed in a way that avoids a single rack, host group, or zone becoming a single point of failure.

## Storage Device Planning

When selecting storage devices, standardize device size and class as much as possible. Mixed devices complicate performance tuning and capacity planning.

Use the following principles:

- Reserve one system disk for the operating system and separate storage devices for Ceph data
- Prefer raw disks or dedicated devices instead of partitioning shared disks
- Keep device counts per node at a manageable level so that recovery and maintenance remain practical

- Track usable capacity rather than raw capacity because replication reduces effective storage space

Capacity planning should also include alert thresholds and expansion policy. Plan expansion before the cluster reaches a near-full state. Running close to full capacity increases rebalance pressure and makes recovery harder.

For related operational guidance, see Managing Storage Pools and Adding Devices/Device Classes.

## Capacity Planning

When planning cluster capacity, calculate usable capacity rather than raw disk capacity. In a replicated Ceph deployment, a portion of raw storage is always consumed by data protection.

Use the following planning principles:

- Keep available capacity ahead of expected business growth instead of expanding only after the cluster is almost full
- Reserve additional headroom for recovery, rebalance, snapshots, and temporary bursts in data usage
- Expand storage in a balanced way across nodes and failure domains so that new capacity does not create skewed utilization
- Review both current utilization and projected growth before adding new workloads to the cluster

The following examples can be used as early planning references for a three-node cluster with one device per node and a 3-replica data protection policy:

| Device size per node | Raw cluster capacity | Approximate usable capacity with 3 replicas |
|---|---|---|
| 0.5 TiB | 1.5 TiB | 0.5 TiB |
| 2 TiB | 6 TiB | 2 TiB |
| 4 TiB | 12 TiB | 4 TiB |

These values are examples only. Usable capacity varies with the actual data protection policy and should not be treated as a general rule for every cluster design.

In day-two operations, capacity should be reviewed before the cluster reaches warning levels. If growth is predictable, expand early rather than waiting for a near-full or full condition.

# Network Requirements

Ceph is sensitive to network quality. Before deployment, validate the following:

- The cluster network can provide stable throughput for replication and recovery traffic
- Latency between failure domains is within the supported range for the selected deployment model
- Required ports are open between storage nodes and consuming clusters
- Any dedicated network design, such as Multus-based separation, is decided in advance

If you plan to isolate storage traffic from general application traffic, confirm the network interfaces, routing policy, and operational ownership before deployment. Network isolation improves security and performance, but it also increases design complexity.

## IPv6 Support

ACP distributed storage planning must follow the cluster network stack selected for the platform.

- IPv6 is supported in single-stack IPv6 environments.
- Dual-stack planning must be validated against the ACP cluster network design before storage deployment.
- Storage nodes and client nodes should use the same address family strategy to avoid connectivity and service discovery issues.

If your environment uses IPv6, confirm the following before installation:

- The ACP cluster network is already configured for IPv6 operation
- All storage nodes can communicate over the required IPv6 routes

- Monitoring, alerting, and external integrations that access storage endpoints also support IPv6

IPv6 should be treated as an installation-time architecture decision. Do not assume that an existing IPv4-oriented storage design can be converted later without revalidation.

# Disaster Recovery Planning

ACP distributed storage can be planned with different recovery objectives. Choose a model based on your recovery point objective (RPO), recovery time objective (RTO), and site topology.

## Regional-DR

ACP supports Regional-DR for cross-region or cross-site disaster recovery scenarios where asynchronous replication and a small amount of potential data loss are acceptable.

When planning Regional-DR, confirm the following items in advance:

- The source and destination clusters have compatible storage and network designs
- Replication latency and failover expectations match the business recovery objectives
- The protected workload type is clear, such as block, file system, or object data

For implementation details, see Disaster Recovery.

## Stretch Cluster

A stretch cluster is appropriate only when the latency between sites is tightly controlled and the topology is designed specifically for this pattern. In general, plan for:

- Two data sites and one quorum or arbiter site
- A minimum of five nodes across three zones
- Manual and explicit failure-domain labels before cluster creation
- Sufficient nodes in each data site to preserve storage service availability

- Inter-zone latency that remains within a low-latency design envelope, typically no more than 10 ms RTT between the data sites

> **WARNING**
>
> Do not treat a stretch cluster as a general solution for long-distance, high-latency, multi-datacenter deployment. If inter-site latency is not tightly controlled, use a dedicated disaster recovery architecture instead.

For ACP-specific stretch cluster deployment guidance, see Create Stretch Type Cluster.

# Performance Planning

Performance should be planned from workload characteristics rather than from raw device counts alone. Before deployment, identify:

- Whether the primary workloads are block, file, or object oriented
- Whether the workload is latency sensitive, throughput sensitive, or capacity heavy
- Whether hot data, backup traffic, or analytics jobs will dominate the cluster

Also confirm whether special tuning or feature-specific design is required. For example, object workloads may need separate planning for gateway capacity, and some environments may require cache-oriented or dedicated-cluster designs.

# Next Steps

After you complete planning, proceed to the deployment guide that matches your selected deployment model:

## Internal deployment

- For a co-resident deployment, see Create Standard Type Cluster.
- For a stretch-cluster deployment, see Create Stretch Type Cluster.

- For a dedicated-node deployment, see Configure a Dedicated Cluster for Distributed Storage.

## External deployment

- To consume storage services from another cluster or an external Ceph environment, see Accessing Storage Services.

## Related follow-up configuration

- To enable encrypted network traffic for deployed storage services, see Configure in-transit encryption.
- To configure disaster recovery after deployment, see Disaster Recovery.

# Architecture

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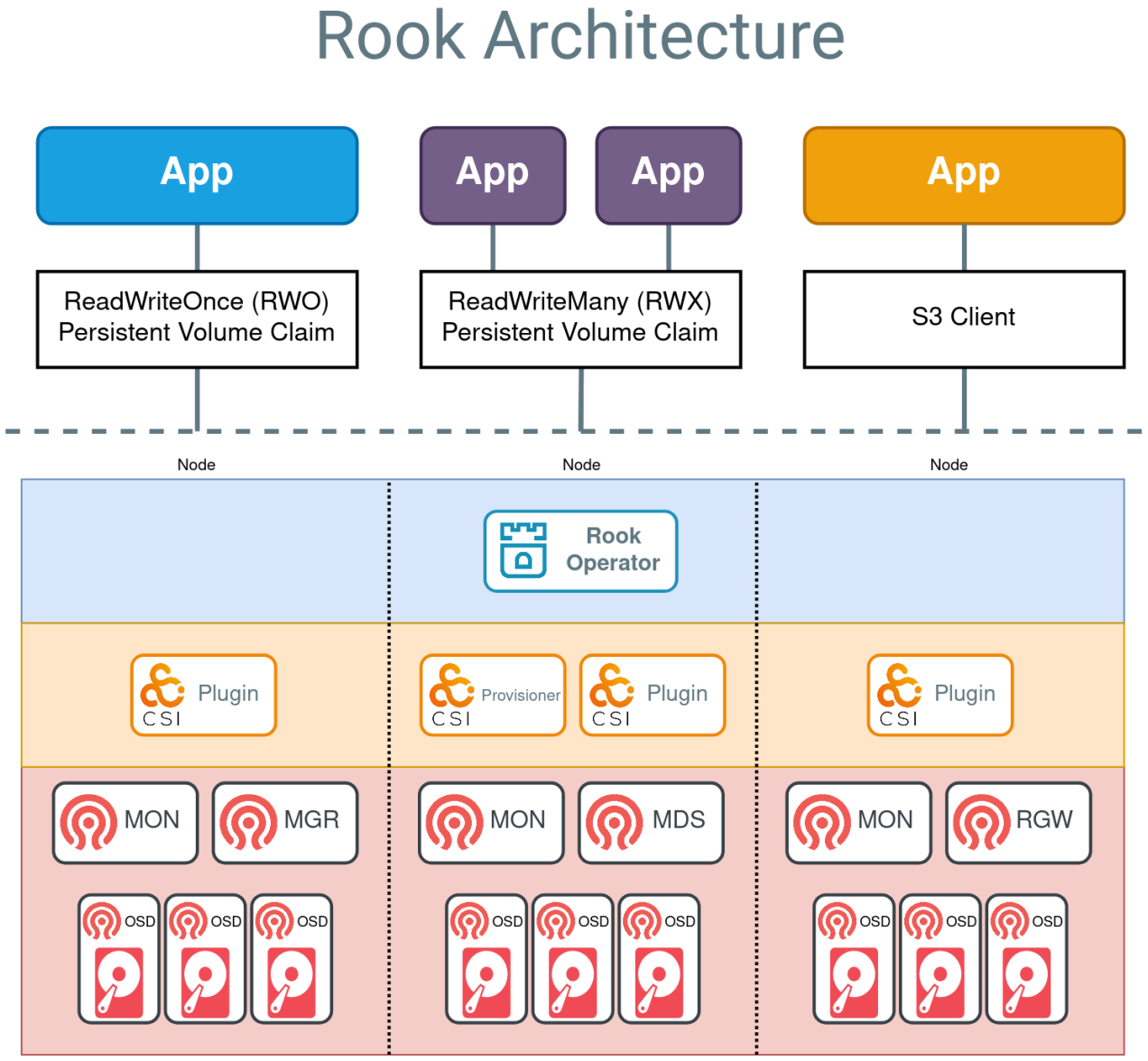
## Technical architecture




Example applications are shown above for the three supported storage types:

- Block Storage is represented with a blue app, which has a ReadWriteOnce (RWO) volume mounted. The application can read and write to the RWO volume, while Ceph manages the IO.
- Shared Filesystem is represented by two purple apps that are sharing a ReadWriteMany (RWX) volume. Both applications can actively read or write simultaneously to the volume. Ceph will ensure the data is safely protected for multiple writers with the MDS daemon.
- Object storage is represented by an orange app that can read and write to a bucket with a standard S3 client.

Below the dotted line in the above diagram, the components fall into three categories:

- Rook operator (blue layer): The operator automates configuration of Ceph
- CSI plugins and provisioners (orange layer): The Ceph-CSI driver provides the provisioning and mounting of volumes
- Ceph daemons (red layer): The Ceph daemons run the core storage architecture. See the Glossary to learn more about each daemon.

**Block Storage**

In the diagram above, the flow to create an application with an RWO volume is:

- The (blue) app creates a PVC to request storage.
- The PVC defines the Ceph RBD storage class (sc) for provisioning the storage.
- K8s calls the Ceph-CSI RBD provisioner to create the Ceph RBD image.
- The kubelet calls the CSI RBD volume plugin to mount the volume in the app.
- The volume is now available for reads and writes.
- A ReadWriteOnce volume can be mounted on one node at a time.

**Shared Filesystem**

In the diagram above, the flow to create a applications with a RWX volume is:

- The (purple) app creates a PVC to request storage.
- The PVC defines the CephFS storage class (sc) for provisioning the storage.
- K8s calls the Ceph-CSI CephFS provisioner to create the CephFS subvolume.
- The kubelet calls the CSI CephFS volume plugin to mount the volume in the app.
- The volume is now available for reads and writes.
- A ReadWriteMany volume can be mounted on multiple nodes for your application to use.

**Object Storage S3**

In the diagram above, the flow to create an application with access to an S3 bucket is:

- The (orange) app creates an BucketClaim to request a bucket.
- The Ceph COSI Driver creates a Ceph RGW bucket.
- The Ceph COSI Driver creates a secret with the credentials for accessing the bucket.
- The app retrieves the credentials from the secret.
- The app can now read and write to the bucket with an S3 client.

# Install

## Create Standard Type Cluster

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## Create Stretch Type Cluster

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# Create Standard Type Cluster

A standard-type cluster is the most typical deployment method for Ceph storage. It distributes data replicas across hard drives on different hosts, ensuring that if a single host fails, the data copies on other hosts can still maintain service availability.

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## Prerequisites

## Prepare Package

- **Download** the **Alauda Container Platform Storage Essentials** installation package corresponding to your platform architecture.
- **Upload** the **Alauda Container Platform Storage Essentials** installation package using the Upload Packages mechanism.
- **Download** the **Alauda Build of Rook-Ceph** installation package corresponding to your platform architecture.
- **Upload** the **Alauda Build of Rook-Ceph** installation package using the Upload Packages mechanism.

## Prepare Infrastructure

- At least 3 nodes are required in the storage cluster.
- Each node must have at least 1 blank hard disk or 1 unformatted hard disk partition available.
- The available hard disk capacity is recommended to be greater than 50 G.
- If you are using an attached Kubernetes cluster with Containerd as the runtime component, please ensure that the `LimitNOFILE` parameter value in the `/etc/systemd/system/containerd.service` file is configured to `1048576` on all nodes of the cluster, to ensure successful deployment of distributed storage. For configuration instructions, please refer to Modifying Containerd Configuration Information.
  **Note**: When upgrading from versions earlier than v3.10.2 to the current version, if you need to deploy Ceph distributed storage on your custom Kubernetes cluster with Containerd as the runtime component, you must also set the `LimitNOFILE` parameter value in the `/etc/systemd/system/containerd.service` file to `1048576` on all nodes of the cluster.

# Precautions

**Creating Storage Service** and **Accessing Storage Service** only support selecting one method.

# Procedure

## 1 Deploy Alauda Container Platform Storage Essentials

1. Login, go to the **Administrator** page.
2. Click **Marketplace** > **OperatorHub** to enter the **OperatorHub** page.
3. Find the **Alauda Container Platform Storage Essentials**, click **Install**, and navigate to the **Install Alauda Container Platform Storage Essentials** page.
   Configuration Parameters:

| Parameter | Recommended Configuration |
| --- | --- |
| **Channel** | The default channel is `stable`. |
| **Installation Mode** | `Cluster`: All namespaces in the cluster share a single Operator instance for creation and management, resulting in lower resource usage. |
| **Installation Place** | Select `Recommended`, Namespace only support **acp-storage**. |
| **Upgrade Strategy** | `Manual`: When there is a new version in the Operator Hub, manual confirmation is required to upgrade the Operator to the latest version. |

## 2 (Optional) Deploy Alauda Build of LocalStorage

When utilizing the `Selection Device` method to add storage devices to your Ceph cluster, it is necessary to deploy the `Alauda Build of LocalStorage Operator`. This Operator is responsible for automatically discovering all hard disk devices across every node within the Kubernetes cluster and collecting comprehensive device information, thereby streamlining the storage integration process.

1. Login, go to the **Administrator** page.
2. Click **Marketplace** > **OperatorHub** to enter the **OperatorHub** page.

3. Find the **Alauda Build of LocalStorage**, click **Install**, and navigate to the **Install Alauda Build of LocalStorage** page.
   Configuration Parameters:

| Parameter | Recommended Configuration |
| --- | --- |
| **Channel** | The default channel is `stable`. |
| **Installation Mode** | `Cluster`: All namespaces in the cluster share a single Operator instance for creation and management, resulting in lower resource usage. |
| **Installation Place** | Select `Recommended`, Namespace only support **acp-storage**. |
| **Upgrade Strategy** | `Manual`: When there is a new version in the Operator Hub, manual confirmation is required to upgrade the Operator to the latest version. |

## 3 Deploy Operator

1. Navigate to **Administrator**.
2. In the left sidebar, click **Storage Management** > **Distributed Storage**.
3. Click **Configure Now**.
4. In the **Deploy Operator** wizard page, click the **Deploy Operator** button at the bottom right.

   - When the page automatically advances to the next step, it indicates that the Operator has been deployed successfully.
   - If the deployment fails, please refer to the prompt on the interface **Clean Up Deployed Information and Retry**, and redeploy the Operator; if you wish to return to the distributed storage selection page, click **Application Store**, first uninstall the resources in the already deployed **rook-operator**, and then uninstall **rook-operator**.

## 4 Create Cluster

1. In the **Create Cluster** wizard page, configure the relevant parameters and click the **Create Cluster** button at the bottom right.

| Parameter | Explanation |
| --- | --- |
| **Cluster Type** | Select **Standard**. |
| **Device Class Type** | Device classes are groupings of hard disks; you can customize device classes according to your storage needs, allocating different storage content to disks of varying performance.<br>• **Default Device Class**: The platform will automatically categorize the types of hard disks in the cluster nodes. For instance, creating device classes named `hdd`, `ssd`, `nvme`.<br>• **Custom Device Class**: Customize the name of the device class for specific combinations of disks in the node; adding multiple device classes is supported. The same hard disk can only belong to one device class. |
| **Device Class - Name** | The name of the device class. When selecting **Custom Device Class**, the device class cannot use the following names: `hdd`, `ssd`, `nvme`. |
| **Device Class - Storage Devices** | To add storage devices to a device class, you can choose between the `Selection Device` and `Input Device` methods:<br>• **Selection Device**:<br>Select from available storage devices. A device is considered available if it meets the following criteria:<br>  • Device type is either disk or mpath<br>  • No file system is detected (fsType is blank)<br>  • Capacity exceeds 10 GiB<br>Devices such as rbd, nbd, and dm-* will not be displayed in the list of available selectable devices. |

| Parameter | Explanation |
| --- | --- |
| | **Note**: Requires prior deployment of the Alauda Build of LocalStorage Operator.<br>• **Input Device**:<br>Manually input the names of the blank devices under the node, such as `sda`.<br>**Note**: For optimal performance and management, it is strongly advised to utilize raw disks as storage devices instead of employing individual partitions on a disk. |
| **Snapshot** | When enabled, it supports creating PVC snapshots and using snapshots to configure new PVCs for quick backup and recovery of business data.<br>If you did not enable snapshots when creating storage, you can still enable them as needed from the **Operations** section on the storage cluster details page.<br>**Note**: Please ensure that you have deployed volume snapshot plugins for the current cluster before using. |
| **Monitoring Alarm** | When enabled, it will provide out-of-the-box monitoring metric collection and alerting capabilities, see Monitoring and Alarming.<br>**Note**: If not enabled at this time, you will need to find alternative solutions for storage monitoring and alarms. For example, manually configuring monitoring dashboards and alert strategies in the operation and maintenance center. |

2. Click **Advanced Configuration** for advanced component configuration.

| Parameter | Explanation |
| --- | --- |
| **Network Configuration** | • **Host Network**: The storage cluster will use the host network, and you should fill in the relevant network optimization parameters in the optimization parameters |

| Parameter | Explanation |
| --- | --- |
| | column, such as configuring the `public` and `cluster` subnets. If left blank, the default host subnet will be used.<br>**Note**: Using the host network may expose security risks due to unencrypted (plaintext) transmission of data through host ports. Please contact the platform support team to obtain the encrypted transmission solution.<br>• **Container Network**: The storage cluster will use container networking; you can create subnets in network management and assign them to the `rook-ceph` namespace. If left blank, the default subnet will be used.<br>**Note**:<br>IPv6 not supported.<br>When using the container network, storage is only accessible within the cluster.<br>Failures or restarts of the Ceph CSI Pod may result in service interruptions. |
| **Optimization Parameters** | Supports filling parameters in Ceph configuration file format; the system will overwrite the default parameters based on the provided content.<br>**Note**: After first filling in or modifying initialization parameters, please click on the initialization parameters; successful initialization is required before a cluster can be created. |
| **Component Fixed-point Deployment** | You can deploy components to specified nodes; at least three nodes are required to ensure minimum availability. The components eligible for fixed-point deployment configuration include MON, MGR, MDS, RGW. |

- When the page automatically advances to the next step, it indicates that the Ceph cluster has been deployed successfully.
- If the creation fails, you may click to clean up **Created Information or Retry** to automatically clean up the resources and recreate the cluster, or manually clean

up resources according to the documentation Distributed Storage Service Resource Cleanup.

## 5 Create Storage Pool

1. In the **Create Storage Pool** wizard page, configure the relevant parameters and click the **Create Storage Pool** button at the bottom right.

| Parameter | Explanation |
| --- | --- |
| **Storage Type** | • File Storage: Provides secure, reliable, and scalable shared file storage services. Suitable for file sharing, data backup, etc.<br>• Block Storage: Provides high IOPS and low-latency storage services. Suitable for databases, virtualization, etc.<br>• Object Storage: Provides standard S3 interface storage services, suitable for big data, backup archiving, cloud storage, etc. |
| **Replica Count** | The larger the number of replicas, the higher the redundancy and data security; however, the utilization rate of storage will decrease. It is usually set to 3 to meet most needs. |
| **Device Class** | Uniformly classify types for the same type of device or disks of the same business logic, selecting from the device classes added in the previous step.<br>• When selecting a device class, data will be stored in the chosen device class.<br>• If no device class is selected, data will be randomly stored across all devices in the storage pool. |

If it is object storage, you also need to configure the following parameters:

| Parameter | Explanation |
| --- | --- |
| **Region** | Specify the region where the storage pool is located. |

| Parameter | Explanation |
| --- | --- |
| **Gateway Type** | Default is S3 and cannot be modified. |
| **Internal Port** | Specify the port for internal access in the cluster. |
| **External Access** | Enabling/disabling external access will create/destroy Nodeport type Service. |
| **Instance Count** | The number of resource instances for object storage. |

- When the page automatically advances to the next step, it indicates that the storage pool has been deployed successfully.
- If the deployment fails, please refer to the interface prompts to check the core components, and then click **Clean Up Created Information and Retry** to recreate the storage pool.

2. Click **Create Storage Pool**. In the **Details** tab, you can view information about the created storage pool.

# Related Operations

## Create Stretch Type Cluster

For details, please refer to Create Stretch Type Cluster.

## Cleanup Distributed Storage

For details, please refer to Cleanup Distributed Storage.

# Create Stretch Type Cluster

A stretch cluster can extend across two geographically distinct locations, providing disaster recovery capabilities for storage infrastructure. In the event of a disaster, when one availability zone in the two zones is completely unavailable, Ceph can still maintain availability.

> ⚠️ **IMPORTANT: Alpha Feature Disclaimer**
> This document describes a feature currently in the **Alpha stage**, provided strictly for early technical validation and evaluation. As the feature provider, we offer no warranties regarding its stability, reliability, or data integrity. By configuring and using this feature, you acknowledge and accept the following technical limitations:
>
> - **Not for Production Use:** This feature lacks comprehensive system-level validation. Deploying it in production environments carries a high risk of process failure or data corruption.
> - **No SLA Guarantee:** This feature falls outside standard Service Level Agreements (SLAs). We do not guarantee technical support response times or provide emergency hotfixes.
> - **Breaking Changes & Deprecation:** API endpoints, configuration schemas, and core processing logic are subject to backwards-incompatible changes in future releases. The feature may also be deprecated entirely without prior notice.
> - **No Smooth Upgrade Path:** We do not provide upgrade scripts or data migration tools between versions. Upgrading to subsequent versions typically requires completely purging existing resources and performing a fresh deployment. Any resulting loss of state or data is the sole responsibility of the user.

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# Terminology

| Term | Explanation |
| --- | --- |
| **Quorum Availability Zone** | Usually located in a separate zone that does not bear primary workloads, focusing on maintaining cluster consistency, and is primarily used for arbitration decisions when a failure occurs in the main data center or a network partition occurs. |
| **Data Availability Zone** | The primary area in the Ceph cluster where data is actually stored and processed, bearing operational loads and data storage tasks, forming a complete high-availability storage system together with the quorum zone. |

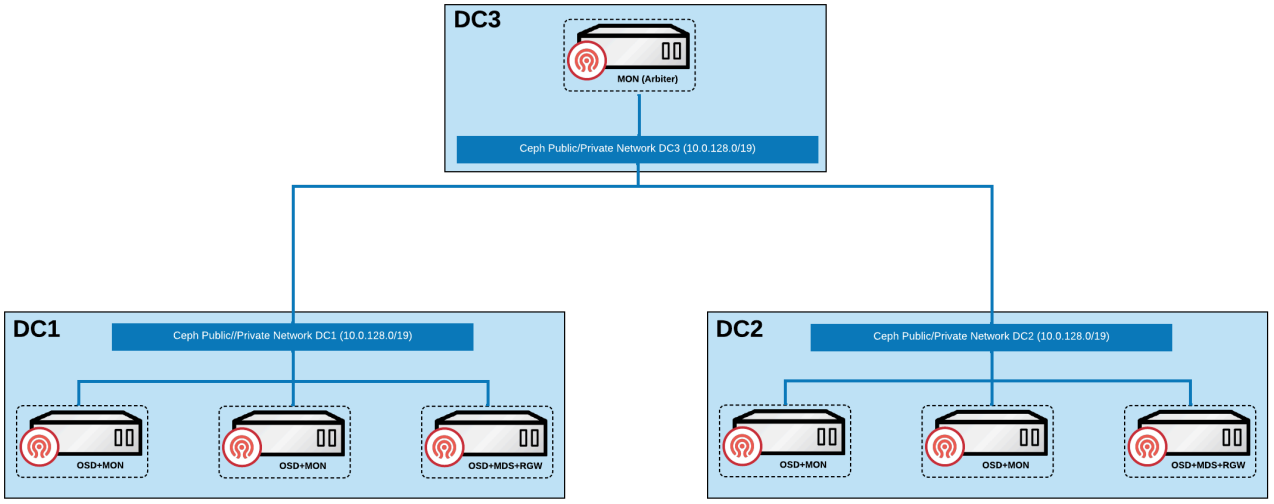
# Typical Deployment Scheme

The following content provides a typical deployment scheme for stretch clusters, along with component descriptions and principles of disaster recovery.

## Component Description

Nodes need to be distributed across three availability zones, including two data availability zones and one quorum availability zone.

- Both data availability zones need to fully deploy all core Ceph components (MON, OSD, MGR, MDS, RGW), and each data availability zone must configure two MON instances for high availability. When both MON instances in the same data availability zone are unavailable, the system will determine that the availability zone is in a failure state.
- The quorum availability zone only requires the deployment of one MON instance, serving as the arbitration decision node.




## Disaster Recovery Explanation

- When a data availability zone completely fails, the Ceph cluster will automatically enter a degraded state and trigger an alarm notification. The system will adjust the minimum number of replicas in the storage pool (min_size) from the default of 2 to 1. Since the other data availability zone still maintains dual replicas, the cluster remains available. When the failed data availability zone recovers, the system will automatically execute data synchronization and return to a healthy state; if the failure cannot be repaired, it is recommended to replace it with a new data availability zone.
- When the network connection between the two data availability zones is interrupted, but they can still connect normally to the quorum availability zone, the quorum availability zone will arbitrate between the two data availability zones based on preset policies, selecting the one in a better state to continue providing services as the primary data zone.

# Constraints and Limitations

- **Storage Pool Limitations**: Erasure-coded storage pools are not supported, and only replica mechanisms can be used for data protection.
- **Device Classification Limitations**: Device class functionality is not supported, and storage cannot be stratified based on device characteristics.
- **Regional Deployment Limitations**: Only two data availability zones are supported; no more than two data availability zones can exist.
- **Data Balancing Requirements**: The OSD weights of the two data availability zones must strictly remain consistent to ensure balanced data distribution.
- **Storage Medium Requirements**: Only all-flash (All-Flash) OSD configurations are permitted, minimizing the time required for recovery after a connection is restored, and reducing the potential for data loss as much as possible.
- **Network Latency Requirements**: The RTT (round-trip time) between the two data availability zones must not exceed 10ms, and the quorum availability zone must meet the ETCD specification latency requirements to ensure the reliability of the arbitration mechanism.

# Prerequisites

Please classify all or part of the nodes in the cluster into three availability zones in advance, as follows:

- Ensure that at least 5 nodes are distributed among one quorum availability zone and two data availability zones. Among them, the quorum availability zone must have at least one node, which can be a virtual machine or cloud host.
- Ensure that at least one availability zone in the three availability zones contains a Master node (control node).
- Ensure that at least 4 computing nodes are evenly distributed across the 2 data availability zones, with at least 2 computing nodes configured in each data availability zone.
- Try to ensure that the number of nodes and disk configurations in the two data availability zones are consistent.

# Procedure

## 1 Tagging Nodes

1. Access **Administrator**.
2. In the left navigation bar, click **Cluster Management** > **Cluster**.
3. Click on the corresponding cluster name to enter the cluster overview page.
4. Switch to the **Nodes** tab.
5. Based on the planning in the Prerequisites, add the `topology.kubernetes.io/zone=<zone>` label to these nodes to classify them into the specified availability zone. Here, replace <zone> with the name of the availability zone.

## 2 Create Storage Service

This document only describes the parameters that differ from standard type clusters; for other parameters, please refer to Create Standard Type Cluster.

### Create Cluster

| Parameter | Description |
| --- | --- |
| **Cluster Type** | Select **Stretch**. |
| **Quorum Availability Zone** | Choose the name of the quorum availability zone. |
| **Data Availability Zone** | Select the names of the availability zones and choose the nodes. |

### Create Storage Pool

| Parameter | Description |
| --- | --- |
| **Number of Replicas** | Default is 4. |

| Parameter | Description |
| --- | --- |
| **Number of Instances** | When the storage type is **Object Storage**, to ensure availability, the minimum number of instances is 2 and the maximum is 5. |

# Related Operations

## Create Standard Type Cluster

For details, please refer to Create Standard Type Cluster.

## Cleanup Distributed Storage

For details, please refer to Cleanup Distributed Storage.

# Core Concepts

## Core Concepts

# Core Concepts

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## Rook Operator

The Rook operator is a simple container that has all that is needed to bootstrap and monitor the storage cluster. The operator will start and monitor Ceph monitor pods, the Ceph OSD daemons to provide RADOS storage, as well as start and manage other Ceph daemons. The operator manages CRDs for pools, object stores (S3/Swift), and filesystems by initializing the pods and other resources necessary to run the services.

The operator will monitor the storage daemons to ensure the cluster is healthy. Ceph mons will be started or failed over when necessary, and other adjustments are made as the cluster grows or shrinks. The operator will also watch for desired state changes specified in the Ceph custom resources (CRs) and apply the changes.

Rook automatically configures the Ceph-CSI driver to mount the storage to your pods. The rook/ceph image includes all necessary tools to manage the cluster.

## Ceph CSI

Ceph CSI plugins implement an interface between a CSI-enabled Container Orchestrator (CO) and Ceph clusters. They enable dynamically provisioning Ceph volumes and attaching them to workloads.

# Ceph module functions

| Module | Function |
| --- | --- |
| MON | The monitor (MON) is the most important component in a Ceph cluster. It manages the Ceph cluster and maintains the status of the entire cluster. The MON ensures that related components of a cluster can be synchronized at the same time. It functions as the leader of the cluster and is responsible for collecting, updating, and publishing cluster information. |
| MGR | The manager (MGR) is a monitoring system that provides collection, storage, analysis (including alarming), and visualization functions. It makes certain cluster parameters available for external systems. |
| OSD | Object storage daemons (OSDs) store the actual user data. Every OSD is usually bound to one physical drive. The OSDs handle the read/write requests from clients. |
| MDS | The Ceph Metadata Server (MDS) tracks the file hierarchy and stores metadata used only for CephFS. The RBD and RGW do not require metadata. The MDS does not directly provide data services for clients. |
| RGW | The RADOS gateway (RGW) is a Ceph object gateway that provides RESTful APIs compatible with S3 and Swift. The RGW also supports multi-tenant and OpenStack Identity service (Keystone). |
| RADOS | Reliable Autonomic Distributed Object Store (RADOS) is the heart of a Ceph storage cluster. Everything in Ceph is stored by RADOS in the form of objects irrespective of their data types. The RADOS layer ensures data consistency and reliability through data replication, fault detection and recovery, and data recovery across cluster nodes. |
| LIBRADOS | Librados is a method that simplifies access to RADOS. Currently, it supports programming languages PHP, Ruby, Java, Python, C, and C++. It provides RADOS, a local interface of the Ceph storage cluster, and is the base component of other services such as the RADOS block device (RBD) and RADOS gateway |

| Module | Function |
| --- | --- |
| | (RGW). In addition, it provides the Portable Operating System Interface (POSIX) for the Ceph file system (CephFS). The Librados API can be used to directly access RADOS, enabling developers to create their own interfaces for accessing the Ceph cluster storage. |
| RBD | The RADOS block device (RBD) is the Ceph block device that provides block storage for external systems. It can be mapped, formatted, and mounted like a drive to a server. |
| CephFS | The CephFS provides a POSIX-compatible distributed file system of any size. It depends on the Ceph MDS to track the file hierarchy, namely the metadata. |

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# Accessing Storage Services

Accessing storage services supports two methods of integration: first, integrating distributed storage resources from other business clusters within the platform to ensure storage and business isolation for easier management and maintenance; second, connecting external Ceph storage resources for distributed storage use.

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# Prerequisites

## Prepare Package

- **Download** the **Alauda Container Platform Storage Essentials** installation package corresponding to your platform architecture.
- **Upload** the **Alauda Container Platform Storage Essentials** installation package using the Upload Packages mechanism.
- **Download** the **Alauda Build of Rook-Ceph** installation package corresponding to your platform architecture.
- **Upload** the **Alauda Build of Rook-Ceph** installation package using the Upload Packages mechanism.

## Prepare Storage

Choose one of the following:

- Distributed storage has been deployed in other business clusters, and a storage pool has been created. Please record the name of the storage pool for later integration use.
- External Ceph storage outside the platform (version ≥ 14.2.3) has been created with a storage pool. Please record the name of the storage pool for later integration use.

## Open Ports

| Destination IP | Destination Port | Source IP | Source Port |
| --- | --- | --- | --- |
| IP of Ceph node | 3300, 6789, 6800-7300, 7480 | IP of all nodes in business cluster | any |

## Obtain Authentication Information (External Ceph)

If the prepared storage is external Ceph storage, authentication information must be obtained using the following commands.

| Parameter | Method of Acquisition |
| --- | --- |
| **FSID** | `ceph fsid` |

| Parameter | Method of Acquisition |
| --- | --- |
| **MON Component Information** | `ceph mon dump`<br>Must be in {name= IP} format, e.g. *a=192.168.100.100:6789* . |
| **Admin Key** | `ceph auth get-key client.admin` |
| **Storage Pool** | • File storage: Use `ceph fs ls` command to get the `name` value.<br>• Block storage: `ceph osd dump` \| `grep "application rbd"` \| `awk '{print $3}'` |
| ***Data Storage Pool*** | (only needed for file storage) Use `ceph fs ls` command to get the `data pools` value. |

# Procedure

**Note**: The following steps take **accessing external Ceph storage** as an example, the operations for accessing distributed storage are similar.

## 1 Deploy Alauda Container Platform Storage Essentials

1. Login, go to the **Administrator** page.
2. Click **Marketplace** > **OperatorHub** to enter the **OperatorHub** page.
3. Find the **Alauda Container Platform Storage Essentials**, click **Install**, and navigate to the **Install Alauda Container Platform Storage Essentials** page.
   Configuration Parameters:

| Parameter | Recommended Configuration |
| --- | --- |
| **Channel** | The default channel is `stable`. |
| **Installation Mode** | `Cluster`: All namespaces in the cluster share a single Operator instance for creation and management, resulting in lower resource |

| Parameter | Recommended Configuration |
| --- | --- |
| | usage. |
| **Installation Place** | Select `Recommended`, Namespace only support **acp-storage**. |
| **Upgrade Strategy** | `Manual`: When there is a new version in the Operator Hub, manual confirmation is required to upgrade the Operator to the latest version. |

## 2 Access Storage

1. In the left navigation bar, click **Storage Management** > **Distributed Storage**.
2. Click **Access Storage**.
3. On the **Access Configuration** wizard page, select **External Ceph**.

| Parameter | Description |
| --- | --- |
| **Snapshot** | When enabled, supports creating PVC snapshots and using snapshots to configure new PVCs for quick backup and restoration of business data.<br>If snapshots were not enabled during storage access, you can still enable them later in the **Operations** section of the storage cluster details page as needed.<br>**Note**: Please ensure that you have deployed the volume snapshot plugin for the current cluster before use. |

| Parameter | Description |
| --- | --- |
| **Network Configuration** | • **Host Network**: Computing components in this cluster will access the **storage cluster** using the **host network**.<br>• **Container Network**: Computing components in this cluster will access the **storage cluster** using the **container network**. You can create a subnet in network management and assign the subnet to the `rook-ceph` namespace. If left empty, the default subnet will be used. |
| **Other Parameters** | Please fill in the authentication parameters for the external Ceph obtained in the prerequisites. |

4. On the **Create Storage Class** wizard page, complete the configuration and click **Access**.

| Parameter | Description |
| --- | --- |
| **Type** | Based on the type of storage pool created above, the default corresponding storage class will be:<br>• File Storage: CephFS File Storage<br>• Block Storage: CephRBD Block Storage |
| **Reclaim Policy** | Reclaim policy for persistent volumes.<br>• Delete: When the persistent volume claim is deleted, the bound persistent volume will also be deleted.<br>• Retain: Even if the persistent volume claim is deleted, the bound persistent volume will still be retained. |
| **Project Allocation** | Projects that can use this type of storage.<br>If there are currently no projects requiring this type of storage, you may choose not to allocate projects for now and update them later. |

> 5. Wait approximately 1-5 minutes for the successful integration.

# Follow-up Actions

- Create Storage Classes: CephFS File Storage, CephRBD Block Storage
- Developers using the above storage classes to create persistent volume claims can extend usage with volume snapshots and scaling features.

**Note**: If you need to maintain storage pools, storage device configurations, etc., for external storage, operations must be performed in the management platform of the storage cluster.

# Managing Storage Pools

A storage pool refers to a logical partition used for storing data. A single storage cluster supports the simultaneous use of different types of storage pools, such as file storage and block storage, to accommodate various business requirements.

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## Creating a Storage Pool

In addition to the storage pools created during the configuration of distributed storage, you can also create additional types of storage pools.

**Tip**: Within the same storage cluster, only one file storage and one object storage pool are allowed, while up to eight block storage pools can be created.

### Procedure

1. Access **Administrator**.
2. In the left navigation bar, click **Storage Management** > **Distributed Storage**.
3. In the **Cluster Information** tab, scroll down to the **Storage Pool** area and click **Create Storage Pool**.
4. Configure the relevant parameters according to the following instructions.

| Parameter | Description |
| --- | --- |
| **Storage Type** | Select the currently undeployed storage type.<br>- File Storage: Provides secure, reliable, and scalable shared file storage services. Suitable for file sharing, data backup, etc.<br>- Block Storage: Provides high IOPS and low latency storage services. Suitable for databases, virtualization, etc.<br>- Object Storage: Provides standard S3 interface storage services, suitable for big data, backup archiving, cloud storage services, etc. |
| **Replica Count** | • **When the cluster type is Standard**: A higher replica count increases redundancy and data security, but it also reduces storage utilization. Usually, a setting of 3 suffices for most needs.<br>• **When the cluster type is Extended**: The default replica count is 4 and cannot be modified. |
| **Device Class** | • **When the cluster type is Standard**: Choose an already added device class within the created storage pool.<br>  • When selecting a device class, data will be stored in the chosen device class.<br>  • If no device class is selected, data will be randomly stored in all devices within the storage pool.<br>• **When the cluster type is Standard**: Adding a device class is not supported. |

If it is an object storage type, you can configure the following parameters as well:

| Parameter | Description |
| --- | --- |
| **Region** | Specify the region where the storage pool is located. |
| **Gateway Type** | Defaults to S3 and cannot be modified. |
| **Internal Port** | Specify the port for internal access to the cluster. |
| **External Access** | Enabling/disabling external access will create/destroy a NodePort type Service. |
| **Instance Count** | Number of resource instances for object storage. |

5. Click **Create**.

# Deleting a Storage Pool

If a certain type of storage is no longer required, the storage pool can be deleted after dissociating it from the storage class.

## Procedure

1. Access **Administrator**.
2. In the left navigation bar, click **Storage Management** > **Distributed Storage**.
3. In the **Cluster Information** tab, scroll down to the **Storage Pool** area, click on the ⋮ next to the storage pool you wish to delete > **Delete**.
4. Read the prompt information and enter the name of the storage pool.
5. Click **Delete**.

# Viewing Object Storage Pool Addresses

After creating an object storage pool, you can view the internal and external access addresses of the storage pool.

## Procedure

1. Access **Administrator**.
2. In the left navigation bar, click **Storage Management** > **Distributed Storage**.
3. In the **Cluster Information** tab, scroll down to the **Storage Pool** area, click on the ⋮ next to the object storage pool and select **View Address**.

# Node-specific Component Deployment

After creating distributed storage, you can still view and modify the deployment location of components, facilitating storage expansion and maintenance.

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# Update Component Deployment Configuration

## Precautions

- Updating the configuration will trigger the system to automatically rebuild component instances, which may affect service access to the storage system. It is recommended to perform the update during off-peak hours.
- When the cluster type is **Extend**, the fixed deployment feature for components is not supported.

## Procedure

1. Go to **Administrator**.
2. In the left navigation bar, click on **Storage Management** > **Distributed Storage**.
3. Under the **Storage Components** tab, click on **Component Deployment Configuration**.
4. Enable/disable the **Fixed Deployment** switch according to business needs, and deploy components to specified nodes. The number of nodes must be no less than three to ensure minimum availability. The components applicable for fixed deployment configuration include MON, MGR, MDS, RGW.
5. Click **Update**, and the components will begin to be scheduled to the designated nodes.

# Restart Storage Components

When you delete the deployed storage components, the system will automatically re-schedule and redeploy components to the nodes according to the current component deployment strategy.

## Procedure

1. Go to **Administrator**.
2. In the left navigation bar, click on **Storage Management** > **Distributed Storage**.
3. Under the **Storage Components** tab, click ⋮ next to the component name > **Delete**.

# Adding Devices/Device Classes

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## Adding Device Classes

Unify the classification of devices of the same type or hard disks with the same business logic in cluster nodes, customize device classes according to storage needs, and allocate different storage contents to different types of storage disks.

### Notes

Adding device classes is not supported when the cluster type is **Extend**.

### Procedure

> 1. Enter **Administrator**.
> 2. In the left navigation bar, click **Storage Management** > **Distributed Storage**.

3. Click the **Device Classes** tab.
4. Click **Add Device Class** and configure the relevant parameters according to the following instructions.

| Parameter | Description |
| --- | --- |
| **Name** | The name of the device class. The following names cannot be used for the device class: `hdd`, `ssd`, `nvme`. |
| **Storage Devices** | To add storage devices to a device class, you can choose between the `Selection Device` and `Input Device` methods:<br>• **Selection Device**:<br>Select from available storage devices. A device is considered available if it meets the following criteria:<br>  • Device type is either disk or mpath<br>  • No file system is detected (fsType is blank)<br>  • Capacity exceeds 10 GiB<br>Devices such as rbd, nbd, and dm-* will not be displayed in the list of available selectable devices.<br>**Note**: Requires prior deployment of the Alauda Build of LocalStorage Operator.<br>• **Input Device**:<br>Manually input the names of the blank devices under the node, such as `sda`.<br>**Note**: For optimal performance and management, it is strongly advised to utilize raw disk as storage devices instead of employing individual partitions on a disk. |

# Adding Devices

Map available hard disks to storage devices for usage and management.

**Note**: Once hard disks are added as storage devices, updating or removing them through the interface is not supported.

## Procedure

1. Enter **Administrator**.
2. In the left navigation bar, click **Storage Management** > **Distributed Storage**.
3. Click the **Device Classes** tab.
4. On the right side of the device class, click **Add Device**, and configure the relevant parameters according to the following instructions.

| Parameter | Description |
| --- | --- |
| **Specified Disks** | To add storage devices to a device class, you can choose between the `Selection Device` and `Input Device` methods:<br>• **Selection Device**:<br>Select from available storage devices. A device is considered available if it meets the following criteria:<br>◦ Device type is either disk or mpath<br>◦ No file system is detected (fsType is blank)<br>◦ Capacity exceeds 10 GiB<br>Devices such as rbd, nbd, and dm-* will not be displayed in the list of available selectable devices.<br>**Note**: Requires prior deployment of the Alauda Build of LocalStorage Operator.<br>• **Input Device**:<br>Manually input the names of the blank devices under the node, such as `sda`. |

| Parameter | Description |
| --- | --- |
| | **Note**: For optimal performance and management, it is strongly advised to utilize raw disks as storage devices instead of employing individual partitions on a disk. |

5. Click **Add**.

# Hard Disk Status

- **Normal**: The corresponding status of the storage device is IN+UP.
- **Abnormal**: The corresponding status of the storage device is IN+DOWN.
- **Offline**: The corresponding status of the storage device is OUT+UP.
- **Fault**: The corresponding status of the storage device is OUT+DOWN.

# Monitoring and Alerts

Distributed storage provides out-of-the-box monitoring metrics collection and alert notification capabilities. Once the monitoring and alerting features are enabled, you can monitor and alert on aspects such as the storage cluster, storage performance, and storage components, with support for configuring notification strategies.

The intuitively presented monitoring data can be used to provide decision support for operation and maintenance inspections or performance tuning, and a comprehensive alert and notification mechanism will help ensure the stable operation of the storage system.

**Tip**: If the monitoring and alerting features were not enabled when creating the distributed storage, you will need to find alternative solutions for storage monitoring and alerting. For example, manually configure monitoring dashboards and alert strategies in the operation and maintenance center.

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# Monitoring

The platform automatically collects common monitoring metrics for distributed storage, such as read and write performance, CPU and memory usage. In the **Storage Management** > **Distributed Storage** section under the **Monitoring** tab, you can view real-time monitoring data for these metrics.

## Storage Overview

Monitor the health status of the storage, physical capacity usage, and the number of active OSD/MON components. In the event of abnormal storage status, you can check the reason for the alert.

## Performance Monitoring

Monitor read and write bandwidth and read and write IOPS from three dimensions: cluster, storage pool, and OSD. Additionally, you can monitor read and write latency specifically for OSD.

## Component Monitoring

Monitor CPU usage and memory usage of components such as MON and OSD.

# Alerts

The platform has a set of default alert strategies enabled. Once a resource becomes abnormal or monitoring data reaches the warning state, alerts will be automatically triggered. The preset strategies are sufficient for common operational needs such as component and cluster status alerts, device capacity alerts, and user data alerts.

## Configure Notifications

To receive alerts in a timely manner, it is recommended that you set up notification strategies in the operation and maintenance center: send alert information via email, SMS, and other

means to relevant personnel, reminding them to take necessary measures to resolve issues or prevent failures. Click **Alert Configuration** to switch to the operation and maintenance center to complete the operation, refer to Create Alert Strategies。

## Handling Alerts

- If the storage cluster is monitored to be in a `Warning` state, it means an alert has been triggered, and the related anomaly may lead to a failure. Please promptly check the details in **Real-time Alerts** and identify and troubleshoot the fault based on the cause.
- If the storage cluster is monitored to be in a `Failure` state, it indicates that the storage cluster is unable to operate normally. Please locate the issue immediately and carry out troubleshooting.

The table below indicates the meanings of the alert levels used by the preset strategies, which can serve as a reference for you when establishing alert handling principles.

| Alert Level | Meaning |
| --- | --- |
| **Disaster** | The resource corresponding to the alert rule has failed, causing platform service interruption, data loss, and significant impact. |
| **Severe** | The resource corresponding to the alert rule has known issues, which may lead to platform function failures and affect the normal operation of services. |
| **Warning** | The resource corresponding to the alert rule faces operational risks, which could affect the normal operation of services if not dealt with promptly. |

## Fault Review

The **Alert History** records all alerts that have been triggered and no longer require action. When conducting a fault review using the alert history, to effectively achieve the purpose of summarizing experiences, you may need to answer the following questions.

- What were the specific abnormal conditions at the time of the incident.
- Is there a pattern to a certain alert that appears repeatedly in the alert list, Can it be prevented before it occurs next time.

- Does the timeline show a surge in alerts during a certain period; was it caused by force majeure or an operational accident, Is there a need to adjust the operational plan.

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# Replacing or Removing Devices

This document describes how to remove a storage device (disk) from a Rook-Ceph cluster managed by the Container Platform. Depending on whether the remaining OSDs have sufficient capacity to absorb the data from the disk being removed, you may need to add a replacement disk first.

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## Prerequisites

- All cluster components are functioning properly.
- The storage cluster was **not** created with the "add all empty disks" option. Verify by running the following command; the output must show `useAllDevices: false`.

```
kubectl get cephcluster -n rook-ceph ceph-cluster -o yaml | grep useAll
Devices
```

- Applicable to platform version 3.8 and above.

## Constraints and Limitations

- During data rebalancing, cluster performance may be temporarily degraded. Avoid operating on multiple disks simultaneously unless absolutely necessary.
- Do not proceed if the cluster is in `HEALTH_ERR` due to reasons **other than** the disk being removed. Proceeding in that state may further compromise data resilience.
- If the disk being removed is the last disk of a particular device class, that device class will cease to exist. Any storage pools or policies that depend on it will be affected. Ensure no pools are tied exclusively to this device class before proceeding.

## Procedure

### 1 Check Cluster State and Capacity

1. Verify overall cluster health.

```
kubectl -n rook-ceph exec -it deploy/rook-ceph-tools -- ceph -s
```

2. Identify the OSD ID and usage of the disk to be removed.

```
kubectl -n rook-ceph exec -it deploy/rook-ceph-tools -- ceph osd d
f
```

Note the **USE** value of the target OSD. Then confirm that the sum of **AVAIL** across all remaining OSDs (excluding the target) is greater than the target OSD's **USE** value. This ensures the remaining OSDs have enough free space to absorb the data after removal.
If remaining capacity is insufficient, proceed to the next step to add a replacement disk first. Otherwise, skip to Scale Down the Rook Operator.

## 2 Add a Replacement Disk (If Needed)

If the remaining OSDs do not have enough free capacity, add a replacement disk before removing the old one. The Rook operator must be running during this step.

1. Enter the **Container Platform**.
2. In the left navigation bar, click **Storage Management** > **Distributed Storage** > **Device Classes**.
3. Click **Add Device**, select the node where the replacement disk is installed, choose the new disk, and assign it to the same device class as the disk being removed.
4. Wait for the new OSD to be created and for data rebalancing to complete. Monitor progress:

```
kubectl -n rook-ceph exec -it deploy/rook-ceph-tools -- ceph -s
```

Wait until the output shows `HEALTH_OK` with no misplaced or recovering PGs.

## 3 Scale Down the Rook Operator

Scale down the Rook operator to prevent it from interfering with the removal process (for example, by recreating deleted OSD deployments mid-procedure).

```
kubectl -n rook-ceph scale deploy rook-ceph-operator --replicas=0
```

## 4 Mark the OSD Out and Wait for Data Migration

1. Enable the rook-ceph-tools pod if it is not already running.

```
kubectl -n rook-ceph scale deploy rook-ceph-tools --replicas=1
```

2. Enter the tools pod.

```
kubectl -n rook-ceph exec -it deploy/rook-ceph-tools -- bash
```

3. Mark the OSD as `out`. This instructs Ceph to migrate all data off the OSD onto the remaining OSDs.

```
ceph osd out osd.<id>
```

4. Monitor rebalancing progress until the cluster returns to `HEALTH_OK` with no misplaced or recovering PGs.

```
ceph -s
```

**Do not proceed until data migration is fully complete.** Removing the OSD before migration finishes will result in data loss.

## 5 Remove the OSD

1. Edit the CephCluster resource to remove the disk entry.

```
kubectl edit cephcluster -n rook-ceph ceph-cluster
```

Locate the disk under `spec.storage.nodes` and delete its entry. Save and exit.

2. Delete the OSD deployment.

```
kubectl -n rook-ceph delete deploy rook-ceph-osd-<osd-id>
```

3. Enter the tools pod and permanently remove the OSD from the cluster. Replace `<id>` with the OSD ID.

```
kubectl -n rook-ceph exec -it deploy/rook-ceph-tools -- bash
```

Inside the tools pod:

```
ceph osd purge osd.<id> --yes-i-really-mean-it
```

## 6 Clean Up the Disk

If the disk will remain physically attached to the node, wipe its metadata to prevent Rook from accidentally picking it up. Run the following commands **on the node** where the disk is located. Replace `/dev/vdb` with the actual device path.

```
# Remove any device-mapper entries left by Ceph
dmsetup remove /dev/mapper/ceph--<vg-name>   # Replace with the actua
l mapper name if present

# Wipe the partition table
sgdisk --zap-all /dev/vdb

# Zero the first 100 MB to clear residual Ceph metadata
dd if=/dev/zero of=/dev/vdb bs=1M count=100 oflag=direct,dsync
```

## 7 Scale Up the Rook Operator

Once the cluster is healthy, restore the Rook operator.

```
kubectl -n rook-ceph scale deploy rook-ceph-operator --replicas=1
```

## 8 Verify Cluster Health

1. Confirm that the removed OSD no longer appears in the cluster.

   ```
   kubectl -n rook-ceph exec -it deploy/rook-ceph-tools -- ceph osd t
   ree
   ```

2. Verify that the cluster has returned to a healthy state.

   ```
   kubectl -n rook-ceph exec -it deploy/rook-ceph-tools -- ceph -s
   ```

> The output should show `HEALTH_OK` with all PGs in the `active+clean` state.

# References

- Rook Ceph OSD Management ↗

# Replacing or Removing Storage Nodes

This document describes how to remove a storage node from a Rook-Ceph cluster managed by the Container Platform. Depending on whether the remaining OSDs have sufficient capacity to absorb the data from the node being removed, you may need to add a replacement node first.

## TOC



## Prerequisites

- All cluster components (except the failing node, if applicable) are functioning properly.

- Before starting, note how many disks the old node has and which device class each disk belongs to.

# Constraints and Limitations

- In a three-node Ceph cluster, losing one node already reduces redundancy. Complete the procedure as quickly as possible to minimize the risk window.
- During data rebalancing, cluster I/O performance may be temporarily degraded.
- Do not proceed if the cluster is in `HEALTH_ERR` due to reasons **other than** the node being removed. Proceeding in that state may further compromise data resilience.

# Procedure

## 1 Check Cluster State and Capacity

1. Identify all OSD IDs running on the node to be removed and their disk usage.

```
kubectl -n rook-ceph get pod -l app=rook-ceph-osd -o wide | grep <
old-node-name>
```

2. Verify overall cluster health.

```
kubectl -n rook-ceph exec -it deploy/rook-ceph-tools -- ceph -s
```

3. Check the capacity of all OSDs.

```
kubectl -n rook-ceph exec -it deploy/rook-ceph-tools -- ceph osd d
f
```

Sum the **USE** values of all OSDs on the node to be removed. Then confirm that the sum of **AVAIL** across all remaining OSDs (on other nodes) is greater than that total. This ensures the remaining OSDs have enough free space to absorb the data after the node is removed.

If remaining capacity is insufficient, proceed to the next step to add a replacement node first. Otherwise, skip to Adjust Component Deployment Configuration.

## 2 Add a Replacement Node (If Needed)

If the remaining OSDs do not have enough free capacity, add a replacement node before removing the old one.

1. Enter the **Container Platform**.
2. Add the replacement machine as a new cluster node using the platform's node management functionality.
3. After the node has joined the cluster, add it as a storage node. Navigate to **Storage Management** > **Distributed Storage** > **Device Classes**.
4. Click **Add Device**, select the new node, and choose the appropriate disks. If the old node had multiple disks across different device classes, repeat this step for each disk/device-class combination until all disks are added.
5. Wait for the new OSDs to become active and for data rebalancing to complete. Monitor progress:

   ```
   kubectl -n rook-ceph exec -it deploy/rook-ceph-tools -- ceph -s
   ```

   **Wait until the cluster returns to** `HEALTH_OK` with no misplaced or recovering PGs before proceeding.

## 3 Adjust Component Deployment Configuration

Rook-managed Ceph daemons (MON, MGR, MDS) may be scheduled on the old node. Exclude the old node from component scheduling so the operator reschedules them onto other nodes.

1. In the **Container Platform**, navigate to **Storage Management** > **Distributed Storage** > **Storage Components** > **Component Deployment Configuration**.
2. Enable node binding and select only the nodes that should remain in the cluster (excluding the node to be removed).
3. Wait for all MON, MGR, and MDS pods to be running on the remaining nodes before proceeding.

```
kubectl -n rook-ceph get pod -o wide
```

## 4 Mark All OSDs Out and Wait for Data Migration

1. Enable the rook-ceph-tools pod if it is not already running.

   ```
   kubectl -n rook-ceph scale deploy rook-ceph-tools --replicas=1
   ```

2. Enter the tools pod.

   ```
   kubectl -n rook-ceph exec -it deploy/rook-ceph-tools -- bash
   ```

3. Mark each OSD on the old node as `out`. This instructs Ceph to migrate all data off those OSDs onto the remaining OSDs.

   ```
   ceph osd out osd.<id>
   ```

   Repeat for each OSD ID on the node.

4. Monitor rebalancing progress until the cluster returns to `HEALTH_OK` with no misplaced or recovering PGs.

   ```
   ceph -s
   ```

   **Do not proceed until data migration is fully complete.** Removing OSDs before migration finishes will result in data loss.

## 5 Remove the Old Node's OSDs

1. Edit the CephCluster resource to remove the old node entry.

   ```
   kubectl edit cephcluster -n rook-ceph ceph-cluster
   ```

   Locate the old node under `spec.storage.nodes` and delete the entire node entry. Save and exit.

2. Delete the OSD deployment for each OSD on the old node.

```
kubectl -n rook-ceph delete deploy rook-ceph-osd-<osd-id>
```

Repeat for each OSD ID on the node.

3. Enter the tools pod and permanently remove each OSD from the cluster.

```
kubectl -n rook-ceph exec -it deploy/rook-ceph-tools -- bash
```

Inside the tools pod, execute the following for **each** OSD:

```
ceph osd purge osd.<id> --yes-i-really-mean-it
```

## 6 Verify Cluster Health

1. Confirm that all removed OSDs no longer appear in the cluster.

```
kubectl -n rook-ceph exec -it deploy/rook-ceph-tools -- ceph osd tree
```

2. Verify that the cluster has returned to a healthy state.

```
kubectl -n rook-ceph exec -it deploy/rook-ceph-tools -- ceph -s
```

The output should show `HEALTH_OK` with all PGs in the `active+clean` state.

# References

- Rook Ceph OSD Management ↗

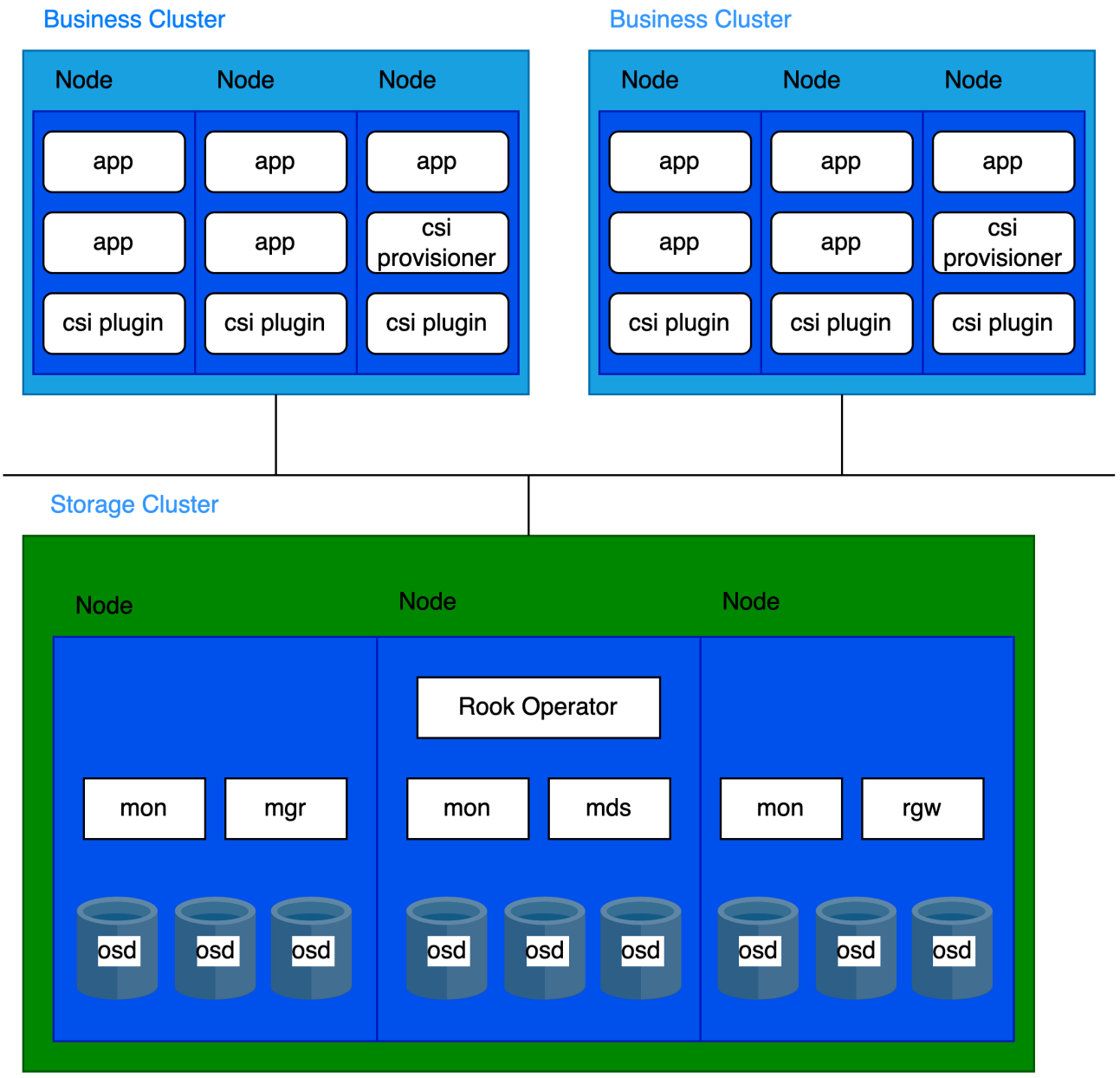
# Configure a Dedicated Cluster for Distributed Storage

Dedicated cluster deployment refers to using an independent cluster to deploy the platform's distributed storage, where other business clusters within the platform access and utilize the storage services it provides through integration.
To ensure the performance and stability of the platform's distributed storage, only the platform's core components and distributed storage components are deployed in the dedicated storage cluster, avoiding the co-location of other business workloads. This separated deployment approach is the recommended best practice for the platform's distributed storage.

## TOC

# Architecture

Storage-Compute Separation Architecture




# Infrastructure requirements

## Platform requirements

Supported in version 3.18 and later.

## Cluster requirements

It is recommended to use bare-metal clusters as dedicated storage clusters.

# Resource requirements

Please refer to the Core Concepts for the components of distributed storage deployment.

Each component has distinct CPU and memory requirements. The recommended configurations are as follows:

| Process | CPU | Memory |
| --- | --- | --- |
| MON | 2c | 3Gi |
| MGR | 3c | 4Gi |
| MDS | 3c | 8Gi |
| RGW | 2c | 4Gi |
| OSD | 4c | 8Gi |

A cluster typically runs:

- 3 MON
- 2 MGR
- multiple OSD
- 2 MDS (if using CephFS)
- 2 RGW (if using CephObjectStorage)

Based on the component distribution, the following per-node resource recommendations apply:

| CPU | Memory |
| --- | --- |
| 16c + (4c * OSD per node) | 20Gi + (8Gi * OSD per node) |

# Storage device requirements

It is recommended to deploy 12 or fewer storage devices per node. This helps restrict the recovery time following a node failure.

## Storage device type requirements

It is recommended to use enterprise SSDs with a capacity of 10TiB or smaller per device, and ensure all disks are identical in size and type.

## Capacity planning

Before deployment, storage capacity must be planned according to specific business requirements. By default, the distributed storage system employs a 3-replica redundancy strategy. Therefore, the usable capacity is calculated by dividing the total raw storage capacity (from all storage devices) by 3.

Example for 30(N) nodes (replica count = 3), The usable capacity scenario is as follows:

| Storage device size(D) | Storage device per node(M) | Total Capacity(D*M*N) | Usable Capacity(D*M*N/3) |
|---|---|---|---|
| 0.5 TiB | 3 | 45 TiB | 15 TiB |
| 2 TiB | 6 | 360 TiB | 120 TiB |
| 4 TiB | 9 | 1080 TiB | 360 TiB |

## Capacity monitoring and expansion

1. **Proactive Capacity Planning**
   Always ensure usable storage capacity exceeds consumption. If storage is fully exhausted, recovery requires manual intervention and cannot be resolved by simply deleting or migrating data.
2. **Capacity Alerts**
   The cluster triggers alerts at two thresholds:

   - **80% utilization** ("near full"): Proactively **free up space** or scale out the cluster.
   - **95% utilization** ("full"): Storage is fully exhausted, and standard commands cannot free space. Contact platform support immediately.

Always address alerts promptly and monitor storage usage regularly to avoid outages.

3. **Scaling Recommendations**

   - **Avoid**: Adding storage devices to existing nodes.
   - **Recommended**: Scale out by adding new storage nodes.
   - **Requirement**: New nodes must use storage devices identical in size, type, and quantity to existing nodes.

# Network requirements

Distributed storage must utilize **HostNetwork**.

## Network Isolation

The network is categorized into two types:

- **Public Network**: Used for client-to-storage component interactions (e.g., I/O requests).
- **Cluster Network**: Dedicated to data replication between replicas and data rebalancing (e.g., recovery).

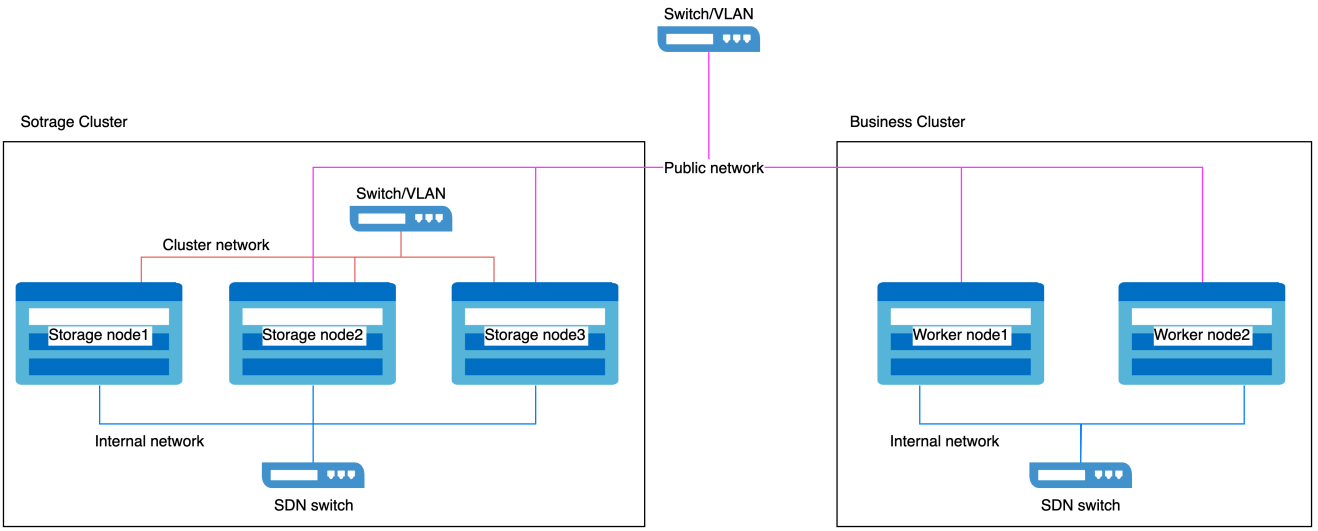
To ensure service quality and performance stability:

1. For Dedicated Storage Clusters:
   Reserve two network interfaces on each host:

   - Public Network: For client and component communication.
   - Cluster Network: For internal replication and rebalancing traffic.

2. For Business Clusters:
   Reserve one network interface on each host to access the storage Public Network.

Example Network Isolation Configuration




## Network interface speed requirements

1. **Storage Nodes**

   - **Public Network** and **Cluster Network** require 10GbE or higher network interfaces.

2. **Business Cluster Nodes**

   - The network interface used to access the storage **Public Network** must be 10GbE or higher.

# Procedure

## 1 Deploy Operator

1. Access **Administrator**.
2. In the left sidebar, click **Storage Management** > **Distributed Storage**.
3. Click **Create Now**.
4. In the **Deploy Operator** wizard page, click the **Deploy Operator** button at the bottom right.

   - When the page automatically advances to the next step, it indicates that the Operator has been deployed successfully.
   - If the deployment fails, please refer to the prompt on the interface **Clean Up Deployed Information and Retry**, and redeploy the Operator; if you wish to return to the distributed storage selection page, click **Application Store**, first uninstall the

resources in the already deployed **rook-operator**, and then uninstall **rook-operator**.

## 2 Create ceph cluster

Execute commands on the **control node** of the storage cluster.

▶ Click to view

**Parameters**:

- **public network cidr**: CIDR of the storage **Public Network** (e.g., `- 10.0.1.0/24`).
- **cluster network cidr**: CIDR of the storage **Cluster Network** (e.g., `- 10.0.2.0/24`).
- **storage devices**: Specify the storage devices to be utilized by the distributed storage.
  Example Formatting:

```
nodes:
- name: storage-node-01
  devices:
  - name: /dev/disk/by-id/wwn-0x5000cca01dd27d60
  useAllDevices: false
- name: storage-node-02
  devices:
  - name: sdb
  - name: sdc
  useAllDevices: false
- name: storage-node-03
  devices:
  - name: sdb
  - name: sdc
  useAllDevices: false
```

**Tip**

Uses the disk's World Wide Name (WWN) for stable naming, which avoids reliance on volatile device paths like `sdb` that may change after reboots.

## 3 Create storage pools

Three storage pool types are available. Select and create the appropriate ones based on your business requirements.

### Create file pool

Execute commands on the **control node** of the storage cluster.

▶ Click to view

### Create block pool

Execute commands on the **control node** of the storage cluster.

▶ Click to view

### Create object pool

Execute commands on the **control node** of the storage cluster.

▶ Click to view

# Follow-up Actions

When other clusters need to utilize the distributed storage service, refer to the following guidelines.

Accessing Storage Services

# Cleanup Distributed Storage

If you need to delete a rook-ceph cluster and redeploy a new one, you should follow this document to sequentially clean the distributed storage service related resources.

## TOC



## Precautions

Before cleaning up rook-ceph, ensure that all PVC and PV resources using Ceph storage have been deleted.

# Procedure

## 1 Deleting VolumeSnapshotClasses

1. Delete the VolumeSnapshotClasses.

```
kubectl delete VolumeSnapshotClass csi-cephfs-snapshotclass csi-rbd-snapshotclass
```

2. Verify that the VolumeSnapshotClasses have been cleaned up.

```
kubectl get VolumeSnapshotClass | grep csi-cephfs-snapshotclass
kubectl get VolumeSnapshotClass | grep csi-rbd-snapshotclass
```

When there is no output from these commands, it indicates that the cleanup is complete.

## 2 Deleting StorageClasses

1. Go to **Administrator**.
2. In the left navigation bar, click **Storage Management** > **Storage Classes**.
3. Click ⋮ > **Delete**, and delete all StorageClasses that use Ceph storage solutions.

## 3 Deleting Storage Pools

This step should be performed after the previous step has been completed.

1. Go to **Administrator**.
2. In the left navigation bar, click **Storage Management** > **Distributed Storage**.
3. In the **Storage Pool Area**, click ⋮ > **Delete**, and delete all storage pools one by one. When the storage pool area shows **No Storage Pools**, it indicates successful deletion of the storage pools.
4. (Optional) If the cluster mode is **Extended**, you also need to execute the following command on the Master node of the cluster to delete the created built-in storage pools.

```
kubectl -n rook-ceph delete cephblockpool -l cpaas.io/builtin=true
```

Response:

```
cephblockpool.ceph.rook.io "builtin-mgr" deleted
```

## 4 Deleting ceph-cluster

This step should be performed after the previous step has been completed.

1. Update the ceph-cluster and enable the cleanup policy.

```
kubectl -n rook-ceph patch cephcluster ceph-cluster --type merge -
p '{"spec":{"cleanupPolicy":{"confirmation":"yes-really-destroy-da
ta"}}}'
```

2. Delete the ceph-cluster.

```
kubectl delete cephcluster ceph-cluster -n rook-ceph
```

3. Delete the jobs that perform the cleanup.

```
kubectl delete jobs --all -n rook-ceph
```

4. Verify that the ceph-cluster cleanup is complete.

```
kubectl get cephcluster  -n rook-ceph | grep ceph-cluster
```

When this command has no output, it indicates that the cleanup is complete.

## 5 Deleting rook-operator

This step should be performed after the previous step has been completed.

1. Delete the rook-operator.

```
kubectl -n rook-ceph delete subscriptions.operators.coreos.com roo
k-operator
```

2. Verify that the rook-operator cleanup is complete.

```
kubectl get subscriptions.operators.coreos.com -n rook-ceph | grep
rook-operator
```

When this command has no output, it indicates that the cleanup is complete.

3. Verify that all ConfigMaps have been cleaned up.

```
kubectl get configmap -n rook-ceph
```

When this command has no output, it indicates that cleanup is complete. If there are output results, execute the following command to clean up, replacing `<configmap>` with the actual output.

```
kubectl -n rook-ceph patch configmap <configmap> --type merge -p
'{"metadata":{"finalizers": []}}'
```

4. Verify that all Secrets have been cleaned up.

```
kubectl get secret -n rook-ceph
```

When this command has no output, it indicates that cleanup is complete. If there are output results, execute the following command to clean up, replacing `<secret>` with the actual output.

```
kubectl -n rook-ceph patch secrets <secret> --type merge -p '{"met
adata":{"finalizers": []}}'
```

5. Verify that the rook-ceph cleanup is complete.

```
kubectl get all -n rook-ceph
```

When this command has no output, it indicates that cleanup is complete.

## 6 Execute Cleanup Script

Once the above steps are completed, it indicates that Kubernetes and Ceph related resources have been cleared. Next, you need to clean up any residuals of rook-ceph on the host.

### Cleanup Script

The contents of the cleanup script clean-rook.sh are as follows:

▶ Click to view

### Precautions

The cleanup script depends on the sgdisk command, so please make sure to have it installed before executing the cleanup script.

- Installation command for Ubuntu: `sudo apt install gdisk`
- Installation command for RedHat or CentOS: `sudo yum install gdisk`

### Procedure

1. Execute the cleanup script clean-rook.sh on each machine in the business cluster where distributed storage is deployed.

   ```
   sh clean-rook.sh /dev/[device_name]
   ```

   Example: `sh clean-rook.sh /dev/vdb`
   When executed, you will be prompted to confirm whether to really clear the device. If confirmed, enter yes to begin cleaning.

2. Use the `lsblk -f` command to check the partition information. When the `FSTYPE` column in the output of this command is empty, it indicates that the cleanup is complete.

# Disaster Recovery

# File Storage Disaster Recovery

CephFS Mirror is a feature of the Ceph file system designed to enable asynchronous data replication between different Ceph clusters, thereby providing cross-cluster disaster recovery. Its core functionality is to synchronize data in a primary-backup mode, ensuring that the backup cluster can rapidly take over services if the primary cluster experiences a failure.

**WARNING**

- CephFS Mirror performs incremental synchronization based on snapshots, with the default snapshot interval set to once per hour (configurable). The differential data between the primary and backup clusters typically consists of the amount of data written within one snapshot cycle.
- CephFS Mirror solely provides the backup of underlying storage data and is incapable of handling the backup of Kubernetes resources. Please utilize the platform's **Backup and Restore** feature to back up PVC and PV resources in conjunction.

## TOC

# Terminology

| Term | Explanation |
| --- | --- |
| **Primary Cluster** | The cluster currently providing storage services. |
| **Secondary Cluster** | Cluster for backup. |

# Backup Configuration

## Prerequisites

- Prepare two clusters suitable for deploying Alauda Build of Rook-Ceph, namely the Primary cluster and the Secondary cluster, ensuring that the networks between the clusters are interconnected.
- The platform versions used by both clusters (v3.12 and above) must be consistent.
- Create a distributed storage service in both the Primary and Secondary clusters
- Create file storage pools with the **same name** in both the Primary and Secondary clusters.

## Procedure

### 1 Enable the Mirror for the file storage pool in the Secondary cluster

Execute the following commands on the Control node of the Secondary cluster:

Command Line

```
kubectl -n rook-ceph patch cephfilesystem <fs-name> \
--type merge -p '{"spec":{"mirroring":{"enabled": true}}}'
```

Output

```
cephfilesystem.ceph.rook.io/<fs-name> patched
```

**Parameters**:

- `<fs-name>`: Name of the file storage pool.

## 2 Obtain the Peer Token

This token is the key credential for establishing a mirroring connection between the two clusters.

Execute the following commands on the Control node of the Secondary cluster:

Command

```
kubectl get secret -n rook-ceph \
$(kubectl -n rook-ceph get cephfilesystem <fs-name> -o jsonpath
='{.status.info.fsMirrorBootstrapPeerSecretName}') \
-o jsonpath='{.data.token}' | base64 -d
```

Output

```
# Due to the involvement of sensitive information, the output ha
s been truncated.
eyJmc2lkIjogImMyYjAyNmMzLTA3ZGQtNDA3Z...
```

**Parameters**:

- `<fs-name>`: Name of the file storage pool.

## 3 Create Peer Secret in the Primary cluster

After obtaining the Peer Token from the Secondary cluster, it is necessary to create a Peer Secret in the Primary cluster.

Execute the following commands on the Control node of the Primary cluster:

Command

```
kubectl -n rook-ceph create secret generic fs-secondary-site-sec
ret \
--from-literal=token=<token> \
--from-literal=pool=<fs-name>
```

Output

```
secret/fs-secondary-site-secret created
```

**Parameters**:

- `<token>`: The token obtained in step 2.
- `<fs-name>`:Name of the file storage pool.

## 4 Enable the Mirror for the file storage pool in the Primary cluster

Execute the following commands on the Control node of the Primary cluster:

Command

```
kubectl -n rook-ceph patch cephfilesystem <fs-name> --type merge
-p \
'{
  "spec": {
    "mirroring": {
      "enabled": true,
      "peers": {
        "secretNames": [
          "fs-secondary-site-secret"
        ]
      },
      "snapshotSchedules": [
        {
          "path": "/",
          "interval": "<schedule-interval>"
        }
      ],
      "snapshotRetention": [
        {
          "path": "/",
          "duration": "<retention-policy>"
        }
      ]
    }
  }
}'
```

Sample

```
kubectl -n rook-ceph patch cephfilesystem cephfs --type merge -p
\
'{
  "spec": {
    "mirroring": {
      "enabled": true,
      "peers": {
        "secretNames": [
          "fs-secondary-site-secret"
        ]
      },
      "snapshotSchedules": [
        {
          "path": "/",
          "interval": "1h"
        }
      ],
      "snapshotRetention": [
        {
          "path": "/",
          "duration": "h 1"
        }
      ]
    }
  }
}'
```

Output

```
cephfilesystem.ceph.rook.io/<fs-name> patched
```

**Parameters**:

- `<fs-name>`:Name of the file storage pool.
- `<schedule-interval>`:Snapshot execution cycle. For details, please refer to the official documentation↗.

- `<retention-policy>`: Snapshot retention policy. details, please refer to the official documentation↗.

## 5 Deploy the Mirror Daemon in the Primary cluster

The Mirror Daemon continuously monitors data changes in the file storage pool (with Mirror enabled). It periodically creates snapshots and pushes the snapshot differences to the Secondary cluster over the network.

Execute the following commands on the Control node of the Primary cluster:

Command

```
cat << EOF | kubectl apply -f -
apiVersion: ceph.rook.io/v1
kind: CephFilesystemMirror
metadata:
  name: cephfs-mirror
  namespace: rook-ceph
spec:
  placement:
    tolerations:
    - key: NoSchedule
      operator: Exists
  resources:
    limits:
      cpu: "500m"
      memory: "1Gi"
    requests:
      cpu: "500m"
      memory: "1Gi"
  priorityClassName: system-node-critical
EOF
```

Output

```
cephfilesystemmirror.ceph.rook.io/cephfs-mirror created
```

# Failover

In the event of a Primary cluster failure, you can directly continue using CephFS in the Secondary cluster.

## Prerequisites

The Kubernetes resources of the Primary cluster have been backed up and restored to the Secondary cluster, including PVCs, PVs, and workloads of the applications.

# Block Storage Disaster Recovery

RBD Mirror is a feature of Ceph Block Storage (RBD) that enables asynchronous data replication between different Ceph clusters, providing cross-cluster Disaster Recovery (DR). Its core function is to synchronize data in a primary-backup mode, ensuring rapid service takeover by the backup cluster when the primary cluster fails.

**WARNING**

- RBD Mirror performs incremental synchronization based on snapshots, with a default snapshot interval of once per hour (configurable). The differential data between primary and backup clusters typically corresponds to writes within one snapshot cycle.
- RBD Mirror only provides underlying storage data backup and does not handle Kubernetes resource backups. Please use the platform's **Backup and Restore** feature to back up PVC and PV resources.

## TOC

# Terminology

| Term | Explanation |
| --- | --- |
| **Primary Cluster** | The cluster currently providing storage services. |
| **Secondary Cluster** | The standby cluster used for backup purposes. |

# Backup Configuration

## Prerequisites

- Prepare two clusters capable of deploying Alauda Build of Rook-Ceph: a Primary cluster and a Secondary cluster.
- Both clusters must run the same platform version (v3.12 or later).
- Create distributed storage services in both Primary and Secondary clusters.
- Create block storage pools with **identical names** in both Primary and Secondary clusters.

- Please ensure that the following two images have been uploaded to the platform's private image repository:
  - `quay.io/csiaddons/k8s-controller:v0.12.0` -> `<registry>/csiaddons/k8s-controller:v0.12.0`
  - `quay.io/csiaddons/k8s-sidecar:v0.12.0` -> `<registry>/csiaddons/k8s-sidecar:v0.12.0`

## network Prerequisites

Synchronization between the Primary and Secondary clusters is performed over the Public network of Ceph. Therefore, the inter-site Public network must satisfy the following requirements:

- Each cluster must have a dedicated Public network segment. The Public networks of the Primary and Secondary clusters must be fully routable and mutually reachable.
- The sustained bandwidth utilization of the Public network should not exceed 60% to ensure sufficient headroom for replication bursts and failover scenarios.
- The round-trip time (RTT) between the two sites should be less than 30 ms.
- The packet loss rate between the two Public networks should be lower than 0.05% to guarantee stable and predictable replication performance.

## Procedures

### Bootstrap Peers( `Primary <-> Secondary` )

1. **Enable Mirroring for Primary Cluster's Block Storage Pool**
   Execute the following command on both Primary and Secondary clusters' Control nodes:

   Command

```
kubectl -n rook-ceph patch cephblockpool <block-pool-name> \
  --type merge -p '{"spec":{"mirroring":{"enabled":true,"mod
e":"image"}}}'
```

Output

```
cephblockpool.ceph.rook.io/<block-pool-name> patched
```

**Parameters**:

- `<block-pool-name>`: Block storage pool name.

2. **Obtained Peer Token**

   This token serves as the critical credential for establishing mirror connections between clusters.

   Execute the following command on both Primary and Secondary clusters' Control nodes:

Command

```
kubectl get secret -n rook-ceph \
  $(kubectl get cephblockpool.ceph.rook.io <block-pool-name> -
n rook-ceph -o jsonpath='{.status.info.rbdMirrorBootstrapPeerS
ecretName}') \
  -o jsonpath='{.data.token}' | base64 -d
```

Output

```
# Output truncated due to sensitive information
eyJmc2lkIjoiMjc2N2I3ZmEtY2YwYi00N...
```

3. **Create Peer Token Secret in Peer Cluster**

   Execute the following command on both Primary and Secondary cluster's Control node:

Command

```
kubectl -n rook-ceph create secret generic rbd-peer-site-secret \
  --from-literal=token=<token> \
  --from-literal=pool=<block-pool-name>
```

Output

```
secret/rbd-peer-site-secret created
```

**Parameters**:

- `<token>`: Token obtained from Step 2.
  On the Primary cluster, configure this field using the token obtained from the Secondary cluster.
  On the Secondary cluster, configure this field using the token obtained from the Primary cluster.
- `<block-pool-name>`: Block storage pool name.

4. **Patch Peer Secret for Block Storage Pool**
   Execute the following command on both Primary and Secondary cluster's Control node:

Command

```
kubectl -n rook-ceph patch cephblockpool <block-pool-name> --type merge -p \
'{
  "spec": {
    "mirroring": {
      "peers": {
        "secretNames": [
          "rbd-peer-site-secret"
        ]
      }
    }
  }
}'
```

Output

```
cephblockpool.ceph.rook.io/<block-pool-name> patched
```

**Parameters**:

- `<block-pool-name>`: Block storage pool name.

5. **Deploy Mirror Daemon**

   This daemon is responsible for monitoring and managing RBD mirror synchronization processes, including data synchronization and error handling.

   Execute the following command on both Primary and Secondary cluster's Control node:

Command

```
cat << EOF | kubectl apply -f -
apiVersion: ceph.rook.io/v1
kind: CephRBDMirror
metadata:
  name: rbd-mirror
  namespace: rook-ceph
spec:
  count: 1
EOF
```

Output

```
cephrbdmirror.ceph.rook.io/rbd-mirror created
```

6. **Verify Mirror Status**

   Execute the following command on both Primary and Secondary cluster's Control node:

   Command

   ```
   kubectl get cephblockpools.ceph.rook.io <block-pool-name> -n r
   ook-ceph -o jsonpath='{.status.mirroringStatus.summary}'
   ```

   Output

   ```
   # All "OK" statuses indicate normal operation
   {"daemon_health":"OK","health":"OK","image_health":"OK","state
   s":{}}
   ```

   **Parameters**:

   - `<block-pool-name>`: Block storage pool name.

## Setup Environment For Volume Replication

This feature enables efficient data replication and synchronization without interrupting primary application operations, enhancing system reliability and availability.

1. **Setup CsiAddons Controller**

   Execute the following commands on both Primary and Secondary clusters' Control nodes:

   ```
   kubectl create -f https://raw.githubusercontent.com/csi-addons/kubernetes-csi-addons/v0.12.0/deploy/controller/crds.yaml
   kubectl create -f https://raw.githubusercontent.com/csi-addons/kubernetes-csi-addons/v0.12.0/deploy/controller/setup-controller.yaml
   kubectl create -f https://raw.githubusercontent.com/csi-addons/kubernetes-csi-addons/v0.12.0/deploy/controller/rbac.yaml
   kubectl create -f https://raw.githubusercontent.com/csi-addons/kubernetes-csi-addons/v0.12.0/deploy/controller/csi-addons-config.yaml

   kubectl -n csi-addons-system set image deployment/csi-addons-controller-manager manager=<registry>/csiaddons/k8s-controller:v0.12.0
   ```

   **Parameters**:

   - `<registry>`: Registry address of platform.

2. **Enable CsiAddons sidecar**

   Execute the following commands on both Primary and Secondary clusters' Control nodes:

```
kubectl patch cm rook-ceph-operator-config -n rook-ceph --type jso
n --patch \
'[
  {
    "op": "add",
    "path": "/data/CSI_ENABLE_OMAP_GENERATOR",
    "value": "true"
  },
  {
    "op": "add",
    "path": "/data/CSI_ENABLE_CSIADDONS",
    "value": "true"
  },
  {
    "op": "add",
    "path": "/data/ROOK_CSIADDONS_IMAGE",
    "value": "<registry>/csiaddons/k8s-sidecar:v0.12.0"
  }
]'
```

Wait for all csi pods to restart successfully

```
kubectl get po -n rook-ceph -w | grep csi
```

3. **Create VolumeReplicationClass**

   Execute the following commands on both Primary and Secondary clusters' Control nodes:

   Command

```
cat << EOF | kubectl apply -f -
apiVersion: replication.storage.openshift.io/v1alpha1
kind: VolumeReplicationClass
metadata:
  name: rbd-volumereplicationclass
spec:
  provisioner: rook-ceph.rbd.csi.ceph.com
  parameters:
    mirroringMode: snapshot
    schedulingInterval: "<scheduling-interval>" 1
    replication.storage.openshift.io/replication-secret-name:
rook-csi-rbd-provisioner
    replication.storage.openshift.io/replication-secret-namesp
ace: rook-ceph
EOF
```

Output

```
volumereplicationclass.replication.storage.openshift.io/rbd-vo
lumereplicationclass created
```

1 `<scheduling-interval>`: Scheduling interval, (e.g., schedulingInterval: "1h" indicates execution every 1 hour.)

## Enable Mirror for PVC

Execute the following command on the Primary cluster's Control node:

Command

```
cat << EOF | kubectl apply -f -
apiVersion: replication.storage.openshift.io/v1alpha1
kind: VolumeReplication
metadata:
  name: <vr-name> 1
  namespace: <namespace> 2
spec:
  autoResync: false
  volumeReplicationClass: rbd-volumereplicationclass
  replicationState: primary
  dataSource:
    apiGroup: ""
    kind: PersistentVolumeClaim
    name: <pvc-name> 3
EOF
```

Output

```
volumereplication.replication.storage.openshift.io/<mirror-pvc-name> created
```

1 `<vr-name>`: The name of the VolumeReplication object, recommended to be the same as the PVC name.

2 `<namespace>`: The namespace to which the VolumeReplication belongs, which must be the same as the PVC namespace.

3 `<pvc-name>`: The name of the PVC for which Mirror needs to be enabled.

**Note** After enabling, the RBD image in the Secondary cluster becomes read-only.

# Planned Migration

Use cases: Datacenter maintenance, technology refresh, disaster avoidance, etc.

## Relocation

The Relocation operation is the process of switching production to a backup facility(normally your recovery site) or vice versa.

For relocation, access to the image on the primary site should be stopped. The image should now be made primary on the secondary cluster so that the access can be resumed there.

## Prerequisites

- The Kubernetes resources of the Primary cluster have been backed up and restored to the Secondary cluster, including PVCs, PVs, application workloads, etc.

## Procedures

Follow the below steps for planned migration of workload from the Primary cluster to the Secondary cluster:

1. Scale down all the application pods which are using the mirrored PVC on the Primary cluster.
2. Update VolumeReplications for all the PVCs which mirroring is enabled on the Primary cluster.
   Set `spec.replicationState` to `secondary`.
3. Create VolumeReplications for all the PVCs for which mirroring is enabled on the Secondary.

   Example

```
cat << EOF | kubectl apply -f -
apiVersion: replication.storage.openshift.io/v1alpha1
kind: VolumeReplication
metadata:
  name: <vr-name> 1
  namespace: <namespace> 2
spec:
  autoResync: false
  volumeReplicationClass: rbd-volumereplicationclass
  replicationState: primary
  dataSource:
    apiGroup: ""
    kind: PersistentVolumeClaim
    name: <pvc-name> 3
EOF
```

1 `<vr-name>`: The name of the VolumeReplication object, recommended to be the same as the PVC name.

2 `<namespace>`: The namespace to which the VolumeReplication belongs, which must be the same as the PVC namespace.

3 `<pvc-name>`: The name of the PVC for which Mirror needs to be enabled.

4. Check VolumeReplication CR status to verify if the image is marked `primary` on the secondary site.
5. Once the Image is marked as `primary`, the PVC is now ready to be used. Now, we can scale up the applications to use the PVC.

# Disaster Recovery

Use cases: Natural disasters, Power failures, System failures, and crashes, etc.

## Failover (abrupt shutdown)

In case of Disaster recovery, create VolumeReplication CR at the Secondary Site.

Since the connection to the Primary Site is lost, the operator automatically sends a GRPC request down to the driver to forcefully mark the dataSource as `primary` on the Secondary Site.

## Prerequisites

- The Kubernetes resources of the Primary cluster have been backed up and restored to the Secondary cluster, including PVCs, PVs, application workloads, etc.

## Procedures

1. Create VolumeReplications for all the PVCs for which mirroring is enabled on the Secondary.

Example

```
cat << EOF | kubectl apply -f -
apiVersion: replication.storage.openshift.io/v1alpha1
kind: VolumeReplication
metadata:
  name: <vr-name> 1
  namespace: <namespace> 2
spec:
  autoResync: false
  volumeReplicationClass: rbd-volumereplicationclass
  replicationState: primary
  dataSource:
    apiGroup: ""
    kind: PersistentVolumeClaim
    name: <pvc-name> 3
EOF
```

1 `<vr-name>`: The name of the VolumeReplication object, recommended to be the same as the PVC name.

2 `<namespace>`: The namespace to which the VolumeReplication belongs, which must be the same as the PVC namespace.

3 `<pvc-name>`: The name of the PVC for which Mirror needs to be enabled.

2. Check VolumeReplication CR status to verify if the image is marked `primary` on the secondary site.
3. Once the Image is marked as `primary`, the PVC is now ready to be used. Now, we can scale up the applications to use the PVC.

# Failback (post-disaster recovery)

Once the failed cluster is recovered on the primary site and you want to failback from secondary site, follow the below steps:

## Prerequisites

- The Kubernetes resources of the Primary cluster have been backed up and restored to the Secondary cluster, including PVCs, PVs, application workloads, etc.

## Procedures

1. Scale down the running applications (if any) on the primary site. Ensure that all persistent volumes in use by the workload are no longer in use on the primary cluster.
2. Update VolumeReplication CR replicationState from primary to secondary on the primary site.
3. Scale down the applications on the secondary site.
4. Update VolumeReplication CR replicationState state from `primary` to `secondary` in secondary site.
5. On the primary site, verify the VolumeReplication status is marked as volume ready to use.
6. Once the volume is marked to ready to use, change the replicationState state from secondary to primary in primary site.
7. Scale up the applications again on the primary site.

# Object Storage Disaster Recovery

The Ceph RGW Multi-Site feature is a cross-cluster asynchronous data replication mechanism designed to synchronize object storage data between geographically distributed Ceph clusters, providing High Availability (HA) and Disaster Recovery (DR) capabilities.

## TOC



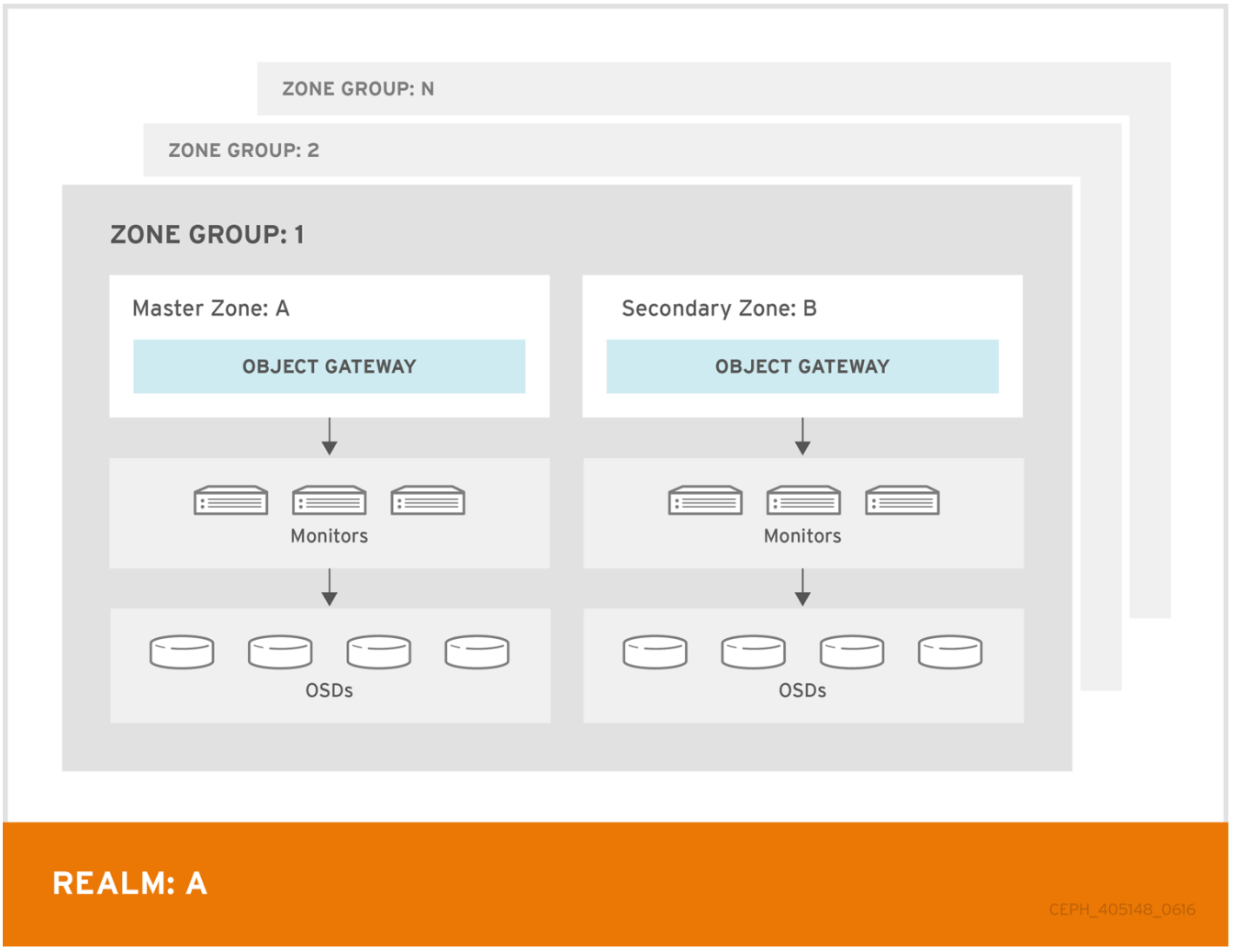
## Terminology

| Term | Explanation |
| --- | --- |
| Primary Cluster | The cluster currently providing storage services. |
| Secondary Cluster | The standby cluster used for backup purposes. |
| Realm, ZoneGroup, Zone | • Realm: The highest-level logical grouping in Ceph object storage. It represents a complete object storage namespace, typically used for multi-site replication and synchronization. A Realm can span different geographical locations or data centers.<br>• ZoneGroup: A logical grouping within a Realm, containing multiple Zones. ZoneGroups enable data synchronization and replication across Zones, usually within the same geographical region.<br>• Zone: A logical grouping within a ZoneGroup that physically stores data. Each Zone manages and stores objects independently and can have its own data/metadata pool configurations. |

# Prerequisites

- Prepare two clusters available for deploying Rook-Ceph (Primary and Secondary clusters) with network connectivity between them.
- Both clusters must use the same platform version (v3.12 or later).
- Ensure no Ceph object storage is deployed on either the Primary or Secondary cluster.
- Refer to the Create Storage Service documentation to deploy Operator and create clusters. Do not proceed with object storage pool creation via the wizard after cluster creation. Instead, use CLI tools for configuration as described below.

# Architecture




# Procedures

This guide provides a synchronization solution between two Zones in the same ZoneGroup.

## 1 Create Object Storage in Primary Cluster

This step creates the Realm, ZoneGroup, Primary Zone, and Primary Zone's gateway resources.

Execute the following commands on the Control node of the Primary cluster:

1. **Set Parameters**

```
export REALM_NAME=<realm-name>
export ZONE_GROUP_NAME=<zonegroup-name>
export PRIMARY_ZONE_NAME=<primary-zone-name>
export PRIMARY_OBJECT_STORE_NAME=<primary-object-store-name>
```

**Parameters description**:

- `<realm-name>`: Realm name.
- `<zonegroup-name>`: ZoneGroup name.
- `<primary-zone-name>`: Primary Zone name.
- `<primary-object-store-name>`: Gateway name.

2. **Create Object Storage**

Command

```
cat << EOF | kubectl apply -f -
---
apiVersion: ceph.rook.io/v1
kind: CephObjectRealm
metadata:
  name: $REALM_NAME
  namespace: rook-ceph

---
apiVersion: ceph.rook.io/v1
kind: CephObjectZoneGroup
metadata:
  name: $ZONE_GROUP_NAME
  namespace: rook-ceph
spec:
  realm: $REALM_NAME

---
apiVersion: ceph.rook.io/v1
kind: CephObjectZone
metadata:
  name: $PRIMARY_ZONE_NAME
  namespace: rook-ceph
spec:
  zoneGroup: $ZONE_GROUP_NAME
  metadataPool:
    failureDomain: host
    replicated:
      size: 3
      requireSafeReplicaSize: true
  dataPool:
    failureDomain: host
    replicated:
      size: 3
      requireSafeReplicaSize: true
    parameters:
      compression_mode: none
  preservePoolsOnDelete: false

---
apiVersion: ceph.rook.io/v1
kind: CephBlockPool
metadata:
```

```
  labels:
    cpaas.io/builtin: "true"
  name: builtin-rgw-root
  namespace: rook-ceph
spec:
  name: .rgw.root
  application: rgw
  enableCrushUpdates: true
  failureDomain: host
  replicated:
    size: 3
  parameters:
    pg_num: "8"

---
apiVersion: ceph.rook.io/v1
kind: CephObjectStore
metadata:
  name: $PRIMARY_OBJECT_STORE_NAME
  namespace: rook-ceph
spec:
  gateway:
    port: 7480
    instances: 2
  zone:
    name: $PRIMARY_ZONE_NAME
EOF
```

Output

```
cephobjectrealm.ceph.rook.io/<realm-name> created
cephobjectzonegroup.ceph.rook.io/<zonegroup-name> created
cephobjectzone.ceph.rook.io/<primary-zone-name> created
cephobjectstore.ceph.rook.io/<primary-object-store-name> creat
ed
```

## 2 Configure External Access for Primary Zone

1. Obtain the UID of the ObjectStore

```
export PRIMARY_OBJECT_STORE_UID=$(kubectl -n rook-ceph get cephobj
ectstore $PRIMARY_OBJECT_STORE_NAME -o jsonpath='{.metadata.uid}')
```

2. Create an external access Service

```
cat << EOF | kubectl apply -f -
apiVersion: v1
kind: Service
metadata:
  name: rook-ceph-rgw-$PRIMARY_OBJECT_STORE_NAME-external
  namespace: rook-ceph
  labels:
    app: rook-ceph-rgw
    rook_cluster: rook-ceph
    rook_object_store: $PRIMARY_OBJECT_STORE_NAME
  ownerReferences:
    - apiVersion: ceph.rook.io/v1
      kind: CephObjectStore
      name: $PRIMARY_OBJECT_STORE_NAME
      uid: $PRIMARY_OBJECT_STORE_UID
spec:
  ports:
    - name: rgw
      port: 7480
      targetPort: 7480
      protocol: TCP
  selector:
    app: rook-ceph-rgw
    rook_cluster: rook-ceph
    rook_object_store: $PRIMARY_OBJECT_STORE_NAME
  sessionAffinity: None
  type: NodePort
EOF
```

3. Add external endpoints to the CephObjectZone.

```
IP=$(kubectl get nodes -l 'node-role.kubernetes.io/control-plane'
-o jsonpath='{.items[0].status.addresses[?(@.type=="InternalIP")].
address}' | cut -d ' ' -f1 | tr -d '\n')
PORT=$(kubectl -n rook-ceph get svc rook-ceph-rgw-$PRIMARY_OBJECT_
STORE_NAME-external -o jsonpath='{.spec.ports[0].nodePort}')
ENDPOINT=http://$IP:$PORT
kubectl -n rook-ceph patch cephobjectzone $PRIMARY_ZONE_NAME --typ
e merge -p "{\"spec\":{\"customEndpoints\":[\"$ENDPOINT\"]}}"
```

## 3 Obtain `access-key` and `secret-key`

```
kubectl -n rook-ceph get secrets $REALM_NAME-keys -o jsonpath='{.dat
a.access-key}'
kubectl -n rook-ceph get secrets $REALM_NAME-keys -o jsonpath='{.dat
a.secret-key}'
```

## 4 Create Secondary Zone and Configure Realm Sync

This section explains how to create the Secondary Zone and configure synchronization by pulling Realm information from the Primary cluster.

Execute the following commands on the Control node of the Secondary cluster:

1. **Set Parameters**

```
export REALM_NAME=<realm-name>
export ZONE_GROUP_NAME=<zonegroup-name>

export REALM_ENDPOINT=<realm-endpoint>
export ACCESS_KEY=<access-key>
export SECRET_KEY=<secret-key>

export SECONDARY_ZONE_NAME=<secondary-zone-name>
export SECONDARY_OBJECT_STORE_NAME=<secondary-object-store-name>
```

**Parameters description**:

- `<realm-name>`: Realm name.

- `<zone-group-name>`: ZoneGroup name.
- `<realm-endpoint>`: External address obtained from the Primary cluster.
- `<access-key>`: AK obtain from here.
- `<secret-key>`: SK obtain from here.
- `<secondary-zone-name>`: Secondary Zone name.
- `<secondary-object-store-name>`: Secondary Gateway name.

2. **Create Secondary Zone and Configure Realm Sync**

```
cat << EOF | kubectl apply -f -
apiVersion: v1
kind: Secret
metadata:
  name: $REALM_NAME-keys
  namespace: rook-ceph
data:
  access-key: $ACCESS_KEY
  secret-key: $SECRET_KEY

---
apiVersion: ceph.rook.io/v1
kind: CephObjectRealm
metadata:
  name: $REALM_NAME
  namespace: rook-ceph
spec:
  pull:
    endpoint: $REALM_ENDPOINT

---
apiVersion: ceph.rook.io/v1
kind: CephObjectZoneGroup
metadata:
  name: $ZONE_GROUP_NAME
  namespace: rook-ceph
spec:
  realm: $REALM_NAME

---
apiVersion: ceph.rook.io/v1
kind: CephObjectZone
metadata:
  name: $SECONDARY_ZONE_NAME
  namespace: rook-ceph
spec:
  zoneGroup: $ZONE_GROUP_NAME
  metadataPool:
    failureDomain: host
    replicated:
      size: 3
      requireSafeReplicaSize: true
  dataPool:
```

```
    failureDomain: host
    replicated:
      size: 3
      requireSafeReplicaSize: true
  preservePoolsOnDelete: false

---
apiVersion: ceph.rook.io/v1
kind: CephBlockPool
metadata:
  labels:
    cpaas.io/builtin: "true"
  name: builtin-rgw-root
  namespace: rook-ceph
spec:
  name: .rgw.root
  application: rgw
  enableCrushUpdates: true
  failureDomain: host
  replicated:
    size: 3
  parameters:
    pg_num: "8"

---
apiVersion: ceph.rook.io/v1
kind: CephObjectStore
metadata:
  name: $SECONDARY_OBJECT_STORE_NAME
  namespace: rook-ceph
spec:
  gateway:
    port: 7480
    instances: 2
  zone:
    name: $SECONDARY_ZONE_NAME
EOF
```

## 5 Configure External Access for Secondary Zone

1. Obtain UID of Secondary Gateway

```
export SECONDARY_OBJECT_STORE_UID=$(kubectl -n rook-ceph get cepho
bjectstore $SECONDARY_OBJECT_STORE_NAME -o jsonpath='{.metadata.ui
d}')
```

2. Create an external access Service

```
cat << EOF | kubectl apply -f -
apiVersion: v1
kind: Service
metadata:
  name: rook-ceph-rgw-$SECONDARY_OBJECT_STORE_NAME-external
  namespace: rook-ceph
  labels:
    app: rook-ceph-rgw
    rook_cluster: rook-ceph
    rook_object_store: $SECONDARY_OBJECT_STORE_NAME
  ownerReferences:
    - apiVersion: ceph.rook.io/v1
      kind: CephObjectStore
      name: $SECONDARY_OBJECT_STORE_NAME
      uid: $SECONDARY_OBJECT_STORE_UID
spec:
  ports:
    - name: rgw
      port: 7480
      targetPort: 7480
      protocol: TCP
  selector:
    app: rook-ceph-rgw
    rook_cluster: rook-ceph
    rook_object_store: $SECONDARY_OBJECT_STORE_NAME
  sessionAffinity: None
  type: NodePort
EOF
```

3. Add external endpoints to the Secondary CephObjectZone

```
IP=$(kubectl get nodes -l 'node-role.kubernetes.io/control-plane'
-o jsonpath='{.items[0].status.addresses[?(@.type=="InternalIP")].
address}' | cut -d ' ' -f1 | tr -d '\n')
PORT=$(kubectl -n rook-ceph get svc rook-ceph-rgw-$SECONDARY_OBJEC
T_STORE_NAME-external -o jsonpath='{.spec.ports[0].nodePort}')
ENDPOINT=http://$IP:$PORT
kubectl -n rook-ceph patch cephobjectzone $SECONDARY_ZONE_NAME --t
ype merge -p "{\"spec\":{\"customEndpoints\":[\"$ENDPOINT\"]}}"
```

## 6 Check Ceph Object Storage Synchronization Status

Execute the following commands in the `rook-ceph-tools` pod of the Secondary cluster

```
# enter rook-ceph-tools pod
kubectl -n rook-ceph exec -it $(kubectl -n rook-ceph get po -l app=ro
ok-ceph-tools -o jsonpath='{range .items[*]}{@.metadata.name}') -- ba
sh

radosgw-admin sync status
```

Output example

```
          realm 962d6b80-b218-4fc8-8198-e498fabc4e9d (relam-primary)
      zonegroup 9de3acd7-0b01-4a04-ac84-1421c6103a16 (zonegroup-prima
ry)
           zone 7b3ce7f5-7090-46f6-afb1-d1bb156053da (zone-secondary)
   current time 2025-12-04T06:27:15Z
zonegroup features enabled: resharding
                   disabled: compress-encrypted
  metadata sync syncing
                full sync: 0/64 shards
                incremental sync: 64/64 shards
                metadata is caught up with master
      data sync source: 6319ca70-964e-47be-8b96-7c5bf5a128b1 (zone-pr
imary)
                        syncing
                        full sync: 0/128 shards
                        incremental sync: 128/128 shards
                        data is caught up with source
```

`metadata is caught up with master` and `data is caught up with source` means sync status is healthy.

# Failover

When the Primary cluster fails, it is necessary to promote the Secondary Zone to the Primary Zone. After the switch, the Secondary Zone's gateway can continue to provide object storage services.

## Procedures

Execute the following commands in the `rook-ceph-tools` pod of the Secondary cluster

```
# enter rook-ceph-tools pod
kubectl -n rook-ceph exec -it $(kubectl -n rook-ceph get po -l app=rook-c
eph-tools -o jsonpath='{range .items[*]}{@.metadata.name}') -- bash

# Make the recovered zone the master and default zone
radosgw-admin zone modify --rgw-realm=<realm-name> --rgw-zonegroup=<zone-
group-name> --rgw-zone=<secondary-zone-name> --master

# Update the period so that the changes take effect
radosgw-admin period update --commit --rgw-realm=<realm-name> --rgw-zoneg
roup=<zone-group-name>
```

**Parameters**

- `<realm-name>`: Realm name.
- `<zone-group-name>`: Secondary Zone Group name.
- `<secondary-zone-name>`: Secondary Zone name.

# Failback

Once the failed cluster is recovered on the primary site and you want to failback from secondary site, follow the below stepss

## Procedures

Execute the following commands in the `rook-ceph-tools` pod of the Primary cluster

```
# enter rook-ceph-tools pod
kubectl -n rook-ceph exec -it $(kubectl -n rook-ceph get po -l app=rook-c
eph-tools -o jsonpath='{range .items[*]}{@.metadata.name}') -- bash

# check sync status, wait for sync from secondary site
radosgw-admin sync status

#           realm 962d6b80-b218-4fc8-8198-e498fabc4e9d (relam-primary)
#       zonegroup 9de3acd7-0b01-4a04-ac84-1421c6103a16 (zonegroup-primar
y)
#            zone 6319ca70-964e-47be-8b96-7c5bf5a128b1 (zone-primary)
#    current time 2025-12-04T07:18:26Z
# zonegroup features enabled: resharding
#                   disabled: compress-encrypted
#   metadata sync syncing
#                 full sync: 0/64 shards
#                 incremental sync: 64/64 shards
#                 metadata is caught up with master
#       data sync source: 7b3ce7f5-7090-46f6-afb1-d1bb156053da (zone-seco
ndary)
#                         syncing
#                         full sync: 0/128 shards
#                         incremental sync: 128/128 shards
#                         data is caught up with source

# Make the recovered zone the master and default zone
radosgw-admin zone modify --rgw-realm=<realm-name> --rgw-zonegroup=<zone-
group-name> --rgw-zone=<primary-zone-name> --master

# Update the period so that the changes take effect
radosgw-admin period update --commit --rgw-realm=<realm-name> --rgw-zoneg
roup=<zone-group-name>
```

### Parameters

- `<realm-name>`: Realm name.
- `<zone-group-name>`: Zone Group name.
- `<primary-zone-name>`: Primary Zone name.

# Update the optimization parameters

The platform supports filling in optimization parameters in Ceph configuration file format when creating a storage cluster, but does not provide a way to modify them through the interface after creation. You need to manually update them according to the following steps.

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## Procedure

1. First, update the storage optimization parameters to the Configmap named `rook-config-override-user`, replace the `.data.config` field, and set the value of the `.metadata.annotations[rook.cpaas.io/need-sync]` field to `true`. For example:

```
apiVersion: v1
data:
  config: |
    [global]
    mon_memory_target=1073741824
    mds_cache_memory_limit=2147483648
    osd_memory_target=4147483648
kind: ConfigMap
metadata:
  annotations:
    cpaas.io/creator: admin
    cpaas.io/updated-at: "2022-03-01T12:24:04Z"
    rook.cpaas.io/need-sync: "true"
    rook.cpaas.io/sync-status: synced
  creationTimestamp: "2022-03-01T12:24:04Z"
  finalizers:
  - rook.cpaas.io/config-merge
  name: rook-config-override-user
  namespace: default
  resourceVersion: "38816864"
  uid: ce3a8f3e-6453-4bdd-bff0-e16cf7d5d5fa
```

2. Execute `ceph tell [mon|osd|mgr|mds|rgw].* config set [key] [value]` in the Pod of rook-ceph-tools to apply the configuration in real time.
3. To start the Pod of tools, edit the ClusterServiceVersion (CSV) under the rook-ceph namespace and set the replicas value of rook-ceph-tools in the Deployments section to 1.

# Create Ceph Object Store User

We allows creation and customization of object store users through the custom resource definitions (CRDs).

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## Prerequisites

- The object storage pool has been created

## Procedure

### 1 Create User

Execute commands on the **control node** of the cluster.

```
cat << EOF | kubectl apply -f -
apiVersion: ceph.rook.io/v1
kind: CephObjectStoreUser
metadata:
  name: <name>
  namespace: <namespace>
spec:
  store: <ObjectStore>
  displayName: <displayName>
  clusterNamespace: <clusterNamespace>
  quotas:
    maxBuckets: 100
    maxSize: -1
    maxObjects: -1
  capabilities:
    user: "*"
    bucket: "*"
EOF
```

### Parameters

| Parameters | Description |
| --- | --- |
| **name** | The name of the object store user to create. |
| **namespace** | The namespace of the object store user is created. |
| **displayName** | The display name. |
| **clusterNamespace** | The namespace where the parent `CephCluster` and `CephObjectStore` are found. If not specified, the user must be in the same namespace as the cluster and object store. To enable this feature, the CephObjectStore `allowUsersInNamespaces` must include the namespace of this user. |
| **ObjectStore** | The object store in which the user will be created. This matches the name of the object storage pool. |
| **quotas** | **optional**<br><br>This represents quota limitation can be set on the user. |

| Parameters | Description |
| --- | --- |
| | • maxBuckets: The maximum bucket limit for the user. Defaults to `100`.<br>• maxSize: Maximum size limit of all objects across all the user's buckets. Set to `-1` indicates no restriction.<br>• maxObjects: Maximum number of objects across all the user's buckets. Set to `-1` indicates no restriction. |
| **capabilities** | **optional**<br><br>Ceph allows users to be given additional permissions. This setting can currently only be used during the creation of the object store user. If a user's capabilities need modified, the user must be deleted and re-created. See the Ceph docs↗ for more info. We supports adding `read`, `write`, `read,write`, or `*` permissions for the following resources:<br><br>• user<br>• buckets<br>• usage<br>• metadata<br>• zone<br>• roles<br>• info<br>• amz-cache<br>• bilog<br>• mdlog<br>• datalog<br>• user-policy<br>• odic-provider<br>• ratelimit |

## 2 Allow create user in other namespaces

If a CephObjectStoreUser is created in a namespace other than the Rook cluster namespace, the namespace must be added to this list of allowed namespaces, or specify "*" to allow all namespaces. This is useful for applications that need object store credentials to be created in their own namespace.

Execute commands on the **control node** of the cluster.

```
kubectl -n rook-ceph patch cephobjectstore <ObjectStore> --type merge
-p '{"spec":{"allowUsersInNamespaces":["*"]}}'
```

## 3 Get user information

Execute commands on the **control node** of the cluster.

```
user_secret=$(kubectl -n <namespace> get cephobjectstoreuser <user-na
me> -o jsonpath='{.status.info.secretName}')

# ACCESS_KEY
kubectl -n <namespace> get secret $user_secret -o jsonpath='{.data.Ac
cessKey}' | base64 --decode

# SECRET_KEY
kubectl -n <namespace> get secret $user_secret -o jsonpath='{.data.Se
cretKey}' | base64 --decode
```

# Setting Storage Pool Quotas

Pool quota is a logical data size limit applied at the Ceph storage pool level. It controls how much logical data can be written by the pool, the actual physical space will be **quota * pool replication**.

## TOC



## Prerequisites

- A Ceph cluster is installed
- Ceph pools are created

## Set pool quota for File Storage Pool

Execute commands on the **control node** of the cluster.

Command

```
SIZE="<size>"
POOL_NAME="<fs-pool-name>"

kubectl patch cephfilesystem $POOL_NAME -n rook-ceph --type=json \
    -p "[{\"op\":\"add\",\"path\":\"/spec/dataPools/0/quotas/maxSize
\",\"value\":\"$SIZE\"}]"
```

Example

```
SIZE="100Gi"
POOL_NAME="cephfs"

kubectl patch cephfilesystem $POOL_NAME -n rook-ceph --type=json \
    -p "[{\"op\":\"add\",\"path\":\"/spec/dataPools/0/quotas/maxSize
\",\"value\":\"$SIZE\"}]"
```

### Parameters

| Parameters | Description |
| --- | --- |
| **size** | quota in bytes as a string with quantity suffixes (e.g. "10Gi") |
| **fs-pool-name** | The name of the File Storage Pool. |

# Set pool quota for Block Storage Pool

Execute commands on the **control node** of the cluster.

Command

```
SIZE="<size>"
POOL_NAME="<block-pool-name>"

kubectl patch cephblockpool $POOL_NAME -n rook-ceph --type=json \
    -p "[{\"op\":\"add\",\"path\":\"/spec/quotas/maxSize\",\"value
\":\"$SIZE\"}]"
```

Example

```
SIZE="100Gi"
POOL_NAME="rbd"

kubectl patch cephblockpool $POOL_NAME -n rook-ceph --type=json \
    -p "[{\"op\":\"add\",\"path\":\"/spec/quotas/maxSize\",\"value
\":\"$SIZE\"}]"
```

### Parameters

| Parameters | Description |
| --- | --- |
| **size** | quota in bytes as a string with quantity suffixes (e.g. "10Gi") |
| **block-pool-name** | The name of the Block Storage Pool. |

# Set pool quota for Object Storage Pool

Execute commands on the **control node** of the cluster.

Command

```
SIZE="<size>"
POOL_NAME="<object-pool-name>"

kubectl patch cephobjectstore $POOL_NAME -n rook-ceph --type=json \
    -p "[{\"op\":\"add\",\"path\":\"/spec/dataPool/quotas/maxSize
\",\"value\":\"$SIZE\"}]"
```

Example

```
SIZE="100Gi"
POOL_NAME="object"

kubectl patch cephobjectstore $POOL_NAME -n rook-ceph --type=json \
    -p "[{\"op\":\"add\",\"path\":\"/spec/dataPool/quotas/maxSize
\",\"value\":\"$SIZE\"}]"
```

### Parameters

| Parameters | Description |
| --- | --- |
| **size** | quota in bytes as a string with quantity suffixes (e.g. "10Gi") |
| **object-pool-name** | The name of the Object Storage Pool. |

# Validate pool quota via Ceph Terminal

```
ceph osd pool ls detail | grep max_bytes

pool 3 'cephfs-data0' replicated size 3 min_size 2 crush_rule 4 object_ha
sh rjenkins pg_num 32 pgp_num 32 autoscale_mode on last_change 100 lfor
0/0/56 flags hashpspool max_bytes 107374182400 stripe_width 0 application
cephfs read_balance_score 1.31
pool 4 'rbd' replicated size 3 min_size 2 crush_rule 5 object_hash rjenki
ns pg_num 32 pgp_num 32 autoscale_mode on last_change 117 lfor 0/0/111 fl
ags hashpspool,selfmanaged_snaps max_bytes 107374182400 stripe_width 0 ap
plication rbd read_balance_score 1.31
pool 12 'object.rgw.buckets.data' replicated size 3 min_size 2 crush_rule
13 object_hash rjenkins pg_num 32 pgp_num 32 autoscale_mode on last_chang
e 304 lfor 0/0/168 flags hashpspool max_bytes 107374182400 stripe_width 0
compression_mode none application rgw read_balance_score 1.59
```

# Enabling D3N Cache for Ceph RGW

D3N (Data Delivery Network) cache accelerates access to hot objects by using **local NVMe/SSD disks on RGW nodes as a cache layer**. It reduces frequent read operations to backend OSDs and significantly improves read performance for hot data.

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## Background

The core idea of D3N is simple but effective: instead of fetching object data repeatedly from the Ceph backend storage, RGW serves hot data directly from a **local persistent cache** located on fast disks (NVMe/SSD) attached to RGW nodes.

This design is especially beneficial for:

- Large object downloads
- Repeated reads of hot objects
- Bandwidth-sensitive workloads

# Prerequisites

- A Ceph cluster is installed
- Rook-Ceph is deployed
- An Object Storage (RGW / CephObjectStore) is created
- High-performance local disks (NVMe / SSD) are available on RGW nodes

# Operation Overview

1. Deploy Ceph and create an Object Storage
2. Prepare a high-speed local disk on RGW nodes and mount it to a directory
3. Configure `CephObjectStore` to:
   - Mount the directory via `hostPath`
   - Enable D3N-related RGW parameters

# Prepare Local Filesystem for Cache

Mount a directory on each node hosting the RGW service. It is recommended to use a high-performance dedicated disk (rather than a partition), formatted with the **XFS** file system, and to configure `/etc/fstab` to ensure the mount persists after a reboot. Replace `</path/to/cache/dir>` in the subsequent documentation with the actual directory path you have configured.

# Enable D3N Cache in CephObjectStore

Edit the `CephObjectStore` resource:

```
kubectl edit cephobjectstore object-store -n rook-ceph
```

Add the following configuration under `gateway`:

```
gateway:
  additionalVolumeMounts:
  - subPath: cache
    volumeSource:
      hostPath:
        path: </path/to/cache/dir>
  rgwConfig:
    rgw_d3n_l1_datacache_persistent_path: /var/rgw/cache/
    rgw_d3n_l1_datacache_size: "10737418240"
    rgw_d3n_l1_local_datacache_enabled: "true"
```

## Parameters

| Parameter | Description |
| --- | --- |
| `rgw_d3n_l1_local_datacache_enabled` | Enable D3N local cache |
| `rgw_d3n_l1_datacache_persistent_path` | Cache directory inside the RGW container |
| `rgw_d3n_l1_datacache_size` | Maximum cache size in bytes |

# Verify D3N Configuration

## Check RGW Configuration via Ceph Tools

In the `rook-ceph-tools` pod, run:

```
ceph config dump | grep d3n
```

Example output:

```
client.rgw.obj.a  advanced  rgw_cache_enabled                    true
client.rgw.obj.a  advanced  rgw_d3n_l1_datacache_persistent_path /var/rg
w/cache/
client.rgw.obj.a  advanced  rgw_d3n_l1_datacache_size            10737418
240
client.rgw.obj.a  advanced  rgw_d3n_l1_local_datacache_enabled   true
```

## Verify RGW Logs

After the RGW pod restarts, D3N initialization logs should appear:

```
kubectl logs -n rook-ceph rook-ceph-rgw-object-store-a-xxxx | grep -i d3n
```

Example output:

```
rgw_d3n: rgw_d3n_l1_local_datacache_enabled=1
rgw_d3n: rgw_d3n_l1_datacache_persistent_path='/var/rgw/cache/'
rgw_d3n: rgw_d3n_l1_datacache_size=10737418240
rgw_d3n: rgw_d3n_l1_evict_cache_on_start=1
rgw_d3n: rgw_d3n_l1_eviction_policy=lru
```

# Validate Cache Behavior

When downloading objects through RGW, cached files will appear in the host cache directory:

```
ls </path/to/cache/dir>
```

Example output:

```
40b934ab-6c7e-45e7-9fed-a35bc143ce95...multipart_v2v-demo.mkv.1
40b934ab-6c7e-45e7-9fed-a35bc143ce95...multipart_v2v-demo.mkv.2
40b934ab-6c7e-45e7-9fed-a35bc143ce95...shadow_v2v-demo.mkv.3_1
...
```

The presence of these files confirms that RGW is serving data from the local D3N cache.

# Configure in-transit encryption

This topic describes how to enable or disable in-transit encryption based on `msgr2` for ACP distributed storage.

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## Overview

Ceph `msgr2` is the second generation of the Ceph messenger protocol. It supports two connection modes:

- `crc`: authenticates the peers and validates data integrity, but does not encrypt payload data.
- `secure`: encrypts traffic on the wire and provides cryptographic integrity protection.

In ACP distributed storage, in-transit encryption is controlled by `CephCluster.spec.network.connections.encryption.enabled`.

# Limitations and prerequisites

Before enabling this feature, pay attention to the following restrictions:

- **ACP Version**
  - v4.3.0 and later.
- **OS and Kernel(ceph daemon and client nodes)**
  - kernel `5.11` and later.
  - `Ubuntu 22.04` and later.

> **WARNING**
>
> In-transit encryption increases CPU overhead and may reduce throughput or increase latency, especially on busy storage nodes or low-frequency CPUs. Evaluate the impact in a staging environment first.

# Enable in-transit encryption for a new cluster

If the storage cluster has not been created yet, add the following fields to the `CephCluster` manifest before creation:

```
spec:
  network:
    connections:
      encryption:
        enabled: true
```

After the cluster is created, verify that:

- CephFS PVCs can still be mounted successfully
- RBD and CephFS workloads on all nodes use supported kernel versions

# Enable in-transit encryption after deployment

If the cluster is already running, changing only the encryption switch is the lowest-risk approach.

## Step 1. Confirm node kernel versions

Run the following command on all Kubernetes nodes that mount Ceph volumes and confirm that the kernel version meets the prerequisite:

```
uname -r
```

If some worker nodes do not meet the requirement, do not enable transport encryption on a production cluster until those nodes are upgraded.

## Step 2. Enable encryption in CephCluster

```
kubectl patch cephcluster ceph-cluster -n rook-ceph --type merge -p '
spec:
  network:
    connections:
      encryption:
        enabled: true
'
```

### Step 3. Wait for the configuration to take effect

After the configuration is updated:

- Check whether related Pods restart normally
- Recreate a test Pod that mounts a CephFS or RBD PVC
- Confirm I/O works as expected

## Disable transport encryption

### Disable encryption on an existing cluster

To disable only transport encryption and keep `msgr2` available:

```
kubectl patch cephcluster ceph-cluster -n rook-ceph --type merge -p '
spec:
  network:
    connections:
      encryption:
        enabled: false
'
```

## Verification

After enabling the feature, verify the cluster from both the Kubernetes side and the Ceph side.

## Check the CephCluster settings

```
kubectl get cephcluster ceph-cluster -n rook-ceph -o yaml
```

Confirm that the output contains:

```
spec:
  network:
    connections:
      encryption:
        enabled: true
```

## Check client compatibility

After in-transit encryption is enabled:

- clients using `msgr2 secure` should connect normally
- clients configured with non-encrypted modes such as `legacy` or `crc` will fail to connect

## Check workload mounts

Create or restart a test workload that mounts:

- a CephFS PVC
- an RBD PVC

Then verify:

- the Pod starts successfully
- the filesystem can be read and written
- no mount-related errors appear in CSI or workload logs

# Troubleshooting suggestions

If enabling encryption causes mount failures or service interruptions, check the following items first:

1. Node kernel version does not satisfy the requirement.
2. Some nodes or external clients do not support `msgr2 secure`, or are still configured with `ms_mode=legacy` or `ms_mode=crc`.
3. Network policies, firewalls, or security groups do not allow port `3300`.
4. CPU resources are insufficient after encryption is enabled.

If the change affects production workloads, disable encryption first and then investigate compatibility and performance bottlenecks.

## Performance impact

ACP cannot provide a fixed percentage for the overhead of `msgr2 secure`. The actual impact depends on CPU model, whether the CPU provides AES acceleration, network bandwidth, I/O size, and whether the workload is CPU-bound or network-bound.

In practice:

- latency usually increases slightly, and the increase is often more visible on small I/O or latency-sensitive workloads
- CPU usage usually increases on both clients and Ceph daemons because traffic must be encrypted and integrity-protected
- the impact is typically more noticeable on high-throughput workloads, slower CPUs, or environments without strong AES acceleration

As an operational estimate, when modern x86 CPUs with AES-NI are used, a reasonable starting expectation is:

- average latency increase: about `5%` to `15%`
- CPU usage increase on storage and client nodes handling heavy I/O: about `10%` to `30%`

These values are an engineering estimate rather than a product guarantee. Before enabling encryption in production, benchmark a representative workload in a staging environment and compare at least the following metrics:

- average and P99 read/write latency
- client node CPU usage
- OSD node CPU usage
- throughput and IOPS

# MinIO Object Storage

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# Introduction

Alauda Container Platform (ACP) Object Storage with MinIO is an object storage service licensed under the Apache License v2.0. It is compatible with the Amazon S3 cloud storage service interface, making it particularly suitable for storing large volumes of unstructured data, such as images, videos, log files, backup data, and container/virtual machine images. An object file can range in size from a few KB to a maximum of 5T.

**The main advantages are as follows:**

- **Simplicity**: Minimalism is the guiding design principle of MinIO, allowing for out-of-the-box functionality. Simplicity reduces the chances of errors, increases uptime, and enhances reliability while also boosting performance.
- **High Performance**: MinIO is a world leader in object storage. On standard hardware, read/write speeds can reach up to 183 GB/sec and 171 GB/sec.
- **Scalability**: Multiple small to medium-sized, easily manageable clusters can be established, supporting the aggregation of multiple clusters into a super-large resource pool across data centers, rather than directly adopting a large-scale, centrally managed distributed cluster.
- **Cloud-Native**: Compliant with all native cloud computing architectures and build processes, and incorporates the latest technologies and concepts in cloud computing, making object storage more user-friendly for Kubernetes.

# Install

Alauda Container Platform (ACP) Object Storage with MinIO is an object storage service based on the Apache License v2.0 open-source protocol. It is compatible with the Amazon S3 cloud storage service interface and is ideal for storing large volumes of unstructured data, such as images, videos, log files, backup data, and container/virtual machine images. An object file can be of any size, ranging from a few kilobytes to a maximum of 5 terabytes.

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## Prerequisites

- MinIO is built on underlying storage, so please ensure that a storage class has been created in the current cluster. TopoLVM is recommended.

- **Download** the **Alauda Container Platform Storage Essentials** installation package corresponding to your platform architecture.
- **Upload** the **Alauda Container Platform Storage Essentials** installation package using the Upload Packages mechanism.
- **Download** the **Alauda Container Platform (ACP) Object Storage with MinIO** installation package corresponding to your platform architecture.
- **Upload** the **Alauda Container Platform (ACP) Object Storage with MinIO** installation package using the Upload Packages mechanism.

# Procedure

## 1 Deploy Alauda Container Platform Storage Essentials

1. Login, go to the **Administrator** page.
2. Click **Marketplace** > **OperatorHub** to enter the **OperatorHub** page.
3. Find the **Alauda Container Platform Storage Essentials**, click **Install**, and navigate to the **Install Alauda Container Platform Storage Essentials** page.
   Configuration Parameters:

| Parameter | Recommended Configuration |
| --- | --- |
| **Channel** | The default channel is `stable`. |
| **Installation Mode** | `Cluster`: All namespaces in the cluster share a single Operator instance for creation and management, resulting in lower resource usage. |
| **Installation Place** | Select `Recommended`, Namespace only support **acp-storage**. |
| **Upgrade Strategy** | `Manual`: When there is a new version in the Operator Hub, manual confirmation is required to upgrade the Operator to the latest version. |

## 2 Deploy Operator

1. In the left navigation bar, click **Storage** > **Object Storage**.
2. Click **Configure Now**.
3. On the **Deploy MinIO Operator** wizard page, click **Deploy Operator** at the bottom right.
   - Once the page automatically proceeds to the next step, it indicates that the Operator deployment was successful.
   - If the deployment fails, refer to the interface prompts to **Clean Up Deployed Information and Retry**, and redeploy the Operator.

## 3 Create Cluster

1. On the **Create Cluster** wizard page, configure the basic information.

| Parameter | Description |
| --- | --- |
| **Access Key** | Access key ID. A unique identifier associated with a private access key; used with the access key ID to encrypt and sign requests. |
| **Secret Key** | Private access key used in conjunction with the access key ID to encrypt and sign requests, identify the sender, and prevent request tampering. |

2. In the **Resource Configuration** area, configure specifications as per the following instructions.

| Parameter | Description |
| --- | --- |
| **Small scale** | Suitable for handling up to 100,000 objects, supporting concurrent access of no more than 50 in test environments or data backup scenarios. The CPU resource request and limit are set to 2 cores by default, and the memory resource request and limit are set to 4 Gi. |

| Parameter | Description |
| --- | --- |
| **Medium scale** | Designed for enterprise-level applications requiring storage of 1,000,000 objects and capable of handling up to 200 concurrent requests. The CPU resource request and limit are set to 4 cores by default, and the memory resource request and limit are set to 8 Gi. |
| **Large scale** | Designed for group users with storage needs of 10,000,000 objects and handling up to 500 concurrent requests, suitable for high-load scenarios. The CPU resource request and limit are set to 8 cores by default, and the memory resource request and limit are set to 16 Gi. |
| **Custom** | Offers flexible configuration options for professional users with specific needs, ensuring precise matching of service scale and performance requirements. Note: When configuring custom specifications, ensure that:<br>• The CPU resource request is greater than 100 m.<br>• The memory resource request is greater than or equal to 2 Gi.<br>• The CPU and memory resource limits are greater than or equal to the resource requests. |

3. In the **Storage Pool** area, configure related information as per the following instructions.

| Parameter | Description |
| --- | --- |
| **Instance Number** | Increasing the number of instances in a MinIO cluster can significantly enhance system performance and reliability, ensuring high data availability. However, too many instances can lead to the following issues:<br>• Increased resource consumption.<br>• If a node hosts multiple instances, a node failure may cause multiple instances to go offline simultaneously, reducing overall cluster reliability. |

| Parameter | Description |
| --- | --- |
| | **Note**:<br>• The minimum number of instances that can be entered is 4.<br>• If the number of instances is greater than 16, the entered value must be a multiple of 8.<br>• When adding additional storage pools, the number of instances must be no less than the first storage pool's number of instances. |
| **Single Storage Volume** | Capacity of a single storage volume PVC. Each storage service manages one storage volume. After entering the capacity of a single storage volume, the platform will automatically calculate the storage pool capacity and other information, which can be viewed in the **Storage Pool Overview**. |
| **Underlying Storage** | The underlying storage used by the MinIO cluster. Please select a storage class that has been created in the current cluster. TopoLVM is recommended. |
| **Storage Nodes** | Select the storage nodes required by the MinIO cluster. It is recommended to use 4-16 storage nodes. The platform will deploy one storage service for each selected storage node. |
| **Storage Pool Overview** | For specific parameters and calculation formulas, please refer to Storage Pool Overview. |

4. In the **Access Configuration** area, configure related information as per the following instructions.

| Parameter | Description |
| --- | --- |
| **External Access** | When enabled, it supports cross-cluster access to MinIO; when disabled, it only supports access within the cluster. |
| **Protocol** | Supports HTTP and HTTPS; when selecting HTTPS, you need to enter the **Domain** and import the **Public Key** and **Private Key** of the domain |

| Parameter | Description |
| --- | --- |
| | name certificate.<br>**Note**:<br>• When the access protocol is HTTP, pods within the cluster can access MinIO directly via the obtained IP or domain name without configuring IP address and domain name mapping; nodes within the cluster can access MinIO directly via the obtained IP, and if domain name access is required, manual configuration of IP address and domain name mapping is needed; external access can be done directly via the obtained IP.<br>• When the access protocol is HTTPS, access to MinIO via IP is not possible both inside and outside the cluster. Manual configuration of the mapping between the obtained IP address and the domain name entered during cluster creation is required to access normally via the domain name. |
| **Access Method** | • **NodePort**: Opens a fixed port on each compute node host to expose the service externally. When configuring domain name access, it is recommended to use VIP for domain name resolution to ensure high availability.<br>• **LoadBalancer**: Uses a load balancer to forward traffic to backend services. Before use, please ensure that the MetalLB plugin is deployed in the current cluster and there are available IPs in the external address pool. |

5. Click **Create Cluster** at the bottom right.

   - Once the page automatically proceeds to **Cluster Details**, it indicates that the cluster creation was successful.
   - If the cluster remains in the creation process, you can click **Cancel**. After cancellation, the deployed cluster information will be cleaned up, and you can return to the cluster creation page to recreate the cluster.

## 4 Create Bucket

Log in to the control node of the cluster and use the command to create a bucket.

1. On the cluster details page, click the **Access Method** tab to view the MinIO access address, or use the following command to query.

```
kubectl get svc -n <tenant ns> minio | grep -w minio | awk '{print $3}'
```

**Note:**

- Replace `tenant ns` with the actual namespace `minio-system`.
- Example: `kubectl get svc -n minio-system minio | grep -w minio | awk '{print $3}'`

2. Obtain the mc command.

```
wget https://dl.min.io/client/mc/release/linux-amd64/mc -O /bin/mc && chmod a+x /bin/mc
```

3. Configure MinIO cluster alias.

- IPv4:

```
mc --insecure alias set <minio cluster alias> http://<minio endpoint>:<port> <accessKey> <secretKey>
```

- IPv6:

```
mc --insecure alias set <minio cluster alias> http://[<minio endpoint>]:<port> <accessKey> <secretKey>
```

- Domain Name:

```
mc --insecure alias set <minio cluster alias> http://<domain name>:<port> <accessKey> <secretKey>
mc --insecure alias set <minio cluster alias> https://<domain name>:<port> <accessKey> <secretKey>
```

**Note:**

- Enter the IP address obtained in step 1 for `minio endpoint`.
- Enter the **Access Key** and **Secret Key** created during cluster creation for `accessKey` and `secretKey`.
- Configuration examples:
  - IPv4: `mc --insecure alias set myminio http://12.4.121.250:80 07Apples@ 07Apples@`
  - IPv6: `mc --insecure alias set myminio http://[2004::192:168:143:117]:80 07Apples@ 07Apples@`
  - Domain Name: `mc --insecure alias set myminio http://test.minio.alauda:80 07Apples@ 07Apples@` or `mc --insecure alias set myminio https://test.minio.alauda:443 07Apples@ 07Apples@`

4. Create a bucket.

```
mc --insecure mb <minio cluster alias>/<bucket name>
```

## 5 Upload/Download Files

Once the bucket is created, you can use the command line to upload files to the bucket or download existing files from the bucket.

1. Create a file for upload testing. This step can be skipped if uploading an existing file.

```
touch <file name>
```

2. Upload files to the bucket.

```
mc --insecure cp <file name> <minio cluster alias>/<bucket name>
```

3. View files in the bucket to confirm successful upload.

```
mc --insecure ls <minio cluster alias>/<bucket name>
```

4. Delete uploaded files.

```
mc --insecure rm <minio cluster alias>/<bucket name>/<file name>
```

# Related Information

## Redundancy Factor Mapping Table

**Note**: When adding additional storage pools, the redundancy factor needs to be calculated based on the number of instances in the first storage pool.

| Instance Number | Redundancy Factor |
| --- | --- |
| **4 - 5** | 2 |
| **6 - 7** | 3 |
| **>= 8** | 4 |

## Storage Pool Overview

| Storage Pool Overview Parameter | Calculation Formula |
| --- | --- |
| **Usable Capacity** | When the Instance Number ≤ 16, Usable Capacity = Single Storage Volume Capacity × (Instance Number - Redundancy Factor). |
| When the number of instances > 16, Usable Capacity = Single Storage Volume Capacity × (Instance Number - 4 × (Instance Number + 15) / 16). The result of "4 × (Instance Number + 15) / 16" should be rounded down. | |
| **Total Capacity** | Total Capacity = Instance Numbers × Single Storage Volume Capacity |

| Storage Pool Overview Parameter | Calculation Formula |
| --- | --- |
| **Number of failover storage services tolerated** | When the Instance Number > 2 × Redundancy Factor, Number of Tolerable Fault Storage Services = Redundancy Factor. |
| When the Instance Number = 2 × Redundancy Factor, the number of tolerable fault storage services = Redundancy Factor - 1 | |

# Architecture

Alauda Container Platform (ACP) Object Storage with MinIO is a high-performance, distributed object storage system designed for cloud-native environments. It leverages erasure coding, distributed storage pools, and high-availability mechanisms to ensure data durability and scalability in Kubernetes.

## TOC



## Core Components:

- **MinIO Operator**: Manages the deployment and upgrade of MinIO clusters.
- **MinIO Peer**: Configures and manages MinIO's site replication functionality.
- **MinIO Pool**: The core component of MinIO, responsible for handling object storage requests. Each pool corresponds to a StatefulSet and provides storage resources.

## Deployment Architecture:

Deploying MinIO in Kubernetes requires defining a MinIO tenant, specifying the number of server instances (pods) and the number of volumes (drives) per instance. Each MinIO server is managed via a StatefulSet, ensuring stable identities and persistent storage. MinIO aggregates all drives into one or more erasure sets and applies erasure coding for fault tolerance.

## Multi-Pool Expansion:

MinIO clusters can scale by adding additional server pools, each with its own erasure set. While this provides greater storage capacity, it introduces complexity in cluster maintenance and reduces overall cluster reliability. A failure in any server pool can render the entire MinIO cluster unavailable, even if other pools remain operational.

## Conclusion:

MinIO is a highly scalable, cloud-native object storage solution that balances performance and reliability. When architecting a MinIO cluster, it is crucial to carefully design storage pools, configure erasure coding settings, and implement high-availability strategies to ensure data integrity and operational stability in Kubernetes environments.

# Concepts

## Core Concepts

# Core Concepts

- **Erasure Coding (EC)**: MinIO employs Reed-Solomon erasure coding to break objects into data and parity shards, distributing them across multiple drives to ensure fault tolerance. For example, in a 16-drive setup, data can be split into 12 data shards and 4 parity shards, allowing the system to rebuild data even if up to 4 drives fail.
- **Server Pools & Erasure Sets**: MinIO Server Pools are logical groupings of storage resources, where each pool consists of multiple nodes sharing storage and compute capabilities. Within a pool, drives are automatically organized into one or more **Erasure Sets**.
  - **Data Distribution**: When an object is stored, it is split into data and parity shards and distributed across different drives within an erasure set.
  - **Redundancy Model**: Erasure sets form the fundamental unit of data redundancy, ensuring resiliency based on configured data-to-parity shard ratios.
  - **Scalability**: A single MinIO storage pool can contain multiple erasure sets, and new data is always written to the erasure set with the most available capacity.

# Guides

# Adding a Storage Pool

A storage pool refers to a logical partition used for storing data. Different types of underlying storage can be used simultaneously within the same storage cluster to meet various business needs.

In addition to the storage pools created during the configuration of object storage, you can also add additional storage pools.

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## Notes

Adding a storage pool will cause a brief interruption in the MinIO service, but it will automatically recover to a normal state afterward.

## Procedure

1. Go to **Administrator**.
2. Click on **Storage Management** > **Object Storage** in the left navigation bar.
3. Under the **Cluster Information** tab, scroll down to the **Storage Pool** section and click **Add Storage Pool**.

4. Configure the relevant parameters according to the instructions below.

| Parameter | Description |
| --- | --- |
| **Underlying Storage** | The underlying storage used by the MinIO cluster. Please select an existing storage class created in the current cluster, with TopoLVM recommended. |
| **Storage Nodes** | Select the storage nodes required for the MinIO cluster. It is recommended to use 4-16 storage nodes; the platform will deploy 1 storage service for each selected storage node.<br>**Note**: When using 3 storage nodes, to ensure reliability, 2 storage services will be deployed for each node. |
| **Single Storage Volume** | The capacity of a single storage volume PVC. Each storage service manages 1 storage volume, and once the capacity of a single storage volume is entered, the platform will automatically calculate the storage pool capacity and other information, which can be viewed in the **Storage Pool Overview**. |

5. Click **Confirm**.

# Monitoring & Alerts

The object storage system comes with built-in monitoring and alerting capabilities, covering storage clusters, service health, and resource utilization. It also supports configurable notification policies to keep your operations team informed. Real-time monitoring insights help with performance tuning and operational decision-making, while automated alerts ensure the stability and reliability of your storage system.

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## Monitoring

By default, the platform collects key metrics on storage clusters and service status. You can access real-time monitoring data under **Storage Management** > **Object Storage** > **Monitoring**.

## Storage Overview

This section provides a high-level view of storage system health, service status, and raw capacity utilization. If the storage status is abnormal, alert details will indicate the root cause, helping you diagnose and resolve issues efficiently.

## Cluster Monitoring

Track raw capacity usage and I/O performance trends across your storage cluster. This helps identify storage bottlenecks, optimize resource allocation, and ensure smooth data operations.

## Object Monitoring

Monitor access patterns, including total request counts and failed requests. These insights help analyze storage workload and detect anomalies that may indicate service disruptions or security risks.

# Alerts

The platform comes with pre-configured alerting policies to detect anomalies and trigger notifications when predefined thresholds are reached. These built-in rules cover essential areas such as component health, capacity usage, and user data integrity.

## Configuring Notifications

To ensure timely responses, configure notification policies in the **Operations Center**. Alerts can be sent via email, SMS, or other channels to notify the right personnel. Fine-tune your settings to match your organization's incident response workflow.

## Handling Alerts

- **Cluster in "Alert" state**: A warning has been triggered, and system stability may be at risk. Check the **Live Alerts** section for details, identify the root cause, and take corrective actions.

- **Cluster in "Failure" state**: The storage cluster is no longer operational. Immediate intervention is required to restore service availability.

The platform categorizes alerts into different severity levels, helping teams prioritize incident response:

| Severity | Description |
| --- | --- |
| **Critical** | A system failure impacting business operations or causing data loss. Immediate action required. |
| **Major** | A known issue that may lead to functionality breakdowns, potentially disrupting business processes. |
| **Warning** | A potential risk that, if unaddressed, could impact performance or availability. |

## Post-Incident Analysis

The **Alert History** logs all past incidents, providing valuable data for post-mortem analysis and system improvements. When reviewing past alerts, consider the following:

1. What were the exact symptoms when the incident occurred?
2. Are certain alerts repeating over time? Can proactive measures be taken to prevent recurrence?
3. Did a specific time window show a spike in alerts? Was it caused by an operational issue or an external factor? Should the response strategy be adjusted?

By continuously analyzing alert patterns and refining monitoring strategies, teams can enhance system resilience, minimize downtime, and ensure seamless storage operations.

# How To

## Data Disaster Recovery

- Applicable Scenarios
- Terminology
- Prerequisites
- Operation Steps
- Related Operations

## MinIO to Rook Ceph RGW Data Migration Gui

1. Overview and Architecture
2. Prerequisites and Preparation
3. Deployment Configuration (Manifests)
4. Execution Workflow
5. Troubleshooting and Tuning Recommendations

# Data Disaster Recovery

MinIO supports the establishment of a disaster recovery center through remote data backup or active-active deployment to ensure that original data is not lost or damaged in the event of a disaster, thereby guaranteeing data security and reliability.

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## Applicable Scenarios

- **Hot Backup**: There are two data centers in the same city or in different locations, one primary and one backup. Data is replicated in real-time from the primary cluster to the backup cluster to ensure data consistency. When a disaster occurs in the primary cluster, business traffic can be seamlessly switched to the backup cluster to ensure business continuity.
- **City-Level Active-Active**: In a city-level active-active (multi-cluster) architecture, there are two data centers located in different clusters. Both data centers are active and can receive business traffic simultaneously. When one data center encounters a disaster, business can continue running uninterrupted in the other data center.

# Terminology

- **Primary Cluster**: Refers to the cluster that is currently active and processing business requests. It is the source of the data or the initiator of operations. In the primary cluster, data is created, modified, or updated, and business traffic is first sent to this cluster for processing.
- **Target Cluster**: Refers to the cluster that receives data replication, migration, or failover. It is typically in a backup or standby state, waiting to receive data from the primary cluster or take over business traffic. When the primary cluster fails or needs to switch, the target cluster will receive data copies from the primary cluster or take over business traffic to ensure business continuity. In an active-active scenario, both clusters can serve as each other's target cluster.

# Prerequisites

- Both the primary cluster and the target cluster must have external network access enabled. For specific configuration methods, please refer to Create Object Storage.
- The primary cluster must use the **LoadBalancer** access method, while the target cluster is recommended to support **load balancing** functionality.
- The primary cluster and the target cluster must use the same access protocol, i.e., either both use HTTP or both use HTTPS.
- When using the HTTPS protocol, both the primary cluster and the target cluster need to configure DNS resolution for themselves and each other.
- When using the HTTPS protocol, it is recommended that both the primary cluster and the target cluster use CA-signed certificates to ensure secure and trusted communication; if self-signed certificates are used, both parties must import and trust each other's self-signed certificates to establish a secure HTTPS connection successfully.

# Operation Steps

1. Enter **Administrator**.
2. In the left navigation bar, click **Storage Management** > **Object Storage**.

3. On the **Data Disaster Recovery** tab, click **Add Target Cluster**.
4. Configure the relevant parameters for the target cluster according to the following instructions.

| Parameter | Description |
| --- | --- |
| **Access Address** | The external access address of the target cluster, starting with http:// or https://. |
| **Access Key** | The Access Key ID for the target cluster. A unique identifier associated with the private access key; used in conjunction with the private access key to encrypt requests. |
| **Secret Key** | The private access key used in conjunction with the Access Key ID to encrypt requests, identify the sender, and prevent request modification. |

5. Click **Add**.

- Upon successful addition, you will be able to view the status of the target cluster and the synchronization status between clusters.

| Parameter | Description |
| --- | --- |
| **Cluster Status** | The status of the target cluster, including **Healthy**, **Abnormal**, or **Unknown**. |
| **Buckets** | The number of buckets pending synchronization and those already synchronized.<br>• In hot backup scenarios, pending synchronization refers to the number of buckets that the primary cluster needs to synchronize with the target cluster.<br>• In city-level active-active scenarios, pending synchronization refers to the total number of buckets that need to be synchronized between the primary and target clusters. |
| | |

| Parameter | Description |
| --- | --- |
| **Objects** | The number of objects that failed to synchronize in the bucket.<br>**Note**: This number is for reference only, as MinIO synchronizes related file configurations during synchronization. |
| **Network Traffic Rate** | The network ingress and egress rate of the primary cluster.<br>• In hot backup scenarios, the network ingress rate is always 0.<br>• In city-level active-active scenarios, both ingress and egress rates have data. |

- If the addition of the target cluster fails, you can click **Re-add** to clear the cluster information and return to the add target cluster page, where you can re-add the target cluster.

# Related Operations

When disaster recovery is no longer needed, you can click **Remove Target Cluster**. Removing the target cluster does not delete the data that has been synchronized; if any data is currently synchronizing, it will be interrupted.

# MinIO to Rook Ceph RGW Data Migration Guide

## TOC



## 1. Overview and Architecture

This document explains how to use the embedded Rclone component in the installed **Alauda Build of VolSync** Operator image to migrate all data from a highly available (HA) MinIO deployment in Kubernetes to Rook Ceph RGW.

## 1.1 Architecture Notes

- **Secure image reuse**: This approach schedules a Kubernetes Job that reuses the security-patched `build-harbor.alauda.cn/acp/volsync` Operator image, overrides the default entrypoint, and directly invokes the internal Rclone binary to perform standard **S3-to-S3** API-level object synchronization.

## 1.2 Synchronization Strategy

Use a three-phase strategy: **"Full -> Incremental -> Cutover"**:

1. **Initial Sync (Full Sync)**: Keep services online while migrating historical data.
2. **Incremental Sync**: Keep services online and run multiple times to catch up newly added or modified data.
3. **Cutover Sync**: Stop writes, enforce strict consistency checks, and complete final switching.

---

# 2. Prerequisites and Preparation

## 2.1 Verify Alauda VolSync Installation and Extract Version (Critical Prerequisite)

Before executing this plan, ensure the **"Alauda Build of VolSync"** Operator is installed in the `volsync-system` namespace. The migration Job image version must strictly match the currently running Operator version.

For detailed installation instructions of **Alauda Build of VolSync**, see Configure PVC DR with VolSync.

**How to get the version:** Log in to the cluster management console, navigate to **Marketplace / OperatorHub**, open **Installed Operators**, locate the VolSync Operator, and record the displayed version (for example, `v0.8.0` or `v0.9.0`). Save this value as `<OPERATOR_VERSION>` for later configuration.

## 2.2 Collect MinIO Source Information

- **Endpoint**: MinIO internal Service address (for example: `http://minio.tenant-ns.svc:9000`).
- **Credentials**: Access Key / Secret Key with `Read` and `List` permissions on all buckets.

## 2.3 Create a Ceph RGW User (Destination)

Apply the following YAML in the Rook Ceph cluster to create a dedicated migration user and grant bucket creation permissions.

```yaml
apiVersion: ceph.rook.io/v1
kind: CephObjectStoreUser
metadata:
  name: volsync-migration-user
  namespace: rook-ceph
spec:
  store: object-store
  displayName: "VolSync Migration Admin"
  capabilities:
    bucket: "*"
```

For least privilege, keep only bucket-level permissions for this migration account and do not grant `user` management capability.

Extract and decode Ceph credentials for later use:

```
# Get Access Key
kubectl -n rook-ceph get secret rook-ceph-object-user-object-store-volsyn
c-migration-user -o jsonpath='{.data.AccessKey}' | base64 -d
# Get Secret Key
kubectl -n rook-ceph get secret rook-ceph-object-user-object-store-volsyn
c-migration-user -o jsonpath='{.data.SecretKey}' | base64 -d
```

---

# 3. Deployment Configuration (Manifests)

It is recommended to deploy migration tasks in the destination-side namespace (Ceph RGW) or in a dedicated operations namespace.

Create the namespace used by both manifests before applying them:

```
kubectl create ns migration-ops
```

> **Deployment location recommendation (Important)**
> During migration, Rclone reads data locally for processing and then uploads it to the target S3 cluster. Therefore, the network location of the cluster running the migration task directly impacts bandwidth and completion time. It is recommended to deploy the VolSync Operator/migration Job in the **MinIO or Ceph cluster** to reduce cross-cluster network overhead and improve transfer stability.

## 3.1 Create the Rclone Config Secret

Write source and destination S3 credentials into a Secret. **Important: never add quotes around `endpoint` or secret values.**

```
apiVersion: v1
kind: Secret
metadata:
  name: volsync-rclone-config-secret
  namespace: migration-ops
type: Opaque
stringData:
  rclone.conf: |
    [source-minio]
    type = s3
    provider = Minio
    env_auth = false
    access_key_id = MINIO_ACCESS_KEY_HERE
    secret_access_key = MINIO_SECRET_KEY_HERE
    endpoint = MINIO_ENDPOINT_HERE
    no_check_certificate = true

    [dest-ceph]
    type = s3
    provider = Ceph
    env_auth = false
    access_key_id = CEPH_ACCESS_KEY_HERE
    secret_access_key = CEPH_SECRET_KEY_HERE
    endpoint = CEPH_ENDPOINT_HERE
    list_version = 2
```

## 3.2 Define the Migration Job

Deploy a Job that calls the security-patched Alauda VolSync image to execute S3 data synchronization.

> **About `remote:bucket[/prefix]` vs `remote:` (Important)**
>
> - For S3 backends, the common Rclone pattern is `remote:bucket` or `remote:bucket/prefix`, which is also the clearest and safest way to define scope.
> - This document intentionally keeps `source-minio:` -> `dest-ceph:` to support **full instance-level migration** (all visible buckets from the source side).

> - **Risk notice**: `remote:` has a broader scope. If credentials are over-privileged, buckets outside the intended scope may be migrated. Always validate in a test environment first, and consider switching to an explicit `remote:bucket[/prefix]` allowlist model for production cutover.

**Be sure to replace `<OPERATOR_VERSION>` in the YAML below with the actual version discovered in section 2.1.**

```yaml
apiVersion: batch/v1
kind: Job
metadata:
  name: volsync-s3-sync-job
  namespace: migration-ops
spec:
  backoffLimit: 0
  template:
    spec:
      restartPolicy: Never
      containers:
        - name: rclone
          # Use Alauda's patched volsync image. Version must exactly match OperatorHub.
          image: build-harbor.alauda.cn/acp/volsync:<OPERATOR_VERSION>
          # Note: In ACP clusters, this image reference is automatically rewritten
          # to an internal registry address after Pod creation
          # (for example: registry.alauda.cn:60070/acp/volsync:<OPERATOR_VERSION>).
          # This is expected behavior.
          # Use `kubectl describe pod <pod-name>` to check effective Image / ImageID.
          imagePullPolicy: IfNotPresent
          # Override default entrypoint and directly invoke rclone inside the image
          command: ["rclone"]
          args:
            - "sync"
            - "source-minio:"
            - "dest-ceph:"
            - "--progress"
            - "--create-empty-src-dirs"
            - "--ignore-errors"
            # --- Performance tuning flags ---
            - "--transfers=32"      # parallel file transfers
            - "--checkers=64"       # parallel checkers
            - "--s3-chunk-size=64M" # large-object chunk size to reduce RGW fragmentation
            - "--fast-list"         # use ListObjectsV2 to reduce API requests
            - "--metadata"          # synchronize object metadata
          resources:
```

```
          requests:
            cpu: "2000m"
            memory: "4Gi"
          limits:
            cpu: "4000m"
            memory: "8Gi"
        env:
          - name: RCLONE_CONFIG
            value: "/config/rclone.conf"
        volumeMounts:
          - name: config-volume
            mountPath: /config
            readOnly: true
      volumes:
        - name: config-volume
          secret:
            secretName: volsync-rclone-config-secret
```

# 4. Execution Workflow

## Phase 1: Initial Full Sync

1. Create the operations namespace: `kubectl create ns migration-ops`
2. Apply the Secret: `kubectl apply -f rclone-secret.yaml`
3. Start the Job: `kubectl apply -f rclone-job.yaml`
4. Monitor progress: `kubectl -n migration-ops logs -f job/volsync-s3-sync-job`

## Phase 2: Incremental Sync

To catch up on newly generated data during full sync, repeat this step as needed.

1. Delete the previous Job: `kubectl -n migration-ops delete job volsync-s3-sync-job`
2. Recreate the Job: `kubectl apply -f rclone-job.yaml`

*Mechanism note: By default, Rclone compares Size and ModTime to decide whether transfer is needed. Existing unmodified files are skipped.*

## Phase 3: Final Cutover

1. **Stop writes**: Stop writes to MinIO at the application layer, or block write traffic via load balancer/Ingress.
2. **Strict sync validation**:

- Delete the current Job: `kubectl -n migration-ops delete job volsync-s3-sync-job`
- Update `rclone-job.yaml`: remove `- "--ignore-errors"` for the final cutover run, then append `- "--checksum"` to `args`. This avoids masking failed objects and prioritizes Size+Checksum (when available) for difference detection.
- **Consistency recommendation (Required)**: Do not rely on object counts or ETag alone. Before cutover, run `rclone check source-minio: dest-ceph: --download --checksum` (or perform sampled downloads of critical objects and compute SHA256) to reduce false positives caused by multipart/ETag differences.
- Re-apply the Job: `kubectl apply -f rclone-job.yaml`

3. **Validate and switch**: After the Job reaches `Completed` and logs show no errors, update the application S3 Endpoint and credentials to Ceph RGW.

---

# 5. Troubleshooting and Tuning Recommendations

| Symptom | Technical Diagnosis | Resolution |
| --- | --- | --- |
| **ImagePullBackOff** | Node cannot pull the image, or version mismatch exists. ACP clusters automatically rewrite `build-harbor.alauda.cn` to an internal registry address. | First run `kubectl describe pod <pod-name>` to verify the effective `Image` (rewritten or not) and `ImageID`. Then validate `<OPERATOR_VERSION>` and check network/authentication for the effective registry (`imagePullSecrets`). |

| Symptom | Technical Diagnosis | Resolution |
| --- | --- | --- |
| **Pod OOMKilled** | `--fast-list` loads metadata in bulk for massive small-object scenarios, consuming high memory. | Increase Pod memory limit to 8Gi+ or remove `--fast-list` (this increases API requests and slows traversal). |
| **403 Forbidden** | Destination Ceph user lacks permission to create buckets. | Check `CephObjectStoreUser` configuration and ensure `capabilities` includes `bucket: "*"`. |
| **dial tcp: lookup "http: no such host"** | Secret config format is invalid; endpoint URL is quoted. | Edit Secret and **remove quotes around the endpoint URL**, ensuring strict format: `endpoint = http://...`. |
| **503 Service Unavailable** | Migration concurrency is too high, causing excessive Ceph RGW write pressure. | Reduce `--transfers` in Job `args`, or add `--bwlimit` to cap transfer bandwidth. |

# TopoLVM Local Storage

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# Introduction

TopoLVM is a Container Storage Interface (CSI) plugin designed specifically for Kubernetes, aimed at providing efficient and convenient management of local storage volumes.

Key features and advantages:

- **Local Volume Management**: TopoLVM focuses on managing local storage devices (such as disks and SSDs) on Kubernetes nodes. Compared to traditional network storage, local volumes offer lower latency and higher performance.
- **Topology Awareness**: TopoLVM can recognize the topology of Kubernetes clusters (e.g., nodes, availability zones), allowing it to automatically allocate storage volumes to the same node based on the actual scheduling location of Pods, further optimizing performance.
- **Dynamic Volume Allocation**: TopoLVM supports dynamically creating, deleting, and resizing storage volumes without manual intervention, significantly simplifying operations and reducing complexity.
- **Deep Integration with Kubernetes**: As a CSI plugin, TopoLVM seamlessly integrates with Kubernetes storage management APIs, enabling users to manage local volumes directly through standard Kubernetes resource objects such as PersistentVolumeClaims.

In summary, TopoLVM addresses common challenges associated with using local storage in Kubernetes, such as manual management, lack of topology awareness, and insufficient dynamic allocation capabilities. It provides a more efficient and user-friendly solution for applications requiring high-performance local storage, such as databases and caches.

# Install

Local storage is a software-defined server-local storage solution that provides a simple, easy-to-maintain, and high-performance local storage service capability. Based on the community's TopoLVM solution, it achieves persistent volume orchestration management of local storage through the system's LVM approach.

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## Prerequisites

- The lvm2 package must be installed on each node of the storage cluster. If not installed, please execute the `yum install -y lvm2` command on the node.
- **Download** the **Alauda Container Platform Storage Essentials** installation package corresponding to your platform architecture.
- **Upload** the **Alauda Container Platform Storage Essentials** installation package using the Upload Packages mechanism.
- **Download** the **Alauda Build of TopoLVM** installation package corresponding to your platform architecture.

- **Upload** the **Alauda Build of TopoLVM** installation package using the Upload Packages mechanism.

# Procedure

## 1 Deploy Alauda Container Platform Storage Essentials

1. Login, go to the **Administrator** page.
2. Click **Marketplace** > **OperatorHub** to enter the **OperatorHub** page.
3. Find the **Alauda Container Platform Storage Essentials**, click **Install**, and navigate to the **Install Alauda Container Platform Storage Essentials** page.
   Configuration Parameters:

| Parameter | Recommended Configuration |
| --- | --- |
| **Channel** | The default channel is `stable`. |
| **Installation Mode** | `Cluster`: All namespaces in the cluster share a single Operator instance for creation and management, resulting in lower resource usage. |
| **Installation Place** | Select `Recommended`, Namespace only support **acp-storage**. |
| **Upgrade Strategy** | `Manual`: When there is a new version in the Operator Hub, manual confirmation is required to upgrade the Operator to the latest version. |

## 2 Deploy Storage

1. Go to **Administrator**.
2. In the left navigation bar, click **Storage Management** > **Local Storage**.
3. Click **Configure Now**.
4. On the **Install Operator** wizard page, click **Start Deployment**.

- When the page automatically proceeds to the next step, it indicates that the Operator deployment was successful.
- If the deployment fails, please refer to the interface prompts for resolution. Then click **Clean Up** and redeploy the Operator.

5. On the **Create Cluster** wizard page, add devices.

| Parameter | Description |
| --- | --- |
| **Select Node** | Node with at least 1 bare disk. |
| **Device Class** | Each device class corresponds to a set of storage devices with the same characteristics. It is recommended to fill in the name based on the disk nature, such as *hdd*, *ssd*. |
| **Device Type** | Only disk types are supported. |
| **Storage Device** | For example, */dev/sda*. If there are multiple disks, they can be added one by one. |
| **Snapshot** | When enabled, it supports creating PVC snapshots and using the snapshots to configure new PVCs for quick backup and recovery of business data.<br>If the snapshot was not enabled when creating the storage, you can still enable it as needed in the **Operations** section of the storage cluster details page.<br>**Note**: Before use, please ensure that the Volume Snapshot Plugin has been deployed for the current cluster. |

- Click Next. When the page automatically proceeds to the next step, it indicates that the cluster deployment was successful.
- If the creation fails, please refer to the interface prompts and clean up resources in a timely manner.

6. On the **Create Storage Class** wizard page, configure the relevant parameters.

| Parameter | Description |
| --- | --- |
| **Name** | The name of the storage class. It must be unique within the current cluster. |
| **Display Name** | A name that helps you identify or filter, such as a Chinese description of the storage class. |
| **Device Class** | The device class is a way to categorize storage devices in TopoLVM. Each device class corresponds to a set of storage devices with the same characteristics. If there are no special requirements, you can use the **Auto-Allocated** device class from the cluster. |
| **File System** | - **XFS** is a high-performance journaling file system adept at handling parallel I/O workloads, supporting large file processing and providing smooth data transfer.<br>- **EXT4** is a journaling file system in Linux, offering extent file storage methods and supporting large file processing. The file system can reach a capacity of 1 EiB, with a maximum supported file size of 16 TiB. |
| **Recycling Policy** | The recycling policy for persistent volumes.<br>- Delete: When the persistent volume claim is deleted, the bound persistent volume is also deleted.<br>- Retain: Even if the persistent volume claim is deleted, the bound persistent volume will still be retained. |
| **Access Mode** | ReadWriteOnce (RWO): Can be mounted by a single node in read-write mode. |
| **Allocation Project** | This type of persistent volume claim can only be created in specific projects.<br>If no project is assigned temporarily, the project can also be **Updated** later. |

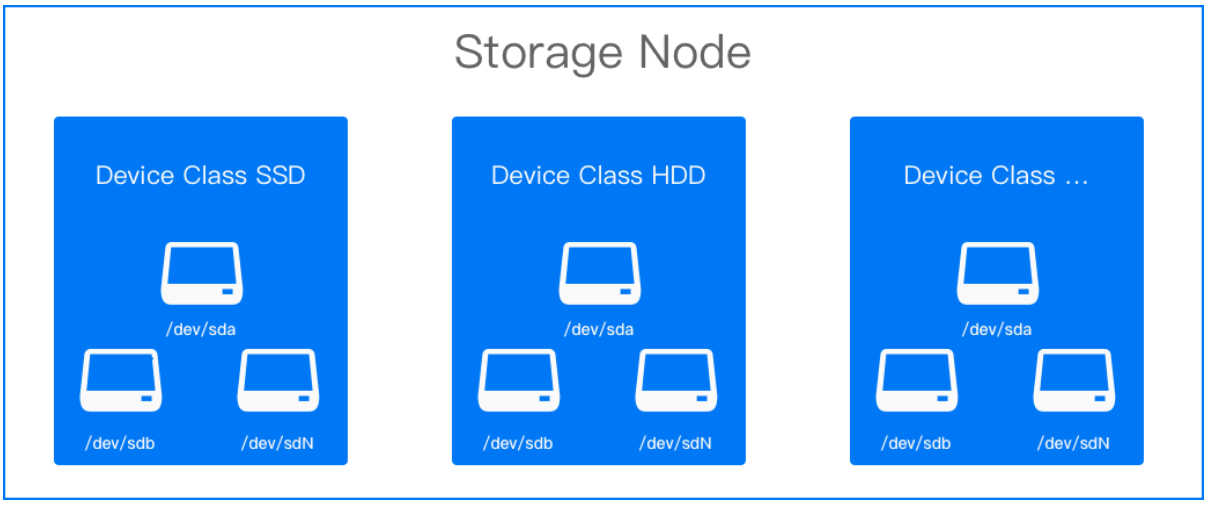
7. Click **Next** and wait for the resource creation to complete.

# Guides

# Device Management

Whether for initial deployment or resource expansion, you need to map the available disks on the node into storage devices for use and management.

Storage devices with similar characteristics are typically used in a centralized manner, and these devices are categorized under **Device Classes** in local storage. Using device classes is equivalent to directly using disks, ensuring zero loss and high performance, while also reducing application awareness and dependence on specific devices.

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## Prerequisites

- At least 1 Device Class (deviceClasses.classes) must have been added when creating the local storage cluster, including devices in the device class.
- There must be at least 1 bare disk present on the node.

# Adding Devices

1. Go to **Administrator**.
2. In the left navigation bar, click **Storage Management** > **Local Storage**.
3. In the **Details** tab, click **Add Storage Node**.
4. Configure the related parameters according to the instructions below.

| Parameter | Description |
| --- | --- |
| **Storage Node** | A node that has at least 1 bare disk. |
| **Device Class** | Each device class corresponds to a group of storage devices with the same characteristics; it is recommended to name it according to the nature of the disks, e.g., *hdd*, *ssd*. |
| **Storage Device** | For example, */dev/sda*. If there are multiple disks, they can be added one by one.<br><br>**Note**: The storage device should be the entire hard disk, not a partition on the hard disk, as this will cause errors. |

5. Click **Add**.
   **Note**: If the device class status is `Unavailable` due to the lack of added devices, you can proceed with the following operations.
6. Switch to the **Storage Devices** tab and click **Add Storage Device**.
7. Add devices according to the prompts on the interface.
8. Click **Add**.

# Monitoring and Alerting

Local storage provides out-of-the-box monitoring metrics collection and alerting capabilities. Once the platform monitoring component is enabled, monitoring and alerts can be configured based on storage clusters, storage performance, and storage capacity, with support for configuring notification policies.

The intuitively presented monitoring data can be utilized to support decision making for operational inspections or performance tuning, and a comprehensive alerting mechanism will help ensure the stable operation of the storage system.

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# Monitoring

## Performance Monitoring

By default, the platform collects commonly used performance monitoring metrics such as read and write bandwidth, IOPS, and latency for local storage. Real-time monitoring data for these metrics can be viewed on the **Monitoring** tab of the **Local Storage** page under **Storage Management**. The platform displays these metrics visually through graphs and charts, allowing administrators to clearly observe current storage performance and quickly identify potential issues.

## Capacity Monitoring

Since local storage can only use locally available storage resources on nodes, users must ensure there is sufficient available capacity on the nodes before declaring local storage to avoid issues caused by over-declaring.

To assist with this, the platform provides detailed capacity monitoring in the **Details** section of local storage, categorized by device types. Users can check available storage space clearly displayed in numerical and graphical formats. If any device type shows insufficient available capacity, space should be cleared or additional disk devices added before using local storage.

# Alerts

The platform includes a set of default alerting policies. If resources become abnormal or monitoring data reaches a warning threshold, alerts are automatically triggered. The preconfigured alerting policies effectively cover common operational needs, including alerts for cluster health status and device type capacity.

## Configuring Notifications

To ensure alerts are received in a timely manner, notification policies should be configured in the operations center. Notifications can be sent through email, SMS, or other methods to relevant personnel, prompting immediate attention to resolve issues or prevent failures. Users can access the notification policy settings directly from the operations center interface. Detailed instructions on configuring alerts can be found in the [Creating Alert Policies] documentation.

## Handling Alerts

- If the health status of the storage cluster changes to `Alert`, administrators should investigate immediately. The **Details** section provides information for troubleshooting and resolving these issues. Common causes include abnormal node services or problems with specific device types.

| Inspection Item | Corresponding Status | Cause |
| --- | --- | --- |
| **Health Status** | Alert | Caused by abnormal node services or device type issues. |
| **Service Status** | Unknown | Node is in a `notready` state, possibly due to network failures or power outages. |
| **Device Type Status** | Unavailable | The disk in use may not be a raw disk, or it might be missing. |

- Real-time alerts triggered on the **Alert** tab require prompt attention, even if the storage cluster status currently appears `Healthy`. Quick responses prevent escalation into more serious issues. The following table outlines alert levels and their implications:

| Alert Level | Meaning |
| --- | --- |
| Critical | Indicates significant issues causing platform service interruptions or data loss, with severe impacts. |
| Major | Known issues potentially affecting platform functionality and normal business operations. |
| Warning | Risk of operational issues exists; timely intervention needed to avoid impact on normal business operations. |

## Post-Mortem Analysis

The **Alert History** logs all alerts triggered previously that no longer require immediate action. During post-mortem analysis, consider the following:

- What specific abnormalities were observed at the time of the incident?
- Are there patterns of specific alerts repeatedly occurring? How can these be proactively prevented in the future?
- Was there a surge in alerts during specific periods linked to external factors or operational incidents? Should operational strategies be adjusted accordingly?

# How To

# Backup and Restore TopoLVM Filesystem PVCs with Velero

Velero enables backup and restoration of Persistent Volume Claims (PVCs) and Persistent Volumes (PVs) for TopoLVM filesystems. This functionality is integrated into the platform.

This guide applies specifically to TopoLVM filesystem PVCs.

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## Prerequisites

1. Deploy the "Alauda Container Platform Data Backup for Velero" via the Marketplace/Cluster Plugins.
2. Configure an S3-compatible storage for Velero's `BackupStorageLocation`. Use platform-provided Ceph or MinIO object storage.

# Limitations

1. The S3 storage must have sufficient free space to store all PV data from the target cluster.
2. During restoration, the namespace quota and storage class must support the total capacity of all PVCs.

# Procedure

## Step 1: Configure Backup Repository

1. Ensure an S3-compatible storage is available.
2. Navigate to **Administrator** > **Cluster Management** > **Backup and Restore** > **Backup Repository**.
3. Create a backup repository using the object storage credentials.

## Step 2: Perform Backup

1. Label the PVCs and associated pods to be backed up:
   Velero needs a pod to restore a Filesystem PVC. The pod mounts the PVC for Velero to import data; without a pod, the PVC remains Pending. For complex apps, pause the application and attach the PVC to a lightweight pod (e.g., Nginx) for backup/restore, then restore the original app configuration post-restoration.

   ```
   kubectl label pvc -n <namespace> <pvc-name> velero-backup=true
   kubectl label pod -n <namespace> <pod-name> velero-backup=true
   ```

2. Go to **Backup and Restore** and create a new backup:
   - Select **Backup Kubernetes Resources and PVC Data Volumes**.
   - Choose the namespaces containing the data to back up.
   - Configure the backup with the following settings:

```yaml
apiVersion: velero.io/v1
kind: Schedule
metadata:
  name: <backup-name>
  namespace: cpaas-system
  annotations:
    cpaas.io/description: ''
spec:
  template:
    includedNamespaces:
      - <namespace>
    includedResources:
      - '*'
    labelSelector:
      matchLabels:
        velero-backup: 'true'
    excludedNamespaces: []
    excludedResources: []
    defaultVolumesToFsBackup: true
    storageLocation: default
    ttl: 720h
  schedule: '@every 876000h'
  skipImmediately: false
status:
  phase: Enabled
```

3. After the backup completes, verify the data in the S3 bucket (e.g., MinIO):

```
mc ls <minio-alias>/<bucket-name>/<backup-path>/<namespace>/
```

Example output:

```
[2025-03-14 00:18:33 CST]  155B STANDARD config
[2025-03-14 09:04:56 CST]   0B data/
[2025-03-14 09:04:56 CST]   0B index/
[2025-03-14 09:04:56 CST]   0B keys/
[2025-03-14 09:04:56 CST]   0B snapshots/
```

## Step 3: Restore Cluster

1. In the target cluster, configure the same S3 bucket as used for the backup. Velero will automatically detect the existing backup.
2. Navigate to **Backup and Restore** and create a restore task:
   - Select the namespace(s) to restore.
   - In the advanced configuration, map the original namespace to the target namespace if needed.
3. Execute the restore operation.
4. After restoration, verify:
   - PVC names match the original cluster.
   - Application data in the PVCs is intact and accessible.

# Remove Disks, Device-Class Volume Groups, or Nodes from ACP TopoLVM Local Storage

This document describes how to remove failed disks, remove device-class volume groups from a device class, and remove storage nodes in ACP TopoLVM Local Storage.

Depending on the failure scope, this document covers the following scenarios:

- Remove a `volume group device` from a `device-class volume group`
- Remove a `device-class volume group` from a `device class`
- Remove a TopoLVM storage node

> **Risk Warning**
>
> - The procedure in this document directly deletes storage resources such as PVCs, PVs, and `logicalvolumes.topolvm.cybozu.com`. After these resources are deleted, data in the affected volumes is usually unrecoverable. Back up the data in advance.
> - Before you proceed, confirm that you have identified the correct disk, device-class volume group, or node, and schedule a maintenance window for the affected workloads.

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# Terms

| Term | Description |
| --- | --- |
| **device class** | A logical storage class composed of one or more device-class volume groups on different nodes. |
| **device-class volume group** | An `LVM volume group` on a node that represents the storage resources of a device class on that node. |
| **volume group device** | A disk on a node. In LVM, it corresponds to a physical volume. |

# Choosing the Correct Scenario

Use the following table to determine which scenario applies to your environment.

| Condition | Scenario 1: Remove a volume group device | Scenario 2: Remove a device-class volume group | Scenario 3: Remove a TopoLVM storage node |
|---|---|---|---|
| Node accessibility | The node is still accessible. | The node is still accessible. | The node is no longer recoverable, or you have decided to permanently remove it from TopolvmCluster. |
| Volume group status | The target `LVM volume group` still exists and is still recognizable. | The target `LVM volume group` no longer exists or is no longer recognizable, but the node is still retained. | The node and all device-class volume groups on that node will be removed together. |
| Scope of removal | Remove one or more failed disks from a volume group. | Remove one device-class volume group from a retained node. | Remove the entire node from TopolvmCluster. |
| Retention plan | The node and the device-class volume group are retained. | The node is retained, but the target device-class volume group is not retained. | Neither the node nor any device-class volume group on that node is retained. |

# Scenario 1: Remove a Volume Group Device from a Device-Class Volume Group

## User Scenario

- Use this procedure when a `device-class volume group` is not completely damaged, but one or more `volume group devices` in the volume group have failed and must be removed.

## Prerequisites

- The target node is still in the cluster and accessible.
- The `Provision Type` of the target device class is `Thick`.
- The target device-class volume group is not completely damaged, and at least one healthy volume group device remains in the volume group.

## Check Whether the Device-Class Volume Group Is Still Recoverable

Run the following command on the target node:

```
vgs <vg-name>
```

Parameters:

- `<vg-name>`: The name of the target LVM volume group.

If the command returns normal output, or only reports that some PVs are missing while the volume group still exists, the device-class volume group is not completely damaged and you can follow this procedure.

Example output:

```
WARNING: Couldn't find device with uuid VJes6j-2a8V-8Cxf-eW84-yEJK-K24A-y
Bc9OD.
WARNING: VG hdd-2ab8f0a2-7d1d-42d7-ba6b-da94c6185c33 is missing PV VJes6j
-2a8V-8Cxf-eW84-yEJK-K24A-yBc9OD (last written to /dev/vdb).
WARNING: Couldn't find all devices for LV hdd-2ab8f0a2-7d1d-42d7-ba6b-da9
4c6185c33/b6b331f0-5242-420f-a531-df90628bef80 while checking used and as
sumed devices.
```

## Procedure

### Step 1: Stop topolvm-operator

Run the following command on the control-plane node to prevent the operator from reconciling resources during cleanup:

```
kubectl -n nativestor-system scale --replicas 0 deployment topolvm-operator
```

## Step 2: Find the affected LVM logical volume

Run the following command on the target node to find the logical volumes that use the failed disk(s):

```
lvs -a -o +devices <vg-name> | egrep "<path-to-disks>|unknown device" | awk '{print $1}'
```

Parameters:

- `<vg-name>`: The name of the target LVM volume group.
- `<path-to-disks>` : The device paths of the failed disks, such as `/dev/vdb`. If you need to match multiple disks, separate them with `|`.

For example:

```
lvs -a -o +devices hdd-2ab8f0a2-7d1d-42d7-ba6b-da94c6185c33 2>/dev/null | egrep "/dev/vdb|unknown" | awk '{print $1}'
```

Example output:

```
b6b331f0-5242-420f-a531-df90628bef80
```

## Step 3: Find the affected PVC and PV

Run the following command on the control-plane node to find the associated PV and PVC by logical volume name:

```
kubectl get pv -o json | jq -r --arg HANDLE <lv-name> '
  .items[]
  | select(.spec.csi.volumeHandle == $HANDLE)
  | [.metadata.name, .spec.claimRef.namespace, .spec.claimRef.name]
  | @tsv
'
```

Parameters:

- `<lv-name>`: The name of the affected LVM logical volume.

Example output:

```
pvc-e11f6c18-0e15-4c70-9a24-e7136fabfb2f    demo-space  pvc-topolvm
```

In the output:

- Column 1 is the `PersistentVolume` name.
- Column 2 is the namespace of the `PersistentVolumeClaim`.
- Column 3 is the `PersistentVolumeClaim` name.

## Step 4: Stop workloads that use the affected PVC

After you identify the affected PVCs, stop the workloads that use them and confirm that all related Pods have stopped before you continue.

## Step 5: Delete the affected Kubernetes storage resources

Run the following commands on the control-plane node:

```
kubectl delete pvc -n <pvc-namespace> <pvc-name>
kubectl delete pv <pv-name>
kubectl delete logicalvolumes.topolvm.cybozu.com <logicalvolume-name>
```

Parameters:

- `<pvc-namespace>`: The namespace of the affected PVC.

- `<pvc-name>`: The name of the affected PVC.
- `<pv-name>`: The name of the affected PV.
- `<logicalvolume-name>`: The name of the TopoLVM `logicalvolumes.topolvm.cybozu.com` resource. It is the same as `<pv-name>`.

If the query result contains multiple resources, delete them one by one according to the mapping.

If a resource cannot be deleted normally, add `--force` as required.

## Step 6: Clean up residual LVM logical volumes

Run the following command on the target node to check whether any logical volume still remains:

```
lvs -a -o +devices <vg-name> 2>/dev/null | egrep "<path-to-disks>|unknown device" | awk '{print $1}'
```

Parameters:

- `<vg-name>`: The name of the target LVM volume group.
- `<path-to-disks>` : The device paths of the failed disks, such as `/dev/vdb`. If you need to match multiple disks, separate them with `|`.

If the command still returns output, delete the remaining logical volumes one by one:

```
lvremove <vg-name>/<lv-name>
```

Parameters:

- `<vg-name>`: The name of the target LVM volume group.
- `<lv-name>`: The name of the logical volume to remove.

If needed, add `--force`.

### Step 7: Remove the missing physical volume from the LVM volume group

Run the following command on the target node:

```
vgreduce --removemissing <vg-name>
```

Parameters:

- `<vg-name>`: The name of the target LVM volume group.

If needed, add `--force`.

### Step 8: Update the TopolvmCluster resource

Run the following command on the control-plane node:

```
kubectl -n nativestor-system edit topolvmclusters.topolvm.cybozu.com
topolvm
```

In the editor, remove the failed volume group device from the `devices` list of the target node. For example, remove `/dev/vdb` from the configuration for `nodeName: 192.168.133.50`.

Before:

```
spec:
  storage:
    deviceClasses:
      - classes:
          - className: hdd
            default: true
            devices:
              - name: /dev/vdb
                type: disk
              - name: /dev/vdc
                type: disk
            volumeGroup: hdd-2ab8f0a2-7d1d-42d7-ba6b-da94c6185c33
        nodeName: 192.168.133.50
```

After:

```
spec:
  storage:
    deviceClasses:
      - classes:
          - className: hdd
            default: true
            devices:
              - name: /dev/vdc
                type: disk
            volumeGroup: hdd-2ab8f0a2-7d1d-42d7-ba6b-da94c6185c33
        nodeName: 192.168.133.50
```

## Step 9: Update the lvmdconfig ConfigMap

Run the following command on the control-plane node:

```
kubectl -n nativestor-system edit configmaps lvmdconfig-<node-name>
```

Parameters:

- `<node-name>`: The name of the target node.

In the editor, remove the status of the failed volume group device from `status.json`. For example, remove the `deviceStates` entry for `/dev/vdb`.

Before:

```
status.json: '{"node":"192.168.133.50","phase":"","failClasses":[],"successClasses":[{"className":"hdd","vgName":"hdd-2ab8f0a2-7d1d-42d7-ba6b-da94c6185c33","state":"Ready","message":"create successful","deviceStates":[{"name":"/dev/vdb","state":"Online"},{"name":"/dev/vdc","state":"Online"}]}],"loops":[],"raids":[]}'
```

After:

```
status.json: '{"node":"192.168.133.50","phase":"","failClasses":[],"successClasses":[{"className":"hdd","vgName":"hdd-2ab8f0a2-7d1d-42d7-ba6b-da94c6185c33","state":"Ready","message":"create successful","deviceStates":[{"name":"/dev/vdc","state":"Online"}]}],"loops":[],"raids":[]}'
```

## Step 10: Start topolvm-operator

Run the following command on the control-plane node:

```
kubectl -n nativestor-system scale --replicas 1 deployment topolvm-operator
```

## Step 11: Verify that the volume group device has been removed

Run the following command on the control-plane node:

```
kubectl -n nativestor-system get topolvmclusters.topolvm.cybozu.com topolvm -o jsonpath="{.status.nodeStorageState}" | jq
```

Confirm that the removed volume group device no longer appears in the `deviceStates` of the target node.

# Scenario 2: Remove a Device-Class Volume Group from a Device Class

## User Scenario

- Use this procedure when a device-class volume group on a node is completely damaged and cannot be recovered by removing only a single volume group device.

## Prerequisites

- The target node is still in the cluster and accessible.
- The target device-class volume group is completely damaged.
- After the target device-class volume group is removed, at least one other device-class volume group remains on the node.

## Check Whether the Device-Class Volume Group Is Completely Damaged

Run the following command on the target node:

```
vgs
```

If the target `LVM volume group` no longer appears in the output, the device-class volume group is completely damaged and you can follow this procedure.

> **Note**
>
> This scenario removes an entire device-class volume group from a node, not just a single volume group device in that volume group.

## Procedure

## Step 1: Stop topolvm-operator

Run the following command on the control-plane node:

```
kubectl -n nativestor-system scale --replicas 0 deployment topolvm-operator
```

## Step 2: Find the affected PVC and PV

Run the following command on the control-plane node to find the PVs, PVCs, and `logicalvolumes.topolvm.cybozu.com` resources associated with the specified storage class on the target node:

```
kubectl get pv -o json | jq -r --arg NODE <node-name> --arg SC <storageclass-name> '
  .items[]
  | select(.spec.nodeAffinity.required.nodeSelectorTerms[]?.matchExpressions[]? | select(.key=="topology.topolvm.cybozu.com/node") | .values[]? == $NODE)
  | select(.spec.storageClassName == $SC)
  | [.metadata.name, .spec.claimRef.namespace, .spec.claimRef.name]
  | @tsv
'
```

Parameters:

- `<node-name>`: The name of the target node.
- `<storageclass-name>`: The name of the storage class associated with the target device-class volume group. If multiple storage classes are involved, run the query separately for each storage class.

Example output:

```
pvc-e11f6c18-0e15-4c70-9a24-e7136fabfb2f    demo-space  pvc-topolvm
```

In the output:

- Column 1 is the name of both the `PersistentVolume` and the `logicalvolumes.topolvm.cybozu.com` resource.
- Columns 2 and 3 are the namespace and name of the `PersistentVolumeClaim`.

If multiple storage classes are associated with the target device-class volume group, repeat this query and the subsequent cleanup steps for each storage class.

## Step 3: Stop workloads that use the affected PVC

After you identify the affected PVCs, stop the workloads that use them and confirm that all related Pods have stopped before you continue.

## Step 4: Delete the affected Kubernetes storage resources

Run the following commands on the control-plane node:

```
kubectl delete pvc -n <pvc-namespace> <pvc-name>
kubectl delete pv <pv-name>
kubectl delete logicalvolumes.topolvm.cybozu.com <logicalvolume-name>
```

Parameters:

- `<pvc-namespace>`: The namespace of the affected PVC.
- `<pvc-name>`: The name of the affected PVC.
- `<pv-name>`: The name of the affected PV.
- `<logicalvolume-name>`: The name of the TopoLVM `logicalvolumes.topolvm.cybozu.com` resource. It is the same as `<pv-name>`.

If the query result contains multiple resources, delete them one by one according to the mapping.

If a resource cannot be deleted normally, add `--force` as required.

## Step 5: Update the TopolvmCluster resource

Run the following command on the control-plane node:

```
kubectl -n nativestor-system edit topolvmclusters.topolvm.cybozu.com
topolvm
```

In the editor, remove the device-class volume group from the target node. For example, in the configuration for `nodeName: 192.168.140.13`, remove the `className: hdd` entry and its associated `volumeGroup` and `devices` configuration.

Before:

```
spec:
  storage:
    deviceClasses:
      - classes:
          - className: ssd
            default: true
            devices:
              - name: /dev/vdc
                type: disk
            volumeGroup: ssd-4a8737fc-48d3-4c61-882d-0a5bcc6f77a1
          - className: hdd
            devices:
              - name: /dev/vdb
                type: disk
            volumeGroup: hdd-97dc00f3-1df6-4f64-8ddc-7b0b6c5d6de5
        nodeName: 192.168.140.13
```

After:

```
spec:
  storage:
    deviceClasses:
      - classes:
          - className: ssd
            default: true
            devices:
              - name: /dev/vdc
                type: disk
            volumeGroup: ssd-4a8737fc-48d3-4c61-882d-0a5bcc6f77a1
        nodeName: 192.168.140.13
```

If the removed `className` entry has `default: true`, designate another remaining class as the default class.

### Step 6: Update the lvmdconfig ConfigMap

Run the following command on the control-plane node:

```
kubectl -n nativestor-system edit configmaps lvmdconfig-<node-name>
```

Parameters:

- `<node-name>`: The name of the target node.

In the editor, remove the configuration that corresponds to the target device-class volume group from both `lvmd.yaml` and `status.json`. For example, remove the configuration for `className: hdd`.

Before:

```
lvmd.yaml: |
  socket-name: /run/topolvm/lvmd.sock
  device-classes:
  - name: ssd
    volume-group: ssd-4a8737fc-48d3-4c61-882d-0a5bcc6f77a1
    default: true
    type: thick
  - name: hdd
    volume-group: hdd-97dc00f3-1df6-4f64-8ddc-7b0b6c5d6de5
    default: false
    type: thick
status.json: '{"node":"192.168.140.13","phase":"","failClasses":[],"s
uccessClasses":[{"className":"hdd","vgName":"hdd-97dc00f3-1df6-4f64-8
ddc-7b0b6c5d6de5","state":"Ready","message":"create successful","devi
ceStates":[{"name":"/dev/vdb","state":"Online"}]},{"className":"ss
d","vgName":"ssd-4a8737fc-48d3-4c61-882d-0a5bcc6f77a1","state":"Read
y","message":"create successful","deviceStates":[{"name":"/dev/vd
c","state":"Online"}]}],"loops":[],"raids":[]}'
```

After:

```
lvmd.yaml: |
  socket-name: /run/topolvm/lvmd.sock
  device-classes:
  - name: ssd
    volume-group: ssd-4a8737fc-48d3-4c61-882d-0a5bcc6f77a1
    default: true
    type: thick
status.json: '{"node":"192.168.140.13","phase":"","failClasses":[],"s
uccessClasses":[{"className":"ssd","vgName":"ssd-4a8737fc-48d3-4c61-8
82d-0a5bcc6f77a1","state":"Ready","message":"create successful","devi
ceStates":[{"name":"/dev/vdc","state":"Online"}]}],"loops":[],"raid
s":[]}'
```

If the removed `className` entry has `default: true`, designate another remaining class as the default class.

### Step 7: Start topolvm-operator

Run the following command on the control-plane node:

```
kubectl -n nativestor-system scale --replicas 1 deployment topolvm-op
erator
```

### Step 8: Verify that the device-class volume group has been removed

Run the following command on the control-plane node:

```
kubectl -n nativestor-system get topolvmclusters.topolvm.cybozu.com t
opolvm -o jsonpath="{.status.nodeStorageState}" | jq
```

Confirm that the removed device-class volume group no longer appears on the target node and that the remaining device-class volume groups are healthy.

## Scenario 3: Remove a TopoLVM Storage Node

## User Scenario

- The target node is no longer recoverable, or you have decided to permanently remove it from TopolvmCluster.

## Prerequisites

- You have decided not to retain any device-class volume groups on the target node.
- Workloads that use local volumes on the target node have been stopped or migrated to other nodes.
- The remaining nodes can continue to host the required workloads after the target node is removed.

## Procedure

### Step 1: Stop topolvm-operator

Run the following command on the control-plane node:

```
kubectl -n nativestor-system scale --replicas 0 deployment topolvm-operator
```

### Step 2: Find the affected PVC and PV

Run the following command on the control-plane node to find the PVs, PVCs, and `logicalvolumes.topolvm.cybozu.com` resources associated with the target node:

```
kubectl get pv -o json | jq -r --arg NODE <node-name> '
  .items[]
  | select(.spec.nodeAffinity.required.nodeSelectorTerms[]?.matchExpressions[]? | select(.key=="topology.topolvm.cybozu.com/node") | .values[]? == $NODE)
  | [.metadata.name, .spec.claimRef.namespace, .spec.claimRef.name]
  | @tsv
'
```

Parameters:

- `<node-name>`: The name of the target node.

### Step 3: Stop workloads that use the affected PVC

After you identify the affected PVCs, stop the workloads that use them and confirm that all related Pods have stopped before you continue.

### Step 4: Delete the affected Kubernetes storage resources

Run the following commands on the control-plane node:

```
kubectl delete pvc -n <pvc-namespace> <pvc-name>
kubectl delete pv <pv-name>
kubectl delete logicalvolumes.topolvm.cybozu.com <logicalvolume-name>
```

Parameters:

- `<pvc-namespace>`: The namespace of the affected PVC.
- `<pvc-name>`: The name of the affected PVC.
- `<pv-name>`: The name of the affected PV.
- `<logicalvolume-name>`: The name of the TopoLVM `logicalvolumes.topolvm.cybozu.com` resource. It is the same as `<pv-name>`.

If the query result contains multiple resources, delete them one by one according to the mapping.

If a resource cannot be deleted normally, add `--force` as required.

### Step 5: Update the TopolvmCluster resource

Run the following command on the control-plane node:

```
kubectl -n nativestor-system edit topolvmclusters.topolvm.cybozu.com
topolvm
```

In the editor, remove the entire configuration block for the target node. For example, remove the block for `nodeName: 192.168.140.13`.

Before:

```
spec:
  storage:
    deviceClasses:
      - classes:
          - className: hdd
            default: true
            devices:
              - name: /dev/vdc
                type: disk
            volumeGroup: hdd-2ab8f0a2-7d1d-42d7-ba6b-da94c6185c33
        nodeName: 192.168.133.50
      - classes:
          - className: ssd
            default: true
            devices:
              - name: /dev/vdc
                type: disk
            volumeGroup: ssd-4a8737fc-48d3-4c61-882d-0a5bcc6f77a1
          - className: hdd
            devices:
              - name: /dev/vdb
                type: disk
            volumeGroup: hdd-97dc00f3-1df6-4f64-8ddc-7b0b6c5d6de5
        nodeName: 192.168.140.13
```

After:

```
spec:
  storage:
    deviceClasses:
      - classes:
          - className: hdd
            default: true
            devices:
              - name: /dev/vdc
                type: disk
            volumeGroup: hdd-2ab8f0a2-7d1d-42d7-ba6b-da94c6185c33
        nodeName: 192.168.133.50
```

## Step 6: Update the lvmdconfig ConfigMap

Run the following command on the control-plane node:

```
kubectl -n nativestor-system edit configmaps lvmdconfig-<node-name>
```

Parameters:

- `<node-name>`: The name of the target node.

In the editor, delete the entire `lvmd.yaml` and `status.json` sections. Do not keep any configuration or status for the removed node.

## Step 7: Start topolvm-operator

Run the following command on the control-plane node:

```
kubectl -n nativestor-system scale --replicas 1 deployment topolvm-operator
```

## Step 8: Verify that the node has been removed

Run the following command on the control-plane node:

```
kubectl -n nativestor-system get topolvmclusters.topolvm.cybozu.com t
opolvm -o jsonpath="{.status.nodeStorageState}" | jq
```

Confirm that the target node no longer appears in `status.nodeStorageState`. For example, `192.168.140.13` should no longer appear in the output.

# Configuring Striped Logical Volumes

When you write data to an LVM logical volume, the file system lays the data out across the underlying physical volumes. You can control the way the data is written to the physical volumes by creating a striped logical volume. For large sequential reads and writes, this can improve the efficiency of the data I/O.

Striping enhances performance by writing data to a predetermined number of physical volumes in round-round fashion. With striping, I/O can be done in parallel. In some situations, this can result in near-linear performance gain for each additional physical volume in the stripe.

TopoLVM achieves this by specifying the `lvcreate-option-class` in the `StorageClass`.

## TOC



## Prerequisites

- The device class must contain **at least two devices** on a single node.

# Procedure

## 1 Using the Default `lvcreate-option-class`

1. Navigate to **Administrator**.
2. In the left sidebar, go to **Storage Management** > **Storage Classes**.
3. Click **Create Storage Class**.
4. Select **Block Storage**.
5. Choose **TopoLVM**, then click **Next**.
6. Configure the required storage class parameters.
7. Switch to **YAML view** and add the `topolvm.io/lvcreate-option-class` parameter:

```
parameters:
  topolvm.io/lvcreate-option-class: striped-default
```

> **NOTE**
>
> `striped-default` is a built-in lvcreate-option-class in Alauda Container Platform. It automatically appends `--stripes=2` `--stripesize=64` to the lvcreate command when the TopoLVM CSI driver provisions logical volumes.

## 2 Creating a Custom lvcreate-option-class (Optional)

If the built-in striped-default class does not meet your needs, you can define a custom LVCreateOptionClass:

```
cat << EOF | kubectl apply -f -
apiVersion: topolvm.cybozu.com/v2
kind: LVCreateOption
metadata:
  name: custom
  namespace: nativestor-system
spec:
  options:
  - name: striped-custom
    type: striped
    options:
    - --stripes=3
    - --stripesize=64
EOF
```

This manifest creates a custom LVCreateOptionClass named striped-custom with 3 stripes and a stripe size of 64 KiB. Once applied, you can reference it in your StorageClass using `topolvm.io/lvcreate-option-class: striped-custom`.