



Red Hat OpenShift Service on AWS 4

Storage

Configuring storage for Red Hat OpenShift Service on AWS clusters

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Abstract

This document provides information about setting up storage for Red Hat OpenShift Service on AWS (ROSA) clusters.

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CHAPTER 1. RED HAT OPENSIFT SERVICE ON AWS STORAGE OVERVIEW

Red Hat OpenShift Service on AWS supports Amazon Elastic Block Store (Amazon EBS) and Amazon Elastic File System (Amazon EFS) storage. You can manage container storage for persistent and non-persistent data in an Red Hat OpenShift Service on AWS cluster.

1.1. GLOSSARY OF COMMON TERMS FOR RED HAT OPENSIFT SERVICE ON AWS STORAGE

This glossary defines common terms that are used in the storage content.

Access modes

Volume access modes describe volume capabilities. You can use access modes to match persistent volume claim (PVC) and persistent volume (PV). The following are the examples of access modes:

- ReadWriteOnce (RWO)
- ReadOnlyMany (ROX)
- ReadWriteMany (RWX)
- ReadWriteOncePod (RWOP)

Config map

A config map provides a way to inject configuration data into pods. You can reference the data stored in a config map in a volume of type **ConfigMap**. Applications running in a pod can use this data.

Container Storage Interface (CSI)

An API specification for the management of container storage across different container orchestration (CO) systems.

Dynamic Provisioning

The framework allows you to create storage volumes on-demand, eliminating the need for cluster administrators to pre-provision persistent storage.

Ephemeral storage

Pods and containers can require temporary or transient local storage for their operation. The lifetime of this ephemeral storage does not extend beyond the life of the individual pod, and this ephemeral storage cannot be shared across pods.

fsGroup

The fsGroup defines a file system group ID of a pod.

hostPath

A hostPath volume in an OpenShift Container Platform cluster mounts a file or directory from the host node's filesystem into your pod.

KMS key

The Key Management Service (KMS) helps you achieve the required level of encryption of your data across different services. you can use the KMS key to encrypt, decrypt, and re-encrypt data.

Local volumes

A local volume represents a mounted local storage device such as a disk, partition or directory.

OpenShift Data Foundation

A provider of agnostic persistent storage for OpenShift Container Platform supporting file, block, and object storage, either in-house or in hybrid clouds

Persistent storage

Pods and containers can require permanent storage for their operation. Red Hat OpenShift Service on AWS uses the Kubernetes persistent volume (PV) framework to allow cluster administrators to provision persistent storage for a cluster. Developers can use PVC to request PV resources without having specific knowledge of the underlying storage infrastructure.

Persistent volumes (PV)

Red Hat OpenShift Service on AWS uses the Kubernetes persistent volume (PV) framework to allow cluster administrators to provision persistent storage for a cluster. Developers can use PVC to request PV resources without having specific knowledge of the underlying storage infrastructure.

Persistent volume claims (PVCs)

You can use a PVC to mount a PersistentVolume into a Pod. You can access the storage without knowing the details of the cloud environment.

Pod

One or more containers with shared resources, such as volume and IP addresses, running in your Red Hat OpenShift Service on AWS cluster. A pod is the smallest compute unit defined, deployed, and managed.

Reclaim policy

A policy that tells the cluster what to do with the volume after it is released. A volume's reclaim policy can be **Retain**, **Recycle**, or **Delete**.

Role-based access control (RBAC)

Role-based access control (RBAC) is a method of regulating access to computer or network resources based on the roles of individual users within your organization.

Stateless applications

A stateless application is an application program that does not save client data generated in one session for use in the next session with that client.

Stateful applications

A stateful application is an application program that saves data to persistent disk storage. A server, client, and applications can use a persistent disk storage. You can use the **Statefulset** object in Red Hat OpenShift Service on AWS to manage the deployment and scaling of a set of Pods, and provides guarantee about the ordering and uniqueness of these Pods.

Static provisioning

A cluster administrator creates a number of PVs. PVs contain the details of storage. PVs exist in the Kubernetes API and are available for consumption.

Storage

Red Hat OpenShift Service on AWS supports many types of storage, both for on-premise and cloud providers. You can manage container storage for persistent and non-persistent data in an Red Hat OpenShift Service on AWS cluster.

Storage class

A storage class provides a way for administrators to describe the classes of storage they offer. Different classes might map to quality of service levels, backup policies, arbitrary policies determined by the cluster administrators.

1.2. STORAGE TYPES

Red Hat OpenShift Service on AWS storage is broadly classified into two categories, namely ephemeral storage and persistent storage.

1.2.1. Ephemeral storage

Pods and containers are ephemeral or transient in nature and designed for stateless applications. Ephemeral storage allows administrators and developers to better manage the local storage for some of their operations. For more information about ephemeral storage overview, types, and management, see [Understanding ephemeral storage](#).

1.2.2. Persistent storage

Stateful applications deployed in containers require persistent storage. Red Hat OpenShift Service on AWS uses a pre-provisioned storage framework called persistent volumes (PV) to allow cluster administrators to provision persistent storage. The data inside these volumes can exist beyond the lifecycle of an individual pod. Developers can use persistent volume claims (PVCs) to request storage requirements. For more information about persistent storage overview, configuration, and lifecycle, see [Understanding persistent storage](#).

1.3. CONTAINER STORAGE INTERFACE (CSI)

CSI is an API specification for the management of container storage across different container orchestration (CO) systems. You can manage the storage volumes within the container native environments, without having specific knowledge of the underlying storage infrastructure. With the CSI, storage works uniformly across different container orchestration systems, regardless of the storage vendors you are using. For more information about CSI, see [Using Container Storage Interface \(CSI\)](#).

1.4. DYNAMIC PROVISIONING

Dynamic Provisioning allows you to create storage volumes on-demand, eliminating the need for cluster administrators to pre-provision storage. For more information about dynamic provisioning, see [Dynamic provisioning](#).

CHAPTER 2. UNDERSTANDING EPHEMERAL STORAGE

2.1. OVERVIEW

In addition to persistent storage, pods and containers can require ephemeral or transient local storage for their operation. The lifetime of this ephemeral storage does not extend beyond the life of the individual pod, and this ephemeral storage cannot be shared across pods.

Pods use ephemeral local storage for scratch space, caching, and logs. Issues related to the lack of local storage accounting and isolation include the following:

- Pods cannot detect how much local storage is available to them.
- Pods cannot request guaranteed local storage.
- Local storage is a best-effort resource.
- Pods can be evicted due to other pods filling the local storage, after which new pods are not admitted until sufficient storage is reclaimed.

Unlike persistent volumes, ephemeral storage is unstructured and the space is shared between all pods running on a node, in addition to other uses by the system, the container runtime, and Red Hat OpenShift Service on AWS. The ephemeral storage framework allows pods to specify their transient local storage needs. It also allows Red Hat OpenShift Service on AWS to schedule pods where appropriate, and to protect the node against excessive use of local storage.

While the ephemeral storage framework allows administrators and developers to better manage local storage, I/O throughput and latency are not directly effected.

2.2. TYPES OF EPHEMERAL STORAGE

Ephemeral local storage is always made available in the primary partition. There are two basic ways of creating the primary partition: root and runtime.

Root

This partition holds the kubelet root directory, `/var/lib/kubelet/` by default, and `/var/log/` directory. This partition can be shared between user pods, the OS, and Kubernetes system daemons. This partition can be consumed by pods through **EmptyDir** volumes, container logs, image layers, and container-writable layers. Kubelet manages shared access and isolation of this partition. This partition is ephemeral, and applications cannot expect any performance SLAs, such as disk IOPS, from this partition.

Runtime

This is an optional partition that runtimes can use for overlay file systems. Red Hat OpenShift Service on AWS attempts to identify and provide shared access along with isolation to this partition. Container image layers and writable layers are stored here. If the runtime partition exists, the **root** partition does not hold any image layer or other writable storage.

2.3. EPHEMERAL STORAGE MANAGEMENT

Cluster administrators can manage ephemeral storage within a project by setting quotas that define the limit ranges and number of requests for ephemeral storage across all pods in a non-terminal state. Developers can also set requests and limits on this compute resource at the pod and container level.

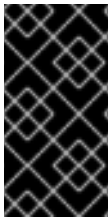
You can manage local ephemeral storage by specifying requests and limits. Each container in a pod can specify the following:

- `spec.containers[].resources.limits.ephemeral-storage`
- `spec.containers[].resources.requests.ephemeral-storage`

2.3.1. Ephemeral storage limits and requests units

Limits and requests for ephemeral storage are measured in byte quantities. You can express storage as a plain integer or as a fixed-point number using one of these suffixes: E, P, T, G, M, k. You can also use the power-of-two equivalents: Ei, Pi, Ti, Gi, Mi, Ki.

For example, the following quantities all represent approximately the same value: 128974848, 129e6, 129M, and 123Mi.



IMPORTANT

The suffixes for each byte quantity are case-sensitive. Be sure to use the correct case. Use the case-sensitive "M", such as used in "400M" to set the request at 400 megabytes. Use the case-sensitive "400Mi" to request 400 mebibytes. If you specify "400m" of ephemeral storage, the storage requests is only 0.4 bytes.

2.3.2. Ephemeral storage requests and limits example

The following example configuration file shows a pod with two containers:

- Each container requests 2GiB of local ephemeral storage.
- Each container has a limit of 4GiB of local ephemeral storage.
- At the pod level, kubelet works out an overall pod storage limit by adding up the limits of all the containers in that pod.
 - In this case, the total storage usage at the pod level is the sum of the disk usage from all containers plus the pod's **emptyDir** volumes.
 - Therefore, the pod has a request of 4GiB of local ephemeral storage, and a limit of 8GiB of local ephemeral storage.

Example ephemeral storage configuration with quotas and limits

```
apiVersion: v1
kind: Pod
metadata:
  name: frontend
spec:
  containers:
  - name: app
    image: images.my-company.example/app:v4
    resources:
      requests:
        ephemeral-storage: "2Gi" 1
      limits:
        ephemeral-storage: "4Gi" 2
```

```

volumeMounts:
- name: ephemeral
  mountPath: "/tmp"
- name: log-aggregator
  image: images.my-company.example/log-aggregator:v6
resources:
  requests:
    ephemeral-storage: "2Gi"
  limits:
    ephemeral-storage: "4Gi"
volumeMounts:
- name: ephemeral
  mountPath: "/tmp"
volumes:
- name: ephemeral
  emptyDir: {}

```

- 1 Container request for local ephemeral storage.
- 2 Container limit for local ephemeral storage.

2.3.3. Ephemeral storage configuration effects pod scheduling and eviction

The settings in the pod spec affect both how the scheduler makes a decision about scheduling pods and when kubelet evicts pods.

- First, the scheduler ensures that the sum of the resource requests of the scheduled containers is less than the capacity of the node. In this case, the pod can be assigned to a node only if the node's available ephemeral storage (allocatable resource) is more than 4GiB.
- Second, at the container level, because the first container sets a resource limit, kubelet eviction manager measures the disk usage of this container and evicts the pod if the storage usage of the container exceeds its limit (4GiB). The kubelet eviction manager also marks the pod for eviction if the total usage exceeds the overall pod storage limit (8GiB).

2.4. MONITORING EPHEMERAL STORAGE

You can use `/bin/df` as a tool to monitor ephemeral storage usage on the volume where ephemeral container data is located, which is `/var/lib/kubelet` and `/var/lib/containers`. The available space for only `/var/lib/kubelet` is shown when you use the `df` command if `/var/lib/containers` is placed on a separate disk by the cluster administrator.

To show the human-readable values of used and available space in `/var/lib`, enter the following command:

```
$ df -h /var/lib
```

The output shows the ephemeral storage usage in `/var/lib`:

Example output

```

Filesystem Size Used Avail Use% Mounted on
/dev/disk/by-partuuid/4cd1448a-01 69G 32G 34G 49% /

```

CHAPTER 3. UNDERSTANDING PERSISTENT STORAGE

3.1. PERSISTENT STORAGE OVERVIEW

Managing storage is a distinct problem from managing compute resources. Red Hat OpenShift Service on AWS uses the Kubernetes persistent volume (PV) framework to allow cluster administrators to provision persistent storage for a cluster. Developers can use persistent volume claims (PVCs) to request PV resources without having specific knowledge of the underlying storage infrastructure.

PVCs are specific to a project, and are created and used by developers as a means to use a PV. PV resources on their own are not scoped to any single project; they can be shared across the entire Red Hat OpenShift Service on AWS cluster and claimed from any project. After a PV is bound to a PVC, that PV can not then be bound to additional PVCs. This has the effect of scoping a bound PV to a single namespace, that of the binding project.

PVs are defined by a **PersistentVolume** API object, which represents a piece of existing storage in the cluster that was either statically provisioned by the cluster administrator or dynamically provisioned using a **StorageClass** object. It is a resource in the cluster just like a node is a cluster resource.

PVs are volume plugins like **Volumes** but have a lifecycle that is independent of any individual pod that uses the PV. PV objects capture the details of the implementation of the storage, be that NFS, iSCSI, or a cloud-provider-specific storage system.



IMPORTANT

High availability of storage in the infrastructure is left to the underlying storage provider.

PVCs are defined by a **PersistentVolumeClaim** API object, which represents a request for storage by a developer. It is similar to a pod in that pods consume node resources and PVCs consume PV resources. For example, pods can request specific levels of resources, such as CPU and memory, while PVCs can request specific storage capacity and access modes. For example, they can be mounted once read-write or many times read-only.

3.2. LIFECYCLE OF A VOLUME AND CLAIM

PVs are resources in the cluster. PVCs are requests for those resources and also act as claim checks to the resource. The interaction between PVs and PVCs have the following lifecycle.

3.2.1. Provision storage

In response to requests from a developer defined in a PVC, a cluster administrator configures one or more dynamic provisioners that provision storage and a matching PV.

3.2.2. Bind claims

When you create a PVC, you request a specific amount of storage, specify the required access mode, and create a storage class to describe and classify the storage. The control loop in the master watches for new PVCs and binds the new PVC to an appropriate PV. If an appropriate PV does not exist, a provisioner for the storage class creates one.

The size of all PVs might exceed your PVC size. This is especially true with manually provisioned PVs. To minimize the excess, Red Hat OpenShift Service on AWS binds to the smallest PV that matches all other criteria.

Claims remain unbound indefinitely if a matching volume does not exist or can not be created with any available provisioner servicing a storage class. Claims are bound as matching volumes become available. For example, a cluster with many manually provisioned 50Gi volumes would not match a PVC requesting 100Gi. The PVC can be bound when a 100Gi PV is added to the cluster.

3.2.3. Use pods and claimed PVs

Pods use claims as volumes. The cluster inspects the claim to find the bound volume and mounts that volume for a pod. For those volumes that support multiple access modes, you must specify which mode applies when you use the claim as a volume in a pod.

Once you have a claim and that claim is bound, the bound PV belongs to you for as long as you need it. You can schedule pods and access claimed PVs by including **persistentVolumeClaim** in the pod's volumes block.



NOTE

If you attach persistent volumes that have high file counts to pods, those pods can fail or can take a long time to start. For more information, see [When using Persistent Volumes with high file counts in OpenShift, why do pods fail to start or take an excessive amount of time to achieve "Ready" state?](#).

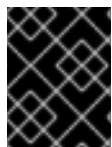
3.2.4. Release a persistent volume

When you are finished with a volume, you can delete the PVC object from the API, which allows reclamation of the resource. The volume is considered released when the claim is deleted, but it is not yet available for another claim. The previous claimant's data remains on the volume and must be handled according to policy.

3.2.5. Reclaim policy for persistent volumes

The reclaim policy of a persistent volume tells the cluster what to do with the volume after it is released. A volume's reclaim policy can be **Retain**, **Recycle**, or **Delete**.

- **Retain** reclaim policy allows manual reclamation of the resource for those volume plugins that support it.
- **Recycle** reclaim policy recycles the volume back into the pool of unbound persistent volumes once it is released from its claim.



IMPORTANT

The **Recycle** reclaim policy is deprecated in Red Hat OpenShift Service on AWS 4. Dynamic provisioning is recommended for equivalent and better functionality.

- **Delete** reclaim policy deletes both the **PersistentVolume** object from Red Hat OpenShift Service on AWS and the associated storage asset in external infrastructure, such as Amazon Elastic Block Store (Amazon EBS) or VMware vSphere.



NOTE

Dynamically provisioned volumes are always deleted.

3.2.6. Reclaiming a persistent volume manually

When a persistent volume claim (PVC) is deleted, the persistent volume (PV) still exists and is considered "released". However, the PV is not yet available for another claim because the data of the previous claimant remains on the volume.

Procedure

To manually reclaim the PV as a cluster administrator:

1. Delete the PV.

```
$ oc delete pv <pv-name>
```

The associated storage asset in the external infrastructure, such as an Amazon Elastic Block Store (Amazon EBS) volume, still exists after the PV is deleted.

2. Clean up the data on the associated storage asset.
3. Delete the associated storage asset. Alternately, to reuse the same storage asset, create a new PV with the storage asset definition.

The reclaimed PV is now available for use by another PVC.

3.2.7. Changing the reclaim policy of a persistent volume

To change the reclaim policy of a persistent volume:

1. List the persistent volumes in your cluster:

```
$ oc get pv
```

Example output

NAME	CAPACITY	ACCESSMODES	RECLAIMPOLICY	STATUS
CLAIM	STORAGECLASS	REASON	AGE	
pvc-b6efd8da-b7b5-11e6-9d58-0ed433a7dd94	4Gi	RWO	Delete	Bound
default/claim1	manual	10s		
pvc-b95650f8-b7b5-11e6-9d58-0ed433a7dd94	4Gi	RWO	Delete	Bound
default/claim2	manual	6s		
pvc-bb3ca71d-b7b5-11e6-9d58-0ed433a7dd94	4Gi	RWO	Delete	Bound
default/claim3	manual	3s		

2. Choose one of your persistent volumes and change its reclaim policy:

```
$ oc patch pv <your-pv-name> -p '{"spec":{"persistentVolumeReclaimPolicy":"Retain"}}'
```

3. Verify that your chosen persistent volume has the right policy:

```
$ oc get pv
```

Example output

NAME	CAPACITY	ACCESSMODES	RECLAIMPOLICY	STATUS
------	----------	-------------	---------------	--------

CLAIM	STORAGECLASS	REASON	AGE			
pvc-b6efd8da-b7b5-11e6-9d58-0ed433a7dd94	4Gi	RWO	Delete	Bound		
default/claim1	manual	10s				
pvc-b95650f8-b7b5-11e6-9d58-0ed433a7dd94	4Gi	RWO	Delete	Bound		
default/claim2	manual	6s				
pvc-bb3ca71d-b7b5-11e6-9d58-0ed433a7dd94	4Gi	RWO	Retain	Bound		
default/claim3	manual	3s				

In the preceding output, the volume bound to claim **default/claim3** now has a **Retain** reclaim policy. The volume will not be automatically deleted when a user deletes claim **default/claim3**.

3.3. PERSISTENT VOLUMES

Each PV contains a **spec** and **status**, which is the specification and status of the volume, for example:

PersistentVolume object definition example

```
apiVersion: v1
kind: PersistentVolume
metadata:
  name: pv0001 ❶
spec:
  capacity:
    storage: 5Gi ❷
  accessModes:
    - ReadWriteOnce ❸
  persistentVolumeReclaimPolicy: Retain ❹
  ...
status:
  ...
```

- ❶ Name of the persistent volume.
- ❷ The amount of storage available to the volume.
- ❸ The access mode, defining the read-write and mount permissions.
- ❹ The reclaim policy, indicating how the resource should be handled once it is released.

3.3.1. Types of PVs

Red Hat OpenShift Service on AWS (ROSA) supports the following persistent volume storage options:

- AWS Elastic Block Store (EBS)
- AWS Elastic File Store (EFS)

ROSA functions with Kubernetes Container Storage Interface (CSI) compatible volume provisioners from other storage vendors. See [Configuring CSI volumes](#) for more information about CSI drivers in ROSA.

3.3.2. Capacity

Generally, a persistent volume (PV) has a specific storage capacity. This is set by using the **capacity** attribute of the PV.

Currently, storage capacity is the only resource that can be set or requested. Future attributes may include IOPS, throughput, and so on.

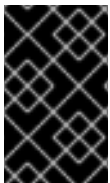
3.3.3. Access modes

A persistent volume can be mounted on a host in any way supported by the resource provider. Providers have different capabilities and each PV's access modes are set to the specific modes supported by that particular volume. For example, NFS can support multiple read-write clients, but a specific NFS PV might be exported on the server as read-only. Each PV gets its own set of access modes describing that specific PV's capabilities.

Claims are matched to volumes with similar access modes. The only two matching criteria are access modes and size. A claim's access modes represent a request. Therefore, you might be granted more, but never less. For example, if a claim requests RWO, but the only volume available is an NFS PV (RWO+ROX+RWX), the claim would then match NFS because it supports RWO.

Direct matches are always attempted first. The volume's modes must match or contain more modes than you requested. The size must be greater than or equal to what is expected. If two types of volumes, such as NFS and iSCSI, have the same set of access modes, either of them can match a claim with those modes. There is no ordering between types of volumes and no way to choose one type over another.

All volumes with the same modes are grouped, and then sorted by size, smallest to largest. The binder gets the group with matching modes and iterates over each, in size order, until one size matches.



IMPORTANT

Volume access modes describe volume capabilities. They are not enforced constraints. The storage provider is responsible for runtime errors resulting from invalid use of the resource. Errors in the provider show up at runtime as mount errors.

The following table lists the access modes:

Table 3.1. Access modes

Access Mode	CLI abbreviation	Description
ReadWriteOnce	RWO	The volume can be mounted as read-write by a single node.
ReadWriteOncePod ^[1]	RWOP	The volume can be mounted as read-write by a single pod on a single node.

1. ReadWriteOncePod access mode for persistent volumes is a Technology Preview feature.



IMPORTANT

ReadWriteOncePod access mode for persistent volumes is a Technology Preview feature only. Technology Preview features are not supported with Red Hat production service level agreements (SLAs) and might not be functionally complete. Red Hat does not recommend using them in production. These features provide early access to upcoming product features, enabling customers to test functionality and provide feedback during the development process.

For more information about the support scope of Red Hat Technology Preview features, see [Technology Preview Features Support Scope](#).

Table 3.2. Supported access modes for persistent volumes

Volume plugin	ReadWriteOnce [1]	ReadWriteOncePod [2]	ReadOnlyMany	ReadWriteMany
AWS EBS [3]	■	■	-	-
AWS EFS	■	■	■	■

1. ReadWriteOnce (RWO) volumes cannot be mounted on multiple nodes. If a node fails, the system does not allow the attached RWO volume to be mounted on a new node because it is already assigned to the failed node. If you encounter a multi-attach error message as a result, force delete the pod on a shutdown or crashed node to avoid data loss in critical workloads, such as when dynamic persistent volumes are attached.
2. ReadWriteOncePod is a Technology Preview feature.
3. Use a recreate deployment strategy for pods that rely on AWS EBS.
4. Only raw block volumes support the ReadWriteMany (RWX) access mode for Fibre Channel and iSCSI. For more information, see "Block volume support".

3.3.4. Phase

Volumes can be found in one of the following phases:

Table 3.3. Volume phases

Phase	Description
Available	A free resource not yet bound to a claim.
Bound	The volume is bound to a claim.
Released	The claim was deleted, but the resource is not yet reclaimed by the cluster.
Failed	The volume has failed its automatic reclamation.

You can view the name of the PVC that is bound to the PV by running the following command:

```
$ oc get pv <pv-claim>
```

3.3.4.1. Mount options

You can specify mount options while mounting a PV by using the attribute **mountOptions**.

For example:

Mount options example

```
apiVersion: v1
kind: PersistentVolume
metadata:
  name: pv0001
spec:
  capacity:
    storage: 1Gi
  accessModes:
    - ReadWriteOnce
  mountOptions: 1
    - nfsvers=4.1
  nfs:
    path: /tmp
    server: 172.17.0.2
  persistentVolumeReclaimPolicy: Retain
  claimRef:
    name: claim1
    namespace: default
```

1 Specified mount options are used while mounting the PV to the disk.

The following PV types support mount options:

- AWS Elastic Block Store (EBS)

3.4. PERSISTENT VOLUME CLAIMS

Each **PersistentVolumeClaim** object contains a **spec** and **status**, which is the specification and status of the persistent volume claim (PVC), for example:

PersistentVolumeClaim object definition example

```
kind: PersistentVolumeClaim
apiVersion: v1
metadata:
  name: myclaim 1
spec:
  accessModes:
    - ReadWriteOnce 2
  resources:
    requests:
```

```

storage: 8Gi 3
storageClassName: gold 4
status:
...
```

- 1** Name of the PVC.
- 2** The access mode, defining the read-write and mount permissions.
- 3** The amount of storage available to the PVC.
- 4** Name of the **StorageClass** required by the claim.

3.4.1. Storage classes

Claims can optionally request a specific storage class by specifying the storage class's name in the **storageClassName** attribute. Only PVs of the requested class, ones with the same **storageClassName** as the PVC, can be bound to the PVC. The cluster administrator can configure dynamic provisioners to service one or more storage classes. The cluster administrator can create a PV on demand that matches the specifications in the PVC.



IMPORTANT

The Cluster Storage Operator installs a default storage class. This storage class is owned and controlled by the Operator. It cannot be deleted or modified beyond defining annotations and labels. If different behavior is desired, you must define a custom storage class.

The cluster administrator can also set a default storage class for all PVCs. When a default storage class is configured, the PVC must explicitly ask for **StorageClass** or **storageClassName** annotations set to "" to be bound to a PV without a storage class.



NOTE

If more than one storage class is marked as default, a PVC can only be created if the **storageClassName** is explicitly specified. Therefore, only one storage class should be set as the default.

3.4.2. Access modes

Claims use the same conventions as volumes when requesting storage with specific access modes.

3.4.3. Resources

Claims, such as pods, can request specific quantities of a resource. In this case, the request is for storage. The same resource model applies to volumes and claims.

3.4.4. Claims as volumes

Pods access storage by using the claim as a volume. Claims must exist in the same namespace as the pod using the claim. The cluster finds the claim in the pod's namespace and uses it to get the **PersistentVolume** backing the claim. The volume is mounted to the host and into the pod, for example:

Mount volume to the host and into the pod example

```

kind: Pod
apiVersion: v1
metadata:
  name: mypod
spec:
  containers:
  - name: myfrontend
    image: dockerfile/nginx
    volumeMounts:
    - mountPath: "/var/www/html" ❶
      name: mypd ❷
  volumes:
  - name: mypd
    persistentVolumeClaim:
      claimName: myclaim ❸

```

- ❶ Path to mount the volume inside the pod.
- ❷ Name of the volume to mount. Do not mount to the container root, `/`, or any path that is the same in the host and the container. This can corrupt your host system if the container is sufficiently privileged, such as the host `/dev/pts` files. It is safe to mount the host by using `/host`.
- ❸ Name of the PVC, that exists in the same namespace, to use.

3.5. BLOCK VOLUME SUPPORT

Red Hat OpenShift Service on AWS can statically provision raw block volumes. These volumes do not have a file system, and can provide performance benefits for applications that either write to the disk directly or implement their own storage service.

Raw block volumes are provisioned by specifying **volumeMode: Block** in the PV and PVC specification.



IMPORTANT

Pods using raw block volumes must be configured to allow privileged containers.

The following table displays which volume plugins support block volumes.

Table 3.4. Block volume support

Volume Plugin	Manually provisioned	Dynamically provisioned	Fully supported
Amazon Elastic Block Store (Amazon EBS)	■	■	■
Amazon Elastic File Storage (Amazon EFS)			

3.5.1. Block volume examples

PV example

```

apiVersion: v1
kind: PersistentVolume
metadata:
  name: block-pv
spec:
  capacity:
    storage: 10Gi
  accessModes:
    - ReadWriteOnce
  volumeMode: Block 1
  persistentVolumeReclaimPolicy: Retain
  fc:
    targetWWNs: ["50060e801049cfd1"]
    lun: 0
    readOnly: false

```

1 **volumeMode** must be set to **Block** to indicate that this PV is a raw block volume.

PVC example

```

apiVersion: v1
kind: PersistentVolumeClaim
metadata:
  name: block-pvc
spec:
  accessModes:
    - ReadWriteOnce
  volumeMode: Block 1
  resources:
    requests:
      storage: 10Gi

```

1 **volumeMode** must be set to **Block** to indicate that a raw block PVC is requested.

Pod specification example

```

apiVersion: v1
kind: Pod
metadata:
  name: pod-with-block-volume
spec:
  containers:
    - name: fc-container
      image: fedora:26
      command: ["/bin/sh", "-c"]
      args: [ "tail -f /dev/null" ]
      volumeDevices: 1
        - name: data

```

```

    devicePath: /dev/xvda 2
  volumes:
  - name: data
    persistentVolumeClaim:
      claimName: block-pvc 3

```

- 1** **volumeDevices**, instead of **volumeMounts**, is used for block devices. Only **PersistentVolumeClaim** sources can be used with raw block volumes.
- 2** **devicePath**, instead of **mountPath**, represents the path to the physical device where the raw block is mapped to the system.
- 3** The volume source must be of type **persistentVolumeClaim** and must match the name of the PVC as expected.

Table 3.5. Accepted values for **volumeMode**

Value	Default
Filesystem	Yes
Block	No

Table 3.6. Binding scenarios for block volumes

PV volumeMode	PVC volumeMode	Binding result
Filesystem	Filesystem	Bind
Unspecified	Unspecified	Bind
Filesystem	Unspecified	Bind
Unspecified	Filesystem	Bind
Block	Block	Bind
Unspecified	Block	No Bind
Block	Unspecified	No Bind
Filesystem	Block	No Bind
Block	Filesystem	No Bind

**IMPORTANT**

Unspecified values result in the default value of **Filesystem**.

3.6. USING FSGROUP TO REDUCE POD TIMEOUTS

If a storage volume contains many files (~1,000,000 or greater), you may experience pod timeouts.

This can occur because, by default, Red Hat OpenShift Service on AWS recursively changes ownership and permissions for the contents of each volume to match the **fsGroup** specified in a pod's **securityContext** when that volume is mounted. For large volumes, checking and changing ownership and permissions can be time consuming, slowing pod startup. You can use the **fsGroupChangePolicy** field inside a **securityContext** to control the way that Red Hat OpenShift Service on AWS checks and manages ownership and permissions for a volume.

fsGroupChangePolicy defines behavior for changing ownership and permission of the volume before being exposed inside a pod. This field only applies to volume types that support **fsGroup**-controlled ownership and permissions. This field has two possible values:

- **OnRootMismatch**: Only change permissions and ownership if permission and ownership of root directory does not match with expected permissions of the volume. This can help shorten the time it takes to change ownership and permission of a volume to reduce pod timeouts.
- **Always**: Always change permission and ownership of the volume when a volume is mounted.

fsGroupChangePolicy example

```
securityContext:
  runAsUser: 1000
  runAsGroup: 3000
  fsGroup: 2000
  fsGroupChangePolicy: "OnRootMismatch" 1
  ...
```

- 1** **OnRootMismatch** specifies skipping recursive permission change, thus helping to avoid pod timeout problems.



NOTE

The **fsGroupChangePolicy** field has no effect on ephemeral volume types, such as `secret`, `configMap`, and `emptydir`.

CHAPTER 4. CONFIGURING PERSISTENT STORAGE

4.1. PERSISTENT STORAGE USING AWS ELASTIC BLOCK STORE

Red Hat OpenShift Service on AWS clusters are prebuilt with four storage classes that use Amazon Elastic Block Store (Amazon EBS) volumes. These storage classes are ready to use and some familiarity with Kubernetes and AWS is assumed.

Following are the four prebuilt storage classes:

Name	Provisioner
gp2	kubernetes.io/aws-ebs
gp2-csi	ebs.csi.aws.com
gp3 (default)	kubernetes.io/aws-ebs
gp3-csi	ebs.csi.aws.com

The gp3 storage class is set as default; however, you can select any of the storage classes as the default storage class.

The Kubernetes persistent volume framework allows administrators to provision a cluster with persistent storage and gives users a way to request those resources without having any knowledge of the underlying infrastructure. You can dynamically provision Amazon EBS volumes. Persistent volumes are not bound to a single project or namespace; they can be shared across the Red Hat OpenShift Service on AWS cluster. Persistent volume claims are specific to a project or namespace and can be requested by users. You can define a KMS key to encrypt container-persistent volumes on AWS. By default, newly created clusters using Red Hat OpenShift Service on AWS version 4.10 and later use gp3 storage and the [AWS EBS CSI driver](#).



IMPORTANT

High-availability of storage in the infrastructure is left to the underlying storage provider.

4.1.1. Creating the EBS storage class

Storage classes are used to differentiate and delineate storage levels and usages. By defining a storage class, users can obtain dynamically provisioned persistent volumes.

4.1.2. Creating the persistent volume claim

Prerequisites

Storage must exist in the underlying infrastructure before it can be mounted as a volume in Red Hat OpenShift Service on AWS.

Procedure

1. In the Red Hat OpenShift Service on AWS console, click **Storage → Persistent Volume Claims**

2. In the persistent volume claims overview, click **Create Persistent Volume Claim**
3. Define the desired options on the page that appears.
 - a. Select the previously-created storage class from the drop-down menu.
 - b. Enter a unique name for the storage claim.
 - c. Select the access mode. This selection determines the read and write access for the storage claim.
 - d. Define the size of the storage claim.
4. Click **Create** to create the persistent volume claim and generate a persistent volume.

4.1.3. Volume format

Before Red Hat OpenShift Service on AWS mounts the volume and passes it to a container, it checks that the volume contains a file system as specified by the **fsType** parameter in the persistent volume definition. If the device is not formatted with the file system, all data from the device is erased and the device is automatically formatted with the given file system.

This verification enables you to use unformatted AWS volumes as persistent volumes, because Red Hat OpenShift Service on AWS formats them before the first use.

4.1.4. Maximum number of EBS volumes on a node

By default, Red Hat OpenShift Service on AWS supports a maximum of 39 EBS volumes attached to one node. This limit is consistent with the [AWS volume limits](#). The volume limit depends on the instance type.



IMPORTANT

As a cluster administrator, you must use either in-tree or Container Storage Interface (CSI) volumes and their respective storage classes, but never both volume types at the same time. The maximum attached EBS volume number is counted separately for in-tree and CSI volumes, which means you could have up to 39 EBS volumes of each type.

For information about accessing additional storage options, such as volume snapshots, that are not possible with in-tree volume plug-ins, see [AWS Elastic Block Store CSI Driver Operator](#).

4.1.5. Encrypting container persistent volumes on AWS with a KMS key

Defining a KMS key to encrypt container-persistent volumes on AWS is useful when you have explicit compliance and security guidelines when deploying to AWS.

Prerequisites

- Underlying infrastructure must contain storage.
- You must create a customer KMS key on AWS.

Procedure

1. Create a storage class:

```
$ cat << EOF | oc create -f -
apiVersion: storage.k8s.io/v1
kind: StorageClass
metadata:
  name: <storage-class-name> 1
parameters:
  fsType: ext4 2
  encrypted: "true"
  kmsKeyId: keyvalue 3
provisioner: ebs.csi.aws.com
reclaimPolicy: Delete
volumeBindingMode: WaitForFirstConsumer
EOF
```

- 1 Specifies the name of the storage class.
- 2 File system that is created on provisioned volumes.
- 3 Specifies the full Amazon Resource Name (ARN) of the key to use when encrypting the container-persistent volume. If you do not provide any key, but the **encrypted** field is set to **true**, then the default KMS key is used. See [Finding the key ID and key ARN on AWS](#) in the AWS documentation.

2. Create a persistent volume claim (PVC) with the storage class specifying the KMS key:

```
$ cat << EOF | oc create -f -
apiVersion: v1
kind: PersistentVolumeClaim
metadata:
  name: mypvc
spec:
  accessModes:
    - ReadWriteOnce
  volumeMode: Filesystem
  storageClassName: <storage-class-name>
resources:
  requests:
    storage: 1Gi
EOF
```

3. Create workload containers to consume the PVC:

```
$ cat << EOF | oc create -f -
kind: Pod
metadata:
  name: mypod
spec:
  containers:
    - name: httpd
      image: quay.io/centos7/httpd-24-centos7
      ports:
        - containerPort: 80
      volumeMounts:
        - mountPath: /mnt/storage
```

```
    name: data
  volumes:
  - name: data
    persistentVolumeClaim:
      claimName: mypvc
EOF
```

4.1.6. Additional resources

- See [AWS Elastic Block Store CSI Driver Operator](#) for information about accessing additional storage options, such as volume snapshots, that are not possible with in-tree volume plugins.

CHAPTER 5. USING CONTAINER STORAGE INTERFACE (CSI)

5.1. CONFIGURING CSI VOLUMES

The Container Storage Interface (CSI) allows Red Hat OpenShift Service on AWS to consume storage from storage back ends that implement the [CSI interface](#) as persistent storage.



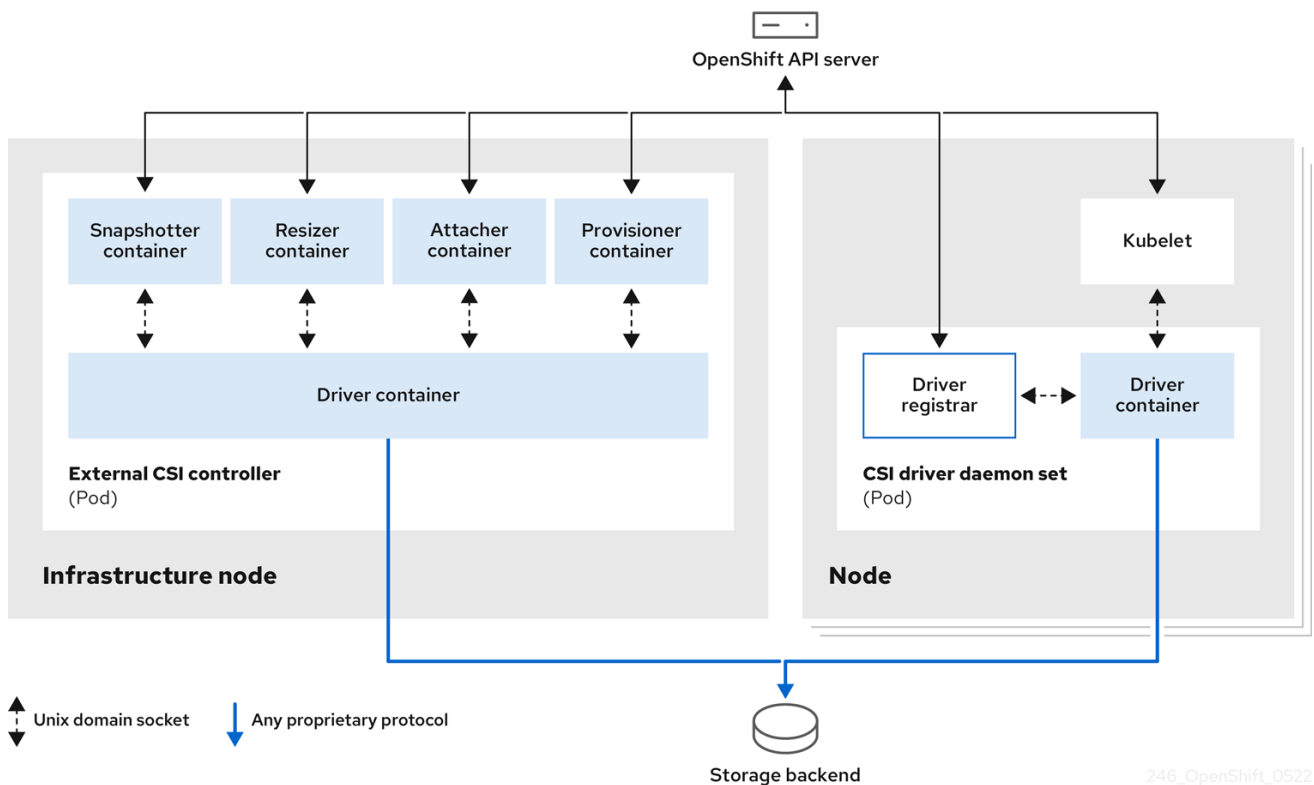
NOTE

Red Hat OpenShift Service on AWS 4 supports version 1.6.0 of the [CSI specification](#).

5.1.1. CSI architecture

CSI drivers are typically shipped as container images. These containers are not aware of Red Hat OpenShift Service on AWS where they run. To use CSI-compatible storage back end in Red Hat OpenShift Service on AWS, the cluster administrator must deploy several components that serve as a bridge between Red Hat OpenShift Service on AWS and the storage driver.

The following diagram provides a high-level overview about the components running in pods in the Red Hat OpenShift Service on AWS cluster.



It is possible to run multiple CSI drivers for different storage back ends. Each driver needs its own external controllers deployment and daemon set with the driver and CSI registrar.

5.1.1.1. External CSI controllers

External CSI controllers is a deployment that deploys one or more pods with five containers:

- The snapshotter container watches **VolumeSnapshot** and **VolumeSnapshotContent** objects and is responsible for the creation and deletion of **VolumeSnapshotContent** object.

- The resizer container is a sidecar container that watches for **PersistentVolumeClaim** updates and triggers **ControllerExpandVolume** operations against a CSI endpoint if you request more storage on **PersistentVolumeClaim** object.
- An external CSI attacher container translates **attach** and **detach** calls from Red Hat OpenShift Service on AWS to respective **ControllerPublish** and **ControllerUnpublish** calls to the CSI driver.
- An external CSI provisioner container that translates **provision** and **delete** calls from Red Hat OpenShift Service on AWS to respective **CreateVolume** and **DeleteVolume** calls to the CSI driver.
- A CSI driver container.

The CSI attacher and CSI provisioner containers communicate with the CSI driver container using UNIX Domain Sockets, ensuring that no CSI communication leaves the pod. The CSI driver is not accessible from outside of the pod.



NOTE

The **attach**, **detach**, **provision**, and **delete** operations typically require the CSI driver to use credentials to the storage backend. Run the CSI controller pods on infrastructure nodes so the credentials are never leaked to user processes, even in the event of a catastrophic security breach on a compute node.



NOTE

The external attacher must also run for CSI drivers that do not support third-party **attach** or **detach** operations. The external attacher will not issue any **ControllerPublish** or **ControllerUnpublish** operations to the CSI driver. However, it still must run to implement the necessary Red Hat OpenShift Service on AWS attachment API.

5.1.1.2. CSI driver daemon set

The CSI driver daemon set runs a pod on every node that allows Red Hat OpenShift Service on AWS to mount storage provided by the CSI driver to the node and use it in user workloads (pods) as persistent volumes (PVs). The pod with the CSI driver installed contains the following containers:

- A CSI driver registrar, which registers the CSI driver into the **openshift-node** service running on the node. The **openshift-node** process running on the node then directly connects with the CSI driver using the UNIX Domain Socket available on the node.
- A CSI driver.

The CSI driver deployed on the node should have as few credentials to the storage back end as possible. Red Hat OpenShift Service on AWS will only use the node plugin set of CSI calls such as **NodePublish/NodeUnpublish** and **NodeStage/NodeUnstage**, if these calls are implemented.

5.1.2. CSI drivers supported by Red Hat OpenShift Service on AWS

Red Hat OpenShift Service on AWS installs certain CSI drivers by default, giving users storage options that are not possible with in-tree volume plugins.

To create CSI-provisioned persistent volumes that mount to these supported storage assets, Red Hat OpenShift Service on AWS installs the necessary CSI driver Operator, the CSI driver, and the required

storage class by default. For more details about the default namespace of the Operator and driver, see the documentation for the specific CSI Driver Operator.

The following table describes the CSI drivers that are installed with Red Hat OpenShift Service on AWS and which CSI features they support, such as volume snapshots and resize.

Table 5.1. Supported CSI drivers and features in Red Hat OpenShift Service on AWS

CSI driver	CSI volume snapshots	CSI cloning	CSI resize	Inline ephemeral volumes
AWS EBS	■	-	■	-
AWS EFS	-	-	-	-

In addition to the drivers listed in the preceding table, ROSA functions with CSI drivers from third-party storage vendors. Red Hat does not oversee third-party provisioners or the connected CSI drivers and the vendors fully control source code, deployment, operation, and Kubernetes compatibility. These volume provisioners are considered customer-managed and the respective vendors are responsible for providing support. See the [Shared responsibilities for Red Hat OpenShift Service on AWS](#) matrix for more information.

5.1.3. Dynamic provisioning

Dynamic provisioning of persistent storage depends on the capabilities of the CSI driver and underlying storage back end. The provider of the CSI driver should document how to create a storage class in Red Hat OpenShift Service on AWS and the parameters available for configuration.

The created storage class can be configured to enable dynamic provisioning.

Procedure

- Create a default storage class that ensures all PVCs that do not require any special storage class are provisioned by the installed CSI driver.

```
# oc create -f - << EOF
apiVersion: storage.k8s.io/v1
kind: StorageClass
metadata:
  name: <storage-class> 1
annotations:
  storageclass.kubernetes.io/is-default-class: "true"
provisioner: <provisioner-name> 2
parameters:
EOF
```

1 The name of the storage class that will be created.

2 The name of the CSI driver that has been installed.

5.1.4. Example using the CSI driver

The following example installs a default MySQL template without any changes to the template.

Prerequisites

- The CSI driver has been deployed.
- A storage class has been created for dynamic provisioning.

Procedure

- Create the MySQL template:

```
# oc new-app mysql-persistent
```

Example output

```
--> Deploying template "openshift/mysql-persistent" to project default
...
```

```
# oc get pvc
```

Example output

NAME	STATUS	VOLUME	CAPACITY
ACCESS MODES	STORAGECLASS	AGE	
mysql	Bound	kubernetes-dynamic-pv-3271ffcb4e1811e8	1Gi
RWO	cinder	3s	

5.2. MANAGING THE DEFAULT STORAGE CLASS

5.2.1. Overview

Managing the default storage class allows you to accomplish several different objectives:

- Enforcing static provisioning by disabling dynamic provisioning.
- When you have other preferred storage classes, preventing the storage operator from re-creating the initial default storage class.
- Renaming, or otherwise changing, the default storage class

To accomplish these objectives, you change the setting for the **spec.storageClassState** field in the **ClusterCSIDriver** object. The possible settings for this field are:

- **Managed:** (Default) The Container Storage Interface (CSI) operator is actively managing its default storage class, so that most manual changes made by a cluster administrator to the default storage class are removed, and the default storage class is continuously re-created if you attempt to manually delete it.

- **Unmanaged:** You can modify the default storage class. The CSI operator is not actively managing storage classes, so that it is not reconciling the default storage class it creates automatically.
- **Removed:** The CSI operators deletes the default storage class.

5.2.2. Managing the default storage class using the web console

Prerequisites

- Access to the Red Hat OpenShift Service on AWS web console.
- Access to the cluster with cluster-admin privileges.

Procedure

To manage the default storage class using the web console:

1. Log in to the web console.
2. Click **Administration** > **CustomResourceDefinitions**.
3. On the **CustomResourceDefinitions** page, type **clustercsidriver** to find the **ClusterCSIDriver** object.
4. Click **ClusterCSIDriver**, and then click the **Instances** tab.
5. Click the name of the desired instance, and then click the **YAML** tab.
6. Add the **spec.storageClassState** field with a value of **Managed**, **Unmanaged**, or **Removed**.

Example

```
...
spec:
  driverConfig:
    driverType: "
  logLevel: Normal
  managementState: Managed
  observedConfig: null
  operatorLogLevel: Normal
  storageClassState: Unmanaged 1
...
```

- 1** **spec.storageClassState** field set to "Unmanaged"

7. Click **Save**.

5.2.3. Managing the default storage class using the CLI

Prerequisites

- Access to the cluster with cluster-admin privileges.

Procedure

To manage the storage class using the CLI, run the following command:

```
oc patch clustercsidriver $DRIVERNAME --type=merge -p '{"spec": {"storageClassState": "${STATE}"}' 1
```

1 Where **STATE** is "Removed" or "Managed" or "Unmanaged".

Where **DRIVERNAME** is the provisioner name. You can find the provisioner name by running the command **oc get sc**.

5.2.4. Absent or multiple default storage classes

5.2.4.1. Multiple default storage classes

Multiple default storage classes can occur if you mark a non-default storage class as default and do not unset the existing default storage class, or you create a default storage class when a default storage class is already present. With multiple default storage classes present, any persistent volume claim (PVC) requesting the default storage class (**pvc.spec.storageClassName=nil**) gets the most recently created default storage class, regardless of the default status of that storage class, and the administrator receives an alert in the alerts dashboard that there are multiple default storage classes, **MultipleDefaultStorageClasses**.

5.2.4.2. Absent default storage class

There are two possible scenarios where PVCs can attempt to use a non-existent default storage class:

- An administrator removes the default storage class or marks it as non-default, and then a user creates a PVC requesting the default storage class.
- During installation, the installer creates a PVC requesting the default storage class, which has not yet been created.

In the preceding scenarios, PVCs remain in the pending state indefinitely. To resolve this situation, create a default storage class or declare one of the existing storage classes as the default. As soon as the default storage class is created or declared, the PVCs get the new default storage class. If possible, the PVCs eventually bind to statically or dynamically provisioned PVs as usual, and move out of the pending state.

5.2.5. Changing the default storage class

Use the following procedure to change the default storage class.

For example, if you have two defined storage classes, **gp3** and **standard**, and you want to change the default storage class from **gp3** to **standard**.

Prerequisites

- Access to the cluster with cluster-admin privileges.

Procedure

To change the default storage class:

1. List the storage classes:

```
$ oc get storageclass
```

Example output

NAME	TYPE
gp3 (default)	kubernetes.io/aws-ebs 1
standard	kubernetes.io/aws-ebs

- 1** **(default)** indicates the default storage class.

2. Make the desired storage class the default.

For the desired storage class, set the **storageclass.kubernetes.io/is-default-class** annotation to **true** by running the following command:

```
$ oc patch storageclass standard -p '{"metadata": {"annotations": {"storageclass.kubernetes.io/is-default-class": "true"}}}'
```



NOTE

You can have multiple default storage classes for a short time. However, you should ensure that only one default storage class exists eventually.

With multiple default storage classes present, any persistent volume claim (PVC) requesting the default storage class (**pvc.spec.storageClassName=nil**) gets the most recently created default storage class, regardless of the default status of that storage class, and the administrator receives an alert in the alerts dashboard that there are multiple default storage classes, **MultipleDefaultStorageClasses**.

3. Remove the default storage class setting from the old default storage class.

For the old default storage class, change the value of the **storageclass.kubernetes.io/is-default-class** annotation to **false** by running the following command:

```
$ oc patch storageclass gp3 -p '{"metadata": {"annotations": {"storageclass.kubernetes.io/is-default-class": "false"}}}'
```

4. Verify the changes:

```
$ oc get storageclass
```

Example output

NAME	TYPE
gp3	kubernetes.io/aws-ebs
standard (default)	kubernetes.io/aws-ebs

5.3. AWS ELASTIC BLOCK STORE CSI DRIVER OPERATOR

5.3.1. Overview

Red Hat OpenShift Service on AWS is capable of provisioning persistent volumes (PVs) using the [AWS EBS CSI driver](#).

Familiarity with [persistent storage](#) and [configuring CSI volumes](#) is recommended when working with a Container Storage Interface (CSI) Operator and driver.

To create CSI-provisioned PVs that mount to AWS EBS storage assets, Red Hat OpenShift Service on AWS installs the [AWS EBS CSI Driver Operator](#) (a Red Hat operator) and the AWS EBS CSI driver by default in the **openshift-cluster-csi-drivers** namespace.

- The *AWS EBS CSI Driver Operator* provides a StorageClass by default that you can use to create PVCs. You can disable this default storage class if desired (see [Managing the default storage class](#)). You also have the option to create the AWS EBS StorageClass as described in [Persistent storage using Amazon Elastic Block Store](#).
- The *AWS EBS CSI driver* enables you to create and mount AWS EBS PVs.

5.3.2. About CSI

Storage vendors have traditionally provided storage drivers as part of Kubernetes. With the implementation of the Container Storage Interface (CSI), third-party providers can instead deliver storage plugins using a standard interface without ever having to change the core Kubernetes code.

CSI Operators give Red Hat OpenShift Service on AWS users storage options, such as volume snapshots, that are not possible with in-tree volume plugins.



IMPORTANT

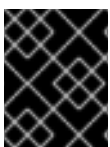
Red Hat OpenShift Service on AWS defaults to using the CSI plugin to provision Amazon Elastic Block Store (Amazon EBS) storage.

For information about dynamically provisioning AWS EBS persistent volumes in Red Hat OpenShift Service on AWS, see [Persistent storage using Amazon Elastic Block Store](#).

Additional resources

- [Persistent storage using Amazon Elastic Block Store](#)
- [Configuring CSI volumes](#)

5.4. SETTING UP AWS ELASTIC FILE SERVICE CSI DRIVER OPERATOR



IMPORTANT

This procedure is specific to the [AWS EFS CSI Driver Operator](#) (a Red Hat operator), which is only applicable for Red Hat OpenShift Service on AWS 4.10 and later versions.

5.4.1. Overview

Red Hat OpenShift Service on AWS is capable of provisioning persistent volumes (PVs) using the [AWS EFS CSI driver](#).

Familiarity with [persistent storage](#) and [configuring CSI volumes](#) is recommended when working with a CSI Operator and driver.

After installing the AWS EFS CSI Driver Operator, Red Hat OpenShift Service on AWS installs the AWS EFS CSI Operator and the AWS EFS CSI driver by default in the **openshift-cluster-csi-drivers** namespace. This allows the AWS EFS CSI Driver Operator to create CSI-provisioned PVs that mount to AWS EFS assets.

- The *AWS EFS CSI Driver Operator*, after being installed, does not create a storage class by default to use to create persistent volume claims (PVCs). However, you can manually create the AWS EFS **StorageClass**. The AWS EFS CSI Driver Operator supports dynamic volume provisioning by allowing storage volumes to be created on-demand. This eliminates the need for cluster administrators to pre-provision storage.
- The *AWS EFS CSI driver* enables you to create and mount AWS EFS PVs.



NOTE

Amazon Elastic File Storage (Amazon EFS) only supports regional volumes, not zonal volumes.

5.4.2. About CSI

Storage vendors have traditionally provided storage drivers as part of Kubernetes. With the implementation of the Container Storage Interface (CSI), third-party providers can instead deliver storage plugins using a standard interface without ever having to change the core Kubernetes code.

CSI Operators give Red Hat OpenShift Service on AWS users storage options, such as volume snapshots, that are not possible with in-tree volume plugins.

5.4.3. Setting up the AWS EFS CSI Driver Operator

1. Install the [AWS EFS CSI Driver Operator](#) (a Red Hat operator).
2. If you are using Amazon Elastic File Storage (Amazon EFS) with AWS Secure Token Service (STS), configure the [AWS EFS CSI driver](#) with STS.
3. If you are using AWS EFS with AWS Secure Token Service (STS), obtain a role Amazon Resource Name (ARN) for STS. This is required for installing the AWS EFS CSI Driver Operator.
4. Install the AWS EFS CSI Driver Operator.
5. Install the AWS EFS CSI Driver.

5.4.3.1. Installing the AWS EFS CSI Driver Operator

The [AWS EFS CSI Driver Operator](#) (a Red Hat operator) is not installed in Red Hat OpenShift Service on AWS by default. Use the following procedure to install and configure the AWS EFS CSI Driver Operator in your cluster.

Prerequisites

- Access to the Red Hat OpenShift Service on AWS web console.

Procedure

To install the AWS EFS CSI Driver Operator from the web console:

1. Log in to the web console.
2. Install the AWS EFS CSI Operator:
 - a. Click **Operators** → **OperatorHub**.
 - b. Locate the AWS EFS CSI Operator by typing **AWS EFS CSI** in the filter box.
 - c. Click the **AWS EFS CSI Driver Operator** button.



IMPORTANT

Be sure to select the **AWS EFS CSI Driver Operator** and not the **AWS EFS Operator**. The **AWS EFS Operator** is a community Operator and is not supported by Red Hat.

- d. On the **AWS EFS CSI Driver Operator** page, click **Install**.
- e. On the **Install Operator** page, ensure that:
 - If you are using AWS EFS with AWS Secure Token Service (STS), in the **role ARN** field, enter the ARN role copied from the last step of the *Obtaining a role Amazon Resource Name for Security Token Service* procedure.
 - **All namespaces on the cluster (default)** is selected.
 - **Installed Namespace** is set to **openshift-cluster-csi-drivers**.
- f. Click **Install**.
After the installation finishes, the AWS EFS CSI Operator is listed in the **Installed Operators** section of the web console.

Next steps

- If you are using Amazon EFS with AWS Secure Token Service (STS), you must configure the AWS EFS CSI driver with STS. For more information, see [Configuring AWS EFS CSI Driver with STS](#).

5.4.3.2. Configuring AWS EFS CSI Driver Operator with Secure Token Service

This procedure explains how to configure the [AWS EFS CSI Driver Operator](#) (a Red Hat operator) with Red Hat OpenShift Service on AWS on AWS Secure Token Service (STS).

Perform this procedure before you have installed the AWS EFS CSI Operator, but not yet installed the [AWS EFS CSI driver](#) as part of the *Installing the AWS EFS CSI Driver Operator* procedure.



IMPORTANT

If you perform this procedure after installing the driver and creating volumes, your volumes will fail to mount into pods.

Prerequisites

- You have access to the cluster as a user with the cluster-admin role.
- AWS account credentials
- You have installed the AWS EFS CSI Operator.

Procedure

1. Prepare the AWS account:
 - a. Create an IAM policy JSON file with the following content:

```
{
  "Version": "2012-10-17",
  "Statement": [
    {
      "Effect": "Allow",
      "Action": [
        "elasticfilesystem:DescribeAccessPoints",
        "elasticfilesystem:DescribeFileSystems",
        "elasticfilesystem:DescribeMountTargets",
        "ec2:DescribeAvailabilityZones",
        "elasticfilesystem:TagResource"
      ],
      "Resource": "*"
    },
    {
      "Effect": "Allow",
      "Action": [
        "elasticfilesystem:CreateAccessPoint"
      ],
      "Resource": "*",
      "Condition": {
        "StringLike": {
          "aws:RequestTag/efs.csi.aws.com/cluster": "true"
        }
      }
    },
    {
      "Effect": "Allow",
      "Action": "elasticfilesystem:DeleteAccessPoint",
      "Resource": "*",
      "Condition": {
        "StringEquals": {
          "aws:ResourceTag/efs.csi.aws.com/cluster": "true"
        }
      }
    }
  ]
}
```

- b. Create an IAM trust JSON file with the following content:

```
{
  "Version": "2012-10-17",
  "Statement": [
```



```

{
  "Effect": "Allow",
  "Principal": {
    "Federated": "arn:aws:iam::<your_aws_account_ID>:oidc-
provider/<openshift_oidc_provider>" ❶
  },
  "Action": "sts:AssumeRoleWithWebIdentity",
  "Condition": {
    "StringEquals": {
      "<openshift_oidc_provider>.sub": [ ❷
        "system:serviceaccount:openshift-cluster-csi-drivers:aws-efs-csi-driver-operator",
        "system:serviceaccount:openshift-cluster-csi-drivers:aws-efs-csi-driver-controller-
sa"
      ]
    }
  }
}

```

- ❶ Specify your AWS account ID and the OpenShift OIDC provider endpoint. Obtain the endpoint by running the following command:

```

$ rosa describe cluster \
-c $(oc get clusterversion -o jsonpath='{.items[].spec.clusterID}' | tr -d '\n') \
-o yaml | awk '/oidc_endpoint_url/ {print $2}' | cut -d '/' -f 3,4

```

- ❷ Specify the OpenShift OIDC endpoint again.

- c. Create the IAM role:

```

ROLE_ARN=$(aws iam create-role \
--role-name "<your_cluster_name>-aws-efs-csi-operator" \
--assume-role-policy-document file://<your_trust_file_name>.json \
--query "Role.Arn" --output text); echo $ROLE_ARN

```

Save the output. You will use it in the next steps.

- d. Create the IAM policy:

```

POLICY_ARN=$(aws iam create-policy \
--policy-name "<your_rosa_cluster_name>-rosa-efs-csi" \
--policy-document file://<your_policy_file_name>.json \
--query 'Policy.Arn' --output text); echo $POLICY_ARN

```

- e. Attach the IAM policy to the IAM role:

```

$ aws iam attach-role-policy \
--role-name "<your_rosa_cluster_name>-aws-efs-csi-operator" \
--policy-arn $POLICY_ARN

```

2. Create a **Secret** YAML file for the driver operator:

```

apiVersion: v1
kind: Secret
metadata:
  name: aws-efs-cloud-credentials
  namespace: openshift-cluster-csi-drivers
stringData:
  credentials: |-
    [default]
    sts_regional_endpoints = regional
    role_arn = <role_ARN> 1
    web_identity_token_file = /var/run/secrets/openshift/serviceaccount/token

```

- 1 Replace **role_ARN** with the output you saved while creating the role.

3. Create the secret:

```
$ oc apply -f aws-efs-cloud-credentials.yaml
```

You are now ready to install the AWS EFS CSI driver.

Additional resources

- [Installing the AWS EFS CSI Driver Operator](#)
- [Installing the AWS EFS CSI Driver](#)

5.4.3.3. Installing the AWS EFS CSI Driver

After installing the [AWS EFS CSI Driver Operator](#) (a Red Hat operator) and configuring it with STS, you install the [AWS EFS CSI driver](#).

Prerequisites

- Access to the Red Hat OpenShift Service on AWS web console.

Procedure

1. Click **Administration** → **CustomResourceDefinitions** → **ClusterCSIDriver**.
2. On the **Instances** tab, click **Create ClusterCSIDriver**.
3. Use the following YAML file:

```

apiVersion: operator.openshift.io/v1
kind: ClusterCSIDriver
metadata:
  name: efs.csi.aws.com
spec:
  managementState: Managed

```

4. Click **Create**.
5. Wait for the following Conditions to change to a "True" status:

- AWSEFSDriverNodeServiceControllerAvailable
- AWSEFSDriverControllerServiceControllerAvailable

5.4.4. Creating the AWS EFS storage class

Storage classes are used to differentiate and delineate storage levels and usages. By defining a storage class, users can obtain dynamically provisioned persistent volumes.

The *AWS EFS CSI Driver Operator* (a Red Hat operator), after being installed, does not create a storage class by default. However, you can manually create the AWS EFS storage class.

5.4.4.1. Creating the AWS EFS storage class using the console

Procedure

1. In the Red Hat OpenShift Service on AWS console, click **Storage** → **StorageClasses**.
2. On the **StorageClasses** page, click **Create StorageClass**.
3. On the **StorageClass** page, perform the following steps:
 - a. Enter a name to reference the storage class.
 - b. Optional: Enter the description.
 - c. Select the reclaim policy.
 - d. Select **efs.csi.aws.com** from the **Provisioner** drop-down list.
 - e. Optional: Set the configuration parameters for the selected provisioner.
4. Click **Create**.

5.4.4.2. Creating the AWS EFS storage class using the CLI

Procedure

- Create a **StorageClass** object:

```
kind: StorageClass
apiVersion: storage.k8s.io/v1
metadata:
  name: efs-sc
provisioner: efs.csi.aws.com
parameters:
  provisioningMode: efs-ap 1
  filesystemId: fs-a5324911 2
  directoryPerms: "700" 3
  gidRangeStart: "1000" 4
  gidRangeEnd: "2000" 5
  basePath: "/dynamic_provisioning" 6
```

- 1** **provisioningMode** must be **efs-ap** to enable dynamic provisioning.

- 2 **fileSystemId** must be the ID of the EFS volume created manually.
- 3 **directoryPerms** is the default permission of the root directory of the volume. In this example, the volume is accessible only by the owner.
- 4 5 **gidRangeStart** and **gidRangeEnd** set the range of POSIX Group IDs (GIDs) that are used to set the GID of the AWS access point. If not specified, the default range is 50000-7000000. Each provisioned volume, and thus AWS access point, is assigned a unique GID from this range.
- 6 **basePath** is the directory on the EFS volume that is used to create dynamically provisioned volumes. In this case, a PV is provisioned as `"/dynamic_provisioning/<random uuid>"` on the EFS volume. Only the subdirectory is mounted to pods that use the PV.



NOTE

A cluster admin can create several **StorageClass** objects, each using a different EFS volume.

5.4.5. Creating and configuring access to EFS volumes in AWS

This procedure explains how to create and configure EFS volumes in AWS so that you can use them in Red Hat OpenShift Service on AWS.

Prerequisites

- AWS account credentials

Procedure

To create and configure access to an EFS volume in AWS:

1. On the AWS console, open <https://console.aws.amazon.com/efs>.
2. Click **Create file system**
 - Enter a name for the file system.
 - For **Virtual Private Cloud (VPC)** select your Red Hat OpenShift Service on AWS's' virtual private cloud (VPC).
 - Accept default settings for all other selections.
3. Wait for the volume and mount targets to finish being fully created:
 - a. Go to <https://console.aws.amazon.com/efs#/file-systems>.
 - b. Click your volume, and on the **Network** tab wait for all mount targets to become available (~1-2 minutes).
4. On the **Network** tab, copy the Security Group ID (you will need this in the next step).
5. Go to <https://console.aws.amazon.com/ec2/v2/home#SecurityGroups>, and find the Security Group used by the EFS volume.

6. On the **Inbound rules** tab, click **Edit inbound rules**, and then add a new rule with the following settings to allow Red Hat OpenShift Service on AWS nodes to access EFS volumes :
 - **Type:** NFS
 - **Protocol:** TCP
 - **Port range:** 2049
 - **Source:** Custom/IP address range of your nodes (for example: "10.0.0.0/16")
This step allows Red Hat OpenShift Service on AWS to use NFS ports from the cluster.
7. Save the rule.

5.4.6. Dynamic provisioning for Amazon Elastic File Storage

The [AWS EFS CSI driver](#) supports a different form of dynamic provisioning than other CSI drivers. It provisions new PVs as subdirectories of a pre-existing EFS volume. The PVs are independent of each other. However, they all share the same EFS volume. When the volume is deleted, all PVs provisioned out of it are deleted too. The EFS CSI driver creates an AWS Access Point for each such subdirectory. Due to AWS AccessPoint limits, you can only dynamically provision 1000 PVs from a single **StorageClass**/EFS volume.



IMPORTANT

Note that **PVC.spec.resources** is not enforced by EFS.

In the example below, you request 5 GiB of space. However, the created PV is limitless and can store any amount of data (like petabytes). A broken application, or even a rogue application, can cause significant expenses when it stores too much data on the volume.

Using monitoring of EFS volume sizes in AWS is strongly recommended.

Prerequisites

- You have created Amazon Elastic File Storage (Amazon EFS) volumes.
- You have created the AWS EFS storage class.

Procedure

To enable dynamic provisioning:

- Create a PVC (or StatefulSet or Template) as usual, referring to the **StorageClass** created previously.

```
apiVersion: v1
kind: PersistentVolumeClaim
metadata:
  name: test
spec:
  storageClassName: efs-sc
  accessModes:
    - ReadWriteMany
```

```
resources:
  requests:
    storage: 5Gi
```

If you have problems setting up dynamic provisioning, see [Amazon Elastic File Storage troubleshooting](#).

Additional resources

- [Creating and configuring access to Amazon EFS volume\(s\)](#)
- [Creating the AWS EFS storage class](#)

5.4.7. Creating static PVs with Amazon Elastic File Storage

It is possible to use an Amazon Elastic File Storage (Amazon EFS) volume as a single PV without any dynamic provisioning. The whole volume is mounted to pods.

Prerequisites

- You have created Amazon EFS volumes.

Procedure

- Create the PV using the following YAML file:

```
apiVersion: v1
kind: PersistentVolume
metadata:
  name: efs-pv
spec:
  capacity: 1
  storage: 5Gi
  volumeMode: Filesystem
  accessModes:
    - ReadWriteMany
    - ReadWriteOnce
  persistentVolumeReclaimPolicy: Retain
  csi:
    driver: efs.csi.aws.com
    volumeHandle: fs-ae66151a 2
    volumeAttributes:
      encryptInTransit: "false" 3
```

1 **spec.capacity** does not have any meaning and is ignored by the CSI driver. It is used only when binding to a PVC. Applications can store any amount of data to the volume.

2 **volumeHandle** must be the same ID as the EFS volume you created in AWS. If you are providing your own access point, **volumeHandle** should be **<EFS volume ID>::<access point ID>**. For example: **fs-6e633ada::fsap-081a1d293f0004630**.

3 If desired, you can disable encryption in transit. Encryption is enabled by default.

If you have problems setting up static PVs, see [Amazon Elastic File Storage troubleshooting](#).

5.4.8. Amazon Elastic File Storage security

The following information is important for Amazon Elastic File Storage (Amazon EFS) security.

When using access points, for example, by using dynamic provisioning as described earlier, Amazon automatically replaces GIDs on files with the GID of the access point. In addition, EFS considers the user ID, group ID, and secondary group IDs of the access point when evaluating file system permissions. EFS ignores the NFS client's IDs. For more information about access points, see <https://docs.aws.amazon.com/efs/latest/ug/efs-access-points.html>.

As a consequence, EFS volumes silently ignore FSGroup; Red Hat OpenShift Service on AWS is not able to replace the GIDs of files on the volume with FSGroup. Any pod that can access a mounted EFS access point can access any file on it.

Unrelated to this, encryption in transit is enabled by default. For more information, see <https://docs.aws.amazon.com/efs/latest/ug/encryption-in-transit.html>.

5.4.9. Amazon Elastic File Storage troubleshooting

The following information provides guidance on how to troubleshoot issues with Amazon Elastic File Storage (Amazon EFS):

- The AWS EFS Operator and CSI driver run in namespace **openshift-cluster-csi-drivers**.
- To initiate gathering of logs of the AWS EFS Operator and CSI driver, run the following command:

```
$ oc adm must-gather
[must-gather ] OUT Using must-gather plugin-in image: quay.io/openshift-release-dev/ocp-v4.0-art-dev@sha256:125f183d13601537ff15b3239df95d47f0a604da2847b561151fedd699f5e3a5
[must-gather ] OUT namespace/openshift-must-gather-xm4wq created
[must-gather ] OUT clusterrolebinding.rbac.authorization.k8s.io/must-gather-2bd8x created
[must-gather ] OUT pod for plug-in image quay.io/openshift-release-dev/ocp-v4.0-art-dev@sha256:125f183d13601537ff15b3239df95d47f0a604da2847b561151fedd699f5e3a5 created
```

- To show AWS EFS Operator errors, view the **ClusterCSIDriver** status:

```
$ oc get clustercsidriver efs.csi.aws.com -o yaml
```

- If a volume cannot be mounted to a pod (as shown in the output of the following command):

```
$ oc describe pod
...
Type      Reason      Age   From           Message
----      -
Normal    Scheduled   2m13s default-scheduler Successfully assigned default/efs-app to ip-10-0-135-94.ec2.internal
Warning   FailedMount 13s   kubelet        MountVolume.Setup failed for volume "pvc-d7c097e6-67ec-4fae-b968-7e7056796449" : rpc error: code = DeadlineExceeded desc = context deadline exceeded 1
```

```
Warning FailedMount 10s kubelet Unable to attach or mount volumes: unmounted
volumes=[persistent-storage], unattached volumes=[persistent-storage kube-api-access-
9j477]: timed out waiting for the condition
```

- 1 Warning message indicating volume not mounted.

This error is frequently caused by AWS dropping packets between an Red Hat OpenShift Service on AWS node and Amazon EFS.

Check that the following are correct:

- AWS firewall and Security Groups
- Networking: port number and IP addresses

5.4.10. Uninstalling the AWS EFS CSI Driver Operator

All EFS PVs are inaccessible after uninstalling the [AWS EFS CSI Driver Operator](#) (a Red Hat operator).

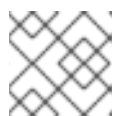
Prerequisites

- Access to the Red Hat OpenShift Service on AWS web console.

Procedure

To uninstall the AWS EFS CSI Driver Operator from the web console:

1. Log in to the web console.
2. Stop all applications that use AWS EFS PVs.
3. Delete all AWS EFS PVs:
 - a. Click **Storage** → **PersistentVolumeClaims**.
 - b. Select each PVC that is in use by the AWS EFS CSI Driver Operator, click the drop-down menu on the far right of the PVC, and then click **Delete PersistentVolumeClaims**.
4. Uninstall the [AWS EFS CSI driver](#):



NOTE

Before you can uninstall the Operator, you must remove the CSI driver first.

- a. Click **Administration** → **CustomResourceDefinitions** → **ClusterCSIDriver**.
 - b. On the **Instances** tab, for **efs.csi.aws.com**, on the far left side, click the drop-down menu, and then click **Delete ClusterCSIDriver**.
 - c. When prompted, click **Delete**.
5. Uninstall the AWS EFS CSI Operator:
 - a. Click **Operators** → **Installed Operators**.

- b. On the **Installed Operators** page, scroll or type AWS EFS CSI into the **Search by name** box to find the Operator, and then click it.
- c. On the upper, right of the **Installed Operators > Operator details** page, click **Actions** → **Uninstall Operator**.
- d. When prompted on the **Uninstall Operator** window, click the **Uninstall** button to remove the Operator from the namespace. Any applications deployed by the Operator on the cluster need to be cleaned up manually.
After uninstalling, the AWS EFS CSI Driver Operator is no longer listed in the **Installed Operators** section of the web console.



NOTE

Before you can destroy a cluster (**openshift-install destroy cluster**), you must delete the EFS volume in AWS. An Red Hat OpenShift Service on AWS cluster cannot be destroyed when there is an EFS volume that uses the cluster's VPC. Amazon does not allow deletion of such a VPC.

5.4.11. Additional resources

- [Configuring CSI volumes](#)

CHAPTER 6. GENERIC EPHEMERAL VOLUMES

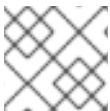
6.1. OVERVIEW

Generic ephemeral volumes are a type of ephemeral volume that can be provided by all storage drivers that support persistent volumes and dynamic provisioning. Generic ephemeral volumes are similar to **emptyDir** volumes in that they provide a per-pod directory for scratch data, which is usually empty after provisioning.

Generic ephemeral volumes are specified inline in the pod spec and follow the pod's lifecycle. They are created and deleted along with the pod.

Generic ephemeral volumes have the following features:

- Storage can be local or network-attached.
- Volumes can have a fixed size that pods are not able to exceed.
- Volumes might have some initial data, depending on the driver and parameters.
- Typical operations on volumes are supported, assuming that the driver supports them, including snapshotting, cloning, resizing, and storage capacity tracking.



NOTE

Generic ephemeral volumes do not support offline snapshots and resize.

6.2. LIFECYCLE AND PERSISTENT VOLUME CLAIMS

The parameters for a volume claim are allowed inside a volume source of a pod. Labels, annotations, and the whole set of fields for persistent volume claims (PVCs) are supported. When such a pod is created, the ephemeral volume controller then creates an actual PVC object (from the template shown in the *Creating generic ephemeral volumes* procedure) in the same namespace as the pod, and ensures that the PVC is deleted when the pod is deleted. This triggers volume binding and provisioning in one of two ways:

- Either immediately, if the storage class uses immediate volume binding. With immediate binding, the scheduler is forced to select a node that has access to the volume after it is available.
- When the pod is tentatively scheduled onto a node (**WaitForFirstConsumervolume** binding mode). This volume binding option is recommended for generic ephemeral volumes because then the scheduler can choose a suitable node for the pod.

In terms of resource ownership, a pod that has generic ephemeral storage is the owner of the PVCs that provide that ephemeral storage. When the pod is deleted, the Kubernetes garbage collector deletes the PVC, which then usually triggers deletion of the volume because the default reclaim policy of storage classes is to delete volumes. You can create quasi-ephemeral local storage by using a storage class with a reclaim policy of retain: the storage outlives the pod, and in this case, you must ensure that volume clean-up happens separately. While these PVCs exist, they can be used like any other PVC. In particular, they can be referenced as data source in volume cloning or snapshotting. The PVC object also holds the current status of the volume.

Additional resources

Additional resources

- [Creating generic ephemeral volumes](#)

6.3. SECURITY

You can enable the generic ephemeral volume feature to allow users who can create pods to also create persistent volume claims (PVCs) indirectly. This feature works even if these users do not have permission to create PVCs directly. Cluster administrators must be aware of this. If this does not fit your security model, use an admission webhook that rejects objects such as pods that have a generic ephemeral volume.

The normal namespace quota for PVCs still applies, so even if users are allowed to use this new mechanism, they cannot use it to circumvent other policies.

6.4. PERSISTENT VOLUME CLAIM NAMING

Automatically created persistent volume claims (PVCs) are named by a combination of the pod name and the volume name, with a hyphen (-) in the middle. This naming convention also introduces a potential conflict between different pods, and between pods and manually created PVCs.

For example, **pod-a** with volume **scratch** and **pod** with volume **a-scratch** both end up with the same PVC name, **pod-a-scratch**.

Such conflicts are detected, and a PVC is only used for an ephemeral volume if it was created for the pod. This check is based on the ownership relationship. An existing PVC is not overwritten or modified, but this does not resolve the conflict. Without the right PVC, a pod cannot start.



IMPORTANT

Be careful when naming pods and volumes inside the same namespace so that naming conflicts do not occur.

6.5. CREATING GENERIC EPHEMERAL VOLUMES

Procedure

1. Create the **pod** object definition and save it to a file.
2. Include the generic ephemeral volume information in the file.

my-example-pod-with-generic-vols.yaml

```
kind: Pod
apiVersion: v1
metadata:
  name: my-app
spec:
  containers:
  - name: my-frontend
    image: busybox:1.28
    volumeMounts:
    - mountPath: "/mnt/storage"
      name: data
    command: [ "sleep", "1000000" ]
```

```
volumes:  
  - name: data 1  
    ephemeral:  
      volumeClaimTemplate:  
        metadata:  
          labels:  
            type: my-app-ephvol  
        spec:  
          accessModes: [ "ReadWriteOnce" ]  
          storageClassName: "gp2-csi"  
          resources:  
            requests:  
              storage: 1Gi
```

1 Generic ephemeral volume claim.

CHAPTER 7. DYNAMIC PROVISIONING

7.1. ABOUT DYNAMIC PROVISIONING

The **StorageClass** resource object describes and classifies storage that can be requested, as well as provides a means for passing parameters for dynamically provisioned storage on demand.

StorageClass objects can also serve as a management mechanism for controlling different levels of storage and access to the storage. Cluster Administrators (**cluster-admin**) or Storage Administrators (**storage-admin**) define and create the **StorageClass** objects that users can request without needing any detailed knowledge about the underlying storage volume sources.

The Red Hat OpenShift Service on AWS persistent volume framework enables this functionality and allows administrators to provision a cluster with persistent storage. The framework also gives users a way to request those resources without having any knowledge of the underlying infrastructure.

Many storage types are available for use as persistent volumes in Red Hat OpenShift Service on AWS. While all of them can be statically provisioned by an administrator, some types of storage are created dynamically using the built-in provider and plugin APIs.

7.2. AVAILABLE DYNAMIC PROVISIONING PLUGINS

Red Hat OpenShift Service on AWS provides the following provisioner plugins, which have generic implementations for dynamic provisioning that use the cluster's configured provider's API to create new storage resources:

Storage type	Provisioner plugin name	Notes
Amazon Elastic Block Store (Amazon EBS)	kubernetes.io/aws-efs	For dynamic provisioning when using multiple clusters in different zones, tag each node with Key=kubernetes.io/cluster/<cluster_name>,Value=<cluster_id> where <cluster_name> and <cluster_id> are unique per cluster.



IMPORTANT

Any chosen provisioner plugin also requires configuration for the relevant cloud, host, or third-party provider as per the relevant documentation.

7.3. DEFINING A STORAGE CLASS

StorageClass objects are currently a globally scoped object and must be created by **cluster-admin** or **storage-admin** users.



IMPORTANT

The Cluster Storage Operator installs a default storage class. This storage class is owned and controlled by the Operator. It cannot be deleted or modified beyond defining annotations and labels. If different behavior is desired, you must define a custom storage class.

The following sections describe the basic definition for a **StorageClass** object and specific examples for each of the supported plugin types.

7.3.1. Basic StorageClass object definition

The following resource shows the parameters and default values that you use to configure a storage class. This example uses the AWS ElasticBlockStore (EBS) object definition.

Sample StorageClass definition

```
kind: StorageClass 1
apiVersion: storage.k8s.io/v1 2
metadata:
  name: <storage-class-name> 3
  annotations: 4
    storageclass.kubernetes.io/is-default-class: 'true'
  ...
provisioner: kubernetes.io/aws-ebs 5
parameters: 6
  type: gp3
...
```

- 1** (required) The API object type.
- 2** (required) The current apiVersion.
- 3** (required) The name of the storage class.
- 4** (optional) Annotations for the storage class.
- 5** (required) The type of provisioner associated with this storage class.
- 6** (optional) The parameters required for the specific provisioner, this will change from plugin to plug-iin.

7.3.2. Storage class annotations

To set a storage class as the cluster-wide default, add the following annotation to your storage class metadata:

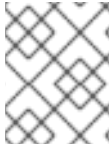
```
storageclass.kubernetes.io/is-default-class: "true"
```

For example:

```
apiVersion: storage.k8s.io/v1
```

```
kind: StorageClass
metadata:
  annotations:
    storageclass.kubernetes.io/is-default-class: "true"
...
```

This enables any persistent volume claim (PVC) that does not specify a specific storage class to automatically be provisioned through the default storage class. However, your cluster can have more than one storage class, but only one of them can be the default storage class.



NOTE

The beta annotation **storageclass.beta.kubernetes.io/is-default-class** is still working; however, it will be removed in a future release.

To set a storage class description, add the following annotation to your storage class metadata:

```
kubernetes.io/description: My Storage Class Description
```

For example:

```
apiVersion: storage.k8s.io/v1
kind: StorageClass
metadata:
  annotations:
    kubernetes.io/description: My Storage Class Description
...
```

7.3.3. AWS Elastic Block Store (EBS) object definition

aws-ebs-storageclass.yaml

```
kind: StorageClass
apiVersion: storage.k8s.io/v1
metadata:
  name: <storage-class-name> 1
provisioner: kubernetes.io/aws-ebs
parameters:
  type: io1 2
  iopsPerGB: "10" 3
  encrypted: "true" 4
  kmsKeyId: keyvalue 5
  fsType: ext4 6
```

- 1 (required) Name of the storage class. The persistent volume claim uses this storage class for provisioning the associated persistent volumes.
- 2 (required) Select from **io1**, **gp3**, **sc1**, **st1**. The default is **gp3**. See the [AWS documentation](#) for valid Amazon Resource Name (ARN) values.

3

Optional: Only for **io1** volumes. I/O operations per second per GiB. The AWS volume plugin multiplies this with the size of the requested volume to compute IOPS of the volume. The value cap

- 4 Optional: Denotes whether to encrypt the EBS volume. Valid values are **true** or **false**.
- 5 Optional: The full ARN of the key to use when encrypting the volume. If none is supplied, but **encrypted** is set to **true**, then AWS generates a key. See the [AWS documentation](#) for a valid ARN value.
- 6 Optional: File system that is created on dynamically provisioned volumes. This value is copied to the **fsType** field of dynamically provisioned persistent volumes and the file system is created when the volume is mounted for the first time. The default value is **ext4**.

7.4. CHANGING THE DEFAULT STORAGE CLASS

Use the following procedure to change the default storage class.

For example, if you have two defined storage classes, **gp3** and **standard**, and you want to change the default storage class from **gp3** to **standard**.

Prerequisites

- Access to the cluster with cluster-admin privileges.

Procedure

To change the default storage class:

1. List the storage classes:

```
$ oc get storageclass
```

Example output

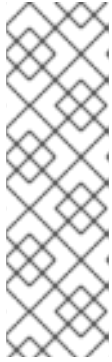
```
NAME                TYPE
gp3 (default)      kubernetes.io/aws-ebs 1
standard           kubernetes.io/aws-ebs
```

- 1 **(default)** indicates the default storage class.

2. Make the desired storage class the default.

For the desired storage class, set the **storageclass.kubernetes.io/is-default-class** annotation to **true** by running the following command:

```
$ oc patch storageclass standard -p '{"metadata": {"annotations": {"storageclass.kubernetes.io/is-default-class": "true"}}}'
```

NOTE

You can have multiple default storage classes for a short time. However, you should ensure that only one default storage class exists eventually.

With multiple default storage classes present, any persistent volume claim (PVC) requesting the default storage class (**pvc.spec.storageClassName=nil**) gets the most recently created default storage class, regardless of the default status of that storage class, and the administrator receives an alert in the alerts dashboard that there are multiple default storage classes, **MultipleDefaultStorageClasses**.

3. Remove the default storage class setting from the old default storage class.
For the old default storage class, change the value of the **storageclass.kubernetes.io/is-default-class** annotation to **false** by running the following command:

```
$ oc patch storageclass gp3 -p '{"metadata": {"annotations": {"storageclass.kubernetes.io/is-default-class": "false"}}}'
```

4. Verify the changes:

```
$ oc get storageclass
```

Example output

```
NAME                TYPE
gp3                  kubernetes.io/aws-ebs
standard (default)  kubernetes.io/aws-ebs
```