Lesson 2 : Provision Persistent Data Volumes

Configure applications by using Kubernetes secrets and configuration maps to initialize environment variables and to provide text and binary configuration files.

Kubernetes Persistent Storage

- Ephemeral storage
  - Cannot be sharead
- Use persistent storage volume
- Two main objects:
  - Persistent Volume (PV)
  - Persistent Volume Claims (PVC)
- Cluster Admin configure PV
- Developers configure PVC

Provisioning storage

- Static provisioning:
  - Requires Cluster Admin
  - Manual process
  - Carry details of real storage
- Dynamic:
  - Uses storage classes
  - Cluster provisioned on demand matching PVC
- Storage classes describe:
  - type/tier of storage
  - quality of service level
  - backup policies

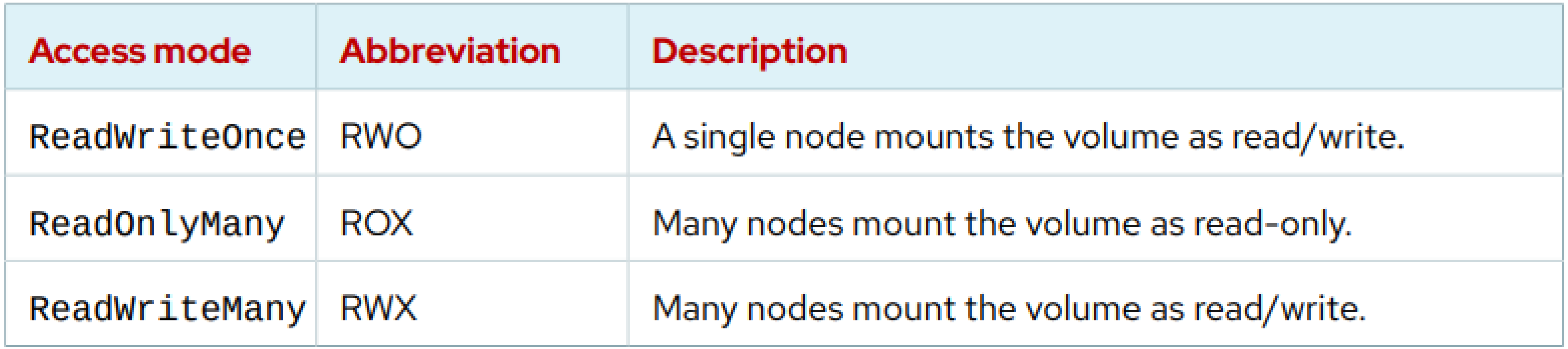
Persistent Volumes (PV) – Configured by Admin

- Volume plugins
- Have independent lifecycle
- Captures details of implementation of the storage: NFS, iSCSI or cloud provider specific
- Not all storage is equal, it can differs in:
  - Cost
  - Performance
  - Reliability
  - Capacity
- Configuration :
  - Storage volume types, Volume Access Mode, Reclaim Policy, Volume Mode

Storage volume types

- configMap volume: externalizes application configuration
- emptyDir: use for scratch data / temp data
- hostPath: mounts to file / directory on host node
- Glusterfs: free and open source scalable network filesystem
- iSCSI: block-level access to storage devices
- local: access local / direct-attached disks (das)
- NFS: access to remote exported folder on NFS servers
- Netapp FlexVolume : Netapp storage

Volume Access mode

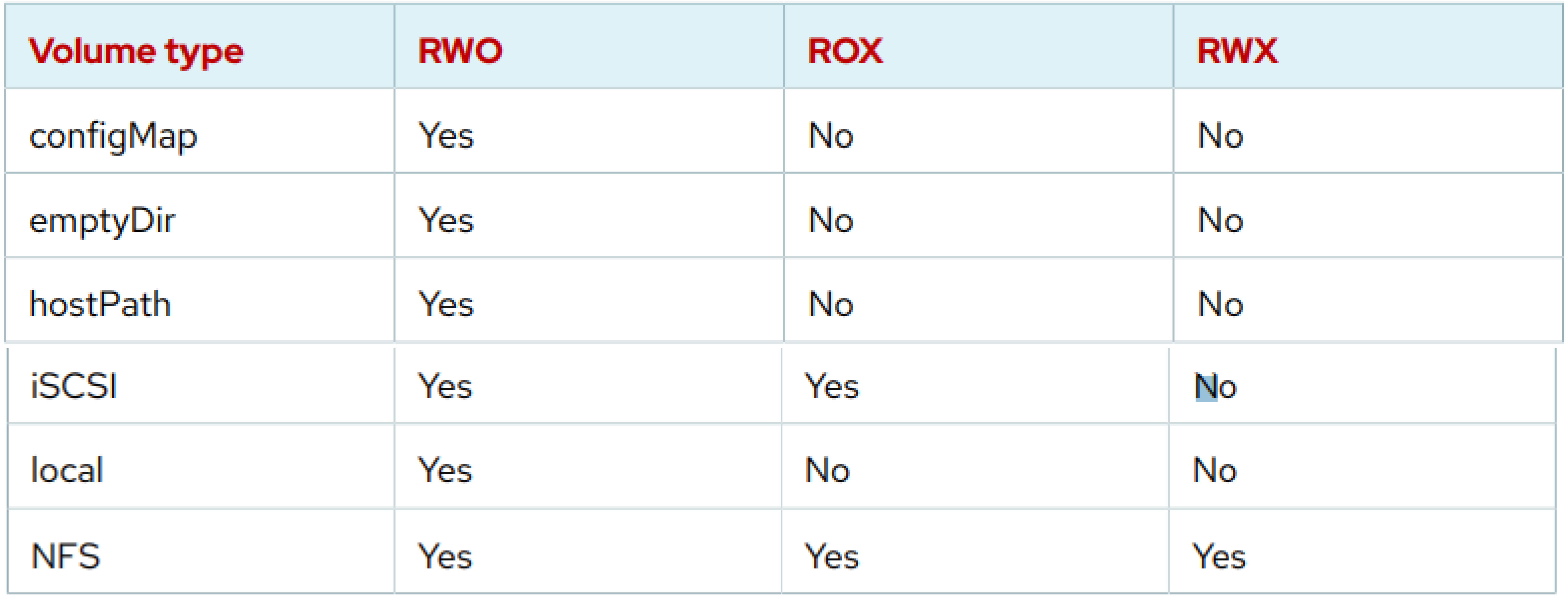


Access mode	Abbreviation	Description
`ReadWriteOnce`	RWO	A single node mounts the volume as read/write.
`ReadOnlyMany`	ROX	Many nodes mount the volume as read-only.
`ReadWriteMany`	RWX	Many nodes mount the volume as read/write.

`ReadWriteOncePod`

FEATURE STATE: `Kubernetes v1.27 [beta]`

Access Mode Support

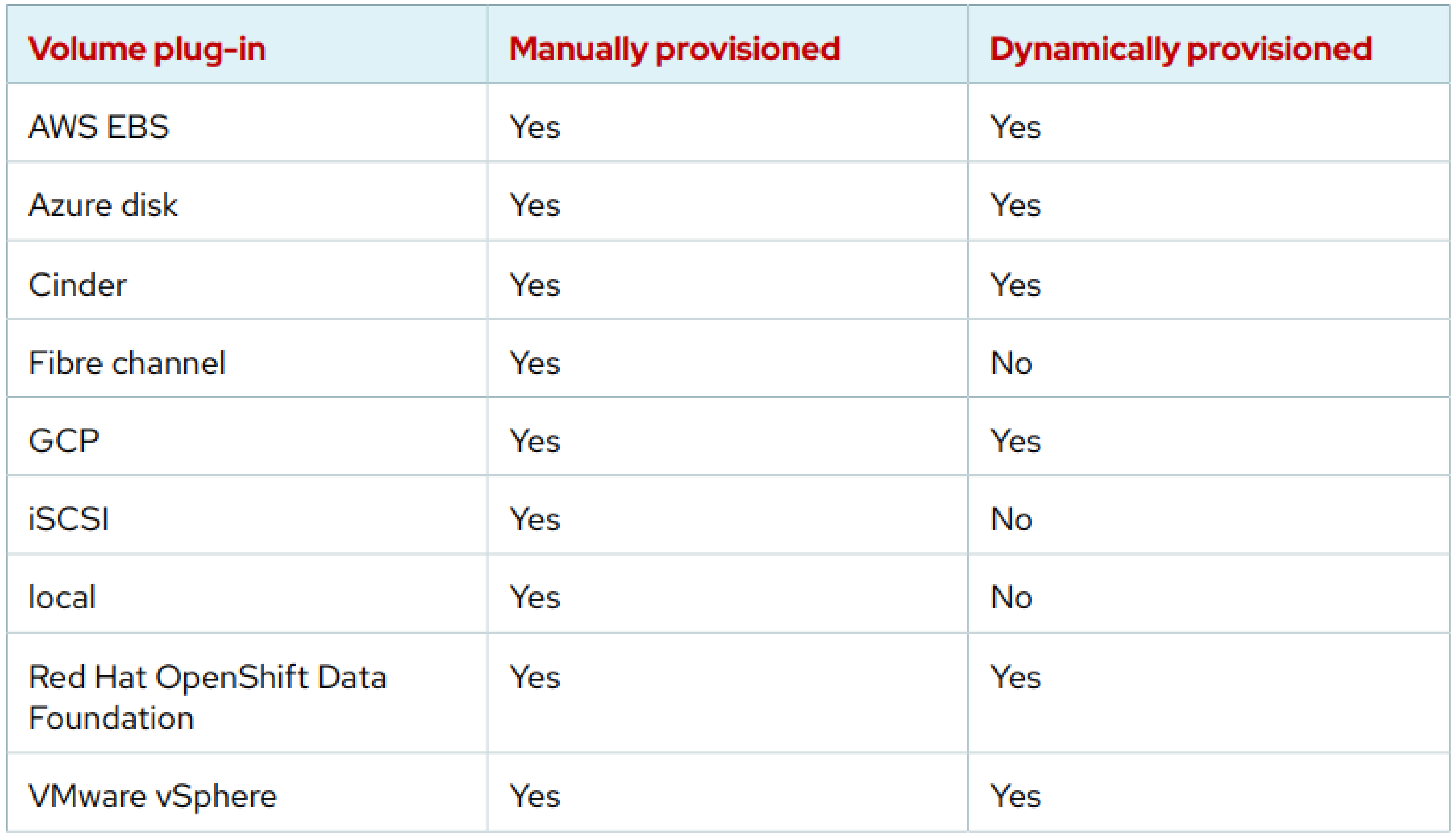


Volume type	RWO	ROX	RWX
configMap	Yes	No	No
emptyDir	Yes	No	No
hostPath	Yes	No	No
iSCSI	Yes	Yes	No
local	Yes	No	No
NFS	Yes	Yes	Yes

Volume Modes

Filesystem (default)	Block
Have file system.	Do not have file system. Application own the storage and create the file system
Mounted into Pods into a directory	Presented as raw block device to Pod
User can access immediately	Performance benefits for applications
k8s will create the filesystem and mount to empty directory	Supported: CSI, FC, GCEPD, iSCSI, local volume, OpenStack Cinder, Vsphere Volume (vVol)

Block Volume support



Volume plug-in	Manually provisioned	Dynamically provisioned
AWS EBS	Yes	Yes
Azure disk	Yes	Yes
Cinder	Yes	Yes
Fibre channel	Yes	No
GCP	Yes	Yes
iSCSI	Yes	No
local	Yes	No
Red Hat OpenShift Data Foundation	Yes	Yes
VMware vSphere	Yes	Yes

Reclaim Policy

Current reclaim policies:

- Retain -- manual reclamation
- Recycle (deprecated) -- basic scrub (rm -rf /thevolume/*)
- Delete -- associated storage asset such as AWS EBS or GCE PD volume is deleted

Currently, only NFS and HostPath support recycling. AWS EBS and GCE PD volumes support deletion.

Manually Creating a PV

```
apiVersion: v1
kind: PersistentVolume ❶
metadata:
  name: block-pv ❷
spec:
  capacity:
    storage: 10Gi ❸
  accessModes:
    - ReadWriteOnce ❹
  volumeMode: Block ❺
  persistentVolumeReclaimPolicy: Retain ❻
  fc: ❼
    targetWWNs: ["50060e801049cfd1"]
    lun: 0
    readOnly: false
```

1 PersistentVolume is the resource type for PVs.

2 Provide a name for the PV, which subsequent claims use to access the PV.

3 Specify the amount of storage that is allocated to this volume.

4 The storage device must support the access mode that the PV specifies.

5 The volumeMode attribute is optional for Filesystem volumes, but is required for Block volumes.

6 The persistentVolumeReclaimPolicy determines how the cluster handles the PV when the PVC is deleted. Valid options are Retain or Delete.

7 The remaining attributes are specific to the storage type. In this example, the fc object specifies the Fiber Channel storage type attributes.

```
[user@host]$ oc create -f my-fc-volume.yaml
```

oc describe pv Command

```
kubectl describe pv task-pv-volume
Name:            task-pv-volume
Labels:          type=local
Annotations:     <none>
Finalizers:      [kubernetes.io/pv-protection]
StorageClass:    standard
Status:          Terminating
Claim:
Reclaim Policy:  Delete
Access Modes:    RWO
Capacity:        1Gi
Message:
Source:
    Type:          HostPath (bare host directory volume)
    Path:          /tmp/data
    HostPathType:
Events:            <none>
```

Persistent Volume Claim (PVC)

- Request for storage by a user / developer
- Pods consume node resources; PVCs consume PV resources
- PVC declares what application needs, K8s provide best-effort basis
  - May specify storage type/tier (should be done in PV), access mode or reclaim policy
- Minimal storage characteristics
  - Request storage size
  - Specifies access modes
- Lifecycle tied to namespace not pod
- Multiple pods connect to same PVC

Manually Creating a PVC using **oc set volumes** command

- Add PVC to deployment

```
[user@host ~]$ oc set volumes deployment/example-application \ ❶
--add \ ❷
--name example-pv-storage \ ❸
--type persistentVolumeClaim \ ❹
--claim-mode rwo \ ❺
--claim-size 15Gi \ ❻
--mount-path /var/lib/example-app \ ❼
--claim-name example-pv-claim ❽
```

- Updating volumes

```
$ oc set volume <object_type>/<name> --add --overwrite [options]
```

- Remove volumes

```
$ oc set volume <object_type>/<name> --remove [options]
```

Manually Creating a PVC using **YAML** manifest

```
---
apiVersion: v1
kind: PersistentVolumeClaim ❶
metadata:
  name: example-pv-claim ❷
  labels:
    app: example-application
spec:
  accessModes:
    - ReadWriteOnce ❸
  resources:
    requests:
      storage: 15Gi ❹
```

```
[user@host ~]$ oc create -f pvc_file_name.yaml
```

1 PersistentVolumeClaim is the resource type for a PVC.

2 Use this name in the claimName field of the persistentVolumeClaim element in the volumes section of a deployment manifest.

3 Specify the access mode that this PVC requests. The storage class provisioner must provide this access mode. If persistent volumes are created statically, then an eligible persistent volume must provide this access mode.

4 The storage class creates a persistent volume that matches this size request. If persistent volumes are created statically, then an eligible persistent volume must be at least the requested size.

Verify PVC and web console

```
[user@host ~]$ oc get pvc
NAME          STATUS   VOLUME           CAPACITY   ACCESS MODES   STORAGECLASS   ...
db-pod-pvc    Bound    pvc-13...ca45    1Gi        RWO            nfs-storage    ...
```

To create a persistent volume claim from the web console, click the **Storage** > **PersistentVolumesClaims** menu.

Click **Create PersistentVolumeClaim** and complete the form by adding the name, the storage class, the size, the access mode, and the volume mode.

Kubernetes Dynamic Provisioning

- Cluster admin must statistically provision storage types
- For on demand or dynamic provisioning, uses **StorageClass** object
- Minimal configuration:
    - access mode
    - storage class
    - size
- OpenShift master node watches for new VPC and binds to appropriate PV
- Example: cluster with many 50Gi PV
    - Pod attempt with 100Gi claim – unbound
    - Later PV with 100Gi added, then Pod bound to it

The commands

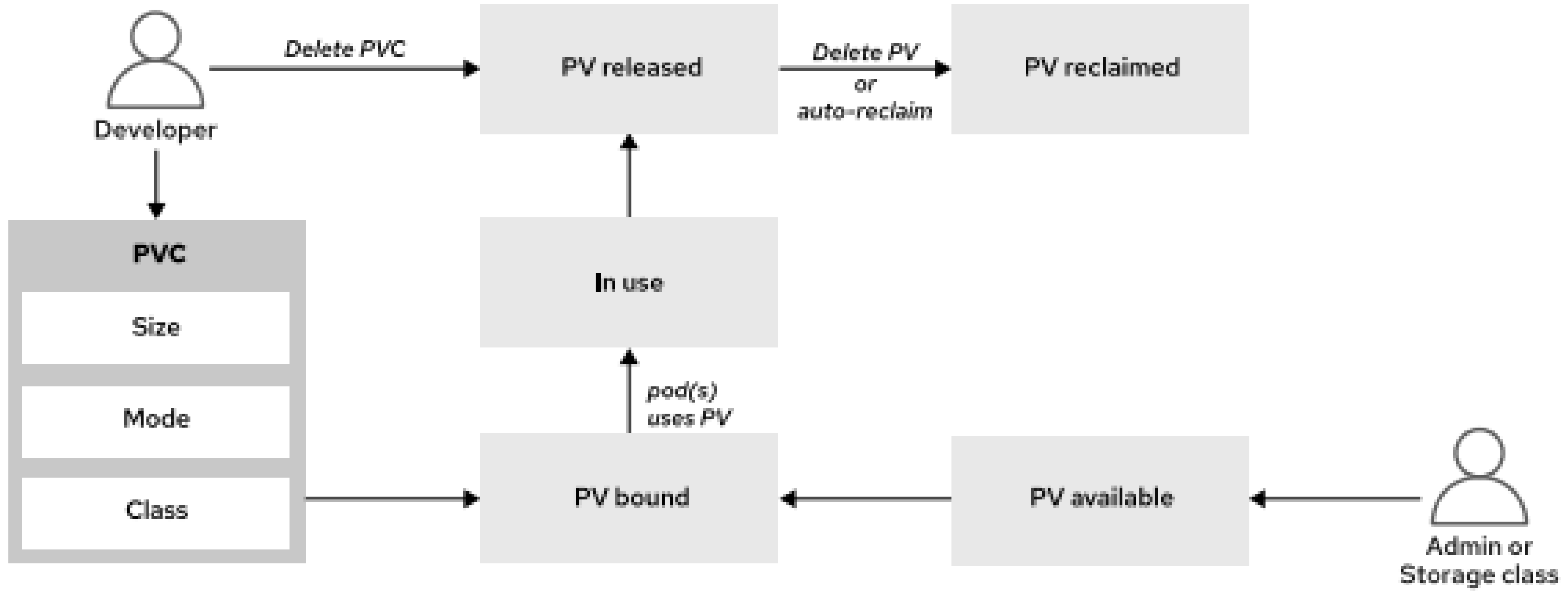
- Use `oc get storageclass` to view the storage classes that the cluster provides.

```
[user@host ~]$ oc get storageclass
NAME                    PROVISIONER                                    ...
nfs-storage (default)   k8s-sigs.io/nfs-subdir-external-provisioner   ...
lvms-vg1             topolvm.io                                 ...
```

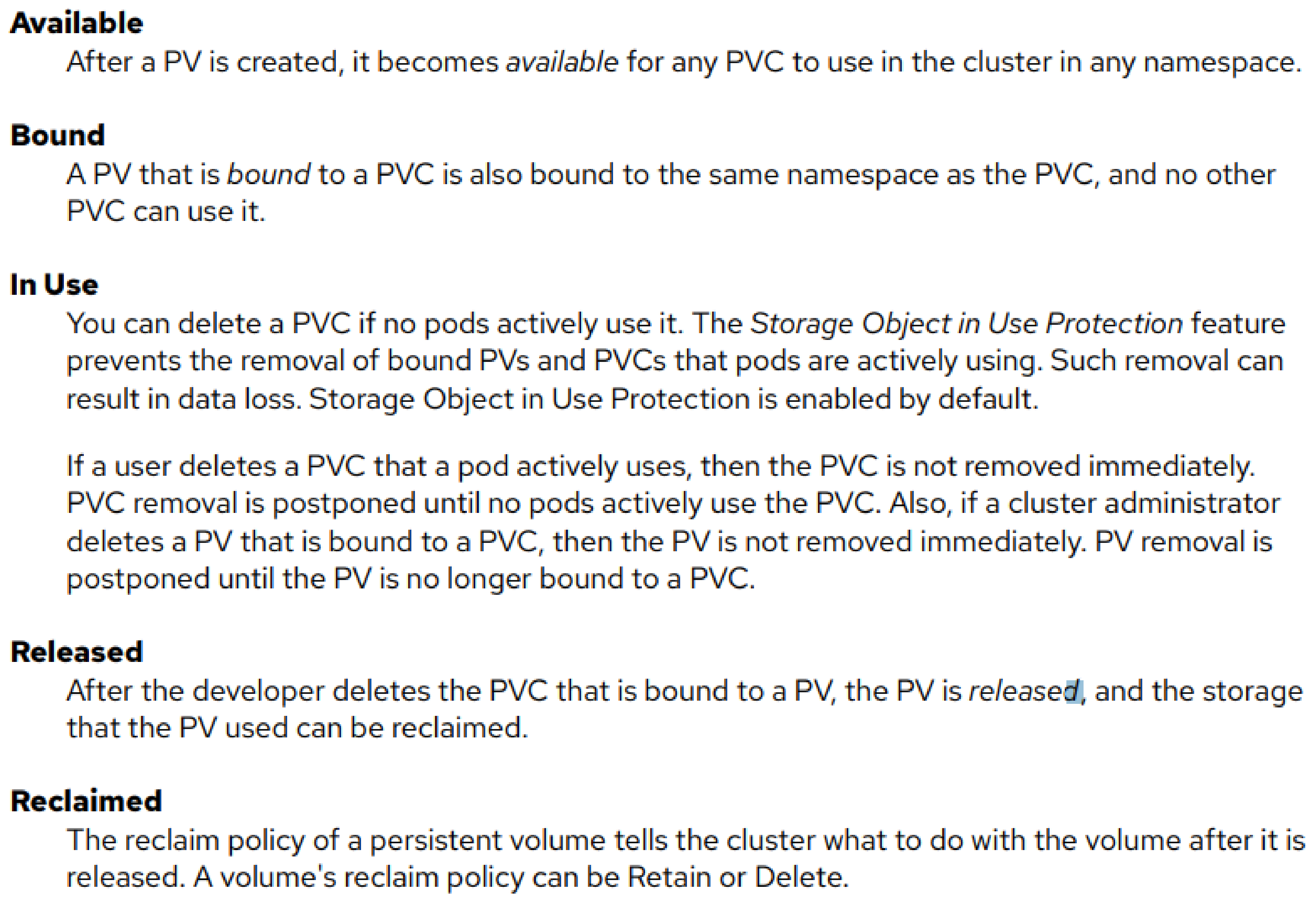
- The following `oc set volume` command example uses the `claim-class` option to specify a dynamically provisioned PV.

```
[user@host ~]$ oc set volumes deployment/example-application \
--add --name example-pv-storage --type pvc --claim-class nfs-storage \
--claim-mode rwo --claim-size 15Gi --mount-path /var/lib/example-app \
--claim-name example-pv-claim
```

PV and PVC Lifecycles



Status



Available

After a PV is created, it becomes *available* for any PVC to use in the cluster in any namespace.

Bound

A PV that is *bound* to a PVC is also bound to the same namespace as the PVC, and no other PVC can use it.

In Use

You can delete a PVC if no pods actively use it. The *Storage Object in Use Protection* feature prevents the removal of bound PVs and PVCs that pods are actively using. Such removal can result in data loss. Storage Object in Use Protection is enabled by default.

If a user deletes a PVC that a pod actively uses, then the PVC is not removed immediately. PVC removal is postponed until no pods actively use the PVC. Also, if a cluster administrator deletes a PV that is bound to a PVC, then the PV is not removed immediately. PV removal is postponed until the PV is no longer bound to a PVC.

Released

After the developer deletes the PVC that is bound to a PV, the PV is *released*, and the storage that the PV used can be reclaimed.

Reclaimed

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 or Delete.

Deleting a Persistent Volume Claim

- **Deleting a Persistent Volume Claim**

  To delete a volume, use the `oc delete` command to delete the PVC. The storage class reclaims the volume after removing the PVC.

```
[user@host ~]$ oc delete pvc/example-pvc-storage
```

- **Volume Reclaim Policy**

Policy	Description
Retain	Enables manual reclamation of the resource for those volume plug-ins that support it.
Delete	Deletes both the `PersistentVolume` object from OpenShift Container Platform and the associated storage asset in external infrastructure.

Guided Exercise: Provision Persistent Data Volumes

You should be able to:

- Deploy a MySQL database with persistent storage from a PVC.
- Identify the PV that backs the application.
- Identify the storage provisioner that created the PV