OpenShift Container Platform 4.4

Migration

Migrating from OpenShift Container Platform 3 to 4
OpenShift Container Platform 4.4 Migration

Migrating from OpenShift Container Platform 3 to 4
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CHAPTER 1. MIGRATING FROM OPENShift CONTAINER PLATFORM 3

1.1. ABOUT MIGRATING OPENShift CONTAINER PLATFORM 3 TO 4

OpenShift Container Platform 4 includes new technologies and functionality that results in a cluster that is self-managing, flexible, and automated. The way that OpenShift Container Platform 4 clusters are deployed and managed drastically differs from OpenShift Container Platform 3.

To successfully transition from OpenShift Container Platform 3 to OpenShift Container Platform 4, it is important that you review the following information:

Planning your transition
Learn about the differences between OpenShift Container Platform versions 3 and 4. Prior to transitioning, be sure that you have reviewed and prepared for storage, networking, logging, security, and monitoring considerations.

Performing your migration
Learn about and use the tools to perform your migration:

- Cluster Application Migration (CAM) tool to migrate your application workloads
- Control Plane Migration Assistant (CPMA) to migrate your control plane

1.2. PLANNING YOUR MIGRATION

Before performing your migration to OpenShift Container Platform 4.4, it is important to take the time to properly plan for the transition. OpenShift Container Platform 4 introduces architectural changes and enhancements, so the procedures that you used to manage your OpenShift Container Platform 3 cluster might not apply for OpenShift Container Platform 4.

NOTE
This planning document assumes that you are transitioning from OpenShift Container Platform 3.11 to OpenShift Container Platform 4.4.

This document provides high-level information on the most important differences between OpenShift Container Platform 3 and OpenShift Container Platform 4 and the most noteworthy migration considerations. For detailed information on configuring your OpenShift Container Platform 4 cluster, review the appropriate sections of the OpenShift Container Platform documentation. For detailed information on new features and other notable technical changes, review the OpenShift Container Platform 4.4 release notes.

It is not possible to upgrade your existing OpenShift Container Platform 3 cluster to OpenShift Container Platform 4. You must start with a new OpenShift Container Platform 4 installation. Tools are available to assist in migrating your control plane settings and application workloads.

1.2.1. Comparing OpenShift Container Platform 3 and OpenShift Container Platform 4
With OpenShift Container Platform 3, administrators individually deployed Red Hat Enterprise Linux (RHEL) hosts, and then installed OpenShift Container Platform on top of these hosts to form a cluster. Administrators were responsible for properly configuring these hosts and performing updates.

OpenShift Container Platform 4 represents a significant change in the way that OpenShift Container Platform clusters are deployed and managed. OpenShift Container Platform 4 includes new technologies and functionality, such as Operators, MachineSets, and Red Hat Enterprise Linux CoreOS (RHCOS), which are core to the operation of the cluster. This technology shift enables clusters to self-manage some functions previously performed by administrators. This also ensures platform stability and consistency, and simplifies installation and scaling.

For more information, see OpenShift Container Platform architecture.

1.2.1.1. Architecture differences

Immutable infrastructure
OpenShift Container Platform 4 uses Red Hat Enterprise Linux CoreOS (RHCOS), which is designed to run containerized applications, and provides efficient installation, Operator-based management, and simplified upgrades. RHCOS is an immutable container host, rather than a customizable operating system like RHEL. RHCOS enables OpenShift Container Platform 4 to manage and automate the deployment of the underlying container host. RHCOS is a part of OpenShift Container Platform, which means that everything runs inside a container and is deployed using OpenShift Container Platform.

In OpenShift Container Platform 4, control plane nodes must run RHCOS, ensuring that full-stack automation is maintained for the control plane. This makes rolling out updates and upgrades a much easier process than in OpenShift Container Platform 3.

For more information, see Red Hat Enterprise Linux CoreOS.

Operators
Operators are a method of packaging, deploying, and managing a Kubernetes application. Operators ease the operational complexity of running another piece of software. They watch over your environment and use the current state to make decisions in real time. Advanced Operators are designed to upgrade and react to failures automatically.

For more information, see Understanding Operators.

1.2.1.2. Installation and update differences

Installation process
To install OpenShift Container Platform 3.11, you prepared your Red Hat Enterprise Linux (RHEL) hosts, set all of the configuration values your cluster needed, and then ran an Ansible playbook to install and set up your cluster.

In OpenShift Container Platform 4.4, you use the OpenShift installation program to create a minimum set of resources required for a cluster. Once the cluster is running, you use Operators to further configure your cluster and to install new services. After first boot, Red Hat Enterprise Linux CoreOS (RHCOS) systems are managed by the Machine Config Operator (MCO) that runs in the OpenShift Container Platform cluster.

For more information, see Installation process.

If you want to add RHEL worker machines to your OpenShift Container Platform 4.4 cluster, you use an Ansible playbook to join the RHEL worker machines after the cluster is running. For more information, see Adding RHEL compute machines to an OpenShift Container Platform cluster.
**Infrastructure options**
In OpenShift Container Platform 3.11, you installed your cluster on infrastructure that you prepared and maintained. In addition to providing your own infrastructure, OpenShift Container Platform 4 offers an option to deploy a cluster on infrastructure that the OpenShift Container Platform installation program provisions and the cluster maintains.

For more information, see [OpenShift Container Platform installation overview](#).

**Upgrading your cluster**
In OpenShift Container Platform 3.11, you upgraded your cluster by running Ansible playbooks. In OpenShift Container Platform 4.4, the cluster manages its own updates, including updates to Red Hat Enterprise Linux CoreOS (RHCOS) on cluster nodes. You can easily upgrade your cluster by using the web console or by using the `oc adm upgrade` command from the OpenShift CLI and the Operators will automatically upgrade themselves. If your OpenShift Container Platform 4.4 cluster has Red Hat Enterprise Linux worker machines, then you will still need to run an Ansible playbook to upgrade those worker machines.

For more information, see [Updating clusters](#).

### 1.2.2. Migration considerations

Review the changes and other considerations that might affect your transition from OpenShift Container Platform 3.11 to OpenShift Container Platform 4.

#### 1.2.2.1. Storage considerations

Review the following storage changes to consider when transitioning from OpenShift Container Platform 3.11 to OpenShift Container Platform 4.4.

**Local volume persistent storage**
Local storage is only supported by using the Local Storage Operator in OpenShift Container Platform 4.4. It is not supported to use the local provisioner method from OpenShift Container Platform 3.11.

For more information, see [Persistent storage using local volumes](#).

**FlexVolume persistent storage**
The FlexVolume plug-in location changed from OpenShift Container Platform 3.11. The new location in OpenShift Container Platform 4.4 is `/etc/kubernetes/kubelet-plugins/volume/exec`. Attachable FlexVolume plug-ins are no longer supported.

For more information, see [Persistent storage using FlexVolume](#).

**Container Storage Interface (CSI) persistent storage**
Persistent storage using the Container Storage Interface (CSI) was Technology Preview in OpenShift Container Platform 3.11. CSI version 1.1.0 is fully supported in OpenShift Container Platform 4.4, but does not ship with any CSI drivers. You must install your own driver.

For more information, see [Persistent storage using the Container Storage Interface (CSI)](#).

**Red Hat OpenShift Container Storage**
Red Hat OpenShift Container Storage 3, which is available for use with OpenShift Container Platform 3.11, uses Red Hat Gluster Storage as the backing storage.

Red Hat OpenShift Container Storage 4, which is available for use with OpenShift Container Platform 4, uses Red Hat Ceph Storage as the backing storage.
For more information, see Persistent storage using Red Hat OpenShift Container Storage and the interoperability matrix article.

Unsupported persistent storage options
Support for the following persistent storage options from OpenShift Container Platform 3.11 has changed in OpenShift Container Platform 4.4:

- GlusterFS is no longer supported.
- CephFS as a standalone product is no longer supported.
- Ceph RBD as a standalone product is no longer supported.

If you used one of these in OpenShift Container Platform 3.11, you must choose a different persistent storage option for full support in OpenShift Container Platform 4.4.

For more information, see Understanding persistent storage.

1.2.2.2. Networking considerations

Review the following networking changes to consider when transitioning from OpenShift Container Platform 3.11 to OpenShift Container Platform 4.4.

Network isolation mode
The default network isolation mode for OpenShift Container Platform 3.11 was `ovs-subnet`, though users frequently switched to use `ovn-multitenant`. The default network isolation mode for OpenShift Container Platform 4.4 is now NetworkPolicy.

If your OpenShift Container Platform 3.11 cluster used the `ovs-subnet` or `ovs-multitenant` mode, it is recommended to switch to the NetworkPolicy mode for your OpenShift Container Platform 4.4 cluster. NetworkPolicy is supported upstream, is more flexible, and also provides the functionality that `ovs-multitenant` does. If you want to maintain the `ovs-multitenant` behavior while using NetworkPolicy in OpenShift Container Platform 4.4, follow the steps to configure multitenant isolation using NetworkPolicy.

For more information, see About network policy.

Encrypting traffic between hosts
In OpenShift Container Platform 3.11, you could use IPsec to encrypt traffic between hosts. OpenShift Container Platform 4.4 does not support IPsec. It is recommended to use Red Hat OpenShift Service Mesh to enable mutual TLS between services.

For more information, see Understanding Red Hat OpenShift Service Mesh.

1.2.2.3. Logging considerations

Review the following logging changes to consider when transitioning from OpenShift Container Platform 3.11 to OpenShift Container Platform 4.4.

Deploying cluster logging
OpenShift Container Platform 4 provides a simple deployment mechanism for cluster logging, by using a Cluster Logging custom resource. Once deployed, the cluster logging experience is the same as it was in OpenShift Container Platform 3.11.

For more information, see About deploying and configuring cluster logging.

Aggregated logging data
You cannot transition your aggregate logging data from OpenShift Container Platform 3.11 into your new OpenShift Container Platform 4 cluster.

For more information, see About cluster logging.

1.2.2.4. Security considerations

Review the following security changes to consider when transitioning from OpenShift Container Platform 3.11 to OpenShift Container Platform 4.4.

**Unauthenticated access to discovery endpoints**

In OpenShift Container Platform 3.11, an unauthenticated user could access the discovery endpoints (for example, /api/* and /apis/*). For security reasons, unauthenticated access to the discovery endpoints is no longer allowed in OpenShift Container Platform 4.4. If you do need to allow unauthenticated access, you can configure the RBAC settings as necessary; however, be sure to consider the security implications as this can expose internal cluster components to the external network.

**Identity providers**

Configuration for identity providers has changed for OpenShift Container Platform 4, including the following notable changes:

- The request header identity provider in OpenShift Container Platform 4.4 requires mutual TLS, where in OpenShift Container Platform 3.11 it did not.

- The configuration of the OpenID Connect identity provider was simplified in OpenShift Container Platform 4.4. It now obtains data, which previously had to be specified in OpenShift Container Platform 3.11, from the provider's .well-known/openid-configuration endpoint.

For more information, see Understanding identity provider configuration.

1.2.2.5. Monitoring considerations

Review the following monitoring changes to consider when transitioning from OpenShift Container Platform 3.11 to OpenShift Container Platform 4.4.

**Alert for monitoring infrastructure availability**

The default alert that triggers to ensure the availability of the monitoring structure was called DeadMansSwitch in OpenShift Container Platform 3.11. This was renamed to Watchdog in OpenShift Container Platform 4. If you had PagerDuty integration set up with this alert in OpenShift Container Platform 3.11, you must set up the PagerDuty integration for the Watchdog alert in OpenShift Container Platform 4.

For more information, see Applying custom Alertmanager configuration.

1.3. MIGRATION TOOLS AND PREREQUISITES

You can migrate application workloads from OpenShift Container Platform 3.7, 3.9, 3.10, and 3.11 to OpenShift Container Platform 4.4 with the Cluster Application Migration (CAM) tool. The CAM tool enables you to control the migration and to minimize application downtime.

The CAM tool’s web console and API, based on Kubernetes Custom Resources, enable you to migrate stateful application workloads at the granularity of a namespace.

The CAM tool supports the file system and snapshot data copy methods for migrating data from the source cluster to the target cluster. You can select a method that is suited for your environment and is supported by your storage provider.
You can use migration hooks to run Ansible playbooks at certain points during the migration. The hooks are added when you create a migration plan.

The Control Plane Migration Assistant (CPMA) is a CLI-based tool that assists you in migrating the control plane. The CPMA processes the OpenShift Container Platform 3 configuration files and generates Custom Resource (CR) manifest files, which are consumed by OpenShift Container Platform 4.4 Operators.

**IMPORTANT**

Before you begin your migration, be sure to review the information on planning your migration.

### 1.3.1. Migration prerequisites

- The source cluster must be OpenShift Container Platform 3.7, 3.9, 3.10, or 3.11.

- You must have **podman** installed.

- You must have **cluster-admin** privileges on all clusters.

- The source and target clusters must have unrestricted network access to the replication repository.

- The cluster on which the Migration controller is installed must have unrestricted access to the other clusters.

- If your application uses images from the **openshift** namespace, the required versions of the images must be present on the target cluster. If the required images are not present, you must update the **imagestreamtags** references to use an available version that is compatible with your application. If the **imagestreamtags** cannot be updated, you can manually upload equivalent images to the application namespaces and update the applications to reference them.

The following **imagestreamtags** have been removed from OpenShift Container Platform 4.2:

- dotnet:1.0, dotnet:1.1, dotnet:2.0
- dotnet-runtime:2.0
- mariadb:10.1
- mongodb:2.4, mongodb:2.6
- mysql:5.5, mysql:5.6
- nginx:1.8
- nodejs:0.10, nodejs:4, nodejs:6
- perl:5.16, perl:5.20
- php:5.5, php:5.6
- python:3.3, python:3.4
The following **imagestreamtags** have been **removed** from OpenShift Container Platform 4.4:

- **ruby**: 2.0, ruby:2.2
- **dotnet**: 2.2
- **dotnet-runtime**: 2.2
- **nginx**: 1.12
- **nodejs**: 8, 8-RHOAR, 10-SCL
- **perl**: 5.24
- **php**: 7.0, 7.1
- **redis**: 3.2

1.3.2. About the Cluster Application Migration tool

The Cluster Application Migration (CAM) tool enables you to migrate Kubernetes resources, persistent volume data, and internal container images from an OpenShift Container Platform source cluster to an OpenShift Container Platform 4.4 target cluster, using the CAM web console or the Kubernetes API.

Migrating an application with the CAM web console involves the following steps:

1. Install the Cluster Application Migration Operator on all clusters.
   You can install the Cluster Application Migration Operator in a restricted environment with limited or no internet access. The source and target clusters must have network access to each other and to a mirror registry.

2. Configure the replication repository, an intermediate object storage that the CAM tool uses to migrate data.
   The source and target clusters must have network access to the replication repository during migration. In a restricted environment, you can use an internally hosted S3 storage repository. If you use a proxy server, you must ensure that replication repository is whitelisted.

3. Add the source cluster to the CAM web console.

4. Add the replication repository to the CAM web console.

5. Create a migration plan, with one of the following data migration options:

   - **Copy**: The CAM tool copies the data from the source cluster to the replication repository, and from the replication repository to the target cluster.
- **Move**: The CAM tool unmounts a remote volume (for example, NFS) from the source cluster, creates a PV resource on the target cluster pointing to the remote volume, and then mounts the remote volume on the target cluster. Applications running on the target cluster use the same remote volume that the source cluster was using. The remote volume must be accessible to the source and target clusters.

**NOTE**

Although the replication repository does not appear in this diagram, it is required for the actual migration.

6. Run the migration plan, with one of the following options:

- **Stage** (optional) copies data to the target cluster without stopping the application. Staging can be run multiple times so that most of the data is copied to the target before migration. This minimizes the actual migration time and application downtime.

- **Migrate** stops the application on the source cluster and recreates its resources on the target cluster. Optionally, you can migrate the workload without stopping the application.
1.3.3. About data copy methods

The CAM tool supports the file system and snapshot data copy methods for migrating data from the source cluster to the target cluster. You can select a method that is suited for your environment and is supported by your storage provider.

1.3.3.1. File system copy method

The CAM tool copies data files from the source cluster to the replication repository, and from there to the target cluster.

Table 1.1. File system copy method summary

<table>
<thead>
<tr>
<th>Benefits</th>
<th>Limitations</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Clusters can have different storage classes</td>
<td>• Slower than the snapshot copy method</td>
</tr>
<tr>
<td>• Supported for all S3 storage providers</td>
<td>• Optional data verification significantly reduces performance</td>
</tr>
<tr>
<td>• Optional data verification with checksum</td>
<td></td>
</tr>
</tbody>
</table>

1.3.3.2. Snapshot copy method

The CAM tool copies a snapshot of the source cluster’s data to a cloud provider’s object storage, configured as a replication repository. The data is restored on the target cluster.

AWS, Google Cloud Provider, and Microsoft Azure support the snapshot copy method.

Table 1.2. Snapshot copy method summary

<table>
<thead>
<tr>
<th>Benefits</th>
<th>Limitations</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Faster than the file system copy method</td>
<td>• Cloud provider must support snapshots.</td>
</tr>
<tr>
<td></td>
<td>• Clusters must be on the same cloud provider.</td>
</tr>
<tr>
<td></td>
<td>• Clusters must be in the same location or region.</td>
</tr>
<tr>
<td></td>
<td>• Clusters must have the same storage class.</td>
</tr>
<tr>
<td></td>
<td>• Storage class must be compatible with snapshots.</td>
</tr>
</tbody>
</table>

1.3.4. About migration hooks

You can use migration hooks to run Ansible playbooks at certain points during the migration. The hooks are added when you create a migration plan.
NOTE

If you do not want to use Ansible playbooks, you can create a custom container image and add it to a migration plan.

Migration hooks perform tasks such as customizing application quiescence, manually migrating unsupported data types, and updating applications after migration.

A single migration hook runs on a source or target cluster at one of the following migration steps:

- **PreBackup**: Before backup tasks are started on the source cluster
- **PostBackup**: After backup tasks are complete on the source cluster
- **PreRestore**: Before restore tasks are started on the target cluster
- **PostRestore**: After restore tasks are complete on the target cluster

You can assign one hook to each migration step, up to a maximum of four hooks for a single migration plan.

The default **hook-runner** image is `registry.redhat.io/rhcam-1-2/openshift-migration-hook-runner-rhel7`. This image is based on Ansible Runner and includes `python-openshift` for Ansible Kubernetes resources and an updated `oc` binary. You can also create your own hook image with additional Ansible modules or tools.

The Ansible playbook is mounted on a hook container as a ConfigMap. The hook container runs as a Job on a cluster with a specified service account and namespace. The Job runs, even if the initial Pod is evicted or killed, until it reaches the default `backoffLimit` (6) or successful completion.

1.3.5. About the Control Plane Migration Assistant

The Control Plane Migration Assistant (CPMA) is a CLI-based tool that assists you in migrating the control plane from OpenShift Container Platform 3.7 (or later) to 4.4. The CPMA processes the OpenShift Container Platform 3 configuration files and generates Custom Resource (CR) manifest files, which are consumed by OpenShift Container Platform 4.4 Operators.

Because OpenShift Container Platform 3 and 4 have significant configuration differences, not all parameters are processed. The CPMA can generate a report that describes whether features are supported fully, partially, or not at all.

Configuration files

CPMA uses the Kubernetes and OpenShift Container Platform APIs to access the following configuration files on an OpenShift Container Platform 3 cluster:

- Master configuration file (default: `/etc/origin/master/master-config.yaml`)
- CRI-O configuration file (default: `/etc/crio/crio.conf`)
- etcd configuration file (default: `/etc/etcd/etcd.conf`)
- Image registries file (default: `/etc/containers/registries.conf`)
- Dependent configuration files:
  - Password files (for example, HTPasswd)
ConfigMaps

- Secrets

**CR Manifests**

CPMA generates CR manifests for the following configurations:

- API server CA certificate: `100_CPMA-cluster-config-APISecret.yaml`

  NOTE
  
  If you are using an unsigned API server CA certificate, you must add the certificate manually to the target cluster.

- CRI-O: `100_CPMA-crio-config.yaml`

- Cluster resource quota: `100_CPMA-cluster-quota-resource-x.yaml`

- Project resource quota: `100_CPMA-resource-quota-x.yaml`

- Portable image registry (`/etc/registries/registries.conf`) and portable image policy (`etc/origin/master/master-config.yaml`): `100_CPMA-cluster-config-image.yaml`

- OAuth providers: `100_CPMA-cluster-config-oauth.yaml`

- Project configuration: `100_CPMA-cluster-config-project.yaml`

- Scheduler: `100_CPMA-cluster-config-scheduler.yaml`

- SDN: `100_CPMA-cluster-config-sdn.yaml`

### 1.4. DEPLOYING THE CLUSTER APPLICATION MIGRATION TOOL

You can install the Cluster Application Migration Operator on an OpenShift Container Platform 4.4 target cluster and an OpenShift Container Platform 3 source cluster. The Cluster Application Migration Operator installs the Cluster Application Migration (CAM) tool on the target cluster by default.

NOTE

Optional: You can configure the Cluster Application Migration Operator to install the CAM tool on an OpenShift Container Platform 3 cluster or on a remote cluster.

In a restricted environment, you can install the Cluster Application Migration Operator from a local mirror registry.

After you have installed the Cluster Application Migration Operator on your clusters, you can launch the CAM tool.

### 1.4.1. Installing the Cluster Application Migration Operator

You can install the Cluster Application Migration Operator with the Operation Lifecycle Manager (OLM) on an OpenShift Container Platform 4.4 target cluster and manually on an OpenShift Container Platform 3 source cluster.
1.4.1.1. Installing the Cluster Application Migration Operator on an OpenShift Container Platform 4.4 target cluster

You can install the Cluster Application Migration Operator on an OpenShift Container Platform 4.4 target cluster with the Operation Lifecycle Manager (OLM).

The Cluster Application Migration Operator installs the Cluster Application Migration tool on the target cluster by default.

**Procedure**

1. In the OpenShift Container Platform web console, click **Operators → OperatorHub**.
2. Use the **Filter by keyword** field (in this case, **Migration**) to find the **Cluster Application Migration Operator**.
3. Select the **Cluster Application Migration Operator** and click **Install**.
4. On the **Create Operator Subscription** page, click **Subscribe**. On the **Installed Operators** page, the **Cluster Application Migration Operator** appears in the **openshift-migration** project with the status **Succeeded**.
5. Click **Cluster Application Migration Operator**.
6. Under **Provided APIs**, locate the **Migration Controller** tile, and click **Create Instance**.
7. Click **Create**.
8. Click **Workloads → Pods** to verify that the Controller Manager, Migration UI, Restic, and Velero Pods are running.

1.4.1.2. Installing the Cluster Application Migration Operator on an OpenShift Container Platform 3 source cluster

You can install the Cluster Application Migration Operator manually on an OpenShift Container Platform 3 source cluster.

**Prerequisites**

- Access to **registry.redhat.io**
- OpenShift Container Platform 3 cluster configured to pull images from **registry.redhat.io**
  To pull images, you must **create an imagestreamsecret** and copy it to each node in your cluster.

**Procedure**

1. Log in to **registry.redhat.io** with your Red Hat Customer Portal credentials:

   ```
   $ sudo podman login registry.redhat.io
   ```

   **NOTE**

   If your system is configured for rootless Podman containers, **sudo** is not required for this procedure.
2. Download the `operator.yml` file:

```bash
$ sudo podman cp $(sudo podman create registry.redhat.io/rhcam-1-2/openshift-migration-rhel7-operator:v1.2):/operator.yml ./
```

3. Download the `controller-3.yml` file:

```bash
$ sudo podman cp $(sudo podman create registry.redhat.io/rhcam-1-2/openshift-migration-rhel7-operator:v1.2):/controller-3.yml ./
```

4. Log in to your OpenShift Container Platform 3 cluster.

5. Verify that the cluster can authenticate with `registry.redhat.io`:

```bash
$ oc run test --image registry.redhat.io/ubi8 --command sleep infinity
```

6. Create the Cluster Application Migration Operator CR object:

```bash
$ oc create -f operator.yml
```

The output resembles the following:

```
namespace/openshift-migration created
rolebinding.rbac.authorization.k8s.io/system:deployers created
serviceaccount/migration-operator created
customresourcedefinition.apiextensions.k8s.io/migrationcontrollers.migration.openshift.io created
role.rbac.authorization.k8s.io/migration-operator created
rolebinding.rbac.authorization.k8s.io/migration-operator created
clusterrolebinding.rbac.authorization.k8s.io/migration-operator created
deployment.apps/migration-operator created
```

```
Error from server (AlreadyExists): error when creating "./operator.yml":
rolebindings.rbac.authorization.k8s.io "system:image-builders" already exists
```

```
Error from server (AlreadyExists): error when creating "./operator.yml":
rolebindings.rbac.authorization.k8s.io "system:image-pullers" already exists
```

1. You can ignore **Error from server (AlreadyExists)** messages. They are caused by the Cluster Application Migration Operator creating resources for earlier versions of OpenShift Container Platform 3 that are provided in later releases.

7. Create the Migration controller CR object:

```bash
$ oc create -f controller-3.yml
```

8. Verify that the Velero and Restic Pods are running:

```bash
$ oc get pods -n openshift-migration
```

**1.4.2. Installing the Cluster Application Migration Operator in a restricted environment**
You can install the Cluster Application Migration Operator with the Operation Lifecycle Manager (OLM) on an OpenShift Container Platform 4.4 target cluster and manually on an OpenShift Container Platform 3 source cluster.

For OpenShift Container Platform 4.4, you can build a custom Operator catalog image, push it to a local mirror image registry, and configure OLM to install the Cluster Application Migration Operator from the local registry. A mapping.txt file is created when you run the `oc adm catalog mirror` command.

On the OpenShift Container Platform 3 cluster, you can create a manifest file based on the Operator image and edit the file to point to your local image registry. The `image` value in the manifest file uses the `sha256` value from the `mapping.txt` file. Then, you can use the local image to create the Cluster Application Migration Operator.

Additional resources

- Using Operator Lifecycle Manager on restricted networks

1.4.2.1. Building an Operator catalog image

Cluster administrators can build a custom Operator catalog image to be used by Operator Lifecycle Manager (OLM) and push the image to a container image registry that supports Docker v2-2. For a cluster on a restricted network, this registry can be a registry that the cluster has network access to, such as the mirror registry created during the restricted network installation.

**IMPORTANT**

The OpenShift Container Platform cluster's internal registry cannot be used as the target registry because it does not support pushing without a tag, which is required during the mirroring process.

For this example, the procedure assumes use of the mirror registry created on the bastion host during a restricted network cluster installation.

**Prerequisites**

- A Linux workstation with unrestricted network access
- `oc` version 4.3.5+
- `podman` version 1.4.4+
- Access to mirror registry that supports Docker v2-2
- If you are working with private registries, set the `REG_CREDS` environment variable to the file path of your registry credentials for use in later steps. For example, for the `podman` CLI:

  ```bash
  $ REG_CREDS=${XDG_RUNTIME_DIR}/containers/auth.json
  ```

**Procedure**

1. On the workstation with unrestricted network access, authenticate with the target mirror registry:

  ```bash
  $ podman login <registry_host_name>
  ```
Also authenticate with `registry.redhat.io` so that the base image can be pulled during the build:

```
$ podman login registry.redhat.io
```

2. Build a catalog image based on the `redhat-operat\ors` catalog from `quay.io`, tagging and pushing it to your mirror registry:

```
$ oc adm catalog build \
  --appregistry-org redhat-operat\ors \ 1
  --from=registry.redhat.io/openshift4/ose-operator-registry:v4.4 \ 2
  --filter-by-os="linux/amd64" \ 3
  --to=<registry_host_name>:<port>/olm/redhat-operat\ors:v1 \ 4
  [-a ${REG_CREDS}] \ 5
  [--insecure] \ 6
```

INFO[0013] loading Bundles
dir=/var/folders/st/9cskxs53ll3wdn434vw4cd80000gn/T/300666084/manifests-829192605

Pushed sha256:f73d42950021f9240389f99dd5b0c7f1b533c054ba344654ff1edaf6bf827e3
to example_registry:5000/olm/redhat-operat\ors:v1

1. Organization (namespace) to pull from an App Registry instance.

2. Set `--from` to the `ose-operator-registry` base image using the tag that matches the target OpenShift Container Platform cluster major and minor version.

3. Set `--filter-by-os` to the operating system and architecture to use for the base image, which must match the target OpenShift Container Platform cluster. Valid values are `linux/amd64`, `linux/ppc64le`, and `linux/s390x`.

4. Name your catalog image and include a tag, for example, `v1`.

5. Optional: If required, specify the location of your registry credentials file.

6. Optional: If you do not want to configure trust for the target registry, add the `--insecure` flag.

Sometimes invalid manifests are accidentally introduced into Red Hat’s catalogs; when this happens, you might see some errors:

```
INFO[0014] directory
dir=/var/folders/st/9cskxs53ll3wdn434vw4cd80000gn/T/300666084/manifests-829192605
file=4.2 load=package
W1114 19:42:37.876180   34665 builder.go:141] error building database: error loading package into db: fuse-camel-k-operator.v7.5.0 specifies replacement that couldn't be found
  Uploading ... 244.9kB/s
```

These errors are usually non-fatal, and if the Operator package mentioned does not contain an Operator you plan to install or a dependency of one, then they can be ignored.

1.4.2.2. Configuring OperatorHub for restricted networks
Cluster administrators can configure OLM and OperatorHub to use local content in a restricted network environment using a custom Operator catalog image. For this example, the procedure uses a custom redhat-operators catalog image previously built and pushed to a supported registry.

Prerequisites

- A Linux workstation with unrestricted network access
- A custom Operator catalog image pushed to a supported registry
- `oc` version 4.3.5+
- `podman` version 1.4.4+
- Access to mirror registry that supports Docker v2-2
- If you are working with private registries, set the `REG_CREDS` environment variable to the file path of your registry credentials for use in later steps. For example, for the `podman` CLI:

  ```bash
  $ REG_CREDS=${XDG_RUNTIME_DIR}/containers/auth.json
  ```

Procedure

1. Disable the default OperatorSources by adding `disableAllDefaultSources: true` to the spec:

   ```bash
   $ oc patch OperatorHub cluster --type json \n   -p '[{"op": "add", "path": "/spec/disableAllDefaultSources", "value": true}]'
   ```

   This disables the default OperatorSources that are configured by default during an OpenShift Container Platform installation.

2. Mirror the contents of your catalog to your target registry. The following `oc adm catalog mirror` command extracts the contents of your custom Operator catalog image to generate the manifests required for mirroring and mirrors the images to your registry:

   ```bash
   $ oc adm catalog mirror \n   <registry_host_name>:<port>/olm/redhat-operators:v1 \n   <registry_host_name>:<port> \n   [-a ${REG_CREDS}] \n   [--insecure] \n   [--filter-by-os="<os>/<arch>"]
   ```

   mirroring ...

1. Specify your Operator catalog image.
2. Optional: If required, specify the location of your registry credentials file.
3. Optional: If you do not want to configure trust for the target registry, add the `--insecure` flag.
4. Optional: Because the catalog might reference images that support multiple architectures and operating systems, you can filter by architecture and operating system to mirror only the images that match. Valid values are `linux/amd64`, `linux/ppc64le`, and `linux/s390x`. 
This command also creates a `<image_name>-manifests/` directory in the current directory and generates the following files:

- The `imageContentSourcePolicy.yaml` file defines an ImageContentSourcePolicy object that can configure nodes to translate between the image references stored in Operator manifests and the mirrored registry.

- The `mapping.txt` file contains all of the source images and where to map them in the target registry. This file is compatible with the `oc image mirror` command and can be used to further customize the mirroring configuration.

3. Apply the manifests:

   ```bash
   $ oc apply -f ./redhat-operators-manifests
   ```

4. Create a CatalogSource object that references your catalog image.

   a. Modify the following to your specifications and save it as a `catalogsource.yaml` file:

   ```yaml
   apiVersion: operators.coreos.com/v1alpha1
   kind: CatalogSource
   metadata:
     name: my-operator-catalog
     namespace: openshift-marketplace
   spec:
     sourceType: grpc
     image: <registry_host_name>:<port>/olm/redhat-operators:v1
     displayName: My Operator Catalog
     publisher: grpc
   ```

   1. Specify your custom Operator catalog image.

   b. Use the file to create the CatalogSource object:

   ```bash
   $ oc create -f catalogsource.yaml
   ```

5. Verify the CatalogSource and package manifest are created successfully:

   ```bash
   # oc get pods -n openshift-marketplace
   NAME READY STATUS RESTARTS AGE
   my-operator-catalog-6njx6 1/1 Running 0 28s
   marketplace-operator-d9f549946-96sgr 1/1 Running 0 26h
   
   # oc get catalogsource -n openshift-marketplace
   NAME DISPLAY TYPE PUBLISHER AGE
   my-operator-catalog My Operator Catalog grpc 5s
   
   # oc get packagemanifest -n openshift-marketplace
   NAME CATALOG AGE
   etcd My Operator Catalog 34s
   ```

   You can also view them from the OperatorHub page in the web console.

---

You can now install the Operators from the OperatorHub page on your restricted network OpenShift.
You can now install the Operators from the OperatorHub page on your restricted network OpenShift Container Platform cluster.

1.4.2.3. Installing the Cluster Application Migration Operator on an OpenShift Container Platform 4.4 target cluster in a restricted environment

You can install the Cluster Application Migration Operator on an OpenShift Container Platform 4.4 target cluster with the Operation Lifecycle Manager (OLM).

The Cluster Application Migration Operator installs the Cluster Application Migration tool on the target cluster by default.

Prerequisites

- You created a custom Operator catalog and pushed it to a mirror registry.
- You configured OLM to install the Cluster Application Migration Operator from the mirror registry.

Procedure

1. In the OpenShift Container Platform web console, click Operators → OperatorHub.
2. Use the Filter by keyword field (in this case, Migration) to find the Cluster Application Migration Operator.
3. Select the Cluster Application Migration Operator and click Install.
4. On the Create Operator Subscription page, click Subscribe.
   On the Installed Operators page, the Cluster Application Migration Operator appears in the openshift-migration project with the status Succeeded.
5. Click Cluster Application Migration Operator.
6. Under Provided APIs, locate the Migration Controller tile, and click Create Instance.
7. Click Create.
8. Click Workloads → Pods to verify that the Controller Manager, Migration UI, Restic, and Velero Pods are running.

1.4.2.4. Installing the Cluster Application Migration Operator on an OpenShift Container Platform 3 source cluster in a restricted environment

You can create a manifest file based on the Cluster Application Migration Operator image and edit the manifest to point to your local image registry. Then, you can use the local image to create the Cluster Application Migration Operator on an OpenShift Container Platform 3 source cluster.

Prerequisites

- Access to registry.redhat.io
- Linux workstation with unrestricted network access
- Mirror registry that supports Docker v2-2
Custom Operator catalog pushed to a mirror registry

Procedure

1. On the workstation with unrestricted network access, log in to registry.redhat.io with your Red Hat Customer Portal credentials:

   ```bash
   $ sudo podman login registry.redhat.io
   ```

   **NOTE**
   
   If your system is configured for rootless Podman containers, `sudo` is not required for this procedure.

2. Download the `operator.yml` file:

   ```bash
   $ sudo podman cp $(sudo podman create registry.redhat.io/rhcam-1-2/openshift-migration-rhel7-operator:v1.2):/operator.yml ./
   ```

3. Download the `controller-3.yml` file:

   ```bash
   $ sudo podman cp $(sudo podman create registry.redhat.io/rhcam-1-2/openshift-migration-rhel7-operator:v1.2):/controller-3.yml ./
   ```

4. Obtain the Operator image value from the `mapping.txt` file that was created when you ran the `oc adm catalog mirror` on the OpenShift Container Platform 4 cluster:

   ```bash
   $ grep openshift-migration-rhel7-operator ./mapping.txt | grep rhcam-1-2
   ```

   The output shows the mapping between the `registry.redhat.io` image and your mirror registry image:

   ```
   registry.redhat.io/rhcam-1-2/openshift-migration-rhel7-operator@sha256:468a6126f73b1ee12085ca53a312d1f96ef5a2ca03442bcb63724af5e2614e8a=<registry.apps.example.com>/rhcam-1-2/openshift-migration-rhel7-operator
   ```

5. Update the `image` and `REGISTRY` values in the `operator.yml` file:

   ```
   containers:
   - name: ansible
     image: <registry.apps.example.com>/rhcam-1-2/openshift-migration-rhel7-operator@sha256:<468a6126f73b1ee12085ca53a312d1f96ef5a2ca03442bcb63724af5e2614e8a>
     ...  
   - name: operator
     image: <registry.apps.example.com>/rhcam-1-2/openshift-migration-rhel7-operator@sha256:<468a6126f73b1ee12085ca53a312d1f96ef5a2ca03442bcb63724af5e2614e8a>
     ...  
     env:
     - name: REGISTRY
       value: <registry.apps.example.com>
   ```
Specify your mirror registry and the sha256 value of the Operator image in the mapping.txt file.

Specify your mirror registry.


7. Create the Cluster Application Migration Operator CR object:

   $ oc create -f operator.yml

   The output resembles the following:

   namespace/openshift-migration created
   rolebinding.rbac.authorization.k8s.io/system:deployers created
   serviceaccount/migration-operator created
   customresourcedefinition.apiextensions.k8s.io/migrationcontrollers.migration.openshift.io created
   role.rbac.authorization.k8s.io/migration-operator created
   rolebinding.rbac.authorization.k8s.io/migration-operator created
   clusterrolebinding.rbac.authorization.k8s.io/migration-operator created
   deployment.apps/migration-operator created

   Error from server (AlreadyExists): error when creating "./operator.yml":
   rolebindings.rbac.authorization.k8s.io "system:image-builders" already exists
   Error from server (AlreadyExists): error when creating "./operator.yml":
   rolebindings.rbac.authorization.k8s.io "system:image-pullers" already exists

   You can ignore Error from server (AlreadyExists) messages. They are caused by the Cluster Application Migration Operator creating resources for earlier versions of OpenShift Container Platform 3 that are provided in later releases.

8. Create the Migration controller CR object:

   $ oc create -f controller-3.yml

9. Verify that the Velero and Restic Pods are running:

   $ oc get pods -n openshift-migration

1.4.3. Launching the CAM web console

You can launch the CAM web console in a browser.

Procedure

1. Log in to the OpenShift Container Platform cluster on which you have installed the CAM tool.

2. Obtain the CAM web console URL by entering the following command:

   $ oc get -n openshift-migration route/migration -o go-template='https://{{ .spec.host }}'
3. Launch a browser and navigate to the CAM web console.

**NOTE**

If you try to access the CAM web console immediately after installing the Cluster Application Migration Operator, the console may not load because the Operator is still configuring the cluster. Wait a few minutes and retry.

4. If you are using self-signed CA certificates, you will be prompted to accept the CA certificate of the source cluster’s API server. The web page guides you through the process of accepting the remaining certificates.

5. Log in with your OpenShift Container Platform username and password.

### 1.5. Configuring a Replication Repository

You must configure an object storage to use as a replication repository. The Cluster Application Migration tool copies data from the source cluster to the replication repository, and then from the replication repository to the target cluster.

The CAM tool supports the file system and snapshot data copy methods for migrating data from the source cluster to the target cluster. You can select a method that is suited for your environment and is supported by your storage provider.

The following storage providers are supported:

- **Multi-Cloud Object Gateway (MCG)**
- **Amazon Web Services (AWS) S3**
- **Google Cloud Provider (GCP)**
- **Microsoft Azure**
- **Generic S3 object storage, for example, Minio or Ceph S3**

The source and target clusters must have network access to the replication repository during migration.

In a restricted environment, you can create an internally hosted replication repository. If you use a proxy server, you must ensure that your replication repository is whitelisted.

#### 1.5.1. Configuring a Multi-Cloud Object Gateway storage bucket as a replication repository

You can install the OpenShift Container Storage Operator and configure a Multi-Cloud Object Gateway (MCG) storage bucket as a replication repository.

1. **1.5.1.1. Installing the OpenShift Container Storage Operator**

   You can install the OpenShift Container Storage Operator from OperatorHub.
1. In the OpenShift Container Platform web console, click Operators → OperatorHub.

2. Use Filter by keyword (in this case, OCS) to find the OpenShift Container Storage Operator.

3. Select the OpenShift Container Storage Operator and click Install.

4. Select an Update Channel, Installation Mode, and Approval Strategy.

5. Click Subscribe.

On the Installed Operators page, the OpenShift Container Storage Operator appears in the openshift-storage project with the status Succeeded.

**1.5.1.2. Creating the Multi-Cloud Object Gateway storage bucket**

You can create the Multi-Cloud Object Gateway (MCG) storage bucket’s Custom Resources (CRs).

**Procedure**

1. Log in to the OpenShift Container Platform cluster:

   ```bash
   $ oc login
   ```

2. Create the NooBaa CR configuration file, noobaa.yml, with the following content:

   ```yaml
   apiVersion: noobaa.io/v1alpha1
   kind: NooBaa
   metadata:
     name: noobaa
     namespace: openshift-storage
   spec:
     dbResources:
       requests:
         cpu: 0.5
         memory: 1Gi
     coreResources:
       requests:
         cpu: 0.5
         memory: 1Gi
   ```

   ![For a very small cluster, you can change the cpu value to 0.1.](image)

3. Create the NooBaa object:

   ```bash
   $ oc create -f noobaa.yml
   ```

4. Create the BackingStore CR configuration file, bs.yml, with the following content:

   ```yaml
   apiVersion: noobaa.io/v1alpha1
   kind: BackingStore
   metadata:
   finalizers:
     - noobaa.io/finalizer
   labels:
   ```
app: noobaa
name: mcg-pv-pool-bs
namespace: openshift-storage
spec:
  pvPool:
    numVolumes: 3 1
    resources:
      storage: 50Gi 2
      storageClass: gp2 3
    type: pv-pool

1. Specify the number of volumes in the PV pool.
2. Specify the size of the volumes.
3. Specify the storage class.

5. Create the **BackingStore** object:

   $ oc create -f bs.yml

6. Create the **BucketClass** CR configuration file, **bc.yml**, with the following content:

   ```yaml
   apiVersion: noobaa.io/v1alpha1
   kind: BucketClass
   metadata:
     app: noobaa
     name: mcg-pv-pool-bc
     namespace: openshift-storage
   spec:
     placementPolicy:
       tiers:
       - backingStores:
         - mcg-pv-pool-bs
       placement: Spread
   ```

7. Create the **BucketClass** object:

   $ oc create -f bc.yml

8. Create the **ObjectBucketClaim** CR configuration file, **obc.yml**, with the following content:

   ```yaml
   apiVersion: objectbucket.io/v1alpha1
   kind: ObjectBucketClaim
   metadata:
     name: migstorage
     namespace: openshift-storage
   spec:
     bucketName: migstorage 1
   ```
Record the bucket name for adding the replication repository to the CAM web console.

9. Create the `ObjectBucketClaim` object:

```bash
$ oc create -f obc.yml
```

10. Watch the resource creation process to verify that the `ObjectBucketClaim` status is **Bound**:

```bash
$ watch -n 30 'oc get -n openshift-storage objectbucketclaim migstorage -o yaml'
```

This process can take five to ten minutes.

11. Obtain and record the following values, which are required when you add the replication repository to the CAM web console:

- S3 endpoint:
  ```bash
  $ oc get route -n openshift-storage s3
  ```

- S3 provider access key:
  ```bash
  $ oc get secret -n openshift-storage migstorage -o go-template='{{.data.AWS_ACCESS_KEY_ID }}' | base64 -d
  ```

- S3 provider secret access key:
  ```bash
  $ oc get secret -n openshift-storage migstorage -o go-template='{{.data.AWS_SECRET_ACCESS_KEY }}' | base64 -d
  ```

### 1.5.2 Configuring an AWS S3 storage bucket as a replication repository

You can configure an AWS S3 storage bucket as a replication repository.

#### Prerequisites

- The AWS S3 storage bucket must be accessible to the source and target clusters.
- You must have the **AWS CLI** installed.
- If you are using the snapshot copy method:
  - You must have access to EC2 Elastic Block Storage (EBS).
  - The source and target clusters must be in the same region.
  - The source and target clusters must have the same storage class.
  - The storage class must be compatible with snapshots.
Procedure

1. Create an AWS S3 bucket:

   ```bash
   $ aws s3api create-bucket \
     --bucket <bucket_name> \
     --region <bucket_region>
   ```

   1 Specify your S3 bucket name.
   2 Specify your S3 bucket region, for example, **us-east-1**.

2. Create the IAM user **velero**:

   ```bash
   $ aws iam create-user --user-name velero
   ```

3. Create an EC2 EBS snapshot policy:

   ```bash
   $ cat > velero-ec2-snapshot-policy.json <<EOF
   {
     "Version": "2012-10-17",
     "Statement": [
       {
         "Effect": "Allow",
         "Action": [
           "ec2:DescribeVolumes",
           "ec2:DescribeSnapshots",
           "ec2:CreateTags",
           "ec2:CreateVolume",
           "ec2:CreateSnapshot",
           "ec2:DeleteSnapshot"
         ],
         "Resource": "*"
       }
     ]
   }
   EOF
   ```

4. Create an AWS S3 access policy for one or for all S3 buckets:

   ```bash
   $ cat > velero-s3-policy.json <<EOF
   {
     "Version": "2012-10-17",
     "Statement": [
       {
         "Effect": "Allow",
         "Action": [
           "s3:GetObject",
           "s3:DeleteObject",
           "s3:PutObject",
           "s3:AbortMultipartUpload",
           "s3:ListMultipartUploadParts"
         ],
         "Resource": [
           ```
"arn:aws:s3::<bucket_name>/*" 1

},
{
  "Effect": "Allow",
  "Action": [
    "s3:ListBucket",
    "s3:GetBucketLocation",
    "s3:ListBucketMultipartUploads"
  ],
  "Resource": [
    "arn:aws:s3::<bucket_name>" 2
  ]
}
}
EOF

To grant access to a single S3 bucket, specify the bucket name. To grant access to all AWS S3 buckets, specify * instead of a bucket name:

"Resource": [
  "arn:aws:s3::*"
]

5. Attach the EC2 EBS policy to velero:

   $ aws iam put-user-policy \
      --user-name velero \
      --policy-name velero-ebs \
      --policy-document file://velero-ec2-snapshot-policy.json

6. Attach the AWS S3 policy to velero:

   $ aws iam put-user-policy \
      --user-name velero \
      --policy-name velero-s3 \
      --policy-document file://velero-s3-policy.json

7. Create an access key for velero:

   $ aws iam create-access-key --user-name velero
   {
     "AccessKey": {
       "UserName": "velero",
       "Status": "Active",
       "CreateDate": "2017-07-31T22:41:57Z",
       "SecretAccessKey": `<AWS_SECRET_ACCESS_KEY>`, 1
       "AccessKeyId": `<AWS_ACCESS_KEY_ID>` 2
     }
   }

1 2 Record the AWS_SECRET_ACCESS_KEY and the AWS_ACCESS_KEY_ID for adding the AWS repository to the CAM web console.
1.5.3. Configuring a Google Cloud Provider storage bucket as a replication repository

You can configure a Google Cloud Provider (GCP) storage bucket as a replication repository.

Prerequisites

- The GCP storage bucket must be accessible to the source and target clusters.
- You must have `gsutil` installed.
- If you are using the snapshot copy method:
  - The source and target clusters must be in the same region.
  - The source and target clusters must have the same storage class.
  - The storage class must be compatible with snapshots.

Procedure

1. Run `gsutil init` to log in:

   ```bash
   $ gsutil init
   Welcome! This command will take you through the configuration of gcloud.
   Your current configuration has been set to: [default]
   To continue, you must login. Would you like to login (Y/n)?
   ```

2. Set the `BUCKET` variable:

   ```bash
   $ BUCKET=<bucket_name>
   ```

   Specify your bucket name.

3. Create a storage bucket:

   ```bash
   $ gsutil mb gs://$BUCKET/
   ```

4. Set the `PROJECT_ID` variable to your active project:

   ```bash
   $ PROJECT_ID=$(gcloud config get-value project)
   ```

5. Create a `velero` service account:

   ```bash
   $ gcloud iam service-accounts create velero
   --display-name "Velero Storage"
   ```

6. Set the `SERVICE_ACCOUNT_EMAIL` variable to the service account’s email address:
$ SERVICE_ACCOUNT_EMAIL=$(gcloud iam service-accounts list \
  --filter="displayName:Velero Storage" \
  --format 'value(email)')

7. Grant permissions to the service account:

$ ROLE_PERMISSIONS=(
  compute.disks.get
  compute.disks.create
  compute.disks.createSnapshot
  compute.snapshots.get
  compute.snapshots.create
  compute.snapshots.useReadOnly
  compute.snapshots.delete
  compute.zones.get
)

gcloud iam roles create velero.server \
  --project $PROJECT_ID \
  --title "Velero Server" \
  --permissions "$(IFS=","; echo "${ROLE_PERMISSIONS[*]}")"

gcloud projects add-iam-policy-binding $PROJECT_ID \
  --member serviceAccount:$SERVICE_ACCOUNT_EMAIL \
  --role projects/$PROJECT_ID/roles/velero.server

gsutil iam ch serviceAccount:$SERVICE_ACCOUNT_EMAIL:objectAdmin gs://${BUCKET}

8. Save the service account’s keys to the credentials-velero file in the current directory:

$ gcloud iam service-accounts keys create credentials-velero \
  --iam-account $SERVICE_ACCOUNT_EMAIL

1.5.4. Configuring a Microsoft Azure Blob storage container as a replication repository

You can configure a Microsoft Azure Blob storage container as a replication repository.

Prerequisites

- You must have an Azure storage account.
- You must have the Azure CLI installed.
- The Azure Blob storage container must be accessible to the source and target clusters.
- If you are using the snapshot copy method:
  - The source and target clusters must be in the same region.
  - The source and target clusters must have the same storage class.
  - The storage class must be compatible with snapshots.
Procedure

1. Set the `AZURE_RESOURCE_GROUP` variable:

   ```
   $ AZURE_RESOURCE_GROUP=Velero_Backups
   ```

2. Create an Azure resource group:

   ```
   $ az group create -n $AZURE_RESOURCE_GROUP --location <CentralUS>  
   ```

   Specify your location.

3. Set the `AZURE_STORAGE_ACCOUNT_ID` variable:

   ```
   $ AZURE_STORAGE_ACCOUNT_ID=velerobackups
   ```

4. Create an Azure storage account:

   ```
   $ az storage account create \
   --name $AZURE_STORAGE_ACCOUNT_ID \
   --resource-group $AZURE_RESOURCE_GROUP \
   --sku Standard_GRS \
   --encryption-services blob \
   --https-only true \
   --kind BlobStorage \
   --access-tier Hot
   ```

5. Set the `BLOB_CONTAINER` variable:

   ```
   $ BLOB_CONTAINER=velero
   ```

6. Create an Azure Blob storage container:

   ```
   $ az storage container create \
   -n $BLOB_CONTAINER \
   --public-access off \
   --account-name $AZURE_STORAGE_ACCOUNT_ID
   ```

7. Create a service principal and credentials for `velero`:

   ```
   $ AZURE_SUBSCRIPTION_ID=`az account list --query '[?isDefault].id' -o tsv`
   $ AZURE_TENANT_ID=`az account list --query '[?isDefault].tenantId' -o tsv`
   $ AZURE_CLIENT_SECRET=`az ad sp create-for-rbac --name "velero" --role "Contributor" --query 'password' -o tsv`
   $ AZURE_CLIENT_ID=`az ad sp list --display-name "velero" --query '[0].appId' -o tsv`
   ```

8. Save the service principal’s credentials in the `credentials-velero` file:

   ```
   $ cat << EOF  > ./credentials-velero
   AZURE_SUBSCRIPTION_ID=${AZURE_SUBSCRIPTION_ID}
   AZURE_TENANT_ID=${AZURE_TENANT_ID}
   AZURE_CLIENT_ID=${AZURE_CLIENT_ID}
   EOF
   ```
1.6. MIGRATING APPLICATIONS WITH THE CAM WEB CONSOLE

You can migrate application workloads by adding your clusters and replication repository to the CAM web console. Then, you can create and run a migration plan.

If your cluster or replication repository are secured with self-signed certificates, you can create a CA certificate bundle file or disable SSL verification.

1.6.1. Creating a CA certificate bundle file

If you use a self-signed certificate to secure a cluster or a replication repository, certificate verification might fail with the following error message: Certificate signed by unknown authority.

You can create a custom CA certificate bundle file and upload it in the CAM web console when you add a cluster or a replication repository.

Procedure

Download a CA certificate from a remote endpoint and save it as a CA bundle file:

```
$ echo -n | openssl s_client -connect <host_FQDN>:<port> \
| sed -ne '/-BEGIN CERTIFICATE-/,/-END CERTIFICATE-/p' > <ca_bundle.cert>
```

1. Specify the host FQDN and port of the endpoint, for example, `api.my-cluster.example.com:6443`.
2. Specify the name of the CA bundle file.

1.6.2. Adding a cluster to the CAM web console

You can add a cluster to the CAM web console.

Prerequisites

If you are using Azure snapshots to copy data:

- You must provide the Azure resource group name when you add the source cluster.
- The source and target clusters must be in the same Azure resource group and in the same location.

Procedure

1. Log in to the cluster.
2. Obtain the service account token:

```
$ oc sa get-token mig -n openshift-migration
eyJhbGciOiJSUzI1NiIsImtpZCI6IiJ9.eyJpc3MiOiJrdWJlcm5ldGVzL3NlcnZpY2VhY2NvdW50Iiwi
a3ViZXJuZXV0cy5pby9zZXJ2aWNlYWNjb3VudC90YW1lOm5ldGVz
```
3. Log in to the CAM web console.

4. In the **Clusters** section, click **Add cluster**.

5. Fill in the following fields:
   - **Cluster name**: May contain lower-case letters (a-z) and numbers (0-9). Must not contain spaces or international characters.
   - **Url**: URL of the cluster’s API server, for example, `https://<master1.example.com>:8443`.
   - **Service account token**: String that you obtained from the source cluster.
   - **Azure cluster**: Optional. Select it if you are using Azure snapshots to copy your data.
   - **Azure resource group**: This field appears if **Azure cluster** is checked.
   - If you use a custom CA bundle, click **Browse** and browse to the CA bundle file.

6. Click **Add cluster**.
   The cluster appears in the **Clusters** section.

### 1.6.3. Adding a replication repository to the CAM web console

You can add an object storage bucket as a replication repository to the CAM web console.

**Prerequisites**

- You must configure an object storage bucket for migrating the data.

**Procedure**

1. Log in to the CAM web console.

2. In the **Replication repositories** section, click **Add repository**.

3. Select a **Storage provider type** and fill in the following fields:
   - **AWS** for AWS S3, MCG, and generic S3 providers:
     - **Replication repository name**: Specify the replication repository name in the CAM web console.
     - **S3 bucket name**: Specify the name of the S3 bucket you created.
- **S3 bucket region**: Specify the S3 bucket region. **Required** for AWS S3. **Optional** for other S3 providers.

- **S3 endpoint**: Specify the URL of the S3 service, not the bucket, for example, `https://<s3-storage.apps.cluster.com>`. **Required** for a generic S3 provider. You must use the `https://` prefix.

- **S3 provider access key**: Specify the `<AWS_SECRET_ACCESS_KEY>` for AWS or the S3 provider access key for MCG.

- **S3 provider secret access key**: Specify the `<AWS_ACCESS_KEY_ID>` for AWS or the S3 provider secret access key for MCG.

- **Require SSL verification**: Clear this check box if you are using a generic S3 provider.

- If you use a custom CA bundle, click **Browse** and browse to the Base64-encoded CA bundle file.

- **GCP**:
  - **Replication repository name**: Specify the replication repository name in the CAM web console.
  - **GCP bucket name**: Specify the name of the GCP bucket.
  - **GCP credential JSON blob**: Specify the string in the `credentials-velero` file.

- **Azure**:
  - **Replication repository name**: Specify the replication repository name in the CAM web console.
  - **Azure resource group**: Specify the resource group of the Azure Blob storage.
  - **Azure storage account name**: Specify the Azure Blob storage account name.
  - **Azure credentials - INI file contents**: Specify the string in the `credentials-velero` file.

4. Click **Add repository** and wait for connection validation.

5. Click **Close**.
   The new repository appears in the **Replication repositories** section.

### 1.6.4. Changing migration plan limits for large migrations

You can change the migration plan limits for large migrations.

**IMPORTANT**

Changes should first be tested in your environment to avoid a failed migration.

A single migration plan has the following default limits:

- **10 namespaces**
  If this limit is exceeded, the CAM web console displays a **Namespace limit exceeded** error and you cannot create a migration plan.
- **100 Pods**
  If the Pod limit is exceeded, the CAM web console displays a warning message similar to the following example: 
  `Plan has been validated with warning condition(s). See warning message. Pod limit: 100 exceeded, found: 104.`

- **100 persistent volumes**
  If the persistent volume limit is exceeded, the CAM web console displays a similar warning message.

### Procedure

1. **Edit the Migration controller CR:**

   ```bash
   $ oc get migrationcontroller -n openshift-migration
   NAME     AGE
   migration-controller 5d19h
   $ oc edit migrationcontroller -n openshift-migration
   ``

2. **Update the following parameters:**

   ```yaml
   migration_controller: true
   # This configuration is loaded into mig-controller, and should be set on the # cluster where `migration_controller: true`
   mig_pv_limit: 100
   mig_pod_limit: 100
   mig_namespace_limit: 10
   ...
   ```

### 1.6.5. Creating a migration plan in the CAM web console

You can create a migration plan in the CAM web console.

### Prerequisites

- The CAM web console must contain the following:
  - Source cluster
  - Target cluster, which is added automatically during the CAM tool installation
  - Replication repository

- The source and target clusters must have network access to each other and to the replication repository.

- If you use snapshots to copy data, the source and target clusters must run on the same cloud provider (AWS, GCP, or Azure) and in the same region.

### Procedure

1. Log in to the CAM web console.
2. In the **Plans** section, click **Add plan**.

3. Enter the **Plan name** and click **Next**.
   The **Plan name** can contain up to 253 lower-case alphanumeric characters (a-z, 0-9). It must not contain spaces or underscores (_).

4. Select a **Source cluster**.

5. Select a **Target cluster**.

6. Select a **Replication repository**.

7. Select the projects to be migrated and click **Next**.

8. Select **Copy** or **Move** for the PVs:
   - **Copy** copies the data in a source cluster’s PV to the replication repository and then restores it on a newly created PV, with similar characteristics, in the target cluster.
     Optional: You can verify data copied with the filesystem method by selecting **Verify copy**. This option, which generates a checksum for each source file and checks it after restoration, significantly reduces performance.
   - **Move** unmounts a remote volume (for example, NFS) from the source cluster, creates a PV resource on the target cluster pointing to the remote volume, and then mounts the remote volume on the target cluster. Applications running on the target cluster use the same remote volume that the source cluster was using. The remote volume must be accessible to the source and target clusters.

9. Click **Next**.

10. Select a **Copy method** for the PVs:
    - **Snapshot** backs up and restores the disk using the cloud provider’s snapshot functionality. It is significantly faster than **Filesystem**.

    **NOTE**
    The storage and clusters must be in the same region and the storage class must be compatible.

    - **Filesystem** copies the data files from the source disk to a newly created target disk.

11. Select a **Storage class** for the PVs.
    If you selected the **Filesystem** copy method, you can change the storage class during migration, for example, from Red Hat Gluster Storage or NFS storage to Red Hat Ceph Storage.

12. Click **Next**.

13. If you want to add a migration hook, click **Add Hook** and perform the following steps:
   a. Specify the name of the hook.

   b. Select **Ansible playbook** to use your own playbook or **Custom container image** for a hook written in another language.

   c. Click **Browse** to upload the playbook.
d. Optional: If you are not using the default Ansible runtime image, specify your custom Ansible image.

e. Specify the cluster on which you want the hook to run.

f. Specify the service account name.

g. Specify the namespace.

h. Select the migration step at which you want the hook to run:
   - PreBackup: Before backup tasks are started on the source cluster
   - PostBackup: After backup tasks are complete on the source cluster
   - PreRestore: Before restore tasks are started on the target cluster
   - PostRestore: After restore tasks are complete on the target cluster

14. Click **Add**.
    You can add up to four hooks to a migration plan, assigning each hook to a different migration step.

15. Click **Finish**.

16. Click **Close**.
    The migration plan appears in the **Plans** section.

### 1.6.6. Running a migration plan in the CAM web console

You can stage or migrate applications and data with the migration plan you created in the CAM web console.

**Prerequisites**

The CAM web console must contain the following:

- Source cluster
- Target cluster, which is added automatically during the CAM tool installation
- Replication repository
- Valid migration plan

**Procedure**

1. Log in to the CAM web console on the target cluster.

2. Select a migration plan.

3. Click **Stage** to copy data from the source cluster to the target cluster without stopping the application.
   You can run **Stage** multiple times to reduce the actual migration time.

4. When you are ready to migrate the application workload, click **Migrate**.
Migrate stops the application workload on the source cluster and recreates its resources on the target cluster.

5. Optional: In the Migrate window, you can select Do not stop applications on the source cluster during migration.

6. Click Migrate.

7. Optional: To stop a migration in progress, click the Options menu and select Cancel.

8. When the migration is complete, verify that the application migrated successfully in the OpenShift Container Platform web console:
   a. Click Home → Projects.
   b. Click the migrated project to view its status.
   c. In the Routes section, click Location to verify that the application is functioning, if applicable.
   d. Click Workloads → Pods to verify that the Pods are running in the migrated namespace.
   e. Click Storage → Persistent volumes to verify that the migrated persistent volume is correctly provisioned.

1.7. MIGRATING CONTROL PLANE SETTINGS WITH THE CONTROL PLANE MIGRATION ASSISTANT (CPMA)

The Control Plane Migration Assistant (CPMA) is a CLI-based tool that assists you in migrating the control plane from OpenShift Container Platform 3.7 (or later) to 4.4. The CPMA processes the OpenShift Container Platform 3 configuration files and generates Custom Resource (CR) manifest files, which are consumed by OpenShift Container Platform 4.4 Operators.

1.7.1. Installing the Control Plane Migration Assistant

You can download the Control Plane Migration Assistant (CPMA) binary file from the Red Hat Customer Portal and install it on Linux, MacOSX, or Windows operating systems.

Procedure

1. In the Red Hat Customer Portal, navigate to Downloads → Red Hat OpenShift Container Platform.


3. Select CPMA 1.0 for RHEL 7 from the Version list. This binary works on RHEL 7 and RHEL 8.

4. Click Download Now to download cpma for Linux or MacOSX or cpma.exe for Windows.

5. Save the file in a directory defined as $PATH for Linux or MacOSX or %PATH% for Windows.

6. For Linux, make the file executable:
$ sudo chmod +x cpma

1.7.2. Using the Control Plane Migration Assistant

The Control Plane Migration Assistant (CPMA) generates CR manifests, which are consumed by OpenShift Container Platform 4.4 Operators, and a report that indicates which OpenShift Container Platform 3 features are supported fully, partially, or not at all.

The CPMA can run in remote mode, retrieving the configuration files from the source cluster using SSH, or in local mode, using local copies of the source cluster’s configuration files.

Prerequisites

- The source cluster must be OpenShift Container Platform 3.7 or later.
- The source cluster must be updated to the latest synchronous release.
- An environment health check must be run on the source cluster to confirm that there are no diagnostic errors or warnings.
- The CPMA binary must be executable.
- You must have `cluster-admin` privileges for the source cluster.

Procedure

1. Log in to the OpenShift Container Platform 3 cluster:

   $ oc login https://<master1.example.com>  

   OpenShift Container Platform 3 master node. You must be logged in to the cluster to receive a token for the Kubernetes and OpenShift Container Platform APIs.

2. Run the CPMA. Each prompt requires you to provide input, as in the following example:

   $ cpma --manifests=false  
   ? Do you wish to save configuration for future use? true  
   ? What will be the source for OCP3 config files? Remote host  
   ? Path to crio config file /etc/crio/crio.conf  
   ? Path to etcd config file /etc/etcd/etcd.conf  
   ? Path to master config file /etc/origin/master/master-config.yaml  
   ? Path to node config file /etc/origin/node/node-config.yaml  
   ? Path to registries config file /etc/containers/registries.conf  
   ? Do wish to find source cluster using KUBECONFIG or prompt it? KUBECONFIG  
   ? Select cluster obtained from KUBECONFIG contexts master1-example-com:443  
   ? Select master node master1.example.com  
   ? SSH login root  
   ? SSH Port 22  
   ? Path to private SSH key /home/user/.ssh/openshift_key  
   ? Path to application data, skip to use current directory .  
   INFO[29 Aug 19 00:07 UTC] Starting manifest and report generation  
   INFO[29 Aug 19 00:07 UTC] Transform:Starting for - API  
   INFO[29 Aug 19 00:07 UTC] APITransform::Extract
INFO[29 Aug 19 00:07 UTC] APITransform::Transform:Reports
INFO[29 Aug 19 00:07 UTC] Transform::Starting for - Cluster
INFO[29 Aug 19 00:08 UTC] ClusterTransform::Transform:Reports
INFO[29 Aug 19 00:08 UTC] ClusterReport::ReportQuotas
INFO[29 Aug 19 00:08 UTC] ClusterReport::ReportPVs
INFO[29 Aug 19 00:08 UTC] ClusterReport::ReportNamespaces
INFO[29 Aug 19 00:08 UTC] ClusterReport::ReportNodes
INFO[29 Aug 19 00:08 UTC] ClusterReport::ReportRBAC
INFO[29 Aug 19 00:08 UTC] ClusterReport::ReportStorageClasses
INFO[29 Aug 19 00:08 UTC] Transform::Starting for - Crio
INFO[29 Aug 19 00:08 UTC] CrioTransform::Extract
WARN[29 Aug 19 00:08 UTC] Skipping Crio: No configuration file available
INFO[29 Aug 19 00:08 UTC] Transform::Starting for - Docker
INFO[29 Aug 19 00:08 UTC] DockerTransform::Extract
INFO[29 Aug 19 00:08 UTC] DockerTransform::Transform:Reports
INFO[29 Aug 19 00:08 UTC] Transform::Starting for - ETCD
INFO[29 Aug 19 00:08 UTC] ETCDTransform::Extract
INFO[29 Aug 19 00:08 UTC] ETCDTransform::Transform:Reports
INFO[29 Aug 19 00:08 UTC] Transform::Starting for - OAuth
INFO[29 Aug 19 00:08 UTC] OAuthTransform::Extract
INFO[29 Aug 19 00:08 UTC] OAuthTransform::Transform:Reports
INFO[29 Aug 19 00:08 UTC] Transform::Starting for - SDN
INFO[29 Aug 19 00:08 UTC] SDNTransform::Extract
INFO[29 Aug 19 00:08 UTC] SDNTransform::Transform:Reports
INFO[29 Aug 19 00:08 UTC] Transform::Starting for - Image
INFO[29 Aug 19 00:08 UTC] ImageTransform::Extract
INFO[29 Aug 19 00:08 UTC] ImageTransform::Transform:Reports
INFO[29 Aug 19 00:08 UTC] Transform::Starting for - Project
INFO[29 Aug 19 00:08 UTC] ProjectTransform::Extract
INFO[29 Aug 19 00:08 UTC] ProjectTransform::Transform:Reports
INFO[29 Aug 19 00:08 UTC] Flushing reports to disk
INFO[29 Aug 19 00:08 UTC] Report:Added: report.json
INFO[29 Aug 19 00:08 UTC] Report:Added: report.html
INFO[29 Aug 19 00:08 UTC] Successfully finished transformations

1. **--manifests=false**: Without generating CR manifests
2. **Remote host**: Remote mode
3. **SSH login**: The SSH user must have `sudo` permissions on the OpenShift Container Platform 3 cluster in order to access the configuration files.

The CPMA creates the following files and directory in the current directory if you did not specify an output directory:

- **cpma.yaml** file: Configuration options that you provided when you ran the CPMA
- **master1.example.com/**: Configuration files from the master node
- **report.json**: JSON-encoded report
- **report.html**: HTML-encoded report

3. Open the **report.html** file in a browser to view the CPMA report.
4. If you generate CR manifests, apply the CR manifests to the OpenShift Container Platform 4.4 cluster, as in the following example:

```bash
$ oc apply -f 100_CPMA-cluster-config-secret-htpasswd-secret.yaml
```

### 1.8. TROUBLESHOOTING

You can view the migration Custom Resources (CRs) and download logs to troubleshoot a failed migration.

If the application was stopped during the failed migration, you must roll it back manually in order to prevent data corruption.

**NOTE**

Manual rollback is not required if the application was not stopped during migration, because the original application is still running on the source cluster.

#### 1.8.1. Viewing migration Custom Resources

The Cluster Application Migration (CAM) tool creates the following Custom Resources (CRs):

**MIG configuration CRs** (on CAM cluster)

1. **MigCluster** (configuration, CAM cluster): Cluster definition
2. **MigStorage** (configuration, CAM cluster): Storage definition

**MIG action CRs**

3. **MigPlan**

**Velero** (Created on source cluster and target cluster)

4. **BackupStorageLocation**
5. **VolumeSnapshotLocation**

**Velero** (Created on target cluster)

6. **MigMigration**

7. **Backup**
8. **Restore**
MigPlan (configuration, CAM cluster): Migration plan

The MigPlan CR describes the source and target clusters, repository, and namespace(s) being migrated. It is associated with 0, 1, or many MigMigration CRs.

NOTE
Deleting a MigPlan CR deletes the associated MigMigration CRs.

BackupStorageLocation (configuration, CAM cluster): Location of Velero backup objects

VolumeSnapshotLocation (configuration, CAM cluster): Location of Velero volume snapshots

MigMigration (action, CAM cluster): Migration, created during migration

A MigMigration CR is created every time you stage or migrate data. Each MigMigration CR is associated with a MigPlan CR.

Backup (action, source cluster): When you run a migration plan, the MigMigration CR creates two Velero backup CRs on each source cluster:

- Backup CR #1 for Kubernetes objects
- Backup CR #2 for PV data

Restore (action, target cluster): When you run a migration plan, the MigMigration CR creates two Velero restore CRs on the target cluster:

- Restore CR #1 (using Backup CR #2) for PV data
- Restore CR #2 (using Backup CR #1) for Kubernetes objects

Procedure

1. Get the CR name:

   ```
   $ oc get <migration_cr> -n openshift-migration
   ``

   Specify the migration CR, for example, migmigration.

   The output is similar to the following:

   ```
   NAME                   AGE
   88435fe0-c9f8-11e9-85e6-5d593ce65e10   6m42s
   ```

2. View the CR:

   ```
   $ oc describe <migration_cr> <88435fe0-c9f8-11e9-85e6-5d593ce65e10> -n openshift-migration
   ```
MigMigration example

name: 88435fe0-c9f8-11e9-85e6-5d593ce65e10
namespace: openshift-migration
labels: <none>
annotations: touch: 3b48b543-b53e-4e44-9d34-33563f0f8147
apiVersion: migration.openshift.io/v1alpha1
kind: MigMigration
metadata:
  creationTimestamp: 2019-08-29T01:01:29Z
  generation: 20
  resourceVersion: 88179
  selfLink: /apis/migration.openshift.io/v1alpha1/namespaces/openshift-migration/migmigrations/88435fe0-c9f8-11e9-85e6-5d593ce65e10
  uid: 8886de4c-c9f8-11e9-95ad-0205fe66cbb6
spec:
  migPlanRef:
    name: socks-shop-mig-plan
    namespace: openshift-migration
  quiescePods: true
  stage: false
status:
  conditions:
    category: Advisory
    durable: True
    lastTransitionTime: 2019-08-29T01:03:40Z
    message: The migration has completed successfully.
    reason: Completed
    status: True
    type: Succeeded
    phase: Completed
    startTimestamp: 2019-08-29T01:01:29Z
  events: <none>

Velero backup CR #2 example (PV data)

apiVersion: velero.io/v1
kind: Backup
metadata:
  annotations:
    openshift.io/migrate-copy-phase: final
    openshift.io/migrate-quiesce-pods: "true"
    openshift.io/migration-registry: 172.30.105.179:5000
    openshift.io/migration-registry-dir: /socks-shop-mig-plan-registry-44dd3bd5-c9f8-11e9-95ad-0205fe66cbb6
  creationTimestamp: "2019-08-29T01:03:15Z"
generateName: 88435fe0-c9f8-11e9-85e6-5d593ce65e10-
generation: 1
labels:
  app.kubernetes.io/part-of: migration
  migmigration: 8886de4c-c9f8-11e9-95ad-0205fe66cbb6
  migration-stage-backup: 8886de4c-c9f8-11e9-95ad-0205fe66cbb6
  velero.io/storage-location: myrepo-vpzq9
name: 88435fe0-c9f8-11e9-85e6-5d593ce65e10-59gb7
namespace: openshift-migration
resourceVersion: "87313"
selfLink: /apis/velero.io/v1/namespaces/openshift-migration/backups/88435fe0-c9f8-11e9-85e6-5d593ce65e10-59gb7
uid: c80dbbc0-c9f8-11e9-95ad-0205fe66cbb6
spec:
excludedNamespaces: []
excludedResources: []
hooks:
  resources:
  includeClusterResources: null
  includedNamespaces:
  - sock-shop
  includedResources:
  - persistentvolumes
  - persistentvolumesclaims
  - namespaces
  - imagestreams
  - imagestreamtags
  - secrets
  - configmaps
  - pods
labelSelector:
  matchLabels:
    migration-included-stage-backup: 8886de4c-c9f8-11e9-95ad-0205fe66cbb6
storageLocation: myrepo-vpzq9
ttl: 720h0m0s
volumeSnapshotLocations:
  - myrepo-wv6fx
status:
  completionTimestamp: "2019-08-29T01:02:36Z"
  errors: 0
  expiration: "2019-09-28T01:02:35Z"
  phase: Completed
  startTimestamp: "2019-08-29T01:02:35Z"
  validationErrors: null
  version: 1
  volumeSnapshotsAttempted: 0
  volumeSnapshotsCompleted: 0
  warnings: 0

Velero restore CR #2 example (Kubernetes resources)

apiVersion: velero.io/v1
kind: Restore
metadata:
  annotations:
    openshift.io/migrate-copy-phase: final
    openshift.io/migrate-quiesce-pods: "true"
    openshift.io/migration-registry: 172.30.90.187:5000
    openshift.io/migration-registry-dir: /socks-shop-mig-plan-registry-36f54ca7-c925-11e9-825a-06fa9fb68c88
  creationTimestamp: "2019-08-28T00:09:49Z"
generateName: e13a1b60-c927-11e9-9555-d129df7f3b96-generation: 3
1.8.2. Downloading migration logs

You can download the Velero, Restic, and Migration controller logs in the CAM web console to troubleshoot a failed migration.

Procedure

1. Log in to the CAM console.

2. Click Plans to view the list of migration plans.

3. Click the Options menu of a specific migration plan and select Logs.

4. Click Download Logs to download the logs of the Migration controller, Velero, and Restic for all clusters.

5. To download a specific log:
   a. Specify the log options:
      - Cluster: Select the source, target, or CAM host cluster.
      - Log source: Select Velero, Restic, or Controller.
• **Pod source**: Select the Pod name, for example, `controller-manager-78c469849c-v6wcf`
  The selected log is displayed.

  You can clear the log selection settings by changing your selection.

  b. Click **Download Selected** to download the selected log.

Optionally, you can access the logs by using the CLI, as in the following example:

```bash
$ oc get pods -n openshift-migration | grep controller
controller-manager-78c469849c-v6wcf           1/1     Running     0          4h49m
$ oc logs controller-manager-78c469849c-v6wcf -f -n openshift-migration
```

### 1.8.3. Updating deprecated API GroupVersionKinds

In OpenShift Container Platform 4.4, some API **GroupVersionKinds** (GVKs) that are used by OpenShift Container Platform 3.x are **deprecated**.

If your source cluster uses deprecated GVKs, the following warning is displayed when you create a migration plan: **Some namespaces contain GVKs incompatible with destination cluster**. You can click **See details** to view the namespace and the incompatible GVKs.

![NOTE]
This warning does not block the migration.

During migration, the deprecated GVKs are saved in the Velero Backup Custom Resource (CR) #1 for Kubernetes objects. You can download the Backup CR, extract the deprecated GVK **yaml** files, and update them with the `oc convert` command. Then you create the updated GVKs on the target cluster.

**Procedure**

1. Run the migration plan.

2. View the MigPlan CR:

   ```bash
   $ oc describe migplan <migplan_name> -n openshift-migration
   ```

   Specify the name of the migration plan.

   The output is similar to the following:

   ```json
   metadata:
   ...
   uid: 79509e05-61d6-11e9-bc55-02ce4781844a
   status:
   ...
   conditions:
   - category: Warn
     lastTransitionTime: 2020-04-30T17:16:23Z
     message: 'Some namespaces contain GVKs incompatible with destination cluster.'
   ```
See: `incompatibleNamespaces` for details
status: "True"
type: GVKsIncompatible
incompatibleNamespaces:
- gvks:
  - group: batch
    kind: cronjobs
      version: v2alpha1
    - group: batch
      kind: scheduledjobs
        version: v2alpha1

1. Record the MigPlan UID.
2. 3. Record the deprecated GVKs.

3. Get the MigMigration name associated with the MigPlan UID:

```bash
$ oc get migmigration -o json | jq -r '.items[] | select(.metadata.ownerReferences[].uid=="<migplan_uid>") | .metadata.name'
```

1. Specify the MigPlan UID.

4. Get the MigMigration UID associated with the MigMigration name:

```bash
$ oc get migmigration <migmigration_name> -o jsonpath='{.metadata.uid}'
```

1. Specify the MigMigration name.

5. Get the Velero Backup name associated with the MigMigration UID:

```bash
$ oc get backup.velero.io --selector migration-initial-backup="<migmigration_uid>" -o jsonpath={.items[*].metadata.name}
```

1. Specify the MigMigration UID.

6. Download the contents of the Velero Backup to your local machine:

- For AWS S3:

  ```bash
  $ aws s3 cp s3://<bucket_name>/velero/backups/<backup_name> <backup_local_dir> --recursive
  ```

  1. Specify the bucket, backup name, and your local backup directory name.

- For GCP:

  ```bash
  $ gsutil cp gs://<bucket_name>/velero/backups/<backup_name> <backup_local_dir> --recursive
  ```

  1. Specify the bucket, backup name, and your local backup directory name.
1. Specify the bucket, backup name, and your local backup directory name.

- For Azure:

```bash
$ azcopy copy 'https://velerobackups.blob.core.windows.net/velero/backups/<backup_name>' '<backup_local_dir>' --recursive
```

2. Specify the backup name and your local backup directory name.

7. Extract the Velero Backup archive file:

```bash
$ tar -xfv <backup_local_dir>/<backup_name>.tar.gz -C <backup_local_dir>
```

8. Run `oc convert` in offline mode on each deprecated GVK:

```bash
$ oc convert <backup_local_dir>/resources/<gvk>.json
```

9. Create the converted GVK on the target cluster:

```bash
$ oc create -f <gvk>.json
```

1. Specify the deprecated GVK.

1. Specify the converted GVK.

1.8.4. Error messages

1.8.4.1. Restic timeout error message in the Velero Pod log

If a migration fails because Restic times out, the following error appears in the Velero Pod log:

```
level=error msg="Error backing up item" backup=velero/monitoring error="timed out waiting for all PodVolumeBackups to complete"
error.file="/go/src/github.com/heptio/velero/pkg/restic/backupper.go:165"
error.function="github.com/heptio/velero/pkg/restic.(*backupper).BackupPodVolumes" group=v1
```

The default value of `restic_timeout` is one hour. You can increase this parameter for large migrations, keeping in mind that a higher value may delay the return of error messages.

Procedure

1. In the OpenShift Container Platform web console, navigate to **Operators → Installed Operators**.

2. Click **Cluster Application Migration Operator**.

3. In the **MigrationController** tab, click **migration-controller**.

4. In the **YAML** tab, update the following parameter value:
Valid units are \texttt{h} (hours), \texttt{m} (minutes), and \texttt{s} (seconds), for example, \texttt{3h30m15s}.

5. Click \textit{Save}.

1.8.4.2. \textbf{ResticVerifyErrors in the MigMigration Custom Resource}

If data verification fails when migrating a PV with the filesystem data copy method, the following error appears in the MigMigration Custom Resource (CR):

\begin{verbatim}
status:
  conditions:
  - category: Warn
durable: true
  lastTransitionTime: 2020-04-16T20:35:16Z
  message: There were verify errors found in 1 Restic volume restores. See restore `registry-example-migration-rvwcm`
    for details
  status: "True"
type: ResticVerifyErrors
\end{verbatim}

1. The error message identifies the Restore CR name.

2. \textbf{ResticErrors} also appears. \textbf{ResticErrors} is a general error warning that includes verification errors.

\begin{quote}
\textbf{NOTE}
A data verification error does not cause the migration process to fail.
\end{quote}

You can check the target cluster’s Restore CR to identify the source of the data verification error.

\textbf{Procedure}

1. Log in to the target cluster.

2. View the Restore CR:

\begin{verbatim}
$ oc describe <registry-example-migration-rvwcm> -n openshift-migration
\end{verbatim}

The output identifies the PV with \textbf{PodVolumeRestore} errors:

\begin{verbatim}
status:
  phase: Completed
podVolumeRestoreErrors:
  - kind: PodVolumeRestore
    name: <registry-example-migration-rvwcm-98t49>
    namespace: openshift-migration
    podVolumeRestoreResticErrors:
\end{verbatim}
3. View the `PodVolumeRestore` CR:

   ```shell
   $ oc describe <migration-example-rvwcm-98t49>
   ``

   The output identifies the Restic Pod that logged the errors:

   ```yaml
   completionTimestamp: 2020-05-01T20:49:12Z
   errors: 1
   resticErrors: 1
   ...
   resticPod: <restic-nr2v5>
   ```

4. View the Restic Pod log:

   ```shell
   $ oc logs -f restic-nr2v5
   ```

### 1.8.5. Manually rolling back a migration

If your application was stopped during a failed migration, you must roll it back manually in order to prevent data corruption in the PV.

This procedure is not required if the application was not stopped during migration, because the original application is still running on the source cluster.

**Procedure**

1. On the target cluster, switch to the migrated project:

   ```shell
   $ oc project <project>
   ```

2. Get the deployed resources:

   ```shell
   $ oc get all
   ```

3. Delete the deployed resources to ensure that the application is not running on the target cluster and accessing data on the PVC:

   ```shell
   $ oc delete <resource_type>
   ```

4. To stop a DaemonSet without deleting it, update the `nodeSelector` in the YAML file:

   ```yaml
   apiVersion: apps/v1
   kind: DaemonSet
   metadata:
     name: hello-daemonset
   spec:
     selector:
       matchLabels:
         name: hello-daemonset
   ```
Specify a nodeSelector value that does not exist on any node.

5. Update each PV’s reclaim policy so that unnecessary data is removed. During migration, the reclaim policy for bound PVs is Retain, to ensure that data is not lost when an application is removed from the source cluster. You can remove these PVs during rollback.

Specify Recycle or Delete.

6. On the source cluster, switch to your migrated project:

   $ oc project <project_name>

7. Obtain the project’s deployed resources:

   $ oc get all

8. Start one or more replicas of each deployed resource:

   $ oc scale --replicas=1 <resource_type>/<resource_name>

9. Update the nodeSelector of a DaemonSet to its original value, if you changed it during the procedure.

1.8.6. Gathering data for a customer support case

If you open a customer support case, you can run the must-gather tool with the openshift-migration-must-gather-rhel8 image to collect information about your cluster and upload it to the Red Hat Customer Portal.
The `openshift-migration-must-gather-rhel8` image collects logs and Custom Resource data that are not collected by the default `must-gather` image.

**Procedure**

1. Navigate to the directory where you want to store the `must-gather` data.

2. Run the `oc adm must-gather` command:

   ```bash
   $ oc adm must-gather --image=registry.redhat.io/rhcam-1-2/openshift-migration-must-gather-rhel8
   ```

   The `must-gather` tool collects the cluster information and stores it in a `must-gather.local.<uid>` directory.

3. Remove authentication keys and other sensitive information from the `must-gather` data.

4. Create an archive file containing the contents of the `must-gather.local.<uid>` directory:

   ```bash
   $ tar cvaf must-gather.tar.gz must-gather.local.<uid>/
   ```

   You can attach the compressed file to your customer support case on the Red Hat Customer Portal.

**1.8.7. Known issues**

This release has the following known issues:

- During migration, the Cluster Application Migration (CAM) tool preserves the following namespace annotations:
  - `openshift.io/sa.scc.mcs`
  - `openshift.io/sa.scc.supplemental-groups`
  - `openshift.io/sa.scc.uid-range`  
    These annotations preserve the UID range, ensuring that the containers retain their file system permissions on the target cluster. There is a risk that the migrated UIDs could duplicate UIDs within an existing or future namespace on the target cluster. (BZ#1748440)

- If an AWS bucket is added to the CAM web console and then deleted, its status remains **True** because the MigStorage CR is not updated. (BZ#1738564)

- Most cluster-scoped resources are not yet handled by the CAM tool. If your applications require cluster-scoped resources, you may have to create them manually on the target cluster.

- If a migration fails, the migration plan does not retain custom PV settings for quiesced pods. You must manually roll back the migration, delete the migration plan, and create a new migration plan with your PV settings. (BZ#1784899)

- If a large migration fails because Restic times out, you can increase the `restic_timeout` parameter value (default: `1h`) in the Migration controller CR.

- If you select the data verification option for PVs that are migrated with the filesystem copy method, performance is significantly slower. Velero generates a checksum for each file and checks it when the file is restored.
- In the current release (CAM 1.2), you cannot migrate from OpenShift Container Platform 3.7 to 4.4 because certain API GroupVersionKinds (GVKs) that are used by the source cluster are deprecated. You can manually update the GVKs after migration. (BZ#1817251)

- If you cannot install CAM 1.2 on an OpenShift Container Platform 3 cluster, download the current operator.yml file, which fixes this problem. (BZ#1843059)
You can migrate application workloads from OpenShift Container Platform 4.1 to 4.4 with the Cluster Application Migration (CAM) tool. The CAM tool enables you to control the migration and to minimize application downtime.

**NOTE**

You can migrate between OpenShift Container Platform clusters of the same version, for example, from 4.1 to 4.1, as long as the source and target clusters are configured correctly.

The CAM tool’s web console and API, based on Kubernetes Custom Resources, enable you to migrate stateful and stateless application workloads at the granularity of a namespace.

The CAM tool supports the file system and snapshot data copy methods for migrating data from the source cluster to the target cluster. You can select a method that is suited for your environment and is supported by your storage provider.

You can use migration hooks to run Ansible playbooks at certain points during the migration. The hooks are added when you create a migration plan.

### 2.1.1. Migration prerequisites

- You must have `cluster-admin` privileges on all clusters.
- The source and target clusters must have unrestricted network access to the replication repository.
- The cluster on which the Migration controller is installed must have unrestricted access to the other clusters.
- If your application uses images from the `openshift` namespace, the required versions of the images must be present on the target cluster.
  - If the required images are not present, you must update the `imagestreamtags` references to use an available version that is compatible with your application. If the `imagestreamtags` cannot be updated, you can manually upload equivalent images to the application namespaces and update the applications to reference them.

The following `imagestreamtags` have been removed from OpenShift Container Platform 4.2:

- `dotnet:1.0`, `dotnet:1.1`, `dotnet:2.0`
- `dotnet-runtime:2.0`
- `mariadb:10.1`
- `mongodb:2.4`, `mongodb:2.6`
- `mysql:5.5`, `mysql:5.6`
- nginx:1.8
- nodejs:0.10, nodejs:4, nodejs:6
- perl:5.16, perl:5.20
- php:5.5, php:5.6
- python:3.3, python:3.4
- ruby:2.0, ruby:2.2

The following imagestreamtags have been removed from OpenShift Container Platform 4.4:

- dotnet: 2.2
- dotnet-runtime: 2.2
- nginx: 1.12
- nodejs: 8, 8-RHOAR, 10-SCL
- perl:5.24
- php: 7.0, 7.1
- redis: 3.2

2.1.2. About the Cluster Application Migration tool

The Cluster Application Migration (CAM) tool enables you to migrate Kubernetes resources, persistent volume data, and internal container images from an OpenShift Container Platform source cluster to an OpenShift Container Platform 4.4 target cluster, using the CAM web console or the Kubernetes API.

Migrating an application with the CAM web console involves the following steps:

1. Install the Cluster Application Migration Operator on all clusters.
   You can install the Cluster Application Migration Operator in a restricted environment with limited or no internet access. The source and target clusters must have network access to each other and to a mirror registry.

2. Configure the replication repository, an intermediate object storage that the CAM tool uses to migrate data.
   The source and target clusters must have network access to the replication repository during migration. In a restricted environment, you can use an internally hosted S3 storage repository. If you use a proxy server, you must ensure that replication repository is whitelisted.

3. Add the source cluster to the CAM web console.

4. Add the replication repository to the CAM web console.

5. Create a migration plan, with one of the following data migration options:
   - **Copy**: The CAM tool copies the data from the source cluster to the replication repository, and from the replication repository to the target cluster.
• **Move**: The CAM tool unmounts a remote volume (for example, NFS) from the source cluster, creates a PV resource on the target cluster pointing to the remote volume, and then mounts the remote volume on the target cluster. Applications running on the target cluster use the same remote volume that the source cluster was using. The remote volume must be accessible to the source and target clusters.

    **NOTE**

    Although the replication repository does not appear in this diagram, it is required for the actual migration.

6. Run the migration plan, with one of the following options:

   • **Stage** (optional) copies data to the target cluster without stopping the application. Staging can be run multiple times so that most of the data is copied to the target before migration. This minimizes the actual migration time and application downtime.

   • **Migrate** stops the application on the source cluster and recreates its resources on the target cluster. Optionally, you can migrate the workload without stopping the application.
2.1.3. About data copy methods

The CAM tool supports the file system and snapshot data copy methods for migrating data from the source cluster to the target cluster. You can select a method that is suited for your environment and is supported by your storage provider.

2.1.3.1. File system copy method

The CAM tool copies data files from the source cluster to the replication repository, and from there to the target cluster.

Table 2.1. File system copy method summary

<table>
<thead>
<tr>
<th>Benefits</th>
<th>Limitations</th>
</tr>
</thead>
<tbody>
<tr>
<td>● Clusters can have different storage classes</td>
<td>● Slower than the snapshot copy method</td>
</tr>
<tr>
<td>● Supported for all S3 storage providers</td>
<td>● Optional data verification significantly reduces performance</td>
</tr>
<tr>
<td>● Optional data verification with checksum</td>
<td></td>
</tr>
</tbody>
</table>

2.1.3.2. Snapshot copy method

The CAM tool copies a snapshot of the source cluster’s data to a cloud provider’s object storage, configured as a replication repository. The data is restored on the target cluster.

AWS, Google Cloud Provider, and Microsoft Azure support the snapshot copy method.
Table 2.2. Snapshot copy method summary

<table>
<thead>
<tr>
<th>Benefits</th>
<th>Limitations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Faster than the file system copy method</td>
<td>Cloud provider must support snapshots.</td>
</tr>
<tr>
<td></td>
<td>Clusters must be on the same cloud provider.</td>
</tr>
<tr>
<td></td>
<td>Clusters must be in the same location or region.</td>
</tr>
<tr>
<td></td>
<td>Clusters must have the same storage class.</td>
</tr>
<tr>
<td></td>
<td>Storage class must be compatible with snapshots.</td>
</tr>
</tbody>
</table>

2.1.4. About migration hooks

You can use migration hooks to run Ansible playbooks at certain points during the migration. The hooks are added when you create a migration plan.

NOTE

If you do not want to use Ansible playbooks, you can create a custom container image and add it to a migration plan.

Migration hooks perform tasks such as customizing application quiescence, manually migrating unsupported data types, and updating applications after migration.

A single migration hook runs on a source or target cluster at one of the following migration steps:

- PreBackup: Before backup tasks are started on the source cluster
- PostBackup: After backup tasks are complete on the source cluster
- PreRestore: Before restore tasks are started on the target cluster
- PostRestore: After restore tasks are complete on the target cluster

You can assign one hook to each migration step, up to a maximum of four hooks for a single migration plan.

The default hook-runner image is registry.redhat.io/rhcam-1-2/openshift-migration-hook-runner-rhel7. This image is based on Ansible Runner and includes python-openshift for Ansible Kubernetes resources and an updated oc binary. You can also create your own hook image with additional Ansible modules or tools.

The Ansible playbook is mounted on a hook container as a ConfigMap. The hook container runs as a Job on a cluster with a specified service account and namespace. The Job runs, even if the initial Pod is evicted or killed, until it reaches the default backoffLimit (6) or successful completion.

2.2. DEPLOYING THE CLUSTER APPLICATION MIGRATION TOOL
You can install the Cluster Application Migration Operator on your OpenShift Container Platform 4.4 target cluster and 4.1 source cluster. The Cluster Application Migration Operator installs the Cluster Application Migration (CAM) tool on the target cluster by default.

NOTE
Optional: You can configure the Cluster Application Migration Operator to install the CAM tool on an OpenShift Container Platform 3 cluster or on a remote cluster.

In a restricted environment, you can install the Cluster Application Migration Operator from a local mirror registry.

After you have installed the Cluster Application Migration Operator on your clusters, you can launch the CAM tool.

2.2.1. Installing the Cluster Application Migration Operator

You can install the Cluster Application Migration Operator with the Operation Lifecycle Manager (OLM) on an OpenShift Container Platform 4.4 target cluster and on an OpenShift Container Platform 4.1 source cluster.

2.2.1.1. Installing the Cluster Application Migration Operator on an OpenShift Container Platform 4.4 target cluster

You can install the Cluster Application Migration Operator on an OpenShift Container Platform 4.4 target cluster with the Operation Lifecycle Manager (OLM).

The Cluster Application Migration Operator installs the Cluster Application Migration tool on the target cluster by default.

Procedure

1. In the OpenShift Container Platform web console, click Operators → OperatorHub.

2. Use the Filter by keyword field (in this case, Migration) to find the Cluster Application Migration Operator.

3. Select the Cluster Application Migration Operator and click Install.

4. On the Create Operator Subscription page, click Subscribe.
   On the Installed Operators page, the Cluster Application Migration Operator appears in the openshift-migration project with the status Succeeded.

5. Click Cluster Application Migration Operator.

6. Under Provided APIs, locate the Migration Controller tile, and click Create Instance.

7. Click Create.

8. Click Workloads → Pods to verify that the Controller Manager, Migration UI, Restic, and Velero Pods are running.

2.2.1.2. Installing the Cluster Application Migration Operator on an OpenShift Container Platform 4.1 source cluster
You can install the Cluster Application Migration Operator on an OpenShift Container Platform 4 source cluster with the Operation Lifecycle Manager (OLM).

Procedure

1. In the OpenShift Container Platform web console, click Catalog → OperatorHub.
2. Use the Filter by keyword field (in this case, Migration) to find the Cluster Application Migration Operator.
3. Select the Cluster Application Migration Operator and click Install.
4. On the Create Operator Subscription page, click Subscribe.
   On the Installed Operators page, the Cluster Application Migration Operator appears in the openshift-migration project with the status Succeeded.
5. Click Cluster Application Migration Operator.
6. Under Provided APIs, locate the Migration Controller tile, and click Create Instance.
7. Set the migration_controller and migration_ui parameters to false and add the deprecated_cors_configuration: true parameter to the spec stanza:

```
spec:
  ...
  migration_controller: false
  migration_ui: false
  ...
  deprecated_cors_configuration: true
```
8. Click Create.
9. Click Workloads → Pods to verify that the Restic and Velero Pods are running.

2.2.2. Installing the Cluster Application Migration Operator in a restricted environment

You can build a custom Operator catalog image for OpenShift Container Platform 4, push it to a local mirror image registry, and configure the Operation Lifecycle Manager to install the Cluster Application Migration Operator from the local registry.

Additional resources

- Using Operator Lifecycle Manager on restricted networks

2.2.2.1. Building an Operator catalog image

Cluster administrators can build a custom Operator catalog image to be used by Operator Lifecycle Manager (OLM) and push the image to a container image registry that supports Docker v2-2. For a cluster on a restricted network, this registry can be a registry that the cluster has network access to, such as the mirror registry created during the restricted network installation.
IMPORTANT

The OpenShift Container Platform cluster’s internal registry cannot be used as the target registry because it does not support pushing without a tag, which is required during the mirroring process.

For this example, the procedure assumes use of the mirror registry created on the bastion host during a restricted network cluster installation.

Prerequisites

- A Linux workstation with unrestricted network access
- `oc` version 4.3.5+
- `podman` version 1.4.4+
- Access to mirror registry that supports Docker v2-2
- If you are working with private registries, set the `REG_CREDS` environment variable to the file path of your registry credentials for use in later steps. For example, for the `podman` CLI:

  ```
  $ REG_CREDS=${XDG_RUNTIME_DIR}/containers/auth.json
  ```

Procedure

1. On the workstation with unrestricted network access, authenticate with the target mirror registry:

   ```
   $ podman login <registry_host_name>
   ```

   Also authenticate with `registry.redhat.io` so that the base image can be pulled during the build:

   ```
   $ podman login registry.redhat.io
   ```

2. Build a catalog image based on the `redhat-operators` catalog from `quay.io`, tagging and pushing it to your mirror registry:

   ```
   $ oc adm catalog build \
   --appregistry-org redhat-operators \1
   --from=registry.redhat.io/openshift4/ose-operator-registry:v4.4 \2
   --filter-by-os="linux/amd64" \3
   --to=<registry_host_name>:<port>/olm/redhat-operators:v1 \4
   [-a ${REG_CREDS}] \5
   [--insecure] \6
   ```

   INFO[0013] loading Bundles
dir=/var/folders/st/9cskxqs53ll3wdn434vw4cd80000gn/T/3006660684/manifests-829192605 ...
   Pushed sha256:f73d42950021f924038f99ddc5b0c7f1b533c054ba344654ff1edaf6bf827e3 to example_registry:5000/olm/redhat-operators:v1

   \1 Organization (namespace) to pull from an App Registry instance.
Set `--from` to the `ose-operator-registry` base image using the tag that matches the target OpenShift Container Platform cluster major and minor version.

Set `--filter-by-os` to the operating system and architecture to use for the base image, which must match the target OpenShift Container Platform cluster. Valid values are `linux/amd64`, `linux/ppc64le`, and `linux/s390x`.

Name your catalog image and include a tag, for example, `v1`.

Optional: If required, specify the location of your registry credentials file.

Optional: If you do not want to configure trust for the target registry, add the `--insecure` flag.

Sometimes invalid manifests are accidentally introduced into Red Hat’s catalogs; when this happens, you might see some errors:

```
INFO[0014] directory
dir=/var/folders/st/9cskxqs53ll3wdn434vw4cd80000gn/T/300666084/manifests-829192605
file=4.2 load=package
package into db: fuse-camel-k-operator.v7.5.0 specifies replacement that couldn't be found
Uploading ... 244.9kB/s
```

These errors are usually non-fatal, and if the Operator package mentioned does not contain an Operator you plan to install or a dependency of one, then they can be ignored.

### 2.2.2.2. Configuring OperatorHub for restricted networks

Cluster administrators can configure OLM and OperatorHub to use local content in a restricted network environment using a custom Operator catalog image. For this example, the procedure uses a custom `redhat-operators` catalog image previously built and pushed to a supported registry.

**Prerequisites**

- A Linux workstation with unrestricted network access
- A custom Operator catalog image pushed to a supported registry
- `oc` version 4.3.5+
- `podman` version 1.4.4+
- Access to mirror registry that supports Docker v2-2
- If you are working with private registries, set the `REG_CREDS` environment variable to the file path of your registry credentials for use in later steps. For example, for the `podman` CLI:

  ```
  $ REG_CREDS=${XDG_RUNTIME_DIR}/containers/auth.json
  ```

**Procedure**

1. Disable the default OperatorSources by adding `disableAllDefaultSources: true` to the spec:
$ oc patch OperatorHub cluster --type json \\
-p \
'["op": "add", "path": "/spec/disableAllDefaultSources", "value": true}]'

This disables the default OperatorSources that are configured by default during an OpenShift Container Platform installation.

2. Mirror the contents of your catalog to your target registry. The following `oc adm catalog mirror` command extracts the contents of your custom Operator catalog image to generate the manifests required for mirroring and mirrors the images to your registry:

```
$ oc adm catalog mirror \\
<registry_host_name>:<port>/olm/redhat-operators:v1 \\
<registry_host_name>:<port> \\
[-a ${REG_CREDS}] \\
[--insecure] \\
[--filter-by-os="<os>/<arch>"]
mirroring ...
```

1. Specify your Operator catalog image.
2. Optional: If required, specify the location of your registry credentials file.
3. Optional: If you do not want to configure trust for the target registry, add the `--insecure` flag.
4. Optional: Because the catalog might reference images that support multiple architectures and operating systems, you can filter by architecture and operating system to mirror only the images that match. Valid values are `linux/amd64`, `linux/ppc64le`, and `linux/s390x`.

This command also creates a `<image_name>-manifests/` directory in the current directory and generates the following files:

- The `imageContentSourcePolicy.yaml` file defines an ImageContentSourcePolicy object that can configure nodes to translate between the image references stored in Operator manifests and the mirrored registry.

- The `mapping.txt` file contains all of the source images and where to map them in the target registry. This file is compatible with the `oc image mirror` command and can be used to further customize the mirroring configuration.

3. Apply the manifests:

```
$ oc apply -f ./redhat-operators-manifests
```

4. Create a CatalogSource object that references your catalog image.

   a. Modify the following to your specifications and save it as a `catalogsource.yaml` file:

   ```yaml
   apiVersion: operators.coreos.com/v1alpha1
   kind: CatalogSource
   metadata:
     name: my-operator-catalog
     namespace: openshift-marketplace
   ```
Specify your custom Operator catalog image.

b. Use the file to create the CatalogSource object:

```bash
$ oc create -f catalogsource.yaml
```

5. Verify the CatalogSource and package manifest are created successfully:

```bash
# oc get pods -n openshift-marketplace
NAME READY STATUS RESTARTS AGE
my-operator-catalog-6njx6 1/1 Running 0 28s
marketplace-operator-d9f549946-96sgr 1/1 Running 0 26h

# oc get catalogsource -n openshift-marketplace
NAME DISPLAY TYPE PUBLISHER AGE
my-operator-catalog My Operator Catalog grpc 5s

# oc get packagemanifest -n openshift-marketplace
NAME CATALOG AGE
etcd My Operator Catalog 34s
```

You can also view them from the OperatorHub page in the web console.

You can now install the Operators from the OperatorHub page on your restricted network OpenShift Container Platform cluster.

### 2.2.2.3. Installing the Cluster Application Migration Operator on an OpenShift Container Platform 4.4 target cluster in a restricted environment

You can install the Cluster Application Migration Operator on an OpenShift Container Platform 4.4 target cluster with the Operation Lifecycle Manager (OLM).

The Cluster Application Migration Operator installs the Cluster Application Migration tool on the target cluster by default.

#### Prerequisites

- You created a custom Operator catalog and pushed it to a mirror registry.
- You configured OLM to install the Cluster Application Migration Operator from the mirror registry.

#### Procedure

1. In the OpenShift Container Platform web console, click Operators → OperatorHub.

2. Use the Filter by keyword field (in this case, Migration) to find the Cluster Application Migration Operator.
3. Select the **Cluster Application Migration Operator** and click **Install**.

4. On the **Create Operator Subscription** page, click **Subscribe**.
   On the **Installed Operators** page, the **Cluster Application Migration Operator** appears in the **openshift-migration** project with the status **Succeeded**.

5. Click **Cluster Application Migration Operator**.

6. Under **Provided APIs**, locate the **Migration Controller** tile, and click **Create Instance**.

7. Click **Create**.

8. Click **Workloads → Pods** to verify that the Controller Manager, Migration UI, Restic, and Velero Pods are running.

### 2.2.2.4. Installing the Cluster Application Migration Operator on an OpenShift Container Platform 4.1 source cluster in a restricted environment

You can install the Cluster Application Migration Operator on an OpenShift Container Platform 4 source cluster with the Operation Lifecycle Manager (OLM).

**Prerequisites**

- You created a custom Operator catalog and pushed it to a mirror registry.
- You configured OLM to install the Cluster Application Migration Operator from the mirror registry.

**Procedure**

1. Use the **Filter by keyword** field (in this case, **Migration**) to find the **Cluster Application Migration Operator**.

2. Select the **Cluster Application Migration Operator** and click **Install**.

3. On the **Create Operator Subscription** page, click **Subscribe**.
   On the **Installed Operators** page, the **Cluster Application Migration Operator** appears in the **openshift-migration** project with the status **Succeeded**.

4. Click **Cluster Application Migration Operator**.

5. Under **Provided APIs**, locate the **Migration Controller** tile, and click **Create Instance**.

6. Click **Create**.

### 2.2.3. Launching the CAM web console

You can launch the CAM web console in a browser.

**Procedure**

1. Log in to the OpenShift Container Platform cluster on which you have installed the CAM tool.

2. Obtain the CAM web console URL by entering the following command:
3. Launch a browser and navigate to the CAM web console.

   **NOTE**

   If you try to access the CAM web console immediately after installing the Cluster Application Migration Operator, the console may not load because the Operator is still configuring the cluster. Wait a few minutes and retry.

4. If you are using self-signed CA certificates, you will be prompted to accept the CA certificate of the source cluster’s API server. The web page guides you through the process of accepting the remaining certificates.

5. Log in with your OpenShift Container Platform **username** and **password**.

### 2.3. CONFIGURING A REPLICATION REPOSITORY

You must configure an object storage to use as a replication repository. The Cluster Application Migration tool copies data from the source cluster to the replication repository, and then from the replication repository to the target cluster.

The CAM tool supports the **file system and snapshot data copy methods** for migrating data from the source cluster to the target cluster. You can select a method that is suited for your environment and is supported by your storage provider.

The following storage providers are supported:

- Multi-Cloud Object Gateway (MCG)
- Amazon Web Services (AWS) S3
- Google Cloud Provider (GCP)
- Microsoft Azure
- Generic S3 object storage, for example, Minio or Ceph S3

The source and target clusters must have network access to the replication repository during migration.

In a restricted environment, you can create an internally hosted replication repository. If you use a proxy server, you must ensure that your replication repository is whitelisted.

#### 2.3.1. Configuring a Multi-Cloud Object Gateway storage bucket as a replication repository

You can install the OpenShift Container Storage Operator and configure a Multi-Cloud Object Gateway (MCG) storage bucket as a replication repository.

#### 2.3.1.1. Installing the OpenShift Container Storage Operator
You can install the OpenShift Container Storage Operator from OperatorHub.

**Procedure**

1. In the OpenShift Container Platform web console, click **Operators → OperatorHub**.
2. Use **Filter by keyword** (in this case, **OCS**) to find the **OpenShift Container Storage Operator**.
3. Select the **OpenShift Container Storage Operator** and click **Install**.
4. Select an **Update Channel**, **Installation Mode**, and **Approval Strategy**.
5. Click **Subscribe**. On the **Installed Operators** page, the **OpenShift Container Storage Operator** appears in the **openshift-storage** project with the status **Succeeded**.

### 2.3.1.2. Creating the Multi-Cloud Object Gateway storage bucket

You can create the Multi-Cloud Object Gateway (MCG) storage bucket’s Custom Resources (CRs).

**Procedure**

1. Log in to the OpenShift Container Platform cluster:
   
   ```
   $ oc login
   ```

2. Create the **NooBaa** CR configuration file, **noobaa.yaml**, with the following content:

   ```yaml
   apiVersion: noobaa.io/v1alpha1
   kind: NooBaa
   metadata:
     name: noobaa
     namespace: openshift-storage
   spec:
     dbResources:
       requests:
         cpu: 0.5
         memory: 1Gi
     coreResources:
       requests:
         cpu: 0.5
         memory: 1Gi
   ```

   **Note:** For a very small cluster, you can change the **cpu** value to **0.1**.

3. Create the **NooBaa** object:

   ```
   $ oc create -f noobaa.yaml
   ```

4. Create the **BackingStore** CR configuration file, **bs.yaml**, with the following content:

   ```yaml
   apiVersion: noobaa.io/v1alpha1
   kind: BackingStore
   ```
Specify the number of volumes in the PV pool.

Specify the size of the volumes.

Specify the storage class.

5. Create the `BackingStore` object:

   ```bash
   $ oc create -f bs.yml
   ```

6. Create the `BucketClass` CR configuration file, `bc.yml`, with the following content:

   ```yaml
   apiVersion: noobaa.io/v1alpha1
   kind: BucketClass
   metadata:
     labels:
       app: noobaa
       name: mcg-pv-pool-bc
       namespace: openshift-storage
   spec:
     placementPolicy:
       tiers:
       - backingStores:
           - mcg-pv-pool-bs
       placement: Spread
   ```

7. Create the `BucketClass` object:

   ```bash
   $ oc create -f bc.yml
   ```

8. Create the `ObjectBucketClaim` CR configuration file, `obc.yml`, with the following content:

   ```yaml
   apiVersion: objectbucket.io/v1alpha1
   kind: ObjectBucketClaim
   metadata:
     name: migstorage
     namespace: openshift-storage
   ```
spec:
  bucketName: migstorage
  storageClassName: openshift-storage.noobaa.io
  additionalConfig:
    bucketclass: mcg-pv-pool-bc

1. Record the bucket name for adding the replication repository to the CAM web console.

9. Create the **ObjectBucketClaim** object:

   ```
   $ oc create -f obc.yml
   ```

10. Watch the resource creation process to verify that the **ObjectBucketClaim** status is **Bound**:

    ```
    $ watch -n 30 'oc get -n openshift-storage objectbucketclaim migstorage -o yaml'
    ```

    This process can take five to ten minutes.

11. Obtain and record the following values, which are required when you add the replication repository to the CAM web console:
    - S3 endpoint:
      ```
      $ oc get route -n openshift-storage s3
      ```
    - S3 provider access key:
      ```
      $ oc get secret -n openshift-storage migstorage -o go-template='{{ .data.AWS_ACCESS_KEY_ID }}' | base64 -d
      ```
    - S3 provider secret access key:
      ```
      $ oc get secret -n openshift-storage migstorage -o go-template='{{ .data.AWS_SECRET_ACCESS_KEY }}' | base64 -d
      ```

2.3.2. Configuring an AWS S3 storage bucket as a replication repository

You can configure an AWS S3 storage bucket as a replication repository.

**Prerequisites**

- The AWS S3 storage bucket must be accessible to the source and target clusters.
- You must have the **AWS CLI** installed.
- If you are using the snapshot copy method:
  - You must have access to EC2 Elastic Block Storage (EBS).
  - The source and target clusters must be in the same region.
  - The source and target clusters must have the same storage class.
The storage class must be compatible with snapshots.

Procedure

1. Create an AWS S3 bucket:

   ```bash
   $ aws s3api create-bucket \
     --bucket <bucket_name> \
     --region <bucket_region>
   ```

   1. Specify your S3 bucket name.
   2. Specify your S3 bucket region, for example, `us-east-1`.

2. Create the IAM user `velero`:

   ```bash
   $ aws iam create-user --user-name velero
   ```

3. Create an EC2 EBS snapshot policy:

   ```json
   $ cat > velero-ec2-snapshot-policy.json <<EOF
   {
     "Version": "2012-10-17",
     "Statement": [
       {
         "Effect": "Allow",
         "Action": [
           "ec2:DescribeVolumes",
           "ec2:DescribeSnapshots",
           "ec2:CreateTags",
           "ec2:CreateVolume",
           "ec2:CreateSnapshot",
           "ec2:DeleteSnapshot"
         ],
         "Resource": "*"
       }
     ],
     "Resource": "*"
   }
   EOF
   ```

4. Create an AWS S3 access policy for one or for all S3 buckets:

   ```json
   $ cat > velero-s3-policy.json <<EOF
   {
     "Version": "2012-10-17",
     "Statement": [
       {
         "Effect": "Allow",
         "Action": [
           "s3:GetObject",
           "s3:DeleteObject",
           "s3:PutObject",
           "s3:AbortMultipartUpload",
           "s3:ListMultipartUploadParts"
         ],
         "Resource": "*"
       }
     ],
     "Resource": "*"
   }
   EOF
   ```
To grant access to a single S3 bucket, specify the bucket name. To grant access to all AWS S3 buckets, specify * instead of a bucket name:

```
"Resource": [
  "arn:aws:s3:::<bucket_name>/"
]
```

5. Attach the EC2 EBS policy to **velero**:

```
$ aws iam put-user-policy \
  --user-name velero \
  --policy-name velero-ebs \
  --policy-document file://velero-ec2-snapshot-policy.json
```

6. Attach the AWS S3 policy to **velero**:

```
$ aws iam put-user-policy \
  --user-name velero \
  --policy-name velero-s3 \
  --policy-document file://velero-s3-policy.json
```

7. Create an access key for **velero**:

```
$ aws iam create-access-key --user-name velero 
{
  "AccessKey": {
    "UserName": "velero",
    "Status": "Active",
    "CreateDate": "2017-07-31T22:24:41.576Z",
    "SecretAccessKey": "<AWS_SECRET_ACCESS_KEY>" 1,
    "AccessKeyId": "<AWS_ACCESS_KEY_ID>" 2
  }
}
```
Record the `AWS_SECRET_ACCESS_KEY` and the `AWS_ACCESS_KEY_ID` for adding the AWS repository to the CAM web console.

2.3.3. Configuring a Google Cloud Provider storage bucket as a replication repository

You can configure a Google Cloud Provider (GCP) storage bucket as a replication repository.

Prerequisites

- The GCP storage bucket must be accessible to the source and target clusters.
- You must have `gsutil` installed.
- If you are using the snapshot copy method:
  - The source and target clusters must be in the same region.
  - The source and target clusters must have the same storage class.
  - The storage class must be compatible with snapshots.

Procedure

1. Run `gsutil init` to log in:

   ```bash
   $ gsutil init
   Welcome! This command will take you through the configuration of gcloud.
   Your current configuration has been set to: [default]
   To continue, you must login. Would you like to login (Y/n)?
   ```

2. Set the `BUCKET` variable:

   ```bash
   $ BUCKET=<bucket_name>
   ```

3. Create a storage bucket:

   ```bash
   $ gsutil mb gs://$BUCKET/
   ```

4. Set the `PROJECT_ID` variable to your active project:

   ```bash
   $ PROJECT_ID=$(gcloud config get-value project)
   ```

5. Create a `velero` service account:

   ```bash
   $ gcloud iam service-accounts create velero --display-name "Velero Storage"
   ```
6. Set the `SERVICE_ACCOUNT_EMAIL` variable to the service account’s email address:

```bash
$ SERVICE_ACCOUNT_EMAIL=$(gcloud iam service-accounts list
   --filter="displayName:Velero Storage"
   --format 'value(email)')
```

7. Grant permissions to the service account:

```bash
$ ROLE_PERMISSIONS=(
   compute.disks.get
   compute.disks.create
   compute.disks.createSnapshot
   compute.snapshots.get
   compute.snapshots.create
   compute.snapshots.useReadOnly
   compute.snapshots.delete
   compute.zones.get
)

gcloud iam roles create velero.server
   --project $PROJECT_ID
   --title "Velero Server"
   --permissions "$(IFS=","; echo "${ROLE_PERMISSIONS[*]}")"

gcloud projects add-iam-policy-binding $PROJECT_ID
   --member serviceAccount:$SERVICE_ACCOUNT_EMAIL
   --role projects/$PROJECT_ID/roles/velero.server

gsutil iam ch serviceAccount:$SERVICE_ACCOUNT_EMAIL:objectAdmin gs://${BUCKET}
```

8. Save the service account’s keys to the `credentials-velero` file in the current directory:

```bash
$ gcloud iam service-accounts keys create credentials-velero
   --iam-account $SERVICE_ACCOUNT_EMAIL
```

2.3.4. Configuring a Microsoft Azure Blob storage container as a replication repository

You can configure a Microsoft Azure Blob storage container as a replication repository.

**Prerequisites**

- You must have an Azure storage account.
- You must have the Azure CLI installed.
- The Azure Blob storage container must be accessible to the source and target clusters.
- If you are using the snapshot copy method:
  - The source and target clusters must be in the same region.
  - The source and target clusters must have the same storage class.
  - The storage class must be compatible with snapshots.
Procedure

1. Set the **AZURE_RESOURCE_GROUP** variable:

   ```bash
   $ AZURE_RESOURCE_GROUP=Velero_Backups
   ```

2. Create an Azure resource group:

   ```bash
   $ az group create -n $AZURE_RESOURCE_GROUP --location <CentralUS>  
   Specify your location.
   ```

3. Set the **AZURE_STORAGE_ACCOUNT_ID** variable:

   ```bash
   $ AZURE_STORAGE_ACCOUNT_ID=velerobackups
   ```

4. Create an Azure storage account:

   ```bash
   $ az storage account create \
      --name $AZURE_STORAGE_ACCOUNT_ID \
      --resource-group $AZURE_RESOURCE_GROUP \
      --sku Standard_GRS \
      --encryption-services blob \
      --https-only true \
      --kind BlobStorage \
      --access-tier Hot
   ```

5. Set the **BLOB_CONTAINER** variable:

   ```bash
   $ BLOB_CONTAINER=velero
   ```

6. Create an Azure Blob storage container:

   ```bash
   $ az storage container create \
      -n $BLOB_CONTAINER \
      --public-access off \
      --account-name $AZURE_STORAGE_ACCOUNT_ID
   ```

7. Create a service principal and credentials for **velero**:

   ```bash
   $ AZURE_SUBSCRIPTION_ID=`az account list --query '[?isDefault].id' -o tsv`
   $ AZURE_TENANT_ID=`az account list --query '[?isDefault].tenantId' -o tsv`
   $ AZURE_CLIENT_SECRET=`az ad sp create-for-rbac --name "velero" --role "Contributor" \
      --query 'password' -o tsv`
   $ AZURE_CLIENT_ID=`az ad sp list --display-name "velero" --query '[0].appId' -o tsv`
   ```

8. Save the service principal’s credentials in the **credentials-velero** file:

   ```bash
   $ cat << EOF  > ./credentials-velero
   AZURE_SUBSCRIPTION_ID=${AZURE_SUBSCRIPTION_ID}
   AZURE_TENANT_ID=${AZURE_TENANT_ID}
   AZURE_CLIENT_ID=${AZURE_CLIENT_ID}
   ```
AZURE_CLIENT_SECRET=${AZURE_CLIENT_SECRET}
AZURE_RESOURCE_GROUP=${AZURE_RESOURCE_GROUP}
AZURE_CLOUD_NAME=AzurePublicCloud
EOF

2.4. MIGRATING APPLICATIONS WITH THE CAM WEB CONSOLE

You can migrate application workloads by adding your clusters and replication repository to the CAM web console. Then, you can create and run a migration plan.

If your cluster or replication repository are secured with self-signed certificates, you can create a CA certificate bundle file or disable SSL verification.

2.4.1. Creating a CA certificate bundle file

If you use a self-signed certificate to secure a cluster or a replication repository, certificate verification might fail with the following error message: Certificate signed by unknown authority.

You can create a custom CA certificate bundle file and upload it in the CAM web console when you add a cluster or a replication repository.

Procedure

Download a CA certificate from a remote endpoint and save it as a CA bundle file:

```
$ echo -n | openssl s_client -connect <host_FQDN>:<port> \
| sed -ne '/-BEGIN CERTIFICATE-,/-END CERTIFICATE-/p' > <ca_bundle.cert>
```

1. Specify the host FQDN and port of the endpoint, for example, api.my-cluster.example.com:6443.
2. Specify the name of the CA bundle file.

2.4.2. Adding a cluster to the CAM web console

You can add a cluster to the CAM web console.

Prerequisites

If you are using Azure snapshots to copy data:

- You must provide the Azure resource group name when you add the source cluster.
- The source and target clusters must be in the same Azure resource group and in the same location.

Procedure

1. Log in to the cluster.
2. Obtain the service account token:

```
$ oc sa get-token mig -n openshift-migration
eyJhbGciOiJSUzI1NiIsImtpZCI6IiJ9.eyJpc3MiOiJrdWJlcm5ldGVzL3NlcnZpY2VhY2NvdW50Iiwi
a3ViZXJuZXRLcy5pby9zZXF1aWNfYWNjb3VudC9uYW1lc3BhY2U2UiOlNCc2Jc6h1LdQbW50dCB7
```

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3. Log in to the CAM web console.

4. In the **Clusters** section, click **Add cluster**.

5. Fill in the following fields:

   - **Cluster name**: May contain lower-case letters (a-z) and numbers (0-9). Must not contain spaces or international characters.
   - **Url**: URL of the cluster’s API server, for example, `https://<master1.example.com>:8443`.
   - **Service account token**: String that you obtained from the source cluster.
   - **Azure cluster**: Optional. Select it if you are using Azure snapshots to copy your data.
   - **Azure resource group**: This field appears if **Azure cluster** is checked.
   - If you use a custom CA bundle, click **Browse** and browse to the CA bundle file.

6. Click **Add cluster**. The cluster appears in the **Clusters** section.

### 2.4.3. Adding a replication repository to the CAM web console

You can add an object storage bucket as a replication repository to the CAM web console.

**Prerequisites**

- You must configure an object storage bucket for migrating the data.

**Procedure**

1. Log in to the CAM web console.

2. In the **Replication repositories** section, click **Add repository**.

3. Select a **Storage provider type** and fill in the following fields:

   - **AWS** for AWS S3, MCG, and generic S3 providers:
     - **Replication repository name**: Specify the replication repository name in the CAM web console.
     - **S3 bucket name**: Specify the name of the S3 bucket you created.
- **S3 bucket region**: Specify the S3 bucket region. **Required** for AWS S3. **Optional** for other S3 providers.

- **S3 endpoint**: Specify the URL of the S3 service, not the bucket, for example, `https://<s3-storage.apps.cluster.com>`. **Required** for a generic S3 provider. You must use the `https://` prefix.

- **S3 provider access key**: Specify the `<AWS_SECRET_ACCESS_KEY>` for AWS or the S3 provider access key for MCG.

- **S3 provider secret access key**: Specify the `<AWS_ACCESS_KEY_ID>` for AWS or the S3 provider secret access key for MCG.

- **Require SSL verification**: Clear this check box if you are using a generic S3 provider.

- If you use a custom CA bundle, click **Browse** and browse to the Base64-encoded CA bundle file.

- **GCP**:
  - **Replication repository name**: Specify the replication repository name in the CAM web console.
  
  - **GCP bucket name**: Specify the name of the GCP bucket.

- **Azure**:
  - **Replication repository name**: Specify the replication repository name in the CAM web console.

  - **Azure resource group**: Specify the resource group of the Azure Blob storage.

  - **Azure storage account name**: Specify the Azure Blob storage account name.

  - **Azure credentials - INI file contents**: Specify the string in the `credentials-velero` file.

4. Click **Add repository** and wait for connection validation.

5. Click **Close**.
   The new repository appears in the **Replication repositories** section.

### 2.4.4. Changing migration plan limits for large migrations

You can change the migration plan limits for large migrations.

**IMPORTANT**

Changes should first be tested in your environment to avoid a failed migration.

A single migration plan has the following default limits:

- **10 namespaces**
  If this limit is exceeded, the CAM web console displays a **Namespace limit exceeded** error and you cannot create a migration plan.
• 100 Pods
  If the Pod limit is exceeded, the CAM web console displays a warning message similar to the following example: **Plan has been validated with warning condition(s). See warning message. Pod limit: 100 exceeded, found: 104.**

• 100 persistent volumes
  If the persistent volume limit is exceeded, the CAM web console displays a similar warning message.

**Procedure**

1. Edit the Migration controller CR:

   ```
   $ oc get migrationcontroller -n openshift-migration
   NAME    AGE
   migration-controller 5d19h
   $ oc edit migrationcontroller -n openshift-migration
   ```

2. Update the following parameters:

   ```
   ...
   migration_controller: true
   # This configuration is loaded into mig-controller, and should be set on the
   # cluster where 'migration_controller: true'
   mig_pv_limit: 100
   mig_pod_limit: 100
   mig_namespace_limit: 10
   ...
   ```

**2.4.5. Creating a migration plan in the CAM web console**

You can create a migration plan in the CAM web console.

**Prerequisites**

- The CAM web console must contain the following:
  - Source cluster
  - Target cluster, which is added automatically during the CAM tool installation
  - Replication repository

- The source and target clusters must have network access to each other and to the replication repository.

- If you use snapshots to copy data, the source and target clusters must run on the same cloud provider (AWS, GCP, or Azure) and in the same region.

**Procedure**

1. Log in to the CAM web console.
2. In the **Plans** section, click **Add plan**.

3. Enter the **Plan name** and click **Next**. The **Plan name** can contain up to 253 lower-case alphanumeric characters (a-z, 0-9). It must not contain spaces or underscores (_).

4. Select a **Source cluster**.

5. Select a **Target cluster**.

6. Select a **Replication repository**.

7. Select the projects to be migrated and click **Next**.

8. Select **Copy** or **Move** for the PVs:
   - **Copy** copies the data in a source cluster’s PV to the replication repository and then restores it on a newly created PV, with similar characteristics, in the target cluster. Optional: You can verify data copied with the filesystem method by selecting **Verify copy**. This option, which generates a checksum for each source file and checks it after restoration, significantly reduces performance.
   - **Move** unmounts a remote volume (for example, NFS) from the source cluster, creates a PV resource on the target cluster pointing to the remote volume, and then mounts the remote volume on the target cluster. Applications running on the target cluster use the same remote volume that the source cluster was using. The remote volume must be accessible to the source and target clusters.

9. Click **Next**.

10. Select a **Copy method** for the PVs:
    - **Snapshot** backs up and restores the disk using the cloud provider’s snapshot functionality. It is significantly faster than **Filesystem**.

    **NOTE**
    The storage and clusters must be in the same region and the storage class must be compatible.

    - **Filesystem** copies the data files from the source disk to a newly created target disk.

11. Select a **Storage class** for the PVs. If you selected the **Filesystem** copy method, you can change the storage class during migration, for example, from Red Hat Gluster Storage or NFS storage to Red Hat Ceph Storage.

12. Click **Next**.

13. If you want to add a migration hook, click **Add Hook** and perform the following steps:
   a. Specify the name of the hook.
   b. Select **Ansible playbook** to use your own playbook or **Custom container image** for a hook written in another language.
   c. Click **Browse** to upload the playbook.
d. Optional: If you are not using the default Ansible runtime image, specify your custom Ansible image.

e. Specify the cluster on which you want the hook to run.

f. Specify the service account name.

g. Specify the namespace.

h. Select the migration step at which you want the hook to run:
   - PreBackup: Before backup tasks are started on the source cluster
   - PostBackup: After backup tasks are complete on the source cluster
   - PreRestore: Before restore tasks are started on the target cluster
   - PostRestore: After restore tasks are complete on the target cluster

14. Click Add.
   You can add up to four hooks to a migration plan, assigning each hook to a different migration step.

15. Click Finish.

16. Click Close.
   The migration plan appears in the Plans section.

2.4.6. Running a migration plan in the CAM web console

You can stage or migrate applications and data with the migration plan you created in the CAM web console.

Prerequisites

The CAM web console must contain the following:

- Source cluster
- Target cluster, which is added automatically during the CAM tool installation
- Replication repository
- Valid migration plan

Procedure

1. Log in to the CAM web console on the target cluster.

2. Select a migration plan.

3. Click Stage to copy data from the source cluster to the target cluster without stopping the application.
   You can run Stage multiple times to reduce the actual migration time.

4. When you are ready to migrate the application workload, click Migrate.
Migrate stops the application workload on the source cluster and recreates its resources on the target cluster.

5. Optional: In the Migrate window, you can select **Do not stop applications on the source cluster during migration.**

6. Click **Migrate**.

7. Optional: To stop a migration in progress, click the Options menu and select **Cancel**.

8. When the migration is complete, verify that the application migrated successfully in the OpenShift Container Platform web console:
   a. Click **Home** → **Projects**.
   b. Click the migrated project to view its status.
   c. In the **Routes** section, click **Location** to verify that the application is functioning, if applicable.
   d. Click **Workloads** → **Pods** to verify that the Pods are running in the migrated namespace.
   e. Click **Storage** → **Persistent volumes** to verify that the migrated persistent volume is correctly provisioned.

### 2.5. TROUBLESHOOTING

You can view the migration Custom Resources (CRs) and download logs to troubleshoot a failed migration.

If the application was stopped during the failed migration, you must roll it back manually in order to prevent data corruption.

**NOTE**

Manual rollback is not required if the application was not stopped during migration, because the original application is still running on the source cluster.

#### 2.5.1. Viewing migration Custom Resources

The Cluster Application Migration (CAM) tool creates the following Custom Resources (CRs):
The MigPlan CR describes the source and target clusters, repository, and namespace(s) being migrated. It is associated with 0, 1, or many MigMigration CRs.

**NOTE**
Deleting a MigPlan CR deletes the associated MigMigration CRs.

1. **MigCluster** (configuration, CAM cluster): Cluster definition
2. **MigStorage** (configuration, CAM cluster): Storage definition
3. **MigPlan** (configuration, CAM cluster): Migration plan

The MigPlan CR describes the source and target clusters, repository, and namespace(s) being migrated. It is associated with 0, 1, or many MigMigration CRs.

4. **BackupStorageLocation** (configuration, CAM cluster): Location of Velero backup objects
5. **VolumeSnapshotLocation** (configuration, CAM cluster): Location of Velero volume snapshots

6. **MigMigration** (action, CAM cluster): Migration, created during migration

A MigMigration CR is created every time you stage or migrate data. Each MigMigration CR is associated with a MigPlan CR.
7 **Backup** (action, source cluster): When you run a migration plan, the MigMigration CR creates two Velero backup CRs on each source cluster:

- Backup CR #1 for Kubernetes objects
- Backup CR #2 for PV data

8 **Restore** (action, target cluster): When you run a migration plan, the MigMigration CR creates two Velero restore CRs on the target cluster:

- Restore CR #1 (using Backup CR #2) for PV data
- Restore CR #2 (using Backup CR #1) for Kubernetes objects

**Procedure**

1. Get the CR name:

   ```
   $ oc get <migration_cr> -n openshift-migration
   ```

   Specify the migration CR, for example, `migmigration`.

   The output is similar to the following:

<table>
<thead>
<tr>
<th>NAME</th>
<th>AGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>88435fe0-c9f8-11e9-85e6-5d593ce65e10</td>
<td>6m42s</td>
</tr>
</tbody>
</table>

2. View the CR:

   ```
   $ oc describe <migration_cr> <88435fe0-c9f8-11e9-85e6-5d593ce65e10> -n openshift-migration
   ```

   The output is similar to the following examples.

**MigMigration example**

```
name:     88435fe0-c9f8-11e9-85e6-5d593ce65e10
namespace: openshift-migration
labels:   <none>
annotations: touch: 3b48b543-b53e-4e44-9d34-33563f0f8147
apiVersion: migration.openshift.io/v1alpha1
kind:      MigMigration
metadata:
creationTimestamp: 2019-08-29T01:01:29Z
generation:          20
resourceVersion:    88179
selfLink:           /apis/migration.openshift.io/v1alpha1/namespaces/openshift-migration/migmigrations/88435fe0-c9f8-11e9-85e6-5d593ce65e10
uid:                 8886de4c-c9f8-11e9-95ad-0205fe66cbb6
spec:
migPlanRef:
  name:     socks-shop-mig-plan
  namespace: openshift-migration
```
quiescePods: true
stage: false
status:
  conditions:
  - category: Advisory
durable: true
  lastTransitionTime: 2019-08-29T01:03:40Z
message: The migration has completed successfully.
reason: Completed
status: True
type: Succeeded
phase: Completed
startTimestamp: 2019-08-29T01:02:29Z

Velero backup CR #2 example (PV data)

```yaml
apiVersion: velero.io/v1
kind: Backup
metadata:
  annotations:
    openshift.io/migrate-copy-phase: final
    openshift.io/migrate-quiesce-pods: "true"
    openshift.io/migration-registry: 172.30.105.179:5000
    openshift.io/migration-registry-dir: /socks-shop-mig-plan-registry-44dd3bd5-c9f8-11e9-95ad-0205fe66cbb6
  creationTimestamp: "2019-08-29T01:03:15Z"
generateName: 88435fe0-c9f8-11e9-85e6-5d593ce65e10-
generation: 1
labels:
  app.kubernetes.io/part-of: migration
migmigration: 8886de4c-c9f8-11e9-95ad-0205fe66cbb6
migration-stage-backup: 8886de4c-c9f8-11e9-95ad-0205fe66cbb6
velero.io/storage-location: myrepo-vpz9
name: 88435fe0-c9f8-11e9-85e6-5d593ce65e10-59gb7
namespace: openshift-migration
resourceVersion: "87313"
selfLink: /apis/velero.io/v1/namespaces/openshift-migration/backups/88435fe0-c9f8-11e9-85e6-5d593ce65e10-59gb7
uid: c80dbbc0-c9f8-11e9-95ad-0205fe66cbb6
spec:
  excludedNamespaces: []
  excludedResources: []
  hooks: []
  includeClusterResources: null
  includedNamespaces:
    - sock-shop
  includedResources:
    - persistentvolumes
    - persistentvolumeclaims
    - namespaces
    - imagestreams
    - imagestreamtags
    - secrets
    - configmaps
```

CHAPTER 2. MIGRATING FROM OPENSOURCE CONTAINER PLATFORM 4.1
- pods
labelSelector:
  matchLabels:
    migration-included-stage-backup: 8886de4c-c9f8-11e9-95ad-0205fe66cbb6
storageLocation: myrepo-vpzq9
ttl: 720h0m0s
volumeSnapshotLocations:
  - myrepo-wv6fx
status:
  completionTimestamp: "2019-08-29T01:02:36Z"
  errors: 0
  expiration: "2019-09-28T01:02:35Z"
  phase: Completed
  startTimestamp: "2019-08-29T01:02:35Z"
  validationErrors: null
  version: 1
  volumeSnapshotsAttempted: 0
  volumeSnapshotsCompleted: 0
  warnings: 0

Velero restore CR #2 example (Kubernetes resources)

apiVersion: velero.io/v1
kind: Restore
metadata:
  annotations:
    openshift.io/migrate-copy-phase: final
    openshift.io/migrate-quiesce-pods: "true"
    openshift.io/migration-registry: 172.30.90.187:5000
    openshift.io/migration-registry-dir: /socks-shop-mig-plan-registry-36f54ca7-c925-11e9-825a-06fa9fb68c88
  creationTimestamp: "2019-08-28T00:09:49Z"
  generateName: e13a1b60-c927-11e9-9555-d129df7f3b96-
  generation: 3
  labels:
    app.kubernetes.io/part-of: migration
    migmigration: e18252c9-c927-11e9-825a-06fa9fb68c88
    migration-final-restore: e18252c9-c927-11e9-825a-06fa9fb68c88
    name: e13a1b60-c927-11e9-9555-d129df7f3b96-gb8nx
namespace: openshift-migration
resourceVersion: "82329"
  selfLink: /apis/velero.io/v1/namespaces/openshift-migration/restores/e13a1b60-c927-11e9-9555-d129df7f3b96-gb8nx
uid: 26983ec0-c928-11e9-825a-06fa9fb68c88
spec:
  backupName: e13a1b60-c927-11e9-9555-d129df7f3b96-sz24f
  excludedNamespaces: null
  excludedResources: null
  - nodes
  - events
  - events.events.k8s.io
  - backups.velero.io
  - restores.velero.io
  - resticrepositories.velero.io
  includedNamespaces: null
  includedResources: null
2.5.2. Downloading migration logs

You can download the Velero, Restic, and Migration controller logs in the CAM web console to troubleshoot a failed migration.

Procedure

1. Log in to the CAM console.

2. Click Plans to view the list of migration plans.

3. Click the Options menu of a specific migration plan and select Logs.

4. Click Download Logs to download the logs of the Migration controller, Velero, and Restic for all clusters.

5. To download a specific log:
   a. Specify the log options:
      - **Cluster**: Select the source, target, or CAM host cluster.
      - **Log source**: Select Velero, Restic, or Controller.
      - **Pod source**: Select the Pod name, for example, controller-manager-78c469849c-v6wcf
        The selected log is displayed.
        You can clear the log selection settings by changing your selection.
   b. Click Download Selected to download the selected log.

Optionally, you can access the logs by using the CLI, as in the following example:

```
$ oc get pods -n openshift-migration | grep controller
controller-manager-78c469849c-v6wcf     1/1   Running   0   4h49m
```

```
$ oc logs controller-manager-78c469849c-v6wcf -f -n openshift-migration
```

2.5.3. Error messages

2.5.3.1. Restic timeout error message in the Velero Pod log

If a migration fails because Restic times out, the following error appears in the Velero Pod log:
level=error msg="Error backing up item" backup=velero/monitoring error="timed out waiting for all PodVolumeBackups to complete"
error.file="/go/src/github.com/heptio/velero/pkg/restic/backupper.go:165"
error.function="github.com/heptio/velero/pkg/restic.(*backupper).BackupPodVolumes" group=v1

The default value of `restic_timeout` is one hour. You can increase this parameter for large migrations, keeping in mind that a higher value may delay the return of error messages.

Procedure

1. In the OpenShift Container Platform web console, navigate to Operators → Installed Operators.

2. Click Cluster Application Migration Operator.

3. In the MigrationController tab, click migration-controller.

4. In the YAML tab, update the following parameter value:

   ```yaml
   spec:
     restic_timeout: 1h
   ```

   1 Valid units are **h** (hours), **m** (minutes), and **s** (seconds), for example, **3h30m15s**.

5. Click Save.

2.5.3.2. ResticVerifyErrors in the MigMigration Custom Resource

If data verification fails when migrating a PV with the filesystem data copy method, the following error appears in the MigMigration Custom Resource (CR):

```
status:
  conditions:
  - category: Warn
durable: true
lastTransitionTime: 2020-04-16T20:35:16Z
message: There were verify errors found in 1 Restic volume restores. See restore `<registry-example-migration-rvwcm>` for details
status: "True"
type: ResticVerifyErrors
```

1 The error message identifies the Restore CR name.

2 `ResticErrors` also appears. `ResticErrors` is a general error warning that includes verification errors.

**NOTE**

A data verification error does not cause the migration process to fail.

You can check the target cluster’s Restore CR to identify the source of the data verification error.
Procedure

1. Log in to the target cluster.

2. View the Restore CR:

   $ oc describe <registry-example-migration-rvwcm> -n openshift-migration

   The output identifies the PV with PodVolumeRestore errors:

   status:
   phase: Completed
   podVolumeRestoreErrors:
   - kind: PodVolumeRestore
     name: <registry-example-migration-rvwcm-98t49>
     namespace: openshift-migration
   podVolumeRestoreResticErrors:
   - kind: PodVolumeRestore
     name: <registry-example-migration-rvwcm-98t49>
     namespace: openshift-migration

3. View the PodVolumeRestore CR:

   $ oc describe <migration-example-rvwcm-98t49>

   The output identifies the Restic Pod that logged the errors:

   completionTimestamp: 2020-05-01T20:49:12Z
   errors: 1
   resticErrors: 1
   ...
   resticPod: <restic-nr2v5>

4. View the Restic Pod log:

   $ oc logs -f restic-nr2v5

2.5.4. Manually rolling back a migration

If your application was stopped during a failed migration, you must roll it back manually in order to prevent data corruption in the PV.

This procedure is not required if the application was not stopped during migration, because the original application is still running on the source cluster.

Procedure

1. On the target cluster, switch to the migrated project:

   $ oc project <project>

2. Get the deployed resources:
$ oc get all

3. Delete the deployed resources to ensure that the application is not running on the target cluster and accessing data on the PVC:

$ oc delete <resource_type>

4. To stop a DaemonSet without deleting it, update the `nodeSelector` in the YAML file:

```
apiVersion: apps/v1
kind: DaemonSet
metadata:
  name: hello-daemonset
spec:
  selector:
    matchLabels:
      name: hello-daemonset
template:
  metadata:
    labels:
      name: hello-daemonset
spec:
  nodeSelector:
    role: worker
```

Specify a `nodeSelector` value that does not exist on any node.

5. Update each PV’s reclaim policy so that unnecessary data is removed. During migration, the reclaim policy for bound PVs is `Retain`, to ensure that data is not lost when an application is removed from the source cluster. You can remove these PVs during rollback.

```
apiVersion: v1
kind: PersistentVolume
metadata:
  name: pv0001
spec:
  capacity:
    storage: 5Gi
  accessModes:
  - ReadWriteOnce
  persistentVolumeReclaimPolicy: Retain
```

Specify `Recycle` or `Delete`.

6. On the source cluster, switch to your migrated project:

```
$ oc project <project_name>
```

7. Obtain the project’s deployed resources:
8. Start one or more replicas of each deployed resource:

   $ oc scale --replicas=1 <resource_type>/<resource_name>

9. Update the nodeSelector of a DaemonSet to its original value, if you changed it during the procedure.

2.5.5. Gathering data for a customer support case

If you open a customer support case, you can run the must-gather tool with the openshift-migration-must-gather-rhel8 image to collect information about your cluster and upload it to the Red Hat Customer Portal.

The openshift-migration-must-gather-rhel8 image collects logs and Custom Resource data that are not collected by the default must-gather image.

**Procedure**

1. Navigate to the directory where you want to store the must-gather data.

2. Run the `oc adm must-gather` command:

   ```
   $ oc adm must-gather --image=registry.redhat.io/rhcam-1-2/openshift-migration-must-gather-rhel8
   
   The must-gather tool collects the cluster information and stores it in a must-gather.local.<uid> directory.
   
   3. Remove authentication keys and other sensitive information from the must-gather data.

   4. Create an archive file containing the contents of the must-gather.local.<uid> directory:

      ```
      $ tar cvaf must-gather.tar.gz must-gather.local.<uid>/
      
      You can attach the compressed file to your customer support case on the Red Hat Customer Portal.
    ```

2.5.6. Known issues

This release has the following known issues:

- During migration, the Cluster Application Migration (CAM) tool preserves the following namespace annotations:
  
  - `openshift.io/sa.scc.mcs`
  
  - `openshift.io/sa.scc.supplemental-groups`
  
  - `openshift.io/sa.scc.uid-range`

  These annotations preserve the UID range, ensuring that the containers retain their file system permissions on the target cluster. There is a risk that the migrated UIDs could duplicate UIDs within an existing or future namespace on the target cluster. (BZ#1748440)
- If an AWS bucket is added to the CAM web console and then deleted, its status remains `True` because the MigStorage CR is not updated. (BZ#1738564)

- Most cluster-scoped resources are not yet handled by the CAM tool. If your applications require cluster-scoped resources, you may have to create them manually on the target cluster.

- If a migration fails, the migration plan does not retain custom PV settings for quiesced pods. You must manually roll back the migration, delete the migration plan, and create a new migration plan with your PV settings. (BZ#1784899)

- If a large migration fails because Restic times out, you can increase the `restic_timeout` parameter value (default: `1h`) in the Migration controller CR.

- If you select the data verification option for PVs that are migrated with the filesystem copy method, performance is significantly slower. Velero generates a checksum for each file and checks it when the file is restored.
CHAPTER 3. MIGRATING FROM OPENSHIFT CONTAINER PLATFORM 4.2 AND LATER

3.1. MIGRATION TOOLS AND PREREQUISITES

You can migrate application workloads from OpenShift Container Platform 4.2 and later to 4.4 with the Cluster Application Migration (CAM) tool. The CAM tool enables you to control the migration and to minimize application downtime.

NOTE

You can migrate between OpenShift Container Platform clusters of the same version, for example, from 4.2 to 4.2 or from 4.3 to 4.3, as long as the source and target clusters are configured correctly.

The CAM tool’s web console and API, based on Kubernetes Custom Resources, enable you to migrate stateful and stateless application workloads at the granularity of a namespace.

The CAM tool supports the file system and snapshot data copy methods for migrating data from the source cluster to the target cluster. You can select a method that is suited for your environment and is supported by your storage provider.

You can use migration hooks to run Ansible playbooks at certain points during the migration. The hooks are added when you create a migration plan.

3.1.1. Migration prerequisites

- You must have cluster-admin privileges on all clusters.
- The source and target clusters must have unrestricted network access to the replication repository.
- The cluster on which the Migration controller is installed must have unrestricted access to the other clusters.
- If your application uses images from the openshift namespace, the required versions of the images must be present on the target cluster.

If the required images are not present, you must update the imagestreamtags references to use an available version that is compatible with your application. If the imagestreamtags cannot be updated, you can manually upload equivalent images to the application namespaces and update the applications to reference them.

The following imagestreamtags have been removed from OpenShift Container Platform 4.2:

- dotnet:1.0, dotnet:1.1, dotnet:2.0
- dotnet-runtime:2.0
- mariadb:10.1
- mongodb:2.4, mongodb:2.6
- mysql:5.5, mysql:5.6
The following imagestreamtags have been removed from OpenShift Container Platform 4.4:

- dotnet: 2.2
- dotnet-runtime: 2.2
- nginx: 1.12
- nodejs: 8, 8-RHOAR, 10-SCL
- perl: 5.24
- php: 7.0, 7.1
- redis: 3.2

3.1.2. About the Cluster Application Migration tool

The Cluster Application Migration (CAM) tool enables you to migrate Kubernetes resources, persistent volume data, and internal container images from an OpenShift Container Platform source cluster to an OpenShift Container Platform 4.4 target cluster, using the CAM web console or the Kubernetes API.

Migrating an application with the CAM web console involves the following steps:

1. Install the Cluster Application Migration Operator on all clusters.
   You can install the Cluster Application Migration Operator in a restricted environment with limited or no internet access. The source and target clusters must have network access to each other and to a mirror registry.

2. Configure the replication repository, an intermediate object storage that the CAM tool uses to migrate data.
   The source and target clusters must have network access to the replication repository during migration. In a restricted environment, you can use an internally hosted S3 storage repository. If you use a proxy server, you must ensure that replication repository is whitelisted.

3. Add the source cluster to the CAM web console.

4. Add the replication repository to the CAM web console.

5. Create a migration plan, with one of the following data migration options:
   - **Copy**: The CAM tool copies the data from the source cluster to the replication repository, and from the replication repository to the target cluster.
**Move**: The CAM tool unmounts a remote volume (for example, NFS) from the source cluster, creates a PV resource on the target cluster pointing to the remote volume, and then mounts the remote volume on the target cluster. Applications running on the target cluster use the same remote volume that the source cluster was using. The remote volume must be accessible to the source and target clusters.

**NOTE**

Although the replication repository does not appear in this diagram, it is required for the actual migration.

6. Run the migration plan, with one of the following options:

- **Stage** (optional) copies data to the target cluster without stopping the application. Staging can be run multiple times so that most of the data is copied to the target before migration. This minimizes the actual migration time and application downtime.

- **Migrate** stops the application on the source cluster and recreates its resources on the target cluster. Optionally, you can migrate the workload without stopping the application.
3.1.3. About data copy methods

The CAM tool supports the file system and snapshot data copy methods for migrating data from the source cluster to the target cluster. You can select a method that is suited for your environment and is supported by your storage provider.

3.1.3.1. File system copy method

The CAM tool copies data files from the source cluster to the replication repository, and from there to the target cluster.

Table 3.1. File system copy method summary

<table>
<thead>
<tr>
<th>Benefits</th>
<th>Limitations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clusters can have different storage classes</td>
<td>Slower than the snapshot copy method</td>
</tr>
<tr>
<td>Supported for all S3 storage providers</td>
<td>Optional data verification significantly reduces performance</td>
</tr>
<tr>
<td>Optional data verification with checksum</td>
<td></td>
</tr>
</tbody>
</table>

3.1.3.2. Snapshot copy method

The CAM tool copies a snapshot of the source cluster’s data to a cloud provider’s object storage, configured as a replication repository. The data is restored on the target cluster.

AWS, Google Cloud Provider, and Microsoft Azure support the snapshot copy method.
### Table 3.2. Snapshot copy method summary

<table>
<thead>
<tr>
<th>Benefits</th>
<th>Limitations</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Faster than the file system copy method</td>
<td>• Cloud provider must support snapshots.</td>
</tr>
<tr>
<td></td>
<td>• Clusters must be on the same cloud provider.</td>
</tr>
<tr>
<td></td>
<td>• Clusters must be in the same location or region.</td>
</tr>
<tr>
<td></td>
<td>• Clusters must have the same storage class.</td>
</tr>
<tr>
<td></td>
<td>• Storage class must be compatible with snapshots.</td>
</tr>
</tbody>
</table>

### 3.1.4. About migration hooks

You can use migration hooks to run Ansible playbooks at certain points during the migration. The hooks are added when you create a migration plan.

**NOTE**

If you do not want to use Ansible playbooks, you can create a custom container image and add it to a migration plan.

Migration hooks perform tasks such as customizing application quiescence, manually migrating unsupported data types, and updating applications after migration.

A single migration hook runs on a source or target cluster at one of the following migration steps:

- **PreBackup**: Before backup tasks are started on the source cluster
- **PostBackup**: After backup tasks are complete on the source cluster
- **PreRestore**: Before restore tasks are started on the target cluster
- **PostRestore**: After restore tasks are complete on the target cluster

You can assign one hook to each migration step, up to a maximum of four hooks for a single migration plan.

The default **hook-runner** image is `registry.redhat.io/rhcam-1-2/openshift-migration-hook-runner-rhel7`. This image is based on Ansible Runner and includes **python-openshift** for Ansible Kubernetes resources and an updated **oc** binary. You can also create your own hook image with additional Ansible modules or tools.

The Ansible playbook is mounted on a hook container as a ConfigMap. The hook container runs as a Job on a cluster with a specified service account and namespace. The Job runs, even if the initial Pod is evicted or killed, until it reaches the default **backoffLimit (6)** or successful completion.

### 3.2. DEPLOYING THE CLUSTER APPLICATION MIGRATION TOOL
You can install the Cluster Application Migration Operator on your OpenShift Container Platform 4.4 target cluster and 4.2 source cluster. The Cluster Application Migration Operator installs the Cluster Application Migration (CAM) tool on the target cluster by default.

NOTE
Optional: You can configure the Cluster Application Migration Operator to install the CAM tool on an OpenShift Container Platform 3 cluster or on a remote cluster.

In a restricted environment, you can install the Cluster Application Migration Operator from a local mirror registry.

After you have installed the Cluster Application Migration Operator on your clusters, you can launch the CAM tool.

3.2.1. Installing the Cluster Application Migration Operator

You can install the Cluster Application Migration Operator with the Operation Lifecycle Manager (OLM) on an OpenShift Container Platform 4.4 target cluster and on an OpenShift Container Platform 4.1 source cluster.

3.2.1.1. Installing the Cluster Application Migration Operator on an OpenShift Container Platform 4.4 target cluster

You can install the Cluster Application Migration Operator on an OpenShift Container Platform 4.4 target cluster with the Operation Lifecycle Manager (OLM).

The Cluster Application Migration Operator installs the Cluster Application Migration tool on the target cluster by default.

Procedure

1. In the OpenShift Container Platform web console, click Operators → OperatorHub.
2. Use the Filter by keyword field (in this case, Migration) to find the Cluster Application Migration Operator.
3. Select the Cluster Application Migration Operator and click Install.
4. On the Create Operator Subscription page, click Subscribe.
   On the Installed Operators page, the Cluster Application Migration Operator appears in the openshift-migration project with the status Succeeded.
5. Click Cluster Application Migration Operator.
6. Under Provided APIs, locate the Migration Controller tile, and click Create Instance.
7. Click Create.
8. Click Workloads → Pods to verify that the Controller Manager, Migration UI, Restic, and Velero Pods are running.

3.2.1.2. Installing the Cluster Application Migration Operator on an OpenShift Container Platform 4.2 source cluster
You can install the Cluster Application Migration Operator on an OpenShift Container Platform 4 source cluster with the Operation Lifecycle Manager (OLM).

**Procedure**

1. In the OpenShift Container Platform web console, click **Operators → OperatorHub**.

2. Use the **Filter by keyword** field (in this case, **Migration**) to find the **Cluster Application Migration Operator**.

3. Select the **Cluster Application Migration Operator** and click **Install**.

4. On the **Create Operator Subscription** page, click **Subscribe**. On the **Installed Operators** page, the **Cluster Application Migration Operator** appears in the **openshift-migration** project with the status **Succeeded**.

5. Click **Cluster Application Migration Operator**.

6. Under **Provided APIs**, locate the **Migration Controller** tile, and click **Create Instance**.

7. Set the **migration_controller** and **migration_ui** parameters to **false** in the **spec** stanza:

   ```yaml
   spec:
     ...
     migration_controller: false
     migration_ui: false
     ...
   ```

8. Click **Create**.

9. Click **Workloads → Pods** to verify that the Restic and Velero Pods are running.

### 3.2.2. Installing the Cluster Application Migration Operator in a restricted environment

You can build a custom Operator catalog image for OpenShift Container Platform 4, push it to a local mirror image registry, and configure OLM to install the Operator from the local registry.

**Additional resources**

- Using Operator Lifecycle Manager on restricted networks

#### 3.2.2.1. Building an Operator catalog image

Cluster administrators can build a custom Operator catalog image to be used by Operator Lifecycle Manager (OLM) and push the image to a container image registry that supports Docker v2-2. For a cluster on a restricted network, this registry can be a registry that the cluster has network access to, such as the mirror registry created during the restricted network installation.

**IMPORTANT**

The OpenShift Container Platform cluster’s internal registry cannot be used as the target registry because it does not support pushing without a tag, which is required during the mirroring process.
For this example, the procedure assumes use of the mirror registry created on the bastion host during a restricted network cluster installation.

**Prerequisites**

- A Linux workstation with unrestricted network access
- `oc` version 4.3.5+
- `podman` version 1.4.4+
- Access to mirror registry that supports Docker v2–2
- If you are working with private registries, set the `REG_CREDS` environment variable to the file path of your registry credentials for use in later steps. For example, for the `podman` CLI:

  ```
  $ REG_CREDS=${XDG_RUNTIME_DIR}/containers/auth.json
  ```

**Procedure**

1. On the workstation with unrestricted network access, authenticate with the target mirror registry:

  ```
  $ podman login <registry_host_name>
  ```

   Also authenticate with `registry.redhat.io` so that the base image can be pulled during the build:

  ```
  $ podman login registry.redhat.io
  ```

2. Build a catalog image based on the `redhat-operators` catalog from `quay.io`, tagging and pushing it to your mirror registry:

  ```
  $ oc adm catalog build \
      --appregistry-org redhat-operators \ 
      --from=registry.redhat.io/openshift4/ose-operator-registry:v4.4 \ 
      --filter-by-os="linux/amd64" \ 
      --to=<registry_host_name>:<port>/olm/redhat-operators:v1 \ 
      [-a ${REG_CREDS}] \ 
      [--insecure]
  ```

   **INFO[0013] loading Bundles**

   ```
   dir=/var/folders/st/9cskxqs53ll3wdn434vw4cd80000gn/T/300666084/manifests-829192605 ...
   ```

   Pushed sha256:f73d42950021f9240389f99ddc5b0c7f1b533c054ba344654ff1eda6bf827e3
to example_registry:5000/olm/redhat-operators:v1

1. Organization (namespace) to pull from an App Registry instance.

2. Set `--from` to the `ose-operator-registry` base image using the tag that matches the target OpenShift Container Platform cluster major and minor version.

3. Set `--filter-by-os` to the operating system and architecture to use for the base image, which must match the target OpenShift Container Platform cluster. Valid values are `linux/amd64`, `linux/ppc64le`, and `linux/s390x`. 
Name your catalog image and include a tag, for example, **v1**.

Optional: If required, specify the location of your registry credentials file.

Optional: If you do not want to configure trust for the target registry, add the **--insecure** flag.

Sometimes invalid manifests are accidentally introduced into Red Hat's catalogs; when this happens, you might see some errors:

```
INFO[0014] directory
dir=/var/folders/st/9cskxqs53ll3wdn434vw4cd80000gn/T/300666084/manifests-829192605
file=4.2 load=package
W1114 19:42:37.876180   34665 builder.go:141] error building database: error loading package into db: fuse-camel-k-operator.v7.5.0 specifies replacement that couldn't be found
Uploading ... 244.9kB/s
```

These errors are usually non-fatal, and if the Operator package mentioned does not contain an Operator you plan to install or a dependency of one, then they can be ignored.

### 3.2.2.2. Configuring OperatorHub for restricted networks

Cluster administrators can configure OLM and OperatorHub to use local content in a restricted network environment using a custom Operator catalog image. For this example, the procedure uses a custom **redhat-operators** catalog image previously built and pushed to a supported registry.

**Prerequisites**

- A Linux workstation with unrestricted network access
- A custom Operator catalog image pushed to a supported registry
- **oc** version 4.3.5+
- **podman** version 1.4.4+
- Access to mirror registry that supports **Docker v2-2**
- If you are working with private registries, set the **REG_CREDS** environment variable to the file path of your registry credentials for use in later steps. For example, for the **podman** CLI:

  ```
  $ REG_CREDS=${XDG_RUNTIME_DIR}/containers/auth.json
  ```

**Procedure**

1. Disable the default OperatorSources by adding **disableAllDefaultSources: true** to the spec:

   ```
   $ oc patch OperatorHub cluster --type json \  
   -p '[["op": "add", "path": "/spec/disableAllDefaultSources", "value": true]]'
   ```

   This disables the default OperatorSources that are configured by default during an OpenShift Container Platform installation.
2. Mirror the contents of your catalog to your target registry. The following `oc adm catalog mirror` command extracts the contents of your custom Operator catalog image to generate the manifests required for mirroring and mirrors the images to your registry:

```
$ oc adm catalog mirror \
    <registry_host_name>:<port>/olm/redhat-operators:v1 \  
    <registry_host_name>:<port> \  
    [-a ${REG_CREDS}]  
    [--insecure] \  
    [--filter-by-os="<os>/<arch>"]
```

mirroring ...

1. Specify your Operator catalog image.
2. Optional: If required, specify the location of your registry credentials file.
3. Optional: If you do not want to configure trust for the target registry, add the `--insecure` flag.
4. Optional: Because the catalog might reference images that support multiple architectures and operating systems, you can filter by architecture and operating system to mirror only the images that match. Valid values are `linux/amd64`, `linux/ppc64le`, and `linux/s390x`.

This command also creates a `<image_name>-manifests/` directory in the current directory and generates the following files:

- The `imageContentSourcePolicy.yaml` file defines an ImageContentSourcePolicy object that can configure nodes to translate between the image references stored in Operator manifests and the mirrored registry.
- The `mapping.txt` file contains all of the source images and where to map them in the target registry. This file is compatible with the `oc image mirror` command and can be used to further customize the mirroring configuration.

3. Apply the manifests:

```
$ oc apply -f ./redhat-operators-manifests
```

4. Create a CatalogSource object that references your catalog image.

a. Modify the following to your specifications and save it as a `catalogsource.yaml` file:

```yaml
apiVersion: operators.coreos.com/v1alpha1
kind: CatalogSource
metadata:
  name: my-operator-catalog
  namespace: openshift-marketplace
spec:
  sourceType: grpc
  image: <registry_host_name>:<port>/olm/redhat-operators:v1
  displayName: My Operator Catalog
  publisher: grpc
```

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1. Specify your custom Operator catalog image.

b. Use the file to create the CatalogSource object:

```bash
$ oc create -f catalogsource.yaml
```

5. Verify the CatalogSource and package manifest are created successfully:

```
# oc get pods -n openshift-marketplace
NAME   READY STATUS    RESTARTS AGE
my-operator-catalog-6njx6 1/1 Running 0 28s
marketplace-operator-d9f549946-96sgr 1/1 Running 0 26h

# oc get catalogsource -n openshift-marketplace
NAME    DISPLAY        TYPE  PUBLISHER AGE
my-operator-catalog My Operator Catalog grpc 5s

# oc get packagemanifest -n openshift-marketplace
NAME CATALOG   AGE
etcd My Operator Catalog 34s
```

You can also view them from the OperatorHub page in the web console.

You can now install the Operators from the OperatorHub page on your restricted network OpenShift Container Platform cluster.

3.2.2.3. Installing the Cluster Application Migration Operator on an OpenShift Container Platform 4.4 target cluster in a restricted environment

You can install the Cluster Application Migration Operator on an OpenShift Container Platform 4.4 target cluster with the Operation Lifecycle Manager (OLM).

The Cluster Application Migration Operator installs the Cluster Application Migration tool on the target cluster by default.

Prerequisites

- You created a custom Operator catalog and pushed it to a mirror registry.
- You configured OLM to install the Cluster Application Migration Operator from the mirror registry.

Procedure

1. In the OpenShift Container Platform web console, click Operators → OperatorHub.
2. Use the Filter by keyword field (in this case, Migration) to find the Cluster Application Migration Operator.
3. Select the Cluster Application Migration Operator and click Install.
4. On the Create Operator Subscription page, click Subscribe.
   On the Installed Operators page, the Cluster Application Migration Operator appears in the openshift-migration project with the status Succeeded.
5. Click **Cluster Application Migration Operator**.

6. Under **Provided APIs**, locate the **Migration Controller** tile, and click **Create Instance**.

7. Click **Create**.

8. Click **Workloads → Pods** to verify that the Controller Manager, Migration UI, Restic, and Velero Pods are running.

### 3.2.2.4. Installing the Cluster Application Migration Operator on an OpenShift Container Platform 4.2 source cluster in a restricted environment

You can install the Cluster Application Migration Operator on an OpenShift Container Platform 4 source cluster with the Operation Lifecycle Manager (OLM).

**Prerequisites**

- You created a custom Operator catalog and pushed it to a mirror registry.
- You configured OLM to install the Cluster Application Migration Operator from the mirror registry.

**Procedure**

1. In the OpenShift Container Platform web console, click **Operators → OperatorHub**.

2. Use the **Filter by keyword** field (in this case, **Migration**) to find the **Cluster Application Migration Operator**.

3. Select the **Cluster Application Migration Operator** and click **Install**.

4. On the **Create Operator Subscription** page, click **Subscribe**.

   On the **Installed Operators** page, the **Cluster Application Migration Operator** appears in the **openshift-migration** project with the status **Succeeded**.

5. Click **Cluster Application Migration Operator**.

6. Under **Provided APIs**, locate the **Migration Controller** tile, and click **Create Instance**.

7. Click **Create**.

### 3.2.3. Launching the CAM web console

You can launch the CAM web console in a browser.

**Procedure**

1. Log in to the OpenShift Container Platform cluster on which you have installed the CAM tool.

2. Obtain the CAM web console URL by entering the following command:

   ```
   $ oc get -n openshift-migration route/migration -o go-template='https://{{ .spec.host }}'
   
   The output resembles the following: **https://migration-openshift-migration.apps.cluster.openshift.com**.
3. Launch a browser and navigate to the CAM web console.

NOTE

If you try to access the CAM web console immediately after installing the Cluster Application Migration Operator, the console may not load because the Operator is still configuring the cluster. Wait a few minutes and retry.

4. If you are using self-signed CA certificates, you will be prompted to accept the CA certificate of the source cluster’s API server. The web page guides you through the process of accepting the remaining certificates.

5. Log in with your OpenShift Container Platform username and password.

3.3. CONFIGURING A REPLICATION REPOSITORY

You must configure an object storage to use as a replication repository. The Cluster Application Migration tool copies data from the source cluster to the replication repository, and then from the replication repository to the target cluster.

The CAM tool supports the file system and snapshot data copy methods for migrating data from the source cluster to the target cluster. You can select a method that is suited for your environment and is supported by your storage provider.

The following storage providers are supported:

- Multi-Cloud Object Gateway (MCG)
- Amazon Web Services (AWS) S3
- Google Cloud Provider (GCP)
- Microsoft Azure
- Generic S3 object storage, for example, Minio or Ceph S3

The source and target clusters must have network access to the replication repository during migration.

In a restricted environment, you can create an internally hosted replication repository. If you use a proxy server, you must ensure that your replication repository is whitelisted.

3.3.1. Configuring a Multi-Cloud Object Gateway storage bucket as a replication repository

You can install the OpenShift Container Storage Operator and configure a Multi-Cloud Object Gateway (MCG) storage bucket as a replication repository.

3.3.1.1. Installing the OpenShift Container Storage Operator

You can install the OpenShift Container Storage Operator from OperatorHub.

Procedure

1. In the OpenShift Container Platform web console, click Operators → OperatorHub.
2. Use Filter by keyword (in this case, OCS) to find the OpenShift Container Storage Operator.

3. Select the OpenShift Container Storage Operator and click Install.

4. Select an Update Channel, Installation Mode, and Approval Strategy.

5. Click Subscribe.
   On the Installed Operators page, the OpenShift Container Storage Operator appears in the openshift-storage project with the status Succeeded.

### 3.3.1.2. Creating the Multi-Cloud Object Gateway storage bucket

You can create the Multi-Cloud Object Gateway (MCG) storage bucket’s Custom Resources (CRs).

**Procedure**

1. Log in to the OpenShift Container Platform cluster:
   ```bash
   $ oc login
   ```

2. Create the NooBaa CR configuration file, `noobaa.yml`, with the following content:
   ```yaml
   apiVersion: noobaa.io/v1alpha1
   kind: NooBaa
   metadata:
     name: noobaa
     namespace: openshift-storage
   spec:
     dbResources:
       requests:
         cpu: 0.5
         memory: 1Gi
     coreResources:
       requests:
         cpu: 0.5
         memory: 1Gi
   ```

   **1** For a very small cluster, you can change the `cpu` value to 0.1.

3. Create the NooBaa object:
   ```bash
   $ oc create -f noobaa.yml
   ```

4. Create the BackingStore CR configuration file, `bs.yml`, with the following content:
   ```yaml
   apiVersion: noobaa.io/v1alpha1
   kind: BackingStore
   metadata:
     finalizers:
     - noobaa.io/finalizer
   labels:
     app: noobaa
   name: mcg-pv-pool-bs
   ```
namespace: openshift-storage
spec:
  pvPool:
    numVolumes: 3
  resources:
    requests:
      storage: 50Gi
    storageClass: gp2
  type: pv-pool

1. Specify the number of volumes in the PV pool.
2. Specify the size of the volumes.
3. Specify the storage class.

5. Create the **BackingStore** object:

```bash
$ oc create -f bs.yml
```

6. Create the **BucketClass** CR configuration file, `bc.yml`, with the following content:

```yaml
apiVersion: noobaa.io/v1alpha1
kind: BucketClass
metadata:
  labels:
    app: noobaa
  name: mcg-pv-pool-bc
namespace: openshift-storage
spec:
  placementPolicy:
    tiers:
      - backingStores:
        - mcg-pv-pool-bs
      placement: Spread
```

7. Create the **BucketClass** object:

```bash
$ oc create -f bc.yml
```

8. Create the **ObjectBucketClaim** CR configuration file, `obc.yml`, with the following content:

```yaml
apiVersion: objectbucket.io/v1alpha1
kind: ObjectBucketClaim
metadata:
  name: migstorage
  namespace: openshift-storage
spec:
  bucketName: migstorage
  storageClassName: openshift-storage.noobaa.io
  additionalConfig:
    bucketclass: mcg-pv-pool-bc
```

CHAPTER 3. MIGRATING FROM OPENSIFT CONTAINER PLATFORM 4.2 AND LATER
Record the bucket name for adding the replication repository to the CAM web console.

9. Create the **ObjectBucketClaim** object:

   ```bash
   $ oc create -f obc.yml
   ```

10. Watch the resource creation process to verify that the **ObjectBucketClaim** status is **Bound**:

    ```bash
    $ watch -n 30 'oc get -n openshift-storage objectbucketclaim migstorage -o yaml'
    ```

    This process can take five to ten minutes.

11. Obtain and record the following values, which are required when you add the replication repository to the CAM web console:
   - S3 endpoint:
     ```bash
     $ oc get route -n openshift-storage s3
     ```
   - S3 provider access key:
     ```bash
     $ oc get secret -n openshift-storage migstorage -o go-template='{{.data.AWS_ACCESS_KEY_ID }}' | base64 -d
     ```
   - S3 provider secret access key:
     ```bash
     $ oc get secret -n openshift-storage migstorage -o go-template='{{.data.AWS_SECRET_ACCESS_KEY }}' | base64 -d
     ```

### 3.3.2. Configuring an AWS S3 storage bucket as a replication repository

You can configure an AWS S3 storage bucket as a replication repository.

**Prerequisites**
- The AWS S3 storage bucket must be accessible to the source and target clusters.
- You must have the [AWS CLI](https://awscli.amazonaws.com/) installed.
- If you are using the snapshot copy method:
  - You must have access to EC2 Elastic Block Storage (EBS).
  - The source and target clusters must be in the same region.
  - The source and target clusters must have the same storage class.
  - The storage class must be compatible with snapshots.

**Procedure**

1. Create an AWS S3 bucket:
$ aws s3api create-bucket \
   --bucket <bucket_name> \
   --region <bucket_region>

1. Specify your S3 bucket name.

2. Specify your S3 bucket region, for example, `us-east-1`.

2. Create the IAM user `velero`:

   $ aws iam create-user --user-name velero

3. Create an EC2 EBS snapshot policy:

   $ cat > velero-ec2-snapshot-policy.json <<EOF
   {
     "Version": "2012-10-17",
     "Statement": [
       {
         "Effect": "Allow",
         "Action": [
           "ec2:DescribeVolumes",
           "ec2:DescribeSnapshots",
           "ec2:CreateTags",
           "ec2:CreateVolume",
           "ec2:CreateSnapshot",
           "ec2:DeleteSnapshot"
         ],
         "Resource": "*"
       }
     ]
   }
   EOF

4. Create an AWS S3 access policy for one or for all S3 buckets:

   $ cat > velero-s3-policy.json <<EOF
   {
     "Version": "2012-10-17",
     "Statement": [
       {
         "Effect": "Allow",
         "Action": [
           "s3:GetObject",
           "s3:DeleteObject",
           "s3:PutObject",
           "s3:AbortMultipartUpload",
           "s3:ListMultipartUploadParts"
         ],
         "Resource": [
           "arn:aws:s3:::<bucket_name>/*"  # 1
         ]
       }
     ]
   }
   EOF
To grant access to a single S3 bucket, specify the bucket name. To grant access to all AWS S3 buckets, specify * instead of a bucket name:

"Resource": [
  "arn:aws:s3:::*"
]

5. Attach the EC2 EBS policy to velero:

$ aws iam put-user-policy \
  --user-name velero \
  --policy-name velero-ebs \
  --policy-document file://velero-ec2-snapshot-policy.json

6. Attach the AWS S3 policy to velero:

$ aws iam put-user-policy \
  --user-name velero \
  --policy-name velero-s3 \
  --policy-document file://velero-s3-policy.json

7. Create an access key for velero:

$ aws iam create-access-key --user-name velero
{
  "AccessKey": {
    "UserName": "velero",
    "Status": "Active",
    "CreateDate": "2017-07-31T22:24:41.576Z",
    "SecretAccessKey": <AWS_SECRET_ACCESS_KEY>,
    "AccessKeyId": <AWS_ACCESS_KEY_ID>
  }
}

Record the AWS_SECRET_ACCESS_KEY and the AWS_ACCESS_KEY_ID for adding the AWS repository to the CAM web console.
3.3.3. Configuring a Google Cloud Provider storage bucket as a replication repository

You can configure a Google Cloud Provider (GCP) storage bucket as a replication repository.

Prerequisites

- The GCP storage bucket must be accessible to the source and target clusters.
- You must have `gsutil` installed.
- If you are using the snapshot copy method:
  - The source and target clusters must be in the same region.
  - The source and target clusters must have the same storage class.
  - The storage class must be compatible with snapshots.

Procedure

1. Run `gsutil init` to log in:

   ```bash
   $ gsutil init
   Welcome! This command will take you through the configuration of gcloud.
   Your current configuration has been set to: [default]
   To continue, you must login. Would you like to login (Y/n)?
   ```

2. Set the `BUCKET` variable:

   ```bash
   $ BUCKET=<bucket_name>  
   ```

   Specify your bucket name.

3. Create a storage bucket:

   ```bash
   $ gsutil mb gs://$BUCKET/
   ```

4. Set the `PROJECT_ID` variable to your active project:

   ```bash
   $ PROJECT_ID=$(gcloud config get-value project)
   ```

5. Create a `velero` service account:

   ```bash
   $ gcloud iam service-accounts create velero \
     --display-name "Velero Storage"
   ```

6. Set the `SERVICE_ACCOUNT_EMAIL` variable to the service account’s email address:
$ SERVICE_ACCOUNT_EMAIL=$(gcloud iam service-accounts list \   --filter="displayName:Velero Storage" \   --format 'value(email)')

7. Grant permissions to the service account:

$ ROLE_PERMISSIONS=(
  compute.disks.get
  compute.disks.create
  compute.disks.createSnapshot
  compute.snapshots.get
  compute.snapshots.create
  compute.snapshots.useReadOnly
  compute.snapshots.delete
  compute.zones.get
)

gcloud iam roles create velero.server \   --project $PROJECT_ID \   --title "Velero Server" \   --permissions "$(IFS=","; echo "${ROLE_PERMISSIONS[*]}")"

gcloud projects add-iam-policy-binding $PROJECT_ID \   --member serviceAccount:$SERVICE_ACCOUNT_EMAIL \   --role projects/$PROJECT_ID/roles/velero.server

gsutil iam ch serviceAccount:$SERVICE_ACCOUNT_EMAIL:objectAdmin gs://${BUCKET}

8. Save the service account’s keys to the credentials-velero file in the current directory:

$ gcloud iam service-accounts keys create credentials-velero \   --iam-account $SERVICE_ACCOUNT_EMAIL

3.3.4. Configuring a Microsoft Azure Blob storage container as a replication repository

You can configure a Microsoft Azure Blob storage container as a replication repository.

Prerequisites

- You must have an Azure storage account.
- You must have the Azure CLI installed.
- The Azure Blob storage container must be accessible to the source and target clusters.
- If you are using the snapshot copy method:
  - The source and target clusters must be in the same region.
  - The source and target clusters must have the same storage class.
  - The storage class must be compatible with snapshots.
Procedure

1. Set the **AZURE_RESOURCE_GROUP** variable:

   ```
   $ AZURE_RESOURCE_GROUP=Velero_Backups
   ```

2. Create an Azure resource group:

   ```sh
gen group create -n $AZURE_RESOURCE_GROUP --location <CentralUS>  
   ```

   Specify your location.

3. Set the **AZURE_STORAGE_ACCOUNT_ID** variable:

   ```
   $ AZURE_STORAGE_ACCOUNT_ID=velerobackups
   ```

4. Create an Azure storage account:

   ```sh
gen storage account create \  
   --name $AZURE_STORAGE_ACCOUNT_ID \  
   --resource-group $AZURE_RESOURCE_GROUP \  
   --sku Standard_GRS \  
   --encryption-services blob \  
   --https-only true \  
   --kind BlobStorage \  
   --access-tier Hot
   ```

5. Set the **BLOB_CONTAINER** variable:

   ```
   $ BLOB_CONTAINER=velero
   ```

6. Create an Azure Blob storage container:

   ```sh
gen storage container create \  
   -n $BLOB_CONTAINER \  
   --public-access off \  
   --account-name $AZURE_STORAGE_ACCOUNT_ID
   ```

7. Create a service principal and credentials for **velero**:

   ```
   $ AZURE_SUBSCRIPTION_ID=`az account list --query '[?isDefault].id' -o tsv`
   $ AZURE_TENANT_ID=`az account list --query '[?isDefault].tenantId' -o tsv`
   $ AZURE_CLIENT_SECRET=`az ad sp create-for-rbac --name "velero" --role "Contributor" --query 'password' -o tsv`
   $ AZURE_CLIENT_ID=`az ad sp list --display-name "velero" --query '[0].appId' -o tsv`
   ```

8. Save the service principal’s credentials in the **credentials-velero** file:

   ```bash
cat << EOF  > ./credentials-velero
AZURE_SUBSCRIPTION_ID=${AZURE_SUBSCRIPTION_ID}
AZURE_TENANT_ID=${AZURE_TENANT_ID}
AZURE_CLIENT_ID=${AZURE_CLIENT_ID}
EOF
```
3.4. MIGRATING APPLICATIONS WITH THE CAM WEB CONSOLE

You can migrate application workloads by adding your clusters and replication repository to the CAM web console. Then, you can create and run a migration plan.

If your cluster or replication repository are secured with self-signed certificates, you can create a CA certificate bundle file or disable SSL verification.

3.4.1. Creating a CA certificate bundle file

If you use a self-signed certificate to secure a cluster or a replication repository, certificate verification might fail with the following error message: Certificate signed by unknown authority.

You can create a custom CA certificate bundle file and upload it in the CAM web console when you add a cluster or a replication repository.

**Procedure**

Download a CA certificate from a remote endpoint and save it as a CA bundle file:

```
$ echo -n | openssl s_client -connect <host_FQDN>:<port> \  
  | sed -ne '/-BEGIN CERTIFICATE-/,/-END CERTIFICATE-/p' > <ca_bundle.cert>
```

1. Specify the host FQDN and port of the endpoint, for example, `api.my-cluster.example.com:6443`.
2. Specify the name of the CA bundle file.

3.4.2. Adding a cluster to the CAM web console

You can add a cluster to the CAM web console.

**Prerequisites**

If you are using Azure snapshots to copy data:

- You must provide the Azure resource group name when you add the source cluster.
- The source and target clusters must be in the same Azure resource group and in the same location.

**Procedure**

1. Log in to the cluster.

2. Obtain the service account token:

```
$ oc sa get-token mig -n openshift-migration 
eyJhbGciOiJSUzI1NiIsImtpZCI6IiJ9.eyJpc3MiOiJrdWJlcm5ldGVzL3NlcnZpY2VhY2NvdW50Iiwi
a3ViZXRlc3poYXQiOjE2MTY2MjIzNTcyfQ.eyJhbGciOiJSUzI1NiIsImtpZCI6IiJ9.eyJpc3MiOiJrdWJlcm5ldGVzL3NlcnZpY2VhY2NvdW50Iiwi
a3ViZXRlc3poYXQiOjE2MTY2MjIzNTcyfQ.eyJhbGciOiJSUzI1NiIsImtpZCI6IiJ9.eyJpc3MiOiJrdWJlcm5ldGVzL3NlcnZpY2VhY2NvdW50Iiwi
a3ViZXRlc3poYXQiOjE2MTY2MjIzNTcyfQ.eyJpc3MiOiJrdWJlcm5ldGVzL3NlcnZpY2VhY2NvdW50Iiwi
```
3. Log in to the CAM web console.

4. In the Clusters section, click Add cluster.

5. Fill in the following fields:
   - **Cluster name**: May contain lower-case letters (a-z) and numbers (0-9). Must not contain spaces or international characters.
   - **Url**: URL of the cluster's API server, for example, https://<master1.example.com>:8443.
   - **Service account token**: String that you obtained from the source cluster.
   - **Azure cluster**: Optional. Select it if you are using Azure snapshots to copy your data.
   - **Azure resource group**: This field appears if Azure cluster is checked.
   - If you use a custom CA bundle, click Browse and browse to the CA bundle file.

6. Click Add cluster.
   The cluster appears in the Clusters section.

### 3.4.3. Adding a replication repository to the CAM web console

You can add an object storage bucket as a replication repository to the CAM web console.

**Prerequisites**

- You must configure an object storage bucket for migrating the data.

**Procedure**

1. Log in to the CAM web console.

2. In the Replication repositories section, click Add repository.

3. Select a Storage provider type and fill in the following fields:
   - **AWS** for AWS S3, MCG, and generic S3 providers:
     - **Replication repository name**: Specify the replication repository name in the CAM web console.
     - **S3 bucket name**: Specify the name of the S3 bucket you created.
- **S3 bucket region**: Specify the S3 bucket region. **Required** for AWS S3. **Optional** for other S3 providers.

- **S3 endpoint**: Specify the URL of the S3 service, not the bucket, for example, `https://<s3-storage.apps.cluster.com>`. **Required** for a generic S3 provider. You must use the `https://` prefix.

- **S3 provider access key**: Specify the `<AWS_SECRET_ACCESS_KEY>` for AWS or the S3 provider access key for MCG.

- **S3 provider secret access key**: Specify the `<AWS_ACCESS_KEY_ID>` for AWS or the S3 provider secret access key for MCG.

- **Require SSL verification**: Clear this check box if you are using a generic S3 provider.

- If you use a custom CA bundle, click **Browse** and browse to the Base64-encoded CA bundle file.

- **GCP**:
  - **Replication repository name**: Specify the replication repository name in the CAM web console.
  - **GCP bucket name**: Specify the name of the GCP bucket.
  - **GCP credential JSON blob**: Specify the string in the `credentials-velero` file.

- **Azure**:
  - **Replication repository name**: Specify the replication repository name in the CAM web console.
  - **Azure resource group**: Specify the resource group of the Azure Blob storage.
  - **Azure storage account name**: Specify the Azure Blob storage account name.
  - **Azure credentials - INI file contents**: Specify the string in the `credentials-velero` file.

4. Click **Add repository** and wait for connection validation.

5. Click **Close**.
   The new repository appears in the **Replication repositories** section.

### 3.4.4. Changing migration plan limits for large migrations

You can change the migration plan limits for large migrations.

**IMPORTANT**

Changes should first be tested in your environment to avoid a failed migration.

A single migration plan has the following default limits:

- 10 namespaces
  If this limit is exceeded, the CAM web console displays a **Namespace limit exceeded** error and you cannot create a migration plan.
• 100 Pods
If the Pod limit is exceeded, the CAM web console displays a warning message similar to the following example: 

Plan has been validated with warning condition(s). See warning message. 
Pod limit: 100 exceeded, found: 104.

• 100 persistent volumes
If the persistent volume limit is exceeded, the CAM web console displays a similar warning message.

Procedure

1. Edit the Migration controller CR:

   $ oc get migrationcontroller -n openshift-migration
   NAME AGE
   migration-controller 5d19h

   $ oc edit migrationcontroller -n openshift-migration

2. Update the following parameters:

   ...
   migration_controller: true
   # This configuration is loaded into mig-controller, and should be set on the
   # cluster where `migration_controller: true`
   mig_pv_limit: 100
   mig_pod_limit: 100
   mig_namespace_limit: 10
   ...

3.4.5. Creating a migration plan in the CAM web console

You can create a migration plan in the CAM web console.

Prerequisites

• The CAM web console must contain the following:
  o Source cluster
  o Target cluster, which is added automatically during the CAM tool installation
  o Replication repository

• The source and target clusters must have network access to each other and to the replication repository.

• If you use snapshots to copy data, the source and target clusters must run on the same cloud provider (AWS, GCP, or Azure) and in the same region.

Procedure

1. Log in to the CAM web console.
2. In the Plans section, click Add plan.

3. Enter the Plan name and click Next.
The Plan name can contain up to 253 lower-case alphanumeric characters (a-z, 0-9). It must not contain spaces or underscores (_).

4. Select a Source cluster.

5. Select a Target cluster.

6. Select a Replication repository.

7. Select the projects to be migrated and click Next.

8. Select Copy or Move for the PVs:
   - **Copy** copies the data in a source cluster's PV to the replication repository and then restores it on a newly created PV, with similar characteristics, in the target cluster.
     Optional: You can verify data copied with the filesystem method by selecting Verify copy. This option, which generates a checksum for each source file and checks it after restoration, significantly reduces performance.
   - **Move** unmounts a remote volume (for example, NFS) from the source cluster, creates a PV resource on the target cluster pointing to the remote volume, and then mounts the remote volume on the target cluster. Applications running on the target cluster use the same remote volume that the source cluster was using. The remote volume must be accessible to the source and target clusters.

9. Click Next.

10. Select a Copy method for the PVs:
    - **Snapshot** backs up and restores the disk using the cloud provider’s snapshot functionality. It is significantly faster than Filesystem.

    **NOTE**
    The storage and clusters must be in the same region and the storage class must be compatible.

    - **Filesystem** copies the data files from the source disk to a newly created target disk.

11. Select a Storage class for the PVs.
    If you selected the Filesystem copy method, you can change the storage class during migration, for example, from Red Hat Gluster Storage or NFS storage to Red Hat Ceph Storage.

12. Click Next.

13. If you want to add a migration hook, click Add Hook and perform the following steps:
   a. Specify the name of the hook.
   b. Select Ansible playbook to use your own playbook or Custom container image for a hook written in another language.
   c. Click Browse to upload the playbook.
d. Optional: If you are not using the default Ansible runtime image, specify your custom Ansible image.

e. Specify the cluster on which you want the hook to run.

f. Specify the service account name.

g. Specify the namespace.

h. Select the migration step at which you want the hook to run:
   - PreBackup: Before backup tasks are started on the source cluster
   - PostBackup: After backup tasks are complete on the source cluster
   - PreRestore: Before restore tasks are started on the target cluster
   - PostRestore: After restore tasks are complete on the target cluster

14. Click Add.
   You can add up to four hooks to a migration plan, assigning each hook to a different migration step.

15. Click Finish.

16. Click Close.
   The migration plan appears in the Plans section.

3.4.6. Running a migration plan in the CAM web console

You can stage or migrate applications and data with the migration plan you created in the CAM web console.

Prerequisites

The CAM web console must contain the following:

- Source cluster
- Target cluster, which is added automatically during the CAM tool installation
- Replication repository
- Valid migration plan

Procedure

1. Log in to the CAM web console on the target cluster.

2. Select a migration plan.

3. Click Stage to copy data from the source cluster to the target cluster without stopping the application.
   You can run Stage multiple times to reduce the actual migration time.

4. When you are ready to migrate the application workload, click Migrate.
Migrate stops the application workload on the source cluster and recreates its resources on the target cluster.

5. Optional: In the Migrate window, you can select Do not stop applications on the source cluster during migration.

6. Click Migrate.

7. Optional: To stop a migration in progress, click the Options menu and select Cancel.

8. When the migration is complete, verify that the application migrated successfully in the OpenShift Container Platform web console:
   a. Click Home → Projects.
   b. Click the migrated project to view its status.
   c. In the Routes section, click Location to verify that the application is functioning, if applicable.
   d. Click Workloads → Pods to verify that the Pods are running in the migrated namespace.
   e. Click Storage → Persistent volumes to verify that the migrated persistent volume is correctly provisioned.

3.5. TROUBLESHOOTING

You can view the migration Custom Resources (CRs) and download logs to troubleshoot a failed migration.

If the application was stopped during the failed migration, you must roll it back manually in order to prevent data corruption.

NOTE

Manual rollback is not required if the application was not stopped during migration, because the original application is still running on the source cluster.

3.5.1. Viewing migration Custom Resources

The Cluster Application Migration (CAM) tool creates the following Custom Resources (CRs):
MigCluster (configuration, CAM cluster): Cluster definition

MigStorage (configuration, CAM cluster): Storage definition

MigPlan (configuration, CAM cluster): Migration plan

The MigPlan CR describes the source and target clusters, repository, and namespace(s) being migrated. It is associated with 0, 1, or many MigMigration CRs.

NOTE
Deleting a MigPlan CR deletes the associated MigMigration CRs.

BackupStorageLocation (configuration, CAM cluster): Location of Velero backup objects

VolumeSnapshotLocation (configuration, CAM cluster): Location of Velero volume snapshots

MigMigration (action, CAM cluster): Migration, created during migration

A MigMigration CR is created every time you stage or migrate data. Each MigMigration CR is associated with a MigPlan CR.
**Backup** (action, source cluster): When you run a migration plan, the MigMigration CR creates two Velero backup CRs on each source cluster:

- Backup CR #1 for Kubernetes objects
- Backup CR #2 for PV data

**Restore** (action, target cluster): When you run a migration plan, the MigMigration CR creates two Velero restore CRs on the target cluster:

- Restore CR #1 (using Backup CR #2) for PV data
- Restore CR #2 (using Backup CR #1) for Kubernetes objects

**Procedure**

1. Get the CR name:

   ```
   $ oc get <migration_cr> -n openshift-migration
   ```

   Specify the migration CR, for example, `migmigration`.

   The output is similar to the following:

   ```
   NAME                                   AGE
   88435fe0-c9f8-11e9-85e6-5d593ce65e10   6m42s
   ```

2. View the CR:

   ```
   $ oc describe <migration_cr> <88435fe0-c9f8-11e9-85e6-5d593ce65e10> -n openshift-migration
   ```

   The output is similar to the following examples.

**MigMigration example**

```
name:         88435fe0-c9f8-11e9-85e6-5d593ce65e10
namespace:    openshift-migration
labels:       <none>
annotations:  touch: 3b48b543-b53e-4e44-9d34-33563f0f8147
apiVersion:  migration.openshift.io/v1alpha1
kind:         MigMigration
metadata:
  creationTimestamp:  2019-08-29T01:01:29Z
  generation:          20
  resourceVersion:    88179
  selfLink:           /apis/migration.openshift.io/v1alpha1/namespaces/openshift-migration/migmigrations/88435fe0-c9f8-11e9-85e6-5d593ce65e10
  uid:                 8886de4c-c9f8-11e9-95ad-0205fe66cbb6
spec:
  migPlanRef:
    name:        socks-shop-mig-plan
    namespace:   openshift-migration
```
quiescePods: true
stage: false
status:
conditions:
category: Advisory
durable: True
lastTransitionTime: 2019-08-29T01:03:40Z
message: The migration has completed successfully.
reason: Completed
status: True
type: Succeeded
phase: Completed
startTimestamp: 2019-08-29T01:01:29Z

Velero backup CR #2 example (PV data)

apiVersion: velero.io/v1
type: Backup

metadata:
annotations:
openshift.io/migrate-copy-phase: final
openshift.io/migrate-quiesce-pods: "true"
openshift.io/migration-registry: 172.30.105.179:5000
openshift.io/migration-registry-dir: /socks-shop-mig-plan-registry-44dd3bd5-c9f8-11e9-95ad-0205fe66cbb6
creationTimestamp: "2019-08-29T01:03:15Z"
generateName: 88435fe0-c9f8-11e9-85e6-5d593ce65e10-
generation: 1
labels:
app.kubernetes.io/part-of: migration
migmigration: 8886de4c-c9f8-11e9-95ad-0205fe66cbb6
migration-stage-backup: 8886de4c-c9f8-11e9-95ad-0205fe66cbb6
velero.io/storage-location: myrepo-vpq9
name: 88435fe0-c9f8-11e9-85e6-5d593ce65e10-59gb7
namespace: openshift-migration
resourceVersion: "87313"
selLink: /apis/velero.io/v1/namespaces/openshift-migration/backups/88435fe0-c9f8-11e9-85e6-5d593ce65e10-59gb7
uid: c80dbbc0-c9f8-11e9-95ad-0205fe66cbb6

spec:
excludedNamespaces: []
excludedResources: []
hooks: []
includeClusterResources: null
includedNamespaces: [- sock-shop
includeResources: [- persistentvolumes
- persistentvolumeclaims
- namespaces
- imagestreams
- imagestreamtags
- secrets
- configmaps]
- pods
  labelSelector:
    matchLabels:
      migration-included-stage-backup: 8886de4c-c9f8-11e9-95ad-0205fe66cbb6
  storageLocation: myrepo-vpzq9
ttl: 720h0m0s
  volumeSnapshotLocations:
  - myrepo-wv6fx
status:
  completionTimestamp: "2019-08-29T01:02:36Z"
  errors: 0
  expiration: "2019-09-28T01:02:35Z"
  phase: Completed
  startTimestamp: "2019-08-29T01:02:35Z"
  validationErrors: null
  version: 1
  volumeSnapshotsAttempted: 0
  volumeSnapshotsCompleted: 0
  warnings: 0

Velero restore CR #2 example (Kubernetes resources)

apiVersion: velero.io/v1
kind: Restore
metadata:
  annotations:
    openshift.io/migrate-copy-phase: final
    openshift.io/migrate-quiesce-pods: "true"
    openshift.io/migration-registry: 172.30.90.187:5000
    openshift.io/migration-registry-dir: /socks-shop-mig-plan-registry-36f54ca7-c925-11e9-825a-06fa9fb68c88
creationTimestamp: "2019-08-28T00:09:49Z"
generateName: e13a1b60-c927-11e9-9555-d129df7f3b96-
generation: 3
  labels:
    app.kubernetes.io/part-of: migration
    migmigration: e18252c9-c927-11e9-825a-06fa9fb68c88
    migration-final-restore: e18252c9-c927-11e9-825a-06fa9fb68c88
    name: e13a1b60-c927-11e9-9555-d129df7f3b96-gb8nx
namespace: openshift-migration
resourceVersion: "82329"
selfLink: /apis/velero.io/v1/namespaces/openshift-migration/restores/e13a1b60-c927-11e9-9555-d129df7f3b96-gb8nx
uid: 26983ec0-c928-11e9-825a-06fa9fb68c88
spec:
  backupName: e13a1b60-c927-11e9-9555-d129df7f3b96-sz24f
  excludedNamespaces: null
  excludedResources: null
  - nodes
  - events
  - events.events.k8s.io
  - backups.velero.io
  - restores.velero.io
  - resticrepositories.velero.io
  includedNamespaces: null
  includedResources: null
3.5.2. Downloading migration logs

You can download the Velero, Restic, and Migration controller logs in the CAM web console to troubleshoot a failed migration.

Procedure

1. Log in to the CAM console.

2. Click Plans to view the list of migration plans.

3. Click the Options menu of a specific migration plan and select Logs.

4. Click Download Logs to download the logs of the Migration controller, Velero, and Restic for all clusters.

5. To download a specific log:
   a. Specify the log options:
      - **Cluster**: Select the source, target, or CAM host cluster.
      - **Log source**: Select Velero, Restic, or Controller.
      - **Pod source**: Select the Pod name, for example, `controller-manager-78c469849c-v6wcf`
        The selected log is displayed.
        You can clear the log selection settings by changing your selection.
   b. Click Download Selected to download the selected log.

Optionally, you can access the logs by using the CLI, as in the following example:

```
$ oc get pods -n openshift-migration | grep controller
controller-manager-78c469849c-v6wcf  1/1   Running      0 4h49m

$ oc logs controller-manager-78c469849c-v6wcf -f -n openshift-migration
```

3.5.3. Error messages

3.5.3.1. Restic timeout error message in the Velero Pod log

If a migration fails because Restic times out, the following error appears in the Velero Pod log:
level=error msg="Error backing up item" backup=velero/monitoring error="timed out waiting for all PodVolumeBackups to complete"
error.file="/go/src/github.com/heptio/velero/pkg/restic/backupper.go:165"
error.function="github.com/heptio/velero/pkg/restic.(*backupper).BackupPodVolumes" group=v1

The default value of `restic_timeout` is one hour. You can increase this parameter for large migrations, keeping in mind that a higher value may delay the return of error messages.

**Procedure**

1. In the OpenShift Container Platform web console, navigate to **Operators** → **Installed Operators**.

2. Click **Cluster Application Migration Operator**.

3. In the **MigrationController** tab, click **migration-controller**.

4. In the **YAML** tab, update the following parameter value:

   ```yaml
   spec:
     restic_timeout: 1h
   ```

   Valid units are **h** (hours), **m** (minutes), and **s** (seconds), for example, **3h30m15s**.

5. Click **Save**.

**3.5.3.2. ResticVerifyErrors in the MigMigration Custom Resource**

If data verification fails when migrating a PV with the filesystem data copy method, the following error appears in the MigMigration Custom Resource (CR):

```yaml
status:
  conditions:
  - category: Warn
durable: true
lastTransitionTime: 2020-04-16T20:35:16Z
message: There were verify errors found in 1 Restic volume restores. See restore `<registry-example-migration-rvwcm>` for details
status: "True"
type: ResticVerifyErrors
```

1 The error message identifies the Restore CR name.

2 **ResticErrors** also appears. **ResticErrors** is a general error warning that includes verification errors.

**NOTE**

A data verification error does not cause the migration process to fail.

You can check the target cluster’s Restore CR to identify the source of the data verification error.
Procedure

1. Log in to the target cluster.

2. View the Restore CR:

   ```
   $ oc describe <registry-example-migration-rvwcm> -n openshift-migration
   ```

   The output identifies the PV with **PodVolumeRestore** errors:

   ```
   status:
   phase: Completed
   podVolumeRestoreErrors:
   - kind: PodVolumeRestore
     name: <registry-example-migration-rvwcm-98t49>
     namespace: openshift-migration
   podVolumeRestoreResticErrors:
   - kind: PodVolumeRestore
     name: <registry-example-migration-rvwcm-98t49>
     namespace: openshift-migration
   ```

3. View the **PodVolumeRestore** CR:

   ```
   $ oc describe <migration-example-rvwcm-98t49>
   ```

   The output identifies the Restic Pod that logged the errors:

   ```
   completionTimestamp: 2020-05-01T20:49:12Z
   errors: 1
   resticErrors: 1
   ...
   resticPod: <restic-nr2v5>
   ```

4. View the Restic Pod log:

   ```
   $ oc logs -f restic-nr2v5
   ```

3.5.4. Manually rolling back a migration

If your application was stopped during a failed migration, you must roll it back manually in order to prevent data corruption in the PV.

This procedure is not required if the application was not stopped during migration, because the original application is still running on the source cluster.

Procedure

1. On the target cluster, switch to the migrated project:

   ```
   $ oc project <project>
   ```

2. Get the deployed resources:
$ oc get all

3. Delete the deployed resources to ensure that the application is not running on the target cluster and accessing data on the PVC:

$ oc delete <resource_type>

4. To stop a DaemonSet without deleting it, update the \texttt{nodeSelector} in the YAML file:

```yaml
apiVersion: apps/v1
kind: DaemonSet
metadata:
  name: hello-daemonset
spec:
  selector:
    matchLabels:
      name: hello-daemonset
template:
  metadata:
    labels:
      name: hello-daemonset
  spec:
    template:
      metadata:
        labels:
          name: hello-daemonset
      spec:
        nodeSelector:
          role: worker
```

Specify a \texttt{nodeSelector} value that does not exist on any node.

5. Update each PV’s reclaim policy so that unnecessary data is removed. During migration, the reclaim policy for bound PVs is \texttt{Retain}, to ensure that data is not lost when an application is removed from the source cluster. You can remove these PVs during rollback.

```yaml
apiVersion: v1
kind: PersistentVolume
metadata:
  name: pv0001
spec:
  capacity:
    storage: 5Gi
  accessModes:
  - ReadWriteOnce
  persistentVolumeReclaimPolicy: Retain
```

Specify \texttt{Recycle} or \texttt{Delete}.

6. On the source cluster, switch to your migrated project:

$ oc project <project_name>

7. Obtain the project’s deployed resources:
$ oc get all

8. Start one or more replicas of each deployed resource:

$ oc scale --replicas=1 <resource_type>/<resource_name>

9. Update the nodeSelector of a DaemonSet to its original value, if you changed it during the procedure.

3.5.5. Gathering data for a customer support case

If you open a customer support case, you can run the `must-gather` tool with the `openshift-migration-must-gather-rhel8` image to collect information about your cluster and upload it to the Red Hat Customer Portal.

The `openshift-migration-must-gather-rhel8` image collects logs and Custom Resource data that are not collected by the default `must-gather` image.

Procedure

1. Navigate to the directory where you want to store the `must-gather` data.

2. Run the `oc adm must-gather` command:

   $ oc adm must-gather --image=registry.redhat.io/rhcam-1-2/openshift-migration-must-gather-rhel8

   The `must-gather` tool collects the cluster information and stores it in a `must-gather.local.<uid>` directory.

3. Remove authentication keys and other sensitive information from the `must-gather` data.

4. Create an archive file containing the contents of the `must-gather.local.<uid>` directory:

   $ tar cvaf must-gather.tar.gz must-gather.local.<uid>/

   You can attach the compressed file to your customer support case on the Red Hat Customer Portal.

3.5.6. Known issues

This release has the following known issues:

- During migration, the Cluster Application Migration (CAM) tool preserves the following namespace annotations:
  - `openshift.io/sa.scc.mcs`
  - `openshift.io/sa.scc.supplemental-groups`
  - `openshift.io/sa.scc.uid-range`

  These annotations preserve the UID range, ensuring that the containers retain their file system permissions on the target cluster. There is a risk that the migrated UIDs could duplicate UIDs within an existing or future namespace on the target cluster. (BZ#1748440)
• If an AWS bucket is added to the CAM web console and then deleted, its status remains True because the MigStorage CR is not updated. (BZ#1738564)

• Most cluster-scoped resources are not yet handled by the CAM tool. If your applications require cluster-scoped resources, you may have to create them manually on the target cluster.

• If a migration fails, the migration plan does not retain custom PV settings for quiesced pods. You must manually roll back the migration, delete the migration plan, and create a new migration plan with your PV settings. (BZ#1784899)

• If a large migration fails because Restic times out, you can increase the restic_timeout parameter value (default: 1h) in the Migration controller CR.

• If you select the data verification option for PVs that are migrated with the filesystem copy method, performance is significantly slower. Velero generates a checksum for each file and checks it when the file is restored.