OpenShift Container Platform 4.9 Migration Toolkit for Containers

Migrating to OpenShift Container Platform 4
Abstract

This document provides instructions for migrating your application workloads from OpenShift Container Platform 4 to the latest version.
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CHAPTER 1. ABOUT THE MIGRATION TOOLKIT FOR CONTAINERS

The Migration Toolkit for Containers (MTC) enables you to migrate stateful application workloads between OpenShift Container Platform 4 clusters at the granularity of a namespace.

You can migrate applications within the same cluster by using state migration.

MTC provides a web console and an API, based on Kubernetes custom resources, to help you control the migration and minimize application downtime.

The MTC console is installed on the target cluster by default. You can configure the Migration Toolkit for Containers Operator to install the console on a remote cluster.

See Advanced migration options for information about the following topics:

- Automating your migration with migration hooks and the MTC API.
- Configuring your migration plan to exclude resources, support large-scale migrations, and enable automatic PV resizing for direct volume migration.

1.1. TERMINOLOGY

Table 1.1. MTC terminology

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Source cluster</td>
<td>Cluster from which the applications are migrated.</td>
</tr>
<tr>
<td>Destination cluster[^1]</td>
<td>Cluster to which the applications are migrated.</td>
</tr>
<tr>
<td>Replication repository</td>
<td>Object storage used for copying images, volumes, and Kubernetes objects during indirect migration or for Kubernetes objects during direct volume migration or direct image migration. The replication repository must be accessible to all clusters.</td>
</tr>
<tr>
<td>Host cluster</td>
<td>Cluster on which the migration-controller pod and the web console are running. The host cluster is usually the destination cluster but this is not required. The host cluster does not require an exposed registry route for direct image migration.</td>
</tr>
<tr>
<td>Remote cluster</td>
<td>A remote cluster is usually the source cluster but this is not required. A remote cluster requires a Secret custom resource that contains the migration-controller service account token. A remote cluster requires an exposed secure registry route for direct image migration.</td>
</tr>
</tbody>
</table>
Indirect migration
Images, volumes, and Kubernetes objects are copied from the source cluster to the replication repository and then from the replication repository to the destination cluster.

Direct volume migration
Persistent volumes are copied directly from the source cluster to the destination cluster.

Direct image migration
Images are copied directly from the source cluster to the destination cluster.

Stage migration
Data is copied to the destination cluster without stopping the application.
Running a stage migration multiple times reduces the duration of the cutover migration.

Cutover migration
The application is stopped on the source cluster and its resources are migrated to the destination cluster.

State migration
Application state is migrated by copying specific persistent volume claims and Kubernetes objects to the destination cluster.

Rollback migration
Rollback migration rolls back a completed migration.

1 Called the target cluster in the MTC web console.

1.2. MTC WORKFLOW

You can migrate Kubernetes resources, persistent volume data, and internal container images to OpenShift Container Platform 4.9 by using the Migration Toolkit for Containers (MTC) web console or the Kubernetes API.

MTC migrates the following resources:

- A namespace specified in a migration plan.

- Namespace-scoped resources: When the MTC migrates a namespace, it migrates all the objects and resources associated with that namespace, such as services or pods. Additionally, if a resource that exists in the namespace but not at the cluster level depends on a resource that exists at the cluster level, the MTC migrates both resources.
  For example, a security context constraint (SCC) is a resource that exists at the cluster level and a service account (SA) is a resource that exists at the namespace level. If an SA exists in a namespace that the MTC migrates, the MTC automatically locates any SCCs that are linked to the SA and also migrates those SCCs. Similarly, the MTC migrates persistent volume claims that are linked to the persistent volumes of the namespace.

NOTE
Cluster-scoped resources might have to be migrated manually, depending on the resource.
Custom resources (CRs) and custom resource definitions (CRDs): MTC automatically migrates CRs and CRDs at the namespace level.

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

1. Install the Migration Toolkit for Containers Operator on all clusters.
   You can install the Migration Toolkit for Containers 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 MTC uses to migrate data.
   The source and target clusters must have network access to the replication repository during migration. If you are using a proxy server, you must configure it to allow network traffic between the replication repository and the clusters.

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

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

5. Create a migration plan, with one of the following data migration options:
   - **Copy**: MTC copies the data from the source cluster to the replication repository, and from the replication repository to the target cluster.

     **NOTE**
     If you are using direct image migration or direct volume migration, the images or volumes are copied directly from the source cluster to the target cluster.

   - **Move**: MTC 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 migration.
6. Run the migration plan, with one of the following options:

- **Stage** copies data to the target cluster without stopping the application. A stage migration can be run multiple times so that most of the data is copied to the target before migration. Running one or more stage migrations reduces the duration of the cutover migration.

- **Cutover** stops the application on the source cluster and moves the resources to the target cluster. Optional: You can clear the **Halt transactions on the source cluster during migration** checkbox.

### 1.3. ABOUT DATA COPY METHODS

The Migration Toolkit for Containers (MTC) 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.

#### 1.3.1. File system copy method
MTC copies data files from the source cluster to the replication repository, and from there to the target cluster.

### Table 1.2. 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>
<tr>
<td>• Supports direct volume migration, which significantly increases performance.</td>
<td></td>
</tr>
</tbody>
</table>

### 1.3.2. Snapshot copy method

MTC copies a snapshot of the source cluster data to the replication repository of a cloud provider. The data is restored on the target cluster.

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

### Table 1.3. 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>
<tr>
<td></td>
<td>• Does not support direct volume migration.</td>
</tr>
</tbody>
</table>

### 1.4. DIRECT VOLUME MIGRATION AND DIRECT IMAGE MIGRATION

You can use direct image migration (DIM) and direct volume migration (DVM) to migrate images and data directly from the source cluster to the target cluster.

If you run DVM with nodes that are in different availability zones, the migration might fail because the migrated pods cannot access the persistent volume claim.

DIM and DVM have significant performance benefits because the intermediate steps of backing up files from the source cluster to the replication repository and restoring files from the replication repository to the target cluster are skipped. The data is transferred with Rsync.
DIM and DVM have additional prerequisites.
The Migration Toolkit for Containers (MTC) enables you to migrate application workloads between OpenShift Container Platform clusters at the granularity of a namespace.

You can migrate from OpenShift Container Platform 3 to 4.9 and between OpenShift Container Platform 4 clusters.

MTC provides a web console and an API, based on Kubernetes custom resources, to help you control the migration and minimize application downtime.

### 2.1. MIGRATION TOOLKIT FOR CONTAINERS 1.6 RELEASE NOTES

The release notes for Migration Toolkit for Containers (MTC) version 1.6 describe new features and enhancements, deprecated features, and known issues.

#### 2.1.1. New features and enhancements

This release has the following new features and enhancements:

- State migration: You can perform repeatable, state-only migrations by selecting specific persistent volume claims (PVCs).
- "New operator version available" notification: The Clusters page of the MTC web console displays a notification when a new Migration Toolkit for Containers Operator is available.

#### 2.1.2. Deprecated features

The following features are deprecated:

- MTC version 1.4 is no longer supported.

#### 2.1.3. Known issues

This release has the following known issues:

- On OpenShift Container Platform 3.10, the MigrationController pod takes too long to restart. The Bugzilla report contains a workaround. ([BZ#1986796](https://bugzilla.redhat.com/show_bug.cgi?id=1986796))

- **Stage** pods fail during direct volume migration from a classic OpenShift Container Platform source cluster on IBM Cloud. The IBM block storage plugin does not allow the same volume to be mounted on multiple pods of the same node. As a result, the PVCs cannot be mounted on the Rsync pods and on the application pods simultaneously. To resolve this issue, stop the application pods before migration. ([BZ#1887526](https://bugzilla.redhat.com/show_bug.cgi?id=1887526))

- **MigPlan** custom resource does not display a warning when an AWS gp2 PVC has no available space. ([BZ#1963927](https://bugzilla.redhat.com/show_bug.cgi?id=1963927))

- Block storage for IBM Cloud must be in the same availability zone. See the IBM FAQ for block storage for virtual private cloud.

### 2.2. MIGRATION TOOLKIT FOR CONTAINERS 1.5 RELEASE NOTES

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The release notes for Migration Toolkit for Containers (MTC) version 1.5 describe new features, enhancements, and known issues.

2.2.1. New features and enhancements

This release has the following new features and enhancements:

- The Migration resource tree on the Migration details page of the web console has been enhanced with additional resources, Kubernetes events, and live status information for monitoring and debugging migrations.
- The web console can support hundreds of migration plans.
- A source namespace can be mapped to a different target namespace in a migration plan. Previously, the source namespace was mapped to a target namespace with the same name.
- Hook phases with status information are displayed in the web console during a migration.
- The number of Rsync retry attempts is displayed in the web console during direct volume migration.
- Persistent volume (PV) resizing can be enabled for direct volume migration to ensure that the target cluster does not run out of disk space.
- The threshold that triggers PV resizing is configurable. Previously, PV resizing occurred when the disk usage exceeded 97%.
- Velero has been updated to version 1.6, which provides numerous fixes and enhancements.
- Cached Kubernetes clients can be enabled to provide improved performance.

2.2.2. Deprecated features

The following features are deprecated:

- MTC versions 1.2 and 1.3 are no longer supported.
- The procedure for updating deprecated APIs has been removed from the troubleshooting section of the documentation because the `oc convert` command is deprecated.

2.2.3. Known issues

This release has the following known issues:

- Microsoft Azure storage is unavailable if you create more than 400 migration plans. The MigStorage custom resource displays the following message: The request is being throttled as the limit has been reached for operation type. (BZ#1977226)
- If a migration fails, the migration plan does not retain custom persistent volume (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)
- PV resizing does not work as expected for AWS gp2 storage unless the `pv_resizing_threshold` is 42% or greater. (BZ#1973148)
PV resizing does not work with OpenShift Container Platform 3.7 and 3.9 source clusters in the following scenarios:

- The application was installed after MTC was installed.
- An application pod was rescheduled on a different node after MTC was installed. OpenShift Container Platform 3.7 and 3.9 do not support the Mount Propagation feature that enables Velero to mount PVs automatically in the Restic pod. The MigAnalytic custom resource (CR) fails to collect PV data from the Restic pod and reports the resources as 0. The MigPlan CR displays a status similar to the following:

```
status:
  conditions:
    - category: Warn
      lastTransitionTime: 2021-07-15T04:11:44Z
      message: Failed gathering extended PV usage information for PVs [nginx-logs nginx-html], please see MigAnalytic openshift-migration/ocp-24706-basicvolmig-migplan-1626319591-szwd6 for details
      reason: FailedRunningDf
      status: "True"
      type: ExtendedPVAnalysisFailed
```

To enable PV resizing, you can manually restart the Restic daemonset on the source cluster or restart the Restic pods on the same nodes as the application. If you do not restart Restic, you can run the direct volume migration without PV resizing. (BZ#1982729)

2.2.4. Technical changes

This release has the following technical changes:

- The legacy Migration Toolkit for Containers Operator version 1.5.1 is installed manually on OpenShift Container Platform versions 3.7 to 4.5.
- The Migration Toolkit for Containers Operator version 1.5.1 is installed on OpenShift Container Platform versions 4.6 and later by using the Operator Lifecycle Manager.

2.3. MIGRATION TOOLKIT FOR CONTAINERS 1.4 RELEASE NOTES

The release notes for Migration Toolkit for Containers (MTC) version 1.4 describe new features, enhancements, and known issues.

2.3.1. Known issues

- MTC 1.4.6 cannot be deployed on OpenShift Container Platform 3.9 (BZ#1981794) or 3.10 (BZ#1981537).
CHAPTER 3. INSTALLING THE MIGRATION TOOLKIT FOR CONTAINERS

You can install the Migration Toolkit for Containers (MTC) on OpenShift Container Platform 4.

After you manually install the legacy Migration Toolkit for Containers Operator on the OpenShift Container Platform 4 source cluster, you install the Migration Toolkit for Containers Operator on the OpenShift Container Platform 4.9 target cluster by using the Operator Lifecycle Manager.

By default, the MTC web console and the Migration Controller pod run on the target cluster. You can configure the Migration Controller custom resource manifest to run the MTC web console and the Migration Controller pod on a remote cluster.

After you have installed MTC, you must configure an object storage to use as a replication repository.

3.1. COMPATIBILITY GUIDELINES

You must install the Migration Toolkit for Containers (MTC) version that is compatible with your OpenShift Container Platform version.

You cannot install MTC 1.6.x on OpenShift Container Platform versions 3.7 to 4.5 because the custom resource definition API versions are incompatible.

You can migrate workloads from a source cluster with MTC 1.5.1 to a target cluster with MTC 1.6.x as long as the MigrationController custom resource and the MTC web console are running on the target cluster.

Table 3.1. OpenShift Container Platform and MTC compatibility

<table>
<thead>
<tr>
<th>OpenShift Container Platform version</th>
<th>MTC version</th>
<th>Migration Toolkit for Containers Operator</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.7</td>
<td>1.5.1</td>
<td>Legacy Migration Toolkit for Containers Operator. Installed manually with the operator-3.7.yml file.</td>
</tr>
<tr>
<td>3.9 to 4.5</td>
<td>1.5.1</td>
<td>Legacy Migration Toolkit for Containers Operator. Installed manually with the operator.yml file.</td>
</tr>
</tbody>
</table>


3.2. INSTALLING THE LEGACY MIGRATION TOOLKIT FOR CONTAINERS OPERATOR ON OPENSSHIFT CONTAINER PLATFORM 4.2 TO 4.5

You can install the legacy Migration Toolkit for Containers Operator manually on OpenShift Container Platform versions 4.2 to 4.5.
Prerequisites

- You must be logged in as a user with **cluster-admin** privileges on all clusters.
- You must have access to **registry.redhat.io**.
- You must have **podman** installed.

Procedure

1. Log in to **registry.redhat.io** with your Red Hat Customer Portal credentials:
   
   ```bash
   $ sudo podman login registry.redhat.io
   ```

2. Download the **operator.yml** file:
   
   ```bash
   $ sudo podman cp $(sudo podman create
registry.redhat.io/rhmtc/openshift-migration-legacy-rhel8-operator:v1.5.1):/operator.yml ./
   ```

3. Download the **controller.yml** file:
   
   ```bash
   $ sudo podman cp $(sudo podman create
registry.redhat.io/rhmtc/openshift-migration-legacy-rhel8-operator:v1.5.1):/controller.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 Migration Toolkit for Containers Operator object:
   
   ```bash
   $ oc create -f operator.yml
   ```

**Example output**

```
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 Migration Toolkit for Containers Operator creating resources for earlier versions of OpenShift Container Platform 3 that are provided in later releases.
7. Create the **MigrationController** object:

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

8. Verify that the MTC pods are running:

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

### 3.3. INSTALLING THE MIGRATION TOOLKIT FOR CONTAINERS OPERATOR ON OPENSSHIFT CONTAINER PLATFORM 4.9

You install the Migration Toolkit for Containers Operator on OpenShift Container Platform 4.9 by using the Operator Lifecycle Manager.

**Prerequisites**

- You must be logged in as a user with **cluster-admin** privileges on all clusters.

**Procedure**

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

2. Use the **Filter by keyword** field to find the **Migration Toolkit for Containers Operator**.

3. Select the **Migration Toolkit for Containers Operator** and click **Install**.

4. Click **Install**.
   
   On the **Installed Operators** page, the **Migration Toolkit for Containers Operator** appears in the **openshift-migration** project with the status **Succeeded**.

5. Click **Migration Toolkit for Containers 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 MTC pods are running.

### 3.4. CONFIGURING PROXIES

For OpenShift Container Platform 4.1 and earlier versions, you must configure proxies in the **MigrationController** custom resource (CR) manifest after you install the Migration Toolkit for Containers Operator because these versions do not support a cluster-wide **proxy** object.

For OpenShift Container Platform 4.2 to 4.9, the Migration Toolkit for Containers (MTC) inherits the cluster-wide proxy settings. You can change the proxy parameters if you want to override the cluster-wide proxy settings.

You must configure the proxies to allow the SPDY protocol and to forward the **Upgrade HTTP** header to the API server. Otherwise, an **Upgrade request required** error is displayed. The **MigrationController** CR uses SPDY to run commands within remote pods. The **Upgrade HTTP** header is required in order to open a websocket connection with the API server.

**Direct volume migration**
If you are performing a direct volume migration (DVM) from a source cluster behind a proxy, you must configure an Stunnel proxy. Stunnel creates a transparent tunnel between the source and target clusters for the TCP connection without changing the certificates.

DVM supports only one proxy. The source cluster cannot access the route of the target cluster if the target cluster is also behind a proxy.

**Prerequisites**

- You must be logged in as a user with `cluster-admin` privileges on all clusters.

**Procedure**

1. Get the **MigrationController** CR manifest:

   ```bash
   $ oc get migrationcontroller <migration_controller> -n openshift-migration
   ```

2. Update the proxy parameters:

   ```yaml
   apiVersion: migration.openshift.io/v1alpha1
   kind: MigrationController
   metadata:
     name: <migration_controller>
     namespace: openshift-migration
   
   spec:
     stunnel_tcp_proxy: http://<username>:<password>@<ip>:<port> ①
     httpProxy: http://<username>:<password>@<ip>:<port> ②
     httpsProxy: http://<username>:<password>@<ip>:<port> ③
     noProxy: example.com ④
   ```

   ① Stunnel proxy URL for direct volume migration.
   ② Proxy URL for creating HTTP connections outside the cluster. The URL scheme must be `http`.
   ③ Proxy URL for creating HTTPS connections outside the cluster. If this is not specified, then `httpProxy` is used for both HTTP and HTTPS connections.
   ④ Comma-separated list of destination domain names, domains, IP addresses, or other network CIDRs to exclude proxying.

   Preface a domain with . to match subdomains only. For example, .y.com matches x.y.com, but not y.com. Use * to bypass proxy for all destinations. If you scale up workers that are not included in the network defined by the `networking.machineNetwork[].cidr` field from the installation configuration, you must add them to this list to prevent connection issues.

   This field is ignored if neither the `httpProxy` nor the `httpsProxy` field is set.

3. Save the manifest as **migration-controller.yaml**.

4. Apply the updated manifest:

   ```bash
   $ oc replace -f migration-controller.yaml -n openshift-migration
   ```
For more information, see Configuring the cluster-wide proxy.

3.5. CONFIGURING A REPLICATION REPOSITORY

You must configure an object storage to use as a replication repository. The Migration Toolkit for Containers (MTC) copies data from the source cluster to the replication repository, and then from the replication repository to the target cluster.

MTC supports the file system and snapshot data copy methods for migrating data from the source cluster to the target cluster. Select a method that is suited for your environment and is supported by your storage provider.

MTC supports the following storage providers:

- Multicloud Object Gateway
- Amazon Web Services S3
- Google Cloud Platform
- Microsoft Azure Blob
- Generic S3 object storage, for example, Minio or Ceph S3

3.5.1. Prerequisites

- All clusters must have uninterrupted network access to the replication repository.
- If you use a proxy server with an internally hosted replication repository, you must ensure that the proxy allows access to the replication repository.

3.5.2. Configuring the Multicloud Object Gateway

You can configure the Multicloud Object Gateway (MCG) as a replication repository for the Migration Toolkit for Containers (MTC). MCG is a component of OpenShift Container Storage.

Procedure

1. Deploy OpenShift Container Storage by using the appropriate OpenShift Container Storage deployment guide.

2. Obtain the S3 endpoint, AWS_ACCESS_KEY_ID, and AWS_SECRET_ACCESS_KEY by running the describe command on the NooBaa custom resource. These values are required in order to add MCG as a replication repository to the MTC web console.

3.5.3. Configuring Amazon Web Services S3

You can configure an Amazon Web Services (AWS) S3 storage bucket as a replication repository for the Migration Toolkit for Containers (MTC).

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:
  o You must have access to EC2 Elastic Block Storage (EBS).
  o The source and target clusters must be in the same region.
  o The source and target clusters must have the same storage class.
  o The storage class must be compatible with snapshots.

Procedure

1. Create an AWS S3 bucket:

   ```bash
   $ aws s3api create-bucket \
     --bucket <bucket> \1
     --region <bucket_region> \2
   
   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
   {
   ```
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 as in the following example:

Example output

```
"Resource": [
  "arn:aws:s3::{bucket}/*"
],
```

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

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 as in the following example:

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:
Record the `AWS_SECRET_ACCESS_KEY` and the `AWS_ACCESS_KEY_ID` for adding the AWS repository to the MTC web console.

### 3.5.4. Configuring Google Cloud Platform

You can configure a Google Cloud Platform (GCP) storage bucket as a replication repository for the Migration Toolkit for Containers (MTC).

#### 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. Log in to `gsutil`:

   ```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>  # Specify your bucket name.
      ```
3. Create a storage bucket:

   $ gsutil mb gs://$BUCKET/

4. Set the PROJECT_ID variable to your active project:

   $ PROJECT_ID=`gcloud config get-value project`

5. Create a velero IAM service account:

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

6. Create the SERVICE_ACCOUNT_EMAIL variable:

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

7. Create the ROLE_PERMISSIONS variable:

   $ 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
   )

8. Create the velero.server custom role:

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

9. Add IAM policy binding to the project:

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

10. Update the IAM service account:

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

11. Save the IAM service account keys to the credentials-velero file in the current directory:

    $ gcloud iam service-accounts keys create credentials-velero \
       --iam-account $SERVICE_ACCOUNT_EMAIL
3.5.5. Configuring Microsoft Azure Blob

You can configure a Microsoft Azure Blob storage container as a replication repository for the Migration Toolkit for Containers (MTC).

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:

```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 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
```

3.5.6. Additional resources for configuring a replication repository

- MTC workflow
- About data copy methods
- Adding a replication repository to the MTC web console
CHAPTER 4. INSTALLING THE MIGRATION TOOLKIT FOR CONTAINERS IN A RESTRICTED NETWORK ENVIRONMENT

You can install the Migration Toolkit for Containers (MTC) on OpenShift Container Platform 4 in a restricted network environment by performing the following procedures:

1. Create a mirrored Operator catalog.
   This process creates a mapping.txt file, which contains the mapping between the registry.redhat.io image and your mirror registry image. The mapping.txt file is required for installing the legacy Migration Toolkit for Containers Operator on an OpenShift Container Platform 4.2 to 4.5 source cluster.

2. Install the Migration Toolkit for Containers Operator on the OpenShift Container Platform 4.9 target cluster by using Operator Lifecycle Manager.
   By default, the MTC web console and the Migration Controller pod run on the target cluster. You can configure the Migration Controller custom resource manifest to run the MTC web console and the Migration Controller pod on a remote cluster.

3. Install the Migration Toolkit for Containers Operator on the source cluster:
   - OpenShift Container Platform 4.6 or later: Install the Migration Toolkit for Containers Operator by using Operator Lifecycle Manager.
   - OpenShift Container Platform 4.2 to 4.5: Install the legacy Migration Toolkit for Containers Operator from the command line interface.

4. Configure object storage to use as a replication repository.

4.1. COMPATIBILITY GUIDELINES

You must install the Migration Toolkit for Containers (MTC) version that is compatible with your OpenShift Container Platform version.

You cannot install MTC 1.6.x on OpenShift Container Platform versions 3.7 to 4.5 because the custom resource definition API versions are incompatible.

You can migrate workloads from a source cluster with MTC 1.5.1 to a target cluster with MTC 1.6.x as long as the MigrationController custom resource and the MTC web console are running on the target cluster.

Table 4.1. OpenShift Container Platform and MTC compatibility

<table>
<thead>
<tr>
<th>OpenShift Container Platform version</th>
<th>MTC version</th>
<th>Migration Toolkit for Containers Operator</th>
</tr>
</thead>
</table>
| 3.7                                 | 1.5.1       | Legacy Migration Toolkit for Containers Operator.  
                                    |             | Installed manually with the operator-3.7.yml file. |
| 3.9 to 4.5                          | 1.5.1       | Legacy Migration Toolkit for Containers Operator.  
                                    |             | Installed manually with the operator.yml file. |
4.6 and later 1.6.x\(^1\) Migration Toolkit for Containers Operator.

1 Latest z-stream release.

### 4.2. INSTALLING THE MIGRATION TOOLKIT FOR CONTAINERS OPERATOR ON OPENSHIFT CONTAINER PLATFORM 4.9

You install the Migration Toolkit for Containers Operator on OpenShift Container Platform 4.9 by using the Operator Lifecycle Manager.

**Prerequisites**

- You must be logged in as a user with `cluster-admin` privileges on all clusters.
- You must create an Operator catalog from a mirror image in a local registry.

**Procedure**

1. In the OpenShift Container Platform web console, click **Operators \rightarrow OperatorHub**.
2. Use the **Filter by keyword** field to find the **Migration Toolkit for Containers Operator**.
3. Select the **Migration Toolkit for Containers Operator** and click **Install**.
4. Click **Install**.
   - On the **Installed Operators** page, the **Migration Toolkit for Containers Operator** appears in the **openshift-migration** project with the status **Succeeded**.
5. Click **Migration Toolkit for Containers Operator**.
6. Under **Provided APIs**, locate the **Migration Controller** tile, and click **Create Instance**.
7. Click **Create**.
8. Click **Workloads \rightarrow Pods** to verify that the MTC pods are running.

### 4.3. INSTALLING THE LEGACY MIGRATION TOOLKIT FOR CONTAINERS OPERATOR ON OPENSHIFT CONTAINER PLATFORM 4.2 TO 4.5

You can install the legacy Migration Toolkit for Containers Operator manually on OpenShift Container Platform versions 4.2 to 4.5.

**Prerequisites**

- You must be logged in as a user with `cluster-admin` privileges on all clusters.
You must have access to registry.redhat.io.

You must have podman installed.

You must have a Linux workstation with network access in order to download files from registry.redhat.io.

You must create a mirror image of the Operator catalog.

You must install the Migration Toolkit for Containers Operator from the mirrored Operatorcatalog on OpenShift Container Platform 4.9.

Procedure

1. Log in to registry.redhat.io with your Red Hat Customer Portal credentials:
   $ sudo podman login registry.redhat.io

2. Download the operator.yml file:
   $ sudo podman cp $(sudo podman create \registry.redhat.io/rhmtc/openshift-migration-legacy-rhel8-operator:v1.5.1):/operator.yml ./

3. Download the controller.yml file:
   $ sudo podman cp $(sudo podman create \registry.redhat.io/rhmtc/openshift-migration-legacy-rhel8-operator:v1.5.1):/controller.yml ./

4. Obtain the Operator image mapping by running the following command:
   $ grep openshift-migration-legacy-rhel8-operator ./mapping.txt | grep rhmtc

   The mapping.txt file was created when you mirrored the Operator catalog. The output shows the mapping between the registry.redhat.io image and your mirror registry image.

Example output

registry.redhat.io/rhmtc/openshift-migration-legacy-rhel8-operator@sha256:468a6126f73b1ee12085ca53a312d1f96ef5a2ca03442bcb63724af5e2614e8a=<registry.apps.example.com>/rhmtc/openshift-migration-legacy-rhel8-operator

5. Update the image values for the ansible and operator containers and the REGISTRY value in the operator.yml file:

   containers:
   - name: ansible
     image: <registry.apps.example.com>/rhmtc/openshift-migration-legacy-rhel8-operator@sha256:<468a6126f73b1ee12085ca53a312d1f96ef5a2ca03442bcb63724af5e2614e8a>
     ...
   - name: operator
     image: <registry.apps.example.com>/rhmtc/openshift-migration-legacy-rhel8-operator@sha256:<468a6126f73b1ee12085ca53a312d1f96ef5a2ca03442bcb63724af5e2614e8a>
Specify your mirror registry and the sha256 value of the Operator image.

Specify your mirror registry.


7. Create the Migration Toolkit for Containers Operator object:

   $ oc create -f operator.yml

   **Example output**

   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
   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 Migration Toolkit for Containers Operator creating resources for earlier versions of OpenShift Container Platform 3 that are provided in later releases.

8. Create the **MigrationController** object:

   $ oc create -f controller.yml

9. Verify that the MTC pods are running:

   $ oc get pods -n openshift-migration

### 4.4. CONFIGURING PROXIES

For OpenShift Container Platform 4.1 and earlier versions, you must configure proxies in the **MigrationController** custom resource (CR) manifest after you install the Migration Toolkit for Containers Operator because these versions do not support a cluster-wide **proxy** object.

For OpenShift Container Platform 4.2 to 4.9, the Migration Toolkit for Containers (MTC) inherits the cluster-wide proxy settings. You can change the proxy parameters if you want to override the cluster-wide proxy settings.
You must configure the proxies to allow the SPDY protocol and to forward the Upgrade HTTP header to the API server. Otherwise, an Upgrade request required error is displayed. The MigrationController CR uses SPDY to run commands within remote pods. The Upgrade HTTP header is required in order to open a websocket connection with the API server.

Direct volume migration

If you are performing a direct volume migration (DVM) from a source cluster behind a proxy, you must configure an Stunnel proxy. Stunnel creates a transparent tunnel between the source and target clusters for the TCP connection without changing the certificates.

DVM supports only one proxy. The source cluster cannot access the route of the target cluster if the target cluster is also behind a proxy.

**Prerequisites**

- You must be logged in as a user with cluster-admin privileges on all clusters.

**Procedure**

1. Get the MigrationController CR manifest:

   ```bash
   $ oc get migrationcontroller <migration_controller> -n openshift-migration
   ```

2. Update the proxy parameters:

   ```yaml
   apiVersion: migration.openshift.io/v1alpha1
   kind: MigrationController
   metadata:
     name: <migration_controller>
     namespace: openshift-migration
   ...
   spec:
     stunnel_tcp_proxy: http://<username>:<password>@<ip>:<port> 1
     httpProxy: http://<username>:<password>@<ip>:<port> 2
     httpsProxy: http://<username>:<password>@<ip>:<port> 3
     noProxy: example.com 4
   ```

   1. Stunnel proxy URL for direct volume migration.
   2. Proxy URL for creating HTTP connections outside the cluster. The URL scheme must be http.
   3. Proxy URL for creating HTTPS connections outside the cluster. If this is not specified, then httpProxy is used for both HTTP and HTTPS connections.
   4. Comma-separated list of destination domain names, domains, IP addresses, or other network CIDRs to exclude proxying.

Preface a domain with . to match subdomains only. For example, .y.com matches x.y.com, but not y.com. Use * to bypass proxy for all destinations. If you scale up workers that are not included in the network defined by the networking.machineNetwork[].cidr field from the installation configuration, you must add them to this list to prevent connection issues.
This field is ignored if neither the httpProxy nor the httpsProxy field is set.

3. Save the manifest as migration-controller.yaml.

4. Apply the updated manifest:

```bash
$ oc replace -f migration-controller.yaml -n openshift-migration
```

For more information, see Configuring the cluster-wide proxy.

### 4.5. CONFIGURING A REPLICATION REPOSITORY

The Multicloud Object Gateway is the only supported option for a restricted network environment.

MTC 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.

#### 4.5.1. Prerequisites

- All clusters must have uninterrupted network access to the replication repository.
- If you use a proxy server with an internally hosted replication repository, you must ensure that the proxy allows access to the replication repository.

#### 4.5.2. Configuring the Multicloud Object Gateway

You can configure the Multicloud Object Gateway (MCG) as a replication repository for the Migration Toolkit for Containers (MTC). MCG is a component of OpenShift Container Storage.

**Procedure**

1. Deploy OpenShift Container Storage by using the appropriate OpenShift Container Storage deployment guide.

2. Obtain the S3 endpoint, AWS_ACCESS_KEY_ID, and AWS_SECRET_ACCESS_KEY by running the describe command on the NooBaa custom resource. These values are required in order to add MCG as a replication repository to the MTC web console.

#### 4.5.3. Additional resources for configuring a replication repository

- Disconnected environment in the Red Hat OpenShift Container Storage documentation.
- MTC workflow
- About data copy methods
- Adding a replication repository to the MTC web console:installing-mtc-restricted!
CHAPTER 5. UPGRADING THE MIGRATION TOOLKIT FOR CONTAINERS

You can upgrade the Migration Toolkit for Containers (MTC) on OpenShift Container Platform 4.9 by using the Operator Lifecycle Manager.

You can upgrade MTC on OpenShift Container Platform versions 4.2 to 4.5 by installing the legacy Migration Toolkit for Containers Operator.

IMPORTANT

If you are upgrading from MTC version 1.3 to 1.6, you must perform an additional procedure to update the MigPlan custom resource (CR).

5.1. UPGRADING THE MIGRATION TOOLKIT FOR CONTAINERS ON OPENSHIFT CONTAINER PLATFORM 4.9

You can upgrade the Migration Toolkit for Containers (MTC) on OpenShift Container Platform 4.9 by using the Operator Lifecycle Manager.

Prerequisites

- You must be logged in as a user with cluster-admin privileges.

Procedure

1. In the OpenShift Container Platform console, navigate to Operators → Installed Operators. Operators that have a pending upgrade display an Upgrade available status.

2. Click Migration Toolkit for Containers Operator.

3. Click the Subscription tab. Any upgrades requiring approval are displayed next to Upgrade Status. For example, it might display 1 requires approval.

4. Click 1 requires approval, then click Preview Install Plan.

5. Review the resources that are listed as available for upgrade and click Approve.

6. Navigate back to the Operators → Installed Operators page to monitor the progress of the upgrade. When complete, the status changes to Succeeded and Up to date.

7. Click Migration Toolkit for Containers Operator.

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

9. Click Workloads → Pods to verify that the MTC pods are running.

5.2. UPGRADING THE MIGRATION TOOLKIT FOR CONTAINERS ON OPENSHIFT CONTAINER PLATFORM VERSIONS 4.2 TO 4.5

You can upgrade Migration Toolkit for Containers (MTC) on OpenShift Container Platform versions 4.2 to 4.5 by manually installing the legacy Migration Toolkit for Containers Operator.
Prerequisites

- You must be logged in as a user with **cluster-admin** privileges.
- You must have access to **registry.redhat.io**.
- You must have podman installed.

Procedure

1. Log in to **registry.redhat.io** with your Red Hat Customer Portal credentials:
   ```bash
   $ sudo podman login registry.redhat.io
   ```

2. Download the **operator.yml** file:
   ```bash
   $ sudo podman cp $(sudo podman create \registry.redhat.io/rhmtc/openshift-migration-legacy-rhel8-operator:v1.5.1)/operator.yml ./
   ```

3. Replace the Migration Toolkit for Containers Operator:
   ```bash
   $ oc replace --force -f operator.yml
   ```

4. Scale the **migration-operator** deployment to **0** to stop the deployment:
   ```bash
   $ oc scale -n openshift-migration --replicas=0 deployment/migration-operator
   ```

5. Scale the **migration-operator** deployment to **1** to start the deployment and apply the changes:
   ```bash
   $ oc scale -n openshift-migration --replicas=1 deployment/migration-operator
   ```

6. Verify that the **migration-operator** was upgraded:
   ```bash
   $ oc -o yaml -n openshift-migration get deployment/migration-operator | grep image: | awk -F"":" '{ print $NF }'
   ```

7. Download the **controller.yml** file:
   ```bash
   $ sudo podman cp $(sudo podman create \registry.redhat.io/rhmtc/openshift-migration-legacy-rhel8-operator:v1.5.1)/controller.yml ./
   ```

8. Create the **migration-controller** object:
   ```bash
   $ oc create -f controller.yml
   ```

9. Verify that the MTC pods are running:
   ```bash
   $ oc get pods -n openshift-migration
   ```

### 5.3. UPGRADING MTC 1.3 TO 1.6

- If you are upgrading Migration Toolkit for Containers (MTC) version 1.3.x to 1.6, you must update the:
  ```bash
  $ sudo podman login registry.redhat.io
  $ sudo podman cp $(sudo podman create \registry.redhat.io/rhmtc/openshift-migration-legacy-rhel8-operator:v1.5.1)/operator.yml ./
  $ oc replace --force -f operator.yml
  $ oc scale -n openshift-migration --replicas=0 deployment/migration-operator
  $ oc scale -n openshift-migration --replicas=1 deployment/migration-operator
  $ oc -o yaml -n openshift-migration get deployment/migration-operator | grep image: | awk -F"":" '{ print $NF }'
  $ sudo podman cp $(sudo podman create \registry.redhat.io/rhmtc/openshift-migration-legacy-rhel8-operator:v1.5.1)/controller.yml ./
  $ oc create -f controller.yml
  $ oc get pods -n openshift-migration
  ```
If you are upgrading Migration Toolkit for Containers (MTC) version 1.3.x to 1.6, you must update the MigPlan custom resource (CR) manifest on the cluster on which the MigrationController pod is running.

Because the indirectImageMigration and indirectVolumeMigration parameters do not exist in MTC 1.3, their default value in version 1.4 is false, which means that direct image migration and direct volume migration are enabled. Because the direct migration requirements are not fulfilled, the migration plan cannot reach a Ready state unless these parameter values are changed to true.

Prerequisites

- You must be logged in as a user with cluster-admin privileges.

Procedure

1. Log in to the cluster on which the MigrationController pod is running.

2. Get the MigPlan CR manifest:

   ```bash
   $ oc get migplan <migplan> -o yaml -n openshift-migration
   ...
   spec:
   indirectImageMigration: true
   indirectVolumeMigration: true
   ```

3. Update the following parameter values and save the file as migplan.yaml:

4. Replace the MigPlan CR manifest to apply the changes:

   ```bash
   $ oc replace -f migplan.yaml -n openshift-migration
   ```

5. Get the updated MigPlan CR manifest to verify the changes:

   ```bash
   $ oc get migplan <migplan> -o yaml -n openshift-migration
   ```
CHAPTER 6. PREMIGRATION CHECKLISTS

Before you migrate your application workloads with the Migration Toolkit for Containers (MTC), review the following checklists.

6.1. CLUSTER HEALTH CHECKLIST

☐ The clusters meet the minimum hardware requirements for the specific platform and installation method, for example, on bare metal.

☐ The MTC version is the same on all clusters.

☐ All MTC prerequisites are met.

☐ All nodes have an active OpenShift Container Platform subscription.

☐ You have verified node health.

☐ The identity provider is working.

☐ The migration network has a minimum throughput of 10 Gbps.

☐ The clusters have sufficient resources for migration.

**NOTE**

Clusters require additional memory, CPUs, and storage in order to run a migration on top of normal workloads. Actual resource requirements depend on the number of Kubernetes resources being migrated in a single migration plan. You must test migrations in a non-production environment in order to estimate the resource requirements.

☐ The etcd disk performance of the clusters has been checked with fio.

6.2. SOURCE CLUSTER CHECKLIST

☐ You have checked for persistent volumes (PVs) with abnormal configurations stuck in a Terminating state by running the following command:

```
$ oc get pv
```

☐ You have checked for pods whose status is other than Running or Completed by running the following command:

```
$ oc get pods --all-namespaces | grep -v 'Running | Completed'
```

☐ You have checked for pods with a high restart count by running the following command:

```
$ oc get pods --all-namespaces --field-selector=status.phase=Running
-o json | jq '.items[]|select(any(.status.containerStatuses[]; .restartCount > 3))|.metadata.name'
```

Even if the pods are in a Running state, a high restart count might indicate underlying problems.
The cluster certificates are valid for the duration of the migration process.

You have checked for pending certificate-signing requests by running the following command:

```
$ oc get csr -A | grep pending -i
```

The registry uses a recommended storage type.

You can read and write images to the registry.

The etcd cluster is healthy.

The average API server response time on the source cluster is less than 50 ms.

6.3. TARGET CLUSTER CHECKLIST

The cluster has the correct network configuration and permissions to access external services, for example, databases, source code repositories, container image registries, and CI/CD tools.

External applications and services that use services provided by the cluster have the correct network configuration and permissions to access the cluster.

Internal container image dependencies are met.

The target cluster and the replication repository have sufficient storage space.
CHAPTER 7. MIGRATING YOUR APPLICATIONS

You can migrate your applications by using the Migration Toolkit for Containers (MTC) web console or the command line.

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

You can use stage migration and cutover migration to migrate an application between clusters:

- Stage migration copies data from the source cluster to the target cluster without stopping the application. You can run a stage migration multiple times to reduce the duration of the cutover migration.
- Cutover migration stops the transactions on the source cluster and moves the resources to the target cluster.

You can use state migration to migrate an application’s state:

- State migration copies selected persistent volume claims (PVCs) and Kubernetes resources.
- You can use state migration to migrate a namespace within the same cluster.

During migration, the Migration Toolkit for Containers (MTC) 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.

7.1. MIGRATION PREREQUISITES

- You must be logged in as a user with `cluster-admin` privileges on all clusters.

Direct image migration

- You must ensure that the secure internal registry of the source cluster is exposed.
- You must create a route to the exposed registry.

Direct volume migration

- If your clusters use proxies, you must configure an Stunnel TCP proxy.

Clusters

- The source cluster must be upgraded to the latest MTC z-stream release.
- The MTC version must be the same on all clusters.
The clusters have unrestricted network access to each other and to the replication repository.

If you copy the persistent volumes with move, the clusters must have unrestricted network access to the remote volumes.

You must enable the following ports on an OpenShift Container Platform 4 cluster:

- **6443** (API server)
- **443** (routes)
- **53** (DNS)

You must enable port 443 on the replication repository if you are using TLS.

**Persistent volumes (PVs)**

- The PVs must be valid.
- The PVs must be bound to persistent volume claims.
- If you use snapshots to copy the PVs, the following additional prerequisites apply:
  - The cloud provider must support snapshots.
  - The PVs must have the same cloud provider.
  - The PVs must be located in the same geographic region.
  - The PVs must have the same storage class.

### 7.2. MIGRATING YOUR APPLICATIONS BY USING THE MTC WEB CONSOLE

You can configure clusters and a replication repository by using the MTC web console. Then, you can create and run a migration plan.

#### 7.2.1. Launching the MTC web console

You can launch the Migration Toolkit for Containers (MTC) web console in a browser.

**Prerequisites**

- The MTC web console must have network access to the OpenShift Container Platform web console.
- The MTC web console must have network access to the OAuth authorization server.

**Procedure**

1. Log in to the OpenShift Container Platform cluster on which you have installed MTC.
2. Obtain the MTC web console URL by entering the following command:
3. Launch a browser and navigate to the MTC web console.

NOTE

If you try to access the MTC web console immediately after installing the Migration Toolkit for Containers Operator, the console might 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 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.

7.2.2. Adding a cluster to the MTC web console

You can add a cluster to the Migration Toolkit for Containers (MTC) web console.

Prerequisites

- If you are using Azure snapshots to copy data:
  - You must specify the Azure resource group name for the cluster.
  - The clusters must be in the same Azure resource group.
  - The clusters must be in the same geographic location.
- If you are using direct image migration, you must expose a route to

Procedure

1. Log in to the cluster.

2. Obtain the migration-controller service account token:

   $ oc sa get-token migration-controller -n openshift-migration

Example output

eyJhbGciOiJSUzI1NiIsIlJlZmVyY29hZCI6IiwiaWlkIjoiaWdpdG11bWVkaW5nIiwib3V0IjoiY2FsaXR5IiwicG9wdWlintcmlnaHQiOiJiZXRc5bpyZ29vZ2xlIiwiYXNzd29yZCI6IiIsInRvbWFpbiI6IiIsImV4cCI6MTg1MDI5MzIyNzUwMCwiZ2VuZXJvZyI6eyJ0eXBlIjoiMjBOb3JlIiwiYXV0aF90ZXN0cyI6W10sImNvbnRlbnRfZG9jdW1lbnQiOiJub29sZCJ9fX0.eyJpc3MiOiJlbWFpbGluZ3MiLCJwYXl0aW9ucyI6IjQiLCJyYXlsb2FkIjoiMjBOb3JlIiwiY2FsaXR5IjoiY2FsaXR5IiwiZGlzaXRzIjpbXQ.sBb2QREpRZoJmiuMk85ROJBrxQcI8Fv3y73bW0oqFmKZ9y40Wv1Jv9uk8jy18 scholarship

OpenShift Container Platform 4.9 Migration Toolkit for Containers
3. In the MTC web console, click Clusters.

4. Click Add cluster.

5. Fill in the following fields:

   - **Cluster name**: The cluster name can contain lower-case letters (a-z) and numbers (0-9). It must not contain spaces or international characters.
   - **URL**: Specify the API server URL, for example, https://<www.example.com>:8443.
   - **Service account token**: Paste the migration-controller service account token.
   - **Exposed route host to image registry**: If you are using direct image migration, specify the exposed route to the image registry of the source cluster. To create the route, run the following command:
     - For OpenShift Container Platform 3:
       ```
       $ oc create route passthrough --service=docker-registry --port=5000 -n default
       ```
     - For OpenShift Container Platform 4:
       ```
       $ oc create route passthrough --service=image-registry --port=5000 -n openshift-image-registry
       ```
   - **Azure cluster**: You must select this option if you use Azure snapshots to copy your data.
   - **Azure resource group**: This field is displayed if Azure cluster is selected. Specify the Azure resource group.
   - **Require SSL verification**: Optional: Select this option to verify SSL connections to the cluster.
   - **CA bundle file**: This field is displayed if Require SSL verification is selected. If you created a custom CA certificate bundle file for self-signed certificates, click Browse, select the CA bundle file, and upload it.

6. Click Add cluster.
   The cluster appears in the Clusters list.

### 7.2.3. Adding a replication repository to the MTC web console

You can add an object storage as a replication repository to the Migration Toolkit for Containers (MTC) web console.

MTC supports the following storage providers:

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

Prerequisites

- You must configure the object storage as a replication repository.

Procedure

1. In the MTC web console, click **Replication repositories**.
2. Click **Add repository**.
3. Select a **Storage provider type** and fill in the following fields:
   - **AWS** for S3 providers, including AWS and MCG:
     - **Replication repository name**: Specify the replication repository name in the MTC web console.
     - **S3 bucket name**: Specify the name of the S3 bucket.
     - **S3 bucket region**: Specify the S3 bucket region. **Required** for AWS S3. **Optional** for some S3 providers. Check the product documentation of your S3 provider for expected values.
     - **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 and other S3 providers.
     - **S3 provider secret access key**: Specify the `<AWS_ACCESS_KEY_ID>` for AWS or the S3 provider secret access key for MCG and other S3 providers.
     - **Require SSL verification**: Clear this checkbox if you are using a generic S3 provider.
     - If you created a custom CA certificate bundle for self-signed certificates, click **Browse** and browse to the Base64-encoded file.
   - **GCP**:
     - **Replication repository name**: Specify the replication repository name in the MTC 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 MTC 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** list.

### 7.2.4. Creating a migration plan in the MTC web console

You can create a migration plan in the Migration Toolkit for Containers (MTC) web console.

**Prerequisites**

- You must be logged in as a user with **cluster-admin** privileges on all clusters.
- You must ensure that the same MTC version is installed on all clusters.
- You must add the clusters and the replication repository to the MTC web console.
- If you want to use the **move** data copy method to migrate a persistent volume (PV), the source and target clusters must have uninterrupted network access to the remote volume.
- If you want to use direct image migration, you must specify the exposed route to the image registry of the source cluster. This can be done by using the MTC web console or by updating the **MigCluster** custom resource manifest.

**Procedure**

1. In the MTC web console, click **Migration plans**.

2. Click **Add migration plan**.

3. Enter the **Plan name**.
   
   The migration plan name must not exceed 253 lower-case alphanumeric characters (a-z, 0-9) and must not contain spaces or underscores (_).

4. Select a **Source cluster**, a **Target cluster**, and a **Repository**.

5. Click **Next**.

6. Select the projects for migration.

7. Optional: Click the edit icon beside a project to change the target namespace.

8. Click **Next**.

9. Select a **Migration type** for each PV:
   
   - The **Copy** option copies the data from the PV of a source cluster to the replication repository and then restores the data on a newly created PV, with similar characteristics, in the target cluster.
   
   - The **Move** option 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.

10. Click **Next**.

11. Select a **Copy method** for each PV:

   - **Snapshot copy** backs up and restores data using the cloud provider’s snapshot functionality. It is significantly faster than **Filesystem copy**.

   - **Filesystem copy** backs up the files on the source cluster and restores them on the target cluster.

     The file system copy method is required for direct volume migration.

12. You can select **Verify copy** to verify data migrated with **Filesystem copy**. Data is verified by generating a checksum for each source file and checking the checksum after restoration. Data verification significantly reduces performance.

13. Select a **Target storage class**.

    If you selected **Filesystem copy**, you can change the target storage class.

14. Click **Next**.

15. On the **Migration options** page, the **Direct image migration** option is selected if you specified an exposed image registry route for the source cluster. The **Direct PV migration** option is selected if you are migrating data with **Filesystem copy**.

    The direct migration options copy images and files directly from the source cluster to the target cluster. This option is much faster than copying images and files from the source cluster to the replication repository and then from the replication repository to the target cluster.

16. Click **Next**.

17. Optional: Click **Add Hook** to add a hook to the migration plan.

    A hook runs custom code. You can add up to four hooks to a single migration plan. Each hook runs during a different migration step.

    a. Enter the name of the hook to display in the web console.

    b. If the hook is an Ansible playbook, select **Ansible playbook** and click **Browse** to upload the playbook or paste the contents of the playbook in the field.

    c. Optional: Specify an Ansible runtime image if you are not using the default hook image.

    d. If the hook is not an Ansible playbook, select **Custom container image** and specify the image name and path.

       A custom container image can include Ansible playbooks.

    e. Select **Source cluster** or **Target cluster**.

    f. Enter the **Service account name** and the **Service account namespace**

    g. Select the migration step for the hook:

       - **preBackup**: Before the application workload is backed up on the source cluster

       - **postBackup**: After the application workload is backed up on the source cluster
• **preRestore**: Before the application workload is restored on the target cluster

• **postRestore**: After the application workload is restored on the target cluster

h. Click Add.

18. Click **Finish**.  
The migration plan is displayed in the **Migration plans** list.

### Additional resources for persistent volume copy methods

- MTC file system copy method
- MTC snapshot copy method

### 7.2.5. Running a migration plan in the MTC web console

You can migrate applications and data with the migration plan you created in the Migration Toolkit for Containers (MTC) web console.

#### Prerequisites

The MTC web console must contain the following:

- Source cluster in a **Ready** state
- Target cluster in a **Ready** state
- Replication repository
- Valid migration plan

#### Procedure

1. Log in to the MTC web console and click **Migration plans**.

2. Click the Options menu next to a migration plan and select one of the following options under **Migration**:

   - **Stage** copies data from the source cluster to the target cluster without stopping the application.
   - **Cutover** stops the transactions on the source cluster and moves the resources to the target cluster.

#### NOTE

During migration, MTC sets the reclaim policy of migrated persistent volumes (PVs) to **Retain** on the target cluster.

The **Backup** custom resource contains a **PVOriginalReclaimPolicy** annotation that indicates the original reclaim policy. You can manually restore the reclaim policy of the migrated PVs.
Optional: In the **Cutover migration** dialog, you can clear the **Halt transactions on the source cluster during migration** checkbox.

- **State** copies selected persistent volume claims (PVCs) and Kubernetes resources that constitute an application’s state. You can use state migration to migrate a namespace within the same cluster.

**IMPORTANT**

Do not use state migration to migrate a namespace between clusters. Use stage or cutover migration instead.

- Select one or more PVCs in the **State migration** dialog and click **Migrate**.

3. 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 volumes are correctly provisioned.
CHAPTER 8. ADVANCED MIGRATION OPTIONS

You can automate your migrations and modify the MigPlan and MigrationController custom resources in order to perform large-scale migrations and to improve performance.

8.1. TERMINOLOGY

Table 8.1. MTC terminology

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Source cluster</td>
<td>Cluster from which the applications are migrated.</td>
</tr>
<tr>
<td>Destination cluster[1]</td>
<td>Cluster to which the applications are migrated.</td>
</tr>
</tbody>
</table>
| Replication repository| Object storage used for copying images, volumes, and Kubernetes objects during indirect migration or for Kubernetes objects during direct volume migration or direct image migration.  
The replication repository must be accessible to all clusters. |
| Host cluster          | Cluster on which the migration-controller pod and the web console are running. The host cluster is usually the destination cluster but this is not required.  
The host cluster does not require an exposed registry route for direct image migration. |
| Remote cluster        | A remote cluster is usually the source cluster but this is not required.     
A remote cluster requires a Secret custom resource that contains the migration-controller service account token.  
A remote cluster requires an exposed secure registry route for direct image migration. |
| Indirect migration    | Images, volumes, and Kubernetes objects are copied from the source cluster to the replication repository and then from the replication repository to the destination cluster. |
| Direct volume migration| Persistent volumes are copied directly from the source cluster to the destination cluster. |
| Direct image migration| Images are copied directly from the source cluster to the destination cluster. |
| Stage migration       | Data is copied to the destination cluster without stopping the application.  
Running a stage migration multiple times reduces the duration of the cutover migration. |
| Cutover migration     | The application is stopped on the source cluster and its resources are migrated to the destination cluster. |
State migration
Application state is migrated by copying specific persistent volume claims and Kubernetes objects to the destination cluster.

Rollback migration
Rollback migration rolls back a completed migration.

<table>
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<tr>
<td>State migration</td>
<td>Application state is migrated by copying specific persistent volume claims and Kubernetes objects to the destination cluster.</td>
</tr>
<tr>
<td>Rollback migration</td>
<td>Rollback migration rolls back a completed migration.</td>
</tr>
</tbody>
</table>

1 Called the target cluster in the MTC web console.

8.2. MIGRATING APPLICATIONS BY USING THE COMMAND LINE

You can migrate applications with the MTC API by using the command line interface (CLI) in order to automate the migration.

8.2.1. Migration prerequisites

- You must be logged in as a user with cluster-admin privileges on all clusters.

Direct image migration

- You must ensure that the secure internal registry of the source cluster is exposed.
- You must create a route to the exposed registry.

Direct volume migration

- If your clusters use proxies, you must configure an Stunnel TCP proxy.

Clusters

- The source cluster must be upgraded to the latest MTC z-stream release.
- The MTC version must be the same on all clusters.

Network

- The clusters have unrestricted network access to each other and to the replication repository.
- If you copy the persistent volumes with move, the clusters must have unrestricted network access to the remote volumes.
- You must enable the following ports on an OpenShift Container Platform 4 cluster:
  - **6443** (API server)
  - **443** (routes)
  - **53** (DNS)
- You must enable port 443 on the replication repository if you are using TLS.

Persistent volumes (PVs)
The PVs must be valid.

The PVs must be bound to persistent volume claims.

If you use snapshots to copy the PVs, the following additional prerequisites apply:

- The cloud provider must support snapshots.
- The PVs must have the same cloud provider.
- The PVs must be located in the same geographic region.
- The PVs must have the same storage class.

### 8.2.2. Creating a registry route for direct image migration

For direct image migration, you must create a route to the exposed internal registry on all remote clusters.

**Prerequisites**

- The internal registry must be exposed to external traffic on all remote clusters. The OpenShift Container Platform 4 registry is exposed by default.

**Procedure**

- To create a route to an OpenShift Container Platform 4 registry, run the following command:

  ```bash
  $ oc create route passthrough --service=image-registry -n openshift-image-registry
  ```

### 8.2.3. Configuring proxies

For OpenShift Container Platform 4.1 and earlier versions, you must configure proxies in the MigrationController custom resource (CR) manifest after you install the Migration Toolkit for Containers Operator because these versions do not support a cluster-wide proxy object.

For OpenShift Container Platform 4.2 to 4.9, the Migration Toolkit for Containers (MTC) inherits the cluster-wide proxy settings. You can change the proxy parameters if you want to override the cluster-wide proxy settings.

You must configure the proxies to allow the SPDY protocol and to forward the Upgrade HTTP header to the API server. Otherwise, an Upgrade request required error is displayed. The MigrationController CR uses SPDY to run commands within remote pods. The Upgrade HTTP header is required in order to open a websocket connection with the API server.

**Direct volume migration**

If you are performing a direct volume migration (DVM) from a source cluster behind a proxy, you must configure an Stunnel proxy. Stunnel creates a transparent tunnel between the source and target clusters for the TCP connection without changing the certificates.

DVM supports only one proxy. The source cluster cannot access the route of the target cluster if the target cluster is also behind a proxy.

**Prerequisites**
- You must be logged in as a user with `cluster-admin` privileges on all clusters.

**Procedure**

1. Get the MigrationController CR manifest:

   ```bash
   $ oc get migrationcontroller <migration_controller> -n openshift-migration
   ```

2. Update the proxy parameters:

   ```yaml
   apiVersion: migration.openshift.io/v1alpha1
   kind: MigrationController
   metadata:
     name: <migration_controller>
     namespace: openshift-migration
   ...
   spec:
     stunnel_tcp_proxy: http://<username>:<password>@<ip>:<port> 1
     httpProxy: http://<username>:<password>@<ip>:<port> 2
     httpsProxy: http://<username>:<password>@<ip>:<port> 3
     noProxy: example.com 4
   ```

   1. Stunnel proxy URL for direct volume migration.
   2. Proxy URL for creating HTTP connections outside the cluster. The URL scheme must be `http`.
   3. Proxy URL for creating HTTPS connections outside the cluster. If this is not specified, then `httpProxy` is used for both HTTP and HTTPS connections.
   4. Comma-separated list of destination domain names, domains, IP addresses, or other network CIDRs to exclude proxying.

   Preface a domain with `. ` to match subdomains only. For example, `y.com` matches `x.y.com`, but not `y.com`. Use `*` to bypass proxy for all destinations. If you scale up workers that are not included in the network defined by the `networking.machineNetwork[].cidr` field from the installation configuration, you must add them to this list to prevent connection issues.

   This field is ignored if neither the `httpProxy` nor the `httpsProxy` field is set.

3. Save the manifest as `migration-controller.yaml`.

4. Apply the updated manifest:

   ```bash
   $ oc replace -f migration-controller.yaml -n openshift-migration
   ```

**8.2.4. Migrating an application by using the MTC API**

You can migrate an application from the command line by using the Migration Toolkit for Containers (MTC) API.

**Procedure**
1. Create a `MigCluster` CR manifest for the host cluster:

```yaml
$ cat << EOF | oc apply -f -
apiVersion: migration.openshift.io/v1alpha1
kind: MigCluster
metadata:
  name: <host_cluster>
namespace: openshift-migration
spec:
  isHostCluster: true
EOF
```

2. Create a `Secret` CR manifest for each remote cluster:

```yaml
$ cat << EOF | oc apply -f -
apiVersion: v1
kind: Secret
metadata:
  name: <cluster_secret>
namespace: openshift-config
type: Opaque
data:
  saToken: <sa_token> 1
EOF
```

Specify the base64-encoded migration-controller service account (SA) token of the remote cluster. You can obtain the token by running the following command:

```bash
$ oc sa get-token migration-controller -n openshift-migration | base64 -w 0
```

3. Create a `MigCluster` CR manifest for each remote cluster:

```yaml
$ cat << EOF | oc apply -f -
apiVersion: migration.openshift.io/v1alpha1
kind: MigCluster
metadata:
  name: <remote_cluster> <.>
namespace: openshift-migration
spec:
  exposedRegistryPath: <exposed_registry_route> <.>
insecure: false <.>
isHostCluster: false
serviceAccountSecretRef:
  name: <remote_cluster_secret> <.>
  namespace: openshift-config
url: <remote_cluster_url> <.>
EOF
```

<> Specify the `Cluster` CR of the remote cluster. <> Optional: For direct image migration, specify the exposed registry route. <> SSL verification is enabled if `false`. CA certificates are not required or checked if `true`. <> Specify the `Secret` CR of the remote cluster. <> Specify the URL of the remote cluster.

4. Verify that all clusters are in a Ready state:

```bash
$ cat << EOF | oc apply -f -
apiVersion: migration.openshift.io/v1alpha1
kind: MigCluster
metadata:
  name: <host_cluster>
namespace: openshift-migration
spec:
  isHostCluster: true
EOF
```

$ cat << EOF | oc apply -f -
apiVersion: v1
kind: Secret
metadata:
  name: <cluster_secret>
namespace: openshift-config
type: Opaque
data:
  saToken: <sa_token> 1
EOF
```

Specify the base64-encoded migration-controller service account (SA) token of the remote cluster. You can obtain the token by running the following command:

```bash
$ oc sa get-token migration-controller -n openshift-migration | base64 -w 0
```

$ cat << EOF | oc apply -f -
apiVersion: migration.openshift.io/v1alpha1
kind: MigCluster
metadata:
  name: <remote_cluster> <.>
namespace: openshift-migration
spec:
  exposedRegistryPath: <exposed_registry_route> <.>
insecure: false <.>
isHostCluster: false
serviceAccountSecretRef:
  name: <remote_cluster_secret> <.>
  namespace: openshift-config
url: <remote_cluster_url> <.>
EOF
```

<> Specify the `Cluster` CR of the remote cluster. <> Optional: For direct image migration, specify the exposed registry route. <> SSL verification is enabled if `false`. CA certificates are not required or checked if `true`. <> Specify the `Secret` CR of the remote cluster. <> Specify the URL of the remote cluster.

4. Verify that all clusters are in a Ready state:
5. Create a **Secret** CR manifest for the replication repository:

```
$ cat << EOF | oc apply -f -
apiVersion: v1
kind: Secret
metadata:
  namespace: openshift-config
  name: <migstorage_creds>
  type: Opaque
data:
  aws-access-key-id: <key_id_base64> 1
  aws-secret-access-key: <secret_key_base64> 2
EOF
```

1. Specify the key ID in base64 format.
2. Specify the secret key in base64 format.

AWS credentials are base64-encoded by default. For other storage providers, you must encode your credentials by running the following command with each key:

```
$ echo -n "<key>" | base64 -w 0 1
```

1. Specify the key ID or the secret key. Both keys must be base64-encoded.

6. Create a **MigStorage** CR manifest for the replication repository:

```
$ cat << EOF | oc apply -f -
apiVersion: migration.openshift.io/v1alpha1
kind: MigStorage
metadata:
  name: <migstorage>
  namespace: openshift-migration
spec:
  backupStorageConfig:
    awsBucketName: <bucket> 1
    credsSecretRef:
      name: <storage_secret> 2
      namespace: openshift-config
  backupStorageProvider: <storage_provider> 3

  volumeSnapshotConfig:
    credsSecretRef:
      name: <storage_secret> 4
      namespace: openshift-config
    volumeSnapshotProvider: <storage_provider> 5
EOF
```

1. Specify the bucket name.
2. Specify the **Secrets** CR of the object storage. You must ensure that the credentials stored in the **Secrets** CR of the object storage are correct.
3. Specify the storage provider.

4. Optional: If you are copying data by using snapshots, specify the Secrets CR of the object storage. You must ensure that the credentials stored in the Secrets CR of the object storage are correct.

5. Optional: If you are copying data by using snapshots, specify the storage provider.

7. Verify that the MigStorage CR is in a Ready state:

   $ oc describe migstorage <migstorage>

8. Create a MigPlan CR manifest:

   ```
   $ cat << EOF | oc apply -f -
   apiVersion: migration.openshift.io/v1alpha1
   kind: MigPlan
   metadata:
     name: <migplan>
     namespace: openshift-migration
   spec:
     destMigClusterRef:
       name: <host_cluster>
       namespace: openshift-migration
     indirectImageMigration: true
     indirectVolumeMigration: true
     migStorageRef:
       name: <migstorage>
       namespace: openshift-migration
     namespaces:
     - <source_namespace_1>
     - <source_namespace_2>
     - <source_namespace_3>:<destination_namespace>
     srcMigClusterRef:
       name: <remote_cluster>
       namespace: openshift-migration
   EOF
   ```

   1. Direct image migration is enabled if false.
   2. Direct volume migration is enabled if false.
   3. Specify the name of the MigStorage CR instance.
   4. Specify one or more source namespaces. By default, the destination namespace has the same name.
   5. Specify a destination namespace if it is different from the source namespace.
   6. Specify the name of the source cluster MigCluster instance.

9. Verify that the MigPlan instance is in a Ready state:
Create a **MigMigration** CR manifest to start the migration defined in the **MigPlan** instance:

```yaml
$ cat << EOF | oc apply -f -
apiVersion: migration.openshift.io/v1alpha1
kind: MigMigration
metadata:
  name: <migmigration>
  namespace: openshift-migration
spec:
  migPlanRef:
    name: <migplan>
    namespace: openshift-migration
  quiescePods: true
  stage: false
  rollback: false
EOF
```

1. Specify the **MigPlan** CR name.
2. The pods on the source cluster are stopped before migration if **true**.
3. A stage migration, which copies most of the data without stopping the application, is performed if **true**.
4. A completed migration is rolled back if **true**.

Verify the migration by watching the **MigMigration** CR progress:

```bash
$ oc watch migmigration <migmigration> -n openshift-migration
```

The output resembles the following:

**Example output**

```
Name:         c8b034c0-6567-11eb-9a4f-0bc004db0fbc
Namespace:    openshift-migration
Labels:       migration.openshift.io/migplan-name=django
Annotations:  openshift.io/touch: e99f9083-6567-11eb-8420-0a580a81020c
API Version:  migration.openshift.io/v1alpha1
Kind:         MigMigration
...
Spec:
  Mig Plan Ref:
    Name: migplan
    Namespace: openshift-migration
  Stage: false
Status:
  Conditions:
    Category: Advisory
    Last Transition Time: 2021-02-02T15:04:09Z
    Message: Step: 19/47
```
<table>
<thead>
<tr>
<th>Type</th>
<th>Reason</th>
<th>Age</th>
<th>From</th>
<th>Message</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal</td>
<td>Running</td>
<td>57s</td>
<td>migmigration_controller</td>
<td>Step: 2/47</td>
</tr>
<tr>
<td>Normal</td>
<td>Running</td>
<td>57s</td>
<td>migmigration_controller</td>
<td>Step: 3/47</td>
</tr>
<tr>
<td>Normal</td>
<td>Running (x3 over 57s)</td>
<td>migmigration_controller</td>
<td>Step: 4/47</td>
<td></td>
</tr>
<tr>
<td>Normal</td>
<td>Running</td>
<td>54s</td>
<td>migmigration_controller</td>
<td>Step: 5/47</td>
</tr>
<tr>
<td>Normal</td>
<td>Running</td>
<td>54s</td>
<td>migmigration_controller</td>
<td>Step: 6/47</td>
</tr>
<tr>
<td>Normal</td>
<td>Running (x2 over 53s)</td>
<td>migmigration_controller</td>
<td>Step: 7/47</td>
<td></td>
</tr>
<tr>
<td>Normal</td>
<td>Running</td>
<td>51s</td>
<td>migmigration_controller</td>
<td>Step: 8/47</td>
</tr>
<tr>
<td>Normal</td>
<td>Ready</td>
<td>50s (x12 over 57s)</td>
<td>migmigration_controller</td>
<td>The migration is ready.</td>
</tr>
<tr>
<td>Normal</td>
<td>Running</td>
<td>50s</td>
<td>migmigration_controller</td>
<td>Step: 9/47</td>
</tr>
<tr>
<td>Normal</td>
<td>Running</td>
<td>50s</td>
<td>migmigration_controller</td>
<td>Step: 10/47</td>
</tr>
</tbody>
</table>
8.2.5. State migration

You can perform repeatable, state-only migrations by using Migration Toolkit for Containers (MTC) to migrate persistent volume claims (PVCs) that constitute an application’s state. You migrate specified PVCs by excluding other PVCs from the migration plan. Persistent volume (PV) data is copied to the target cluster. The PV references are not moved. The application pods continue to run on the source cluster. You can map the PVCs to ensure that the source and target PVCs are synchronized.

You can perform a one-time migration of Kubernetes objects that constitute an application’s state.

If you have a CI/CD pipeline, you can migrate stateless components by deploying them on the target cluster. Then you can migrate stateful components by using MTC.

You can perform a state migration between clusters or within the same cluster.

**IMPORTANT**

State migration migrates only the components that constitute an application’s state. If you want to migrate an entire namespace, use stage or cutover migration.

**Additional resources for state migration**

- See [Excluding PVCs from migration](#) to select PVCs for state migration.
- See [Mapping PVCs](#) to migrate source PV data to provisioned PVCs on the destination cluster.
- See [Migrating Kubernetes objects](#) to migrate the Kubernetes objects that constitute an application’s state.

8.3. MIGRATION HOOKS

You can add up to four migration hooks to a single migration plan, with each hook running at a different phase of the migration. Migration hooks perform tasks such as customizing application quiescence, manually migrating unsupported data types, and updating applications after migration.

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

- **PreBackup**: Before resources are backed up on the source cluster.
- **PostBackup**: After resources are backed up on the source cluster.
- **PreRestore**: Before resources are restored on the target cluster.
- **PostRestore**: After resources are restored on the target cluster.

You can create a hook by creating an Ansible playbook that runs with the default Ansible image or with a custom hook container.

**Ansible playbook**

The Ansible playbook is mounted on a hook container as a config map. The hook container runs as a job, using the cluster, service account, and namespace specified in the `MigPlan` custom resource. The job continues to run until it reaches the default limit of 6 retries or a successful completion. This continues even if the initial pod is evicted or killed.
The default Ansible runtime image is `registry.redhat.io/rhmtc/openshift-migration-hook-runner-rhel7:1.6`. This image is based on the Ansible Runner image and includes `python-openshift` for Ansible Kubernetes resources and an updated `oc` binary.

Custom hook container

You can use a custom hook container instead of the default Ansible image.

**8.3.1. Writing an Ansible playbook for a migration hook**

You can write an Ansible playbook to use as a migration hook. The hook is added to a migration plan by using the MTC web console or by specifying values for the `spec.hooks` parameters in the `MigPlan` custom resource (CR) manifest.

The Ansible playbook is mounted onto a hook container as a config map. The hook container runs as a job, using the cluster, service account, and namespace specified in the `MigPlan` CR. The hook container uses a specified service account token so that the tasks do not require authentication before they run in the cluster.

**8.3.1.1. Ansible modules**

You can use the Ansible `shell` module to run `oc` commands.

**Example shell module**

```yaml
- hosts: localhost
  gather_facts: false
  tasks:
    - name: get pod name
      shell: oc get po --all-namespaces
```

You can use `kubernetes.core` modules, such as `k8s_info`, to interact with Kubernetes resources.

**Example k8s_facts module**

```yaml
- hosts: localhost
  gather_facts: false
  tasks:
    - name: Get pod
      k8s_info:
        kind: pods
        api: v1
        namespace: openshift-migration
        name: "{{ lookup( 'env', 'HOSTNAME') }}"
        register: pods
    - name: Print pod name
      debug:
        msg: "{{ pods.resources[0].metadata.name }}"
```

You can use the `fail` module to produce a non-zero exit status in cases where a non-zero exit status would not normally be produced, ensuring that the success or failure of a hook is detected. Hooks run as jobs and the success or failure status of a hook is based on the exit status of the job container.

**Example fail module**

```yaml
- hosts: localhost
  gather_facts: false
  tasks:
    - name: Get pod
      k8s_info:
        kind: pods
        api: v1
        namespace: openshift-migration
        name: "{{ lookup( 'env', 'HOSTNAME') }}"
        register: pods
    - name: Print pod name
      debug:
        msg: "{{ pods.resources[0].metadata.name }}"
```

You can use the `fail` module to produce a non-zero exit status in cases where a non-zero exit status would not normally be produced, ensuring that the success or failure of a hook is detected. Hooks run as jobs and the success or failure status of a hook is based on the exit status of the job container.
8.3.1.2. Environment variables

The **MigPlan** CR name and migration namespaces are passed as environment variables to the hook container. These variables are accessed by using the **lookup** plug-in.

**Example environment variables**

```
- hosts: localhost
gather_facts: false
tasks:
  - name: Set a boolean
    set_fact:
      do_fail: true
  - name: "fail"
    fail:
      msg: "Cause a failure"
      when: do_fail
```

8.4. MIGRATION PLAN OPTIONS

You can exclude, edit, and map components in the **MigPlan** custom resource (CR).

8.4.1. Excluding resources

You can exclude resources, for example, image streams, persistent volumes (PVs), or subscriptions, from a Migration Toolkit for Containers (MTC) migration plan to reduce the resource load for migration or to migrate images or PVs with a different tool.

By default, the MTC excludes service catalog resources and Operator Lifecycle Manager (OLM) resources from migration. These resources are parts of the service catalog API group and the OLM API group, neither of which is supported for migration at this time.

**Procedure**

1. Edit the **MigrationController** custom resource manifest:

   ```
   $ oc edit migrationcontroller <migration_controller> -n openshift-migration
   ```
2. Update the `spec` section by adding a parameter to exclude specific resources or by adding a resource to the `excluded_resources` parameter if it does not have its own exclusion parameter:

```yaml
apiVersion: migration.openshift.io/v1alpha1
kind: MigrationController
metadata:
  name: migration-controller
  namespace: openshift-migration
spec:
  disable_image_migration: true
  disable_pv_migration: true
...
  excluded_resources:
    - imagetags
    - templateinstances
    - clusterserviceversions
    - packagemanifests
    - subscriptions
    - servicebrokers
    - servicebindings
    - serviceclasses
    - serviceinstances
    - serviceplans
    - operatorgroups
    - events
    - events.events.k8s.io
```

1. Add `disable_image_migration: true` to exclude image streams from the migration. Do not edit the `excluded_resources` parameter. `imagestreams` is added to `excluded_resources` when the `MigrationController` pod restarts.

2. Add `disable_pv_migration: true` to exclude PVs from the migration plan. Do not edit the `excluded_resources` parameter. `persistentvolumes` and `persistentvolumeclaims` are added to `excluded_resources` when the `MigrationController` pod restarts. Disabling PV migration also disables PV discovery when you create the migration plan.

3. You can add OpenShift Container Platform resources to the `excluded_resources` list. Do not delete the default excluded resources. These resources are problematic to migrate and must be excluded.

3. Wait two minutes for the `MigrationController` pod to restart so that the changes are applied.

4. Verify that the resource is excluded:

```bash
$ oc get deployment -n openshift-migration migration-controller -o yaml | grep EXCLUDED_RESOURCES -A1
```

The output contains the excluded resources:

**Example output**

```
  - name: EXCLUDED_RESOURCES
    value:
```
8.4.2. Mapping namespaces

If you map namespaces in the MigPlan custom resource (CR), you must ensure that the namespaces are not duplicated on the source or the destination clusters because the UID and GID ranges of the namespaces are copied during migration.

Two source namespaces mapped to the same destination namespace

```yaml
spec:
  namespaces:
    - namespace_2
    - namespace_1:namespace_2
```

If you want the source namespace to be mapped to a namespace of the same name, you do not need to create a mapping. By default, a source namespace and a target namespace have the same name.

Incorrect namespace mapping

```yaml
spec:
  namespaces:
    - namespace_1:namespace_1
```

Correct namespace reference

```yaml
spec:
  namespaces:
    - namespace_1
```

8.4.3. Excluding persistent volume claims

You select persistent volume claims (PVCs) for state migration by excluding the PVCs that you do not want to migrate. You exclude PVCs by setting the `spec.persistentVolumes.pvc.selection.action` parameter of the MigPlan custom resource (CR) after the persistent volumes (PVs) have been discovered.

Prerequisites

- MigPlan CR is in a Ready state.

Procedure

- Add the `spec.persistentVolumes.pvc.selection.action` parameter to the MigPlan CR and set it to skip:

```yaml
apiVersion: migration.openshift.io/v1alpha1
kind: MigPlan
metadata:
  name: <migplan>
namespace: openshift-migration
```
8.4.4. Mapping persistent volume claims

You can migrate persistent volume (PV) data from the source cluster to persistent volume claims (PVCs) that are already provisioned in the destination cluster in the MigPlan CR by mapping the PVCs. This mapping ensures that the destination PVCs of migrated applications are synchronized with the source PVCs.

You map PVCs by updating the `spec.persistentVolumes.pvc.name` parameter in the MigPlan custom resource (CR) after the PVs have been discovered.

**Prerequisites**

- MigPlan CR is in a Ready state.

**Procedure**

- Update the `spec.persistentVolumes.pvc.name` parameter in the MigPlan CR:

```yaml
apiVersion: migration.openshift.io/v1alpha1
cr: MigPlan
metadata:
  name: <migplan>
  namespace: openshift-migration
spec:
  ...
  persistentVolumes:
    - capacity: 10Gi
      name: <pv_name>
      pvc:
        name: <source_pvc>:<destination_pvc>

1 Specify the PVC on the source cluster and the PVC on the destination cluster. If the destination PVC does not exist, it will be created. You can use this mapping to change the PVC name during migration.

8.4.5. Editing persistent volume attributes

You can edit the storage class and the access mode of persistent volumes (PVs) in the MigPlan custom resource (CR) after the PVs have been discovered by the MigrationController CR.

**Prerequisites**

- MigPlan CR is in a Ready state.
Procedure

- Edit the values of `spec.persistentVolumes.selection.storageClass` and `spec.persistentVolumes.selection.accessMode` in the `MigPlan` CR:

```yaml
apiVersion: migration.openshift.io/v1alpha1
kind: MigPlan
metadata:
  name: <migplan>
  namespace: openshift-migration
spec:
  persistentVolumes:
  - capacity: 10Gi
    name: pvc-095a6559-b27f-11eb-b27f-021bddd6f6e4
    proposedCapacity: 10Gi
    pvc:
      accessModes:
      - ReadWriteMany
      hasReference: true
      name: mysql
      namespace: mysql-persistent
    selection:
      action: copy
      copyMethod: filesystem
      storageClass: ceph
      accessMode: ReadWriteMany
    storageClass: ceph

1 Destination storage class.
2 Destination access mode.
```

8.4.6. Migrating Kubernetes objects

You can perform a one-time migration of Kubernetes objects that constitute an application's state.

**NOTE**

After migration, the `closed` parameter of the `MigPlan` CR is set to `true`. You cannot create another `MigMigration` CR for this `MigPlan` CR.

You add Kubernetes objects to the `MigPlan` CR by using one of the following options:

- Adding the Kubernetes objects to the `includedResources` section.
- Using the `labelSelector` parameter to reference labeled Kubernetes objects.
- Adding Kubernetes objects to the `includedResources` section and then filtering them with the `labelSelector` parameter, for example, `Secret` and `ConfigMap` resources with the label `app: frontend`.

Procedure

- Update the `MigPlan` CR:
Specify the Kubernetes object, for example, Secret or ConfigMap.

Specify the label of the resources to migrate, for example, app: frontend.

### 8.5. MIGRATION CONTROLLER OPTIONS

You can edit migration plan limits, enable persistent volume resizing, or enable cached Kubernetes clients in the MigrationController custom resource (CR) for large migrations and improved performance.

#### 8.5.1. Increasing limits for large migrations

You can increase the limits on migration objects and container resources for large migrations with the Migration Toolkit for Containers (MTC).

**IMPORTANT**

You must test these changes before you perform a migration in a production environment.

**Procedure**

1. Edit the MigrationController custom resource (CR) manifest:

   ```bash
   $ oc edit migrationcontroller -n openshift-migration
   ...
   mig_controller_limits_cpu: "1" ①
   mig_controller_limits_memory: "10Gi" ②
   ...
   mig_controller_requests_cpu: "100m" ③
   mig_controller_requests_memory: "350Mi" ④
   ...
   mig_pv_limit: 100 ⑤
   ...
   ```

2. Update the following parameters:
Specifies the number of CPUs available to the MigrationController CR.

2. Specifies the amount of memory available to the MigrationController CR.

3. Specifies the number of CPU units available for MigrationController CR requests. 100m represents 0.1 CPU units (100 * 1e-3).

4. Specifies the amount of memory available for MigrationController CR requests.

5. Specifies the number of persistent volumes that can be migrated.

6. Specifies the number of pods that can be migrated.

7. Specifies the number of namespaces that can be migrated.

3. Create a migration plan that uses the updated parameters to verify the changes. If your migration plan exceeds the MigrationController CR limits, the MTC console displays a warning message when you save the migration plan.

8.5.2. Enabling persistent volume resizing for direct volume migration

You can enable persistent volume (PV) resizing for direct volume migration to avoid running out of disk space on the destination cluster.

When the disk usage of a PV reaches a configured level, the MigrationController custom resource (CR) compares the requested storage capacity of a persistent volume claim (PVC) to its actual provisioned capacity. Then, it calculates the space required on the destination cluster.

A pv_resizing_threshold parameter determines when PV resizing is used. The default threshold is 3%. This means that PV resizing occurs when the disk usage of a PV is more than 97%. You can increase this threshold so that PV resizing occurs at a lower disk usage level.

PVC capacity is calculated according to the following criteria:

- If the requested storage capacity (spec.resources.requests.storage) of the PVC is not equal to its actual provisioned capacity (status.capacity.storage), the greater value is used.

- If a PV is provisioned through a PVC and then subsequently changed so that its PV and PVC capacities no longer match, the greater value is used.

Prerequisites

- The PVCs must be attached to one or more running pods so that the MigrationController CR can execute commands.

Procedure

1. Log in to the host cluster.

2. Enable PV resizing by patching the MigrationController CR:
Set the value to `false` to disable PV resizing.

3. Optional: Update the `pv_resizing_threshold` parameter to increase the threshold:

```
$ oc patch migrationcontroller migration-controller -p '{"spec":{"pv_resizing_threshold":41}}'  
--type='merge' -n openshift-migration
```

The default value is 3.

When the threshold is exceeded, the following status message is displayed in the `MigPlan` CR status:

```
status:
  conditions:
  ...
  - category: Warn
durable: true
lastTransitionTime: "2021-06-17T08:57:01Z"
message: 'Capacity of the following volumes will be automatically adjusted to avoid disk capacity issues in the target cluster:  
pvc-b800eb7b-cf3b-11eb-a3f7-0eae3e0555f3'
reason: Done
status: "False"
type: PvCapacityAdjustmentRequired
```

**NOTE**

For AWS gp2 storage, this message does not appear unless the `pv_resizing_threshold` is 42% or greater because of the way gp2 calculates volume usage and size. ([BZ#1973148](#))

### 8.5.3. Enabling cached Kubernetes clients

You can enable cached Kubernetes clients in the `MigrationController` custom resource (CR) for improved performance during migration. The greatest performance benefit is displayed when migrating between clusters in different regions or with significant network latency.

**NOTE**

Delegated tasks, for example, Rsync backup for direct volume migration or Velero backup and restore, however, do not show improved performance with cached clients.

Cached clients require extra memory because the `MigrationController` CR caches all API resources that are required for interacting with `MigCluster` CRs. Requests that are normally sent to the API server are directed to the cache instead. The cache watches the API server for updates.
You can increase the memory limits and requests of the MigrationController CR if OOMKilled errors occur after you enable cached clients.

Procedure

1. Enable cached clients by running the following command:

   ```
   $ oc -n openshift-migration patch migrationcontroller migration-controller --type=json --patch "
   [{ "op": "replace", "path": "/spec/mig_controller_enable_cache", "value": true}]"
   ```

2. Optional: Increase the MigrationController CR memory limits by running the following command:

   ```
   $ oc -n openshift-migration patch migrationcontroller migration-controller --type=json --patch "
   [{ "op": "replace", "path": "/spec/mig_controller_limits_memory", "value": <10Gi}>]"
   ```

3. Optional: Increase the MigrationController CR memory requests by running the following command:

   ```
   $ oc -n openshift-migration patch migrationcontroller migration-controller --type=json --patch "
   [{ "op": "replace", "path": "/spec/mig_controller_requests_memory", "value": "<350Mi>}]"
   ```
CHAPTER 9. TROUBLESHOOTING

This section describes resources for troubleshooting the Migration Toolkit for Containers (MTC).

For known issues, see the MTC release notes.

9.1. MTC WORKFLOW

You can migrate Kubernetes resources, persistent volume data, and internal container images to OpenShift Container Platform 4.9 by using the Migration Toolkit for Containers (MTC) web console or the Kubernetes API.

MTC migrates the following resources:

- A namespace specified in a migration plan.
- Namespace-scoped resources: When the MTC migrates a namespace, it migrates all the objects and resources associated with that namespace, such as services or pods. Additionally, if a resource that exists in the namespace but not at the cluster level depends on a resource that exists at the cluster level, the MTC migrates both resources.
  
  For example, a security context constraint (SCC) is a resource that exists at the cluster level and a service account (SA) is a resource that exists at the namespace level. If an SA exists in a namespace that the MTC migrates, the MTC automatically locates any SCCs that are linked to the SA and also migrates those SCCs. Similarly, the MTC migrates persistent volume claims that are linked to the persistent volumes of the namespace.

  **NOTE**

  Cluster-scoped resources might have to be migrated manually, depending on the resource.

- Custom resources (CRs) and custom resource definitions (CRDs): MTC automatically migrates CRs and CRDs at the namespace level.

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

1. Install the Migration Toolkit for Containers Operator on all clusters.
   You can install the Migration Toolkit for Containers 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 MTC uses to migrate data.
   The source and target clusters must have network access to the replication repository during migration. If you are using a proxy server, you must configure it to allow network traffic between the replication repository and the clusters.

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

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

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

   - **Copy**: MTC copies the data from the source cluster to the replication repository, and from the replication repository to the target cluster.
NOTE

If you are using direct image migration or direct volume migration, the images or volumes are copied directly from the source cluster to the target cluster.

Move: MTC 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 migration.

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

- **Stage** copies data to the target cluster without stopping the application. A stage migration can be run multiple times so that most of the data is copied to the target before migration. Running one or more stage migrations reduces the duration of the cutover migration.

- **Cutover** stops the application on the source cluster and moves the resources to the target cluster. Optional: You can clear the **Halt transactions on the source cluster during migration** checkbox.
About MTC custom resources
The Migration Toolkit for Containers (MTC) creates the following custom resources (CRs):
MigCluster (configuration, MTC cluster): Cluster definition

MigStorage (configuration, MTC cluster): Storage definition

MigPlan (configuration, MTC cluster): Migration plan

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

NOTE
Deleting a MigPlan CR deletes the associated MigMigration CRs.

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

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

MigMigration (action, MTC cluster): Migration, 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

9.2. MTC CUSTOM RESOURCE MANIFESTS
Migration Toolkit for Containers (MTC) uses the following custom resource (CR) manifests for migrating applications.

9.2.1. DirectImageMigration
The DirectImageMigration CR copies images directly from the source cluster to the destination cluster.

```yaml
apiVersion: migration.openshift.io/v1alpha1
kind: DirectImageMigration
metadata:
  labels:
    controller-tools.k8s.io: "1.0"
  name: <direct_image_migration>
spec:
```

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One or more namespaces containing images to be migrated. By default, the destination namespace has the same name as the source namespace.

Source namespace mapped to a destination namespace with a different name.

### 9.2.2. DirectImageStreamMigration

The **DirectImageStreamMigration** CR copies image stream references directly from the source cluster to the destination cluster.

```yaml
apiVersion: migration.openshift.io/v1alpha1
crDeps:
  - kind: DirectImageStreamMigration
    metadata:
      name: <direct_image_stream_migration>
    spec:
      srcMigClusterRef:
        name: <source_cluster>
        namespace: openshift-migration
      destMigClusterRef:
        name: <destination_cluster>
        namespace: openshift-migration
      namespaces:
      - <source_namespace_1>
      - <source_namespace_2>:<destination_namespace_3>
```

### 9.2.3. DirectVolumeMigration

The **DirectVolumeMigration** CR copies persistent volumes (PVs) directly from the source cluster to the destination cluster.

```yaml
apiVersion: migration.openshift.io/v1alpha1
crDeps:
  - kind: DirectVolumeMigration
    metadata:
      name: <direct_volume_migration>
    spec:
      createDestinationNamespaces: false
      deleteProgressReportingCRs: false
      destMigClusterRef:
        name: <host_cluster>
```

1. One or more namespaces containing images to be migrated. By default, the destination namespace has the same name as the source namespace.
2. Source namespace mapped to a destination namespace with a different name.
Set to true to create namespaces for the PVs on the destination cluster.

Set to true to delete DirectVolumeMigrationProgress CRs after migration. The default is false so that DirectVolumeMigrationProgress CRs are retained for troubleshooting.

Update the cluster name if the destination cluster is not the host cluster.

Specify one or more PVCs to be migrated.

9.2.4. DirectVolumeMigrationProgress

The DirectVolumeMigrationProgress CR shows the progress of the DirectVolumeMigration CR.

```
apiVersion: migration.openshift.io/v1alpha1
group: migration.openshift.io
category: migration
kind: DirectVolumeMigrationProgress
metadata:
  labels:
    controller-tools.k8s.io: "1.0"
  name: <direct_volume_migration_progress>
spec:
  clusterRef:
    name: <source_cluster>
    namespace: openshift-migration
  podRef:
    name: <rsync_pod>
    namespace: openshift-migration
```

9.2.5. MigAnalytic

The MigAnalytic CR collects the number of images, Kubernetes resources, and the persistent volume (PV) capacity from an associated MigPlan CR.

You can configure the data that it collects.

```
apiVersion: migration.openshift.io/v1alpha1
group: migration.openshift.io
category: migration
kind: MigAnalytic
metadata:
  annotations:
    migplan: <migplan>
  name: <miganalytic>
  namespace: openshift-migration
  labels:
    migplan: <migplan>
spec:
  analyzeImageCount: true <.>
  analyzeK8SResources: true <.>
```
analyzePVCapacity: true
listImages: false
listImagesLimit: 50

migPlanRef:
  name: <migplan>
  namespace: openshift-migration

<> Optional: Returns the number of images. <> Optional: Returns the number, kind, and API version of the Kubernetes resources. <> Optional: Returns the PV capacity. <> Returns a list of image names. The default is false so that the output is not excessively long. <> Optional: Specify the maximum number of image names to return if listImages is true.

9.2.6. MigCluster

The MigCluster CR defines a host, local, or remote cluster.

apiVersion: migration.openshift.io/v1alpha1
kind: MigCluster
metadata:
  labels:
    controller-tools.k8s.io: "1.0"
  name: <host_cluster>
  namespace: openshift-migration
spec:
  isHostCluster: true

# The 'azureResourceGroup' parameter is relevant only for Microsoft Azure.
  azureResourceGroup: <azure_resource_group>

# The 'restartRestic' parameter is relevant for a source cluster.
  restartRestic: true

# The following parameters are relevant for a remote cluster.
  exposedRegistryPath: <registry_route>
  url: <destination_cluster_url>
  serviceAccountSecretRef:
    name: <source_secret>
    namespace: openshift-config

1. Update the cluster name if the migration-controller pod is not running on this cluster.
2. The migration-controller pod runs on this cluster if true.
3. Microsoft Azure only: Specify the resource group.
4. Optional: If you created a certificate bundle for self-signed CA certificates and if the insecure parameter value is false, specify the base64-encoded certificate bundle.
5. Set to true to disable SSL verification.
6. Set to true to validate the cluster.
7. Set to true to restart the Restic pods on the source cluster after the Stage pods are created.
Remote cluster and direct image migration only: Specify the exposed secure registry path.

Remote cluster only: Specify the URL.

Remote cluster only: Specify the name of the Secret CR.

### 9.2.7. MigHook

The MigHook CR defines a migration hook that runs custom code at a specified stage of the migration. You can create up to four migration hooks. Each hook runs during a different phase of the migration.

You can configure the hook name, runtime duration, a custom image, and the cluster where the hook will run.

The migration phases and namespaces of the hooks are configured in the MigPlan CR.

```yaml
apiVersion: migration.openshift.io/v1alpha1
kind: MigHook
metadata:
  generateName: <hook_name_prefix> 1
  name: <mighook> 2
  namespace: openshift-migration
spec:
  activeDeadlineSeconds: 1800 3
  custom: false 4
  image: <hook_image> 5
  playbook: <ansible_playbook_base64> 6
  targetCluster: source 7
```

1. Optional: A unique hash is appended to the value for this parameter so that each migration hook has a unique name. You do not need to specify the value of the name parameter.

2. Specify the migration hook name, unless you specify the value of the generateName parameter.

3. Optional: Specify the maximum number of seconds that a hook can run. The default is 1800.

4. The hook is a custom image if true. The custom image can include Ansible or it can be written in a different programming language.

5. Specify the custom image, for example, quay.io/konveyor/hook-runner:latest. Required if custom is true.

6. Base64-encoded Ansible playbook. Required if custom is false.

7. Specify the cluster on which the hook will run. Valid values are source or destination.

### 9.2.8. MigMigration

The MigMigration CR runs a MigPlan CR.

You can configure a Migmigration CR to run a stage or incremental migration, to cancel a migration in progress, or to roll back a completed migration.
Set to **true** to cancel a migration in progress.

Set to **true** to roll back a completed migration.

Set to **true** to run a stage migration. Data is copied incrementally and the pods on the source cluster are not stopped.

Set to **true** to stop the application during migration. The pods on the source cluster are scaled to **0** after the **Backup** stage.

Set to **true** to retain the labels and annotations applied during the migration.

Set to **true** to check the status of the migrated pods on the destination cluster are checked and to return the names of pods that are not in a **Running** state.

### 9.2.9. MigPlan

The **MigPlan** CR defines the parameters of a migration plan.

You can configure destination namespaces, hook phases, and direct or indirect migration.

**NOTE**

By default, a destination namespace has the same name as the source namespace. If you configure a different destination namespace, you must ensure that the namespaces are not duplicated on the source or the destination clusters because the UID and GID ranges are copied during migration.
The migration has completed if true. You cannot create another MigMigration CR for this MigPlan CR.

Optional: You can specify up to four migration hooks. Each hook must run during a different migration phase.

Optional: Specify the namespace in which the hook will run.

Optional: Specify the migration phase during which a hook runs. One hook can be assigned to one phase. Valid values are PreBackup, PostBackup, PreRestore, and PostRestore.

Optional: Specify the name of the MigHook CR.

Optional: Specify the namespace of MigHook CR.

Optional: Specify a service account with cluster-admin privileges.

Direct image migration is disabled if true. Images are copied from the source cluster to the replication repository and from the replication repository to the destination cluster.

Direct volume migration is disabled if true. PVs are copied from the source cluster to the replication repository and from the replication repository to the destination cluster.

Specify one or more source namespaces. If you specify only the source namespace, the destination namespace is the same.

Specify the destination namespace if it is different from the source namespace.

The MigPlan CR is validated if true.
9.2.10. MigStorage

The MigStorage CR describes the object storage for the replication repository.

Amazon Web Services (AWS), Microsoft Azure, Google Cloud Storage, Multi-Cloud Object Gateway, and generic S3-compatible cloud storage are supported.

AWS and the snapshot copy method have additional parameters.

```yaml
apiVersion: migration.openshift.io/v1alpha1
kind: MigStorage
metadata:
  labels:
    controller-tools.k8s.io: "1.0"
  name: <migstorage>
namespace: openshift-migration
spec:
  backupStorageProvider: <backup_storage_provider>  
  volumeSnapshotProvider: <snapshot_storage_provider>  
  backupStorageConfig:
    awsBucketName: <bucket>  
    awsRegion: <region>  
    credsSecretRef:
      namespace: openshift-config
      name: <storage_secret>  
    awsKmsKeyId: <key_id>  
    awsPublicUrl: <public_url>  
    awsSignatureVersion: <signature_version>  
  volumeSnapshotConfig:
    awsRegion: <region>  
    credsSecretRef:
      namespace: openshift-config
      name: <storage_secret>  
  refresh: false
```

1. Specify the storage provider.
2. Snapshot copy method only: Specify the storage provider.
3. AWS only: Specify the bucket name.
4. AWS only: Specify the bucket region, for example, us-east-1.
5. Specify the name of the Secret CR that you created for the storage.
6. AWS only: If you are using the AWS Key Management Service, specify the unique identifier of the key.
7. AWS only: If you granted public access to the AWS bucket, specify the bucket URL.
8. AWS only: Specify the AWS signature version for authenticating requests to the bucket, for example, 4.
9. Snapshot copy method only: Specify the geographical region of the clusters.
10. Snapshot copy method only: Specify the name of the **Secret** CR that you created for the storage.

11. Set to **true** to validate the cluster.

### 9.3. LOGS AND DEBUGGING TOOLS

This section describes logs and debugging tools that you can use for troubleshooting.

#### 9.3.1. Viewing migration plan resources

You can view migration plan resources to monitor a running migration or to troubleshoot a failed migration by using the MTC web console and the command line interface (CLI).

**Procedure**

1. In the MTC web console, click **Migration Plans**.
2. Click the **Migrations** number next to a migration plan to view the **Migrations** page.
3. Click a migration to view the **Migration details**.
4. Expand **Migration resources** to view the migration resources and their status in a tree view.

   **NOTE**

   To troubleshoot a failed migration, start with a high-level resource that has failed and then work down the resource tree towards the lower-level resources.

5. Click the Options menu next to a resource and select one of the following options:

   - **Copy oc describe command** copies the command to your clipboard.
     - Log in to the relevant cluster and then run the command.
     - The conditions and events of the resource are displayed in YAML format.

   - **Copy oc logs command** copies the command to your clipboard.
     - Log in to the relevant cluster and then run the command.
     - If the resource supports log filtering, a filtered log is displayed.

   - **View JSON** displays the resource data in JSON format in a web browser.
     - The data is the same as the output for the **oc get <resource>** command.

#### 9.3.2. Viewing a migration plan log

You can view an aggregated log for a migration plan. You use the MTC web console to copy a command to your clipboard and then run the command from the command line interface (CLI).

The command displays the filtered logs of the following pods:

- **Migration Controller**
- Velero
- Restic
- Rsync
- Stunnel
- Registry

Procedure

1. In the MTC web console, click **Migration Plans**.
2. Click the **Migrations** number next to a migration plan.
3. Click **View logs**.
4. Click the Copy icon to copy the oc logs command to your clipboard.
5. Log in to the relevant cluster and enter the command on the CLI. The aggregated log for the migration plan is displayed.

### 9.3.3. Using the migration log reader

You can use the migration log reader to display a single filtered view of all the migration logs.

Procedure

1. Get the mig-log-reader pod:
   ```
   $ oc -n openshift-migration get pods | grep log
   ```
2. Enter the following command to display a single migration log:
   ```
   $ oc -n openshift-migration logs -f <mig-log-reader-pod> -c color
   ```
   The -c plain option displays the log without colors.

### 9.3.4. Accessing performance metrics

The **MigrationController** custom resource (CR) records metrics and pulls them into on-cluster monitoring storage. You can query the metrics by using Prometheus Query Language (PromQL) to diagnose migration performance issues. All metrics are reset when the Migration Controller pod restarts.

You can access the performance metrics and run queries by using the OpenShift Container Platform web console.

Procedure

1. In the OpenShift Container Platform web console, click **Monitoring → Metrics**.
2. Enter a PromQL query, select a time window to display, and click **Run Queries**. If your web browser does not display all the results, use the Prometheus console.
9.3.4.1. Provided metrics

The MigrationController custom resource (CR) provides metrics for the MigMigration CR count and for its API requests.

9.3.4.1.1. cam_app_workload_migrations

This metric is a count of MigMigration CRs over time. It is useful for viewing alongside the mtc_client_request_count and mtc_client_request_elapsed metrics to collate API request information with migration status changes. This metric is included in Telemetry.

Table 9.1. cam_app_workload_migrations metric

<table>
<thead>
<tr>
<th>Queryable label name</th>
<th>Sample label values</th>
<th>Label description</th>
</tr>
</thead>
<tbody>
<tr>
<td>status</td>
<td>running, idle, failed, completed</td>
<td>Status of the MigMigration CR</td>
</tr>
<tr>
<td>type</td>
<td>stage, final</td>
<td>Type of the MigMigration CR</td>
</tr>
</tbody>
</table>

9.3.4.1.2. mtc_client_request_count

This metric is a cumulative count of Kubernetes API requests that MigrationController issued. It is not included in Telemetry.

Table 9.2. mtc_client_request_count metric

<table>
<thead>
<tr>
<th>Queryable label name</th>
<th>Sample label values</th>
<th>Label description</th>
</tr>
</thead>
<tbody>
<tr>
<td>cluster</td>
<td><a href="https://migcluster-url:443">https://migcluster-url:443</a></td>
<td>Cluster that the request was issued against</td>
</tr>
<tr>
<td>component</td>
<td>MigPlan, MigCluster</td>
<td>Sub-controller API that issued request</td>
</tr>
<tr>
<td>function</td>
<td>(*ReconcileMigPlan).Reconcile</td>
<td>Function that the request was issued from</td>
</tr>
<tr>
<td>kind</td>
<td>SecretList, Deployment</td>
<td>Kubernetes kind the request was issued for</td>
</tr>
</tbody>
</table>

9.3.4.1.3. mtc_client_request_elapsed

This metric is a cumulative latency, in milliseconds, of Kubernetes API requests that MigrationController issued. It is not included in Telemetry.

Table 9.3. mtc_client_request_elapsed metric

<table>
<thead>
<tr>
<th>Queryable label name</th>
<th>Sample label values</th>
<th>Label description</th>
</tr>
</thead>
</table>
### Queryable label name
<table>
<thead>
<tr>
<th>Sample label values</th>
<th>Label description</th>
</tr>
</thead>
<tbody>
<tr>
<td>cluster</td>
<td><a href="https://cluster-url.com:443">https://cluster-url.com:443</a></td>
</tr>
<tr>
<td>component</td>
<td>migplan, migcluster</td>
</tr>
<tr>
<td>function</td>
<td>(*ReconcileMigPlan).Reconcile</td>
</tr>
<tr>
<td>kind</td>
<td>SecretList, Deployment</td>
</tr>
</tbody>
</table>

### 9.3.4.1.4. Useful queries

The table lists some helpful queries that can be used for monitoring performance.

**Table 9.4. Useful queries**

<table>
<thead>
<tr>
<th>Query</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>mtc_client_request_count</td>
<td>Number of API requests issued, sorted by request type</td>
</tr>
<tr>
<td>sum(mtc_client_request_count)</td>
<td>Total number of API requests issued</td>
</tr>
<tr>
<td>mtc_client_request_elapsed</td>
<td>API request latency, sorted by request type</td>
</tr>
<tr>
<td>sum(mtc_client_request_elapsed)</td>
<td>Total latency of API requests</td>
</tr>
<tr>
<td>sum(mtc_client_requestElapsedTime) / sum(mtc_client_requestCount)</td>
<td>Average latency of API requests</td>
</tr>
<tr>
<td>mtc_client_requestElapsedTime / mtc_client_requestCount</td>
<td>Average latency of API requests, sorted by request type</td>
</tr>
<tr>
<td>cam_app_workload_migrations{status=&quot;running&quot;} * 100</td>
<td>Count of running migrations, multiplied by 100 for easier viewing alongside request counts</td>
</tr>
</tbody>
</table>

### 9.3.5. Using the must-gather tool

You can collect logs, metrics, and information about MTC custom resources by using the **must-gather** tool.

The **must-gather** data must be attached to all customer cases.

You can collect data for a one-hour or a 24-hour period and view the data with the Prometheus console.
Prerequisites

- You must be logged in to the OpenShift Container Platform cluster as a user with the cluster-admin role.
- You must have the OpenShift CLI (oc) installed.

Procedure

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

2. Run the `oc adm must-gather` command:
   - To gather data for the past hour:
     ```bash
     $ oc adm must-gather --image=registry.redhat.io/rhmtc/openshift-migration-must-gather-rhel8:v1.6
     
     The data is saved as /must-gather/must-gather.tar.gz. You can upload this file to a support case on the Red Hat Customer Portal.
     
   - To gather data for the past 24 hours:
     ```bash
     $ oc adm must-gather --image=\registry.redhat.io/rhmtc/openshift-migration-must-gather-rhel8:\v1.6 -- /usr/bin/gather_metrics_dump
     
     This operation can take a long time. The data is saved as /must-gather/metrics/prom_data.tar.gz. You can view this file with the Prometheus console.
     
To view data with the Prometheus console

1. Create a local Prometheus instance:
   ```bash
   $ make prometheus-run
   
   The command outputs the Prometheus URL:
   
   Output
   
   Started Prometheus on http://localhost:9090
   
   2. Launch a web browser and navigate to the URL to view the data by using the Prometheus web console.
   
   3. After you have viewed the data, delete the Prometheus instance and data:
   ```bash
   $ make prometheus-cleanup
   
9.3.6. Using the Velero CLI to debug Backup and Restore CRs

You can debug the Backup and Restore custom resources (CRs) and partial migration failures with the Velero command line interface (CLI). The Velero CLI runs in the velero pod.
9.3.6.1. Velero command syntax

Velero CLI commands use the following syntax:

```
$ oc exec $(oc get pods -n openshift-migration -o name | grep velero) -- ./velero <resource> <command> <resource_id>
```

You can specify `velero-<pod>` -n openshift-migration in place of $(oc get pods -n openshift-migration -o name | grep velero).

9.3.6.2. Help command

The Velero help command lists all the Velero CLI commands:

```
$ oc exec $(oc get pods -n openshift-migration -o name | grep velero) -- ./velero --help
```

9.3.6.3. Describe command

The Velero describe command provides a summary of warnings and errors associated with a Velero resource:

```
$ oc exec $(oc get pods -n openshift-migration -o name | grep velero) -- ./velero <resource> describe <resource_id>
```

Example

```
$ oc exec $(oc get pods -n openshift-migration -o name | grep velero) -- ./velero backup describe 0e44ae00-5dc3-11eb-9ca8-df7e5254778b-2d8ql
```

9.3.6.4. Logs command

The Velero logs command provides the logs associated with a Velero resource:

```
velero <resource> logs <resource_id>
```

Example

```
$ oc exec $(oc get pods -n openshift-migration -o name | grep velero) -- ./velero restore logs ccc7c2d0-6017-11eb-afab-85d0007f5a19-x4lbf
```

9.3.7. Debugging a partial migration failure

You can debug a partial migration failure warning message by using the Velero CLI to examine the Restore custom resource (CR) logs.

A partial failure occurs when Velero encounters an issue that does not cause a migration to fail. For example, if a custom resource definition (CRD) is missing or if there is a discrepancy between CRD versions on the source and target clusters, the migration completes but the CR is not created on the target cluster.

Velero logs the issue as a partial failure and then processes the rest of the objects in the Backup CR.
Procedure

1. Check the status of a MigMigration CR:

   $ oc get migmigration <migmigration> -o yaml

   **Example output**

   ```yaml
   status:
   conditions:
   - category: Warn
durable: true
   lastTransitionTime: "2021-01-26T20:48:40Z"
   message: 'Final Restore openshift-migration/ccc7c2d0-6017-11eb-afab-85d0007f5a19-x4lbf: partially failed on destination cluster'
   status: "True"
type: VeleroFinalRestorePartiallyFailed
   - category: Advisory
durable: true
   lastTransitionTime: "2021-01-26T20:48:42Z"
   message: The migration has completed with warnings, please look at `Warn` conditions.
   reason: Completed
   status: "True"
type: SucceededWithWarnings
   ```

2. Check the status of the Restore CR by using the Velero describe command:

   $ oc exec $(oc get pods -n openshift-migration -o name | grep velero) -n openshift-migration -
   - ./velero restore describe <restore>

   **Example output**

   Phases: PartiallyFailed (run `velero restore logs ccc7c2d0-6017-11eb-afab-85d0007f5a19-x4lbf` for more information)

   Errors:
   - Velero: <none>
   - Cluster: <none>
   - Namespaces:
   - migration-example: error restoring example.com/migration-example/migration-example: the server could not find the requested resource

3. Check the Restore CR logs by using the Velero logs command:

   $ oc exec $(oc get pods -n openshift-migration -o name | grep velero) -n openshift-migration -
   - ./velero restore logs <restore>

   **Example output**

   ```
   time="2021-01-26T20:48:37Z" level=info msg="Attempting to restore migration-example:
migration-example" logSource="pkg/restore/restore.go:1107" restore=openshift-
migration/ccc7c2d0-6017-11eb-afab-85d0007f5a19-x4lbf
   ```
time="2021-01-26T20:48:37Z" level=info msg="error restoring migration-example: the server could not find the requested resource" logSource="pkg/restore/restore.go:1170" restore=openshift-migration/ccc7c2d0-6017-11eb-afab-85d0007f5a19-x4lbf

The Restore CR log error message, the server could not find the requested resource, indicates the cause of the partially failed migration.

### 9.3.8. Using MTC custom resources for troubleshooting

You can check the following Migration Toolkit for Containers (MTC) custom resources (CRs) to troubleshoot a failed migration:

- MigCluster
- MigStorage
- MigPlan
- BackupStorageLocation
  The BackupStorageLocation CR contains a migrationcontroller label to identify the MTC instance that created the CR:

```
labels:
migrationcontroller: ebe13bee-c803-47d0-a9e9-83f380328b93
```

- VolumeSnapshotLocation
  The VolumeSnapshotLocation CR contains a migrationcontroller label to identify the MTC instance that created the CR:

```
labels:
migrationcontroller: ebe13bee-c803-47d0-a9e9-83f380328b93
```

- MigMigration
- Backup
  MTC changes the reclaim policy of migrated persistent volumes (PVs) to Retain on the target cluster. The Backup CR contains an openshift.io/orig-reclaim-policy annotation that indicates the original reclaim policy. You can manually restore the reclaim policy of the migrated PVs.

- Restore

#### Procedure

1. List the MigMigration CRs in the openshift-migration namespace:

   ```
   $ oc get migmigration -n openshift-migration
   ```

#### Example output

```
NAME                        AGE
88435fe0-c9f8-11e9-85e6-5d593ce65e10  6m42s
```
2. Inspect the **MigMigration** CR:

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

The output is similar to the following examples.

**MigMigration example output**

```
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 output that describes the 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
    openshift.io/orig-reclaim-policy: delete
  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-vpzoq9
  - 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: c80dbc0-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-vpzoq9
  - 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 output that describes the Kubernetes resources**

```yaml
apiVersion: velero.io/v1
kind: Restore
metadata: 
  annotations:
    - openshift.io/migrate-copy-phase: final
    - openshift.io/migrate-quiesce-pods: "true"
```
9.4. COMMON ISSUES AND CONCERNS

This section describes common issues and concerns that can cause issues during migration.

9.4.1. Direct volume migration does not complete

If direct volume migration does not complete, the target cluster might not have the same node-selector annotations as the source cluster.

Migration Toolkit for Containers (MTC) migrates namespaces with all annotations to preserve security context constraints and scheduling requirements. During direct volume migration, MTC creates Rsync transfer pods on the target cluster in the namespaces that were migrated from the source cluster. If a target cluster namespace does not have the same annotations as the source cluster namespace, the Rsync transfer pods cannot be scheduled. The Rsync pods remain in a Pending state.

You can identify and fix this issue by performing the following procedure.

Procedure
1. Check the status of the MigMigration CR:
   
   ```
   $ oc describe migmigration <pod> -n openshift-migration
   ```
   
   The output includes the following status message:

   **Example output**

   ```
   Some or all transfer pods are not running for more than 10 mins on destination cluster
   ```

2. On the source cluster, obtain the details of a migrated namespace:
   
   ```
   $ oc get namespace <namespace> -o yaml
   ```

   Specify the migrated namespace.

3. On the target cluster, edit the migrated namespace:
   
   ```
   $ oc edit namespace <namespace>
   ```

4. Add the missing `openshift.io/node-selector` annotations to the migrated namespace as in the following example:
   
   ```yaml
   apiVersion: v1
   kind: Namespace
   metadata:
     annotations:
       openshift.io/node-selector: "region=east"
   ...
   ```

5. Run the migration plan again.

**9.4.2. Error messages and resolutions**

This section describes common error messages you might encounter with the Migration Toolkit for Containers (MTC) and how to resolve their underlying causes.

**9.4.2.1. CA certificate error displayed when accessing the MTC console for the first time**

If a **CA certificate error** message is displayed the first time you try to access the MTC console, the likely cause is the use of self-signed CA certificates in one of the clusters.

To resolve this issue, navigate to the `oauth-authorization-server` URL displayed in the error message and accept the certificate. To resolve this issue permanently, add the certificate to the trust store of your web browser.

If an **Unauthorized** message is displayed after you have accepted the certificate, navigate to the MTC console and refresh the web page.

**9.4.2.2. OAuth timeout error in the MTC console**
If a **connection has timed out** message is displayed in the MTC console after you have accepted a self-signed certificate, the causes are likely to be the following:

- Interrupted network access to the OAuth server
- Interrupted network access to the OpenShift Container Platform console
- Proxy configuration that blocks access to the `oauth-authorization-server` URL. See [MTC console inaccessible because of OAuth timeout error](#) for details.

To determine the cause of the timeout:

- Inspect the MTC console web page with a browser web inspector.
- Check the **Migration UI** pod log for errors.

### 9.4.2.3. Certificate signed by unknown authority error

If you use a self-signed certificate to secure a cluster or a replication repository for the Migration Toolkit for Containers (MTC), 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 MTC 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>  \1
| sed -ne '/-BEGIN CERTIFICATE-/,-END CERTIFICATE-/p' > <ca_bundle.cert>  \2
```

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.

### 9.4.2.4. Backup storage location errors in the Velero pod log

If a **Velero Backup** custom resource contains a reference to a backup storage location (BSL) that does not exist, the **Velero** pod log might display the following error messages:

```
$ oc logs <MigrationUI_Pod> -n openshift-migration
```

You can ignore these error messages. A missing BSL cannot cause a migration to fail.

### 9.4.2.5. Pod volume backup timeout error in the Velero pod log

If a migration fails because Restic times out, the following error is displayed in the **Velero** pod log:

```bash
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 **Migration Toolkit for Containers 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**.

### 9.4.2.6. Restic verification errors in the MigMigration custom resource

If data verification fails when migrating a persistent volume with the file system data copy method, the following error is displayed in the **MigMigration CR**.

#### Example output

```
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. **ResticVerifyErrors** is a general error warning type that includes verification errors.

#### NOTE

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

You can check the **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 persistent volume with PodVolumeRestore errors.

   **Example output**

   ```
   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.

   **Example output**

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

4. View the Restic pod log to locate the errors:
   
   ```
   $ oc logs -f <restic-nr2v5>
   ```

---

**9.4.2.7. Restic permission error when migrating from NFS storage with root_squash enabled**

If you are migrating data from NFS storage and `root_squash` is enabled, Restic maps to `nfsnobody` and does not have permission to perform the migration. The following error is displayed in the Restic pod log.

**Example output**

```
backup=openshift-migration/<backup_id> controller=pod-volume-backup error="fork/exec /usr/bin/restic: permission denied" error.file="/go/src/github.com/vmware-tanzu/velero/pkg/controller/pod_volume_backup_controller.go:280"
error.function="github.com/vmware-tanzu/velero/pkg/controller.(*podVolumeBackupController).processBackup"
logSource="pkg/controller/pod_volume_backup_controller.go:280" name=<backup_id>
namespace=openshift-migration
```
You can resolve this issue by creating a supplemental group for Restic and adding the group ID to the MigrationController CR manifest.

**Procedure**

1. Create a supplemental group for Restic on the NFS storage.
2. Set the `setgid` bit on the NFS directories so that group ownership is inherited.
3. Add the `restic_supplemental_groups` parameter to the MigrationController CR manifest on the source and target clusters:

   ```yaml
   spec:
   restic_supplemental_groups: <group_id>  
   ```

   Specify the supplemental group ID.

4. Wait for the Restic pods to restart so that the changes are applied.

### 9.5. ROLLING BACK A MIGRATION

You can roll back a migration by using the MTC web console or the CLI.

You can also roll back a migration manually.

**9.5.1. Rolling back a migration by using the MTC web console**

You can roll back a migration by using the Migration Toolkit for Containers (MTC) web console.

**NOTE**

The following resources remain in the migrated namespaces for debugging after a failed direct volume migration (DVM):

- Config maps (source and destination clusters)
- Secret CRs (source and destination clusters)
- Rsync CRs (source cluster)

These resources do not affect rollback. You can delete them manually.

If you later run the same migration plan successfully, the resources from the failed migration are deleted automatically.

If your application was stopped during a failed migration, you must roll back the migration to prevent data corruption in the persistent volume.

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

**Procedure**
1. In the MTC web console, click Migration plans.

2. Click the Options menu beside a migration plan and select Rollback under Migration.

3. Click Rollback and wait for rollback to complete. In the migration plan details, Rollback succeeded is displayed.

4. Verify that rollback was successful in the OpenShift Container Platform web console of the source cluster:
   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.

9.5.2. Rolling back a migration from the command line interface

You can roll back a migration by creating a MigMigration custom resource (CR) from the command line interface.

NOTE

The following resources remain in the migrated namespaces for debugging after a failed direct volume migration (DVM):

- Config maps (source and destination clusters)
- Secret CRs (source and destination clusters)
- Rsync CRs (source cluster)

These resources do not affect rollback. You can delete them manually.

If you later run the same migration plan successfully, the resources from the failed migration are deleted automatically.

If your application was stopped during a failed migration, you must roll back the migration to prevent data corruption in the persistent volume.

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

Procedure

1. Create a MigMigration CR based on the following example:

   $ cat << EOF | oc apply -f -

OpenShift Container Platform 4.9 Migration Toolkit for Containers
apiVersion: migration.openshift.io/v1alpha1
cr:
kind: MigMigration
metadata:
  labels:
    controller-tools.k8s.io: "1.0"
nm: <migmigration>
namespace: openshift-migration
spec:
  rollback: true
  ...
  migPlanRef:
    name: <migplan>
    namespace: openshift-migration
EOF

1 Specify the name of the associated MigPlan CR.

2. In the MTC web console, verify that the migrated project resources have been removed from the target cluster.

3. Verify that the migrated project resources are present in the source cluster and that the application is running.

9.5.3. Rolling back a migration manually

You can roll back a failed migration manually by deleting the stage pods and unquiescing the application.

If you run the same migration plan successfully, the resources from the failed migration are deleted automatically.

NOTE

The following resources remain in the migrated namespaces after a failed direct volume migration (DVM):

- Config maps (source and destination clusters)
- Secret CRs (source and destination clusters)
- Rsync CRs (source cluster)

These resources do not affect rollback. You can delete them manually.

Procedure

1. Delete the stage pods on all clusters:

   $ oc delete $(oc get pods -l migration.openshift.io/is-stage-pod -n <namespace>)

   Namespaces specified in the MigPlan CR.
2. Unquiesce the application on the source cluster by scaling the replicas to their premigration number:

   $ oc scale deployment <deployment> --replicas=<premigration_replicas>

The `migration.openshift.io/preQuiesceReplicas` annotation in the `Deployment` CR displays the premigration number of replicas:

   apiVersion: extensions/v1beta1
   kind: Deployment
   metadata:
     annotations:
       deployment.kubernetes.io/revision: "1"
       migration.openshift.io/preQuiesceReplicas: "1"

3. Verify that the application pods are running on the source cluster:

   $ oc get pod -n <namespace>

9.6. UNINSTALLING MTC AND DELETING RESOURCES

You can uninstall the Migration Toolkit for Containers (MTC) and delete its resources to clean up the cluster.

   **NOTE**

   Deleting the `velero` CRDs removes Velero from the cluster.

**Prerequisites**

- You must be logged in as a user with `cluster-admin` privileges.

**Procedure**

1. Delete the `MigrationController` custom resource (CR) on all clusters:

   $ oc delete migrationcontroller <migration_controller>

2. Uninstall the Migration Toolkit for Containers Operator on OpenShift Container Platform 4 by using the Operator Lifecycle Manager.

3. Delete cluster-scoped resources on all clusters by running the following commands:

   - `migration` custom resource definitions (CRDs):
     
     $ oc delete $(oc get crds -o name | grep 'migration.openshift.io')

   - `velero` CRDs:
     
     $ oc delete $(oc get crds -o name | grep 'velero')

   - `migration` cluster roles:
$ oc delete $(oc get clusterroles -o name | grep 'migration.openshift.io')

- **migration-operator** cluster role:
  $ oc delete clusterrole migration-operator

- **velero** cluster roles:
  $ oc delete $(oc get clusterroles -o name | grep 'velero')

- **migration** cluster role bindings:
  $ oc delete $(oc get clusterrolebindings -o name | grep 'migration.openshift.io')

- **migration-operator** cluster role bindings:
  $ oc delete clusterrolebindings migration-operator

- **velero** cluster role bindings:
  $ oc delete $(oc get clusterrolebindings -o name | grep 'velero')

**Additional resources for uninstalling MTC**

- [Deleting Operators from a cluster using the web console](#)