Red Hat OpenShift Data Foundation 4.17

Configuring OpenShift Data Foundation Disaster Recovery for OpenShift Workloads

The OpenShift Data Foundation Disaster Recovery capabilities for Metropolitan and Regional regions is now General Available which also includes Disaster Recovery with stretch cluster.

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Abstract

The intent of this solution guide is to detail the steps necessary to deploy OpenShift Data Foundation for disaster recovery with Advanced Cluster Management and stretch cluster to achieve a highly available storage infrastructure.

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MAKING OPEN SOURCE MORE INCLUSIVE

Red Hat is committed to replacing problematic language in our code, documentation, and web properties. We are beginning with these four terms: master, slave, blacklist, and whitelist. Because of the enormity of this endeavor, these changes will be implemented gradually over several upcoming releases. For more details, see our CTO Chris Wright’s message .

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CHAPTER 1. INTRODUCTION TO OPENSHIFT DATA FOUNDATION DISASTER RECOVERY

Disaster recovery (DR) is the ability to recover and continue business critical applications from natural or human created disasters. It is a component of the overall business continuance strategy of any major organization as designed to preserve the continuity of business operations during major adverse events.

The OpenShift Data Foundation DR capability enables DR across multiple Red Hat OpenShift Container Platform clusters, and is categorized as follows:

- **Metro-DR**
  Metro-DR ensures business continuity during the unavailability of a data center with no data loss. In the public cloud these would be similar to protecting from an Availability Zone failure.

- **Regional-DR**
  Regional-DR ensures business continuity during the unavailability of a geographical region, accepting some loss of data in a predictable amount. In the public cloud this would be similar to protecting from a region failure.

- **Disaster Recovery with stretch cluster**
  Stretch cluster solution ensures business continuity with no-data loss disaster recovery protection with OpenShift Data Foundation based synchronous replication in a single OpenShift cluster, stretched across two data centers with low latency and one arbiter node.

Zone failure in Metro-DR and region failure in Regional-DR is usually expressed using the terms, **Recovery Point Objective (RPO)** and **Recovery Time Objective (RTO)**.

- **RPO** is a measure of how frequently you take backups or snapshots of persistent data. In practice, the RPO indicates the amount of data that will be lost or need to be reentered after an outage.

- **RTO** is the amount of downtime a business can tolerate. The RTO answers the question, “How long can it take for our system to recover after we are notified of a business disruption?”

The intent of this guide is to detail the Disaster Recovery steps and commands necessary to be able to failover an application from one OpenShift Container Platform cluster to another and then relocate the same application to the original primary cluster.

CHAPTER 2. DISASTER RECOVERY SUBSCRIPTION REQUIREMENT

Disaster Recovery features supported by Red Hat OpenShift Data Foundation require all of the following prerequisites to successfully implement a disaster recovery solution:

- A valid Red Hat OpenShift Data Foundation Advanced entitlement
- A valid Red Hat Advanced Cluster Management for Kubernetes subscription

Any Red Hat OpenShift Data Foundation Cluster containing PVs participating in active replication either as a source or destination requires OpenShift Data Foundation Advanced entitlement. This subscription should be active on both source and destination clusters.

To know how subscriptions for OpenShift Data Foundation work, see knowledgebase article on OpenShift Data Foundation subscriptions.

IMPORTANT

OpenShift Data Foundation deployed with Multus networking is not supported for Regional Disaster Recovery (Regional-DR) setups.

CHAPTER 3. METRO-DR SOLUTION FOR OPENSHIFT DATA FOUNDATION

This section of the guide provides details of the Metro Disaster Recovery (Metro-DR) steps and commands necessary to be able to failover an application from one OpenShift Container Platform cluster to another and then failback the same application to the original primary cluster. In this case the OpenShift Container Platform clusters will be created or imported using Red Hat Advanced Cluster Management (RHACM) and have distance limitations between the OpenShift Container Platform clusters of less than 10ms RTT latency.

The persistent storage for applications is provided by an external Red Hat Ceph Storage (RHCS) cluster stretched between the two locations with the OpenShift Container Platform instances connected to this storage cluster. An arbiter node with a storage monitor service is required at a third location (different location than where OpenShift Container Platform instances are deployed) to establish quorum for the RHCS cluster in the case of a site outage. This third location can be in the range of ~100ms RTT from the storage cluster connected to the OpenShift Container Platform instances.

This is a general overview of the Metro DR steps required to configure and execute OpenShift Disaster Recovery (ODR) capabilities using OpenShift Data Foundation and RHACM across two distinct OpenShift Container Platform clusters separated by distance. In addition to these two clusters called managed clusters, a third OpenShift Container Platform cluster is required that will be the Red Hat Advanced Cluster Management (RHACM) hub cluster.

IMPORTANT

You can now easily set up Metropolitan disaster recovery solutions for workloads based on OpenShift virtualization technology using OpenShift Data Foundation. For more information, see the knowledgebase article.

3.1. COMPONENTS OF METRO-DR SOLUTION

Metro-DR is composed of Red Hat Advanced Cluster Management for Kubernetes, Red Hat Ceph Storage and OpenShift Data Foundation components to provide application and data mobility across OpenShift Container Platform clusters.

Red Hat Advanced Cluster Management for Kubernetes

Red Hat Advanced Cluster Management (RHACM) provides the ability to manage multiple clusters and application lifecycles. Hence, it serves as a control plane in a multi-cluster environment.

RHACM is split into two parts:

- RHACM Hub: components that run on the multi-cluster control plane.
- Managed clusters: components that run on the clusters that are managed.

For more information about this product, see RHACM documentation and the RHACM “Manage Applications” documentation.

Red Hat Ceph Storage

Red Hat Ceph Storage is a massively scalable, open, software-defined storage platform that combines the most stable version of the Ceph storage system with a Ceph management platform, deployment utilities, and support services. It significantly lowers the cost of storing enterprise data and helps organizations manage exponential data growth. The software is a robust and modern petabyte-scale storage platform for public or private cloud deployments.

For more product information, see Red Hat Ceph Storage .

OpenShift Data Foundation

OpenShift Data Foundation provides the ability to provision and manage storage for stateful applications in an OpenShift Container Platform cluster. It is backed by Ceph as the storage provider, whose lifecycle is managed by Rook in the OpenShift Data Foundation component stack and Ceph-CSI provides the provisioning and management of Persistent Volumes for stateful applications.

OpenShift DR

OpenShift DR is a disaster recovery orchestrator for stateful applications across a set of peer OpenShift clusters which are deployed and managed using RHACM and provides cloud-native interfaces to orchestrate the life-cycle of an application's state on Persistent Volumes. These include:

- Protecting an application and its state relationship across OpenShift clusters
- Failing over an application and its state to a peer cluster
- Relocate an application and its state to the previously deployed cluster

OpenShift DR is split into three components:

- **ODF Multicluster Orchestrator**: Installed on the multi-cluster control plane (RHACM Hub), it orchestrates configuration and peering of OpenShift Data Foundation clusters for Metro and Regional DR relationships.
- **OpenShift DR Hub Operator**: Automatically installed as part of ODF Multicluster Orchestrator installation on the hub cluster to orchestrate failover or relocation of DR enabled applications.
- **OpenShift DR Cluster Operator**: Automatically installed on each managed cluster that is part of a Metro and Regional DR relationship to manage the lifecycle of all PVCs of an application.

3.2. METRO-DR DEPLOYMENT WORKFLOW

This section provides an overview of the steps required to configure and deploy Metro-DR capabilities using the latest versions of Red Hat OpenShift Data Foundation, Red Hat Ceph Storage (RHCS) and Red Hat Advanced Cluster Management for Kubernetes (RHACM) version 2.10 or later, across two distinct OpenShift Container Platform clusters. In addition to two managed clusters, a third OpenShift Container Platform cluster will be required to deploy the Advanced Cluster Management.

To configure your infrastructure, perform the below steps in the order given:

1. Ensure requirements across the Hub, Primary and Secondary Openshift Container Platform clusters that are part of the DR solution are met. See Requirements for enabling Metro-DR.
2. Ensure you meet the requirements for deploying Red Hat Ceph Storage stretch cluster with arbiter. See Requirements for deploying Red Hat Ceph Storage .
3. Deploy and configure Red Hat Ceph Storage stretch mode. For instructions on enabling Ceph cluster on two different data centers using stretched mode functionality, see Deploying Red Hat Ceph Storage.
4. Install OpenShift Data Foundation operator and create a storage system on Primary and Secondary managed clusters. See Installing OpenShift Data Foundation on managed clusters .

5. Install the ODF Multicluster Orchestrator on the Hub cluster. See Installing ODF Multicluster Orchestrator on Hub cluster.

6. Configure SSL access between the Hub, Primary and Secondary clusters. See Configuring SSL access across clusters.

7. Create a DRPolicy resource for use with applications requiring DR protection across the Primary and Secondary clusters. See Creating Disaster Recovery Policy on Hub cluster .

   NOTE

   The Metro-DR solution can only have one DRpolicy.

8. Testing your disaster recovery solution with:

   a. **Subscription-based** application:

      - Create sample applications. See Creating sample application.

      - Test failover and relocate operations using the sample application between managed clusters. See Subscription-based application failover and relocating subscription-based application.

   b. **ApplicationSet-based** application:

      - Create sample applications. See Creating ApplicationSet-based applications.

      - Test failover and relocate operations using the sample application between managed clusters. See ApplicationSet-based application failover and relocating ApplicationSet-based application.

   c. **Discovered applications**

      - Ensure all requirements mentioned in Prerequisites is addressed. See Prerequisites for disaster recovery protection of discovered applications

      - Create a sample discovered application. See Creating a sample discovered application

      - Enroll the discovered application. See Enrolling a sample discovered application for disaster recovery protection

      - Test failover and relocate. See Discovered application failover and relocate

3.3. REQUIREMENTS FOR ENABLING METRO-DR

The prerequisites to installing a disaster recovery solution supported by Red Hat OpenShift Data Foundation are as follows:

- You must have the following OpenShift clusters that have network reachability between them:

  - **Hub cluster** where Red Hat Advanced Cluster Management (RHACM) for Kubernetes operator are installed.

  - **Primary managed cluster** where OpenShift Data Foundation is running.

  - **Secondary managed cluster** where OpenShift Data Foundation is running.

NOTE

For configuring hub recovery setup, you need a 4th cluster which acts as the passive hub. The primary managed cluster (Site-1) can be co-situated with the active RHACM hub cluster while the passive hub cluster is situated along with the secondary managed cluster (Site-2). Alternatively, the active RHACM hub cluster can be placed in a neutral site (Site-3) that is not impacted by the failures of either of the primary managed cluster at Site-1 or the secondary cluster at Site-2. In this situation, if a passive hub cluster is used it can be placed with the secondary cluster at Site-2. For more information, see Configuring passive hub cluster for hub recovery.

Hub recovery is a Technology Preview feature and is subject to Technology Preview support limitations.

- Ensure that RHACM operator and MultiClusterHub is installed on the Hub cluster. See RHACM installation guide for instructions.
  After the operator is successfully installed, a popover with a message that the Web console update is available appears on the user interface. Click **Refresh web console** from this popover for the console changes to reflect.

IMPORTANT

Ensure that application traffic routing and redirection are configured appropriately.

- On the Hub cluster
  - Navigate to **All Clusters** → **Infrastructure** → **Clusters**.
  - Import or create the **Primary managed cluster** and the **Secondary managed cluster** using the RHACM console.
  - Choose the appropriate options for your environment.

  After the managed clusters are successfully created or imported, you can see the list of clusters that were imported or created on the console. For instructions, see Creating a cluster and Importing a target managed cluster to the hub cluster .

WARNING

The Openshift Container Platform managed clusters and the Red Hat Ceph Storage (RHCS) nodes have distance limitations. The network latency between the sites must be below 10 milliseconds round-trip time (RTT).

3.4. REQUIREMENTS FOR DEPLOYING RED HAT CEPH STORAGE STRETCH CLUSTER WITH ARBITER

Red Hat Ceph Storage is an open-source enterprise platform that provides unified software-defined storage on standard, economical servers and disks. With block, object, and file storage combined into one platform, Red Hat Ceph Storage efficiently and automatically manages all your data, so you can focus on the applications and workloads that use it.

This section provides a basic overview of the Red Hat Ceph Storage deployment. For more complex deployment, refer to the official documentation guide for Red Hat Ceph Storage 7 .

NOTE

Only Flash media is supported since it runs with **min_size=1** when degraded. Use stretch mode only with all-flash OSDs. Using all-flash OSDs minimizes the time needed to recover once connectivity is restored, thus minimizing the potential for data loss.

IMPORTANT

Erasure coded pools cannot be used with stretch mode.

3.4.1. Hardware requirements

For information on minimum hardware requirements for deploying Red Hat Ceph Storage, see Minimum hardware recommendations for containerized Ceph.

Table 3.1. Physical server locations and Ceph component layout for Red Hat Ceph Storage cluster deployment:

Node name	Datacenter	Ceph components
ceph1	DC1	OSD+MON+MGR
ceph2	DC1	OSD+MON
ceph3	DC1	OSD+MDS+RGW
ceph4	DC2	OSD+MON+MGR
ceph5	DC2	OSD+MON
ceph6	DC2	OSD+MDS+RGW
ceph7	DC3	MON

3.4.2. Software requirements

Use the latest software version of **Red Hat Ceph Storage 7**.

For more information on the supported Operating System versions for Red Hat Ceph Storage, see knowledgebase article on Red Hat Ceph Storage: Supported configurations .

3.4.3. Network configuration requirements

The recommended Red Hat Ceph Storage configuration is as follows:

- You must have two separate networks, one public network and one private network.

- You must have three different datacenters that support VLANS and subnets for Cephs private and public network for all datacenters.

  NOTE

  You can use different subnets for each of the datacenters.

- The latencies between the two datacenters running the Red Hat Ceph Storage Object Storage Devices (OSDs) cannot exceed 10 ms RTT. For the **arbiter** datacenter, this was tested with values as high up to 100 ms RTT to the other two OSD datacenters.

Here is an example of a basic network configuration that we have used in this guide:

- **DC1: Ceph public/private network:** 10.0.40.0/24
- **DC2: Ceph public/private network:** 10.0.40.0/24
- **DC3: Ceph public/private network:** 10.0.40.0/24

For more information on the required network environment, see Ceph network configuration .

3.5. DEPLOYING RED HAT CEPH STORAGE

3.5.1. Node pre-deployment steps

Before installing the Red Hat Ceph Storage Ceph cluster, perform the following steps to fulfill all the requirements needed.

1. Register all the nodes to the Red Hat Network or Red Hat Satellite and subscribe to a valid pool:

   ```
   subscription-manager register
   subscription-manager subscribe --pool=8a8XXXXXX9e0
   ```

2. Enable access for all the nodes in the Ceph cluster for the following repositories:

   - **rhel9-for-x86_64-baseos-rpms**
   - **rhel9-for-x86_64-appstream-rpms**

     ```
     subscription-manager repos --disable="*" --enable="rhel9-for-x86_64-baseos-rpms" --
     enable="rhel9-for-x86_64-appstream-rpms"
     ```

3. Update the operating system RPMs to the latest version and reboot if needed:

   ```
   dnf update -y
   reboot
   ```

4. Select a node from the cluster to be your bootstrap node. **ceph1** is our bootstrap node in this example going forward.
   Only on the bootstrap node **ceph1**, enable the **ansible-2.9-for-rhel-9-x86_64-rpms** and **rhceph-6-tools-for-rhel-9-x86_64-rpms** repositories:

```
subscription-manager repos --enable="ansible-2.9-for-rhel-9-x86_64-rpms" --
enable="rhceph-6-tools-for-rhel-9-x86_64-rpms"
```

5. Configure the **hostname** using the bare/short hostname in all the hosts.

   ```
   hostnamectl set-hostname <short_name>
   ```

6. Verify the hostname configuration for deploying Red Hat Ceph Storage with cephadm.

   ```
   $ hostname
   ```

   Example output:

   ```
   ceph1
   ```

7. Modify /etc/hosts file and add the fqdn entry to the 127.0.0.1 IP by setting the DOMAIN variable with our DNS domain name.

   ```
   DOMAIN="example.domain.com"

   cat <<EOF >/etc/hosts
   127.0.0.1 $(hostname).${DOMAIN} $(hostname) localhost localhost.localdomain localhost4
   localhost4.localdomain4
   ::1       $(hostname).${DOMAIN} $(hostname) localhost6 localhost6.localdomain6
   EOF
   ```

8. Check the long hostname with the **fqdn** using the **hostname -f** option.

   ```
   $ hostname -f
   ```

   Example output:

   ```
   ceph1.example.domain.com
   ```

   NOTE

   To know more about why these changes are required, see Fully Qualified Domain Names vs Bare Host Names.

9. Run the following steps on the bootstrap node. In our example, the bootstrap node is **ceph1**.

   a. Install the **cephadm-ansible** RPM package:

      ```
      $ sudo dnf install -y cephadm-ansible
      ```

      IMPORTANT

      To run the ansible playbooks, you must have **ssh** passwordless access to all the nodes that are configured to the Red Hat Ceph Storage cluster. Ensure that the configured user (for example, **deployment-user**) has root privileges to invoke the **sudo** command without needing a password.

b. To use a custom key, configure the selected user (for example, **deployment-user**) ssh config file to specify the id/key that will be used for connecting to the nodes via ssh:

```
cat <<EOF > ~/.ssh/config
Host ceph*
   User deployment-user
   IdentityFile ~/.ssh/ceph.pem
EOF
```

c. Build the ansible inventory

```
cat <<EOF > /usr/share/cephadm-ansible/inventory
ceph1
ceph2
ceph3
ceph4
ceph5
ceph6
ceph7
[admin]
ceph1
ceph4
EOF
```

NOTE

Here, the Hosts (**Ceph1** and **Ceph4**) belonging to two different data centers are configured as part of the [admin] group on the inventory file and are tagged as **_admin** by **cephadm**. Each of these admin nodes receive the admin ceph keyring during the bootstrap process so that when one data center is down, we can check using the other available admin node.

d. Verify that **ansible** can access all nodes using the ping module before running the pre-flight playbook.

```
$ ansible -i /usr/share/cephadm-ansible/inventory -m ping all -b
```

Example output:

```
ceph6 | SUCCESS => {
    "ansible_facts": {
        "discovered_interpreter_python": "/usr/libexec/platform-python"
    },
    "changed": false,
    "ping": "pong"
}
ceph4 | SUCCESS => {
    "ansible_facts": {
        "discovered_interpreter_python": "/usr/libexec/platform-python"
    },
    "changed": false,
    "ping": "pong"
}
ceph3 | SUCCESS => {
    "ansible_facts": {
        "discovered_interpreter_python": "/usr/libexec/platform-python"
    },
    "changed": false,
    "ping": "pong"
}
ceph2 | SUCCESS => {
    "ansible_facts": {
        "discovered_interpreter_python": "/usr/libexec/platform-python"
    },
    "changed": false,
    "ping": "pong"
}
ceph5 | SUCCESS => {
    "ansible_facts": {
        "discovered_interpreter_python": "/usr/libexec/platform-python"
    },
    "changed": false,
    "ping": "pong"
}
ceph1 | SUCCESS => {
    "ansible_facts": {
        "discovered_interpreter_python": "/usr/libexec/platform-python"
    },
    "changed": false,
    "ping": "pong"
}
ceph7 | SUCCESS => {
    "ansible_facts": {
        "discovered_interpreter_python": "/usr/libexec/platform-python"
    },
    "changed": false,
    "ping": "pong"
}
```

e. Navigate to the **/usr/share/cephadm-ansible** directory.

f. Run ansible-playbook with relative file paths.

```
$ ansible-playbook -i /usr/share/cephadm-ansible/inventory /usr/share/cephadm-ansible/cephadm-preflight.yml --extra-vars "ceph_origin=rhcs"
```

The preflight playbook Ansible playbook configures the RHCS **dnf** repository and prepares the storage cluster for bootstrapping. It also installs podman, lvm2, chronyd, and cephadm. The default location for **cephadm-ansible** and **cephadm-preflight.yml** is **/usr/share/cephadm-ansible**. For additional information, see Running the preflight playbook

3.5.2. Cluster bootstrapping and service deployment with cephadm utility

The cephadm utility installs and starts a single Ceph Monitor daemon and a Ceph Manager daemon for a new Red Hat Ceph Storage cluster on the local node where the cephadm bootstrap command is run.

In this guide we are going to bootstrap the cluster and deploy all the needed Red Hat Ceph Storage services in one step using a cluster specification yaml file.

If you find issues during the deployment, it may be easier to troubleshoot the errors by dividing the deployment into two steps:

1. Bootstrap

2. Service deployment

NOTE

For additional information on the bootstrapping process, see Bootstrapping a new storage cluster.

Procedure

1. Create json file to authenticate against the container registry using a json file as follows:

```
$ cat <<EOF > /root/registry.json
{
 "url":"registry.redhat.io",
 "username":"User",
 "password":"Pass"
}
EOF
```

2. Create a **cluster-spec.yaml** that adds the nodes to the Red Hat Ceph Storage cluster and also sets specific labels for where the services should run following table 3.1.

```
cat <<EOF > /root/cluster-spec.yaml
service_type: host
addr: 10.0.40.78  ## <XXX.XXX.XXX.XXX>
hostname: ceph1   ##  <ceph-hostname-1>
location:
  root: default
  datacenter: DC1
labels:
  - osd
  - mon
  - mgr
---
service_type: host
addr: 10.0.40.35
hostname: ceph2
location:
  datacenter: DC1
labels:
  - osd
  - mon
---
service_type: host
addr: 10.0.40.24
hostname: ceph3
location:
  datacenter: DC1
labels:
  - osd
  - mds
  - rgw
---
service_type: host
addr: 10.0.40.185
hostname: ceph4
location:
  root: default
  datacenter: DC2
labels:
  - osd
  - mon
  - mgr
---
service_type: host
addr: 10.0.40.88
hostname: ceph5
location:
  datacenter: DC2
labels:
  - osd
  - mon
---
service_type: host
addr: 10.0.40.66
hostname: ceph6
location:
  datacenter: DC2
labels:
  - osd
  - mds
  - rgw
---
service_type: host
addr: 10.0.40.221
hostname: ceph7
labels:
  - mon
---
service_type: mon
placement:
  label: "mon"
---
service_type: mds
service_id: cephfs
placement:
  label: "mds"
---
service_type: mgr
service_name: mgr
placement:
  label: "mgr"
---
service_type: osd
service_id: all-available-devices
service_name: osd.all-available-devices
```

```
placement:
  label: "osd"
spec:
  data_devices:
    all: true
---
service_type: rgw
service_id: objectgw
service_name: rgw.objectgw
placement:
  count: 2
  label: "rgw"
spec:
  rgw_frontend_port: 8080
EOF
```

3. Retrieve the IP for the NIC with the Red Hat Ceph Storage public network configured from the bootstrap node. After substituting **10.0.40.0** with the subnet that you have defined in your ceph public network, execute the following command.

```
$ ip a | grep 10.0.40
```

Example output:

```
10.0.40.78
```

4. Run the **cephadm** bootstrap command as the **root** user on the node that will be the initial Monitor node in the cluster. The **IP_ADDRESS** option is the node's IP address that you are using to run the **cephadm bootstrap** command.

NOTE

If you have configured a different user instead of **root** for passwordless SSH access, then use the **--ssh-user=** flag with the **cepadm bootstrap** command.

If you are using non default/id_rsa ssh key names, then use **--ssh-private-key** and **--ssh-public-key** options with **cephadm** command.

```
$ cephadm  bootstrap --ssh-user=deployment-user --mon-ip 10.0.40.78 --apply-spec
/root/cluster-spec.yaml --registry-json /root/registry.json
```

IMPORTANT

If the local node uses fully-qualified domain names (FQDN), then add the **--allow-fqdn-hostname** option to **cephadm bootstrap** on the command line.

Once the bootstrap finishes, you will see the following output from the previous cephadm bootstrap command:

```
You can access the Ceph CLI with:

 sudo /usr/sbin/cephadm shell --fsid dd77f050-9afe-11ec-a56c-029f8148ea14 -c
```

```
/etc/ceph/ceph.conf -k /etc/ceph/ceph.client.admin.keyring

Consider enabling telemetry to help improve Ceph:

 ceph telemetry on

For more information see:

 https://docs.ceph.com/docs/pacific/mgr/telemetry/
```

5. Verify the status of Red Hat Ceph Storage cluster deployment using the Ceph CLI client from ceph1:

```
$ ceph -s
```

Example output:

```
cluster:
  id:     3a801754-e01f-11ec-b7ab-005056838602
  health: HEALTH_OK

services:
  mon: 5 daemons, quorum ceph1,ceph2,ceph4,ceph5,ceph7 (age 4m)
  mgr: ceph1.khuuot(active, since 5m), standbys: ceph4.zotfsp
  osd: 12 osds: 12 up (since 3m), 12 in (since 4m)
  rgw: 2 daemons active (2 hosts, 1 zones)

data:
  pools:   5 pools, 107 pgs
  objects: 191 objects, 5.3 KiB
  usage:   105 MiB used, 600 GiB / 600 GiB avail
           105 active+clean
```

NOTE

It may take several minutes for all the services to start.

It is normal to get a global recovery event while you do not have any OSDs configured.

You can use **ceph orch ps** and **ceph orch ls** to further check the status of the services.

6. Verify if all the nodes are part of the **cephadm** cluster.

```
$ ceph orch host ls
```

Example output:

```
HOST   ADDR         LABELS  STATUS
ceph1  10.0.40.78    _admin osd mon mgr
ceph2  10.0.40.35    osd mon
ceph3  10.0.40.24    osd mds rgw
ceph4  10.0.40.185   osd mon mgr
```

```
ceph5  10.0.40.88    osd mon
ceph6  10.0.40.66    osd mds rgw
ceph7  10.0.40.221   mon
```

NOTE

You can run Ceph commands directly from the host because **ceph1** was configured in the **cephadm-ansible** inventory as part of the [admin] group. The Ceph admin keys were copied to the host during the **cephadm bootstrap** process.

7. Check the current placement of the Ceph monitor services on the datacenters.

```
$ ceph orch ps | grep mon | awk '{print $1 " " $2}'
```

Example output:

```
mon.ceph1 ceph1
mon.ceph2 ceph2
mon.ceph4 ceph4
mon.ceph5 ceph5
mon.ceph7 ceph7
```

8. Check the current placement of the Ceph manager services on the datacenters.

```
$ ceph orch ps | grep mgr | awk '{print $1 " " $2}'
```

Example output:

```
mgr.ceph2.ycgwyz ceph2
mgr.ceph5.kremtt ceph5
```

9. Check the ceph osd crush map layout to ensure that each host has one OSD configured and its status is **UP**. Also, double-check that each node is under the right datacenter bucket as specified in table 3.1

```
$ ceph osd tree
```

Example output:

```
ID   CLASS  WEIGHT   TYPE NAME           STATUS  REWEIGHT  PRI-AFF
-1          0.87900  root default
-16         0.43950      datacenter DC1
-11         0.14650          host ceph1
  2   ssd   0.14650              osd.2       up   1.00000  1.00000
 -3         0.14650          host ceph2
  3   ssd   0.14650              osd.3       up   1.00000  1.00000
-13         0.14650          host ceph3
  4   ssd   0.14650              osd.4       up   1.00000  1.00000
-17         0.43950      datacenter DC2
 -5         0.14650          host ceph4
  0   ssd   0.14650              osd.0       up   1.00000  1.00000
 -9         0.14650          host ceph5
```

```
  1    ssd  0.14650            osd.1      up   1.00000  1.00000
 -7         0.14650        host ceph6
  5    ssd  0.14650            osd.5      up   1.00000  1.00000
```

10. Create and enable a new RDB block pool.

```
$ ceph osd pool create 32 32
$ ceph osd pool application enable rbdpool rbd
```

NOTE

The number 32 at the end of the command is the number of PGs assigned to this pool. The number of PGs can vary depending on several factors like the number of OSDs in the cluster, expected % used of the pool, etc. You can use the following calculator to determine the number of PGs needed: Ceph Placement Groups (PGs) per Pool Calculator.

11. Verify that the RBD pool has been created.

```
$ ceph osd lspools | grep rbdpool
```

Example output:

```
 3 rbdpool
```

12. Verify that MDS services are active and have located one service on each datacenter.

```
$ ceph orch ps | grep mds
```

Example output:

```
mds.cephfs.ceph3.cjpbqo    ceph3            running (17m)   117s ago  17m    16.1M        -
16.2.9
mds.cephfs.ceph6.lqmgqt    ceph6            running (17m)   117s ago  17m    16.1M        -
16.2.9
```

13. Create the CephFS volume.

```
$ ceph fs volume create cephfs
```

NOTE

The **ceph fs volume create** command also creates the needed data and meta CephFS pools. For more information, see Configuring and Mounting Ceph File Systems.

14. Check the **Ceph** status to verify how the MDS daemons have been deployed. Ensure that the state is active where **ceph6** is the primary MDS for this filesystem and **ceph3** is the secondary MDS.

```
$ ceph fs status
```

Example output:

```
cephfs - 0 clients
======
RANK  STATE         MDS           ACTIVITY     DNS    INOS   DIRS   CAPS
 0    active  cephfs.ceph6.ggjywj  Reqs:    0 /s    10     13     12      0
        POOL           TYPE     USED  AVAIL
cephfs.cephfs.meta  metadata  96.0k   284G
cephfs.cephfs.data    data       0    284G
    STANDBY MDS
cephfs.ceph3.ogcqkl
```

15. Verify that RGW services are active.

```
$ ceph orch ps | grep rgw
```

Example output:

```
rgw.objectgw.ceph3.kkmxgb  ceph3  *:8080       running (7m)      3m ago   7m    52.7M        -
16.2.9
rgw.objectgw.ceph6.xmnpah  ceph6  *:8080       running (7m)      3m ago   7m    53.3M        -
16.2.9
```

3.5.3. Configuring Red Hat Ceph Storage stretch mode

Once the Red Hat Ceph Storage cluster is fully deployed using **cephadm**, use the following procedure to configure the stretch cluster mode. The new stretch mode is designed to handle the 2-site case.

Procedure

1. Check the current election strategy being used by the monitors with the ceph mon dump command. By default in a ceph cluster, the connectivity is set to classic.

```
ceph mon dump | grep election_strategy
```

Example output:

```
dumped monmap epoch 9
election_strategy: 1
```

2. Change the monitor election to connectivity.

```
ceph mon set election_strategy connectivity
```

3. Run the previous ceph mon dump command again to verify the election_strategy value.

```
$ ceph mon dump | grep election_strategy
```

Example output:

```
dumped monmap epoch 10
election_strategy: 3
```

To know more about the different election strategies, see Configuring monitor election strategy.

4. Set the location for all our Ceph monitors:

```
ceph mon set_location ceph1 datacenter=DC1
ceph mon set_location ceph2 datacenter=DC1
ceph mon set_location ceph4 datacenter=DC2
ceph mon set_location ceph5 datacenter=DC2
ceph mon set_location ceph7 datacenter=DC3
```

5. Verify that each monitor has its appropriate location.

```
$ ceph mon dump
```

Example output:

```
epoch 17
fsid dd77f050-9afe-11ec-a56c-029f8148ea14
last_changed 2022-03-04T07:17:26.913330+0000
created 2022-03-03T14:33:22.957190+0000
min_mon_release 16 (pacific)
election_strategy: 3
0: [v2:10.0.143.78:3300/0,v1:10.0.143.78:6789/0] mon.ceph1; crush_location
{datacenter=DC1}
1: [v2:10.0.155.185:3300/0,v1:10.0.155.185:6789/0] mon.ceph4; crush_location
{datacenter=DC2}
2: [v2:10.0.139.88:3300/0,v1:10.0.139.88:6789/0] mon.ceph5; crush_location
{datacenter=DC2}
3: [v2:10.0.150.221:3300/0,v1:10.0.150.221:6789/0] mon.ceph7; crush_location
{datacenter=DC3}
4: [v2:10.0.155.35:3300/0,v1:10.0.155.35:6789/0] mon.ceph2; crush_location
{datacenter=DC1}
```

6. Create a CRUSH rule that makes use of this OSD crush topology by installing the **ceph-base** RPM package in order to use the **crushtool** command:

```
$ dnf -y install ceph-base
```

To know more about CRUSH ruleset, see Ceph CRUSH ruleset .

7. Get the compiled CRUSH map from the cluster:

```
$ ceph osd getcrushmap > /etc/ceph/crushmap.bin
```

8. Decompile the CRUSH map and convert it to a text file in order to be able to edit it:

```
$ crushtool -d /etc/ceph/crushmap.bin -o /etc/ceph/crushmap.txt
```

9. Add the following rule to the CRUSH map by editing the text file **/etc/ceph/crushmap.txt** at the end of the file.

```
$ vim /etc/ceph/crushmap.txt
```

```
rule stretch_rule {
        id 1
        type replicated
        min_size 1
        max_size 10
        step take default
        step choose firstn 0 type datacenter
        step chooseleaf firstn 2 type host
        step emit
}
# end crush map
```

This example is applicable for active applications in both OpenShift Container Platform clusters.

NOTE

The rule **id** has to be unique. In the example, we only have one more crush rule with id 0 hence we are using id 1. If your deployment has more rules created, then use the next free id.

The CRUSH rule declared contains the following information:

- **Rule name**
  - Description: A unique whole name for identifying the rule.
  - Value: **stretch_rule**
- **id**
  - Description: A unique whole number for identifying the rule.
  - Value: **1**
- **type**
  - Description: Describes a rule for either a storage drive replicated or erasure-coded.
  - Value: **replicated**
- **min_size**
  - Description: If a pool makes fewer replicas than this number, CRUSH will not select this rule.
  - Value: 1
- **max_size**
  - Description: If a pool makes more replicas than this number, CRUSH will not select this rule.
  - Value: 10
- **step take default**
  - Description: Takes the root bucket called **default**, and begins iterating down the tree.

- Description: Takes the root bucket called **default**, and begins iterating down the tree.

- **step choose firstn 0 type datacenter**
  - Description: Selects the datacenter bucket, and goes into its subtrees.
- **step chooseleaf firstn 2 type host**
  - Description: Selects the number of buckets of the given type. In this case, it is two different hosts located in the datacenter it entered at the previous level.
- **step emit**
  - Description: Outputs the current value and empties the stack. Typically used at the end of a rule, but may also be used to pick from different trees in the same rule.

10. Compile the new CRUSH map from the file **/etc/ceph/crushmap.txt** and convert it to a binary file called **/etc/ceph/crushmap2.bin**:

```
$ crushtool -c /etc/ceph/crushmap.txt -o /etc/ceph/crushmap2.bin
```

11. Inject the new crushmap we created back into the cluster:

```
$ ceph osd setcrushmap -i /etc/ceph/crushmap2.bin
```

Example output:

```
17
```

NOTE

The number 17 is a counter and it will increase (18,19, and so on) depending on the changes you make to the crush map.

12. Verify that the stretched rule created is now available for use.

```
ceph osd crush rule ls
```

Example output:

```
replicated_rule
stretch_rule
```

13. Enable the stretch cluster mode.

```
$ ceph mon enable_stretch_mode ceph7 stretch_rule datacenter
```

In this example, **ceph7** is the arbiter node, **stretch_rule** is the crush rule we created in the previous step and **datacenter** is the dividing bucket.

14. Verify all our pools are using the **stretch_rule** CRUSH rule we have created in our Ceph cluster:

```
$ for pool in $(rados lspools);do echo -n "Pool: ${pool}; ";ceph osd pool get ${pool}
crush_rule;done
```

Example output:

```
Pool: device_health_metrics; crush_rule: stretch_rule
Pool: cephfs.cephfs.meta; crush_rule: stretch_rule
Pool: cephfs.cephfs.data; crush_rule: stretch_rule
Pool: .rgw.root; crush_rule: stretch_rule
Pool: default.rgw.log; crush_rule: stretch_rule
Pool: default.rgw.control; crush_rule: stretch_rule
Pool: default.rgw.meta; crush_rule: stretch_rule
Pool: rbdpool; crush_rule: stretch_rule
```

This indicates that a working Red Hat Ceph Storage stretched cluster with arbiter mode is now available.

3.6. INSTALLING OPENSHIFT DATA FOUNDATION ON MANAGED CLUSTERS

To configure storage replication between the two OpenShift Container Platform clusters, OpenShift Data Foundation operator must be installed first on each managed cluster.

Prerequisites

- Ensure that you have met the hardware requirements for OpenShift Data Foundation external deployments. For a detailed description of the hardware requirements, see External mode requirements.

Procedure

1. Install and configure the latest **OpenShift Data Foundation** cluster on each of the managed clusters.

2. After installing the operator, create a StorageSystem using the option **Full deployment** type and **Connect with external storage platform** where your **Backing storage type** is **Red Hat Ceph Storage**.
   For detailed instructions, refer to Deploying OpenShift Data Foundation in external mode .

   Use the following flags with the **ceph-external-cluster-details-exporter.py** script.

   a. At a minimum, you must use the following three flags with the **ceph-external-cluster-details-exporter.py script**:

      --rbd-data-pool-name

      With the name of the RBD pool that was created during RHCS deployment for OpenShift Container Platform. For example, the pool can be called **rbdpool**.

      --rgw-endpoint

      Provide the endpoint in the format **<ip_address>:<port>**. It is the RGW IP of the RGW daemon running on the same site as the OpenShift Container Platform cluster that you are configuring.

      --run-as-user

      With a different client name for each site.

   b. The following flags are **optional** if default values were used during the RHCS deployment:

--cephfs-filesystem-name

With the name of the CephFS filesystem we created during RHCS deployment for OpenShift Container Platform, the default filesystem name is **cephfs**.

--cephfs-data-pool-name

With the name of the CephFS data pool we created during RHCS deployment for OpenShift Container Platform, the default pool is called **cephfs.data**.

--cephfs-metadata-pool-name

With the name of the CephFS metadata pool we created during RHCS deployment for OpenShift Container Platform, the default pool is called **cephfs.meta**.

c. Run the following command on the bootstrap node **ceph1**, to get the IP for the RGW endpoints in datacenter1 and datacenter2:

```
ceph orch ps | grep rgw.objectgw
```

Example output:

```
rgw.objectgw.ceph3.mecpzm  ceph3  *:8080       running (5d)     31s ago   7w     204M
-  16.2.7-112.el8cp
rgw.objectgw.ceph6.mecpzm  ceph6  *:8080       running (5d)     31s ago   7w     204M
-  16.2.7-112.el8cp
```

```
host ceph3.example.com
host ceph6.example.com
```

Example output:

```
ceph3.example.com has address 10.0.40.24
ceph6.example.com has address 10.0.40.66
```

d. Run the **ceph-external-cluster-details-exporter.py** with the parameters that are configured for the first OpenShift Container Platform managed cluster **cluster1** on bootstrapped node **ceph1**.

```
python3 ceph-external-cluster-details-exporter.py --rbd-data-pool-name rbdpool --cephfs-
filesystem-name cephfs --cephfs-data-pool-name cephfs.cephfs.data  --cephfs-metadata-
pool-name cephfs.cephfs.meta --<rgw-endpoint> XXX.XXX.XXX.XXX:8080 --run-as-user
client.odf.cluster1 > ocp-cluster1.json
```

NOTE

Modify the <rgw-endpoint> XXX.XXX.XXX.XXX according to your environment.

e. Run the **ceph-external-cluster-details-exporter.py** with the parameters that are configured for the first OpenShift Container Platform managed cluster **cluster2** on bootstrapped node **ceph1**.

```
python3 ceph-external-cluster-details-exporter.py --rbd-data-pool-name rbdpool --cephfs-
filesystem-name cephfs --cephfs-data-pool-name cephfs.cephfs.data  --cephfs-metadata-
pool-name cephfs.cephfs.meta --rgw-endpoint XXX.XXX.XXX.XXX:8080 --run-as-user
```

```
client.odf.cluster2 > ocp-cluster2.json
```

NOTE

Modify the <rgw-endpoint> XXX.XXX.XXX.XXX according to your environment.

- Save the two files generated in the bootstrap cluster (ceph1) **ocp-cluster1.json** and **ocp-cluster2.json** to your local machine.
- Use the contents of file **ocp-cluster1.json** on the OpenShift Container Platform console on **cluster1** where external OpenShift Data Foundation is being deployed.
- Use the contents of file **ocp-cluster2.json** on the OpenShift Container Platform console on **cluster2** where external OpenShift Data Foundation is being deployed.

3. Review the settings and then select **Create StorageSystem**.
4. Validate the successful deployment of OpenShift Data Foundation on each managed cluster with the following command:

   ```
   $ oc get storagecluster -n openshift-storage ocs-external-storagecluster -o
   jsonpath='{.status.phase}{"\n"}'
   ```

   For the Multicloud Gateway (MCG):

   ```
   $ oc get noobaa -n openshift-storage noobaa -o jsonpath='{.status.phase}{"\n"}'
   ```

   Wait for the status result to be Ready for both queries on the **Primary managed cluster** and the **Secondary managed cluster**.
5. On the OpenShift Web Console, navigate to **Installed Operators → OpenShift Data Foundation → Storage System → ocs-external-storagecluster-storagesystem → Resources**. Verify that the **Status** of **StorageCluster** is **Ready** and has a green tick mark next to it.
6. Enable read affinity for RBD and CephFS volumes to be served from the nearest datacenter.
   a. On the Primary managed cluster, label all the nodes.

      ```
      $ oc label nodes --all metro-dr.openshift-storage.topology.io/datacenter=DC1
      ```

      Execute the following commands to enable read affinity:

      ```
      $ oc patch storageclusters.ocs.openshift.io -n openshift-storage ocs-external-
      storagecluster -p '{"spec":{"csi":{"readAffinity":{"enabled":true,"crushLocationLabels":
      ["metro-dr.openshift-storage.topology.io/datacenter"]}}}}' --type=merge
      ```

      ```
      $ oc delete po -n openshift-storage -l 'app in (csi-cephfsplugin,csi-rbdplugin)'
      ```

   b. On the Secondary managed cluster, label all the nodes:

      ```
      $ oc label nodes --all metro-dr.openshift-storage.topology.io/datacenter=DC2
      ```

Execute the following commands to enable read affinity:

```
$ oc patch storageclusters.ocs.openshift.io -n openshift-storage ocs-external-
storagecluster -p '{"spec":{"csi":{"readAffinity":{"enabled":true,"crushLocationLabels":
["metro-dr.openshift-storage.topology.io/datacenter"]}}}}' --type=merge
```

```
$ oc delete po -n openshift-storage -l 'app in (csi-cephfsplugin,csi-rbdplugin)'
```

3.7. INSTALLING OPENSHIFT DATA FOUNDATION MULTICLUSTER ORCHESTRATOR OPERATOR

OpenShift Data Foundation Multicluster Orchestrator is a controller that is installed from OpenShift Container Platform’s OperatorHub on the Hub cluster.

Procedure

1. On the **Hub cluster**, navigate to **OperatorHub** and use the keyword filter to search for **ODF Multicluster Orchestrator**.

2. Click **ODF Multicluster Orchestrator** tile.

3. Keep all default settings and click **Install**.
   Ensure that the operator resources are installed in **openshift-operators** project and available to all namespaces.

   NOTE

   The **ODF Multicluster Orchestrator** also installs the **Openshift DR Hub Operator** on the RHACM hub cluster as a dependency.

4. Verify that the operator **Pods** are in a **Running** state. The **OpenShift DR Hub operator** is also installed at the same time in **openshift-operators** namespace.

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

   Example output:

   ```
   NAME                                   READY   STATUS      RESTARTS    AGE
   odf-multicluster-console-6845b795b9-blxrn   1/1     Running     0          4d20h
   odfmo-controller-manager-f9d9dfb59-jbrsd    1/1     Running     0          4d20h
   ramen-hub-operator-6fb887f885-fss4w         2/2     Running     0          4d20h
   ```

3.8. CONFIGURING SSL ACCESS ACROSS CLUSTERS

Configure network (SSL) access between the **primary and secondary clusters** so that metadata can be stored on the alternate cluster in a Multicloud Gateway (MCG) **object bucket** using a secure transport protocol and in the **Hub cluster** for verifying access to the object buckets.

NOTE

If all of your OpenShift clusters are deployed using a signed and valid set of certificates for your environment then this section can be skipped.

Procedure

1. Extract the ingress certificate for the Primary managed cluster and save the output to **primary.crt**.

   ```
   $ oc get cm default-ingress-cert -n openshift-config-managed -o jsonpath="{['data']['ca-bundle\.crt']}" > primary.crt
   ```

2. Extract the ingress certificate for the Secondary managed cluster and save the output to **secondary.crt**.

   ```
   $ oc get cm default-ingress-cert -n openshift-config-managed -o jsonpath="{['data']['ca-bundle\.crt']}" > secondary.crt
   ```

3. Create a new **ConfigMap** file to hold the remote cluster’s certificate bundle with filename **cm-clusters-crt.yaml**.

   NOTE

   There could be more or less than three certificates for each cluster as shown in this example file. Also, ensure that the certificate contents are correctly indented after you copy and paste from the **primary.crt** and **secondary.crt** files that were created before.

   ```
   apiVersion: v1
   data:
     ca-bundle.crt: |
       -----BEGIN CERTIFICATE-----
       <copy contents of cert1 from primary.crt here>
       -----END CERTIFICATE-----

       -----BEGIN CERTIFICATE-----
       <copy contents of cert2 from primary.crt here>
       -----END CERTIFICATE-----

       -----BEGIN CERTIFICATE-----
       <copy contents of cert3 primary.crt here>
       -----END CERTIFICATE----

       -----BEGIN CERTIFICATE-----
       <copy contents of cert1 from secondary.crt here>
       -----END CERTIFICATE-----

       -----BEGIN CERTIFICATE-----
       <copy contents of cert2 from secondary.crt here>
       -----END CERTIFICATE-----

       -----BEGIN CERTIFICATE-----
       <copy contents of cert3 from secondary.crt here>
   ```

```
    -----END CERTIFICATE-----
kind: ConfigMap
metadata:
  name: user-ca-bundle
  namespace: openshift-config
```

4. Create the **ConfigMap** on the **Primary managed cluster**, **Secondary managed cluster**, and the **Hub cluster**.

```
$ oc create -f cm-clusters-crt.yaml
```

Example output:

```
configmap/user-ca-bundle created
```

5. Patch default proxy resource on the **Primary managed cluster**, **Secondary managed cluster**, and the **Hub cluster**.

```
$ oc patch proxy cluster --type=merge  --patch='{"spec":{"trustedCA":{"name":"user-ca-bundle"}}}'
```

Example output:

```
proxy.config.openshift.io/cluster patched
```

3.9. CREATING DISASTER RECOVERY POLICY ON HUB CLUSTER

Openshift Disaster Recovery Policy (DRPolicy) resource specifies OpenShift Container Platform clusters participating in the disaster recovery solution and the desired replication interval. DRPolicy is a cluster scoped resource that users can apply to applications that require Disaster Recovery solution.

The **ODF MultiCluster Orchestrator** Operator facilitates the creation of each **DRPolicy** and the corresponding **DRClusters** through the **Multicluster Web console**.

Prerequisites

- Ensure that there is a minimum set of two managed clusters.

Procedure

1. On the **OpenShift console**, navigate to **All Clusters → Data Services → Disaster recovery**.

2. On the Overview tab, click **Create a disaster recovery policy**or you can navigate to Policies tab and click **Create DRPolicy**.

3. Enter **Policy name**. Ensure that each DRPolicy has a unique name (for example: **ocp4perf1-ocp4perf2**).

4. Select two clusters from the list of managed clusters to which this new policy will be associated with.

5. **Replication policy** is automatically set to **sync** based on the OpenShift clusters selected.

6. Click **Create**.

7. Verify that the **DRPolicy** is created successfully. Run this command on the **Hub cluster** for each of the DRPolicy resources created, where *<drpolicy_name>* is replaced with your unique name.

    ```
    $ oc get drpolicy <drpolicy_name> -o jsonpath='{.status.conditions[].reason}{"\n"}'
    ```

    Example output:

    ```
    Succeeded
    ```

    When a DRPolicy is created, along with it, two DRCluster resources are also created. It could take up to 10 minutes for all three resources to be validated and for the status to show as **Succeeded**.

    NOTE

    Editing of **SchedulingInterval**, **ReplicationClassSelector**, **VolumeSnapshotClassSelector** and **DRClusters** field values are not supported in the DRPolicy.

8. Verify the object bucket access from the **Hub cluster** to both the **Primary managed cluster** and the **Secondary managed cluster**.

    a. Get the names of the **DRClusters** on the Hub cluster.

    ```
    $ oc get drclusters
    ```

    Example output:

    ```
    NAME        AGE
    ocp4perf1   4m42s
    ocp4perf2   4m42s
    ```

    b. Check S3 access to each bucket created on each managed cluster. Use the DRCluster validation command, where *<drcluster_name>* is replaced with your unique name.

    NOTE

    Editing of **Region** and **S3ProfileName** field values are non supported in DRClusters.

    ```
    $ oc get drcluster <drcluster_name> -o jsonpath='{.status.conditions[2].reason}{"\n"}'
    ```

    Example output:

    ```
    Succeeded
    ```

    NOTE

    Make sure to run commands for both **DRClusters** on the **Hub cluster**.

9. Verify that the **OpenShift DR Cluster operator** installation was successful on the **Primary managed cluster** and the **Secondary managed cluster**.

```
$ oc get csv,pod -n openshift-dr-system
```

Example output:

```
NAME                                                                    DISPLAY                 VERSION
REPLACES   PHASE
clusterserviceversion.operators.coreos.com/odr-cluster-operator.v4.15.0         Openshift DR
Cluster Operator   4.15.0                  Succeeded
clusterserviceversion.operators.coreos.com/volsync-product.v0.8.0              VolSync
0.8.0                      Succeeded

NAME                                          READY   STATUS    RESTARTS   AGE
pod/ramen-dr-cluster-operator-6467cf5d4c-cc8kz   2/2     Running   0          3d12h
```

You can also verify that **OpenShift DR Cluster Operator** is installed successfully on the **OperatorHub** of each managed cluster.

10. Verify that the secret is propagated correctly on the Primary managed cluster and the Secondary managed cluster.

```
oc get secrets -n openshift-dr-system | grep Opaque
```

Match the output with the s3SecretRef from the Hub cluster:

```
oc get cm -n openshift-operators ramen-hub-operator-config -oyaml
```

3.10. CONFIGURE DRCLUSTERS FOR FENCING AUTOMATION

This configuration is required for enabling fencing prior to application failover. In order to prevent writes to the persistent volume from the cluster which is hit by a disaster, OpenShift DR instructs Red Hat Ceph Storage (RHCS) to fence the nodes of the cluster from the RHCS external storage. This section guides you on how to add the IPs or the IP Ranges for the nodes of the DRCluster.

3.10.1. Add node IP addresses to DRClusters

1. Find the **IP addresses** for all of the OpenShift nodes in the managed clusters by running this command in the **Primary managed cluster** and the **Secondary managed cluster**.

```
$ oc get nodes -o jsonpath='{range .items[*]}{.status.addresses[?
(@.type=="ExternalIP")].address}{"\n"}{end}'
```

Example output:

```
10.70.56.118
10.70.56.193
10.70.56.154
10.70.56.242
10.70.56.136
10.70.56.99
```

Once you have the **IP addresses** then the **DRCluster** resources can be modified for each managed cluster.

2. Find the **DRCluster** names on the Hub Cluster.

```
$ oc get drcluster
```

Example output:

```
NAME        AGE
ocp4perf1   5m35s
ocp4perf2   5m35s
```

3. Edit each **DRCluster** to add your unique IP addresses after replacing **<drcluster_name>** with your unique name.

```
$ oc edit drcluster <drcluster_name>
```

```
apiVersion: ramendr.openshift.io/v1alpha1
kind: DRCluster
metadata:
[...]
spec:
  s3ProfileName: s3profile-<drcluster_name>-ocs-external-storagecluster
  ## Add this section
  cidrs:
    -  <IP_Address1>/32
    -  <IP_Address2>/32
    -  <IP_Address3>/32
    -  <IP_Address4>/32
    -  <IP_Address5>/32
    -  <IP_Address6>/32
[...]
```

Example output:

```
drcluster.ramendr.openshift.io/ocp4perf1 edited
```

NOTE

There could be more than six IP addresses.

Modify this **DRCluster** configuration also for **IP addresses** on the **Secondary managed clusters** in the peer DRCluster resource (e.g., ocp4perf2).

3.10.2. Add fencing annotations to DRClusters

Add the following annotations to all the DRCluster resources. These annotations include details needed for the **NetworkFence** resource created later in these instructions (prior to testing application failover).

NOTE

Replace *<drcluster_name>* with your unique name.

```
$ oc edit drcluster <drcluster_name>
```

```
apiVersion: ramendr.openshift.io/v1alpha1
kind: DRCluster
metadata:
  ## Add this section
  annotations:
    drcluster.ramendr.openshift.io/storage-clusterid: openshift-storage
    drcluster.ramendr.openshift.io/storage-driver: openshift-storage.rbd.csi.ceph.com
    drcluster.ramendr.openshift.io/storage-secret-name: rook-csi-rbd-provisioner
    drcluster.ramendr.openshift.io/storage-secret-namespace: openshift-storage
[...]
```

Example output:

```
drcluster.ramendr.openshift.io/ocp4perf1 edited
```

Make sure to add these annotations for both **DRCluster** resources (for example: **ocp4perf1** and **ocp4perf2**).

3.11. CREATE SAMPLE APPLICATION FOR TESTING DISASTER RECOVERY SOLUTION

OpenShift Data Foundation disaster recovery (DR) solution supports disaster recovery for Subscription-based and ApplicationSet-based applications that are managed by RHACM. For more details, see Subscriptions and ApplicationSet documentation.

The following sections detail how to create an application and apply a DRPolicy to an application.

- Subscription-based applications
  OpenShift users that do not have cluster-admin permissions, see the knowledge article on how to assign necessary permissions to an application user for executing disaster recovery actions.

- ApplicationSet-based applications
  OpenShift users that do not have cluster-admin permissions cannot create ApplicationSet-based applications.

3.11.1. Subscription-based applications

3.11.1.1. Creating a sample Subscription-based application

In order to test **failover** from the **Primary managed cluster** to the **Secondary managed cluster** and **relocate**, we need a sample application.

Prerequisites

- When creating an application for general consumption, ensure that the application is deployed to ONLY one cluster.

- Use the sample application called **busybox** as an example.
- Ensure all external routes of the application are configured using either Global Traffic Manager (GTM) or Global Server Load Balancing (GLSB) service for traffic redirection when the application fails over or is relocated.
- As a best practice, group Red Hat Advanced Cluster Management (RHACM) subscriptions that belong together, refer to a single Placement Rule to DR protect them as a group. Further create them as a single application for a logical grouping of the subscriptions for future DR actions like failover and relocate.

NOTE

If unrelated subscriptions refer to the same Placement Rule for placement actions, they are also DR protected as the DR workflow controls all subscriptions that references the Placement Rule.

Procedure

1. On the Hub cluster, navigate to **Applications** and click **Create application**.
2. Select type as **Subscription**.
3. Enter your application **Name** (for example, **busybox**) and **Namespace** (for example, **busybox-sample**).
4. In the Repository location for resources section, select **Repository type Git**.
5. Enter the Git repository URL for the sample application, the github **Branch** and **Path** where the resources **busybox** Pod and PVC will be created.
   Use the sample application repository as **https://github.com/red-hat-storage/ocm-ramen-samples** where the **Branch** is **release-4.17** and **Path** is **busybox-odr-metro**.
6. Scroll down in the form until you see **Deploy application resources on clusters with all specified labels**.
   - Select the global **Cluster sets** or the one that includes the correct managed clusters for your environment.
   - Add a label *<name>* with its value set to the **managed cluster** name.
7. Click **Create** which is at the top right hand corner.
   On the follow-on screen go to the **Topology** tab. You should see that there are all Green checkmarks on the application topology.

   NOTE

   To get more information, click on any of the topology elements and a window will appear on the right of the topology view.

8. Validating the sample application deployment.
   Now that the **busybox** application has been deployed to your preferred Cluster, the deployment can be validated.

   Log in to your managed cluster where **busybox** was deployed by RHACM.

```
$ oc get pods,pvc -n busybox-sample
```

Example output:

```
NAME                          READY   STATUS    RESTARTS   AGE
pod/busybox-67bf494b9-zl5tr   1/1     Running   0          77s


NAME                              STATUS   VOLUME                                     CAPACITY   ACCESS
MODES   STORAGECLASS                  AGE
persistentvolumeclaim/busybox-pvc   Bound    pvc-c732e5fe-daaf-4c4d-99dd-462e04c18412
5Gi        RWO            ocs-storagecluster-ceph-rbd   77s
```

3.11.1.2. Apply Data policy to sample application

Prerequisites

- Ensure that both managed clusters referenced in the Data policy are reachable. If not, the application will not be protected for disaster recovery until both clusters are online.

Procedure

1. On the Hub cluster, navigate to **All Clusters → Applications**.
2. Click the Actions menu at the end of application to view the list of available actions.
3. Click **Manage data policy→ Assign data policy**.
4. Select **Policy** and click **Next**.
5. Select an **Application resource** and then use **PVC label selector** to select **PVC label** for the selected application resource.

   NOTE

   You can select more than one PVC label for the selected application resources. You can also use the **Add application resource** option to add multiple resources.

6. After adding all the application resources, click **Next**.
7. Review the **Policy configuration details** and click **Assign**. The newly assigned Data policy is displayed on the **Manage data policy** modal list view.
8. Verify that you can view the assigned policy details on the Applications page.
   a. On the Applications page, navigate to the **Data policy** column and click the **policy link** to expand the view.
   b. Verify that you can see the number of policies assigned along with failover and relocate status.
   c. Click **View more details** to view the status of ongoing activities with the policy in use with the application.

9. After you apply DRPolicy to the applications, confirm whether the **ClusterDataProtected** is set to **True** in the drpc yaml output.

3.11.2. ApplicationSet-based applications

3.11.2.1. Creating ApplicationSet-based applications

Prerequisite

- Ensure that the Red Hat OpenShift GitOps operator is installed on all three clusters: **Hub cluster**, **Primary managed cluster** and **Secondary managed cluster**. For instructions, see Installing Red Hat OpenShift GitOps Operator in web console .

- On the Hub cluster, ensure that both Primary and Secondary managed clusters are registered to GitOps. For registration instructions, see Registering managed clusters to GitOps . Then check if the Placement used by **GitOpsCluster** resource to register both managed clusters, has the tolerations to deal with cluster unavailability. You can verify if the following tolerations are added to the Placement using the command **oc get placement <placement-name> -n openshift-gitops -o yaml**.

  ```
  tolerations:
  - key: cluster.open-cluster-management.io/unreachable
    operator: Exists
  - key: cluster.open-cluster-management.io/unavailable
    operator: Exists
  ```

  In case the tolerations are not added, see Configuring application placement tolerations for Red Hat Advanced Cluster Management and OpenShift GitOps.

- Ensure that you have created the **ClusterRoleBinding** yaml on both the **Primary** and **Secondary managed** clusters. For instruction, see the Prerequisites chapter in RHACM documentation.

Procedure

1. On the Hub cluster, navigate to **All Clusters** → **Applications** and click **Create application**.

2. Choose the application type as **Argo CD ApplicationSet - Pull model**

3. In the **General** step, enter your **Application set name**.

4. Select **Argo server openshift-gitops** and **Requeue time** as **180** seconds.

5. Click **Next**.

6. In the Repository location for resources section, select **Repository type Git**.

7. Enter the Git repository URL for the sample application, the github Branch and Path where the resources busybox Pod and PVC will be created.

   a. Use the sample application repository as https://github.com/red-hat-storage/ocm-ramen-samples

   b. Select **Revision** as **release-4.17**

   c. Choose Path as **busybox-odr-metro**.

8. Enter **Remote namespace** value. (example, busybox-sample) and click **Next**.
9. Choose the **Sync policy** settings as per your requirement or go with the default selections, and then click **Next**.
   You can choose one or more options.
10. In Label expressions, add a label *<name>* with its value set to the **managed cluster** name.
11. Click **Next**.
12. Review the setting details and click **Submit**.

3.11.2.2. Apply Data policy to sample ApplicationSet-based application

Prerequisites

- Ensure that both managed clusters referenced in the Data policy are reachable. If not, the application will not be protected for disaster recovery until both clusters are online.

Procedure

1. On the Hub cluster, navigate to **All Clusters → Applications**.
2. Click the Actions menu at the end of application to view the list of available actions.
3. Click **Manage data policy→ Assign data policy**.
4. Select **Policy** and click **Next**.
5. Select an **Application resource** and then use **PVC label selector** to select **PVC label** for the selected application resource.

   > NOTE
   >
   > You can select more than one PVC label for the selected application resources.

6. After adding all the application resources, click **Next**.
7. Review the **Policy configuration details** and click **Assign**. The newly assigned Data policy is displayed on the **Manage data policy** modal list view.
8. Verify that you can view the assigned policy details on the Applications page.
   a. On the Applications page, navigate to the **Data policy** column and click the **policy link** to expand the view.
   b. Verify that you can see the number of policies assigned along with failover and relocate status.
9. After you apply DRPolicy to the applications, confirm whether the **ClusterDataProtected** is set to **True** in the drpc yaml output.

3.11.3. Deleting sample application

This section provides instructions for deleting the sample application **busybox** using the RHACM console.

IMPORTANT

When deleting a DR protected application, access to both clusters that belong to the DRPolicy is required. This is to ensure that all protected API resources and resources in the respective S3 stores are cleaned up as part of removing the DR protection. If access to one of the clusters is not healthy, deleting the **DRPlacementControl** resource for the application, on the hub, would remain in the Deleting state.

Prerequisites

- These instructions to delete the sample application should not be executed until the failover and relocate testing is completed and the application is ready to be removed from RHACM and the managed clusters.

Procedure

1. On the RHACM console, navigate to **Applications**.
2. Search for the sample application to be deleted (for example, **busybox**).
3. Click the Action Menu **(⋮)** next to the application you want to delete.
4. Click **Delete application**.
   When the **Delete application** is selected a new screen will appear asking if the application related resources should also be deleted.
5. Select **Remove application related resources**checkbox to delete the Subscription and PlacementRule.
6. Click **Delete**. This will delete the busybox application on the Primary managed cluster (or whatever cluster the application was running on).
7. In addition to the resources deleted using the RHACM console, delete the **DRPlacementControl** if it is not auto-deleted after deleting the **busybox** application.
   a. Log in to the OpenShift Web console for the Hub cluster and navigate to Installed Operators for the project **busybox-sample**.
      For ApplicationSet applications, select the project as **openshift-gitops**.
   b. Click **OpenShift DR Hub Operator** and then click the **DRPlacementControl** tab.
   c. Click the Action Menu **(⋮)** next to the **busybox** application DRPlacementControl that you want to delete.
   d. Click **Delete DRPlacementControl**.
   e. Click **Delete**.

NOTE

This process can be used to delete any application with a **DRPlacementControl** resource.

3.12. SUBSCRIPTION-BASED APPLICATION FAILOVER BETWEEN MANAGED CLUSTERS

Perform a failover when a managed cluster becomes unavailable, due to any reason. This failover method is application-based.

Prerequisites

- If your setup has active and passive RHACM hub clusters, see Hub recovery using Red Hat Advanced Cluster Management.
- When the primary cluster is in a state other than **Ready**, check the actual status of the cluster as it might take some time to update.
    1. Navigate to the **RHACM console → Infrastructure → Clusters → Cluster list**tab.
    2. Check the status of both the managed clusters individually before performing failover operation.
       However, failover operation can still be performed when the cluster you are failing over to is in a *Ready* state.

Procedure

1. Enable fencing on the **Hub cluster**.
    a. Open CLI terminal and edit the **DRCluster resource**, where *<drcluster_name>* is your unique name.

       CAUTION

       Once the managed cluster is fenced, **all** communication from applications to the OpenShift Data Foundation external storage cluster will fail and some **Pods** will be in an unhealthy state (for example: **CreateContainerError**, **CrashLoopBackOff**) on the cluster that is now fenced.

```
$ oc edit drcluster <drcluster_name>
```

```
apiVersion: ramendr.openshift.io/v1alpha1
kind: DRCluster
metadata:
[...]
spec:
  ## Add this line
  clusterFence: Fenced
  cidrs:
  [...]
[...]
```

Example output:

```
drcluster.ramendr.openshift.io/ocp4perf1 edited
```

b. Verify the fencing status on the **Hub cluster** for the **Primary managed cluster**, replacing <drcluster_name> is your unique identifier.

```
$ oc get drcluster.ramendr.openshift.io <drcluster_name> -o jsonpath='{.status.phase}
{"\n"}'
```

Example output:

```
Fenced
```

c. Login to your Ceph cluster and verify that the IPs that belong to the OpenShift Container Platform cluster nodes are now in the blocklist.

```
$ ceph osd blocklist ls
```

Example output

```
cidr:10.1.161.1:0/32 2028-10-30T22:30:03.585634+0000
cidr:10.1.161.14:0/32 2028-10-30T22:30:02.483561+0000
cidr:10.1.161.51:0/32 2028-10-30T22:30:01.272267+0000
cidr:10.1.161.63:0/32 2028-10-30T22:30:05.099655+0000
cidr:10.1.161.129:0/32 2028-10-30T22:29:58.335390+0000
cidr:10.1.161.130:0/32 2028-10-30T22:29:59.861518+0000
```

2. On the Hub cluster, navigate to **Applications**.

3. Click the **Actions** menu at the end of application row to view the list of available actions.

4. Click **Failover application**.

5. After the **Failover application** modal is shown, select **policy** and **target cluster** to which the associated application will failover in case of a disaster.

6. Click the **Select subscription group** dropdown to verify the default selection or modify this setting.
By default, the subscription group that replicates for the application resources is selected.

7. Check the status of the **Failover readiness**.

   - If the status is **Ready** with a green tick, it indicates that the target cluster is ready for failover to start. Proceed to step 7.

   - If the status is **Unknown** or **Not ready**, then wait until the status changes to **Ready**.

8. Click **Initiate**. The busybox application is now failing over to the **Secondary-managed cluster**.

9. Close the modal window and track the status using the **Data policy** column on the Applications page.

10. Verify that the activity status shows as **FailedOver** for the application.

    a. Navigate to the **Applications** → **Overview** tab.

b. In the **Data policy** column, click the **policy** link for the application you applied the policy to.

c. On the **Data policy** popover, click the **View more details** link.

3.13. APPLICATIONSET-BASED APPLICATION FAILOVER BETWEEN MANAGED CLUSTERS

Perform a failover when a managed cluster becomes unavailable, due to any reason. This failover method is application-based.

Prerequisites

- If your setup has active and passive RHACM hub clusters, see Hub recovery using Red Hat Advanced Cluster Management.

- When the primary cluster is in a state other than **Ready**, check the actual status of the cluster as it might take some time to update.

  1. Navigate to the **RHACM console → Infrastructure → Clusters → Cluster list**tab.

  2. Check the status of both the managed clusters individually before performing failover operation.
     However, failover operation can still be performed when the cluster you are failing over to is in a *Ready* state.

Procedure

1. Enable fencing on the **Hub cluster**.

   a. Open CLI terminal and edit the **DRCluster resource**, where *<drcluster_name>* is your unique name.

   #### CAUTION

   Once the managed cluster is fenced, **all** communication from applications to the OpenShift Data Foundation external storage cluster will fail and some **Pods** will be in an unhealthy state (for example: **CreateContainerError**, **CrashLoopBackOff**) on the cluster that is now fenced.

   ```
   $ oc edit drcluster <drcluster_name>
   ```

   ```
   apiVersion: ramendr.openshift.io/v1alpha1
   kind: DRCluster
   metadata:
   [...]
   spec:
     ## Add this line
     clusterFence: Fenced
     cidrs:
     [...]
   [...]
   ```

   Example output:

```
drcluster.ramendr.openshift.io/ocp4perf1 edited
```

b. Verify the fencing status on the **Hub cluster** for the **Primary managed cluster**, replacing <drcluster_name> is your unique identifier.

```
$ oc get drcluster.ramendr.openshift.io <drcluster_name> -o jsonpath='{.status.phase}
{"\n"}'
```

Example output:

```
Fenced
```

c. Login to your Ceph cluster and verify that the IPs that belong to the OpenShift Container Platform cluster nodes are now in the blocklist.

```
$ ceph osd blocklist ls
```

Example output

```
cidr:10.1.161.1:0/32 2028-10-30T22:30:03.585634+0000
cidr:10.1.161.14:0/32 2028-10-30T22:30:02.483561+0000
cidr:10.1.161.51:0/32 2028-10-30T22:30:01.272267+0000
cidr:10.1.161.63:0/32 2028-10-30T22:30:05.099655+0000
cidr:10.1.161.129:0/32 2028-10-30T22:29:58.335390+0000
cidr:10.1.161.130:0/32 2028-10-30T22:29:59.861518+0000
```

2. On the Hub cluster, navigate to **Applications**.

3. Click the **Actions** menu at the end of application row to view the list of available actions.

4. Click **Failover application**.

5. When the **Failover application** modal is shown, verify the details presented are correct and check the status of the Failover **readiness**. If the status is **Ready** with a green tick, it indicates that the target cluster is ready for failover to start.

6. Click **Initiate**. The busybox resources are now created on the target cluster.

7. Close the modal window and track the status using the **Data policy** column on the Applications page.

8. Verify that the activity status shows as **FailedOver** for the application.

    a. Navigate to the **Applications → Overview** tab.

    b. In the **Data policy** column, click the **policy** link for the application you applied the policy to.

    c. On the **Data policy** popover, verify that you can see one or more policy names and the ongoing activities associated with the policy in use with the application.

3.14. RELOCATING SUBSCRIPTION-BASED APPLICATION BETWEEN MANAGED CLUSTERS

Relocate an application to its preferred location when all managed clusters are available.

Prerequisite

- If your setup has active and passive RHACM hub clusters, see Hub recovery using Red Hat Advanced Cluster Management.
- When the primary cluster is in a state other than **Ready**, check the actual status of the cluster as it might take some time to update. Relocate can only be performed when both primary and preferred clusters are up and running.
    1. Navigate to **RHACM console → Infrastructure → Clusters → Cluster list**tab.
    2. Check the status of both the managed clusters individually before performing relocate operation.
- Verify that applications were cleaned up from the cluster before unfencing it.

Procedure

1. Disable fencing on the Hub cluster.
    a. Edit the **DRCluster resource** for this cluster, replacing <drcluster_name> with a unique name.

```
$ oc edit drcluster <drcluster_name>
```

```
apiVersion: ramendr.openshift.io/v1alpha1
kind: DRCluster
metadata:
[...]
spec:
  cidrs:
  [...]
  ## Modify this line
  clusterFence: Unfenced
  [...]
[...]
```

Example output:

```
drcluster.ramendr.openshift.io/ocp4perf1 edited
```

b. Gracefully reboot OpenShift Container Platform nodes that were **Fenced**. A reboot is required to resume the I/O operations after unfencing to avoid any further recovery orchestration failures. Reboot all nodes of the cluster by following the steps in the procedure, Rebooting a node gracefully.

> **NOTE**
>
> Make sure that all the nodes are initially cordoned and drained before you reboot and perform uncordon operations on the nodes.

c. After all OpenShift nodes are rebooted and are in a **Ready** status, verify that all Pods are in a healthy state by running this command on the Primary managed cluster (or whatever cluster has been Unfenced).

```
oc get pods -A | egrep -v 'Running|Completed'
```

Example output:

```
NAMESPACE                                    NAME
READY   STATUS     RESTARTS      AGE
```

The output for this query should be zero Pods before proceeding to the next step.

> **IMPORTANT**
>
> If there are Pods still in an unhealthy status because of severed storage communication, troubleshoot and resolve before continuing. Because the storage cluster is external to OpenShift, it also has to be properly recovered after a site outage for OpenShift applications to be healthy.

Alternatively, you can use the OpenShift Web Console dashboards and Overview tab to assess the health of applications and the external ODF storage cluster. The detailed OpenShift Data Foundation dashboard is found by navigating to **Storage → Data Foundation**.

d. Verify that the **Unfenced** cluster is in a healthy state. Validate the fencing status in the Hub cluster for the Primary-managed cluster, replacing <drcluster_name> with a unique name.

```
$ oc get drcluster.ramendr.openshift.io <drcluster_name> -o jsonpath='{.status.phase}
{"\n"}'
```

Example output:

```
Unfenced
```

e. Login to your Ceph cluster and verify that the IPs that belong to the OpenShift Container Platform cluster nodes are NOT in the blocklist.

```
$ ceph osd blocklist ls
```

Ensure that you do not see the IPs added during fencing.

2. On the Hub cluster, navigate to **Applications**.

3. Click the **Actions** menu at the end of application row to view the list of available actions.

4. Click **Relocate application**.

5. When the **Relocate application** modal is shown, select **policy** and **target cluster** to which the associated application will relocate to in case of a disaster.

6. By default, the subscription group that will deploy the application resources is selected. Click the **Select subscription group** dropdown to verify the default selection or modify this setting.

7. Check the status of the **Relocation readiness**.

    - If the status is **Ready** with a green tick, it indicates that the target cluster is ready for relocation to start. Proceed to step 7.

- If the status is **Unknown** or **Not ready**, then wait until the status changes to **Ready**.

8. Click **Initiate**. The busybox resources are now created on the target cluster.

9. Close the modal window and track the status using the **Data policy** column on the Applications page.

10. Verify that the activity status shows as **Relocated** for the application.

    a. Navigate to the **Applications → Overview** tab.

    b. In the **Data policy** column, click the **policy** link for the application you applied the policy to.

    c. On the **Data policy** popover, click the **View more details** link.

3.15. RELOCATING AN APPLICATIONSET-BASED APPLICATION BETWEEN MANAGED CLUSTERS

Relocate an application to its preferred location when all managed clusters are available.

Prerequisite

- If your setup has active and passive RHACM hub clusters, see Hub recovery using Red Hat Advanced Cluster Management.

- When the primary cluster is in a state other than **Ready**, check the actual status of the cluster as it might take some time to update. Relocate can only be performed when both primary and preferred clusters are up and running.

    1. Navigate to **RHACM console → Infrastructure → Clusters → Cluster list**tab.

    2. Check the status of both the managed clusters individually before performing relocate operation.

- Verify that applications were cleaned up from the cluster before unfencing it.

Procedure

1. Disable fencing on the Hub cluster.

    a. Edit the **DRCluster resource** for this cluster, replacing <drcluster_name> with a unique name.

```
$ oc edit drcluster <drcluster_name>
```

```
apiVersion: ramendr.openshift.io/v1alpha1
kind: DRCluster
metadata:
[...]
spec:
  cidrs:
  [...]
  ## Modify this line
  clusterFence: Unfenced
  [...]
[...]
```

Example output:

```
drcluster.ramendr.openshift.io/ocp4perf1 edited
```

b. Gracefully reboot OpenShift Container Platform nodes that were **Fenced**. A reboot is required to resume the I/O operations after unfencing to avoid any further recovery orchestration failures. Reboot all nodes of the cluster by following the steps in the procedure, Rebooting a node gracefully.

NOTE

Make sure that all the nodes are initially cordoned and drained before you reboot and perform uncordon operations on the nodes.

c. After all OpenShift nodes are rebooted and are in a **Ready** status, verify that all Pods are in a healthy state by running this command on the Primary managed cluster (or whatever cluster has been Unfenced).

```
oc get pods -A | egrep -v 'Running|Completed'
```

Example output:

```
NAMESPACE                                    NAME
READY   STATUS      RESTARTS       AGE
```

The output for this query should be zero Pods before proceeding to the next step.

IMPORTANT

If there are Pods still in an unhealthy status because of severed storage communication, troubleshoot and resolve before continuing. Because the storage cluster is external to OpenShift, it also has to be properly recovered after a site outage for OpenShift applications to be healthy.

Alternatively, you can use the OpenShift Web Console dashboards and Overview tab to assess the health of applications and the external ODF storage cluster. The detailed OpenShift Data Foundation dashboard is found by navigating to **Storage → Data Foundation**.

d. Verify that the **Unfenced** cluster is in a healthy state. Validate the fencing status in the Hub cluster for the Primary-managed cluster, replacing <drcluster_name> with a unique name.

```
$ oc get drcluster.ramendr.openshift.io <drcluster_name> -o jsonpath='{.status.phase}
{"\n"}'
```

Example output:

```
Unfenced
```

e. Login to your Ceph cluster and verify that the IPs that belong to the OpenShift Container Platform cluster nodes are NOT in the blocklist.

```
$ ceph osd blocklist ls
```

Ensure that you do not see the IPs added during fencing.

2. On the Hub cluster, navigate to **Applications**.

3. Click the **Actions** menu at the end of application row to view the list of available actions.

4. Click **Relocate application**.

5. When the **Relocate application** modal is shown, select **policy** and **target cluster** to which the associated application will relocate to in case of a disaster.

6. Click **Initiate**. The busybox resources are now created on the target cluster.

7. Close the modal window and track the status using the **Data policy** column on the Applications page.

8. Verify that the activity status shows as **Relocated** for the application.

   a. Navigate to the **Applications** → **Overview** tab.

   b. In the **Data policy** column, click the **policy** link for the application you applied the policy to.

   c. On the **Data policy** popover, verify that you can see one or more policy names and the relocation status associated with the policy in use with the application.

3.16. DISASTER RECOVERY PROTECTION FOR DISCOVERED APPLICATIONS

Red Hat OpenShift Data Foundation now provides disaster recovery (DR) protection and support for workloads that are deployed in one of the managed clusters directly without using Red Hat Advanced Cluster Management (RHACM). These workloads are called discovered applications.

The workloads that are deployed using RHACM are now called managed applications. When a workload is deployed directly on one of the managed clusters without using RHACM, then those workloads are called discovered applications. Though these workload details can be seen on the RHACM console, the application lifecycle (create, delete, edit) is not managed by RHACM.

3.16.1. Prerequisites for disaster recovery protection of discovered applications

This section provides instructions to guide you through the prerequisites for protecting discovered applications. This includes tasks such as assigning a data policy and initiating DR actions such as failover and relocate.

1. Ensure that all the DR configurations have been installed on the Primary managed cluster and the Secondary managed cluster.

2. Install the OADP 1.4 operator.

NOTE

Any version before OADP 1.4 will not work for protecting discovered applications.

a. On the **Primary** and **Secondary managed cluster**, navigate to **OperatorHub** and use the keyword filter to search for **OADP**.

b. Click the **OADP** tile.

c. Keep all default settings and click **Install**. Ensure that the operator resources are installed in the **openshift-adp** project.

NOTE

If OADP 1.4 is installed after DR configuration has been completed then the **ramen-dr-cluster-operator** pods on the **Primary managed cluster** and the **Secondary managed cluster** in namespace **openshift-dr-system** must be restarted (deleted and recreated).

3. [Optional] Add CACertificates to **ramen-hub-operator-config ConfigMap**.
Configure network (SSL) access between the primary and secondary clusters so that metadata can be stored on the alternate cluster in a Multicloud Gateway (MCG) object bucket using a secure transport protocol and in the Hub cluster for verifying access to the object buckets.

NOTE

If all of your OpenShift clusters are deployed using a signed and valid set of certificates for your environment then this section can be skipped.

If you are using self-signed certificates, then you have already created a **ConfigMap** named **user-ca-bundle** in the **openshift-config** namespace and added this ConfigMap to the default Proxy cluster resource. **This means you need to add thecaCertificates parameter to the configmap ramen-hub-operator-config with the encoded value.**

a. Find the encoded value for the CACertificates.

```
$ oc get configmap user-ca-bundle -n openshift-config -o jsonpath="{['data']['ca-
bundle\.crt']}" |base64 -w 0
```

b. Add this base64 encoded value to the configmap **ramen-hub-operator-config** on the Hub cluster. Example below shows where to add CACertificates.

```
$ oc edit configmap ramen-hub-operator-config -n openshift-operators
```

```
[...]
  ramenOpsNamespace: openshift-dr-ops
  s3StoreProfiles:
  - s3Bucket: odrbucket-36bceb61c09c
    s3CompatibleEndpoint: https://s3-openshift-storage.apps.hyper3.vmw.ibmfusion.eu
    s3ProfileName: s3profile-hyper3-ocs-storagecluster
    s3Region: noobaa
    s3SecretRef:
      name: 60f2ea6069e168346d5ad0e0b5faa59bb74946f
```

```
     caCertificates: {input base64 encoded value here}
   - s3Bucket: odrbucket-36bceb61c09c
     s3CompatibleEndpoint: https://s3-openshift-storage.apps.hyper4.vmw.ibmfusion.eu
     s3ProfileName: s3profile-hyper4-ocs-storagecluster
     s3Region: noobaa
     s3SecretRef:
       name: cc237eba032ad5c422fb939684eb633822d7900
     caCertificates: {input base64 encoded value here}
```

4. Verify that there are DR secrets created in the OADP operator default namespace **openshift-adp** on the **Primary managed cluster** and the **Secondary managed cluster**. The DR secrets that were created when the first DRPolicy was created, will be similar to the secrets below. The DR secret name is preceded with the letter **v**.

```
$ oc get secrets -n openshift-adp
NAME                                       TYPE     DATA   AGE
v60f2ea6069e168346d5ad0e0b5faa59bb74946f   Opaque   1      3d20h
vcc237eba032ad5c422fb939684eb633822d7900   Opaque   1      3d20h
[...]
```

NOTE

There will be one DR created secret for each managed cluster in the **openshift-adp** namespace.

5. Verify if the Data Protection Application (DPA) is already installed on each managed cluster in the OADP namespace **openshift-adp**. If not already created then follow the next step to create this resource.

   a. Create the DPA by copying the following YAML definition content to **dpa.yaml**.

```
apiVersion: oadp.openshift.io/v1alpha1
kind: DataProtectionApplication
metadata:
  labels:
    app.kubernetes.io/component: velero
  name: velero
  namespace: openshift-adp
spec:
  backupImages: false
  configuration:
    nodeAgent:
      enable: false
      uploaderType: restic
    velero:
      defaultPlugins:
        - openshift
        - aws
      noDefaultBackupLocation: true
```

   b. Create the DPA resource.

```
$ oc create -f dpa.yaml -n openshift-adp
```

```
dataprotectionapplication.oadp.openshift.io/velero created
```

c. Verify that the OADP resources are created and are in **Running** state.

```
$ oc get pods,dpa -n openshift-adp
NAME                                                    READY   STATUS    RESTARTS   AGE
pod/openshift-adp-controller-manager-7b64b74fcd-msjbs   1/1     Running   0
5m30s
pod/velero-694b5b8f5c-b4kwg                             1/1     Running   0          3m31s


NAME                                             AGE
dataprotectionapplication.oadp.openshift.io/velero   3m31s
```

3.16.2. Creating a sample discovered application

In order to test **failover** from the **Primary managed cluster** to the **Secondary managed cluster** and **relocate** for discovered applications, you need a sample application that is installed without using the RHACM create application capability.

Procedure

1. Log in to the **Primary managed cluster** and clone the sample application repository.

```
$ git clone https://github.com/red-hat-storage/ocm-ramen-samples.git
```

2. Verify that you are on the **main** branch.

```
$ cd ~/ocm-ramen-samples
$ git branch
* main
```

The correct directory should be used when creating the sample application based on your scenario, metro or regional.

NOTE

Only applications using CephRBD or block volumes are supported for discovered applications.

```
$ ls workloads/deployment | egrep -v 'cephfs|k8s|base'
odr-metro-rbd
odr-regional-rbd
```

3. Create a project named **busybox-discovered** on both the **Primary and Secondary managed clusters**.

```
$ oc new-project busybox-discovered
```

4. Create the **busybox** application on the **Primary managed cluster**. This sample application example is for Metro-DR using a block (Ceph RBD) volume.

```
$ oc apply -k workloads/deployment/odr-metro-rbd -n busybox-discovered
persistentvolumeclaim/busybox-pvc created
deployment.apps/busybox created
```

> **NOTE**
>
> OpenShift Data Foundation Disaster Recovery solution now extends protection to discovered applications that span across multiple namespaces.

5. Verify that busybox is running in the correct project on the **Primary managed cluster**.

```
$ oc get pods,pvc,deployment -n busybox-discovered
```

```
NAME                          READY   STATUS    RESTARTS   AGE
pod/busybox-796fccbb95-qmxjf   1/1     Running   0          18s


NAME                            STATUS   VOLUME                                     CAPACITY   ACCESS
MODES   STORAGECLASS                  VOLUMEATTRIBUTESCLASS   AGE
persistentvolumeclaim/busybox-pvc   Bound    pvc-b20e4129-902d-47c7-b962-
040ad64130c4   1Gi        RWO            ocs-storagecluster-ceph-rbd   <unset>                 18s


NAME                      READY   UP-TO-DATE   AVAILABLE   AGE
deployment.apps/busybox   1/1     1            1           18
```

3.16.3. Enrolling a sample discovered application for disaster recovery protection

This section guides you on how to apply an existing DR Policy to a discovered application from the **Protected applications** tab.

Prerequisites

- Ensure that Disaster Recovery has been configured and that at least one DR Policy has been created.

Procedure

1. On RHACM console, navigate to **Disaster recovery → Protected applications** tab.
2. Click **Enroll application** to start configuring existing applications for DR protection.
3. Select **ACM discovered applications**.
4. In the Namespace page, choose the **DR cluster** which is the name of the **Primary managed cluster** where **busybox** is installed.
5. Select **namespace** where the application is installed. For example, **busybox-discovered**.

> **NOTE**
>
> If you have workload spread across multiple namespaces then you can select all of those namespaces to DR protect.

6. Choose a unique **Name**, for example **busybox-rbd**, for the discovered application and click **Next**.

7. In the Configuration page, the **Resource label** is used to protect your resources where you can set which resources will be included in the **kubernetes-object** backup and what volume’s persistent data will be replicated. **Resource label** is selected by default.

8. Provide Label expressions and PVC label selector. Choose the **label appname=busybox** for both the **kubernetes-objects** and for the **PVC(s)**.

9. Click **Next**.

10. In the Replication page, select an existing **DR Policy** and the **kubernetes-objects backup interval**.

    NOTE

    It is recommended to choose the same duration for the PVC data replication and kubernetes-object backup interval (i.e., 5 minutes).

11. Click **Next**.

12. Review the configuration and click **Save**.
    Use the **Back** button to go back to the screen to correct any issues.

13. Verify that the **Application volumes (PVCs)** and the **Kubernetes-objects** backup have a *Healthy* status before proceeding to DR Failover and Relocate testing. You can view the status of your Discovered applications on the **Protected applications** tab.

    a. To see the status of the DRPC, run the following command on the Hub cluster:

    ```
    $ oc get drpc {drpc_name} -o wide -n openshift-dr-ops
    ```

    The discovered applications store resources such as DRPlacementControl (DRPC) and Placement on the Hub cluster in a new namespace called **openshift-dr-ops**. The DRPC name can be identified by the unique Name configured in prior steps (i.e., **busybox-rbd**).

    b. To see the status of the VolumeReplicationGroup (VRG) for discovered applications, run the following command on the managed cluster where the busybox application was manually installed.

    ```
    $ oc get vrg {vrg_name} -n openshift-dr-ops
    ```

    The VRG resource is stored in the namespace **openshift-dr-ops** after a DR Policy is assigned to the discovered application. The VRG name can be identified by the unique Name configured in prior steps (i.e., **busybox-rbd**).

3.16.4. Discovered application failover and relocate

A protected Discovered application can *Failover* or *Relocate* to its peer cluster similar to **managed applications**. However, there are some additional steps for discovered applications since RHACM does not manage the lifecycle of the application as it does for Managed applications.

This section guides you through the Failover and Relocate process for a protected discovered application.

IMPORTANT

Never initiate a Failover or Relocate of an application when one or both resource types are in a Warning or Critical status.

3.16.4.1. Failover disaster recovery protected discovered application

This section guides you on how to failover a discovered application which is disaster recovery protected.

Prerequisites

- Ensure that the application namespace is created in both managed clusters (for example, **busybox-discovered**).

Procedure

1. Enable fencing on the **Hub cluster**.

    a. Open CLI terminal and edit the **DRCluster resource**, where *<drcluster_name>* is your unique name.

    CAUTION

    Once the managed cluster is fenced, **all** communication from applications to the OpenShift Data Foundation external storage cluster will fail and some **Pods** will be in an unhealthy state (for example: **CreateContainerError**, **CrashLoopBackOff**) on the cluster that is now fenced.

    ```
    $ oc edit drcluster <drcluster_name>
    ```

    ```
    apiVersion: ramendr.openshift.io/v1alpha1
    kind: DRCluster
    metadata:
    [...]
    spec:
      ## Add this line
      clusterFence: Fenced
      cidrs:
      [...]
    [...]
    ```

    Example output:

    ```
    drcluster.ramendr.openshift.io/ocp4perf1 edited
    ```

    b. Verify the fencing status on the **Hub cluster** for the **Primary managed cluster**, replacing <drcluster_name> is your unique identifier.

    ```
    $ oc get drcluster.ramendr.openshift.io <drcluster_name> -o jsonpath='{.status.phase}
    {"\n"}'
    ```

    Example output:

```
Fenced
```

c. Login to your Ceph cluster and verify that the IPs that belong to the OpenShift Container Platform cluster nodes are now in the blocklist.

```
$ ceph osd blocklist ls
```

Example output

```
cidr:10.1.161.1:0/32 2028-10-30T22:30:03.585634+0000
cidr:10.1.161.14:0/32 2028-10-30T22:30:02.483561+0000
cidr:10.1.161.51:0/32 2028-10-30T22:30:01.272267+0000
cidr:10.1.161.63:0/32 2028-10-30T22:30:05.099655+0000
cidr:10.1.161.129:0/32 2028-10-30T22:29:58.335390+0000
cidr:10.1.161.130:0/32 2028-10-30T22:29:59.861518+0000
```

2. In the RHACM console, navigate to **Disaster Recovery → Protected applications** tab.

3. At the end of the application row, click on the **Actions** menu and choose to initiate *Failover*.

4. In the Failover application modal window, review the status of the application and the target cluster.

5. Click **Initiate**. Wait for the **Failover** process to complete.

6. Verify that the busybox application is running on the **Secondary managed cluster**.

```
$ oc get pods,pvc -n busybox-discovered
NAME                         READY   STATUS    RESTARTS   AGE
pod/busybox-796fccbb95-qmxjf   1/1     Running   0          2m46s


NAME                              STATUS   VOLUME                                     CAPACITY   ACCESS
MODES   STORAGECLASS                  VOLUMEATTRIBUTESCLASS   AGE
persistentvolumeclaim/busybox-pvc   Bound    pvc-b20e4129-902d-47c7-b962-
040ad64130c4   1Gi        RWO            ocs-storagecluster-ceph-rbd   <unset>
2m57s
```

7. Check the progression status of Failover until the result is **WaitOnUserToCleanup**. The DRPC name can be identified by the unique Name configured in prior steps (for example, **busybox-rbd**).

```
$ oc get drpc {drpc_name} -n openshift-dr-ops -o jsonpath='{.status.progression}{"\n"}'
WaitOnUserToCleanUp
```

8. Remove the busybox application from the **Primary managed cluster** to complete the **Failover** process.

   a. Navigate to the **Protected applications** tab. You will see a message to remove the application.

   b. Navigate to the cloned repository for **busybox** and run the following commands on the **Primary managed cluster** where you **failed** over from. Use the same directory that was used to create the application (for example, **odr-metro-rbd**).

```
$ cd ~/ocm-ramen-samples/
$ git branch
* main
$ oc delete -k workloads/deployment/odr-metro-rbd -n busybox-discovered
persistentvolumeclaim "busybox-pvc" deleted
deployment.apps "busybox" deleted
```

9. After deleting the application, navigate to the **Protected applications** tab and verify that the busybox resources are both in *Healthy* status.

3.16.4.2. Relocate disaster recovery protected discovered application

This section guides you on how to relocate a discovered application which is disaster recovery protected.

Procedure

1. Disable fencing on the Hub cluster.

    a. Edit the **DRCluster resource** for this cluster, replacing <drcluster_name> with a unique name.

    ```
    $ oc edit drcluster <drcluster_name>
    ```

    ```
    apiVersion: ramendr.openshift.io/v1alpha1
    kind: DRCluster
    metadata:
    [...]
    spec:
      cidrs:
      [...]
      ## Modify this line
      clusterFence: Unfenced
      [...]
    [...]
    ```

    Example output:

    ```
    drcluster.ramendr.openshift.io/ocp4perf1 edited
    ```

    b. Gracefully reboot OpenShift Container Platform nodes that were **Fenced**. A reboot is required to resume the I/O operations after unfencing to avoid any further recovery orchestration failures. Reboot all nodes of the cluster by following the steps in the procedure, Rebooting a node gracefully.

    > **NOTE**
    >
    > Make sure that all the nodes are initially cordoned and drained before you reboot and perform uncordon operations on the nodes.

    c. After all OpenShift nodes are rebooted and are in a **Ready** status, verify that all Pods are in a healthy state by running this command on the Primary managed cluster (or whatever cluster has been Unfenced).

```
oc get pods -A | egrep -v 'Running|Completed'
```

Example output:

```
NAMESPACE                              NAME
READY   STATUS     RESTARTS      AGE
```

The output for this query should be zero Pods before proceeding to the next step.

IMPORTANT

If there are Pods still in an unhealthy status because of severed storage communication, troubleshoot and resolve before continuing. Because the storage cluster is external to OpenShift, it also has to be properly recovered after a site outage for OpenShift applications to be healthy.

Alternatively, you can use the OpenShift Web Console dashboards and Overview tab to assess the health of applications and the external ODF storage cluster. The detailed OpenShift Data Foundation dashboard is found by navigating to **Storage → Data Foundation**.

d. Verify that the **Unfenced** cluster is in a healthy state. Validate the fencing status in the Hub cluster for the Primary-managed cluster, replacing <drcluster_name> with a unique name.

```
$ oc get drcluster.ramendr.openshift.io <drcluster_name> -o jsonpath='{.status.phase}
{"\n"}'
```

Example output:

```
Unfenced
```

e. Login to your Ceph cluster and verify that the IPs that belong to the OpenShift Container Platform cluster nodes are NOT in the blocklist.

```
$ ceph osd blocklist ls
```

Ensure that you do not see the IPs added during fencing.

2. In the RHACM console, navigate to **Disaster Recovery → Protected applications** tab.

3. At the end of the application row, click on the **Actions** menu and choose to initiate *Relocate*.

4. In the Relocate application modal window, review the status of the application and the target cluster.

5. Click **Initiate**.

6. Check the progression status of Relocate until the result is **WaitOnUserToCleanup**. The DRPC name can be identified by the unique Name configured in prior steps (for example, **busybox-rbd**).

```
$ oc get drpc {drpc_name} -n openshift-dr-ops -o jsonpath='{.status.progression}{"\n"}'
WaitOnUserToCleanUp
```

7. Remove the busybox application from the **Secondary managed cluster** before *Relocate* to the **Primary managed cluster** is completed.
   Navigate to the cloned repository for **busybox** and run the following commands on the **Secondary managed cluster** where you **relocated** from. Use the same directory that was used to create the application (for example, **odr-metro-rbd**).

```
$ cd ~/ocm-ramen-samples/
$ git branch
* main
$ oc delete -k workloads/deployment/odr-metro-rbd -n busybox-discovered
persistentvolumeclaim "busybox-pvc" deleted
deployment.apps "busybox" deleted
```

8. After deleting the application, navigate to the **Protected applications** tab and verify that the busybox resources are both in *Healthy* status.

9. Verify that the **busybox** application is running on the **Primary managed cluster**.

```
$ oc get pods,pvc -n busybox-discovered
NAME                          READY   STATUS    RESTARTS   AGE
pod/busybox-796fccbb95-qmxjf   1/1     Running   0          2m46s


NAME                              STATUS   VOLUME                                     CAPACITY   ACCESS
MODES   STORAGECLASS                  VOLUMEATTRIBUTESCLASS   AGE
persistentvolumeclaim/busybox-pvc   Bound    pvc-b20e4129-902d-47c7-b962-
040ad64130c4   1Gi        RWO            ocs-storagecluster-ceph-rbd   <unset>
2m57s
```

3.16.5. Disable disaster recovery for protected applications

This section guides you to disable disaster recovery resources when you want to delete the protected applications or when the application no longer needs to be protected.

Procedure

1. Login to the Hub cluster.

2. List the **DRPlacementControl** (DRPC) resources. Each DRPC resource was created when the application was assigned a DR policy.

```
$ oc get drpc -n openshift-dr-ops
```

3. Find the **DRPC** that has a name that includes the unique identifier that you chose when assigning a DR policy (for example, **busybox-rbd**) and delete the DRPC.

```
$ oc delete {drpc_name} -n openshift-dr-ops
```

4. List the **Placement** resources. Each Placement resource was created when the application was assigned a DR policy.

```
$ oc get placements -n openshift-dr-ops
```

5. Find the **Placement** that has a name that includes the unique identifier that you chose when assigning a DR policy (for example, **busybox-rbd-placement-1**) and delete the **Placement**.

```
$ oc delete placements {placement_name} -n openshift-dr-ops
```

3.17. RECOVERING TO A REPLACEMENT CLUSTER WITH METRO-DR

When there is a failure with the primary cluster, you get the options to either repair, wait for the recovery of the existing cluster, or replace the cluster entirely if the cluster is irredeemable. This solution guides you when replacing a failed primary cluster with a new cluster and enables failback (relocate) to this new cluster.

In these instructions, we are assuming that a RHACM managed cluster must be replaced after the applications have been installed and protected. For purposes of this section, the RHACM managed cluster is the **replacement cluster**, while the cluster that is not replaced is the **surviving cluster** and the new cluster is the **recovery cluster**.

NOTE

Replacement cluster recovery for Discovered applications is currently not supported. Only Managed applications are supported.

Prerequisite

- Ensure that the Metro-DR environment has been configured with applications installed using Red Hat Advance Cluster Management (RHACM).
- Ensure that the applications are assigned a Data policy which protects them against cluster failure.

Procedure

1. Perform the following steps on the **Hub cluster**:

   a. Fence the replacement cluster by using the CLI terminal to edit the **DRCluster** resource, where *<drcluster_name>* is the replacement cluster name.

   ```
   oc edit drcluster <drcluster_name>
   ```

   ```
   apiVersion: ramendr.openshift.io/v1alpha1
   kind: DRCluster
   metadata:
   [...]
   spec:
     ## Add or modify this line
     clusterFence: Fenced
     cidrs:
     [...]
   [...]
   ```

   b. Using the RHACM console, navigate to **Applications** and failover all protected applications from the failed cluster to the surviving cluster.

   c. Verify and ensure that all protected applications are now running on the surviving cluster.

> **NOTE**
>
> The **PROGRESSION** state for each application DRPlacementControl will show as **Cleaning Up**. This is expected if the replacement cluster is offline or down.

2. Unfence the replacement cluster.
   Using the CLI terminal, edit the DRCluster resource, where *<drcluster_name>* is the replacement cluster name.

```
$ oc edit drcluster <drcluster_name>
```

```
apiVersion: ramendr.openshift.io/v1alpha1
kind: DRCluster
metadata:
[...]
spec:
  ## Modify this line
  clusterFence: Unfenced
  cidrs:
  [...]
[...]
```

3. Delete the DRCluster for the replacement cluster.

```
$ oc delete drcluster <drcluster_name> --wait=false
```

> **NOTE**
>
> Use --wait=false since the DRCluster will not be deleted until a later step.

4. Disable disaster recovery on the **Hub cluster** for each protected application on the surviving cluster.

   a. For each application, edit the Placement and ensure that the surviving cluster is selected.

> **NOTE**
>
> For Subscription-based applications the associated Placement can be found in the same namespace on the hub cluster similar to the managed clusters. For ApplicationSets-based applications the associated Placement can be found in the **openshift-gitops** namespace on the hub cluster.

```
$ oc edit placement <placement_name> -n <namespace>
```

```
apiVersion: cluster.open-cluster-management.io/v1beta1
kind: Placement
metadata:
annotations:
  cluster.open-cluster-management.io/experimental-scheduling-disable: "true"
[...]
spec:
```

```
clusterSets:
- submariner
predicates:
- requiredClusterSelector:
    claimSelector: {}
    labelSelector:
      matchExpressions:
      - key: name
        operator: In
        values:
        - cluster1  <-- Modify to be surviving cluster name
[...]
```

b. Verify that the **s3Profile** is removed for the replacement cluster by running the following command on the surviving cluster for each protected application's VolumeReplicationGroup.

```
$ oc get vrg -n <application_namespace> -o jsonpath='{.items[0].spec.s3Profiles}' | jq
```

c. After the protected application **Placement** resources are all configured to use the surviving cluster and replacement cluster s3Profile(s) removed from protected applications, all **DRPlacementControl** resources must be deleted from the **Hub cluster**.

```
$ oc delete drpc <drpc_name> -n <namespace>
```

NOTE

For Subscription-based applications the associated DRPlacementControl can be found in the same namespace as the managed clusters on the hub cluster. For ApplicationSets-based applications the associated DRPlacementControl can be found in the **openshift-gitops** namespace on the hub cluster.

d. Verify that all DRPlacementControl resources are deleted before proceeding to the next step. This command is a query across all namespaces. There should be no resources found.

```
$ oc get drpc -A
```

e. The last step is to edit each applications **Placement** and remove the annotation **cluster.open-cluster-management.io/experimental-scheduling-disable: "true"**.

```
$ oc edit placement <placement_name> -n <namespace>
```

```
apiVersion: cluster.open-cluster-management.io/v1beta1
kind: Placement
metadata:
annotations:
  ## Remove this annotation
  cluster.open-cluster-management.io/experimental-scheduling-disable: "true"
[...]
```

5. Repeat the process detailed in the last step and the sub-steps for every protected application on the surviving cluster. Disabling DR for protected applications is now completed.

6. On the Hub cluster, run the following script to remove all disaster recovery configurations from the **surviving cluster** and the **hub cluster**.

```
#!/bin/bash
secrets=$(oc get secrets -n openshift-operators | grep Opaque | cut -d" " -f1)
echo $secrets
for secret in $secrets
do
   oc patch -n openshift-operators secret/$secret -p '{"metadata":{"finalizers":null}}' --
type=merge
done
mirrorpeers=$(oc get mirrorpeer -o name)
echo $mirrorpeers
for mp in $mirrorpeers
do
   oc patch $mp -p '{"metadata":{"finalizers":null}}' --type=merge
   oc delete $mp
done
drpolicies=$(oc get drpolicy -o name)
echo $drpolicies
for drp in $drpolicies
do
   oc patch $drp -p '{"metadata":{"finalizers":null}}' --type=merge
   oc delete $drp
done
drclusters=$(oc get drcluster -o name)
echo $drclusters
for drp in $drclusters
do
   oc patch $drp -p '{"metadata":{"finalizers":null}}' --type=merge
   oc delete $drp
done
oc delete project openshift-operators
managedclusters=$(oc get managedclusters -o name | cut -d"/" -f2)
echo $managedclusters
for mc in $managedclusters
do
   secrets=$(oc get secrets -n $mc | grep multicluster.odf.openshift.io/secret-type | cut -d" " -
f1)
   echo $secrets
   for secret in $secrets
   do
      set -x
      oc patch -n $mc secret/$secret -p '{"metadata":{"finalizers":null}}' --type=merge
      oc delete -n $mc secret/$secret
   done
done

oc delete clusterrolebinding spoke-clusterrole-bindings
```

NOTE

This script used the command **oc delete project openshift-operators** to remove the Disaster Recovery (DR) operators in this namespace on the hub cluster. If there are other non-DR operators in this namespace, you must install them again from OperatorHub.

7. After the namespace **openshift-operators** is automatically created again, add the monitoring label back for collecting the disaster recovery metrics.

```
$ oc label namespace openshift-operators openshift.io/cluster-monitoring='true'
```

8. On the surviving cluster, ensure that the object bucket created during the DR installation is deleted. Delete the object bucket if it was not removed by script. The name of the object bucket used for DR starts with **odrbucket**.

```
$ oc get obc -n openshift-storage
```

9. On the RHACM console, navigate to **Infrastructure → Clusters view**.

    a. Detach the replacement cluster.

    b. Create a new OpenShift cluster (recovery cluster) and import the new cluster into the RHACM console. For instructions, see Creating a cluster and Importing a target managed cluster to the hub cluster.

10. Install OpenShift Data Foundation operator on the recovery cluster and connect it to the same external Ceph storage system as the surviving cluster. For detailed instructions, refer to Deploying OpenShift Data Foundation in external mode .

    NOTE

    Ensure that the OpenShift Data Foundation version is 4.15 (or greater) and the same version of OpenShift Data Foundation is on the surviving cluster.

11. On the hub cluster, install the ODF Multicluster Orchestrator operator from OperatorHub. For instructions, see chapter on Installing OpenShift Data Foundation Multicluster Orchestrator operator.

12. Using the RHACM console, navigate to **Data Services → Data policies**.

    a. Select **Create DRPolicy** and name your policy.

    b. Select the **recovery cluster** and the **surviving cluster**.

    c. Create the policy. For instructions see chapter on Creating Disaster Recovery Policy on Hub cluster.

    Proceed to the next step only after the status of DRPolicy changes to **Validated**.

13. Apply the DRPolicy to the applications on the surviving cluster that were originally protected before the replacement cluster failed.

14. Relocate the newly protected applications on the surviving cluster back to the new recovery (primary) cluster. Using the RHACM console, navigate to the **Applications** menu to perform the relocation.

3.18. HUB RECOVERY USING RED HAT ADVANCED CLUSTER MANAGEMENT [TECHNOLOGY PREVIEW]

When your setup has active and passive Red Hat Advanced Cluster Management for Kubernetes (RHACM) hub clusters, and in case where the active hub is down, you can use the passive hub to failover or relocate the disaster recovery protected workloads.

IMPORTANT

Hub recovery for Metro-DR is a Technology Preview feature and is subject to Technology Preview support limitations. Technology Preview features are not supported with Red Hat production service level agreements (SLAs) and might not be functionally complete. Red Hat does not recommend using them in production. These features provide early access to upcoming product features, enabling customers to test functionality and provide feedback during the development process.

For more information, see Technology Preview Features Support Scope .

3.18.1. Configuring passive hub cluster

To perform hub recovery in case the active hub is down or unreachable, follow the procedure in this section to configure the passive hub cluster and then failover or relocate the disaster recovery protected workloads.

Procedure

1. Ensure that RHACM operator and **MultiClusterHub** is installed on the passive hub cluster. See RHACM installation guide for instructions.
   After the operator is successfully installed, a popover with a message that the Web console update is available appears on the user interface. Click **Refresh web console** from this popover for the console changes to reflect.

2. Before hub recovery, configure backup and restore. See Backup and restore topics of *RHACM Business continuity* guide.

3. Install the multicluster orchestrator (MCO) operator along with Red Hat OpenShift GitOps operator on the passive RHACM hub prior to the restore. For instructions to restore your RHACM hub, see Installing OpenShift Data Foundation Multicluster Orchestrator operator .

4. Ensure that **.spec.cleanupBeforeRestore** is set to **None** for the **Restore.cluster.open-cluster-management.io** resource. For details, see Restoring passive resources while checking for backups chapter of RHACM documentation.

5. If SSL access across clusters was configured manually during setup, then re-configure SSL access across clusters. For instructions, see Configuring SSL access across clusters chapter.

6. On the passive hub, add label to **openshift-operators** namespace to enable basic monitoring of **VolumeSyncronizationDelay** alert using this command. For alert details, see Disaster recovery alerts chapter.

```
$ oc label namespace openshift-operators openshift.io/cluster-monitoring='true'
```

3.18.2. Switching to passive hub cluster

Use this procedure when active hub is down or unreachable.

Procedure

1. During the restore procedure, to avoid eviction of resources when **ManifestWorks** are not regenerated correctly, you can enlarge the **AppliedManifestWork eviction** grace period. On the passive hub cluster, check for existing global **KlusterletConfig**.

    - If global **KlusterletConfig** exists then edit and set the value for **appliedManifestWorkEvictionGracePeriod** parameter to a larger value. For example, 24 hours or more.

    - If global **KlusterletConfig** does not exist, then create the **Klusterletconfig** using the following yaml:

    ```
    apiVersion: config.open-cluster-management.io/v1alpha1
    kind: KlusterletConfig
    metadata:
      name: global
    spec:
      appliedManifestWorkEvictionGracePeriod: "24h"
    ```

    The configuration will be propagated to all the managed clusters automatically.

2. Restore the backups on the passive hub cluster. For information, see Restoring a hub cluster from backup.

    IMPORTANT

    Recovering a failed hub to its passive instance will only restore applications and their DR protected state to its last scheduled backup. Any application that was DR protected after the last scheduled backup would need to be protected again on the new hub.

3. Verify that the restore is complete.

    ```
    $ oc -n <restore-namespace> wait restore <restore-name> --
    for=jsonpath='{.status.phase}'=Finished --timeout=120s
    ```

4. Verify that the Primary and Secondary managed clusters are successfully imported into the RHACM console and they are accessible. If any of the managed clusters are down or unreachable then they will not be successfully imported.

5. Wait until DRPolicy validation succeeds.

6. Verify that the **DRPolicy** is created successfully. Run this command on the **Hub cluster** for each of the DRPolicy resources created, where *<drpolicy_name>* is replaced with a unique name.

    ```
    $ oc get drpolicy <drpolicy_name> -o jsonpath='{.status.conditions[].reason}{"\n"}'
    ```

    Example output:

```
Succeeded
```

7. Refresh the RHACM console to make the DR monitoring dashboard tab accessible if it was enabled on the Active hub cluster.

8. Verify the DRPC output using the following command on the new hub cluster:

   ```
   $ oc get drpc -A -o wide
   ```

   If **PROGRESSION** shows a status of **PAUSED**, administrative intervention is required to unpause it. **PROGRESSION** enters **PAUSED** state under the following conditions:

   - **Cluster Query Failure**: None of the clusters were successfully queried during the DRPC reconciliation. This situation can occur during hub recovery.
   - **Action Mismatch**: The DRPC action differs from the queried VRG action.
   - **Cluster Mismatch**: The DRPC action and the VRG action are the same, but the Primary VRG is found in a different cluster than the one expected by the DRPC.

     IMPORTANT

     If you cannot diagnose and resolve the cause of the pause, contact Red Hat Customer Support.

     If **PROGRESSION** is in either **Completed** or **Cleaning up**, it is safe to proceed.

9. Edit the global **KlusterletConfig** on the new hub and remove the parameter **appliedManifestWorkEvictionGracePeriod** and its value.

10. Depending on whether the active hub cluster, or both the active hub cluster along with the primary managed cluster had been down, follow the next steps based on your scenario:

    a. If only the active hub cluster had been down, and if the managed clusters are still accessible, no further action is required.

    b. If the primary managed cluster had been down, along with the active hub cluster, you need to fail over the workloads from the primary managed cluster to the secondary managed cluster.
    For failover instructions, based on your workload type, see Subscription-based applications or ApplicationSet-based applications.

11. Verify that the failover is successful. If the Primary managed cluster is also down, then the PROGRESSION status for the workload would be in **Cleaning Up** phase until the down Primary managed cluster is back online and successfully imported into the RHACM console.
    On the passive hub cluster, run the following command to check the PROGRESSION status.

    ```
    $ oc get drpc -o wide -A
    ```

CHAPTER 4. REGIONAL-DR SOLUTION FOR OPENSHIFT DATA FOUNDATION

This section of the guide provides details of the Regional Disaster Recovery (Regional-DR) steps and commands necessary to be able to failover an application from one OpenShift Container Platform cluster to another and then failback the same application to the original primary cluster. In this case the OpenShift Container Platform clusters will be created or imported using Red Hat Advanced Cluster Management (RHACM).

Though Regional-DR solution is built on Asynchronous data replication and hence could have a potential data loss but provides the protection against a broad set of failures.

This is a general overview of the Regional-DR steps required to configure and execute OpenShift Disaster Recovery (ODR) capabilities using OpenShift Data Foundation and RHACM across two distinct OpenShift Container Platform clusters separated by distance. In addition to these two clusters called managed clusters, a third OpenShift Container Platform cluster is required that will be the Red Hat Advanced Cluster Management (RHACM) hub cluster.

IMPORTANT

You can now easily set up Regional disaster recovery solutions for workloads based on OpenShift virtualization technology using OpenShift Data Foundation. For more information, see the knowledgebase article.

4.1. COMPONENTS OF REGIONAL-DR SOLUTION

Regional-DR is composed of Red Hat Advanced Cluster Management for Kubernetes and OpenShift Data Foundation components to provide application and data mobility across Red Hat OpenShift Container Platform clusters.

Red Hat Advanced Cluster Management for Kubernetes

Red Hat Advanced Cluster Management (RHACM) provides the ability to manage multiple clusters and application lifecycles. Hence, it serves as a control plane in a multi-cluster environment.

RHACM is split into two parts:

- RHACM Hub: components that run on the multi-cluster control plane.
- Managed clusters: components that run on the clusters that are managed.

For more information about this product, see RHACM documentation and the RHACM “Manage Applications” documentation.

OpenShift Data Foundation

OpenShift Data Foundation provides the ability to provision and manage storage for stateful applications in an OpenShift Container Platform cluster.

OpenShift Data Foundation is backed by Ceph as the storage provider, whose lifecycle is managed by Rook in the OpenShift Data Foundation component stack. Ceph-CSI provides the provisioning and management of Persistent Volumes for stateful applications.

OpenShift Data Foundation stack is now enhanced with the following abilities for disaster recovery:

- Enable RBD block pools for mirroring across OpenShift Data Foundation instances (clusters)

- Ability to mirror specific images within an RBD block pool
- Provides csi-addons to manage per Persistent Volume Claim (PVC) mirroring

OpenShift DR

OpenShift DR is a set of orchestrators to configure and manage stateful applications across a set of peer OpenShift clusters which are managed using RHACM and provides cloud-native interfaces to orchestrate the life-cycle of an application's state on Persistent Volumes. These include:

- Protecting an application and its state relationship across OpenShift clusters
- Failing over an application and its state to a peer cluster
- Relocate an application and its state to the previously deployed cluster

OpenShift DR is split into three components:

- **ODF Multicluster Orchestrator**: Installed on the multi-cluster control plane (RHACM Hub), it orchestrates configuration and peering of OpenShift Data Foundation clusters for Metro and Regional DR relationships
- **OpenShift DR Hub Operator**: Automatically installed as part of ODF Multicluster Orchestrator installation on the hub cluster to orchestrate failover or relocation of DR enabled applications.
- **OpenShift DR Cluster Operator**: Automatically installed on each managed cluster that is part of a Metro and Regional DR relationship to manage the lifecycle of all PVCs of an application.

4.2. REGIONAL-DR DEPLOYMENT WORKFLOW

This section provides an overview of the steps required to configure and deploy Regional-DR capabilities using the latest version of Red Hat OpenShift Data Foundation across two distinct OpenShift Container Platform clusters. In addition to two managed clusters, a third OpenShift Container Platform cluster will be required to deploy the Red Hat Advanced Cluster Management (RHACM).

To configure your infrastructure, perform the below steps in the order given:

1. Ensure requirements across the three: Hub, Primary and Secondary Openshift Container Platform clusters that are part of the DR solution are met. See Requirements for enabling Regional-DR.
2. Install OpenShift Data Foundation operator and create a storage system on Primary and Secondary managed clusters. See Creating OpenShift Data Foundation cluster on managed clusters.
3. Install the ODF Multicluster Orchestrator on the Hub cluster. See Installing ODF Multicluster Orchestrator on Hub cluster.
4. Configure SSL access between the Hub, Primary and Secondary clusters. See Configuring SSL access across clusters.
5. Create a DRPolicy resource for use with applications requiring DR protection across the Primary and Secondary clusters. See Creating Disaster Recovery Policy on Hub cluster .

   NOTE

   There can be more than a single policy.

6. Testing your disaster recovery solution with:

   a. **Subscription-based** application:

      - Create Subscription-based applications. See Creating sample application.

      - Test failover and relocate operations using the sample subscription-based application between managed clusters. See Subscription-based application failover and relocating subscription-based application.

   b. **ApplicationSet-based** application:

      - Create sample applications. See Creating ApplicationSet-based applications.

      - Test failover and relocate operations using the sample application between managed clusters. See ApplicationSet-based application failover and relocating ApplicationSet-based application.

   c. **Discovered applications**

      - Ensure all requirements mentioned in Prerequisites is addressed. See Prerequisites for disaster recovery protection of discovered applications

      - Create a sample discovered application. See Creating a sample discovered application

      - Enroll the discovered application. See Enrolling a sample discovered application for disaster recovery protection

      - Test failover and relocate. See Discovered application failover and relocate

4.3. REQUIREMENTS FOR ENABLING REGIONAL-DR

The prerequisites to installing a disaster recovery solution supported by Red Hat OpenShift Data Foundation are as follows:

- You must have three OpenShift clusters that have network reachability between them:

  - **Hub cluster** where Red Hat Advanced Cluster Management (RHACM) for Kubernetes operator is installed.

  - **Primary managed cluster** where OpenShift Data Foundation is running.

  - **Secondary managed cluster** where OpenShift Data Foundation is running.

NOTE

For configuring hub recovery setup, you need a 4th cluster which acts as the passive hub. The primary managed cluster (Site-1) can be co-situated with the active RHACM hub cluster while the passive hub cluster is situated along with the secondary managed cluster (Site-2). Alternatively, the active RHACM hub cluster can be placed in a neutral site (Site-3) that is not impacted by the failures of either of the primary managed cluster at Site-1 or the secondary cluster at Site-2. In this situation, if a passive hub cluster is used it can be placed with the secondary cluster at Site-2. For more information, see Configuring passive hub cluster for hub recovery.

- Ensure that RHACM operator and MultiClusterHub is installed on the Hub cluster. See RHACM installation guide for instructions.
  After the operator is successfully installed, a popover with a message that the Web console update is available appears on the user interface. Click **Refresh web console** from this popover for the console changes to reflect.

IMPORTANT

Ensure that application traffic routing and redirection are configured appropriately.

- On the Hub cluster
  - Navigate to **All Clusters** → **Infrastructure** → **Clusters**.
  - Import or create the **Primary managed cluster** and the **Secondary managed cluster** using the RHACM console.
  - Choose the appropriate options for your environment.

  For instructions, see Creating a cluster and Importing a target managed cluster to the hub cluster.

- Connect the private OpenShift cluster and service networks using the RHACM Submariner add-ons. Verify that the two clusters have non-overlapping service and cluster private networks. Otherwise, ensure that the Globalnet is enabled during the Submariner add-ons installation.
  Run the following command for each of the managed clusters to determine if Globalnet needs to be enabled. The following example is for non-overlapping cluster and service networks so Globalnet would not be enabled.

```
$ oc get networks.config.openshift.io cluster -o json | jq .spec
```

Example output for Primary cluster:

```
{
  "clusterNetwork": [
    {
      "cidr": "10.5.0.0/16",
      "hostPrefix": 23
    }
  ],
  "externalIP": {
    "policy": {}
  },
  "networkType": "OVNKubernetes",
  "serviceNetwork": [
    "10.15.0.0/16"
  ]
}
```

Example output for Secondary cluster:

```
{
  "clusterNetwork": [
    {
      "cidr": "10.6.0.0/16",
      "hostPrefix": 23
    }
  ],
  "externalIP": {
    "policy": {}
  },
  "networkType": "OVNKubernetes",
  "serviceNetwork": [
    "10.16.0.0/16"
  ]
}
```

Additionally, if Submariner and OpenShift Data Foundation are already installed on the managed clusters, use the OpenShift Data Foundation command line interface (CLI) tool to get additional information about the clusters. This information can determine the need for enabling Globalnet during submariner installation based on the clusters service and private networks.

Download the the OpenShift Data Foundation CLI tool from the customer portal.

Run the following command on one of the two managed clusters, where **PeerManagedClusterName(ClusterID** is the name of the peer OpenShift Data Foundation cluster:

```
$ odf get dr-prereq <PeerManagedClusterName(ClusterID)>
```

If submariner is not installed with Globalnet on clusters with overlapping services, the following output shows:

```
Info: Submariner is installed.
Info: Globalnet is required.
Info: Globalnet is not enabled.
```

NOTE

This requires Submariner to be uninstalled and then reinstalled with Globalnet enabled.

If submariner is installed with Globalnet on clusters with overlapping services, the following output shows:

```
Info: Submariner is installed.
Info: Globalnet is required.
Info: Globalnet is enabled.
```

If submariner is installed without Globalnet on clusters with non-overlapping services, the following output shows:

```
Info: Submariner is installed.
Info: Globalnet is not required.
Info: Globalnet is not enabled.
```

If submariner is installed with Globalnet on clusters with non-overlapping services, the following output shows:

```
Info: Submariner is installed.
Info: Globalnet is not required.
Info: Globalnet is enabled.
```

For more information, see Submariner documentation.

4.4. CREATING AN OPENSHIFT DATA FOUNDATION CLUSTER ON MANAGED CLUSTERS

In order to configure storage replication between the two OpenShift Container Platform clusters, create an OpenShift Data Foundation storage system after you install the OpenShift Data Foundation operator.

> **NOTE**
>
> Refer to OpenShift Data Foundation deployment guides and instructions that are specific to your infrastructure (AWS, VMware, BM, Azure, etc.).

Procedure

1. Install and configure the latest **OpenShift Data Foundation** cluster on each of the managed clusters.
   For information about the OpenShift Data Foundation deployment, refer to your infrastructure specific deployment guides (for example, AWS, VMware, Bare metal, Azure).

   > **NOTE**
   >
   > While creating the storage cluster, in the **Data Protection** step, you must select the **Prepare cluster for disaster recovery (Regional-DR only)**checkbox.

2. Validate the successful deployment of OpenShift Data Foundation on each managed cluster with the following command:

   ```
   $ oc get storagecluster -n openshift-storage ocs-storagecluster -o jsonpath='{.status.phase}
   {"\n"}'
   ```

   For the Multicloud Gateway (MCG):

   ```
   $ oc get noobaa -n openshift-storage noobaa -o jsonpath='{.status.phase}{"\n"}'
   ```

   If the status result is **Ready** for both queries on the **Primary managed cluster** and the **Secondary managed cluster**, then continue with the next step.

3. In the OpenShift Web Console, navigate to **Installed Operators → OpenShift Data Foundation → Storage System → ocs-storagecluster-storagesystem → Resources** and verify that the **Status** of **StorageCluster** is **Ready** and has a green tick mark next to it.

4. [Optional] If Globalnet was enabled when Submariner was installed, then edit the **StorageCluster** after the OpenShift Data Foundation install finishes.
   For Globalnet networks, manually edit the **StorageCluster** yaml to add the **clusterID** and set **enabled** to **true**. Replace *<clustername>* with your RHACM imported or newly created managed cluster name. Edit the **StorageCluster** on both the Primary managed cluster and the Secondary

managed cluster.

> WARNING
>
> Do not make this change in the **StorageCluster** unless you enabled Globalnet when Submariner was installed.

```
$ oc edit storagecluster -o yaml -n openshift-storage
```

```
spec:
  network:
    multiClusterService:
      clusterID: <clustername>
      enabled: true
```

> IMPORTANT
>
> If **multiClusterService** is enabled, it can not be disabled or undone as it failsover the MONs and restarts the OSDs with GlobalNet IP addresses which can not be changed once assigned.

5. After the above changes are made,

   a. Wait for the OSD pods to restart and OSD services to be created.

   b. Wait for all MONS to failover.

   c. Ensure that the MONS and OSD services are exported.

   ```
   $ oc get serviceexport -n openshift-storage
   ```

   ```
   NAME              AGE
   rook-ceph-mon-d   4d14h
   rook-ceph-mon-e   4d14h
   rook-ceph-mon-f   4d14h
   rook-ceph-osd-0   4d14h
   rook-ceph-osd-1   4d14h
   rook-ceph-osd-2   4d14h
   ```

   d. Ensure that cluster is in a **Ready** state and cluster health has a green tick indicating **Health ok**. Verify using step 3.

4.5. INSTALLING OPENSHIFT DATA FOUNDATION MULTICLUSTER ORCHESTRATOR OPERATOR

OpenShift Data Foundation Multicluster Orchestrator is a controller that is installed from OpenShift Container Platform’s OperatorHub on the Hub cluster.

Procedure

1. On the **Hub cluster**, navigate to **OperatorHub** and use the keyword filter to search for **ODF Multicluster Orchestrator**.

2. Click **ODF Multicluster Orchestrator** tile.

3. Keep all default settings and click **Install**.
   Ensure that the operator resources are installed in **openshift-operators** project and available to all namespaces.

   > NOTE
   >
   > The **ODF Multicluster Orchestrator** also installs the **Openshift DR Hub Operator** on the RHACM hub cluster as a dependency.

4. Verify that the operator **Pods** are in a **Running** state. The **OpenShift DR Hub operator** is also installed at the same time in **openshift-operators** namespace.

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

   Example output:

   ```
   NAME                                        READY   STATUS      RESTARTS    AGE
   odf-multicluster-console-6845b795b9-blxrn   1/1     Running     0           4d20h
   odfmo-controller-manager-f9d9dfb59-jbrsd    1/1     Running     0           4d20h
   ramen-hub-operator-6fb887f885-fss4w         2/2     Running     0           4d20h
   ```

4.6. CONFIGURING SSL ACCESS ACROSS CLUSTERS

Configure network (SSL) access between the **primary and secondary clusters** so that metadata can be stored on the alternate cluster in a Multicloud Gateway (MCG) **object bucket** using a secure transport protocol and in the **Hub cluster** for verifying access to the object buckets.

> NOTE
>
> If all of your OpenShift clusters are deployed using a signed and valid set of certificates for your environment then this section can be skipped.

Procedure

1. Extract the ingress certificate for the Primary managed cluster and save the output to **primary.crt**.

   ```
   $ oc get cm default-ingress-cert -n openshift-config-managed -o jsonpath="{['data']['ca-
   bundle\.crt']}" > primary.crt
   ```

2. Extract the ingress certificate for the Secondary managed cluster and save the output to **secondary.crt**.

   ```
   $ oc get cm default-ingress-cert -n openshift-config-managed -o jsonpath="{['data']['ca-
   bundle\.crt']}" > secondary.crt
   ```

3. Create a new **ConfigMap** file to hold the remote cluster's certificate bundle with filename **cm-clusters-crt.yaml**.

   NOTE

   There could be more or less than three certificates for each cluster as shown in this example file. Also, ensure that the certificate contents are correctly indented after you copy and paste from the **primary.crt** and **secondary.crt** files that were created before.

```
apiVersion: v1
data:
  ca-bundle.crt: |
    -----BEGIN CERTIFICATE-----
    <copy contents of cert1 from primary.crt here>
    -----END CERTIFICATE-----

    -----BEGIN CERTIFICATE-----
    <copy contents of cert2 from primary.crt here>
    -----END CERTIFICATE-----

    -----BEGIN CERTIFICATE-----
    <copy contents of cert3 primary.crt here>
    -----END CERTIFICATE----

    -----BEGIN CERTIFICATE-----
    <copy contents of cert1 from secondary.crt here>
    -----END CERTIFICATE-----

    -----BEGIN CERTIFICATE-----
    <copy contents of cert2 from secondary.crt here>
    -----END CERTIFICATE-----

    -----BEGIN CERTIFICATE-----
    <copy contents of cert3 from secondary.crt here>
    -----END CERTIFICATE-----
kind: ConfigMap
metadata:
  name: user-ca-bundle
  namespace: openshift-config
```

4. Create the **ConfigMap** on the **Primary managed cluster**, **Secondary managed cluster**, and the **Hub cluster**.

```
$ oc create -f cm-clusters-crt.yaml
```

   Example output:

```
configmap/user-ca-bundle created
```

5. Patch default proxy resource on the **Primary managed cluster**, **Secondary managed cluster**, and the **Hub cluster**.

```
$ oc patch proxy cluster --type=merge  --patch='{"spec":{"trustedCA":{"name":"user-ca-
bundle"}}}'
```

Example output:

```
proxy.config.openshift.io/cluster patched
```

4.7. CREATING DISASTER RECOVERY POLICY ON HUB CLUSTER

Openshift Disaster Recovery Policy (DRPolicy) resource specifies OpenShift Container Platform clusters participating in the disaster recovery solution and the desired replication interval. DRPolicy is a cluster scoped resource that users can apply to applications that require Disaster Recovery solution.

The **ODF MultiCluster Orchestrator** Operator facilitates the creation of each **DRPolicy** and the corresponding **DRClusters** through the **Multicluster Web console**.

Prerequisites

- Ensure that there is a minimum set of two managed clusters.

Procedure

1. On the **OpenShift console**, navigate to **All Clusters → Data Services → Disaster recovery**.
2. On the Overview tab, click **Create a disaster recovery policy**or you can navigate to Policies tab and click **Create DRPolicy**.
3. Enter **Policy name**. Ensure that each DRPolicy has a unique name (for example: **ocp4bos1-ocp4bos2-5m**).
4. Select two clusters from the list of managed clusters to which this new policy will be associated with.
5. **Replication policy** is automatically set to **Asynchronous** based on the OpenShift clusters selected and a **Sync schedule** option will become available.
6. Set **Sync schedule**.

   IMPORTANT

   For every desired replication interval a new **DRPolicy** must be created with a unique name (such as: **ocp4bos1-ocp4bos2-10m**). The same clusters can be selected but the **Sync schedule** can be configured with a different replication interval in minutes/hours/days. The minimum is one minute.

7. **Optional**: Expand **Advanced settings** and check the **Enable disaster recovery support for restored and cloned PersistentVolumeClaims (For Data Foundation only)** checkbox. See Disaster recovery protection for cloned and restored RBD volumes for more details.

NOTE

This option should only be used with discovered applications. If there are existing Disaster Recovery protected workloads in the same namespace, Disaster Recovery protection may need to be disabled and re-enabled with a new DRPolicy created using this advanced option.

8. Click **Create**.

9. Verify that the **DRPolicy** is created successfully. Run this command on the **Hub cluster** for each of the DRPolicy resources created, where *<drpolicy_name>* is replaced with your unique name.

```
$ oc get drpolicy <drpolicy_name> -o jsonpath='{.status.conditions[].reason}{"\n"}'
```

Example output:

```
Succeeded
```

When a DRPolicy is created, along with it, two DRCluster resources are also created. It could take up to 10 minutes for all three resources to be validated and for the status to show as **Succeeded**.

NOTE

Editing of **SchedulingInterval**, **ReplicationClassSelector**, **VolumeSnapshotClassSelector** and **DRClusters** field values are not supported in the DRPolicy.

10. Verify the object bucket access from the **Hub cluster** to both the **Primary managed cluster** and the **Secondary managed cluster**.

    a. Get the names of the **DRClusters** on the Hub cluster.

    ```
    $ oc get drclusters
    ```

    Example output:

    ```
    NAME       AGE
    ocp4bos1   4m42s
    ocp4bos2   4m42s
    ```

    b. Check S3 access to each bucket created on each managed cluster. Use the DRCluster validation command, where *<drcluster_name>* is replaced with your unique name.

    NOTE

    Editing of **Region** and **S3ProfileName** field values are non supported in DRClusters.

    ```
    $ oc get drcluster <drcluster_name> -o jsonpath='{.status.conditions[2].reason}{"\n"}'
    ```

    Example output:

```
Succeeded
```

NOTE

Make sure to run commands for both **DRClusters** on the **Hub cluster**.

11. Verify that the **OpenShift DR Cluster operator** installation was successful on the **Primary managed cluster** and the **Secondary managed cluster**.

```
$ oc get csv,pod -n openshift-dr-system
```

Example output:

```
NAME                                                                         DISPLAY                   VERSION
REPLACES   PHASE
clusterserviceversion.operators.coreos.com/odr-cluster-operator.v4.15.0         Openshift DR
Cluster Operator   4.15.0                 Succeeded
clusterserviceversion.operators.coreos.com/volsync-product.v0.8.0              VolSync
0.8.0                   Succeeded

NAME                                         READY   STATUS    RESTARTS   AGE
pod/ramen-dr-cluster-operator-6467cf5d4c-cc8kz   2/2     Running   0          3d12h
```

You can also verify that **OpenShift DR Cluster Operator** is installed successfully on the **OperatorHub** of each managed cluster.

NOTE

On the initial run, VolSync operator is installed automatically. VolSync is used to set up volume replication between two clusters to protect CephFs-based PVCs. The replication feature is enabled by default.

12. Verify that the status of the OpenShift Data Foundation mirroring **daemon** health on the **Primary managed cluster** and the **Secondary managed cluster**.

```
$ oc get cephblockpool ocs-storagecluster-cephblockpool -n openshift-storage -o
jsonpath='{.status.mirroringStatus.summary}{"\n"}'
```

Example output:

```
{"daemon_health":"OK","health":"OK","image_health":"OK","states":{}}
```

CAUTION

It could take up to 10 minutes for the **daemon_health** and **health** to go from **Warning** to **OK**. If the status does not become **OK** eventually, then use the RHACM console to verify that the Submariner connection between managed clusters is still in a healthy state. Do not proceed until all values are **OK**.

4.8. DISASTER RECOVERY PROTECTION FOR CLONED AND RESTORED RBD VOLUMES

Cloned and restored RBD volumes are copy-on-write clones of the corresponding datasources. Such RBD volumes are still linked to the parent volume to optimize space consumption and Ceph cluster performance. In order to be able to mirror RBD images backing such volumes, they need to be separated from the parent RBD image.

Selecting the advanced option in Step 7 of Creating Disaster Recovery Policy on Hub cluster instructs CephCSI driver to perform necessary operations on the cloned or restored RBD volumes to prepare them for Disaster Recovery protection. The necessary operation has the following consequences:

- Space consumption may increase up to the total capacity of all cloned and restored RBD volumes being protected. It is recommended to make sure there is enough space available in the cluster to avoid the cluster getting full.
- Ceph cluster resource usage increases.
- The time taken for the operation to complete depends on the number of the RBD volumes, size of each volume, Ceph cluster resource availability, and client IO going on the RBD volume. Therefore, the amount of time required for completion of the operation cannot be determined.

NOTE

This option should only be used with discovered applications. If there are existing Disaster Recovery protected workloads in the same namespace, Disaster Recovery protection may need to be disabled and re-enabled with a new DRPolicy created using this advanced option.

4.9. CREATE SAMPLE APPLICATION FOR TESTING DISASTER RECOVERY SOLUTION

OpenShift Data Foundation disaster recovery (DR) solution supports disaster recovery for Subscription-based and ApplicationSet-based applications that are managed by RHACM. For more details, see Subscriptions and ApplicationSet documentation.

The following sections detail how to create an application and apply a DRPolicy to an application.

- Subscription-based applications
  OpenShift users that do not have cluster-admin permissions, see the knowledge article on how to assign necessary permissions to an application user for executing disaster recovery actions.
- ApplicationSet-based applications
  OpenShift users that do not have cluster-admin permissions cannot create ApplicationSet-based applications.

4.9.1. Subscription-based applications

4.9.1.1. Creating a sample Subscription-based application

In order to test **failover** from the **Primary managed cluster** to the **Secondary managed cluster** and **relocate**, we need a sample application.

Prerequisites

- When creating an application for general consumption, ensure that the application is deployed to ONLY one cluster.

- Use the sample application called **busybox** as an example.
- Ensure all external routes of the application are configured using either Global Traffic Manager (GTM) or Global Server Load Balancing (GLSB) service for traffic redirection when the application fails over or is relocated.
- As a best practice, group Red Hat Advanced Cluster Management (RHACM) subscriptions that belong together, refer to a single Placement Rule to DR protect them as a group. Further create them as a single application for a logical grouping of the subscriptions for future DR actions like failover and relocate.

NOTE

If unrelated subscriptions refer to the same Placement Rule for placement actions, they are also DR protected as the DR workflow controls all subscriptions that references the Placement Rule.

Procedure

1. On the Hub cluster, navigate to **Applications** and click **Create application**.
2. Select type as **Subscription**.
3. Enter your application **Name** (for example, **busybox**) and **Namespace** (for example, **busybox-sample**).
4. In the Repository location for resources section, select **Repository type Git**.
5. Enter the Git repository URL for the sample application, the github **Branch** and **Path** where the resources **busybox** Pod and PVC will be created.
    - Use the sample application repository as **https://github.com/red-hat-storage/ocm-ramen-samples**
    - Select **Branch** as **release-4.17**.
    - Choose one of the following **Path**
        - **busybox-odr** to use RBD Regional-DR.
        - **busybox-odr-cephfs** to use CephFS Regional-DR.
6. Scroll down in the form until you see **Deploy application resources on clusters with all specified labels**.
    - Select the global **Cluster sets** or the one that includes the correct managed clusters for your environment.
    - Add a label *<name>* with its value set to the **managed cluster** name.
7. Click **Create** which is at the top right hand corner.
   On the follow-on screen go to the **Topology** tab. You should see that there are all Green checkmarks on the application topology.

> **NOTE**
>
> To get more information, click on any of the topology elements and a window will appear on the right of the topology view.

8. Validating the sample application deployment.
   Now that the **busybox** application has been deployed to your preferred Cluster, the deployment can be validated.

   Log in to your managed cluster where **busybox** was deployed by RHACM.

   ```
   $ oc get pods,pvc -n busybox-sample
   ```

   Example output:

   ```
   NAME                          READY   STATUS    RESTARTS   AGE
   pod/busybox-67bf494b9-zl5tr   1/1     Running   0          77s


   NAME                                STATUS   VOLUME                                     CAPACITY   ACCESS
   MODES   STORAGECLASS                  AGE
   persistentvolumeclaim/busybox-pvc   Bound    pvc-c732e5fe-daaf-4c4d-99dd-462e04c18412
   5Gi        RWO            ocs-storagecluster-ceph-rbd   77s
   ```

4.9.1.2. Apply Data policy to sample application

Prerequisites

- Ensure that both managed clusters referenced in the Data policy are reachable. If not, the application will not be protected for disaster recovery until both clusters are online.

Procedure

1. On the Hub cluster, navigate to **All Clusters → Applications**.
2. Click the Actions menu at the end of application to view the list of available actions.
3. Click **Manage data policy→ Assign data policy**.
4. Select **Policy** and click **Next**.
5. Select an **Application resource** and then use **PVC label selector** to select **PVC label** for the selected application resource.

   > **NOTE**
   >
   > You can select more than one PVC label for the selected application resources. You can also use the **Add application resource** option to add multiple resources.

6. After adding all the application resources, click **Next**.
7. Review the **Policy configuration details** and click **Assign**. The newly assigned Data policy is displayed on the **Manage data policy** modal list view.

8. Verify that you can view the assigned policy details on the Applications page.

    a. On the Applications page, navigate to the **Data policy** column and click the **policy link** to expand the view.

    b. Verify that you can see the number of policies assigned along with failover and relocate status.

    c. Click **View more details** to view the status of ongoing activities with the policy in use with the application.

9. Optional: Verify RADOS block device (RBD) **volumereplication** and **volumereplicationgroup** on the primary cluster.

    ```
    $ oc get volumereplications.replication.storage.openshift.io -A
    ```

    Example output:

    ```
    NAME           AGE     VOLUMEREPLICATIONCLASS                PVCNAME
    DESIREDSTATE   CURRENTSTATE
    busybox-pvc     2d16h   rbd-volumereplicationclass-1625360775   busybox-pvc      primary
    Primary
    ```

    ```
    $ oc get volumereplicationgroups.ramendr.openshift.io -A
    ```

    Example output:

    ```
    NAME           DESIREDSTATE   CURRENTSTATE
    busybox-drpc   primary        Primary
    ```

10. Optional: Verify CephFS volsync replication source has been set up successfully in the primary cluster and VolSync ReplicationDestination has been set up in the failover cluster.

    ```
    $ oc get replicationsource -n busybox-sample
    ```

    Example output:

    ```
    NAME           SOURCE          LAST SYNC              DURATION          NEXT SYNC
    busybox-pvc     busybox-pvc     2022-12-20T08:46:07Z   1m7.794661104s    2022-12-
    20T08:50:00Z
    ```

    ```
    $ oc get replicationdestination -n busybox-sample
    ```

    Example output:

    ```
    NAME           LAST SYNC              DURATION          NEXT SYNC
    busybox-pvc     2022-12-20T08:46:32Z   4m39.52261108s
    ```

4.9.2. ApplicationSet-based applications

4.9.2.1. Creating ApplicationSet-based applications

Prerequisite

- Ensure that the Red Hat OpenShift GitOps operator is installed on all three clusters: **Hub cluster**, **Primary managed cluster** and **Secondary managed cluster**. For instructions, see Installing Red Hat OpenShift GitOps Operator in web console .
- On the Hub cluster, ensure that both Primary and Secondary managed clusters are registered to GitOps. For registration instructions, see Registering managed clusters to GitOps . Then check if the Placement used by **GitOpsCluster** resource to register both managed clusters, has the tolerations to deal with cluster unavailability. You can verify if the following tolerations are added to the Placement using the command **oc get placement <placement-name> -n openshift-gitops -o yaml**.

```
tolerations:
- key: cluster.open-cluster-management.io/unreachable
  operator: Exists
- key: cluster.open-cluster-management.io/unavailable
  operator: Exists
```

  In case the tolerations are not added, see Configuring application placement tolerations for Red Hat Advanced Cluster Management and OpenShift GitOps.
- Ensure that you have created the **ClusterRoleBinding** yaml on both the **Primary** and **Secondary managed** clusters. For instruction, see the Prerequisites chapter in RHACM documentation.

Procedure

1. On the Hub cluster, navigate to **All Clusters → Applications** and click **Create application**.
2. Choose the application type as **Argo CD ApplicationSet - Pull model**
3. In the **General** step, enter your **Application set name**.
4. Select **Argo server openshift-gitops** and **Requeue time** as **180** seconds.
5. Click **Next**.
6. In the Repository location for resources section, select **Repository type Git**.
7. Enter the Git repository URL for the sample application, the github Branch and Path where the resources busybox Pod and PVC will be created.
   a. Use the sample application repository as https://github.com/red-hat-storage/ocm-ramen-samples
   b. Select **Revision** as **release-4.17**
   c. Choose one of the following Path:
      - **busybox-odr** to use RBD Regional-DR.
      - **busybox-odr-cephfs** to use CephFS Regional-DR.
8. Enter **Remote namespace** value. (example, busybox-sample) and click **Next**.

9. Choose the **Sync policy** settings as per your requirement or go with the default selections, and then click **Next**.
   You can choose one or more options.

10. In Label expressions, add a label *<name>* with its value set to the **managed cluster** name.

11. Click **Next**.

12. Review the setting details and click **Submit**.

4.9.2.2. Apply Data policy to sample ApplicationSet-based application

Prerequisites

- Ensure that both managed clusters referenced in the Data policy are reachable. If not, the application will not be protected for disaster recovery until both clusters are online.

Procedure

1. On the Hub cluster, navigate to **All Clusters → Applications**.

2. Click the Actions menu at the end of application to view the list of available actions.

3. Click **Manage data policy→ Assign data policy**.

4. Select **Policy** and click **Next**.

5. Select an **Application resource** and then use **PVC label selector** to select **PVC label** for the selected application resource.

   NOTE

   You can select more than one PVC label for the selected application resources.

6. After adding all the application resources, click **Next**.

7. Review the **Policy configuration details** and click **Assign**. The newly assigned Data policy is displayed on the **Manage data policy** modal list view.

8. Verify that you can view the assigned policy details on the Applications page.

   a. On the Applications page, navigate to the **Data policy** column and click the **policy link** to expand the view.

   b. Verify that you can see the number of policies assigned along with failover and relocate status.

9. Optional: Verify Rados block device (RBD) **volumereplication** and **volumereplicationgroup** on the primary cluster.

   ```
   $ oc get volumereplications.replication.storage.openshift.io -A
   ```

   Example output:

   ```
   NAME          AGE    VOLUMEREPLICATIONCLASS              PVCNAME
   ```

```
DESIREDSTATE   CURRENTSTATE
busybox-pvc      2d16h   rbd-volumereplicationclass-1625360775   busybox-pvc      primary
Primary
```

```
$ oc get volumereplicationgroups.ramendr.openshift.io -A
```

Example output:

```
NAME          DESIREDSTATE   CURRENTSTATE
busybox-drpc   primary        Primary
```

10. Optional: Verify CephFS volsync replication source has been setup successfully in the primary cluster and VolSync ReplicationDestination has been setup in the failover cluster.

```
$ oc get replicationsource -n busybox-sample
```

Example output:

```
NAME           SOURCE          LAST SYNC             DURATION         NEXT SYNC
busybox-pvc     busybox-pvc     2022-12-20T08:46:07Z   1m7.794661104s    2022-12-
20T08:50:00Z
```

```
$ oc get replicationdestination -n busybox-sample
```

Example output:

```
NAME           LAST SYNC             DURATION         NEXT SYNC
busybox-pvc     2022-12-20T08:46:32Z   4m39.52261108s
```

4.9.3. Deleting sample application

This section provides instructions for deleting the sample application **busybox** using the RHACM console.

IMPORTANT

When deleting a DR protected application, access to both clusters that belong to the DRPolicy is required. This is to ensure that all protected API resources and resources in the respective S3 stores are cleaned up as part of removing the DR protection. If access to one of the clusters is not healthy, deleting the **DRPlacementControl** resource for the application, on the hub, would remain in the Deleting state.

Prerequisites

- These instructions to delete the sample application should not be executed until the failover and relocate testing is completed and the application is ready to be removed from RHACM and the managed clusters.

Procedure

1. On the RHACM console, navigate to **Applications**.

2. Search for the sample application to be deleted (for example, **busybox**).

3. Click the Action Menu **(⋮)** next to the application you want to delete.

4. Click **Delete application**.
   When the **Delete application** is selected a new screen will appear asking if the application related resources should also be deleted.

5. Select **Remove application related resources** checkbox to delete the Subscription and PlacementRule.

6. Click **Delete**. This will delete the busybox application on the Primary managed cluster (or whatever cluster the application was running on).

7. In addition to the resources deleted using the RHACM console, delete the **DRPlacementControl** if it is not auto-deleted after deleting the **busybox** application.

   a. Log in to the OpenShift Web console for the Hub cluster and navigate to Installed Operators for the project **busybox-sample**.
      For ApplicationSet applications, select the project as **openshift-gitops**.

   b. Click **OpenShift DR Hub Operator** and then click the **DRPlacementControl** tab.

   c. Click the Action Menu **(⋮)** next to the **busybox** application DRPlacementControl that you want to delete.

   d. Click **Delete DRPlacementControl**.

   e. Click **Delete**.

NOTE

This process can be used to delete any application with a **DRPlacementControl** resource.

4.10. SUBSCRIPTION-BASED APPLICATION FAILOVER BETWEEN MANAGED CLUSTERS

Failover is a process that transitions an application from a primary cluster to a secondary cluster in the event of a primary cluster failure. While failover provides the ability for the application to run on the secondary cluster with minimal interruption, making an uninformed failover decision can have adverse consequences, such as complete data loss in the event of unnoticed replication failure from primary to secondary cluster. If a significant amount of time has gone by since the last successful replication, it’s best to wait until the failed primary is recovered.

LastGroupSyncTime is a critical metric that reflects the time since the last successful replication occurred for all PVCs associated with an application. In essence, it measures the synchronization health between the primary and secondary clusters. So, prior to initiating a failover from one cluster to another, check for this metric and only initiate the failover if the LastGroupSyncTime is within a reasonable time in the past.

NOTE

During the course of failover the Ceph-RBD mirror deployment on the failover cluster is scaled down to ensure a clean failover for volumes that are backed by Ceph-RBD as the storage provisioner.

Prerequisites

- If your setup has active and passive RHACM hub clusters, see Hub recovery using Red Hat Advanced Cluster Management.
- When the primary cluster is in a state other than **Ready**, check the actual status of the cluster as it might take some time to update.
    1. Navigate to the **RHACM console → Infrastructure → Clusters → Cluster list**tab.
    2. Check the status of both the managed clusters individually before performing failover operation.
       However, failover operation can still be performed when the cluster you are failing over to is in a *Ready* state.
- Run the following command on the Hub Cluster to check if **lastGroupSyncTime** is within an acceptable data loss window, when compared to current time.

  ```
  $ oc get drpc -o yaml -A | grep lastGroupSyncTime
  ```

  Example output:

  ```
  [...]
  lastGroupSyncTime: "2023-07-10T12:40:10Z"
  ```

Procedure

1. On the Hub cluster, navigate to **Applications**.
2. Click the **Actions** menu at the end of application row to view the list of available actions.
3. Click **Failover application**.
4. After the **Failover application** modal is shown, select **policy** and **target cluster** to which the associated application will failover in case of a disaster.
5. Click the **Select subscription group** dropdown to verify the default selection or modify this setting.
   By default, the subscription group that replicates for the application resources is selected.
6. Check the status of the **Failover readiness**.
    - If the status is **Ready** with a green tick, it indicates that the target cluster is ready for failover to start. Proceed to step 7.
    - If the status is **Unknown** or **Not ready**, then wait until the status changes to **Ready**.
7. Click **Initiate**. The busybox application is now failing over to the **Secondary-managed cluster**.
8. Close the modal window and track the status using the **Data policy** column on the Applications page.
9. Verify that the activity status shows as **FailedOver** for the application.
    a. Navigate to the **Applications → Overview** tab.

b. In the **Data policy** column, click the **policy** link for the application you applied the policy to.

c. On the **Data policy** popover, click the **View more details** link.

d. Verify that you can see one or more policy names and the ongoing activities (Last sync time and Activity status) associated with the policy in use with the application.

4.11. APPLICATIONSET-BASED APPLICATION FAILOVER BETWEEN MANAGED CLUSTERS

Failover is a process that transitions an application from a primary cluster to a secondary cluster in the event of a primary cluster failure. While failover provides the ability for the application to run on the secondary cluster with minimal interruption, making an uninformed failover decision can have adverse consequences, such as complete data loss in the event of unnoticed replication failure from primary to secondary cluster. If a significant amount of time has gone by since the last successful replication, it’s best to wait until the failed primary is recovered.

LastGroupSyncTime is a critical metric that reflects the time since the last successful replication occurred for all PVCs associated with an application. In essence, it measures the synchronization health between the primary and secondary clusters. So, prior to initiating a failover from one cluster to another, check for this metric and only initiate the failover if the LastGroupSyncTime is within a reasonable time in the past.

NOTE

During the course of failover the Ceph-RBD mirror deployment on the failover cluster is scaled down to ensure a clean failover for volumes that are backed by Ceph-RBD as the storage provisioner.

Prerequisites

- If your setup has active and passive RHACM hub clusters, see Hub recovery using Red Hat Advanced Cluster Management .
- When the primary cluster is in a state other than **Ready**, check the actual status of the cluster as it might take some time to update.
  1. Navigate to the **RHACM console → Infrastructure → Clusters → Cluster list**tab.
  2. Check the status of both the managed clusters individually before performing failover operation.
     However, failover operation can still be performed when the cluster you are failing over to is in a *Ready* state.
- Run the following command on the Hub Cluster to check if **lastGroupSyncTime** is within an acceptable data loss window, when compared to current time.

  ```
  $ oc get drpc -o yaml -A | grep lastGroupSyncTime
  ```

  Example output:

  ```
  [...]
  lastGroupSyncTime: "2023-07-10T12:40:10Z"
  ```

Procedure

1. On the Hub cluster, navigate to **Applications**.
2. Click the **Actions** menu at the end of application row to view the list of available actions.
3. Click **Failover application**.
4. When the **Failover application** modal is shown, verify the details presented are correct and check the status of the Failover **readiness**. If the status is **Ready** with a green tick, it indicates that the target cluster is ready for failover to start.
5. Click **Initiate**. The busybox resources are now created on the target cluster.
6. Close the modal window and track the status using the **Data policy** column on the Applications page.
7. Verify that the activity status shows as **FailedOver** for the application.
    a. Navigate to the **Applications → Overview** tab.
    b. In the **Data policy** column, click the **policy** link for the application you applied the policy to.
    c. On the **Data policy** popover, verify that you can see one or more policy names and the ongoing activities associated with the policy in use with the application.

4.12. RELOCATING SUBSCRIPTION-BASED APPLICATION BETWEEN MANAGED CLUSTERS

Relocate an application to its preferred location when all managed clusters are available.

Prerequisite

- If your setup has active and passive RHACM hub clusters, see Hub recovery using Red Hat Advanced Cluster Management.
- When the primary cluster is in a state other than **Ready**, check the actual status of the cluster as it might take some time to update. Relocate can only be performed when both primary and preferred clusters are up and running.
    1. Navigate to **RHACM console → Infrastructure → Clusters → Cluster list**tab.
    2. Check the status of both the managed clusters individually before performing relocate operation.
- Perform relocate when **lastGroupSyncTime** is within the replication interval (for example, 5 minutes) when compared to current time. This is recommended to minimize the Recovery Time Objective (RTO) for any single application.
  Run this command on the Hub Cluster:

  ```
  $ oc get drpc -o yaml -A | grep lastGroupSyncTime
  ```

  Example output:

  ```
  [...]
  lastGroupSyncTime: "2023-07-10T12:40:10Z"
  ```

Compare the output time (UTC) to current time to validate that all **lastGroupSyncTime** values are within their application replication interval. If not, wait to Relocate until this is true for all **lastGroupSyncTime** values.

Procedure

1. On the Hub cluster, navigate to **Applications**.
2. Click the **Actions** menu at the end of application row to view the list of available actions.
3. Click **Relocate application**.
4. When the **Relocate application** modal is shown, select **policy** and **target cluster** to which the associated application will relocate to in case of a disaster.
5. By default, the subscription group that will deploy the application resources is selected. Click the **Select subscription group** dropdown to verify the default selection or modify this setting.
6. Check the status of the **Relocation readiness**.
   - If the status is **Ready** with a green tick, it indicates that the target cluster is ready for relocation to start. Proceed to step 7.
   - If the status is **Unknown** or **Not ready**, then wait until the status changes to **Ready**.
7. Click **Initiate**. The busybox resources are now created on the target cluster.
8. Close the modal window and track the status using the **Data policy** column on the Applications page.
9. Verify that the activity status shows as **Relocated** for the application.
   a. Navigate to the **Applications** → **Overview** tab.
   b. In the **Data policy** column, click the **policy** link for the application you applied the policy to.
   c. On the **Data policy** popover, click the **View more details** link.
   d. Verify that you can see one or more policy names and the ongoing activities (Last sync time and Activity status) associated with the policy in use with the application.

4.13. RELOCATING AN APPLICATIONSET-BASED APPLICATION BETWEEN MANAGED CLUSTERS

Relocate an application to its preferred location when all managed clusters are available.

Prerequisite

- If your setup has active and passive RHACM hub clusters, see Hub recovery using Red Hat Advanced Cluster Management.
- When the primary cluster is in a state other than **Ready**, check the actual status of the cluster as it might take some time to update. Relocate can only be performed when both primary and preferred clusters are up and running.
  1. Navigate to **RHACM console → Infrastructure → Clusters → Cluster list**tab.

2. Check the status of both the managed clusters individually before performing relocate operation.

- Perform relocate when **lastGroupSyncTime** is within the replication interval (for example, 5 minutes) when compared to current time. This is recommended to minimize the Recovery Time Objective (RTO) for any single application.
  Run this command on the Hub Cluster:

  ```
  $ oc get drpc -o yaml -A | grep lastGroupSyncTime
  ```

  Example output:

  ```
  [...]
  lastGroupSyncTime: "2023-07-10T12:40:10Z"
  ```

  Compare the output time (UTC) to current time to validate that all **lastGroupSyncTime** values are within their application replication interval. If not, wait to Relocate until this is true for all **lastGroupSyncTime** values.

Procedure

1. On the Hub cluster, navigate to **Applications**.
2. Click the **Actions** menu at the end of application row to view the list of available actions.
3. Click **Relocate application**.
4. When the **Relocate application** modal is shown, select **policy** and **target cluster** to which the associated application will relocate to in case of a disaster.
5. Click **Initiate**. The busybox resources are now created on the target cluster.
6. Close the modal window and track the status using the **Data policy** column on the Applications page.
7. Verify that the activity status shows as **Relocated** for the application.
   a. Navigate to the **Applications → Overview** tab.
   b. In the **Data policy** column, click the **policy** link for the application you applied the policy to.
   c. On the **Data policy** popover, verify that you can see one or more policy names and the relocation status associated with the policy in use with the application.

4.14. DISASTER RECOVERY PROTECTION FOR DISCOVERED APPLICATIONS

Red Hat OpenShift Data Foundation now provides disaster recovery (DR) protection and support for workloads that are deployed in one of the managed clusters directly without using Red Hat Advanced Cluster Management (RHACM). These workloads are called discovered applications.

Workloads deployed using RHACM are termed managed applications, while those deployed directly on one of the managed clusters without using RHACM are called discovered applications. Although RHACM displays the details of both types of workloads, it does not manage the lifecycle (create, delete, edit) of discovered applications.

4.14.1. Prerequisites for disaster recovery protection of discovered applications

This section provides instructions to guide you through the prerequisites for protecting discovered applications. This includes tasks such as assigning a data policy and initiating DR actions such as failover and relocate.

1. Ensure that all the DR configurations have been installed on the Primary managed cluster and the Secondary managed cluster.

2. Install the OADP 1.4 operator.

   NOTE

   Any version before OADP 1.4 will not work for protecting discovered applications.

   a. On the **Primary** and **Secondary managed cluster**, navigate to **OperatorHub** and use the keyword filter to search for **OADP**.

   b. Click the **OADP** tile.

   c. Keep all default settings and click **Install**. Ensure that the operator resources are installed in the **openshift-adp** project.

   NOTE

   If OADP 1.4 is installed after DR configuration has been completed then the **ramen-dr-cluster-operator** pods on the **Primary managed cluster** and the **Secondary managed cluster** in namespace **openshift-dr-system** must be restarted (deleted and recreated).

3. [Optional] Add CACertificates to **ramen-hub-operator-config ConfigMap**.
   Configure network (SSL) access between the primary and secondary clusters so that metadata can be stored on the alternate cluster in a Multicloud Gateway (MCG) object bucket using a secure transport protocol and in the Hub cluster for verifying access to the object buckets.

   NOTE

   If all of your OpenShift clusters are deployed using a signed and valid set of certificates for your environment then this section can be skipped.

   If you are using self-signed certificates, then you have already created a **ConfigMap** named **user-ca-bundle** in the **openshift-config** namespace and added this ConfigMap to the default Proxy cluster resource. **This means you need to add thecaCertificates parameter to the configmap ramen-hub-operator-config with the encoded value.**

   a. Find the encoded value for the CACertificates.

   ```
   $ oc get configmap user-ca-bundle -n openshift-config -o jsonpath="{['data']['ca-bundle\.crt']}" |base64 -w 0
   ```

   b. Add this base64 encoded value to the configmap **ramen-hub-operator-config** on the Hub cluster. Example below shows where to add CACertificates.

```
$ oc edit configmap ramen-hub-operator-config -n openshift-operators
```

```
[...]
    ramenOpsNamespace: openshift-dr-ops
    s3StoreProfiles:
    - s3Bucket: odrbucket-36bceb61c09c
      s3CompatibleEndpoint: https://s3-openshift-storage.apps.hyper3.vmw.ibmfusion.eu
      s3ProfileName: s3profile-hyper3-ocs-storagecluster
      s3Region: noobaa
      s3SecretRef:
        name: 60f2ea6069e168346d5ad0e0b5faa59bb74946f
      caCertificates: {input base64 encoded value here}
    - s3Bucket: odrbucket-36bceb61c09c
      s3CompatibleEndpoint: https://s3-openshift-storage.apps.hyper4.vmw.ibmfusion.eu
      s3ProfileName: s3profile-hyper4-ocs-storagecluster
      s3Region: noobaa
      s3SecretRef:
        name: cc237eba032ad5c422fb939684eb633822d7900
      caCertificates: {input base64 encoded value here}
```

4. Verify that there are DR secrets created in the OADP operator default namespace **openshift-adp** on the **Primary managed cluster** and the **Secondary managed cluster**. The DR secrets that were created when the first DRPolicy was created, will be similar to the secrets below. The DR secret name is preceded with the letter **v**.

```
$ oc get secrets -n openshift-adp
NAME                                       TYPE     DATA   AGE
v60f2ea6069e168346d5ad0e0b5faa59bb74946f   Opaque   1      3d20h
vcc237eba032ad5c422fb939684eb633822d7900   Opaque   1      3d20h
[...]
```

NOTE

There will be one DR created secret for each managed cluster in the **openshift-adp** namespace.

5. Verify if the Data Protection Application (DPA) is already installed on each managed cluster in the OADP namespace **openshift-adp**. If not already created then follow the next step to create this resource.

   a. Create the DPA by copying the following YAML definition content to **dpa.yaml**.

```
apiVersion: oadp.openshift.io/v1alpha1
kind: DataProtectionApplication
metadata:
  labels:
    app.kubernetes.io/component: velero
  name: velero
  namespace: openshift-adp
spec:
  backupImages: false
  configuration:
    nodeAgent:
      enable: false
      uploaderType: restic
    velero:
      defaultPlugins:
        - openshift
        - aws
      noDefaultBackupLocation: true
```

b. Create the DPA resource.

```
$ oc create -f dpa.yaml -n openshift-adp
```

```
dataprotectionapplication.oadp.openshift.io/velero created
```

c. Verify that the OADP resources are created and are in **Running** state.

```
$ oc get pods,dpa -n openshift-adp
NAME                                                 READY   STATUS    RESTARTS   AGE
pod/openshift-adp-controller-manager-7b64b74fcd-msjbs   1/1     Running   0
5m30s
pod/velero-694b5b8f5c-b4kwg                          1/1     Running   0          3m31s


NAME                                                 AGE
dataprotectionapplication.oadp.openshift.io/velero   3m31s
```

4.14.2. Creating a sample discovered application

In order to test **failover** from the **Primary managed cluster** to the **Secondary managed cluster** and **relocate** for discovered applications, you need a sample application that is installed without using the RHACM create application capability.

Procedure

1. Log in to the **Primary managed cluster** and clone the sample application repository.

```
$ git clone https://github.com/red-hat-storage/ocm-ramen-samples.git
```

2. Verify that you are on the **main** branch.

```
$ cd ~/ocm-ramen-samples
$ git branch
* main
```

The correct directory should be used when creating the sample application based on your scenario, metro or regional.

NOTE

Only applications using CephRBD or block volumes are supported for discovered applications.

```
$ ls workloads/deployment | egrep -v 'cephfs|k8s|base'
odr-metro-rbd
odr-regional-rbd
```

3. Create a project named **busybox-discovered** on both the **Primary and Secondary managed clusters**.

```
$ oc new-project busybox-discovered
```

4. Create the **busybox** application on the **Primary managed cluster**. This sample application example is for Regional-DR using a block (Ceph RBD) volume.

```
$ oc apply -k workloads/deployment/odr-regional-rbd -n busybox-discovered
persistentvolumeclaim/busybox-pvc created
deployment.apps/busybox created
```

NOTE

OpenShift Data Foundation Disaster Recovery solution now extends protection to discovered applications that span across multiple namespaces.

5. Verify that busybox is running in the correct project on the **Primary managed cluster**.

```
$ oc get pods,pvc,deployment -n busybox-discovered
```

```
NAME                           READY   STATUS    RESTARTS   AGE
pod/busybox-796fccbb95-qmxjf   1/1     Running   0          18s


NAME                                STATUS   VOLUME                                     CAPACITY   ACCESS
MODES   STORAGECLASS                  VOLUMEATTRIBUTESCLASS   AGE
persistentvolumeclaim/busybox-pvc   Bound    pvc-b20e4129-902d-47c7-b962-
040ad64130c4   1Gi        RWO            ocs-storagecluster-ceph-rbd   <unset>                 18s


NAME                      READY   UP-TO-DATE   AVAILABLE   AGE
deployment.apps/busybox   1/1     1            1           18
```

4.14.3. Enrolling a sample discovered application for disaster recovery protection

This section guides you on how to apply an existing DR Policy to a discovered application from the **Protected applications** tab.

Prerequisites

- Ensure that Disaster Recovery has been configured and that at least one DR Policy has been created.

Procedure

1. On RHACM console, navigate to **Disaster recovery → Protected applications** tab.

2. Click **Enroll application** to start configuring existing applications for DR protection.

3. Select **ACM discovered applications**.

4. In the Namespace page, choose the **DR cluster** which is the name of the **Primary managed cluster** where **busybox** is installed.

5. Select **namespace** where the application is installed. For example, **busybox-discovered**.

   NOTE

   If you have workload spread across multiple namespaces then you can select all of those namespaces to DR protect.

6. Choose a unique **Name**, for example **busybox-rbd**, for the discovered application and click **Next**.

7. In the Configuration page, the **Resource label** is used to protect your resources where you can set which resources will be included in the **kubernetes-object** backup and what volume's persistent data will be replicated. **Resource label** is selected by default.

8. Provide Label expressions and PVC label selector. Choose the **label appname=busybox** for both the **kubernetes-objects** and for the **PVC(s)**.

9. Click **Next**.

10. In the Replication page, select an existing **DR Policy** and the **kubernetes-objects backup interval**.

    NOTE

    It is recommended to choose the same duration for the PVC data replication and kubernetes-object backup interval (i.e., 5 minutes).

11. Click **Next**.

12. Review the configuration and click **Save**.
    Use the **Back** button to go back to the screen to correct any issues.

13. Verify that the **Application volumes (PVCs)** and the **Kubernetes-objects** backup have a *Healthy* status before proceeding to DR Failover and Relocate testing. You can view the status of your Discovered applications on the **Protected applications** tab.

    a. To see the status of the DRPC, run the following command on the Hub cluster:

    ```
    $ oc get drpc {drpc_name} -o wide -n openshift-dr-ops
    ```

    The discovered applications store resources such as DRPlacementControl (DRPC) and Placement on the Hub cluster in a new namespace called **openshift-dr-ops**. The DRPC name can be identified by the unique Name configured in prior steps (i.e., **busybox-rbd**).

    b. To see the status of the VolumeReplicationGroup (VRG) for discovered applications, run the following command on the managed cluster where the busybox application was manually installed.

```
$ oc get vrg {vrg_name} -n openshift-dr-ops
```

The VRG resource is stored in the namespace **openshift-dr-ops** after a DR Policy is assigned to the discovered application. The VRG name can be identified by the unique Name configured in prior steps (i.e., **busybox-rbd**).

4.14.4. Discovered application failover and relocate

A protected Discovered application can *Failover* or *Relocate* to its peer cluster similar to **managed applications**. However, there are some additional steps for discovered applications since RHACM does not manage the lifecycle of the application as it does for Managed applications.

This section guides you through the Failover and Relocate process for a protected discovered application.

IMPORTANT

Never initiate a Failover or Relocate of an application when one or both resource types are in a Warning or Critical status.

4.14.4.1. Failover disaster recovery protected discovered application

This section guides you on how to failover a discovered application which is disaster recovery protected.

Prerequisites

- Ensure that the application namespace is created in both managed clusters (for example, **busybox-discovered**).

Procedure

1. In the RHACM console, navigate to **Disaster Recovery → Protected applications** tab.
2. At the end of the application row, click on the **Actions** menu and choose to initiate *Failover*.
3. In the Failover application modal window, review the status of the application and the target cluster.
4. Click **Initiate**. Wait for the **Failover** process to complete.
5. Verify that the busybox application is running on the **Secondary managed cluster**.

```
$ oc get pods,pvc,volumereplication -n busybox-discovered
NAME                           READY   STATUS    RESTARTS   AGE
pod/busybox-796fccbb95-qmxjf   1/1     Running   0          2m46s


NAME                               STATUS   VOLUME                                     CAPACITY   ACCESS
MODES   STORAGECLASS                  VOLUMEATTRIBUTESCLASS   AGE
persistentvolumeclaim/busybox-pvc   Bound    pvc-b20e4129-902d-47c7-b962-
040ad64130c4   1Gi        RWO          ocs-storagecluster-ceph-rbd   <unset>
2m57s


NAME                                                     AGE     VOLUMEREPLICATIONCLASS
```

```
PVCNAME       DESIREDSTATE   CURRENTSTATE
volumereplication.replication.storage.openshift.io/busybox-pvc   2m45s   rbd-
volumereplicationclass-1625360775   busybox-pvc   primary        Primary
```

6. Check the progression status of Failover until the result is **WaitOnUserToCleanup**. The DRPC name can be identified by the unique Name configured in prior steps (for example, **busybox-rbd**).

   ```
   $ oc get drpc {drpc_name} -n openshift-dr-ops -o jsonpath='{.status.progression}{"\n"}'
   WaitOnUserToCleanUp
   ```

7. Remove the busybox application from the **Primary managed cluster** to complete the **Failover** process.

   a. Navigate to the **Protected applications** tab. You will see a message to remove the application.

   b. Navigate to the cloned repository for **busybox** and run the following commands on the **Primary managed cluster** where you **failed** over from. Use the same directory that was used to create the application (for example, **odr-regional-rbd**).

   ```
   $ cd ~/ocm-ramen-samples/
   $ git branch
   * main
   $ oc delete -k workloads/deployment/odr-regional-rbd -n busybox-discovered
   persistentvolumeclaim "busybox-pvc" deleted
   deployment.apps "busybox" deleted
   ```

8. After deleting the application, navigate to the **Protected applications** tab and verify that the busybox resources are both in *Healthy* status.

4.14.4.2. Relocate disaster recovery protected discovered application

This section guides you on how to relocate a discovered application which is disaster recovery protected.

Procedure

1. In the RHACM console, navigate to **Disaster Recovery → Protected applications** tab.

2. At the end of the application row, click on the **Actions** menu and choose to initiate *Relocate*.

3. In the Relocate application modal window, review the status of the application and the target cluster.

4. Click **Initiate**.

5. Check the progression status of Relocate until the result is **WaitOnUserToCleanup**. The DRPC name can be identified by the unique Name configured in prior steps (for example, **busybox-rbd**).

   ```
   $ oc get drpc {drpc_name} -n openshift-dr-ops -o jsonpath='{.status.progression}{"\n"}'
   WaitOnUserToCleanUp
   ```

6. Remove the busybox application from the **Secondary managed cluster** before *Relocate* to the **Primary managed cluster** is completed.
   Navigate to the cloned repository for **busybox** and run the following commands on the **Secondary managed cluster** where you **relocated** from. Use the same directory that was used to create the application (for example, **odr-regional-rbd**).

   ```
   $ cd ~/ocm-ramen-samples/
   $ git branch
   * main
   $ oc delete -k workloads/deployment/odr-regional-rbd -n busybox-discovered
   persistentvolumeclaim "busybox-pvc" deleted
   deployment.apps "busybox" deleted
   ```

7. After deleting the application, navigate to the **Protected applications** tab and verify that the busybox resources are both in *Healthy* status.

8. Verify that the **busybox** application is running on the **Primary managed cluster**.

   ```
   $ oc get pods,pvc -n busybox-discovered
   NAME                          READY   STATUS    RESTARTS   AGE
   pod/busybox-796fccbb95-qmxjf   1/1     Running   0          2m46s


   NAME                                STATUS   VOLUME                                     CAPACITY   ACCESS
   MODES   STORAGECLASS                  VOLUMEATTRIBUTESCLASS   AGE
   persistentvolumeclaim/busybox-pvc   Bound    pvc-b20e4129-902d-47c7-b962-
   040ad64130c4   1Gi        RWO            ocs-storagecluster-ceph-rbd   <unset>
   2m57s


   NAME                                                          AGE     VOLUMEREPLICATIONCLASS
   PVCNAME       DESIREDSTATE   CURRENTSTATE
   volumereplication.replication.storage.openshift.io/busybox-pvc   2m45s   rbd-
   volumereplicationclass-1625360775   busybox-pvc   primary        Primary
   ```

4.14.5. Disable disaster recovery for protected applications

This section guides you to disable disaster recovery resources when you want to delete the protected applications or when the application no longer needs to be protected.

Procedure

1. Login to the Hub cluster.

2. List the **DRPlacementControl** (DRPC) resources. Each DRPC resource was created when the application was assigned a DR policy.

   ```
   $ oc get drpc -n openshift-dr-ops
   ```

3. Find the **DRPC** that has a name that includes the unique identifier that you chose when assigning a DR policy (for example, **busybox-rbd**) and delete the DRPC.

   ```
   $ oc delete {drpc_name} -n openshift-dr-ops
   ```

4. List the **Placement** resources. Each Placement resource was created when the application was assigned a DR policy.

   ```
   $ oc get placements -n openshift-dr-ops
   ```

5. Find the **Placement** that has a name that includes the unique identifier that you chose when assigning a DR policy (for example, **busybox-rbd-placement-1**) and delete the **Placement**.

   ```
   $ oc delete placements {placement_name} -n openshift-dr-ops
   ```

4.15. RECOVERING TO A REPLACEMENT CLUSTER WITH REGIONAL-DR

When there is a failure with the primary cluster, you get the options to either repair, wait for the recovery of the existing cluster, or replace the cluster entirely if the cluster is irredeemable. This solution guides you when replacing a failed primary cluster with a new cluster and enables failback (relocate) to this new cluster.

In these instructions, we are assuming that a RHACM managed cluster must be replaced after the applications have been installed and protected. For purposes of this section, the RHACM managed cluster is the **replacement cluster**, while the cluster that is not replaced is the **surviving cluster** and the new cluster is the **recovery cluster**.

> **NOTE**
>
> Replacement cluster recovery for Discovered applications is currently not supported. Only Managed applications are supported.

Prerequisite

- Ensure that the Regional-DR environment has been configured with applications installed using Red Hat Advance Cluster Management (RHACM).
- Ensure that the applications are assigned a Data policy which protects them against cluster failure.

Procedure

1. On the Hub cluster, navigate to **Applications** and failover all protected applications on the failed replacement cluster to the surviving cluster.
2. Validate that all protected applications are running on the surviving cluster before moving to the next step.

   > **NOTE**
   >
   > The PROGRESSION state for each application **DRPlacementControl** shows as **Cleaning Up**. This is to be expected if the replacement cluster is offline or down.

3. From the Hub cluster, delete the DRCluster for the **replacement cluster**.

   ```
   $ oc delete drcluster <drcluster_name> --wait=false
   ```

NOTE

Use **--wait=false** since the DRCluster will not be deleted until a later step.

4. Disable disaster recovery for each protected application on the surviving cluster. Perform all the sub-steps on the hub cluster.

    a. For each application, edit the Placement and ensure that the surviving cluster is selected.

    ```
    $ oc edit placement <placement_name> -n <namespace>
    ```

    ```
    apiVersion: cluster.open-cluster-management.io/v1beta1
    kind: Placement
    metadata:
    annotations:
      cluster.open-cluster-management.io/experimental-scheduling-disable: "true"
    [...]
    spec:
    clusterSets:
    - submariner
    predicates:
    - requiredClusterSelector:
        claimSelector: {}
        labelSelector:
          matchExpressions:
          - key: name
            operator: In
            values:
            - cluster1  <-- Modify to be surviving cluster name
    [...]
    ```

    NOTE

    For Subscription-based applications the associated Placement can be found in the same namespace on the hub cluster similar to the managed clusters. For ApplicationSets-based applications the associated Placement can be found in the **openshift-gitops** namespace on the hub cluster.

    b. Verify that the **s3Profile** is removed for the replacement cluster by running the following command on the surviving cluster for each protected application's VolumeReplicationGroup.

    ```
    $ oc get vrg -n <application_namespace> -o jsonpath='{.items[0].spec.s3Profiles}' | jq
    ```

    c. Disable DR for the managed applications in the RHACM console.

        i. On the Hub cluster, navigate to **All Clusters → Applications**.

        ii. In the **Overview** tab, at the end of the protected application row from the action menu, select **Manage disaster recovery**.

        iii. Click **Remove disaster recovery**.

        iv. Click **Confirm remove**.

> **WARNING**
>
> Your application will lose disaster recovery protection, preventing volume synchronization (replication) between clusters.

> **NOTE**
>
> The application continues to be visible in the **Applications Overview** menu but the Data policy is removed.

d. Edit each applications **Placement** and remove the annotation **cluster.open-cluster-management.io/experimental-scheduling-disable: "true"**.

```
$ oc edit placement {placement_name} -n {namespace}
```

```
apiVersion: cluster.open-cluster-management.io/v1beta1
kind: Placement
metadata:
annotations:
  ## Remove this annotation
  cluster.open-cluster-management.io/experimental-scheduling-disable: "true"
[...]
```

5. Repeat the process detailed in the last step and the sub-steps for every protected application on the surviving cluster. Disabling DR for protected applications is now completed.

6. on the **hub cluster**, run the following script to remove all disaster recovery configurations from the **surviving cluster** and the **hub cluster**.

```
#!/bin/bash

secrets=$(oc get secrets -n openshift-operators | grep Opaque | cut -d" " -f1)
echo $secrets
for secret in $secrets
do
   oc patch -n openshift-operators secret/$secret -p '{"metadata":{"finalizers":null}}' --
type=merge
done

mirrorpeers=$(oc get mirrorpeer -o name)
echo $mirrorpeers
for mp in $mirrorpeers
do
   oc patch $mp -p '{"metadata":{"finalizers":null}}' --type=merge
   oc delete $mp
done

drpolicies=$(oc get drpolicy -o name)
echo $drpolicies
for drp in $drpolicies
```

```
do
   oc patch $drp -p '{"metadata":{"finalizers":null}}' --type=merge
   oc delete $drp
done

drclusters=$(oc get drcluster -o name)
echo $drclusters
for drp in $drclusters
do
   oc patch $drp -p '{"metadata":{"finalizers":null}}' --type=merge
   oc delete $drp
done

oc delete project openshift-operators

managedclusters=$(oc get managedclusters -o name | cut -d"/" -f2)
echo $managedclusters
for mc in $managedclusters
do
   secrets=$(oc get secrets -n $mc | grep multicluster.odf.openshift.io/secret-type | cut -d" " -
f1)
   echo $secrets
   for secret in $secrets
   do
      set -x
      oc patch -n $mc secret/$secret -p '{"metadata":{"finalizers":null}}' --type=merge
      oc delete -n $mc secret/$secret
   done
done

oc delete clusterrolebinding spoke-clusterrole-bindings
```

NOTE

This script uses the command **oc delete project openshift-operators** to remove the Disaster Recovery (DR) operators in this namespace on the hub cluster. If there are other non-DR operators in this namespace, you must install them again from **OperatorHub**.

7. After the namespace **openshift-operators** is automatically created again, add the monitoring label back for collecting the disaster recovery metrics.

```
$ oc label namespace openshift-operators openshift.io/cluster-monitoring='true'
```

8. On the **surviving cluster**, ensure that the object bucket created during the DR installation is deleted. Delete the object bucket if it was not removed by script. The name of the object bucket used for DR starts with **odrbucket**.

```
$ oc get obc -n openshift-storage
```

9. Uninstall **Submariner** for only the **replacement cluster** (failed cluster) using the RHACM console.

   a. Navigate to **Infrastructure → Clusters → Clustersets → Submariner add-ons**view and uninstall Submariner for only the replacement cluster.

uninstall Submariner for only the replacement cluster.

> NOTE
>
> The uninstall process of Submariner for the replacement cluster (failed cluster) will stay GREEN and not complete until the replacement cluster has been detached from the RHACM console.

b. Navigate back to **Clusters view** and detach replacement cluster.

c. Create new OpenShift cluster (recovery cluster) and import into **Infrastructure → Clusters view**.

d. Add the new recovery cluster to the **Clusterset** used by Submariner.

e. Install **Submariner add-ons** only for the new **recovery cluster**.

> NOTE
>
> If GlobalNet is used for the surviving cluster make sure to enable GlobalNet for the recovery cluster as well.

10. Install **OpenShift Data Foundation** on the **recovery cluster**. The OpenShift Data Foundation version should be OpenShift Data Foundation 4.17 (or greater) and the same version of ODF as on the surviving cluster. While creating the storage cluster, in the **Data Protection** step, you must select the **Prepare cluster for disaster recovery (Regional-DR only)**checkbox.

> NOTE
>
> Make sure to follow the optional instructions in the documentation to modify the OpenShift Data Foundation storage cluster on the recovery cluster if GlobalNet has been enabled when installing Submariner.

11. On the **Hub cluster**, install the **ODF Multicluster Orchestrator** operator from OperatorHub. For instructions, see chapter on Installing OpenShift Data Foundation Multicluster Orchestrator operator.

12. Using the RHACM console, navigate to **Data Services → Disaster recovery → Policies**tab.

    a. Select **Create DRPolicy** and name your policy.

    b. Select the **recovery cluster** and the **surviving cluster**.

    c. Create the policy. For instructions see chapter on Creating Disaster Recovery Policy on Hub cluster.

    Proceed to the next step only after the status of DRPolicy changes to **Validated**.

13. Verify that **cephblockpool** IDs remain unchanged.

    a. Run the following command on the **recovery cluster**.

    ```
    $ oc get cm -n openshift-storage rook-ceph-csi-mapping-config -o yaml
    ```

    The result is the sample output.

```
apiVersion: v1
data:
  csi-mapping-config-json: '[{"ClusterIDMapping":{"openshift-storage":"openshift-storage"},"RBDPoolIDMapping":[{"1":"1"}]}]'
kind: ConfigMap
[...]
```

b. Run the following command on the **surviving cluster**.

```
$ oc get cm -n openshift-storage rook-ceph-csi-mapping-config -o yaml
```

The result is the sample output.

```
apiVersion: v1
data:
  csi-mapping-config-json: '[{"ClusterIDMapping":{"openshift-storage":"openshift-storage"},"RBDPoolIDMapping":[{"3":"1"}]}]'
kind: ConfigMap
[...]
```

c. Check the **RBDPoolIDMapping** in the yaml for both the clusters. If **RBDPoolIDMapping** does not match, then edit the **rook-ceph-csi-mapping-config** config map of **recovery cluster** to add the additional or missing **RBDPoolIDMapping** directly as shown in the following examples.

```
csi-mapping-config-json: '[{"ClusterIDMapping":{"openshift-storage":"openshift-storage"},"RBDPoolIDMapping":[{"1":"1"}]},{"ClusterIDMapping":{"openshift-storage":"openshift-storage"},"RBDPoolIDMapping":[{"1":"3"}]}]’
```

NOTE

After editing the configmap, restart **rook-ceph-operator** pod in the namespace **openshift-storage** on the surviving cluster by deleting the pod.

14. Apply the DRPolicy to the applications on the surviving cluster that were originally protected before the replacement cluster failed.

15. Relocate the newly protected applications on the **surviving cluster** back to the new **recovery cluster**. Using the RHACM console, navigate to the **Applications** menu to perform the relocation.

NOTE

If any issues are encountered while following this process, then reach out to Red Hat Customer Support.

4.16. VIEWING RECOVERY POINT OBJECTIVE VALUES FOR DISASTER RECOVERY ENABLED APPLICATIONS

Recovery Point Objective (RPO) value is the most recent sync time of persistent data from the cluster where the application is currently active to its peer. This sync time helps determine duration of data lost during failover.

NOTE

This RPO value is applicable only for Regional-DR during failover. Relocation ensures there is no data loss during the operation, as all peer clusters are available.

You can view the Recovery Point Objective (RPO) value of all the protected volumes for their workload on the Hub cluster.

Procedure

1. On the Hub cluster, navigate to **Applications** → **Overview** tab.
2. In the **Data policy** column, click the **policy** link for the application you applied the policy to.
   A **Data Policies** modal page appears with the number of disaster recovery policies applied to each application along with failover and relocation status.
3. On the **Data Policies** modal page, click the **View more details** link.
   A detailed **Data Policies** modal page is displayed that shows the policy names and the ongoing activities (Last sync, Activity status) associated with the policy that is applied to the application.

   The **Last sync time** reported in the modal page, represents the most recent sync time of all volumes that are DR protected for the application.

4.17. HUB RECOVERY USING RED HAT ADVANCED CLUSTER MANAGEMENT

When your setup has active and passive Red Hat Advanced Cluster Management for Kubernetes (RHACM) hub clusters, and in case where the active hub is down, you can use the passive hub to failover or relocate the disaster recovery protected workloads.

4.17.1. Configuring passive hub cluster

To perform hub recovery in case the active hub is down or unreachable, follow the procedure in this section to configure the passive hub cluster and then failover or relocate the disaster recovery protected workloads.

Procedure

1. Ensure that RHACM operator and **MultiClusterHub** is installed on the passive hub cluster. See RHACM installation guide for instructions.
   After the operator is successfully installed, a popover with a message that the Web console update is available appears on the user interface. Click **Refresh web console** from this popover for the console changes to reflect.
2. Before hub recovery, configure backup and restore. See Backup and restore topics of *RHACM Business continuity* guide.
3. Install the multicluster orchestrator (MCO) operator along with Red Hat OpenShift GitOps operator on the passive RHACM hub prior to the restore. For instructions to restore your RHACM hub, see Installing OpenShift Data Foundation Multicluster Orchestrator operator .
4. Ensure that **.spec.cleanupBeforeRestore** is set to **None** for the **Restore.cluster.open-cluster-management.io** resource. For details, see Restoring passive resources while checking for backups chapter of RHACM documentation.

5. If SSL access across clusters was configured manually during setup, then re-configure SSL access across clusters. For instructions, see Configuring SSL access across clusters chapter.

6. On the passive hub, add a label to **openshift-operators** namespace to enable basic monitoring of **VolumeSyncronizationDelay** alert using this command. For alert details, see Disaster recovery alerts chapter.

```
$ oc label namespace openshift-operators openshift.io/cluster-monitoring='true'
```

4.17.2. Switching to passive hub cluster

Use this procedure when the active hub is down or unreachable.

Procedure

1. During the restore procedure, to avoid eviction of resources when **ManifestWorks** are not regenerated correctly, you can enlarge the **AppliedManifestWork eviction** grace period. On the passive hub cluster, check for existing global **KlusterletConfig**.

   - If global **KlusterletConfig** exists then edit and set the value for **appliedManifestWorkEvictionGracePeriod** parameter to a larger value. For example, 24 hours or more.

   - If global **KlusterletConfig** does not exist, then create the **Klusterletconfig** using the following yaml:

     ```
     apiVersion: config.open-cluster-management.io/v1alpha1
     kind: KlusterletConfig
     metadata:
       name: global
     spec:
       appliedManifestWorkEvictionGracePeriod: "24h"
     ```

     The configuration will be propagated to all the managed clusters automatically.

2. Restore the backups on the passive hub cluster. For information, see Restoring a hub cluster from backup.

   IMPORTANT

   Recovering a failed hub to its passive instance will only restore applications and their DR protected state to its last scheduled backup. Any application that was DR protected after the last scheduled backup would need to be protected again on the new hub.

3. Verify that the restore is complete.

   ```
   $ oc -n <restore-namespace> wait restore <restore-name> --
   for=jsonpath='{.status.phase}'=Finished --timeout=120s
   ```

4. Verify that the Primary and Secondary managed clusters are successfully imported into the RHACM console and they are accessible. If any of the managed clusters are down or unreachable then they will not be successfully imported.
   Wait until DRPolicy validation succeeds before performing any DR operation.

NOTE

Submariner is automatically installed once the managed clusters are imported on the passive hub.

5. Verify that the **DRPolicy** is created successfully. Run this command on the **Hub cluster** for each of the DRPolicy resources created, where *<drpolicy_name>* is replaced with a unique name.

   ```
   $ oc get drpolicy <drpolicy_name> -o jsonpath='{.status.conditions[].reason}{"\n"}'
   ```

   Example output:

   ```
   Succeeded
   ```

6. Refresh the RHACM console to make the DR monitoring dashboard tab accessible if it was enabled on the Active hub cluster.

7. Verify the DRPC output using the following command on the new hub cluster:

   ```
   $ oc get drpc -A -o wide
   ```

   If **PROGRESSION** shows a status of **PAUSED**, administrative intervention is required to unpause it. **PROGRESSION** enters **PAUSED** state under the following conditions:

   - **Cluster Query Failure**: None of the clusters were successfully queried during the DRPC reconciliation. This situation can occur during hub recovery.
   - **Action Mismatch**: The DRPC action differs from the queried VRG action.
   - **Cluster Mismatch**: The DRPC action and the VRG action are the same, but the Primary VRG is found in a different cluster than the one expected by the DRPC.

     IMPORTANT

     If you cannot diagnose and resolve the cause of the pause, contact Red Hat Customer Support.

     If **PROGRESSION** is in either **Completed** or **Cleaning up**, it is safe to proceed.

8. Edit the global **KlusterletConfig** on the new hub and remove the parameter **appliedManifestWorkEvictionGracePeriod** and its value.

9. Depending on whether the active hub cluster, or both the active hub cluster along with the primary managed cluster had been down, follow the next steps based on your scenario:

   a. If only the active hub cluster had been down, and if the managed clusters are still accessible, no further action is required.

   b. If the primary managed cluster had been down, along with the active hub cluster, you need to fail over the workloads from the primary managed cluster to the secondary managed cluster.
   For failover instructions, based on your workload type, see Subscription-based applications or ApplicationSet-based applications.

10. Verify that the failover is successful. If the Primary managed cluster is also down, then the PROGRESSION status for the workload would be in the **Cleaning Up** phase until the down Primary managed cluster is back online and successfully imported into the RHACM console. On the passive hub cluster, run the following command to check the PROGRESSION status.

    ```
    $ oc get drpc -o wide -A
    ```

CHAPTER 5. DISASTER RECOVERY WITH STRETCH CLUSTER FOR OPENSHIFT DATA FOUNDATION

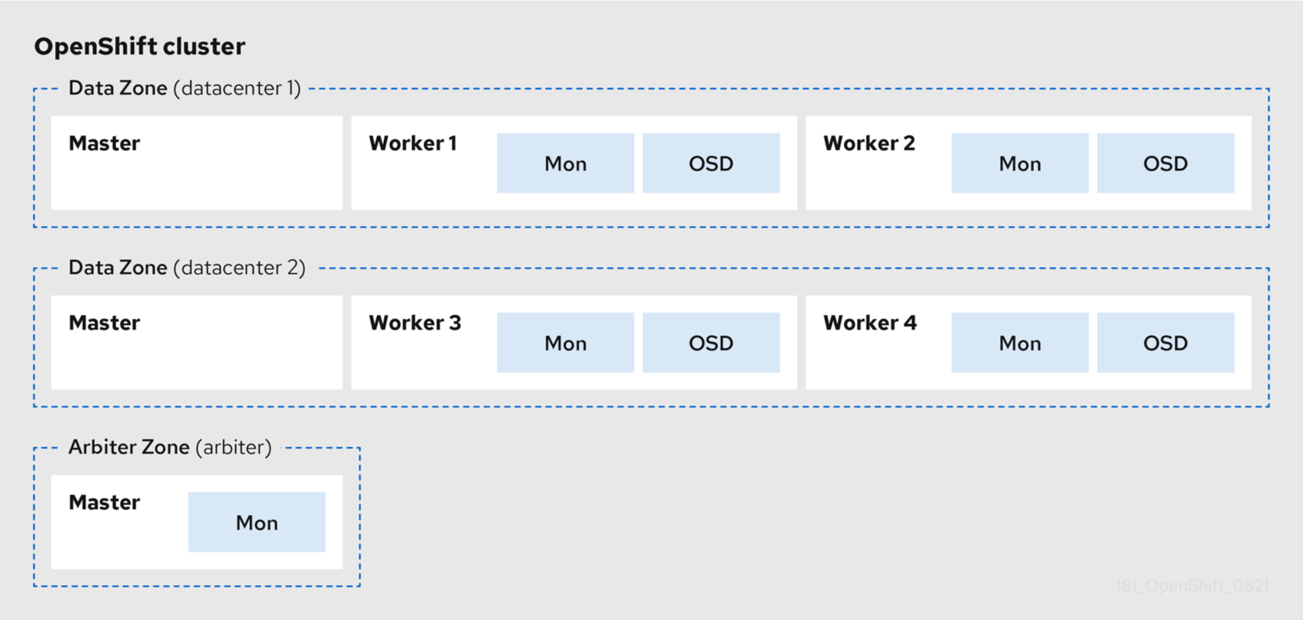
Red Hat OpenShift Data Foundation deployment can be stretched between two different geographical locations to provide the storage infrastructure with disaster recovery capabilities. When faced with a disaster, such as one of the two locations is partially or totally not available, OpenShift Data Foundation deployed on the OpenShift Container Platform deployment must be able to survive. This solution is available only for metropolitan spanned data centers with specific latency requirements between the servers of the infrastructure.

NOTE

The stretch cluster solution is designed for deployments where latencies do not exceed 10 ms maximum round-trip time (RTT) between the zones containing data volumes. For Arbiter nodes follow the latency requirements specified for etcd, see Guidance for Red Hat OpenShift Container Platform Clusters - Deployments Spanning Multiple Sites(Data Centers/Regions). Contact Red Hat Customer Support if you are planning to deploy with higher latencies.

The following diagram shows the simplest deployment for a stretched cluster:

OpenShift nodes and OpenShift Data Foundation daemons



In the diagram the OpenShift Data Foundation monitor pod deployed in the Arbiter zone has a built-in tolerance for the master nodes. The diagram shows the master nodes in each Data Zone which are required for a highly available OpenShift Container Platform control plane. Also, it is important that the OpenShift Container Platform nodes in one of the zones have network connectivity with the OpenShift Container Platform nodes in the other two zones.

IMPORTANT

You can now easily set up disaster recovery with stretch cluster for workloads based on OpenShift virtualization technology using OpenShift Data Foundation. For more information, see OpenShift Virtualization in OpenShift Container Platform guide.

5.1. REQUIREMENTS FOR ENABLING STRETCH CLUSTER

- Ensure you have addressed OpenShift Container Platform requirements for deployments spanning multiple sites. For more information, see knowledgebase article on cluster deployments spanning multiple sites.

- Ensure that you have at least three OpenShift Container Platform master nodes in three different zones. One master node in each of the three zones.

- Ensure that you have at least four OpenShift Container Platform worker nodes evenly distributed across the two Data Zones.

- For stretch clusters on bare metall, use the SSD drive as the root drive for OpenShift Container Platform master nodes.

- Ensure that each node is pre-labeled with its zone label. For more information, see the Applying topology zone labels to OpenShift Container Platform node section.

- The stretch cluster solution is designed for deployments where latencies do not exceed 10 ms between zones. Contact Red Hat Customer Support if you are planning to deploy with higher latencies.

> **NOTE**
>
> Flexible scaling and Arbiter both cannot be enabled at the same time as they have conflicting scaling logic. With Flexible scaling, you can add one node at a time to your OpenShift Data Foundation cluster. Whereas in an Arbiter cluster, you need to add at least one node in each of the two data zones.

5.2. APPLYING TOPOLOGY ZONE LABELS TO OPENSHIFT CONTAINER PLATFORM NODES

During a site outage, the zone that has the arbiter function makes use of the arbiter label. These labels are arbitrary and must be unique for the three locations.

For example, you can label the nodes as follows:

```
topology.kubernetes.io/zone=arbiter for Master0

topology.kubernetes.io/zone=datacenter1 for Master1, Worker1, Worker2

topology.kubernetes.io/zone=datacenter2 for Master2, Worker3, Worker4
```

- To apply the labels to the node:

  ```
  $ oc label node <NODENAME> topology.kubernetes.io/zone=<LABEL>
  ```

  <NODENAME>

  Is the name of the node

  <LABEL>

  Is the topology zone label

- To validate the labels using the example labels for the three zones:

```
$ oc get nodes -l topology.kubernetes.io/zone=<LABEL> -o name
```

<LABEL>

Is the topology zone label
Alternatively, you can run a single command to see all the nodes with its zone.

```
$ oc get nodes -L topology.kubernetes.io/zone
```

The stretch cluster topology zone labels are now applied to the appropriate OpenShift Container Platform nodes to define the three locations.

Next step

- Install the local storage operator from the OpenShift Container Platform web console .

5.3. INSTALLING LOCAL STORAGE OPERATOR

Install the Local Storage Operator from the Operator Hub before creating Red Hat OpenShift Data Foundation clusters on local storage devices.

Procedure

1. Log in to the OpenShift Web Console.
2. Click **Operators → OperatorHub**.
3. Type **local storage** in the **Filter by keyword** box to find the **Local Storage Operator** from the list of operators, and click on it.
4. Set the following options on the **Install Operator** page:
   a. Update channel as **stable**.
   b. Installation mode as **A specific namespace on the cluster**.
   c. Installed Namespace as **Operator recommended namespace openshift-local-storage**.
   d. Update approval as **Automatic**.
5. Click **Install**.

Verification steps

- Verify that the Local Storage Operator shows a green tick indicating successful installation.

5.4. INSTALLING RED HAT OPENSHIFT DATA FOUNDATION OPERATOR

You can install Red Hat OpenShift Data Foundation Operator using the Red Hat OpenShift Container Platform Operator Hub.

Prerequisites

- Access to an OpenShift Container Platform cluster using an account with cluster-admin and Operator installation permissions.
- You must have at least four worker nodes evenly distributed across two data centers in the Red Hat OpenShift Container Platform cluster.
- For additional resource requirements, see Planning your deployment.

IMPORTANT

- When you need to override the cluster-wide default node selector for OpenShift Data Foundation, you can use the following command in command-line interface to specify a blank node selector for the **openshift-storage** namespace (create openshift-storage namespace in this case):

```
$ oc annotate namespace openshift-storage openshift.io/node-selector=
```

- Taint a node as **infra** to ensure only Red Hat OpenShift Data Foundation resources are scheduled on that node. This helps you save on subscription costs. For more information, see How to use dedicated worker nodes for Red Hat OpenShift Data Foundation chapter in the *Managing and Allocating Storage Resources* guide.

Procedure

1. Log in to the OpenShift Web Console.
2. Click **Operators → OperatorHub**.
3. Scroll or type **OpenShift Data Foundation** into the **Filter by keyword** box to search for the **OpenShift Data Foundation** Operator.
4. Click **Install**.
5. Set the following options on the **Install Operator** page:
    a. Update Channel as **stable-4.15**.
    b. Installation Mode as **A specific namespace on the cluster**.
    c. Installed Namespace as **Operator recommended namespace openshift-storage**. If Namespace **openshift-storage** does not exist, it is created during the operator installation.
    d. Select **Approval Strategy** as **Automatic** or **Manual**.
    If you select **Automatic** updates, then the Operator Lifecycle Manager (OLM) automatically upgrades the running instance of your Operator without any intervention.

    If you selected **Manual** updates, then the OLM creates an update request. As a cluster administrator, you must then manually approve that update request to update the Operator to a newer version.
6. Ensure that the **Enable** option is selected for the **Console plugin**.
7. Click **Install**.

Verification steps

- After the operator is successfully installed, a pop-up with a message, **Web console update is available** appears on the user interface. Click **Refresh web console** from this pop-up for the console changes to reflect.

- In the Web Console:

  - Navigate to Installed Operators and verify that the **OpenShift Data Foundation** Operator shows a green tick indicating successful installation.

  - Navigate to **Storage** and verify if the **Data Foundation** dashboard is available.

Next steps

- Create an OpenShift Data Foundation cluster .

5.5. CREATING OPENSHIFT DATA FOUNDATION CLUSTER

Prerequisites

- Ensure that you have met all the requirements in Requirements for enabling stretch cluster section.

Procedure

1. In the OpenShift Web Console, click **Operators → Installed Operators** to view all the installed operators.
   Ensure that the **Project** selected is **openshift-storage**.

2. Click on the **OpenShift Data Foundation** operator and then click **Create StorageSystem**.

3. In the Backing storage page, select the **Create a new StorageClass using the local storage devices** option.

4. Click **Next**.

   IMPORTANT

   You are prompted to install the Local Storage Operator if it is not already installed. Click **Install**, and follow the procedure as described in Installing Local Storage Operator.

5. In the **Create local volume set** page, provide the following information:

   a. Enter a name for the **LocalVolumeSet** and the **StorageClass**.
      By default, the local volume set name appears for the storage class name. You can change the name.

   b. Choose one of the following:

      - **Disks on all nodes**
        Uses the available disks that match the selected filters on all the nodes.

      - **Disks on selected nodes**
        Uses the available disks that match the selected filters only on selected nodes.

IMPORTANT

If the nodes selected do not match the OpenShift Data Foundation cluster requirement of an aggregated 30 CPUs and 72 GiB of RAM, a minimal cluster is deployed.

For minimum starting node requirements, see the Resource requirements section in the *Planning* guide.

c. Select **SSD** or **NVMe** to build a supported configuration. You can select **HDDs** for unsupported test installations.

d. Expand the **Advanced** section and set the following options:

Volume Mode	Block is selected by default.
Device Type	Select one or more device types from the dropdown list.
Disk Size	Set a minimum size of 100GB for the device and maximum available size of the device that needs to be included.
Maximum Disks Limit	This indicates the maximum number of PVs that can be created on a node. If this field is left empty, then PVs are created for all the available disks on the matching nodes.

e. Click **Next**.
A pop-up to confirm the creation of LocalVolumeSet is displayed.

f. Click **Yes** to continue.

6. In the **Capacity and nodes** page, configure the following:

a. **Available raw capacity** is populated with the capacity value based on all the attached disks associated with the storage class. This takes some time to show up.
The **Selected nodes** list shows the nodes based on the storage class.

b. Select **Enable arbiter** checkbox if you want to use the stretch clusters. This option is available only when all the prerequisites for arbiter are fulfilled and the selected nodes are populated. For more information, see Arbiter stretch cluster requirements in Requirements for enabling stretch cluster.
Select the **arbiter zone** from the dropdown list.

7. Choose a performance profile for **Configure performance**.
You can also configure the performance profile after the deployment using the **Configure performance** option from the options menu of the **StorageSystems** tab.

> **IMPORTANT**
>
> Before selecting a resource profile, make sure to check the current availability of resources within the cluster. Opting for a higher resource profile in a cluster with insufficient resources might lead to installation failures. For more information about resource requirements, see Resource requirement for performance profiles.

a. Click **Next**.

8. Optional: In the Security and network page, configure the following based on your requirement:

   a. To enable encryption, select **Enable data encryption for block and file storage**

   b. Select one of the following **Encryption level**:

      - **Cluster-wide encryption** to encrypt the entire cluster (block and file).
      - **StorageClass encryption** to create encrypted persistent volume (block only) using encryption enabled storage class.

   c. Optional: Select the **Connect to an external key management service**checkbox. This is optional for cluster-wide encryption.

      i. From the **Key Management Service Provider**drop-down list, either select **Vault** or **Thales CipherTrust Manager (using KMIP)**. If you selected **Vault**, go to the next step. If you selected **Thales CipherTrust Manager (using KMIP)**, go to step iii.

      ii. Select an **Authentication Method**.

      Using Token authentication method

      - Enter a unique **Connection Name**, host **Address** of the Vault server ('https://<hostname or ip>'), **Port** number and **Token**.
      - Expand **Advanced Settings** to enter additional settings and certificate details based on your **Vault** configuration:
        - Enter the Key Value secret path in the **Backend Path** that is dedicated and unique to OpenShift Data Foundation.
        - Optional: Enter **TLS Server Name** and **Vault Enterprise Namespace**.
        - Upload the respective PEM encoded certificate file to provide the **CA Certificate**, **Client Certificate** and **Client Private Key** .
        - Click **Save** and skip to step iv.

      Using Kubernetes authentication method

      - Enter a unique Vault **Connection Name**, host **Address** of the Vault server ('https://<hostname or ip>'), **Port** number and **Role** name.
      - Expand **Advanced Settings** to enter additional settings and certificate details based on your **Vault** configuration:
        - Enter the Key Value secret path in the **Backend Path** that is dedicated and unique to OpenShift Data Foundation.

- Optional: Enter **TLS Server Name** and **Authentication Path** if applicable.
- Upload the respective PEM encoded certificate file to provide the **CA Certificate**, **Client Certificate** and **Client Private Key** .
- Click **Save** and skip to step iv.

iii. To use **Thales CipherTrust Manager (using KMIP)** as the KMS provider, follow the steps below:

A. Enter a unique **Connection Name** for the Key Management service within the project.

B. In the **Address** and **Port** sections, enter the IP of Thales CipherTrust Manager and the port where the KMIP interface is enabled. For example:

- **Address**: 123.34.3.2
- **Port**: 5696

C. Upload the **Client Certificate**, **CA certificate**, and **Client Private Key**.

D. If StorageClass encryption is enabled, enter the Unique Identifier to be used for encryption and decryption generated above.

E. The **TLS Server** field is optional and used when there is no DNS entry for the KMIP endpoint. For example, **kmip_all_<port>.ciphertrustmanager.local**.

d. **Network** is set to Default (OVN) if you are using a single network.
You can switch to Custom (Multus) if you are using multiple network interfaces and then choose any one of the following:

i. Select a Public Network Interface from the dropdown.

ii. Select a Cluster Network Interface from the dropdown.

NOTE

If you are using only one additional network interface, select the single **NetworkAttachementDefinition**, that is, **ocs-public-cluster** for the Public Network Interface, and leave the Cluster Network Interface blank.

a. Click **Next**.

9. In the **Data Protection** page, click **Next**.
10. In the **Review and create** page, review the configuration details.
To modify any configuration settings, click **Back** to go back to the previous configuration page.
11. Click **Create StorageSystem**.

Verification steps

- To verify the final Status of the installed storage cluster:

a. In the OpenShift Web Console, navigate to **Installed Operators → OpenShift Data**

Foundation → Storage System → ocs-storagecluster-storagesystem → Resources.

b. Verify that the **Status** of **StorageCluster** is **Ready** and has a green tick mark next to it.

- For arbiter mode of deployment:

   a. In the OpenShift Web Console, navigate to **Installed Operators → OpenShift Data Foundation → Storage System → ocs-storagecluster-storagesystem → Resources → ocs-storagecluster**.

   b. In the YAML tab, search for the **arbiter** key in the **spec** section and ensure **enable** is set to **true**.

```
spec:
  arbiter:
   enable: true
  [..]
  nodeTopologies:
   arbiterLocation: arbiter #arbiter zone
  storageDeviceSets:
  - config: {}
   count: 1
    [..]
   replica: 4
status:
  conditions:
  [..]
  failureDomain: zone
```

- To verify that all the components for OpenShift Data Foundation are successfully installed, see Verifying your OpenShift Data Foundation installation.

5.6. VERIFYING OPENSHIFT DATA FOUNDATION DEPLOYMENT

To verify that OpenShift Data Foundation is deployed correctly:

- Verify the state of the pods.
- Verify that the OpenShift Data Foundation cluster is healthy.
- Verify that the Multicloud Object Gateway is healthy.
- Verify that the OpenShift Data Foundation specific storage classes exist.

5.6.1. Verifying the state of the pods

Procedure

1. Click **Workloads → Pods** from the OpenShift Web Console.
2. Select **openshift-storage** from the **Project** drop-down list.

NOTE

If the **Show default projects** option is disabled, use the toggle button to list all the default projects.

For more information about the expected number of pods for each component and how it varies depending on the number of nodes, see Table 5.1, “Pods corresponding to OpenShift Data Foundation cluster”.

3. Click the **Running** and **Completed** tabs to verify that the following pods are in **Running** and **Completed** state:

Table 5.1. Pods corresponding to OpenShift Data Foundation cluster

Component	Corresponding pods
OpenShift Data Foundation Operator	● **ocs-operator-*** (1 pod on any worker node) ● **ocs-metrics-exporter-*** (1 pod on any worker node) ● **odf-operator-controller-manager-*** (1 pod on any worker node) ● **odf-console-*** (1 pod on any worker node) ● **csi-addons-controller-manager-*** (1 pod on any worker node)
Rook-ceph Operator	**rook-ceph-operator-*** (1 pod on any worker node)
Multicloud Object Gateway	● **noobaa-operator-*** (1 pod on any worker node) ● **noobaa-core-*** (1 pod on any storage node) ● **noobaa-db-pg-*** (1 pod on any storage node) ● **noobaa-endpoint-*** (1 pod on any storage node)
MON	**rook-ceph-mon-*** (5 pods are distributed across 3 zones, 2 per data-center zones and 1 in arbiter zone)

Component	Corresponding pods
MGR	**rook-ceph-mgr-*** (2 pods on any storage node)
MDS	**rook-ceph-mds-ocs-storagecluster-cephfilesystem-*** (2 pods are distributed across 2 data-center zones)
RGW	**rook-ceph-rgw-ocs-storagecluster-cephobjectstore-*** (2 pods are distributed across 2 data-center zones)
CSI	● **cephfs** ○ **csi-cephfsplugin-*** (1 pod on each worker node) ○ **csi-cephfsplugin-provisioner-*** (2 pods distributed across worker nodes) ● **rbd** ○ **csi-rbdplugin-*** (1 pod on each worker node) ○ **csi-rbdplugin-provisioner-*** (2 pods distributed across worker nodes)
rook-ceph-crashcollector	**rook-ceph-crashcollector-*** (1 pod on each storage node and 1 pod in arbiter zone)
OSD	● **rook-ceph-osd-*** (1 pod for each device) ● **rook-ceph-osd-prepare-ocs-deviceset-*** (1 pod for each device)

5.6.2. Verifying the OpenShift Data Foundation cluster is healthy

Procedure

1. In the OpenShift Web Console, click **Storage → Data Foundation**.

2. In the **Status** card of the **Overview** tab, click **Storage System** and then click the storage system link from the pop up that appears.

3. In the **Status** card of the **Block and File** tab, verify that the *Storage Cluster* has a green tick.

4. In the **Details** card, verify that the cluster information is displayed.

For more information on the health of the OpenShift Data Foundation cluster using the **Block and File** dashboard, see Monitoring OpenShift Data Foundation.

5.6.3. Verifying the Multicloud Object Gateway is healthy

Procedure

1. In the OpenShift Web Console, click **Storage → Data Foundation**.
2. In the **Status** card of the **Overview** tab, click **Storage System** and then click the storage system link from the pop up that appears.
   a. In the **Status card** of the **Object** tab, verify that both *Object Service* and *Data Resiliency* have a green tick.
   b. In the **Details** card, verify that the MCG information is displayed.

For more information on the health of the OpenShift Data Foundation cluster using the object service dashboard, see Monitoring OpenShift Data Foundation.

IMPORTANT

The Multicloud Object Gateway only has a single copy of the database (NooBaa DB). This means if NooBaa DB PVC gets corrupted and we are unable to recover it, can result in total data loss of applicative data residing on the Multicloud Object Gateway. Because of this, Red Hat recommends taking a backup of NooBaa DB PVC regularly. If NooBaa DB fails and cannot be recovered, then you can revert to the latest backed-up version. For instructions on backing up your NooBaa DB, follow the steps in this knowledgabase article.

5.6.4. Verifying that the specific storage classes exist

Procedure

1. Click **Storage → Storage Classes**from the left pane of the OpenShift Web Console.
2. Verify that the following storage classes are created with the OpenShift Data Foundation cluster creation:
   - **ocs-storagecluster-ceph-rbd**
   - **ocs-storagecluster-cephfs**
   - **openshift-storage.noobaa.io**
   - **ocs-storagecluster-ceph-rgw**

5.7. INSTALL ZONE AWARE SAMPLE APPLICATION

Deploy a zone aware sample application to validate whether an OpenShift Data Foundation, stretch cluster setup is configured correctly.

IMPORTANT

With latency between the data zones, you can expect to see performance degradation compared to an OpenShift cluster with low latency between nodes and zones (for example, all nodes in the same location). The rate of or amount of performance degradation depends on the latency between the zones and on the application behavior using the storage (such as heavy write traffic). Ensure that you test the critical applications with stretch cluster configuration to ensure sufficient application performance for the required service levels.

A ReadWriteMany (RWX) Persistent Volume Claim (PVC) is created using the **ocs-storagecluster-cephfs** storage class. Multiple pods use the newly created RWX PVC at the same time. The application used is called File Uploader.

Demonstration on how an application is spread across topology zones so that it is still available in the event of a site outage:

NOTE

This demonstration is possible since this application shares the same RWX volume for storing files. It works for persistent data access as well because Red Hat OpenShift Data Foundation is configured as a stretched cluster with zone awareness and high availability.

1. Create a new project.

```
$ oc new-project my-shared-storage
```

2. Deploy the example PHP application called file-uploader.

```
$ oc new-app openshift/php:latest~https://github.com/mashetty330/openshift-php-upload-
demo --name=file-uploader
```

Example Output:

```
Found image 4f2dcc0 (9 days old) in image stream "openshift/php" under tag "7.2-ubi8" for
"openshift/php:7.2-
ubi8"

Apache 2.4 with PHP 7.2
-----------------------
PHP 7.2 available as container is a base platform for building and running various PHP 7.2
applications and frameworks. PHP is an HTML-embedded scripting language. PHP attempts
to make it easy for developers to write dynamically generated web pages. PHP also offers
built-in database integration for several commercial and non-commercial database
management systems, so writing a database-enabled webpage with PHP is fairly simple.
The most common
use of PHP coding is probably as a replacement for CGI scripts.

Tags: builder, php, php72, php-72

* A source build using source code from https://github.com/christianh814/openshift-php-
upload-demo will be cr
eated
* The resulting image will be pushed to image stream tag "file-uploader:latest"
* Use 'oc start-build' to trigger a new build

--> Creating resources ...
    imagestream.image.openshift.io "file-uploader" created
    buildconfig.build.openshift.io "file-uploader" created
    deployment.apps "file-uploader" created
    service "file-uploader" created
--> Success
    Build scheduled, use 'oc logs -f buildconfig/file-uploader' to track its progress.

    Application is not exposed. You can expose services to the outside world by executing one
or more of the commands below:
     'oc expose service/file-uploader'

    Run 'oc status' to view your app.
```

3. View the build log and wait until the application is deployed.

   ```
   $ oc logs -f bc/file-uploader -n my-shared-storage
   ```

   Example Output:

   ```
   Cloning "https://github.com/christianh814/openshift-php-upload-demo" ...

       [...]
       Generating dockerfile with builder image image-registry.openshift-image-regis
   try.svc:5000/openshift/php@sha256:d97466f33999951739a76bce922ab17088885db610c
   0e05b593844b41d5494ea
   STEP 1: FROM image-registry.openshift-image-registry.svc:5000/openshift/php@s
   ha256:d97466f33999951739a76bce922ab17088885db610c0e05b593844b41d5494ea
   STEP 2: LABEL "io.openshift.build.commit.author"="Christian Hernandez <christ
   ian.hernandez@yahoo.com>"       "io.openshift.build.commit.date"="Sun Oct 1 1
   7:15:09 2017 -0700"       "io.openshift.build.commit.id"="288eda3dff43b02f7f7
   b6b6b6f93396ffdf34cb2"       "io.openshift.build.commit.ref"="master"       "
   io.openshift.build.commit.message"="trying to modularize"       "io.openshift
   .build.source-location"="https://github.com/christianh814/openshift-php-uploa
   d-demo"       "io.openshift.build.image"="image-registry.openshift-image-regi
   stry.svc:5000/openshift/php@sha256:d97466f33999951739a76bce922ab17088885db610
   c0e05b593844b41d5494ea"
   STEP 3: ENV OPENSHIFT_BUILD_NAME="file-uploader-1"
   OPENSHIFT_BUILD_NAMESP
   ACE="my-shared-storage"     OPENSHIFT_BUILD_SOURCE="https://github.com/christ
   ianh814/openshift-php-upload-demo"     OPENSHIFT_BUILD_COMMIT="288eda3dff43b0
   2f7f7b6b6b6f93396ffdf34cb2"
   STEP 4: USER root
   STEP 5: COPY upload/src /tmp/src
   STEP 6: RUN chown -R 1001:0 /tmp/src
   STEP 7: USER 1001
   STEP 8: RUN /usr/libexec/s2i/assemble
   ---> Installing application source...
   => sourcing 20-copy-config.sh ...
   ---> 17:24:39     Processing additional arbitrary httpd configuration provide
   d by s2i ...
   => sourcing 00-documentroot.conf ...
   => sourcing 50-mpm-tuning.conf ...
   => sourcing 40-ssl-certs.sh ...
   ```

```
STEP 9: CMD /usr/libexec/s2i/run
STEP 10: COMMIT temp.builder.openshift.io/my-shared-storage/file-uploader-1:3
b83e447
Getting image source signatures

[...]
```

The command prompt returns out of the tail mode after you see **Push successful**.

NOTE

The new-app command deploys the application directly from the git repository and does not use the OpenShift template, hence the OpenShift route resource is not created by default. You need to create the route manually.

5.7.1. Scaling the application after installation

Procedure

1. Scale the application to four replicas and expose its services to make the application zone aware and available.

```
$ oc expose svc/file-uploader -n my-shared-storage
```

```
$ oc scale --replicas=4 deploy/file-uploader -n my-shared-storage
```

```
$ oc get pods -o wide -n my-shared-storage
```

You should have four file-uploader pods in a few minutes. Repeat the above command until there are 4 file-uploader pods in the **Running** status.

2. Create a PVC and attach it into an application.

```
$ oc set volume deploy/file-uploader --add --name=my-shared-storage \
-t pvc --claim-mode=ReadWriteMany --claim-size=10Gi \
--claim-name=my-shared-storage --claim-class=ocs-storagecluster-cephfs \
--mount-path=/opt/app-root/src/uploaded \
-n my-shared-storage
```

This command:

- Creates a PVC.
- Updates the application deployment to include a volume definition.
- Updates the application deployment to attach a volume mount into the specified mount-path.
- Creates a new deployment with the four application pods.

3. Check the result of adding the volume.

```
$ oc get pvc -n my-shared-storage
```

Example Output:

```
NAME              STATUS   VOLUME                                     CAPACITY   ACCESS MODES
STORAGECLASS               AGE
my-shared-storage   Bound    pvc-5402cc8a-e874-4d7e-af76-1eb05bd2e7c7   10Gi       RWX
ocs-storagecluster-cephfs   52s
```

Notice the **ACCESS MODE** is set to RWX.

All the four **file-uploader** pods are using the same RWX volume. Without this access mode, OpenShift does not attempt to attach multiple pods to the same Persistent Volume (PV) reliably. If you attempt to scale up the deployments that are using ReadWriteOnce (RWO) PV, the pods may get colocated on the same node.

5.7.2. Modify Deployment to be Zone Aware

Currently, the **file-uploader** Deployment is not zone aware and can schedule all the pods in the same zone. In this case, if there is a site outage then the application is unavailable. For more information, see Controlling pod placement by using pod topology spread constraints .

1. Add the pod placement rule in the application deployment configuration to make the application zone aware.

   a. Run the following command, and review the output:

      ```
      $ oc get deployment file-uploader -o yaml -n my-shared-storage | less
      ```

      Example Output:

      ```
      [...]
      spec:
        progressDeadlineSeconds: 600
        replicas: 4
        revisionHistoryLimit: 10
        selector:
          matchLabels:
            deployment: file-uploader
        strategy:
          rollingUpdate:
            maxSurge: 25%
            maxUnavailable: 25%
          type: RollingUpdate
        template:
          metadata:
            annotations:
              openshift.io/generated-by: OpenShiftNewApp
            creationTimestamp: null
            labels:
              deployment: file-uploader
            spec: # <-- Start inserted lines after here
              containers: # <-- End inserted lines before here
              - image: image-registry.openshift-image-registry.svc:5000/my-shared-storage/file-
      uploader@sha256:a458ea62f990e431ad7d5f84c89e2fa27bdebdd5e29c5418c70c56eb81f
      0a26b
      ```

```
     imagePullPolicy: IfNotPresent
     name: file-uploader
[...]
```

b. Edit the deployment to use the topology zone labels.

```
$ oc edit deployment file-uploader -n my-shared-storage
```

Add add the following new lines between the **Start** and **End** (shown in the output in the previous step):

```
[...]
  spec:
   topologySpreadConstraints:
    - labelSelector:
      matchLabels:
       deployment: file-uploader
     maxSkew: 1
     topologyKey: topology.kubernetes.io/zone
     whenUnsatisfiable: DoNotSchedule
    - labelSelector:
      matchLabels:
       deployment: file-uploader
     maxSkew: 1
     topologyKey: kubernetes.io/hostname
     whenUnsatisfiable: ScheduleAnyway
   nodeSelector:
    node-role.kubernetes.io/worker: ""
   containers:
[...]
```

Example output:

```
deployment.apps/file-uploader edited
```

2. Scale down the deployment to **zero** pods and then back to **four** pods. This is needed because the deployment changed in terms of pod placement.

Scaling down tozero pods

```
$ oc scale deployment file-uploader --replicas=0 -n my-shared-storage
```

Example output:

```
deployment.apps/file-uploader scaled
```

Scaling up tofour pods

```
$ oc scale deployment file-uploader --replicas=4 -n my-shared-storage
```

Example output:

```
deployment.apps/file-uploader scaled
```

3. Verify that the four pods are spread across the four nodes in datacenter1 and datacenter2 zones.

   ```
   $ oc get pods -o wide -n my-shared-storage | egrep '^file-uploader'| grep -v build | awk '{print
   $7}' | sort | uniq -c
   ```

   Example output:

   ```
     1 perf1-mz8bt-worker-d2hdm
     1 perf1-mz8bt-worker-k68rv
     1 perf1-mz8bt-worker-ntkp8
     1 perf1-mz8bt-worker-qpwsr
   ```

   Search for the zone labels used.

   ```
   $ oc get nodes -L topology.kubernetes.io/zone | grep datacenter | grep -v master
   ```

   Example output:

   ```
   perf1-mz8bt-worker-d2hdm   Ready    worker   35d   v1.20.0+5fbfd19   datacenter1
   perf1-mz8bt-worker-k68rv   Ready    worker   35d   v1.20.0+5fbfd19   datacenter1
   perf1-mz8bt-worker-ntkp8   Ready    worker   35d   v1.20.0+5fbfd19   datacenter2
   perf1-mz8bt-worker-qpwsr   Ready    worker   35d   v1.20.0+5fbfd19   datacenter2
   ```

4. Use the file-uploader web application using your browser to upload new files.

   a. Find the route that is created.

   ```
   $ oc get route file-uploader -n my-shared-storage -o jsonpath --
   template="http://{.spec.host}{'\n'}"
   ```

   Example Output:

   ```
   http://file-uploader-my-shared-storage.apps.cluster-ocs4-abdf.ocs4-
   abdf.sandbox744.opentlc.com
   ```

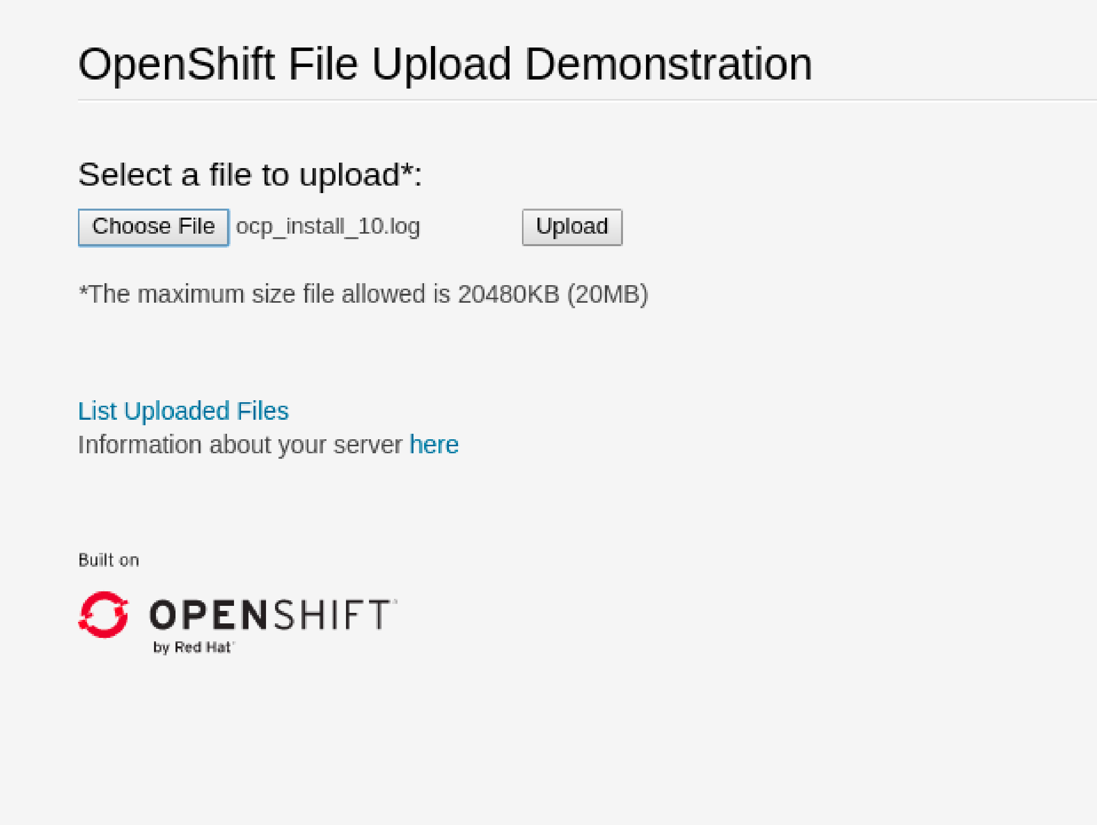
   b. Point your browser to the web application using the route in the previous step.
   The web application lists all the uploaded files and offers the ability to upload new ones as well as you download the existing data. Right now, there is nothing.

   c. Select an arbitrary file from your local machine and upload it to the application.

   i. Click **Choose file** to select an arbitrary file.

   ii. Click **Upload**.

Figure 5.1. A simple PHP-based file upload tool



OpenShift File Upload Demonstration

Select a file to upload*:

*The maximum size file allowed is 20480KB (20MB)

Information about your server here

d. Click **List uploaded files** to see the list of all currently uploaded files.

NOTE

The OpenShift Container Platform image registry, ingress routing, and monitoring services are not zone aware.

5.8. RECOVERING OPENSHIFT DATA FOUNDATION STRETCH CLUSTER

Given that the stretch cluster disaster recovery solution is to provide resiliency in the face of a complete or partial site outage, it is important to understand the different methods of recovery for applications and their storage.

How the application is architected determines how soon it becomes available again on the active zone.

There are different methods of recovery for applications and their storage depending on the site outage. The recovery time depends on the application architecture. The different methods of recovery are as follows:

- Recovering zone-aware HA applications with RWX storage .
- Recovering HA applications with RWX storage .
- Recovering applications with RWO storage .
- Recovering StatefulSet pods.

5.8.1. Understanding zone failure

For the purpose of this section, zone failure is considered as a failure where all OpenShift Container Platform, master and worker nodes in a zone are no longer communicating with the resources in the second data zone (for example, powered down nodes). If communication between the data zones is still partially working (intermittently up or down), the cluster, storage, and network admins should disconnect the communication path between the data zones for recovery to succeed.

IMPORTANT

When you install the sample application, power off the OpenShift Container Platform nodes (at least the nodes with OpenShift Data Foundation devices) to test the failure of a data zone in order to validate that your file-uploader application is available, and you can upload new files.

5.8.2. Recovering zone-aware HA applications with RWX storage

Applications that are deployed with **topologyKey: topology.kubernetes.io/zone** have one or more replicas scheduled in each data zone, and are using shared storage, that is, ReadWriteMany (RWX) CephFS volume, terminate themselves in the failed zone after few minutes and new pods are rolled in and stuck in pending state until the zones are recovered.

An example of this type of application is detailed in the Install Zone Aware Sample Application section.

IMPORTANT

During zone recovery if application pods go into CrashLoopBackOff (CLBO) state with permission denied error while mounting the CephFS volume, then restart the nodes where the pods are scheduled. Wait for some time and then check if the pods are running again.

5.8.3. Recovering HA applications with RWX storage

Applications that are using **topologyKey: kubernetes.io/hostname** or no topology configuration have no protection against all of the application replicas being in the same zone.

NOTE

This can happen even with *podAntiAffinity* and **topologyKey: kubernetes.io/hostname** in the **Pod** spec because this anti-affinity rule is host-based and not zone-based.

If this happens and all replicas are located in the zone that fails, the application using ReadWriteMany (RWX) storage takes 6-8 minutes to recover on the active zone. This pause is for the OpenShift Container Platform nodes in the failed zone to become **NotReady** (60 seconds) and then for the default pod eviction timeout to expire (300 seconds).

5.8.4. Recovering applications with RWO storage

Applications that use ReadWriteOnce (RWO) storage have a known behavior described in this Kubernetes issue. Because of this issue, if there is a data zone failure, any application pods in that zone mounting RWO volumes (for example, **cephrbd** based volumes) are stuck with **Terminating** status after 6-8 minutes and are not re-created on the active zone without manual intervention.

Check the OpenShift Container Platform nodes with a status of **NotReady**. There may be an issue that prevents the nodes from communicating with the OpenShift control plane. However, the nodes may still be performing I/O operations against Persistent Volumes (PVs).

If two pods are concurrently writing to the same RWO volume, there is a risk of data corruption. Ensure that processes on the **NotReady** node are either terminated or blocked until they are terminated.

Example solutions:

- Use an out of band management system to power off a node, with confirmation, to ensure process termination.
- Withdraw a network route that is used by nodes at a failed site to communicate with storage.

> NOTE
>
> Before restoring service to the failed zone or nodes, confirm that all the pods with PVs have terminated successfully.

To get the **Terminating** pods to recreate on the active zone, you can either force delete the pod or delete the finalizer on the associated PV. Once one of these two actions are completed, the application pod should recreate on the active zone and successfully mount its RWO storage.

Force deleting the pod

Force deletions do not wait for confirmation from the kubelet that the pod has been terminated.

```
$ oc delete pod <PODNAME> --grace-period=0 --force --namespace <NAMESPACE>
```

<PODNAME>

Is the name of the pod

<NAMESPACE>

Is the project namespace

> WARNING
>
> OpenShift Data Foundation does not support taints relating to non-graceful node shutdown for automated pod eviction and volume detachment operations. For information, see Non-graceful node shutdown handling . It is mandatory to ensure that the node is shutdown, or network route to the node is withdrawn, prior to force deleting pods.

5.8.5. Recovering StatefulSet pods

Pods that are part of a StatefulSet have a similar issue as pods mounting ReadWriteOnce (RWO) volumes. More information is referenced in the Kubernetes resource StatefulSet considerations.

To get the pods part of a StatefulSet to re-create on the active zone after 6-8 minutes you need to force delete the pod with the same requirements (that is, OpenShift Container Platform node powered off or communication disconnected) as pods with RWO volumes.

CHAPTER 6. DISABLING DISASTER RECOVERY FOR A DISASTER RECOVERY ENABLED APPLICATION

This section guides you to disable disaster recovery (DR) for an application deployed using Red Hat Advanced Cluster Management (RHACM).

- Disabling DR managed applications .
- Disabling DR discovered applications .

6.1. DISABLING DR MANAGED APPLICATIONS

1. On the Hub cluster, navigate to **All Clusters → Applications**.
2. In the **Overview** tab, at the end of the protected application row from the action menu, select **Manage disaster recovery**.
3. Click **Remove disaster recovery**.
4. Click **Confirm remove**.

> **WARNING**
>
> Your application will lose disaster recovery protection, preventing volume synchronization (replication) between clusters.

> **NOTE**
>
> The application continues to be visible in the **Applications Overview** menu but the Data policy is removed.

6.2. DISABLING DR DISCOVERED APPLICATIONS

1. In the RHACM console, navigate to **All Clusters → Data Services → Protected applications** tab.
2. At the end of the application row, click on the **Actions** menu and choose **Remove disaster recovery**.
3. Click **Remove** in the next prompt.

> **WARNING**
>
> Your application will lose disaster recovery protection, preventing volume synchronization (replication) between clusters.

NOTE

The application is no longer in the **Protected applications** tab once the DR is removed.

CHAPTER 7. MONITORING DISASTER RECOVERY HEALTH

7.1. ENABLE MONITORING FOR DISASTER RECOVERY

Use this procedure to enable basic monitoring for your disaster recovery setup.

Procedure

1. On the Hub cluster, open a terminal window
2. Add the following label to **openshift-operator** namespace.

```
$ oc label namespace openshift-operators openshift.io/cluster-monitoring='true'
```

NOTE

You must always add this label for Regional-DR solution.

7.2. ENABLING DISASTER RECOVERY DASHBOARD ON HUB CLUSTER

This section guides you to enable the disaster recovery dashboard for advanced monitoring on the Hub cluster.

For Regional-DR, the dashboard shows monitoring status cards for operator health, cluster health, metrics, alerts and application count.

For Metro-DR, you can configure the dashboard to only monitor the ramen setup health and application count.

Prerequisites

- Ensure that you have already installed the following
  - OpenShift Container Platform version 4.17 and have administrator privileges.
  - ODF Multicluster Orchestrator with the console plugin enabled.
  - Red Hat Advanced Cluster Management for Kubernetes 2.11 (RHACM) from Operator Hub. For instructions on how to install, see Installing RHACM.
- Ensure you have enabled observability on RHACM. See Enabling observability guidelines.

Procedure

1. On the Hub cluster, open a terminal window and perform the next steps.
2. Create the configmap file named **observability-metrics-custom-allowlist.yaml**.
   You can use the following YAML to list the disaster recovery metrics on Hub cluster. For details, see Adding custom metrics. To know more about ramen metrics, see Disaster recovery metrics.

```
kind: ConfigMap
apiVersion: v1
metadata:
  name: observability-metrics-custom-allowlist
  namespace: open-cluster-management-observability
data:
  metrics_list.yaml: |
    names:
      - ceph_rbd_mirror_snapshot_sync_bytes
      - ceph_rbd_mirror_snapshot_snapshots
    matches:
      - __name__="csv_succeeded",exported_namespace="openshift-dr-system",name=~"odr-cluster-operator.*"
      - __name__="csv_succeeded",exported_namespace="openshift-operators",name=~"volsync.*"
```

3. In the **open-cluster-management-observability** namespace, run the following command:

```
$ oc apply -n open-cluster-management-observability -f observability-metrics-custom-allowlist.yaml
```

4. After **observability-metrics-custom-allowlist** yaml is created, RHACM starts collecting the listed OpenShift Data Foundation metrics from all the managed clusters.
   To exclude a specific managed cluster from collecting the observability data, add the following cluster label to the **clusters: observability: disabled**.

7.3. VIEWING HEALTH STATUS OF DISASTER RECOVERY REPLICATION RELATIONSHIPS

Prerequisites

Ensure that you have enabled the disaster recovery dashboard for monitoring. For instructions, see chapter Enabling disaster recovery dashboard on Hub cluster .

Procedure

1. On the Hub cluster, ensure **All Clusters** option is selected.

2. Refresh the console to make the DR monitoring dashboard tab accessible.

3. Navigate to **Data Services** and click **Data policies**.

4. On the Overview tab, you can view the health status of the operators, clusters and applications. Green tick indicates that the operators are running and available..

5. Click the **Disaster recovery** tab to view a list of DR policy details and connected applications.

7.4. DISASTER RECOVERY METRICS

These are the ramen metrics that are scrapped by prometheus.

- ramen_last_sync_timestamp_seconds

- ramen_policy_schedule_interval_seconds

- ramen_last_sync_duration_seconds

- ramen_last_sync_data_bytes
- ramen_workload_protection_status

Run these metrics from the Hub cluster where Red Hat Advanced Cluster Management for Kubernetes (RHACM operator) is installed.

7.4.1. Last synchronization timestamp in seconds

This is the time in seconds which gives the time of the most recent successful synchronization of all PVCs per application.

Metric name

ramen_last_sync_timestamp_seconds

Metrics type

Gauge

Labels

- **ObjType**: Type of the object, here its DRPC
- **ObjName**: Name of the object, here it is DRPC-Name
- **ObjNamespace**: DRPC namespace
- **Policyname**: Name of the DRPolicy
- **SchedulingInterval**: Scheduling interval value from DRPolicy

Metric value

Value is set as Unix seconds which is obtained from **lastGroupSyncTime** from DRPC status.

7.4.2. Policy schedule interval in seconds

This gives the scheduling interval in seconds from DRPolicy.

Metric name

ramen_policy_schedule_interval_seconds

Metrics type

Gauge

Labels

- **Policyname**: Name of the DRPolicy

Metric value

This is set to a scheduling interval in seconds which is taken from DRPolicy.

7.4.3. Last synchronization duration in seconds

This represents the longest time taken to sync from the most recent successful synchronization of all PVCs per application.

Metric name

ramen_last_sync_duration_seconds

Metrics type

Gauge

Labels

- **obj_type**: Type of the object, here it is DRPC
- **obj_name**: Name of the object, here it is DRPC-Name
- **obj_namespace**: DRPC namespace
- **scheduling_interval**: Scheduling interval value from DRPolicy

Metric value

The value is taken from **lastGroupSyncDuration** from DRPC status.

7.4.4. Total bytes transferred from most recent synchronization

This value represents the total bytes transferred from the most recent successful synchronization of all PVCs per application.

Metric name

ramen_last_sync_data_bytes

Metrics type

Gauge

Labels

- **obj_type**: Type of the object, here it is DRPC
- **obj_name**: Name of the object, here it is DRPC-Name
- **obj_namespace**: DRPC namespace
- **scheduling_interval**: Scheduling interval value from DRPolicy

Metric value

The value is taken from **lastGroupSyncBytes** from DRPC status.

7.4.5. Workload protection status

This value provides the application protection status per application that is DR protected.

Metric name

ramen_workload_protection_status

Metrics type

Gauge

Labels

- **ObjType**: Type of the object, here its DRPC

- **ObjName**: Name of the object, here it is DRPC-Name
- **ObjNamespace**: DRPC namespace

Metric value

The value is either a "1" or a "0", where "1" indicates application DR protection is healthy and a "0" indicates application protection degraged and potentially unprotected.

7.5. DISASTER RECOVERY ALERTS

This section provides a list of all supported alerts associated with Red Hat OpenShift Data Foundation within a disaster recovery environment.

Recording rules

- Record: **ramen_sync_duration_seconds**

  Expression

  ```
  sum by (obj_name, obj_namespace, obj_type, job, policyname)(time() -
  (ramen_last_sync_timestamp_seconds > 0))
  ```

  Purpose

  The time interval between the volume group’s last sync time and the time now in seconds.

- Record: **ramen_rpo_difference**

  Expression

  ```
  ramen_sync_duration_seconds{job="ramen-hub-operator-metrics-service"} /
  on(policyname, job) group_left() (ramen_policy_schedule_interval_seconds{job="ramen-
  hub-operator-metrics-service"})
  ```

  Purpose

  The difference between the expected sync delay and the actual sync delay taken by the volume replication group.

- Record: **count_persistentvolumeclaim_total**

  Expression

  ```
  count(kube_persistentvolumeclaim_info)
  ```

  Purpose

  Sum of all PVC from the managed cluster.

Alerts

- Alert: **VolumeSynchronizationDelay**

  Impact

  Critical

Purpose

Actual sync delay taken by the volume replication group is thrice the expected sync delay.

YAML

```
alert: VolumeSynchronizationDelay
expr: ramen_rpo_difference >= 3
for: 5s
labels:
  severity: critical
annotations:
  description: "The syncing of volumes is exceeding three times the scheduled snapshot interval, or the volumes have been recently protected. (DRPC: {{ $labels.obj_name }}, Namespace: {{ $labels.obj_namespace }})"
  alert_type: "DisasterRecovery"
```

- Alert: **VolumeSynchronizationDelay**

Impact

Warning

Purpose

Actual sync delay taken by the volume replication group is twice the expected sync delay.

YAML

```
alert: VolumeSynchronizationDelay
expr: ramen_rpo_difference > 2 and ramen_rpo_difference < 3
for: 5s
labels:
  severity: warning
annotations:
  description: "The syncing of volumes is exceeding two times the scheduled snapshot interval, or the volumes have been recently protected. (DRPC: {{ $labels.obj_name }}, Namespace: {{ $labels.obj_namespace }})"
  alert_type: "DisasterRecovery"
```

- Alert: **WorkloadUnprotected**

Impact

Critical

Purpose

Application protection status is degraded for more than 10 minutes

YAML

```
alert: WorkloadUnprotected
expr: ramen_workload_protection_status == 0
for: 10m
labels:
  severity: critical
annotations:
  description: "Workload is not protected for disaster recovery (DRPC: {{ $labels.obj_name
}}, Namespace: {{ $labels.obj_namespace }})."
  alert_type: "DisasterRecovery"
```

CHAPTER 8. TROUBLESHOOTING DISASTER RECOVERY

8.1. TROUBLESHOOTING METRO-DR

8.1.1. A statefulset application stuck after failover

Problem

While relocating to a preferred cluster, DRPlacementControl is stuck reporting PROGRESSION as "MovingToSecondary".
Previously, before Kubernetes v1.23, the Kubernetes control plane never cleaned up the PVCs created for StatefulSets. This activity was left to the cluster administrator or a software operator managing the StatefulSets. Due to this, the PVCs of the StatefulSets were left untouched when their Pods were deleted. This prevents Ramen from relocating an application to its preferred cluster.

Resolution

1. If the workload uses StatefulSets, and relocation is stuck with PROGRESSION as "MovingToSecondary", then run:

   ```
   $ oc get pvc -n <namespace>
   ```

2. For each bounded PVC for that namespace that belongs to the StatefulSet, run

   ```
   $ oc delete pvc <pvcname> -n namespace
   ```

   Once all PVCs are deleted, Volume Replication Group (VRG) transitions to secondary, and then gets deleted.

3. Run the following command

   ```
   $ oc get drpc -n <namespace> -o wide
   ```

   After a few seconds to a few minutes, the PROGRESSION reports "Completed" and relocation is complete.

Result

The workload is relocated to the preferred cluster

BZ reference: [2118270]

8.1.2. DR policies protect all applications in the same namespace

Problem

While only a single application is selected to be used by a DR policy, all applications in the same namespace will be protected. This results in PVCs, that match the **DRPlacementControl spec.pvcSelector** across multiple workloads or if the selector is missing across all workloads, replication management to potentially manage each PVC multiple times and cause data corruption or invalid operations based on individual **DRPlacementControl** actions.

Resolution

Label PVCs that belong to a workload uniquely, and use the selected label as the DRPlacementControl **spec.pvcSelector** to disambiguate which DRPlacementControl protects and manages which subset of PVCs within a namespace. It is not possible to specify the **spec.pvcSelector** field for the DRPlacementControl using the user interface, hence the DRPlacementControl for such applications must be deleted and created using the command line.

BZ reference: [2128860]

8.1.3. Relocate or failback might be stuck in Initiating state

Problem

When a primary cluster is down and comes back online while the secondary goes down, **relocate** or **failback** might be stuck in the **Initiating** state.

Resolution

To avoid this situation, cut off all access from the old active hub to the managed clusters. Alternatively, you can scale down the ApplicationSet controller on the old active hub cluster either before moving workloads or when they are in the clean-up phase.

On the old active hub, scale down the two deployments using the following commands:

```
$ oc scale deploy -n openshift-gitops-operator openshift-gitops-operator-controller-manager --replicas=0

$ oc scale statefulset -n openshift-gitops openshift-gitops-application-controller --replicas=0
```

BZ reference: [2243804]

8.2. TROUBLESHOOTING REGIONAL-DR

8.2.1. rbd-mirror daemon health is in warning state

Problem

There appears to be numerous cases where WARNING gets reported if mirror service **::get_mirror_service_status** calls **Ceph** monitor to get service status for **rbd-mirror**. Following a network disconnection, **rbd-mirror** daemon health is in the **warning** state while the connectivity between both the managed clusters is fine.

Resolution

Run the following command in the toolbox and look for **leader:false**

```
rbd mirror pool status --verbose ocs-storagecluster-cephblockpool | grep 'leader:'
```

If you see the following in the output:

leader: false	It indicates that there is a daemon startup issue and the most likely root cause could be due to problems reliably connecting to the secondary cluster. Workaround: Move the **rbd-mirror** pod to a different node by simply deleting the pod and verify that it has been rescheduled on another node.

leader: true or no output	Contact Red Hat Support

BZ reference: [2118627]

8.2.2. **volsync-rsync-src** pod is in error state as it is unable to resolve the destination hostname

Problem

VolSync source pod is unable to resolve the hostname of the VolSync destination pod. The log of the VolSync Pod consistently shows an error message over an extended period of time similar to the following log snippet.

```
$ oc logs -n busybox-workloads-3-2 volsync-rsync-src-dd-io-pvc-1-p25rz
```

Example output

```
VolSync rsync container version: ACM-0.6.0-ce9a280
Syncing data to volsync-rsync-dst-dd-io-pvc-1.busybox-workloads-3-2.svc.clusterset.local:22 ...
ssh: Could not resolve hostname volsync-rsync-dst-dd-io-pvc-1.busybox-workloads-3-
2.svc.clusterset.local: Name or service not known
```

Resolution

Restart **submariner-lighthouse-agent** on both nodes.

```
$ oc delete pod -l app=submariner-lighthouse-agent -n submariner-operator
```

8.2.3. Cleanup and data sync for ApplicationSet workloads remain stuck after older primary managed cluster is recovered post failover

Problem

ApplicationSet based workload deployments to managed clusters are not garbage collected in cases when the hub cluster fails. It is recovered to a standby hub cluster, while the workload has been failed over to a surviving managed cluster. The cluster that the workload was failed over from, rejoins the new recovered standby hub.
ApplicationSets that are DR protected, with a regional DRPolicy, hence starts firing the VolumeSynchronizationDelay alert. Further such DR protected workloads cannot be failed over to the peer cluster or relocated to the peer cluster as data is out of sync between the two clusters.

Resolution

The workaround requires that **openshift-gitops** operators can own the workload resources that are orphaned on the managed cluster that rejoined the hub post a failover of the workload was performed from the new recovered hub. To achieve this the following steps can be taken:

1. Determine the Placement that is in use by the ArgoCD ApplicationSet resource on the hub cluster in the **openshift-gitops** namespace.

2. Inspect the placement label value for the ApplicationSet in this field: **spec.generators.clusterDecisionResource.labelSelector.matchLabels**
   This would be the name of the Placement resource *<placement-name>*

3. Ensure that there exists a **PlacemenDecision** for the ApplicationSet referenced **Placement**.

   ```
   $ oc get placementdecision -n openshift-gitops --selector cluster.open-cluster-
   management.io/placement=<placement-name>
   ```

   This results in a single **PlacementDecision** that places the workload in the currently desired failover cluster.

4. Create a new **PlacementDecision** for the ApplicationSet pointing to the cluster where it should be cleaned up.
   For example:

   ```
   apiVersion: cluster.open-cluster-management.io/v1beta1
   kind: PlacementDecision
   metadata:
     labels:
       cluster.open-cluster-management.io/decision-group-index: "1" # Typically one higher
   than the same value in the esisting PlacementDecision determined at step (2)
       cluster.open-cluster-management.io/decision-group-name: ""
       cluster.open-cluster-management.io/placement: cephfs-appset-busybox10-placement
     name: <placemen-name>-decision-<n> # <n> should be one higher than the existing
   PlacementDecision as determined in step (2)
     namespace: openshift-gitops
   ```

5. Update the newly created **PlacementDecision** with a status **subresource**.

   ```
   decision-status.yaml:
   status:
     decisions:
     - clusterName: <managedcluster-name-to-clean-up> # This would be the cluster from
   where the workload was failed over, NOT the current workload cluster
       reason: FailoverCleanup
   ```

   ```
   $ oc patch placementdecision -n openshift-gitops <placemen-name>-decision-<n> --
   patch-file=decision-status.yaml --subresource=status --type=merge
   ```

6. Watch and ensure that the Application resource for the ApplicationSet has been placed on the desired cluster

   ```
   $ oc get application -n openshift-gitops  <applicationset-name>-<managedcluster-name-
   to-clean-up>
   ```

   In the output, check if the SYNC STATUS shows as **Synced** and the HEALTH STATUS shows as **Healthy**.

7. Delete the PlacementDecision that was created in step (3), such that ArgoCD can garbage collect the workload resources on the <managedcluster-name-to-clean-up>

```
$ oc delete placementdecision -n openshift-gitops <placemen-name>-decision-<n>
```

ApplicationSets that are DR protected, with a regional DRPolicy, stops firing the **VolumeSynchronizationDelay** alert.

BZ reference: [2268594]

8.3. TROUBLESHOOTING 2-SITE STRETCH CLUSTER WITH ARBITER

8.3.1. Recovering workload pods stuck in ContainerCreating state post zone recovery

Problem

After performing complete zone failure and recovery, the workload pods are sometimes stuck in **ContainerCreating** state with the any of the below errors:

- MountDevice failed to create newCsiDriverClient: driver name openshift-storage.rbd.csi.ceph.com not found in the list of registered CSI drivers
- MountDevice failed for volume *<volume_name>* : rpc error: code = Aborted desc = an operation with the given Volume ID *<volume_id>* already exists
- MountVolume.SetUp failed for volume *<volume_name>* : rpc error: code = Internal desc = staging path *<path>* for volume *<volume_id>* is not a mountpoint

Resolution

If the workload pods are stuck with any of the above mentioned errors, perform the following workarounds:

- For **ceph-fs** workload stuck in **ContainerCreating**:
  1. Restart the nodes where the stuck pods are scheduled
  2. Delete these stuck pods
  3. Verify that the new pods are running
- For **ceph-rbd** workload stuck in **ContainerCreating** that do not self recover after sometime
  1. Restart csi-rbd plugin pods in the nodes where the stuck pods are scheduled
  2. Verify that the new pods are running