Replacing devices

Instructions for safely replacing operational or failed devices
Instructions for safely replacing operational or failed devices
Abstract

This document explains how to safely replace storage devices for Red Hat OpenShift Data Foundation.
# Table of Contents

**MAKING OPEN SOURCE MORE INCLUSIVE** ................................................. 3

**PROVIDING FEEDBACK ON RED HAT DOCUMENTATION** ................................................. 4

**PREFACE** ................................................................................................................. 5

**CHAPTER 1. DYNAMICALLY PROVISIONED OPENS SHIFT DATA FOUNDATION DEPLOYED ON AWS** ...... 6
  1.1. REPLACING OPERATIONAL OR FAILED STORAGE DEVICES ON AWS USER-PROVISIONED INFRASTRUCTURE ................................................. 6
  1.2. REPLACING OPERATIONAL OR FAILED STORAGE DEVICES ON AWS INSTALLER-PROVISIONED INFRASTRUCTURE ................................................. 6

**CHAPTER 2. DYNAMICALLY PROVISIONED OPENS SHIFT DATA FOUNDATION DEPLOYED ON VMWARE** 7
  2.1. REPLACING OPERATIONAL OR FAILED STORAGE DEVICES ON VMWARE INFRASTRUCTURE ................................................. 7

**CHAPTER 3. DYNAMICALLY PROVISIONED OPENS SHIFT DATA FOUNDATION DEPLOYED ON RED HAT VIRTUALIZATION** ................................................. 13
  3.1. REPLACING OPERATIONAL OR FAILED STORAGE DEVICES ON RED HAT VIRTUALIZATION INSTALLER-PROVISIONED INFRASTRUCTURE ................................................. 13

**CHAPTER 4. DYNAMICALLY PROVISIONED OPENS SHIFT DATA FOUNDATION DEPLOYED ON MICROSOFT AZURE** ................................................. 18
  4.1. REPLACING OPERATIONAL OR FAILED STORAGE DEVICES ON AZURE INSTALLER-PROVISIONED INFRASTRUCTURE ................................................. 18

**CHAPTER 5. OPENS SHIFT DATA FOUNDATION DEPLOYED USING LOCAL STORAGE DEVICES** ........... 19
  5.1. REPLACING OPERATIONAL OR FAILED STORAGE DEVICES ON CLUSTERS BACKED BY LOCAL STORAGE DEVICES ................................................. 19
  5.2. REPLACING OPERATIONAL OR FAILED STORAGE DEVICES ON IBM POWER ................................................. 25
  5.3. REPLACING OPERATIONAL OR FAILED STORAGE DEVICES ON IBM Z OR LINUXONE INFRASTRUCTURE ................................................. 35
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.
PROVIDING FEEDBACK ON RED HAT DOCUMENTATION

We appreciate your input on our documentation. Do let us know how we can make it better. To give feedback:

- For simple comments on specific passages:
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  2. As the Component, use Documentation.
  3. Fill in the Description field with your suggestion for improvement. Include a link to the relevant part(s) of documentation.
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Depending on the type of your deployment, you can choose one of the following procedures to replace a storage device:

- For dynamically created storage clusters deployed on AWS, see:
  - Section 1.1, “Replacing operational or failed storage devices on AWS user-provisioned infrastructure”.
  - Section 1.2, “Replacing operational or failed storage devices on AWS installer-provisioned infrastructure”.

- For dynamically created storage clusters deployed on VMware, see Section 2.1, “Replacing operational or failed storage devices on VMware infrastructure”.

- For dynamically created storage clusters deployed on Red Hat Virtualization, see Section 3.1, “Replacing operational or failed storage devices on Red Hat Virtualization installer-provisioned infrastructure”.

- For dynamically created storage clusters deployed on Microsoft Azure, see Section 4.1, “Replacing operational or failed storage devices on Azure installer-provisioned infrastructure”.

- For storage clusters deployed using local storage devices, see:
  - Section 5.1, “Replacing operational or failed storage devices on clusters backed by local storage devices”.
  - Section 5.2, “Replacing operational or failed storage devices on IBM Power”.
  - Section 5.3, “Replacing operational or failed storage devices on IBM Z or LinuxONE infrastructure”.

**NOTE**

OpenShift Data Foundation does not support heterogeneous OSD sizes.
CHAPTER 1. DYNAMICALLY PROVISIONED OCP DATA FOUNDATION DEPLOYED ON AWS

1.1. REPLACING OPERATIONAL OR FAILED STORAGE DEVICES ON AWS USER-PROVISIONED INFRASTRUCTURE

When you need to replace a device in a dynamically created storage cluster on an AWS user-provisioned infrastructure, you must replace the storage node. For information about how to replace nodes, see:

- Replacing an operational AWS node on user-provisioned infrastructure.
- Replacing a failed AWS node on user-provisioned infrastructure.

1.2. REPLACING OPERATIONAL OR FAILED STORAGE DEVICES ON AWS INSTALLER-PROVISIONED INFRASTRUCTURE

When you need to replace a device in a dynamically created storage cluster on an AWS installer-provisioned infrastructure, you must replace the storage node. For information about how to replace nodes, see:

- Replacing an operational AWS node on installer-provisioned infrastructure.
- Replacing a failed AWS node on installer-provisioned infrastructure.
2.1. REPLACING OPERATIONAL OR FAILED STORAGE DEVICES ON VMWARE INFRASTRUCTURE

Create a new Persistent Volume Claim (PVC) on a new volume, and remove the old object storage device (OSD) when one or more virtual machine disks (VMDK) needs to be replaced in OpenShift Data Foundation which is deployed dynamically on VMware infrastructure.

Prerequisites

- Ensure that the data is resilient.
  - In the OpenShift Web Console, click Storage → Data Foundation.
  - Click the Storage Systems tab, and then click ocs-storagecluster-storagesystem.
  - In the Status card of Block and File dashboard, under the Overview tab, verify that Data Resiliency has a green tick mark.

Procedure

1. Identify the OSD that needs to be replaced and the OpenShift Container Platform node that has the OSD scheduled on it.

   ```bash
   $ oc get -n openshift-storage pods -l app=rook-ceph-osd -o wide
   ```

   Example output:

   ```plaintext
   rook-ceph-osd-0-6d77d6c7c6-m8xj6    0/1    CrashLoopBackOff    0    24h   10.129.0.16   compute-2   <none>           <none>
   rook-ceph-osd-1-85d99fb95f-2svc7    1/1    Running             0    24h   10.128.2.24   compute-0   <none>           <none>
   rook-ceph-osd-2-6c66cdeb977-jp542    1/1    Running             0    24h   10.130.0.18   compute-1   <none>           <none>
   ```

   In this example, `rook-ceph-osd-0-6d77d6c7c6-m8xj6` needs to be replaced and `compute-2` is the OpenShift Container platform node on which the OSD is scheduled.

   **NOTE**
   
   If the OSD to be replaced is healthy, the status of the pod will be **Running**.

2. Scale down the OSD deployment for the OSD to be replaced.

   Each time you want to replace the OSD, update the `osd_id_to_remove` parameter with the OSD ID, and repeat this step.

   ```bash
   $ osd_id_to_remove=0
   $ oc scale -n openshift-storage deployment rook-ceph-osd-$(osd_id_to_remove) --replicas=0
   ```
where, \texttt{osd\_id\_to\_remove} is the integer in the pod name immediately after the \texttt{rook-ceph-osd} prefix. In this example, the deployment name is \texttt{rook-ceph-osd-0}.

Example output:

```
deployment.extensions/rook-ceph-osd-0 scaled
```

3. Verify that the \texttt{rook-ceph-osd} pod is terminated.

```
$ oc get -n openshift-storage pods -l ceph-osd-id=${osd\_id\_to\_remove}
```

Example output:

```
No resources found.
```

\textbf{IMPORTANT}

If the \texttt{rook-ceph-osd} pod is in \texttt{terminating} state, use the \texttt{force} option to delete the pod.

```
$ oc delete pod rook-ceph-osd-0-6d77d6c7c6-m8xj6 --force --grace-period=0
```

Example output:

```
warning: Immediate deletion does not wait for confirmation that the running resource has been terminated. The resource may continue to run on the cluster indefinitely.

pod “rook-ceph-osd-0-6d77d6c7c6-m8xj6” force deleted
```

4. Remove the old OSD from the cluster so that you can add a new OSD.

a. Delete any old \texttt{ocs-osd-removal} jobs.

```
$ oc delete -n openshift-storage job ocs-osd-removal-job
```

Example output:

```
job.batch “ocs-osd-removal-job” deleted
```

b. Navigate to the \texttt{openshift-storage} project.

```
$ oc project openshift-storage
```

c. Remove the old OSD from the cluster.

```
$ oc process -n openshift-storage ocs-osd-removal -p
FAILED_OSD_IDS=${osd\_id\_to\_remove} FORCE_OSD_REMOVAL=false |oc create -n openshift-storage -f -
```

You can add comma separated OSD IDs in the command to remove more than one OSD. (For example, \texttt{FAILED_OSD_IDS=0,1,2}).
The FORCE_OSD_REMOVAL value must be changed to “true” in clusters that only have three OSDs, or clusters with insufficient space to restore all three replicas of the data after the OSD is removed.

**WARNING**

This step results in OSD being completely removed from the cluster. Ensure that the correct value of **osd_id_to_remove** is provided.

5. Verify that the OSD is removed successfully.

   - Check the status of the **ocs-osd-removal** pod.
     A status of **Completed** confirms that the OSD removal job succeeded.

     ```
     $ oc get pod -l job-name=ocs-osd-removal-job -n openshift-storage
     ```

     **IMPORTANT**

     If the **ocs-osd-removal** pod fails and the pod is not in the expected **Completed** state, check the pod logs for further debugging.

     For example:

     ```
     $ oc logs -l job-name=ocs-osd-removal-job -n openshift-storage --tail=-1
     ```

6. If encryption was enabled at the time of install, remove **dm-crypt** managed **device-mapper** mapping from the OSD devices that are removed from the respective OpenShift Data Foundation nodes.

   a. Get the PVC name(s) of the replaced OSD(s) from the logs of **ocs-osd-removal-job** pod.

     ```
     $ oc logs -l job-name=ocs-osd-removal-job -n openshift-storage --tail=-1 | egrep -i 'pvc|deviceset'
     ```

     Example output:

     ```
     2021-05-12 14:31:34.666000 I | cephosd: removing the OSD PVC "ocs-deviceset-xxxx-xxx-xxx-xxx"
     ```

   b. For each of the previously identified nodes, do the following:

      i. Create a **debug** pod and **chroot** to the host on the storage node.

      ```
      $ oc debug node/<node name>
      ```

      `<node name>`

      Is the name of the node.
$ chroot /host

ii. Find a relevant device name based on the PVC names identified in the previous step.

$ dmsetup ls| grep <pvc name>

<pvc name>
Is the name of the PVC.
Example output:

ocs-deviceset-xxx-xxx-xxx-xxx-block-dmcrypt (253:0)

iii. Remove the mapped device.

$ cryptsetup luksClose --debug --verbose ocs-deviceset-xxx-xxx-xxx-xxx-block-dmcrypt

IMPORTANT
If the above command gets stuck due to insufficient privileges, run the following commands:

- Press **CTRL+Z** to exit the above command.
- Find the PID of the process which was stuck.

$ ps -ef | grep crypt

- Terminate the process using the **kill** command.

$ kill -9 <PID>

<PID>
Is the process ID.

- Verify that the device name is removed.

$ dmsetup ls

7. Delete the **ocs-osd-removal** job.

$ oc delete -n openshift-storage job ocs-osd-removal-job

Example output:

job.batch "ocs-osd-removal-job" deleted
When using an external key management system (KMS) with data encryption, the old OSD encryption key can be removed from the Vault server as it is now an orphan key.

**Verification steps**

1. Verify that there is a new OSD running.
   
   $ oc get -n openshift-storage pods -l app=rook-ceph-osd
   
   Example output:
   
   ```
   rook-ceph-osd-0-5f7f4747d4-snshw 1/1 Running 0 4m47s
   rook-ceph-osd-1-85d99fb95f-2svc7 1/1 Running 0 1d20h
   rook-ceph-osd-2-6c66c6db977-jp542 1/1 Running 0 1d20h
   ```

2. Verify that there is a new PVC created which is in **Bound** state.

   $ oc get -n openshift-storage pvc
   
   Example output:
   
   ```
   NAME                      STATUS   VOLUME                                     CAPACITY   ACCESS
   MODES   STORAGECLASS    AGE
   ocs-deviceset-0-0-2s6w4   Bound    pvc-7c9bca77-de68-40e1-95f9-0b0d7c0ae2fc   512Gi
   RWO            thin            5m
   ocs-deviceset-1-0-q8fw4   Bound    pvc-9e7e00cb-6b33-402e-9dc5-b8df4fd9010f   512Gi
   RWO            thin            1d20h
   ocs-deviceset-2-0-9v8lq   Bound    pvc-38cdfceea7e-42a5-a6e1-aaa6d4924291   512Gi
   RWO            thin            1d20h
   ```

3. Optional: If cluster-wide encryption is enabled on the cluster, verify that the new OSD devices are encrypted.

   a. Identify the node(s) where the new OSD pod(s) are running.

      $ oc get -o=custom-columns=NODE:.spec.nodeName pod/<OSD pod name>

   <**OSD pod name**>

      Is the name of the OSD pod.

      For example:

      $ oc get -o=custom-columns=NODE:.spec.nodeName pod/rook-ceph-osd-0-544db49d7f-qrgqm

   b. For each of the nodes identified in the previous step, do the following:

      i. Create a debug pod and open a chroot environment for the selected host(s).

         $ oc debug node/<node name>
<node name>

Is the name of the node.

$ chroot /host

ii. Check for the crypt keyword beside the ocs-deviceset name(s).

$ lsblk

4. Log in to OpenShift Web Console and view the storage dashboard.
CHAPTER 3. DYNAMICALLY PROVISIONED OPENSIFT DATA FOUNDATION DEPLOYED ON RED HAT VIRTUALIZATION

3.1. REPLACING OPERATIONAL OR FAILED STORAGE DEVICES ON RED HAT VIRTUALIZATION INSTALLER-PROVISIONED INFRASTRUCTURE

Create a new Persistent Volume Claim (PVC) on a new volume, and remove the old object storage device (OSD).

Prerequisites

- Ensure that the data is resilient.
  - In the OpenShift Web Console, click Storage → Data Foundation.
  - Click the Storage Systems tab, and then click ocs-storagecluster-storagesystem.
  - In the Status card of Block and File dashboard, under the Overview tab, verify that Data Resiliency has a green tick mark.

Procedure

1. Identify the OSD that needs to be replaced and the OpenShift Container Platform node that has the OSD scheduled on it.

   $ oc get -n openshift-storage pods -l app=rook-ceph-osd -o wide

   Example output:

   rook-ceph-osd-0-6d77d6c7c6-m8xj6 0/1 CrashLoopBackOff 0 24h 10.129.0.16
   compute-2 <none> <none>
   rook-ceph-osd-1-85d99fb95f-2svc7 1/1 Running 0 24h 10.128.2.24 compute-0 <none> <none>
   rook-ceph-osd-2-6c66cdb977-jp542 1/1 Running 0 24h 10.130.0.18 compute-1 <none> <none>

   In this example, rook-ceph-osd-0-6d77d6c7c6-m8xj6 needs to be replaced and compute-2 is the OpenShift Container platform node on which the OSD is scheduled.

   **NOTE**

   If the OSD to be replaced is healthy, the status of the pod will be Running.

2. Scale down the OSD deployment for the OSD to be replaced.

   Each time you want to replace the OSD, update the osd_id_to_remove parameter with the OSD ID, and repeat this step.

   $ osd_id_to_remove=0

   $ oc scale -n openshift-storage deployment rook-ceph-osd-$osd_id_to_remove --replicas=0
where, `osd_id_to_remove` is the integer in the pod name immediately after the `rook-ceph-osd` prefix. In this example, the deployment name is `rook-ceph-osd-0`.

Example output:

```
deployment.extensions/rook-ceph-osd-0 scaled
```

3. Verify that the `rook-ceph-osd` pod is terminated.

```
$ oc get -n openshift-storage pods -l ceph-osd-id=${osd_id_to_remove}
```

Example output:

```
No resources found.
```

**IMPORTANT**

If the `rook-ceph-osd` pod is in **terminating** state, use the `force` option to delete the pod.

```
$ oc delete pod rook-ceph-osd-0-6d77d6c7c6-m8xj6 --force --grace-period=0
```

Example output:

```
warning: Immediate deletion does not wait for confirmation that the running resource has been terminated. The resource may continue to run on the cluster indefinitely.

pod "rook-ceph-osd-0-6d77d6c7c6-m8xj6" force deleted
```

4. Remove the old OSD from the cluster so that you can add a new OSD.

a. Delete any old `ocs-osd-removal` jobs.

```
$ oc delete -n openshift-storage job ocs-osd-removal-job
```

Example output:

```
job.batch "ocs-osd-removal-job"
```

b. Navigate to the `openshift-storage` project.

```
$ oc project openshift-storage
```

c. Remove the old OSD from the cluster.

```
$ oc process -n openshift-storage ocs-osd-removal -p FAILED_OSD_IDS=${osd_id_to_remove} FORCE_OSD_REMOVAL=false | oc create -n openshift-storage -f -
```

You can add comma separated OSD IDs in the command to remove more than one OSD. (For example, FAILED_OSD_IDS=0,1,2).
The FORCE_OSD_REMOVAL value must be changed to “true” in clusters that only have three OSDs, or clusters with insufficient space to restore all three replicas of the data after the OSD is removed.

**WARNING**

This step results in OSD being completely removed from the cluster. Ensure that the correct value of `osd_id_to_remove` is provided.

5. Verify that the OSD is removed successfully.

   - Check the status of the `ocs-osd-removal` pod. A status of **Completed** confirms that the OSD removal job succeeded.

   ```shell
   $ oc get pod -l job-name=ocs-osd-removal-job -n openshift-storage
   ```

   **IMPORTANT**

   If `ocs-osd-removal` fails and the pod is not in the expected **Completed** state, check the pod logs for further debugging. For example:

   ```shell
   $ oc logs -l job-name=ocs-osd-removal-job -n openshift-storage --tail=-1
   ```

6. If encryption was enabled at the time of install, remove `dm-crypt` managed `device-mapper` mapping from the OSD devices that are removed from the respective OpenShift Data Foundation nodes.

   a. Get the PVC name(s) of the replaced OSD(s) from the logs of `ocs-osd-removal-job` pod.

      ```shell
      $ oc logs -l job-name=ocs-osd-removal-job -n openshift-storage --tail=-1 | egrep -i 'pvc|deviceset'
      ```

      Example output:

      ```plaintext
      2021-05-12 14:31:34.666000 I | cephosd: removing the OSD PVC "ocs-deviceset-xxxx-xxx-xxx-xxx"
      ```

   b. For each of the previously identified nodes, do the following:

      i. Create a **debug** pod and **chroot** to the host on the storage node.

      ```shell
      $ oc debug node/<node name>
      <node name>
      ```

      Is the name of the node.

      ```bash
      $ chroot /host
      ```
ii. Find a relevant device name based on the PVC names identified in the previous step.

$ dmsetup ls| grep <pvc name>

<pvc name>
Is the name of the PVC.
Example output:

ocs-deviceset-xxx-xxx-xxx-xxx-block-dmcrypt (253:0)

iii. Remove the mapped device.

$ cryptsetup luksClose --debug --verbose ocs-deviceset-xxx-xxx-xxx-xxx-block-dmcrypt

**IMPORTANT**

If the above command gets stuck due to insufficient privileges, run the following commands:

- Press **CTRL+Z** to exit the above command.
- Find the PID of the process which was stuck.

$ ps -ef | grep crypt

- Terminate the process using the **kill** command.

$ kill -9 <PID>

<PID>
Is the process ID.

- Verify that the device name is removed.

$ dmsetup ls

7. Delete the **ocs-osd-removal** job.

$ oc delete -n openshift-storage job ocs-osd-removal-job

Example output:

job.batch "ocs-osd-removal-job" deleted

**NOTE**

When using an external key management system (KMS) with data encryption, the old OSD encryption key can be removed from the Vault server as it is now an orphan key.
**Verification steps**

1. Verify that there is a new OSD running.

   ```bash
   $ oc get -n openshift-storage pods -l app=rook-ceph-osd
   ```

   Example output:

   ```
   rook-ceph-osd-0-5f7f4747d4-snshw 1/1 Running 0 4m47s
   rook-ceph-osd-1-85d99fb95f-2svc7 1/1 Running 0 1d20h
   rook-ceph-osd-2-6c66cdb977-jp542 1/1 Running 0 1d20h
   ```

2. Verify that there is a new PVC created which is in **Bound** state.

   ```bash
   $ oc get -n openshift-storage pvc
   ```

3. Optional: If cluster-wide encryption is enabled on the cluster, verify that the new OSD devices are encrypted.
   
   a. Identify the node(s) where the new OSD pod(s) are running.

      ```bash
      $ oc get -o=custom-columns=NODE:.spec.nodeName pod/<OSD pod name>
      ```

   b. For each of the previously identified nodes, do the following:

      i. Create a debug pod and open a chroot environment for the selected host(s).

         ```bash
         $ oc debug node/<node name>
         ```

      ii. Check for the **crypt** keyword beside the **ocs-deviceset** name(s).

         ```bash
         $ lsblk
         ```

4. Log in to OpenShift Web Console and view the storage dashboard.
CHAPTER 4. DYNAMICALLY PROVISIONED OPENSSHIFT DATA FOUNDATION DEPLOYED ON MICROSOFT AZURE

4.1. REPLACING OPERATIONAL OR FAILED STORAGE DEVICES ON AZURE INSTALLER-PROVISIONED INFRASTRUCTURE

When you need to replace a device in a dynamically created storage cluster on an Azure installer-provisioned infrastructure, you must replace the storage node. For information about how to replace nodes, see:

- Replacing operational nodes on Azure installer-provisioned infrastructure.
- Replacing failed nodes on Azure installer-provisioned infrastructures.
CHAPTER 5. OPENSHIFT DATA FOUNDATION DEPLOYED USING LOCAL STORAGE DEVICES

5.1. REPLACING OPERATIONAL OR FAILED STORAGE DEVICES ON CLUSTERS BACKED BY LOCAL STORAGE DEVICES

You can replace an object storage device (OSD) in OpenShift Data Foundation deployed using local storage devices on the following infrastructures:

- Bare metal
- VMware
- Red Hat Virtualization

**NOTE**

One or more underlying storage devices may need to be replaced.

**Prerequisites**

- Red Hat recommends that replacement devices are configured with similar infrastructure and resources to the device being replaced.
- Ensure that the data is resilient.
  
  - In the OpenShift Web Console, click **Storage → Data Foundation**.
  
  - Click the **Storage Systems** tab, and then click **ocs-storagecluster-storagesystem**.
  
  - In the **Status card** of **Block and File** dashboard, under the **Overview** tab, verify that **Data Resiliency** has a green tick mark.

**Procedure**

1. Remove the underlying storage device from relevant worker node.

2. Verify that relevant OSD Pod has moved to CrashLoopBackOff state. Identify the OSD that needs to be replaced and the OpenShift Container Platform node that has the OSD scheduled on it.

   ```bash
   $ oc get -n openshift-storage pods -l app=rook-ceph-osd -o wide
   ```

   Example output:

   ```
   rook-ceph-osd-0-6d77d6c7c6-m8xj6 0/1 CrashLoopBackOff 0 24h 10.129.0.16
   compute-2 <none> <none>
   rook-ceph-osd-1-85d99fb95f-2svc7 1/1 Running 0 24h 10.128.2.24 compute-0 <none> <none>
   rook-ceph-osd-2-6c66cdb977-jp542 1/1 Running 0 24h 10.130.0.18 compute-1 <none> <none>
   ```
In this example, `rook-ceph-osd-0-6d77d6c7c6-m8xj6` needs to be replaced and `compute-2` is the OpenShift Container platform node on which the OSD is scheduled.

3. Scale down the OSD deployment for the OSD to be replaced.

   ```
   $ osd_id_to_remove=0
   $ oc scale -n openshift-storage deployment rook-ceph-osd-${osd_id_to_remove} --replicas=0
   ```

   where, `osd_id_to_remove` is the integer in the pod name immediately after the `rook-ceph-osd` prefix. In this example, the deployment name is `rook-ceph-osd-0`.

   Example output:

   ```
   deployment.extensions/rook-ceph-osd-0 scaled
   ```

4. Verify that the `rook-ceph-osd` pod is terminated.

   ```
   $ oc get -n openshift-storage pods -l ceph-osd-id=${osd_id_to_remove}
   ```

   Example output:

   ```
   No resources found in openshift-storage namespace.
   ```

   **IMPORTANT**

   If the `rook-ceph-osd` pod is in `terminating` state for more than a few minutes, use the `force` option to delete the pod.

   ```
   $ oc delete -n openshift-storage pod rook-ceph-osd-0-6d77d6c7c6-m8xj6 --grace-period=0 --force
   ```

   Example output:

   ```
   warning: Immediate deletion does not wait for confirmation that the running resource has been terminated. The resource may continue to run on the cluster indefinitely.
   pod "rook-ceph-osd-0-6d77d6c7c6-m8xj6" force deleted
   ```

5. Remove the old OSD from the cluster so that you can add a new OSD.

   a. Delete any old `ocs-osd-removal` jobs.

      ```
      $ oc delete -n openshift-storage job ocs-osd-removal-job
      ```

      Example output:

      ```
      job.batch "ocs-osd-removal-job" deleted
      ```

   b. Navigate to the `openshift-storage` project.
$ oc project openshift-storage

c. Remove the old OSD from the cluster.

$ oc process -n openshift-storage ocs-osd-removal -p
   FAILED_OSD_IDS=${osd_id_to_remove} FORCE_OSD_REMOVAL=false | oc create -n
    openshift-storage -f -

You can add comma separated OSD IDs in the command to remove more than one OSD. (For example, FAILED_OSD_IDS=0,1,2).

The FORCE_OSD_REMOVAL value must be changed to “true” in clusters that only have
three OSDs, or clusters with insufficient space to restore all three replicas of the data after
the OSD is removed.

WARNING

This step results in OSD being completely removed from the cluster.
Ensure that the correct value of osd_id_to_remove is provided.

6. Verify that the OSD is removed successfully.

   • Check the status of the ocs-osd-removal pod.
     A status of Completed confirms that the OSD removal job succeeded.

     $ oc get pod -l job-name=ocs-osd-removal-job -n openshift-storage

     IMPORTANT

     If ocs-osd-removal fails and the pod is not in the expected Completed
     state, check the pod logs for further debugging.

     For example:

     $ oc logs -l job-name=ocs-osd-removal-job -n openshift-storage --tail=-1

7. If encryption was enabled at the time of install, remove dm-crypt managed device-mapper
mapping from the OSD devices that are removed from the respective OpenShift Data
Foundation nodes.

   a. Get the Persistent Volume Claim (PVC) name(s) of the replaced OSD(s) from the logs of
      ocs-osd-removal-job pod.

      $ oc logs -l job-name=ocs-osd-removal-job -n openshift-storage --tail=-1 |
         grep -i 'pvc|deviceset'

      Example output:
For each of the previously identified nodes, do the following:

i. Create a **debug** pod and **chroot** to the host on the storage node.

   ```bash
   $ oc debug node/<node name>
  
   <node name>
   
   Is the name of the node.
   
   $ chroot /host
   ```

ii. Find the relevant device name based on the PVC names identified in the previous step.

   ```bash
   $ dmsetup ls | grep <pvc name>
   
   <pvc name>
   
   Is the name of the PVC.
   
   Example output:
   
   ocs-deviceset-xxx-xxx-xxx-xxx-block-dmcrypt (253:0)
   ```

iii. Remove the mapped device.

   ```bash
   $ cryptsetup luksClose --debug --verbose ocs-deviceset-xxx-xxx-xxx-xxx-block-dmcrypt
   ```

**IMPORTANT**

If the above command gets stuck due to insufficient privileges, run the following commands:

- Press **CTRL+Z** to exit the above command.
- Find the PID of the process which was stuck.

   ```bash
   $ ps -ef | grep crypt
   ```

- Terminate the process using the **kill** command.

   ```bash
   $ kill -9 <PID>
   
   <PID>
   
   Is the process ID.
   ```

- Verify that the device name is removed.

   ```bash
   $ dmsetup ls
   ```
8. Find the persistent volume (PV) that need to be deleted.

```bash
$ oc get pv -L kubernetes.io/hostname | grep localblock | grep Released
```

Example output:

```
local-pv-d6bf175b           1490Gi       RWO         Delete          Released            openshift-storage/ocs-deviceset-0-data-0-6c5pw      localblock      2d22h       compute-1
```

9. Delete the PV.

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

<pv-name>

Is the name of the PV.

10. Physically add a new device to the node.

11. Track the provisioning of PVs for the devices that match the `deviceInclusionSpec`. It can take a few minutes to provision the PVs.

```bash
$ oc -n openshift-local-storage describe localvolumeset localblock
```

Example output:

```
[...]
Status:
  Conditions:
  Last Transition Time:          2020-11-17T05:03:32Z
  Message:                       DiskMaker: Available, LocalProvisioner: Available
  Status:                        True
  Type:                          DaemonSetsAvailable
  Last Transition Time:          2020-11-17T05:03:34Z
  Message:                       Operator reconciled successfully.
  Status:                        True
  Type:                          Available
  Observed Generation:             1
  Total Provisioned Device Count: 4
Events:
  Type    Reason      Age          From                Message
  ----    ------      ----         ----                -------
  Normal  Discovered  2m30s (x4    localvolumeset-     node.example.com -
                NewDevice over 2m30s)  symlink-controller  found possible
                matching disk,
                waiting 1m to claim

  Normal  FoundMatch  89s (x4      localvolumeset-     node.example.com -
                ingDisk over 89s)    symlink-controller  symlinking matching
                disk
```

Once the PV is provisioned, a new OSD pod is automatically created for the PV.

12. Delete the `ocs-osd-removal` job(s).
$ oc delete -n openshift-storage job ocs-osd-removal-job

Example output:

job.batch "ocs-osd-removal-job" deleted

NOTE

When using an external key management system (KMS) with data encryption, the old OSD encryption key can be removed from the Vault server as it is now an orphan key.

Verification steps

1. Verify that there is a new OSD running.

   $ oc get -n openshift-storage pods -l app=rook-ceph-osd

   Example output:

   rook-ceph-osd-0-5f7f4747d4-snshw    1/1     Running     0          4m47s
   rook-ceph-osd-1-85d99fb95f-2svc7    1/1     Running     0          1d20h
   rook-ceph-osd-2-6c66c7bd977-jp542    1/1     Running     0          1d20h

   IMPORTANT

   If the new OSD does not show as Running after a few minutes, restart the rook-ceph-operator pod to force a reconciliation.

   $ oc delete pod -n openshift-storage -l app=rook-ceph-operator

   Example output:

   pod "rook-ceph-operator-6f74fb5bff-2d982" deleted

2. Verify that a new PVC is created.

   $ oc get -n openshift-storage pvc | grep localblock

   Example output:

   ocs-deviceset-0-0-c2mqb Bound local-pv-b481410 1490Gi RWO localblock 5m
   ocs-deviceset-1-0-959rp Bound local-pv-4147555e0 1490Gi RWO localblock 1d20h
   ocs-deviceset-2-0-79j94 Bound local-pv-3e8964d3 1490Gi RWO localblock 1d20h

3. Optional: If cluster-wide encryption is enabled on the cluster, verify that the new OSD devices are encrypted.

   a. Identify the node(s) where the new OSD pod(s) are running.
$ oc get -o=custom-columns=NODE:.spec.nodeName pod/<OSD pod name>

<OSD pod name>
Is the name of the OSD pod.
For example:

oc get -o=custom-columns=NODE:.spec.nodeName pod/rook-ceph-osd-0-544db49d7f-qrgqm

b. For each of the nodes identified in the previous step, do the following:

i. Create a debug pod and open a chroot environment for the selected host(s).

$ oc debug node/<node name>

<node name>
Is the name of the node.

$ chroot /host

ii. Check for the crypt keyword beside the ocs-deviceset name(s).

$ lsblk

4. Log in to OpenShift Web Console and check the OSD status on the storage dashboard.

NOTE
A full data recovery may take longer depending on the volume of data being recovered.

5.2. REPLACING OPERATIONAL OR FAILED STORAGE DEVICES ON IBM POWER

You can replace an object storage device (OSD) in OpenShift Data Foundation deployed using local storage devices on IBM Power.

NOTE
One or more underlying storage devices may need to be replaced.

Prerequisites

- Red Hat recommends that replacement devices are configured with similar infrastructure and resources to the device being replaced.

- Ensure that the data is resilient.
  - In the OpenShift Web Console, click Storage → Data Foundation.
  - Click the Storage Systems tab, and then click ocs-storagecluster-storagesystem.
- In the Status card of Block and File dashboard, under the Overview tab, verify that Data Resiliency has a green tick mark.

Procedure

1. Identify the OSD that needs to be replaced and the OpenShift Container Platform node that has the OSD scheduled on it.

   ```bash
   $ oc get -n openshift-storage pods -l app=rook-ceph-osd -o wide
   ```

   Example output:

   ```
   rook-ceph-osd-0-86bf8cdc8-4nb5t  0/1     crashLoopBackOff   0   24h   10.129.2.26
   worker-0         <none>       <none>
   rook-ceph-osd-1-7c99657c9f-jdzvz  1/1     Running   0          24h     10.128.2.46     worker-1
   <none>       <none>
   rook-ceph-osd-2-5f9f605b-2mnn9    1/1     Running   0          24h     10.131.0.33    worker-2
   <none>       <none>
   ```

   In this example, `rook-ceph-osd-0-86bf8cdc8-4nb5t` needs to be replaced and `worker-0` is the RHOCP node on which the OSD is scheduled.

   **NOTE**

   If the OSD to be replaced is healthy, the status of the pod will be Running.

2. Scale down the OSD deployment for the OSD to be replaced.

   ```bash
   $ osd_id_to_remove=0
   $ oc scale -n openshift-storage deployment rook-ceph-osd-0 -replicas=0
   ```

   Example output:

   ```
   deployment.extensions/rook-ceph-osd-0 scaled
   ```

3. Verify that the rook-ceph-osd pod is terminated.

   ```bash
   $ oc get -n openshift-storage pods -l ceph-osd-id=${osd_id_to_remove}
   ```

   Example output:

   ```
   No resources found in openshift-storage namespace.
   ```
IMPORTANT

If the rook-ceph-osd pod is in terminating state for more than a few minutes, use the force option to delete the pod.

```bash
$ oc delete -n openshift-storage pod rook-ceph-osd-0-86bf8cd8-4nb5t --
grace-period=0 --force
```

Example output:

```
warning: Immediate deletion does not wait for confirmation that the running
resource has been terminated. The resource may continue to run on the
cluster indefinitely.

pod “rook-ceph-osd-0-86bf8cd8-4nb5t” force deleted
```

4. Remove the old OSD from the cluster so that you can add a new OSD.

a. Identify the DeviceSet associated with the OSD to be replaced.

```bash
$ oc get -n openshift-storage -o yaml deployment rook-ceph-osd-$(osd_id_to_remove) |
grep ceph.rook.io/pvc
```

Example output:

```
ceph.rook.io/pvc: ocs-deviceset-localblock-0-data-0-64xjl
ceph.rook.io/pvc: ocs-deviceset-localblock-0-data-0-64xjl
```

In this example, the Persistent Volume Claim (PVC) name is `ocs-deviceset-localblock-0-data-0-64xjl`.

b. Identify the Persistent Volume (PV) associated with the PVC.

```bash
$ oc get -n openshift-storage pvc ocs-deviceset-<x>-<y>-<pvc-suffix>
```

where, `x`, `y`, and `pvc-suffix` are the values in the DeviceSet identified in an earlier step.

Example output:

```
NAME                      STATUS        VOLUME        CAPACITY   ACCESS MODES
STORAGECLASS   AGE
ocs-deviceset-localblock-0-data-0-64xjl Bound local-pv-8137c873 256Gi RWO
localblock     24h
```

In this example, the associated PV is `local-pv-8137c873`.

c. Identify the name of the device to be replaced.

```bash
$ oc get pv local-pv-<pv-suffix> -o yaml | grep path
```

where, `pv-suffix` is the value in the PV name identified in an earlier step.

Example output:
In this example, the device name is `vdc`.

d. Identify the `prepare-pod` associated with the OSD to be replaced.

   ```
   $ oc describe -n openshift-storage pvc ocs-deviceset-<x>-<y>-<pvc-suffix> | grep Used
   ```

   where, `x`, `y`, and `pvc-suffix` are the values in the DeviceSet identified in an earlier step.

   Example output:

   ```
   Used By:    rook-ceph-osd-prepare-ocs-deviceset-localblock-0-data-0-64knzkc
   ```

   In this example, the `prepare-pod` name is `rook-ceph-osd-prepare-ocs-deviceset-localblock-0-data-0-64knzkc`.

e. Delete any old `ocs-osd-removal` jobs.

   ```
   $ oc delete -n openshift-storage job ocs-osd-removal-job
   ```

   Example output:

   ```
   job.batch "ocs-osd-removal-job" deleted
   ```

f. Change to the `openshift-storage` project.

   ```
   $ oc project openshift-storage
   ```

g. Remove the old OSD from the cluster.

   ```
   $ oc process -n openshift-storage ocs-osd-removal -p FAILED_OSD_IDS=${osd_id_to_remove} FORCE_OSD_REMOVAL=false |oc create -n openshift-storage -f -
   ```

   You can add comma separated OSD IDs in the command to remove more than one OSD. (For example, FAILED_OSD_IDS=0,1,2).

   The FORCE_OSD_REMOVAL value must be changed to “true” in clusters that only have three OSDs, or clusters with insufficient space to restore all three replicas of the data after the OSD is removed.

   **WARNING**
   
   This step results in OSD being completely removed from the cluster. Ensure that the correct value of `osd_id_to_remove` is provided.

5. Verify that the OSD is removed successfully.
Check the status of the **ocs-osd-removal** pod. A status of **Completed** confirms that the OSD removal job succeeded.

```bash
$ oc get pod -l job-name=ocs-osd-removal-job -n openshift-storage
```

**IMPORTANT**

If **ocs-osd-removal** fails and the pod is not in the expected **Completed** state, check the pod logs for further debugging.

For example:

```bash
$ oc logs -l job-name=ocs-osd-removal-job -n openshift-storage --tail=-1
```

6. If encryption was enabled at the time of install, remove **dm-crypt** managed **device-mapper** mapping from the OSD devices that are removed from the respective OpenShift Data Foundation nodes.

   a. Get the PVC name(s) of the replaced OSD(s) from the logs of **ocs-osd-removal-job** pod.

      ```bash
      $ oc logs -l job-name=ocs-osd-removal-job -n openshift-storage --tail=-1 | egrep -i 'pvc|deviceset'
      ```

      Example output:

      ```
      2021-05-12 14:31:34.666000 I | cephosd: removing the OSD PVC "ocs-deviceset-xxx-xxx-xxx-xxx"
      ```

   b. For each of the previously identified nodes, do the following:

      i. Create a **debug** pod and **chroot** to the host on the storage node.

      ```bash
      $ oc debug node/<node name>
      <node name>
      
      Is the name of the node.
      
      $ chroot /host
      ```

      ii. Find the relevant device name based on the PVC names identified in the previous step.

      ```bash
      $ dmsetup ls| grep <pvc name>
      <pvc name>
      
      Is the name of the PVC.
      Example output:
      
      ```
      ocs-deviceset-xxx-xxx-xxx-xxx-block-dmcrypt (253:0)
      ```

      iii. Remove the mapped device.
$ cryptsetup luksClose --debug --verbose ocs-deviceset-xxx-xxx-xxx-xxx-block-dmcrypt

**IMPORTANT**

If the above command gets stuck due to insufficient privileges, run the following commands:

- Press **CTRL+Z** to exit the above command.
- Find the PID of the process which was stuck.
  
  ```
  $ ps -ef | grep crypt
  ```
- Terminate the process using the **kill** command.
  
  ```
  $ kill -9 <PID>
  ```

  `<PID>`

  Is the process ID.
- Verify that the device name is removed.

  ```
  $ dmsetup ls
  ```

7. Find the PV that need to be deleted.

```
$ oc get pv -L kubernetes.io/hostname | grep localblock | grep Released
```

Example output:

```
local-pv-d6bf175b 1490Gi RWO Delete Released openshift-storage/ocs-deviceset-0-data-0-6c5pw localblock 2d22h compute-1
```

8. Delete the PV.

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

`<pv-name>`

Is the name of the PV.

9. Replace the old device and use the new device to create a new OpenShift Container Platform PV.

a. Log in to the OpenShift Container Platform node with the device to be replaced. In this example, the OpenShift Container Platform node is **worker-0**.

```
$ oc debug node/worker-0
```

Example output:

```
Starting pod/worker-0-debug ...
```
To use host binaries, run `chroot /host`  
Pod IP: 192.168.88.21  
If you don’t see a command prompt, try pressing enter.  
```
# chroot /host
```

b. Record the `/dev/disk` that is to be replaced using the device name, `vdc`, identified earlier.
```
# ls -alh /mnt/local-storage/localblock
```

Example output:

```
total 0  
drwxr-xr-x. 2 root root 17 Nov  18 15:23 .  
drwxr-xr-x. 3 root root 24 Nov  18 15:23 ..  
lrwxrwxrwx. 1 root root  8 Nov  18 15:23 vdc -> /dev/vdc
```

c. Find the name of the `LocalVolume` CR, and remove or comment out the device `/dev/disk` that is to be replaced.
```
$ oc get -n openshift-local-storage localvolume
```

Example output:

```
NAME     AGE
localblock 25h
```
```
# oc edit -n openshift-local-storage localvolume localblock
```

Example output:

```
[...]
storageClassDevices:
- devicePaths:
  # - /dev/vdc
    storageClassName: localblock
    volumeMode: Block
[...]
```

Make sure to save the changes after editing the CR.

10. Log in to the OpenShift Container Platform node with the device to be replaced and remove the old `symlink`.
```
$ oc debug node/worker-0
```

Example output:

```
Starting pod/worker-0-debug ...  
To use host binaries, run `chroot /host`  
Pod IP: 192.168.88.21  
If you don’t see a command prompt, try pressing enter.  
# chroot /host
```
a. Identify the old symlink for the device name to be replaced. In this example, the device name is `vdc`.

```
# ls -alh /mnt/local-storage/localblock
```

Example output:

```
total 0
drwxr-xr-x. 2 root root 17 Nov 18 15:23 .
drwxr-xr-x. 3 root root 24 Nov 18 15:23 ..
lnwxrwxrwx. 1 root root 8 Nov 18 15:23 vdc -> /dev/vdc
```

b. Remove the symlink.

```
# rm /mnt/local-storage/localblock/vdc
```

c. Verify that the symlink is removed.

```
# ls -alh /mnt/local-storage/localblock
```

Example output:

```
total 0
drwxr-xr-x. 2 root root 6 Nov 18 17:11 .
drwxr-xr-x. 3 root root 24 Nov 18 15:23 ..
```

11. Replace the old device with the new device.

12. Log back into the correct OpenShift Container Platform node and identify the device name for the new drive. The device name must change unless you are resetting the same device.

```
# lsblk
```

Example output:

```
NAME                         MAJ:MIN RM   SIZE RO TYPE MOUNTPOINT
vda                          252:0    0   40G  0 disk
 |-vda1                       252:1    0    4M  0 part
 |-vda2                       252:2    0  384M  0 part /boot
 `-vda4                       252:4    0 39.6G  0 part
    `-coreos-luks-root-nocrypt 253:0    0 39.6G  0 dm /sysroot
vdb                          252:16   0  512B  1 disk
vdd                          252:32   0 256G  0 disk
```

In this example, the new device name is `vdd`.

13. After the new `/dev/disk` is available, you can add a new disk entry to the LocalVolume CR.

a. Edit the LocalVolume CR and add the new `/dev/disk`.

In this example, the new device is `/dev/vdd`.

```
# oc edit -n openshift-local-storage localvolume localblock
```
Example output:

```yaml
[...]
  storageClassDevices:
  - devicePaths:
    # - /dev/vdc
    - /dev/vdd
    storageClassName: localblock
    volumeMode: Block
[...]
```

Make sure to save the changes after editing the CR.

14. Verify that there is a new PV in Available state and of the correct size.

```bash
$ oc get pv | grep 256Gi
```

Example output:

```
local-pv-1e31f771 256Gi RWO Delete Bound openshift-storage/ocs-deviceset-localblock-2-data-0-6xhkf localblock 24h
local-pv-ec7f2b80 256Gi RWO Delete Bound openshift-storage/ocs-deviceset-localblock-1-data-0-hr2fx localblock 24h
local-pv-8137c873 256Gi RWO Delete Available localblock 32m
```

15. Create a new OSD for the new device.

Deploy the new OSD. You need to restart the `rook-ceph-operator` to force operator reconciliation.

a. Identify the name of the `rook-ceph-operator`.

```bash
$ oc get -n openshift-storage pod -l app=rook-ceph-operator
```

Example output:

```
NAME                              READY STATUS    RESTARTS AGE
rook-ceph-operator-85f6494db4-sg62v 1/1     Running 0 1d20h
```

b. Delete the `rook-ceph-operator`.

```bash
$ oc delete -n openshift-storage pod rook-ceph-operator-85f6494db4-sg62v
```

Example output:

```
pod "rook-ceph-operator-85f6494db4-sg62v" deleted
```

In this example, the `rook-ceph-operator` pod name is `rook-ceph-operator-85f6494db4-sg62v`.

c. Verify that the `rook-ceph-operator` pod is restarted.

```bash
$ oc get -n openshift-storage pod -l app=rook-ceph-operator
```
Example output:

<table>
<thead>
<tr>
<th>NAME</th>
<th>READY</th>
<th>STATUS</th>
<th>RESTARTS</th>
<th>AGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>rook-ceph-operator-85f6494db4-wx9xx</td>
<td>1/1</td>
<td>Running</td>
<td>0</td>
<td>50s</td>
</tr>
</tbody>
</table>

Creation of the new OSD may take several minutes after the operator restarts.

16. Delete the **ocs-osd-removal** job(s).

```bash
$ oc delete -n openshift-storage job ocs-osd-removal-job
```

Example output:

```
job.batch "ocs-osd-removal-job" deleted
```

**NOTE**

When using an external key management system (KMS) with data encryption, the old OSD encryption key can be removed from the Vault server as it is now an orphan key.

**Verification steps**

1. Verify that there is a new OSD running.

```bash
$ oc get -n openshift-storage pods -l app=rook-ceph-osd
```

Example output:

```
rook-ceph-osd-0-76d8fb97f9-mn8qz   1/1     Running   0          23m
rook-ceph-osd-1-7c99657cfb-jdzvz   1/1     Running   1          25h
rook-ceph-osd-2-5f9f6dfb5b-2mnw9   1/1     Running   0          25h
```

2. Verify that a new PVC is created.

```bash
$ oc get -n openshift-storage pvc | grep localblock
```

Example output:

```
ochs-deviceset-localblock-0-data-0-q4q6b-Bound local-pv-8137c873       256Gi     RWO
localblock         10m

ocs-deviceset-localblock-1-data-0-hr2fx-Bound local-pv-ec7f2b80       256Gi     RWO
localblock         1d20h

ocs-deviceset-localblock-2-data-0-6xhf-Bound local-pv-1e31f771       256Gi     RWO
localblock         1d20h
```

3. Optional: If cluster-wide encryption is enabled on the cluster, verify that the new OSD devices are encrypted.

   a. Identify the node(s) where the new OSD pod(s) are running.

```bash
$ oc get -o=custom-columns=NODE:.spec.nodeName pod/<OSD pod name>
```
For each of the previously identified nodes, do the following:

i. Create a debug pod and open a chroot environment for the selected host(s).

```bash
$ oc debug node/<node name>
```

$ chroot /host

ii. Check for the `crypt` keyword beside the `ocs-deviceset` name(s).

```bash
$ lsblk
```

4. Log in to OpenShift Web Console and check the status card in the Openshift Data Foundation dashboard under Storage section.

**NOTE**

A full data recovery may take longer depending on the volume of data being recovered.

### 5.3. REPLACING OPERATIONAL OR FAILED STORAGE DEVICES ON IBM Z OR LINUXONE INFRASTRUCTURE

You can replace operational or failed storage devices on IBM Z or LinuxONE infrastructure with new Small Computer System Interface (SCSI) disks.

IBM Z or LinuxONE supports SCSI FCP disk logical units (SCSI disks) as persistent storage devices from external disk storage. You can identify a SCSI disk using its FCP Device number, two target worldwide port names (WWPN1 and WWPN2), and the logical unit number (LUN). For more information, see https://www.ibm.com/support/knowledgecenter/SSB27U_6.4.0/com.ibm.zvm.v640.hcpa5/scsiover.html

**Prerequisites**

- Ensure that the data is resilient.
  - In the OpenShift Web Console, click Storage → Data Foundation.
  - Click the Storage Systems tab, and then click `ocs-storagecluster-storagesystem`.
  - In the Status card of Block and File dashboard, under the Overview tab, verify that Data Resiliency has a green tick mark.
Procedure

1. List all the disks.

   $ lszdev

   Example output:

<table>
<thead>
<tr>
<th>TYPE</th>
<th>ID</th>
<th>ON</th>
<th>PERS</th>
<th>NAMES</th>
</tr>
</thead>
<tbody>
<tr>
<td>zfcp-host</td>
<td>0.0.8204</td>
<td>yes</td>
<td>yes</td>
<td></td>
</tr>
<tr>
<td>zfcp-lun</td>
<td>0.0.8204:0x102107630b1b5060:0x4001402900000000 yes</td>
<td>no</td>
<td>sda sg0</td>
<td></td>
</tr>
<tr>
<td>zfcp-lun</td>
<td>0.0.8204:0x500407630c0b50a4:0x3002b30000000000 yes</td>
<td>yes</td>
<td>sdb sg1</td>
<td></td>
</tr>
<tr>
<td>qeth</td>
<td>0.0.bdd0:0.0.bdd1:0.0.bdd2</td>
<td>yes</td>
<td>no</td>
<td>encbdo</td>
</tr>
<tr>
<td>generic-ccw</td>
<td>0.0.0009</td>
<td>yes</td>
<td>no</td>
<td></td>
</tr>
</tbody>
</table>

   A SCSI disk is represented as a `zfcp-lun` with the structure `<device-id>::<wwpn>::<lun-id>` in the ID section. The first disk is used for the operating system. If one storage device fails, you can replace it with a new disk.

2. Remove the disk.

   Run the following command on the disk, replacing `scsi-id` with the SCSI disk identifier of the disk to be replaced:

   $ chzdev -d scsi-id

   For example, the following command removes one disk with the device ID `0.0.8204`, the WWPN `0x500507630a0b50a4`, and the LUN `0x4002403000000000`:

   $ chzdev -d 0.0.8204:0x500407630c0b50a4:0x3002b030000000000

3. Append a new SCSI disk.

   $ chzdev -e 0.0.8204:0x500507630b1b50a4:0x4001302a00000000

   **NOTE**

   The device ID for the new disk must be the same as the disk to be replaced. The new disk is identified with its WWPN and LUN ID.

4. List all the FCP devices to verify the new disk is configured.

   $ lszdev zfcp-lun

   Example output:

<table>
<thead>
<tr>
<th>TYPE</th>
<th>ID</th>
<th>ON</th>
<th>PERS</th>
<th>NAMES</th>
</tr>
</thead>
<tbody>
<tr>
<td>zfcp-lun</td>
<td>0.0.8204:0x102107630b1b5060:0x4001402900000000 yes</td>
<td>no</td>
<td>sda sg0</td>
<td></td>
</tr>
<tr>
<td>zfcp-lun</td>
<td>0.0.8204:0x500507630b1b50a4:0x4001302a00000000 yes</td>
<td>yes</td>
<td>sdb sg1</td>
<td></td>
</tr>
</tbody>
</table>