Red Hat Enterprise Linux 9

Configuring device mapper multipath

Configuring and managing the Device Mapper Multipath feature

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Abstract

With Device mapper multipathing (DM Multipath), you can configure multiple I/O paths between server nodes and storage arrays into a single device. These I/O paths are physical Storage Area Network (SAN) connections that can include separate cables, switches, and controllers. Multipathing aggregates the I/O paths and creates a new device that consists of the aggregated paths.

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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. OVERVIEW OF DEVICE MAPPER MULTIPATHING

DM Multipath provides:

Redundancy

DM Multipath can provide failover in an active/passive configuration. In an active/passive configuration, only a subset of the paths is used at any time for I/O. If any element of an I/O path such as the cable, switch, or controller fails, DM Multipath switches to an alternate path.

NOTE

The number of paths is dependent on the setup. Usually, DM Multipath setups have 2, 4, or 8 paths to the storage, but this is a common setup and other numbers are possible for the paths.

Improved Performance

DM Multipath can be configured in an active/active mode, where I/O is spread over the paths in a round-robin fashion. In some configurations, DM Multipath can detect loading on the I/O paths and dynamically rebalance the load.

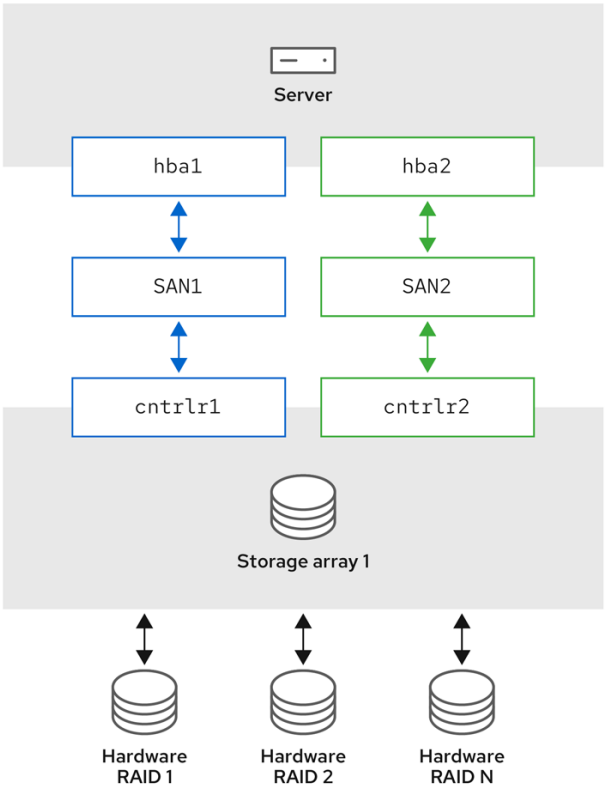
1.1. ACTIVE/PASSIVE MULTIPATH CONFIGURATION WITH ONE RAID DEVICE

In this configuration, there are two Host Bus Adapters (HBAs) on the server, two SAN switches, and two RAID controllers. Following are the possible failure in this configuration:

- HBA failure
- Fibre Channel cable failure
- SAN switch failure
- Array controller port failure

With DM Multipath configured, a failure at any of these points causes DM Multipath to switch to the alternate I/O path. The following image describes the configuration with two I/O paths from the server to a RAID device. Here, there is one I/O path that goes through **hba1**, **SAN1**, and **cntrlr1** and a second I/O path that goes through **hba2**, **SAN2**, and **cntrlr2**.

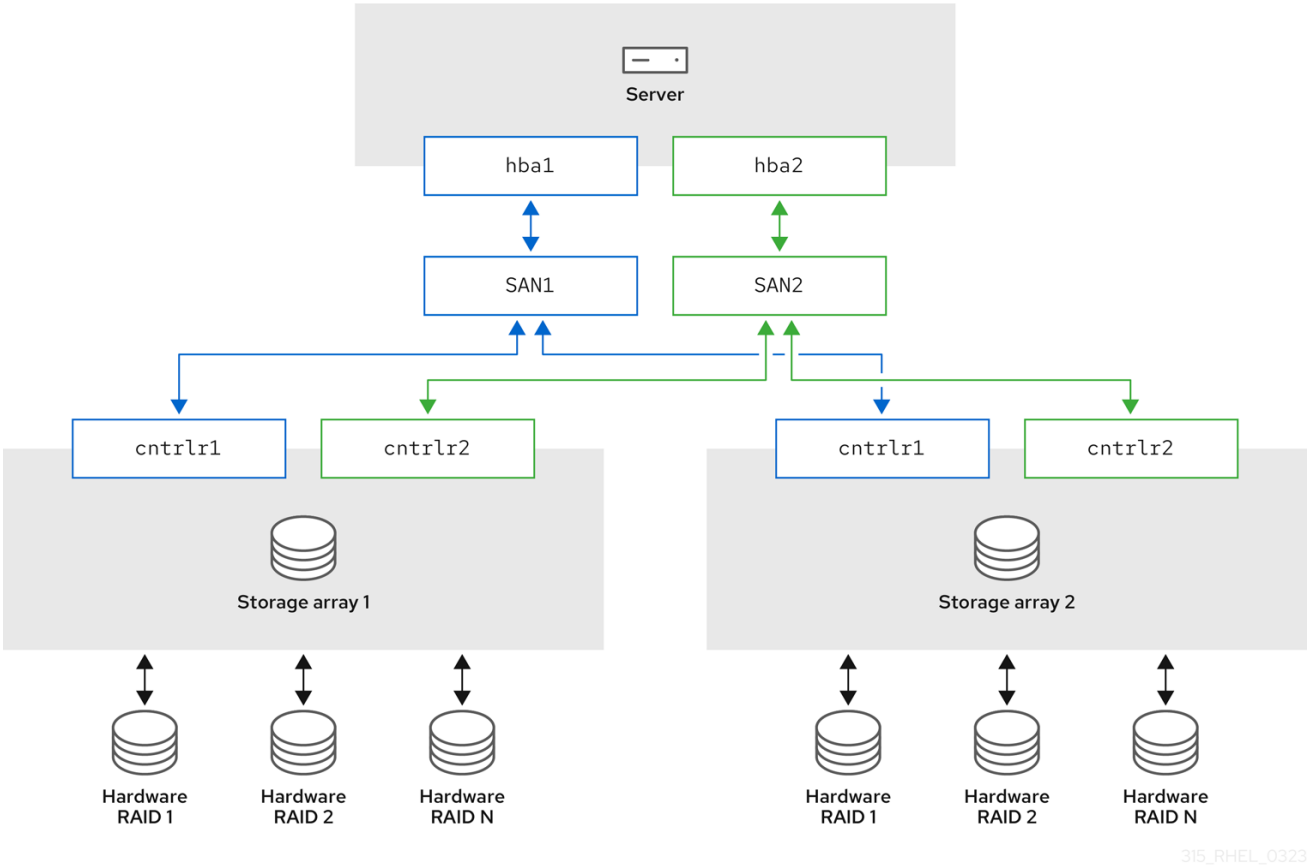
Figure 1.1. Active/Passive multipath configuration with one RAID device



1.2. ACTIVE/PASSIVE MULTIPATH CONFIGURATION WITH TWO RAID DEVICES

In this configuration, there are two HBAs on the server, two SAN switches, and two RAID devices with two RAID controllers each. With DM Multipath configured, a failure at any of the points of the I/O path to either of the RAID devices causes DM Multipath to switch to the alternate I/O path for that device. The following image describes the configuration with two I/O paths to each RAID device. Here, there are two I/O paths to each RAID device.

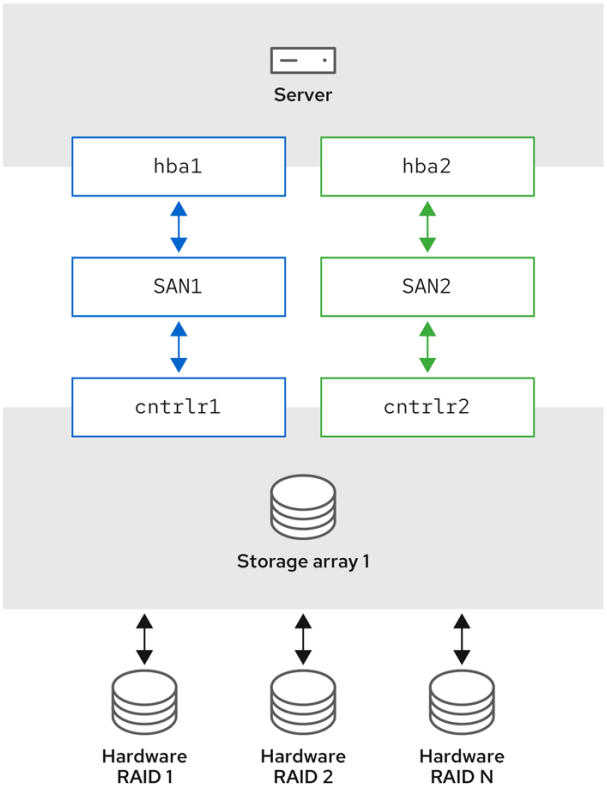
Figure 1.2. Active/Passive multipath configuration with two RAID device



1.3. ACTIVE/ACTIVE MULTIPATH CONFIGURATION WITH ONE RAID DEVICE

In this configuration, there are two HBAs on the server, two SAN switches, and two RAID controllers. The following image describes the configuration with two I/O paths from the server to a storage device. Here, I/O can be spread among these two paths.

Figure 1.3. Active/Active multipath configuration with one RAID device



1.4. DM MULTIPATH COMPONENTS

The following table describes the DM Multipath components.

Table 1.1. Components of DM Multipath

Component	Description
dm_multipath kernel module	Reroutes I/O and supports failover for paths and path groups.
mpathconf utility	Configures and enables device mapper multipathing.
multipath command	Lists and configures the multipath devices. It is also executed by **udev** whenever a block device is added, to determine if the device should be part of a multipath device or not.
multipathd daemon	Automatically creates and removes multipath devices and monitors paths; as paths fail and come back, it may update the multipath device. Allows interactive changes to multipath devices. Reload the service if there are any changes to the **/etc/multipath.conf** file.

kpartx command	Creates device mapper devices for the partitions on a device. This command is automatically executed by **udev** when multipath devices are created to create partition devices on top of them. The **kpartx** command is provided in its own package, but the **device-mapper-multipath** package depends on it.
mpathpersist	Sets up **SCSI-3** persistent reservations on multipath devices. This command works similarly to the way **sg_persist** works for SCSI devices that are not multipathed, but it handles setting persistent reservations on all paths of a multipath device. It coordinates with **multipathd** to ensure that the reservations are set up correctly on paths that are added later. To use this functionality, the **reservation_key** attribute must be defined in the **/etc/multipath.conf** file. Otherwise the **multipathd** daemon will not check for persistent reservations for newly discovered paths or reinstated paths.

1.5. THE MULTIPATH COMMAND

The **multipath** command is used to detect and combine multiple paths to devices. It provides a variety of options you can use to administer your multipathed devices.

The following table describes some options of the **multipath** command that you may find useful.

Table 1.2. Useful multipath command options

Option	Description
-l	Display the current multipath topology gathered from **sysfs** and the device mapper.
-ll	Display the current multipath topology gathered from **sysfs**, the device mapper, and all other available components on the system.
-f *device*	Remove the named multipath device.
-F	Remove all unused multipath devices.
-w *device*	Remove the **wwid** of the specified device from the **wwids** file.
-W	Reset the **wwids** file to include only the current multipath devices.
-r	Force reload of the multipath device.

1.6. DISPLAYING MULTIPATH TOPOLOGY

To effectively monitor paths, troubleshoot multipath issues, or check whether the multipath configurations are set correctly, you can display the multipath topology.

Procedure

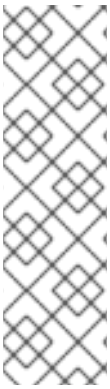
1. Display the multipath device topology:

```
# multipath -ll
mpatha (3600d0230000000000e13954ed5f89300) dm-4 WINSYS,SF2372
size=233G features='1 queue_if_no_path' hwhandler='0' wp=rw
`-+- policy='service-time 0' prio=1 status=active
  `- 6:0:0:0 sdf 8:80 active ready running
```

The output can be split into three parts. Each part displays information for the following group:

- Multipath device information:
  - **mpatha (3600d0230000000000e13954ed5f89300)**: alias (wwid if it's different from the alias)
  - **dm-4**: dm device name
  - **WINSYS,SF2372**: vendor, product
  - **size=233G**: size
  - **features='1 queue_if_no_path'**: features
  - **hwhandler='0'**: hardware handler
  - **wp=rw**: write permissions
- Path group information:
  - **policy='service-time 0'**: scheduling policy
  - **prio=1**: path group priority
  - **status=active**: path group status
- Path information:
  - **6:0:0:0**: host:channel:id:lun
  - **sdf**: devnode
  - **8:80**: major:minor numbers
  - **active**: dm status
  - **ready**: path status
  - **running**: online status
    For more information about the dm, path and online status, see Path status.

Other multipath commands, which are used to list, create, or reload multipath devices, also display the device topology. However, some information might be unknown and shown as **undef** in the output. This is normal behavior. Use the **multipath -ll** command to view the correct state.



NOTE

In certain cases, such as creating a multipath device, the multipath topology displays a parameter, which represents if any action was taken. For example, the following command output shows the **create:** parameter to represent that a multipath device was created:

```
create: mpatha (3600d0230000000000e13954ed5f89300) undef WINSYS,SF2372
size=233G features='1 queue_if_no_path' hwhandler='0' wp=undef
`-+- policy='service-time 0' prio=1 status=undef
  `- 6:0:0:0 sdf 8:80 undef ready running
```

1.7. PATH STATUS

The path status is updated periodically by the **multipathd** daemon based on the polling interval defined in the **/etc/multipath.conf** file. In terms of the kernel, the **dm** status is similar to the path status. The **dm** state will retain its current status until the path checker has completed.

Path status

ready, ghost

The path is up and ready for I/O.

faulty, shaky

The path is down.

i/o pending

The checker is actively checking this path, and the state will be updated shortly.

i/o timeout

The checker did not return **success**/**failure** before the timeout period. This is treated the same as **faulty**.

removed

The path has been removed from the system, and will shortly be removed from the multipath device. This is treated the same as **faulty**.

wild

multipathd was unable to run the path checker, because of an internal error or configuration issue. This is treated the same as **faulty**, except multipath will skip many actions on the path.

unchecked

The path checker has not run on this path, either because it has just been discovered, it does not have an assigned path checker, or the path checker encountered an error. This is treated the same as **wild**.

delayed

The path checker returns that the path is up, but multipath is delaying the reinstatement of the path because the path has recently failed multiple times and multipath has been configured to delay paths in this case. This is treated the same as **faulty**.

Dm status

Active

Maps to the **ready** and **ghost** path status.

Failed

Maps to all other path status, except **i/o pending** that does not have an equivalent **dm** state.

Online status

Running

The device is enabled.

Offline

The device has been disabled.

1.8. ADDITIONAL RESOURCES

- **multipath(8)** and **multipathd(8)** man pages
- **/etc/multipath.conf** file

CHAPTER 2. MULTIPATH DEVICES

DM Multipath provides a way of organizing the I/O paths logically, by creating a single multipath device on top of the underlying devices. Without DM Multipath, system treats each path from a server node to a storage controller as a separate device, even when the I/O path connects the same server node to the same storage controller.

2.1. MULTIPATH DEVICE IDENTIFIERS

When new devices are under the control of DM Multipath, these devices are created in the **/dev/mapper/** and **/dev/** directory.

NOTE

Any devices of the form **/dev/dm-X** are for internal use only and should never be used by the administrator directly.

The following describes multipath device names:

- When the **user_friendly_names** configuration option is set to **no**, the name of the multipath device is set to World Wide Identifier (WWID). By default, the name of a multipath device is set to its WWID. The device name would be **/dev/mapper/WWID**. It is also created in the **/dev/** directory, named as **/dev/dm-X**.
- Alternately, you can set the **user_friendly_names** option to **yes** in the **/etc/multipath.conf** file. This sets the **alias** in the **multipath** section to a node-unique name of the form **mpathN**. The device name would be **/dev/mapper/mpathN** and **/dev/dm-X**. But the device name is not guaranteed to be the same on all nodes using the multipath device. Similarly, if you set the **alias** option in the **/etc/multipath.conf** file, the name is not automatically consistent across all nodes in the cluster.

NOTE

This should not cause any difficulties if you use LVM to create logical devices from the multipath device. To keep your multipath device names consistent in every node, Red Hat recommends disabling the **user_friendly_names** option.

For example, a node with two HBAs attached to a storage controller with two ports by means of a single unzoned FC switch sees four devices: **/dev/sda**, **/dev/sdb**, **/dev/sdc**, and **/dev/sdd**. DM Multipath creates a single device with a unique WWID that reroutes I/O to those four underlying devices according to the multipath configuration.

In addition to the **user_friendly_names** and **alias** options, a multipath device also has other attributes. You can modify these attributes for a specific multipath device by creating an entry for that device in the **multipaths** section of the **/etc/multipath.conf** file.

Additional resources

- **multipath(8)** and **multipath.conf(8)** man pages
- **/etc/multipath.conf** file
- DM Multipath components

2.2. MULTIPATH DEVICES IN LOGICAL VOLUMES

After creating multipath devices, you can use the multipath device names as you would use a physical device name when creating an Logical volume manager (LVM) physical volume. For example, if **/dev/mapper/mpatha** is the name of a multipath device, the **pvcreate /dev/mapper/mpatha** command marks **/dev/mapper/mpatha** as a physical volume.

You can use the resulting LVM physical device when you create an LVM volume group just as you would use any other LVM physical device.

To filter all the **sd** devices in the **/etc/lvm/lvm.conf** file, add the **filter = ["r/block/", "r/disk/", "r/sd./", "a/./"]** filter in the **devices** section of the file.

NOTE

If you attempt to create an LVM physical volume on a whole device on which you have configured partitions, the **pvcreate** command fails. The Anaconda and Kickstart installation programs create empty partition tables if you do not specify otherwise for every block device. If you want to use the whole device instead of creating a partition, remove the existing partitions from the device. You can remove existing partitions with the **kpartx -d** device command and the **fdisk** utility. If your system has block devices that are greater than 2Tb, use the **parted** utility to remove partitions.

When you create an LVM logical volume that uses **active/passive** multipath arrays as the underlying physical devices, you can optionally include filters in the **/etc/lvm/lvm.conf** file to exclude the disks that underline the multipath devices. This is because if the array automatically changes the active path to the passive path when it receives I/O, multipath will failover and failback whenever LVM scans the passive path, if these devices are not filtered.

The kernel changes the active/passive state by automatically detecting the correct hardware handler to use. For active/passive paths that require intervention to change their state, multipath automatically uses this hardware handler to do so as necessary. If the kernel does not automatically detect the correct hardware handler to use, you can configure which hardware handler to use in the multipath.conf file with the "hardware_handler" option. For **active/passive** arrays that require a command to make the passive path active, LVM prints a warning message when this occurs.

Depending on your configuration, LVM may print any of the following messages:

- LUN not ready:

```
end_request: I/O error, dev sdc, sector 0
sd 0:0:0:3: Device not ready: <6>: Current: sense key: Not Ready
    Add. Sense: Logical unit not ready, manual intervention required
```

- Read failed:

```
/dev/sde: read failed after 0 of 4096 at 0: Input/output error
```

The following are the reasons for the mentioned errors:

- Multipath is not set up on storage devices that are providing active/passive paths to a machine.
- Paths are accessed directly, instead of through the multipath device.

Additional resources

- **lvm.conf** man page
- DM Multipath components

CHAPTER 3. CONFIGURING DM MULTIPATH

You can set up DM Multipath with the **mpathconf** utility. This utility creates or edits the **/etc/multipath.conf** multipath configuration file based on the following scenarios:

- If the **/etc/multipath.conf** file already exists, the **mpathconf** utility will edit it.
- If the **/etc/multipath.conf** file does not exist, the **mpathconf** utility will create the **/etc/multipath.conf** file from scratch.

3.1. CHECKING FOR THE DEVICE-MAPPER-MULTIPATH PACKAGE

Before setting up DM Multipath on your system, ensure that your system is up-to-date and includes the **device-mapper-multipath** package.

Procedure

1. Check if your system includes the **device-mapper-multipath** package:

```
# rpm -q device-mapper-multipath
device-mapper-multipath-current-package-version
```

   If your system does not include the package, it prints the following:

```
package device-mapper-multipath is not installed
```

2. If your system does not include the package, install it by running the following command:

```
# dnf install device-mapper-multipath
```

3.2. SETTING UP BASIC FAILOVER CONFIGURATION WITH DM MULTIPATH

You can set up DM Multipath for a basic failover configuration and edit the **/etc/multipath.conf** file before starting the multipathd daemon.

Prerequisites

- Administrative access.

Procedure

1. Enable and initialize the multipath configuration file:

```
# mpathconf --enable
```

2. Optional: Edit the **/etc/multipath.conf** file.
   Most default settings are already configured, including **path_grouping_policy** which is set to **failover**.

3. Optional: The default naming format of multipath devices is set to **/dev/mapper/mpathn** format. If you prefer a different naming format:

a. Configure DM Multipath to use the multipath device WWID as its name, instead of the mpath_n_ user-friendly naming scheme:

```
# mpathconf --enable --user_friendly_names n
```

b. Reload the configuration of the DM Multipath daemon:

```
# systemctl reload multipathd.service
```

4. Start the DM Multipath daemon:

```
# systemctl start multipathd.service
```

Verification

- Confirm that the DM Multipath daemon is running without issues:

```
# systemctl status multipathd.service
```

- Verify the naming format of multipath devices:

```
# ls /dev/mapper/
```

3.3. IGNORING LOCAL DISKS WHEN GENERATING MULTIPATH DEVICES

Some machines have local SCSI cards for their internal disks and DM Multipath is not recommended for these devices. If you set the **find_multipaths** configuration parameter to **yes**, you do not have to disable multipathing on these devices.

If you do not set the **find_multipaths** configuration parameter to **yes**, you can use the following procedure to modify the DM Multipath configuration file to ignore the local disks when configuring multipath.

Procedure

1. Identify the internal disk using any known parameters such as the device's model, path or vendor, and determine its WWID by using any one of the following options:

- Display existing multipath devices:

```
# multipath -v2 -l

mpatha (WDC_WD800JD-75MSA3_WD-WMAM9FU71040) dm-2 ATA,WDC WD800JD-
75MS
size=33 GB features="0" hwhandler="0" wp=rw
`-+- policy='round-robin 0' prio=0 status=active
  |- 0:0:0:0 sda 8:0 active undef running
```

- Display additional multipath devices that DM Multipath could create:

```
# multipath -v2 -d
```

```
: mpatha (WDC_WD800JD-75MSA3_WD-WMAM9FU71040) dm-2 ATA,WDC
WD800JD-75MS
size=33 GB features="0" hwhandler="0" wp=undef
`-+- policy='round-robin 0' prio=1 status=undef
  |- 0:0:0:0 sda 8:0  undef ready running
```

- Display device information:

```
# multipathd show paths raw format "%d %w" | grep sda
sda WDC_WD800JD-75MSA3_WD-WMAM9FU71040
```

In this example, **/dev/sda** is the internal disk and its WWID is **WDC_WD800JD-75MSA3_WD-WMAM9FU71040**.

2. Edit the **blacklist** section of the **/etc/multipath.conf** file to ignore this device, using its WWID attribute:

```
blacklist {
    wwid WDC_WD800JD-75MSA3_WD-WMAM9FU71040
}
```

WARNING

Although you could identify the device using its **devnode** parameter, such as **sda**, it would not be a safe procedure, because **/dev/sda** is not guaranteed to refer to the same device on reboot.

3. Check for any configuration errors in the **/etc/multipath.conf** file:

```
# multipath -t > /dev/null
```

To see the full report, do not discard the command output:

```
# multipath -t
```

4. If the disk is included in **initramfs** remake the initramfs. For more information see Configuring multipathing in initramfs.

5. Reload the **/etc/multipath.conf** file by reconfiguring the **multipathd** daemon:

```
# systemctl reload multipathd
```

NOTE

Multipath devices on top of local disks cannot be removed when in use. To ignore such device, stop all users of the device. For example, by unmounting any filesystem on top of it and deactivating any logical volumes using it. If this is not possible, you can reboot the system to remove the multipath device.

Verification

1. Verify that the internal disk is ignored and it is not displayed in the multipath output:
   - List the multipathed devices:

     ```
     # multipath -v2 -l
     ```

   - List the additional devices that DM Multipath could create:

     ```
     # multipath -v2 -d
     ```

Additional resources

- **multipath.conf(5)** man page

3.4. CONFIGURING ADDITIONAL STORAGE WITH DM MULTIPATH

By default, DM Multipath includes built-in configurations for the most common storage arrays, which support DM Multipath. If your storage array does not already have a configuration, you can add one by editting the **/etc/multipath.conf** file.

NOTE

Add additional storage devices during the initial configuration to align the setup with your anticipated needs. DM Multipath enables adding devices later for scalability or upgrades, but this approach may require adjusting configurations to ensuring compatibility.

Prerequisites

- Administrative access.

Procedure

1. View the default configuration value and supported devices:

   ```
   # multipathd show config
   ```

2. Edit the **/etc/multipath.conf** file to set up your multipath configuration.

   Example 3.1. DM Multipath Configuration for HP OPEN-V Storage Device

   ```
   # Set default configurations for all devices managed by DM Multipath

   defaults {
      # Enable user-friendly names for devices
      user_friendly_names yes
   }
   ```

```
devices {
    # Define configuration for HP OPEN-V storage
    device {
        vendor "HP"
        pproduct "OPEN-V"
        no_path_retry 18
    }
}
```

3. Save your changes and close the editor.
4. Update the multipath device list by scanning for new devices:

```
# multipath -r
```

Verification

- Confirm that the multipath devices are recognized correctly:

```
# multipath -ll
```

3.5. CONFIGURING MULTIPATHING IN INITRAMFS

Setting up multipathing in the **initramfs** file system is essential for seamless storage functionality, particularly in scenarios requiring redundancy and load balancing. This setup guarantees that multipath devices are available early in the boot process, which is crucial for maintaining the integrity of the storage setup and preventing potential issues.

Prerequisites

- Administrative access.
- Configured DM multipath on your system.

Procedure

1. Rebuild the **initramfs** file system with the multipath configuration files:

```
# dracut --force --add multipath
```

NOTE

When using multipath in the **initramfs** and modifying its configuration files, remember to rebuild the **initramfs** for the changes to tale effect. If your root device employs multipath, the **dracut** command will automatically include the multipath module in the **initramfs**.

2. Optional: If multipath in the **initramfs** is no longer necessary:
   a. Remove the multipath configuration file:

```
# rm /etc/dracut.conf.d/multipath.conf
```

b. Rebuild the **initramfs** with the added multipath configuration:

```
# dracut --force --omit multipath
```

Verification

- Check if multipath-related files and configurations are present:

```
# lsinitrd /path/to/initramfs.img -m | grep multipath
```

NOTE

While verefication steps provided can give you an indication of success, a final test boot-up is recommended to ensure that the configuration works as expected.

- After the reboot, confirm that the multipath devices are recognized correctly:

```
# multipath -ll
```

CHAPTER 4. ENABLING MULTIPATHING ON NVME DEVICES

You can multipath Non-volatile Memory Express™ (NVMe™) devices that are connected to your system over a fabric transport, such as Fibre Channel (FC). You can select between multiple multipathing solutions.

4.1. NATIVE NVME MULTIPATHING AND DM MULTIPATH

Non-volatile Memory Express™ (NVMe™) devices support a native multipathing functionality. When configuring multipathing on NVMe, you can select between the standard DM Multipath framework and the native NVMe multipathing.

Both DM Multipath and native NVMe multipathing support the Asymmetric Namespace Access (ANA) multipathing scheme of NVMe devices. ANA identifies optimized paths between the controller and the host, and improves performance.

When native NVMe multipathing is enabled, it applies globally to all NVMe devices. It can provide higher performance, but does not contain all of the functionality that DM Multipath provides. For example, native NVMe multipathing supports only the **numa** and **round-robin** path selection methods.

By default, NVMe multipathing is enabled in Red Hat Enterprise Linux 9 and is the recommended multipathing solution.

4.2. ENABLING DM MULTIPATH ON NVME DEVICES

The default kernel setting for the **nvme_core.multipath** option is set to **Y**, which means that the native Non-volatile Memory Express™ (NVMe™) multipathing is enabled. You can enable DM Multipath on connected NVMe devices by disabling native NVMe multipathing.

Prerequisites

- The NVMe devices are connected to your system. For more information, see Overview of NVMe over fabric devices.

Procedure

1. Check if the native NVMe multipathing is enabled:

   ```
   # cat /sys/module/nvme_core/parameters/multipath
   ```

   The command displays one of the following:

   N
   Native NVMe multipathing is disabled.

   Y
   Native NVMe multipathing is enabled.

2. If the native NVMe multipathing is enabled, disable it by using one of the following methods:

   - Using a kernel option:

     a. Add the **nvme_core.multipath=N** option to the command line:

```
# grubby --update-kernel=ALL --args="nvme_core.multipath=N"
```

b. On the 64-bit IBM Z architecture, update the boot menu:

```
# zipl
```

c. Reboot the system.

- Using a kernel module configuration file:

a. Create the **/etc/modprobe.d/nvme_core.conf** configuration file with the following content:

```
options nvme_core multipath=N
```

b. Back up the **initramfs** file:

```
# cp /boot/initramfs-$(uname -r).img /boot/initramfs-$(uname r).bak.$(date
+%m%d-%H%M%S).img
```

c. Rebuild the **initramfs**:

```
# cp /boot/initramfs-$(uname -r).img /boot/initramfs-$(uname -r).bak.$(date
+%m-%d-%H%M%S).img
# dracut --force --verbose
```

d. Reboot the system.

3. Enable DM Multipath:

```
# systemctl enable --now multipathd.service
```

4. Distribute I/O on all available paths. Add the following content in the **/etc/multipath.conf** file:

```
devices {
        device {
                vendor "NVME"
                product ".*"
                path_grouping_policy group_by_prio
        }
}
```

NOTE

The **/sys/class/nvme-subsystem/nvme-subsys0/iopolicy** configuration file has no effect on the I/O distribution when DM Multipath manages the NVMe devices.

5. Reload the **multipathd** service to apply the configuration changes:

```
# multipath -r
```

Verification

- Verify if the native NVMe multipathing is disabled:

```
# cat /sys/module/nvme_core/parameters/multipath
N
```

- Verify if DM multipath recognizes the nvme devices:

```
# multipath -l

eui.00007a8962ab241100a0980000d851c8 dm-6 NVME,NetApp E-Series
size=20G features='0' hwhandler='0' wp=rw
`-+- policy='service-time 0' prio=0 status=active
  |- 0:10:2:2 nvme0n2 259:3 active undef running
`-+- policy='service-time 0' prio=0 status=enabled
  |- 4:11:2:2 nvme4n2 259:28 active undef running
`-+- policy='service-time 0' prio=0 status=enabled
  |- 5:32778:2:2 nvme5n2 259:38 active undef running
`-+- policy='service-time 0' prio=0 status=enabled
  |- 6:32779:2:2 nvme6n2 259:44 active undef running
```

Additional resources

- Configuring kernel command-line parameters
- Configuring DM Multipath

4.3. ENABLING NATIVE NVME MULTIPATHING

If native NVMe multipathing is disabled, you can enable it using the following solution.

Prerequisites

- The NVMe devices are connected to your system. For more information, see Overview of NVMe over fabric devices.

Procedure

1. Check if native NVMe multipathing is enabled in the kernel:

```
# cat /sys/module/nvme_core/parameters/multipath
```

   The command displays one of the following:

   N
   Native NVMe multipathing is disabled.

   Y
   Native NVMe multipathing is enabled.

2. If native NVMe multipathing is disabled, enable it by using one of the following methods:

   - Using a kernel option:

     a. Remove the **nvme_core.multipath=N** option from the kernel command line:

```
# grubby --update-kernel=ALL --remove-args="nvme_core.multipath=N"
```

b. On the 64-bit IBM Z architecture, update the boot menu:

```
# zipl
```

c. Reboot the system.

- Using a kernel module configuration file:

a. Remove the **/etc/modprobe.d/nvme_core.conf** configuration file:

```
# rm /etc/modprobe.d/nvme_core.conf
```

b. Back up the **initramfs** file:

```
# cp /boot/initramfs-$(uname -r).img /boot/initramfs-$(uname -r).bak.$(date +%m-%d-%H%M%S).img
```

c. Rebuild the **initramfs**:

```
# dracut --force --verbose
```

d. Reboot the system.

3. Optional: On the running system, change the I/O policy on NVMe devices to distribute the I/O on all available paths:

```
# echo "round-robin" > /sys/class/nvme-subsystem/nvme-subsys0/iopolicy
```

4. Optional: Set the I/O policy persistently using **udev** rules. Create the **/etc/udev/rules.d/71-nvme-io-policy.rules** file with the following content:

```
ACTION=="add|change", SUBSYSTEM=="nvme-subsystem", ATTR{iopolicy}="round-robin"
```

Verification

1. Verify if your system recognizes the NVMe devices. The following example assumes you have a connected NVMe over fabrics storage subsystem with two NVMe namespaces:

```
# nvme list

Node             SN                   Model                                    Namespace Usage
Format           FW Rev
---------------- -------------------- ---------------------------------------- --------- --------------------------
- ---------------- --------
/dev/nvme0n1     a34c4f3a0d6f5cec     Linux                                    1         250.06  GB /
250.06  GB    512   B +  0 B   4.18.0-2
/dev/nvme0n2     a34c4f3a0d6f5cec     Linux                                    2         250.06  GB /
250.06  GB    512   B +  0 B   4.18.0-2
```

2. List all connected NVMe subsystems:

```
# nvme list-subsys

nvme-subsys0 - NQN=testnqn
\
 +- nvme0 fc traddr=nn-0x20000090fadd597a:pn-0x10000090fadd597a host_traddr=nn-
0x20000090fac7e1dd:pn-0x10000090fac7e1dd live
 +- nvme1 fc traddr=nn-0x20000090fadd5979:pn-0x10000090fadd5979 host_traddr=nn-
0x20000090fac7e1dd:pn-0x10000090fac7e1dd live
 +- nvme2 fc traddr=nn-0x20000090fadd5979:pn-0x10000090fadd5979 host_traddr=nn-
0x20000090fac7e1de:pn-0x10000090fac7e1de live
 +- nvme3 fc traddr=nn-0x20000090fadd597a:pn-0x10000090fadd597a host_traddr=nn-
0x20000090fac7e1de:pn-0x10000090fac7e1de live
```

Check the active transport type. For example, **nvme0 fc** indicates that the device is connected over the Fibre Channel transport, and **nvme tcp** indicates that the device is connected over TCP.

3. If you edited the kernel options, verify if native NVMe multipathing is enabled on the kernel command line:

```
# cat /proc/cmdline

BOOT_IMAGE=[...] nvme_core.multipath=Y
```

4. If you changed the I/O policy, verify if **round-robin** is the active I/O policy on NVMe devices:

```
# cat /sys/class/nvme-subsystem/nvme-subsys0/iopolicy

round-robin
```

Additional resources

- Configuring kernel command-line parameters

CHAPTER 5. MODIFYING THE DM MULTIPATH CONFIGURATION FILE

By default, DM Multipath provides configuration values for the most common uses of multipathing. In addition, DM Multipath includes support for the most common storage arrays that themselves support DM Multipath. You can override the default configuration values for DM Multipath by editing the **/etc/multipath.conf** configuration file. If necessary, you can also add an unsupported by default storage array to the configuration file.

For information about the default configuration values, including supported devices, run either of the following commands:

```
# multipathd show config
# multipath -t
```

NOTE

If you run multipath from the **initramfs** file system and you make any changes to the multipath configuration files, you must rebuild the **initramfs** file system for the changes to take effect

In the multipath configuration file, you need to specify only the sections that you need for your configuration, or that you need to change from the default values. If there are sections of the file that are not relevant to your environment or for which you do not need to override the default values, you can leave them commented out, as they are in the initial file.

The configuration file allows regular expression description syntax.

5.1. CONFIGURATION FILE OVERVIEW

The multipath configuration file is divided into the following sections:

blacklist

Listing of specific devices that will not be considered for multipath.

blacklist_exceptions

Listing of multipath devices that would otherwise be ignored according to the parameters of the **blacklist** section.

defaults

General default settings for DM Multipath.

multipaths

Settings for the characteristics of individual multipath devices. These values overwrite what is specified in the **overrides**, **devices**, and **defaults** sections of the configuration file.

devices

Settings for the individual storage controllers. These values overwrite what is specified in the **defaults** section of the configuration file. If you are using a storage array that is not supported by default, you may need to create a **devices** subsection for your array.

overrides

Settings that are applied to all devices. These values overwrite what is specified in the **devices** and **defaults** sections of the configuration file.

When the system determines the attributes of a multipath device, it checks the settings of the separate sections from the **multipath.conf** file in the following order:

1. **multipaths** section
2. **overrides** section
3. **devices** section
4. **defaults** section

5.2. CONFIGURATION FILE DEFAULTS

The **/etc/multipath.conf** configuration file contains a **defaults** section. This section includes the default configuration of Device Mapper (DM) Multipath. The default values might differ based on your initial device settings.

The following are the ways to view the default configurations:

- If you install your machine on a multipath device, the default multipath configuration applies automatically. The default configuration includes the following:
  - For a complete list of the default configuration values, execute either **multipath -t** or **multipathd show config** command.
  - For a list of configuration options with descriptions, see the **multipath.conf** man page.
- If you did not set up multipathing during installation, execute the **mpathconf --enable** command to get the default configuration.

The following table describes the attributes, set in the **defaults** section of the **multipath.conf** configuration file. Attributes specified in the **multipaths** section have higher priority over values in the **devices** section. Attributes specified in the **devices** section have higher priority over the default values. Use the **overrides** section to set attribute values for all device types, even if those device types have a builtin configuration entry in the **devices** section. The **overrides** section has no mandatory attributes. However, any attribute set in this section takes precedence over values in the **devices** or **defaults** sections.

Table 5.1. Multipath configuration defaults

Attribute	Description
polling_interval	Specifies the interval between two path checks in seconds. For properly functioning paths, the interval between checks gradually increases to **max_polling_interval**. The default value is **5**.
max_polling_interval	Specifies the maximum length of the interval between two path checks in seconds.
	The default value is **4 * polling_interval**.
find_multipaths	Defines the mode for setting up multipath devices. Available values include:

Attribute	Description
	no: If **find_multipaths** is set to **no**, **multipath** applies rules as with the **strict** value and the **multipathd** daemon applies rules as with the **greedy** value.
	yes: If there are at least two devices that are not on the **blacklist** with the same World Wide Identifier (WWID), or if multipath created a multipath device with a device WWID before (even if that multipath device is no longer present), then the device is treated as a multipath device path.
	greedy: Both **multipathd** and **multipath** treat every non-blacklisted device as a multipath device path.
	smart: Multipath automatically considers that every non-blacklisted device is a multipath device path. If a second path, with the same WWID does not appear within the time set for **find_multipaths_timeout**, multipath releases the device and enables it for use by the rest of the system. The **multipathd** daemon applies rules as with the **yes** value.
	strict: This value only treats a device as a multipath path, if you create a multipath device with the device WWID.
	The default value is **off**. The default **multipath.conf** file sets **find_multipaths** to **yes**.
find_multipaths_timeout	This represents the timeout in seconds, to wait for additional paths after detecting the first one, if **find_multipaths smart** is set. Possible values include:
	Positive value: If set with a positive value, the timeout applies for all non-blacklisted devices.
	Negative value: If set with a negative value, the timeout applies only to known devices that have an entry in the multipath hardware table, either in the built-in table, or in a **device** section. Other unknown devices use a timeout of only 1 second to avoid booting delays.
	0: The system applies the built-in default for this attribute.
	The default value for known hardware is **-10**. This means that known devices have a 10 second timeout. Unknown devices have a 1 second timeout. If the **find_multipaths** attribute has a value other than **smart**, this attribute has no effect.
uxsock_timeout	Set the timeout of **multipathd** interactive commands in milliseconds.

Attribute	Description
	For systems with a large number of devices, **multipathd** interactive commands might timeout and fail. If this happens, increase this timeout to resolve the issue.
	The default value is **4000**.
reassign_maps	Enable reassigning of device-mapper maps. With this option, the **multipathd** daemon remaps existing device-mapper maps to always point to the multipath device, not the underlying block devices. Possible values are **yes** and **no**. The default value is **no**.
verbosity	The default verbosity value is **2**. Higher values increase the verbosity level. Valid levels are between **0** and **4**.
path_selector	Specifies the default algorithm to use in determining what path to use for the next I/O operation. Possible values include:
	round-robin 0: Loop through every path in the path group, sending the same number of I/O requests, determined by **rr_min_io** or **rr_min_io_rq**, to each.
	queue-length 0: Send the next group of I/O requests down the path with the least number of outstanding I/O requests.
	service-time 0: Send the next group of I/O requests down the path with the shortest estimated service time. This is determined by dividing the total size of the outstanding I/O to each path by the relative throughput.
	The default value is **service-time 0**.
path_grouping_policy	Specifies the default path grouping policy to apply to unspecified multipaths. Possible values include:
	failover: 1 path per priority group.
	multibus: All valid paths in 1 priority group.
	group_by_serial: 1 priority group per detected serial number.
	group_by_prio: 1 priority group per path priority value. Priorities are determined by the **prio** attribute.
	group_by_node_name: 1 priority group per target node name. The **/sys/class/fc_transport/target*/node_name** directory includes target node names.

Attribute	Description
	The default value is **failover**.
uid_attrs	Set this option to activate merging **uevents** by WWID. This action might improve uevent processing efficiency. It is also an alternative method to configure the udev properties to use for determining unique path identifiers (WWIDs).
	The value of this option is a space separated list of records like **type:ATTR**, where **type** is matched against the beginning of the device node name, and **ATTR** is the name of the udev property to use for matching devices.
	If you configure this option and it matches the device node name of a device, it overrides any other configured methods for determining the WWID for this device.
	You can enable **uevent** merging by setting this value to **sd:ID_SERIAL dasd:ID_UID nvme:ID_WWN**.
	The default is **unset**.
prio	Specifies the default function to call to obtain a path priority value. For example, the ALUA bits in SPC-3 provide an exploitable **prio** value. Possible values include:
	const: Set a priority of 1 to all paths.
	emc: Generate the path priority for EMC arrays.
	sysfs: Generate the path priority from **sysfs**. This prioritizer accepts the optional **prio_arg** value **exclusive_pref_bit**. The **sysfs** value uses the **sysfs** attributes **access_state** and **preferred_path**.
	alua: Generate the path priority based on the SCSI-3 ALUA settings. If you specify **prio alua** and **prio_args exclusive_pref_bit** in your device configuration, multipath creates a path group that contains only the path with the **exclusive_pref_bit** set, and assigns that path group the highest priority. Refer to the **multipath.conf(5)** man page for more information about this type of cases.
	ontap: Generate the path priority for NetApp arrays.
	rdac: Generate the path priority for LSI/Engenio RDAC controller.
	hp_sw: Generate the path priority for Compaq/HP controller in active/standby mode.
	hds: Generate the path priority for Hitachi HDS Modular storage arrays.

Attribute	Description
	random: Generate a random priority between 1 and 10.
	weightedpath: Generate the path priority based on the regular expression and the provided priority as an argument. Requires a **prio_args** keyword.
	path_latency: Generate the path priority based on a latency algorithm. Requires a **prio_args** keyword.
	ana: Generate the path priority based on the NVMe ANA settings. This priority routine is hardware dependent.
	datacore: Generate the path priority for some DataCore storage arrays. Requires a **prio_args** keyword. This priority routine is hardware dependent.
	iet: Generate path priority for iSCSI targets based on IP their address. Requires a **prio_args** keyword. This priority routine is available only with iSCSI.
	The default value depends on the **detect_prio** setting. If **detect_prio** is set to **yes**, then the default priority algorithm is **sysfs**. The only exception is for NetAPP E-Series, where the default is **alua**. If **detect_prio** is set to **no**, the default priority algorithm is **const**.
prio_args	Arguments to pass to the **prio** function. This applies only to the following prioritizers:
	weighted: Needs a value of the form **<hbtl,devname,serial,wwn> <regex1> <prio1> <regex2> <prio2>**
	hbtl: The Regex value can be of SCSI H:B:T:L format. For example: **1:0:.:. , *:0:0:**.
	devname: The Regex value can be in device name format. For example: **sda**, **sd.e**.
	serial: The Regex value can be in serial number format. Look up **serial** through **sysfs**, or by running the command **multipathd show paths format "%z"**.
	wwn: The Regex value can be in the form **host_wwnn:host_wwpn:target_wwnn:target_wwpn**. These values can be looked up through **sysfs** or by running the command **multipathd show paths format %N:%R:%n:%r"**.

Attribute	Description
	path_latency: Requires a value in the form**io_num= <integer> base_num=<integer>**.
	io_num: The number of read IOs, continuously sent to the current path. This value helps calculate the average path latency. Valid values include **Integer**, **[2, 200]**.
	base_num: The base number value of logarithmic scale. This value helps to partition different priority ranks. Valid values include **Integer**, **[2, 10]**. The maximum average latency value is**100s** and the minimum average latency value is **1us**.
	alua: If the**exclusive_pref_bit** value is set, paths with the **preferred_path_bit** set always create their own path group.
	sysfs: If the**exclusive_pref_bit** value is set, paths with the **preferred_path_bit** set always create their own path group.
	datacore: Requires a value of the form**timeout=<milliseconds> preferredsds=<name>**.
	preferredsds: This value is mandatory and it represents the preferred SDS name.
	timeout: This value is optional. Set the timeout for the inquiry in milliseconds.
	iet: Requires a value of the form**preferredip=<ip_address>**.
	preferredip: This value is mandatory. This is the preferred IP address, in dotted decimal notation, for iSCSI targets.
	The default value is **unset**.
features	The default extra features of multipath devices, using the format: *"number_of_features_plus_arguments feature1 ..."*.
	Possible values for **features** include:
	queue_if_no_path: The same as setting**no_path_retry** to **queue**.
	pg_init_retries *n*: Retry path group initialization up to*n* times before failing. The number must be between 1 and 50.
	pg_init_delay_msecs *msecs*: Number of milliseconds before **pg_init** retry initiates. The number must be between 0 and 60000.

Attribute	Description
	queue_mode *mode*: Select the queueing mode per multipath device. The *mode* value options are **bio**, **rq** or **mq**. These correspond to bio-based, request-based, and block-multiqueue request-based (**blk-mq**), respectively.
	By default, the value is *unset*.
path_checker	Specifies the default method to determine the state of the paths. Possible values include:
	readsector0: Read the first sector of the device.
	tur: Issue a **TEST UNIT READY** command to the device.
	emc_clariion: Query the EMC Clariion specific EVPD page 0xC0 to determine the path.
	hp_sw: Check the path state for HP storage arrays with Active/Standby firmware.
	rdac: Check the path state for LSI/Engenio RDAC storage controller.
	directio: Read the first sector with direct I/O.
	cciss_tur: Check the path state for HP/COMPAQ Smart Array(CCISS) controllers. This is hardware dependent.
	none: Does not check the device. Falls back to use values retrieved from **sysfs**.
	The default value is **tur**.
alias_prefix	This attribute represents the **user_friendly_names** prefix.
	The default value is **mpath**.
failback	Manages path group failback. Possible values include:
	immediate: Specifies immediate failback to the highest priority path group that contains active paths.
	manual: Specifies that there is no immediate failback, but that failback can happen only with operator intervention.

Attribute	Description
	followover: Specifies that automatic failback can only be performed when the first path of a path group becomes active. This keeps a node from automatically failing back, when another node requested the failover.
	A numeric value greater than zero, specifies deferred failback, and is expressed in seconds.
	The default value is **manual**.
rr_min_io	Specifies the number of I/O requests to route to a path before switching to the next path in the current path group. This setting is only for systems running kernels older than 2.6.31. Newer systems should use **rr_min_io_rq**. The default value is **1000**.
rr_min_io_rq	Specifies the number of I/O requests to route to a path, before switching to the next path in the current path group. Uses a request-based device-mapper-multipath. This setting can be used on systems running current kernels. On systems running kernels older than 2.6.31, use **rr_min_io**. The default value is **1**.
no_path_retry	A numeric value for this attribute specifies the number of times that the path checker must fail for all paths in a multipath device, before disabling queuing.
	A value of **fail** indicates immediate failure, without queuing.
	A value of **queue** indicates that queuing should not stop until the path is fixed.
	The default value is **fail**.
user_friendly_names	Possible values include:
	yes: Specifies that the system can use the **/etc/multipath/bindings** file to assign a persistent and unique alias to the multipath, in the form of **mpath<n>**.
	no: The system uses the WWID as the alias for the multipath. Any device-specific alias you set in the **multipaths** section of the configuration file, overrides this name.
	The default value is **no**.
queue_without_daemon	If set to **no**, the **multipathd** daemon disables queuing for all devices, when it is shut down. The default value is **no**.

Attribute	Description
flush_on_last_del	If set to **yes**, the **multipathd** daemon disables queuing when the last path to a device is deleted. The default value is no.
max_fds	Sets the maximum number of open file descriptors that can be opened by multipath and the **multipathd** daemon. This is equivalent to the **ulimit -n** command. The default value is **max**, which sets this to the system limit from **/proc/sys/fs/nr_open**.
checker_timeout	The timeout to use for prioritizers and path checkers that issue SCSI commands with an explicit timeout, in seconds. The **sys/block/sd<x>/device/timeout** directory contains the default value.
fast_io_fail_tmo	The number of seconds the SCSI layer waits after a problem is detected on an FC remote port, before failing I/O to devices on that remote port. This value must be smaller than the value of **dev_loss_tmo**. Setting this to **off** disables the timeout. The default value is **5**. The **fast_io_fail_tmo** option overrides the values of the **recovery_tmo** and **replacement_timeout** options of the underlying path devices.
dev_loss_tmo	The number of seconds the SCSI layer waits after a problem is detected on an FC remote port, before removing it from the system. Setting this to infinity will set this to 2147483647 seconds, or 68 years. The OS determines the default value.
eh_deadline	Specifies the maximum number of seconds the SCSI layer spends performing error handling, when SCSI devices fail. After this timeout, the scsi layer performs a full HBA reset. Setting this is necessary in cases where the **rport** is never lost, so **fast_io_fail_tmo** and **dev_loss_tmo** never trigger, but **scsi** commands still hang. When the SCSI error handler performs the HBA reset, this affects all target paths on that HBA. The **eh_deadline** value should only be set in cases where all targets on the affected HBAs are multipathed.
	The default value is **unset**.
detect_prio	If this is set to **yes**, multipath detects if the device is a SCSI device that supports Asymmetric Logical Unit Access (ALUA), or a NVMe device that supports Asymmetric Namespace Access (ANA). If the device supports ALUA, multipath automatically assigns it the **alua** prioritizer. If the device supports ANA, multipath automatically assigns it the **ana** prioritizer.
	If **detect_prio** is set to **no**, or if the device does not support ALUA or ANA, the **prio** attribute sets the prioritizer.
	The default value is **yes**.
uid_attribute	Specifies the **udev** attribute to use for the device WWID.

Attribute	Description
	The default value is device dependent: **ID_SERIAL** for SCSI devices, **ID_UID** for DASD devices, and **ID_WWN** for NVMe devices.
force_sync	If set to **yes**, this parameter prevents path checkers from running in async mode. This means that only one checker runs at a time. This is useful in cases where many **multipathd** checkers run in parallel, and can cause significant CPU pressure.
	The default value is **no**.
strict_timing	If set to **yes**, the **multipathd** daemon starts a new path checker loop after exactly one second, so that each path check occurs at the exactly set seconds for **polling_interval**. On busy systems, path checks might take longer than one second. The missing ticks are accounted for in the next round. A warning prints if path checks take longer than the set seconds for **polling_interval**.
	The default value is **no**.
retrigger_tries, **retrigger_delay**	Use the **retrigger_tries** and **retrigger_delay** parameters in conjunction to make **multipathd** retrigger uevents. If **udev** fails to completely process the original **uevents**, this leaves multipath unable to use the device. The **retrigger_tries** parameter sets the number of times that multipath tries to retrigger a **uevent**, in case a device is not completely set up. The **retrigger_delay** parameter sets the number of seconds between retries. Both of these options accept numbers greater than or equal to **0**. Setting the **retrigger_tries** parameter to **0** disables retries. Setting the **retrigger_delay** parameter to **0** causes the **uevent** to be reissued on the next loop of the path checker.
	The default value of **retrigger_tries** is **3**. The default value of **retrigger_delay** is 10.
missing_uev_wait_timeout	This attribute controls the number of seconds the **multipathd** daemon waits to receive a change event from **udev** for a newly created multipath device. After that it automatically enables device reloads. In most cases, **multipathd** delays reloads on a device, until it receives a change **uevent** from the initial table load.
	The default value is **30**.
deferred_remove	If set to **yes**, **multipathd** performs a deferred remove, instead of a regular remove, when the last path device is deleted. This ensures that if a multipathed device is in use when a regular remove is performed and the remove fails, the device is automatically removed, when the last user closes the device. The default value is **no**.

Attribute	Description
san_path_err_threshold, **san_path_err_forget_rate**, **san_path_err_recovery_time**	If you set all three of these attributes to integers greater than zero, they enable the **multipathd** daemon to keep shaky paths from reinstating, by monitoring how frequently the path checker fails. If a path checker fails a path more than the value in the **san_path_err_threshold** attribute, within **san_path_err_forget_rate** checks, then the **multipathd** daemon does not reinstate the path until the value of the **san_path_err_recovery_time** attribute in seconds passes, without any path checker failures.
	See the **Shaky paths detection** section of the **multipath.conf(5)** for more information.
	The default value is **no**.
marginal_path_double_failed_time, **marginal_path_err_sample_time**, **marginal_path_err_rate_threshold**, **marginal_path_err_recheck_gap_time**	If **marginal_path_double_failed_time**, **marginal_path_err_rate_threshold**, and **marginal_path_err_recheck_gap_time** are set to integers greater than **0** and **marginal_path_err_sample_time** is set to an integer greater than **120**, they enable the **multipathd** daemon to keep shaky paths from reinstating, by testing the I/O failure rate of paths that repeatedly fail.
	If a path fails twice within the value set in the **marginal_path_double_failed_time** attribute in seconds, the **multipathd** daemon does not immediately reinstate it, when the path checker determines that it is back up. Instead, **multipathd** issues a steady stream of read I/Os to the path for the value set in the **marginal_path_err_sample_time** attribute in seconds. If there are more than the value set in the **marginal_path_err_rate_threshold** attribute number of errors per thousand I/Os, **multipathd** waits for **marginal_path_err_recheck_gap_time** seconds, and then starts another cycle of testing the path with read I/Os. Otherwise, **multipathd** reinstates the path.
	See the **Shaky paths detection** section of the **multipath.conf(5)** for more information.
	The default value is **no**.
marginal_pathgroups	Possible values include:
	on: When one of the marginal path detecting methods determines that a path is marginal, the system reinstates the path and places it in a separate pathgroup. This group comes into effect only after all the non-marginal path groups are tried first. This prevents the possibility of IO errors occurring while the system can still use some marginal paths. The path returns to a regular path group as soon as it passes monitoring for a configured time.

Attribute	Description
	off: The **delay_*_checks**, **marginal_path_***, and **san_path_err_*** attributes keep the system from reinstating any **marginal**, or **shaky** paths, until they are monitored for a configured time.
	fpin: The **multipathd** daemon receives **fpin** notifications, sets path states to **marginal**, and regroups paths, as described for the **on** value.
	The **marginal_path_*** and **san_path_err_*** attributes are implicitly set to **no**.
	See the **Shaky paths detection** section of the **multipath.conf(5)** for more information.
	The default value is **no**.
log_checker_err	If set to **once**, **multipathd** logs the first path checker error at verbosity level 2. The system logs any further errors at verbosity level 3, until the device is restored. If the **log_checker_err** parameter is set to **always**, **multipathd** always logs the path checker error at verbosity level 2. The default value is **always**.
skip_kpartx	If set to **yes**, **kpartx** does not automatically create partitions on the device. This enables you to create a multipath device, without creating partitions, even if the device has a partition table. The default value of this option is **no**.
max_sectors_kb	Using this option, you can set the **max_sectors_kb** device queue parameter to the specified value on all underlying paths of a multipath device, before the first activation of a multipath device. Whenever the system creates a new multipath device, the device inherits the **max_sectors_kb** value from the path devices. Manually raising this value for the multipath device, or lowering this value for the path devices, can cause multipath to create I/O operations larger than the path devices allow. Using the **max_sectors_kb** parameter is an easy way to set these values, before the creation of a multipath device on top of the path devices, and prevent passing any invalid-sized I/O operations. If you do not set this parameter, the path devices driver sets it automatically, and the multipath device inherits it from the path devices.
ghost_delay	This attribute sets the number of seconds that multipath waits after creating a device with only ghost paths, before marking it ready for use in **systemd**. This gives the active paths time to appear before the multipath runs the hardware handler to switch the ghost paths to active ones.
	Setting this to **0** or **no** makes multipath immediately mark a device with only ghost paths as ready.

Attribute	Description
	The default value is **no**.
enable_foreign	This attribute enables or disables foreign libraries.
	The value is a regular expression. Foreign libraries are loaded if their name matches the expression.
	By default, no foreign libraries are enabled. Use **nvme** to enable NVMe native multipath support, or **".*"** to enable all foreign libraries.
recheck_wwid	If set to **yes**, when a failed path is restored, the**multipathd** daemon rechecks the path WWID. If there is a change in the WWID, the path is removed from the current multipath device, and added again as a new path. The **multipathd** daemon also checks the path WWID again if it is manually re-added.
	This option only works for SCSI devices with configuration to use the default **uid_attribute**, **ID_SERIAL**, or **sysfs**, for getting their WWID.
	The default value is **no**.
remove_retries	This option sets the number of times multipath retries removing a device that is in use. Between each attempt, multipath becomes inactive for 1 second. The default value is **0**, which means that multipath does not retry the remove.
detect_checker	If set to **yes**, multipath checks if the device supports ALUA or Redundant Disk Array Controller (RDAC). If the device supports ALUA, multipath assigns it the **tur path_checker**. If the device supports RDAC, the **multipathd** daemon assigns it the**rdac path_checker**. If the device does not support ALUA or RDAC, or the **detect_checker** is set to **no**, the **path_checker** attribute sets the path checker.
	The default value is **yes**.
reservation_key	The **mpathpersist** parameter uses this service action reservation key. It must be set for all multipath devices using persistent reservations, and it must be the same as the **RESERVATION KEY** field of the **PERSISTENT RESERVE OUT** parameter list, which contains an 8-byte value provided by the application client to the device server to identify the I_T nexus. If you use the **--param-aptpl** option when registering the key with **mpathpersist**, you must append**:aptpl** to the end of the reservation key.

Attribute	Description
	This parameter can also be set to **file**, which causes **mpathpersist** to automatically store the **RESERVATION KEY** used to register the multipath device in the **prkeys** file. The **multipathd** daemon then uses this key to register additional paths as they appear. When you remove the registration, this automatically removes the **RESERVATION KEY** from the **prkeys** file. It is **unset** by default. If persistent reservations are necessary, it is recommended to set this attribute to **file**.
all_tg_pt	If this option is set to **yes** when **mpathpersist** registers keys, it treats a registered key from one host to one target port, as going from one host to all target ports. This must be set to **yes** to successfully use **mpathpersist** on arrays that automatically set and clear registration keys on all target ports from a host, instead of per target port per host. The default value is **no**.

Additional resources

- **multipath.conf(5)** man page

5.3. CONFIGURATION FILE MULTIPATHS SECTION

Set attributes of individual multipath devices by using the **multipaths** section of the **multipath.conf** configuration file. Device Mapper (DM) Multipath uses these attributes to override all other configuration settings, including those from the **overrides** section. Refer to Configuration file overrides section for a list of attributes from the **overrides** section.

The **multipaths** section recognizes only the **multipath** subsection as an attribute. The following table shows the attributes that you can set in the **multipath** subsection, for each specific multipath device. These attributes apply only to one specified multipath. If several **multipath** subsections match a specific device World Wide Identifier (WWID), the contents of those subsections merge. The settings from latest entries have priority over any previous versions.

Table 5.2. Multipath subsection attributes

Attribute	Description
wwid	Specifies the WWID of the multipath device, to which the multipath attributes apply. This parameter is mandatory for this section of the **multipath.conf** file.
alias	Specifies the symbolic name for the multipath device, to which the multipath attributes apply. If you are using **user_friendly_names**, do not set this value to **mpath <n>**. This might cause conflicts with an automatically assigned user friendly name, and give you incorrect device node names.

The attributes in the following list are optional. If you do not set them, default values from the **overrides**, **devices**, or **defaults** sections apply. Refer to Configuration file defaults for a full description of these attributes.

- **path_grouping_policy**
- **path_selector**
- **prio**
- **prio_args**
- **failback**
- **no_path_retry**
- **rr_min_io**
- **rr_min_io_rq**
- **flush_on_last_del**
- **features**
- **reservation_key**
- **user_friendly_names**
- **deferred_remove**
- **san_path_err_threshold**
- **san_path_err_forget_rate**
- **san_path_err_recovery_time**
- **marginal_path_err_sample_time**
- **marginal_path_err_rate_threshold**
- **marginal_path_err_recheck_gap_time**
- **marginal_path_double_failed_time**
- **delay_watch_checks**
- **delay_wait_checks**
- **skip_kpartx**
- **max_sectors_kb**
- **ghost_delay**

The following example shows multipath attributes specified in the configuration file for two specific multipath devices. The first device has a WWID of **3600508b4000156d70001200000b0000** and a symbolic name of **yellow**.

The second multipath device in the example has a WWID of **1DEC_321816758474** and a symbolic name of **red**.

Example 5.1. Multipath attributes specification

```
multipaths {
        multipath {
                wwid                    3600508b4000156d70001200000b0000
                alias                   yellow
                path_grouping_policy    multibus
                path_selector           "round-robin 0"
                failback                manual
                no_path_retry           5
        }
        multipath {
                wwid                    1DEC_321816758474
                alias                   red
        }
}
```

Additional resources

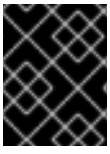
- **multipath.conf(5)** man page
- Configuration file defaults
- Configuration file overrides section

5.4. CONFIGURATION FILE DEVICES SECTION

Use the **devices** section of the **multipath.conf** configuration file to define settings for individual storage controller types. Values set in this section overwrite specified values in the **defaults** section.

The system identifies the storage controller types by the **vendor**, **product**, and **revision** keywords. These keywords are regular expressions and must match the **sysfs** information about the specific device.

The **devices** section recognizes only the **device** subsection as an attribute. If there are multiple keyword matches for a device, the attributes of all matching entries apply to it. If an attribute is specified in several matching **device** subsections, later versions of entries have priority over any previous entries.



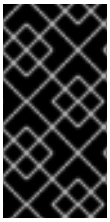
IMPORTANT

Configuration attributes in the latest version of the **device** subsections override attributes in any previous **devices** subsections and from the **defaults** section.

The following table shows the attributes that you can set in the **device** subsection.

Table 5.3. Devices section attributes

Attribute	Description
vendor	Specifies the regular expression to match the device vendor name. This is a mandatory attribute.
product	Specifies the regular expression to match the device product name. This is a mandatory attribute.
revision	Specifies the regular expression to match the device product revision. If the revision attribute is missing, all device revisions match.
product_blacklist	Multipath uses this attribute to create a device **blacklist** entry that has a **vendor** attribute that matches the**vendor** attribute of this device entry, and a **product** attribute that matches this**product_blacklist** attribute.
vpd_vendor	Shows the vendor specific Vital Product Data (VPD) page information, using the VPD page abbreviation.
	The **multipathd** daemon uses this information to gather device specific information. Currently only the **hp3par** VPD page is supported.
hardware_handler	Specifies the hardware handler to use for a particular device type. All possible values are hardware dependent and include:
	emc: Hardware handler for DGC class arrays, as CLARiiON CX/AX and EMC VNX and Unity families.
	rdac: Hardware handler for LSI/Engenio/NetApp RDAC class, as NetApp SANtricity E/EF Series, and OEM arrays from IBM DELL SGI STK and SUN.
	hp_sw: Hardware handler for HP/COMPAQ/DEC HSG80 and MSA/HSV arrays with Active/Standby mode exclusively.
	alua: Hardware handler for SCSI-3 ALUA compatible arrays.
	ana: Hardware handler for NVMe ANA compatible arrays.
	The default value is **unset**.



IMPORTANT

Linux kernels, versions 4.3 and newer, automatically attach a device handler to known devices. This includes all devices supporting SCSI-3 ALUA). The kernel does not enable changing the handler later on. Setting the hardware_handler attribute for such devices on these kernels takes no effect.

The attributes in the following list are optional. If you do not set them, the default values from the **defaults** sections apply. Refer to Configuration file defaults for a full description of these attributes.

- **path_grouping_policy**
- **uid_attribute**
- **getuid_callout**
- **path_selector**
- **path_checker**
- **prio**
- **prio_args**
- **failback**
- **alias_prefix**
- **no_path_retry**
- **rr_min_io**
- **rr_min_io_rq**
- **flush_on_last_del**
- **features**
- **reservation_key**
- **user_friendly_names**
- **deferred_remove**
- **san_path_err_threshold**
- **san_path_err_forget_rate**
- **san_path_err_recovery_time**
- **marginal_path_err_sample_time**
- **marginal_path_err_rate_threshold**
- **marginal_path_err_recheck_gap_time**
- **marginal_path_double_failed_time**
- **delay_watch_checks**
- **delay_wait_checks**
- **skip_kpartx**
- **max_sectors_kb**

- **ghost_delay**
- **all_tg_pt**

Additional resources

- **multipath.conf(5)** man page
- Configuration file defaults

5.5. CONFIGURATION FILE OVERRIDES SECTION

The **overrides** section recognizes the optional **protocol** subsection, and can contain multiple **protocol** subsections. The system matches path devices against the **protocol** subsection, using the mandatory **type** attribute. Attributes in a matching **protocol** subsection have priority over attributes in the rest of the **overrides** section. If there are multiple matching **protocol** subsections, later entries have higher priority.

The attributes in the following list are optional. If you do not set them, default values from the **devices** or **defaults** sections apply.

- **path_grouping_policy**
- **uid_attribute**
- **getuid_callout**
- **path_selector**
- **path_checker**
- **alias_prefix**
- **features**
- **prio**
- **prio_args**
- **failback**
- **no_path_retry**
- **rr_min_io**
- **rr_min_io_rq**
- **flush_on_last_del**
- **fast_io_fail_tmo**
- **dev_loss_tmo**
- **eh_deadline**
- **user_friendly_names**

- **retain_attached_hw_handler**
- **detect_prio**
- **detect_checker**
- **deferred_remove**
- **san_path_err_threshold**
- **san_path_err_forget_rate**
- **san_path_err_recovery_time**
- **marginal_path_err_sample_time**
- **marginal_path_err_rate_threshold**
- **marginal_path_err_recheck_gap_time**
- **marginal_path_double_failed_time**
- **delay_watch_checks**
- **delay_wait_checks**
- **skip_kpartx**
- **max_sectors_kb**
- **ghost_delay**
- **all_tg_pt**

The **protocol** subsection recognizes the following mandatory attribute:

Table 5.4. Protocol subsection attribute

Attribute	Description
type	Specifies the protocol string of the path device. Possible values include:
	scsi:fcp, **scsi:spi**, **scsi:ssa**, **scsi:sbp**, **scsi:srp**, **scsi:iscsi**, **scsi:sas**, **scsi:adt**, **scsi:ata**, **scsi:unspec**, **ccw**, **cciss**, **nvme**, **undef**
	This attribute is not a regular expression. The path device protocol string must match exactly.

The attributes in the following list are optional for the **protocol** subsection. If you do not set them, default values from the **overrides**, **devices** or **defaults** sections apply.

- **fast_io_fail_tmo**
- **dev_loss_tmo**

- **eh_deadline**

Additional resources

- **multipath.conf(5)** man page
- Configuration file defaults

5.6. DM MULTIPATH OVERRIDES OF THE DEVICE TIMEOUT

The **recovery_tmo sysfs** option controls the timeout for a particular iSCSI device. The following options globally override the **recovery_tmo** values:

- The **replacement_timeout** configuration option globally overrides the **recovery_tmo** value for all iSCSI devices.
- For all iSCSI devices that are managed by DM Multipath, the **fast_io_fail_tmo** option in DM Multipath globally overrides the **recovery_tmo** value.
  The **fast_io_fail_tmo** option in DM Multipath also overrides the **fast_io_fail_tmo** option in Fibre Channel devices.

The DM Multipath **fast_io_fail_tmo** option takes precedence over **replacement_timeout**. Red Hat does not recommend using **replacement_timeout** to override **recovery_tmo** in devices managed by DM Multipath because DM Multipath always resets **recovery_tmo**, when the **multipathd** service reloads.

5.7. MODIFYING MULTIPATH CONFIGURATION FILE DEFAULTS

The **/etc/multipath.conf** configuration file includes a **defaults** section that sets the **user_friendly_names** parameter to **yes**, as follows.

```
defaults {
        user_friendly_names yes
}
```

This overwrites the default value of the **user_friendly_names** parameter. The default values that are set in the defaults section on the **multipath.conf file**, are used by DM Multipath unless they are overwritten by the attributes specified in the devices, multipath, or overrides sections of the **multipath.conf** file.

Procedure

1. View the **/etc/multipath.conf** configuration file, which includes a template of configuration defaults:

```
#defaults {
#       polling_interval        10
#       path_selector           "round-robin 0"
#       path_grouping_policy    multibus
#       uid_attribute           ID_SERIAL
#       prio                    alua
#       path_checker            readsector0
#       rr_min_io               100
#       max_fds                 8192
#       rr_weight               priorities
```

```
#       failback                immediate
#       no_path_retry           fail
#       user_friendly_names     yes
#}
```

2. Overwrite the default value for any of the configuration parameters. You can copy the relevant line from this template into the **defaults** section and uncomment it.
   For example, to overwrite the **path_grouping_policy** parameter to **multibus** instead of the default value of **failover**, copy the appropriate line from the template to the initial defaults section of the configuration file, and uncomment it, as follows:

```
defaults {
        user_friendly_names     yes
        path_grouping_policy    multibus
}
```

3. Validate the **/etc/multipath.conf** file after modifying the multipath configuration file by running one of the following commands:
   - To display any configuration errors, run:

```
# multipath -t > /dev/null
```

   - To display the new configuration with the changes added, run:

```
# multipath -t
```

4. Reload the **/etc/multipath.conf** file and reconfigure the **multipathd** daemon for changes to take effect:

```
# service multipathd reload
```

Additional resources

- **multipath.conf(5)** and **multipathd(8)** man pages

5.8. MODIFYING MULTIPATH SETTINGS FOR SPECIFIC DEVICES

In the **multipaths** section of the **multipath.conf** configuration file, you can add configurations that are specific to an individual multipath device, referenced by the mandatory WWID parameter.

These defaults are used by DM Multipath and override attributes set in the **overrides**, **defaults**, and **devices** sections of the **multipath.conf** file. There can be any number of multipath subsections in the **multipaths** section.

Procedure

1. Modify the **multipaths** section for specific multipath device. The following example shows multipath attributes specified in the configuration file for two specific multipath devices:
   - The first device has a WWID of **3600508b4000156d70001200000b0000** and a symbolic name of **yellow**.

- The second multipath device in the example has a WWID of **1DEC_321816758474** and a symbolic name of **red**.

In this example, the **rr_weight** attribute is set to **priorities**.

```
multipaths {
        multipath {
                wwid                    3600508b4000156d70001200000b0000
                alias                   yellow
                path_grouping_policy    multibus
                path_selector           "round-robin 0"
                failback                manual
                rr_weight               priorities
                no_path_retry           5
        }
        multipath {
                wwid                    1DEC_321816758474
                alias                   red
                rr_weight               priorities
        }
}
```

2. Validate the **/etc/multipath.conf** file after modifying the multipath configuration file by running one of the following commands:

   - To display any configuration errors, run:

     ```
     # multipath -t > /dev/null
     ```

   - To display the new configuration with the changes added, run:

     ```
     # multipath -t
     ```

3. Reload the **/etc/multipath.conf** file and reconfigure the **multipathd** daemon for changes to take effect:

   ```
   # service multipathd reload
   ```

Additional resources

- **multipath.conf(5)** man page

5.9. MODIFYING THE MULTIPATH CONFIGURATION FOR SPECIFIC DEVICES WITH PROTOCOL

You can configure multipath device paths, based on their transport protocol. By using the **protocol** subsection of the **overrides** section in the **/etc/multipath.conf** file, you can override the multipath configuration settings on certain paths. This enables access to multipath devices over multiple transport protocols, like Fiber Channel (FC) or Internet Small Computer Systems Interface (iSCSI).

Options set in the **protocol** subsection override values in the **overrides**, **devices** and **defaults** sections. These options apply only to devices using a transport protocol which matches the **type** parameter of the subsection.

Prerequisites

- You have configured Device Mapper (DM) multipath in your system.
- You have multipath devices where not all paths use the same transport protocol.

Procedure

1. View the specific path protocol by running the following:

```
# multipathd show paths format "%d %P"
dev protocol
sda scsi:ata
sdb scsi:fcp
sdc scsi:fcp
```

2. Edit the **overrides** section of the **/etc/multipath.conf** file, by adding **protocol** subsections for each multipath type.

   - Settings for path devices, which use the **scsi:fcp** protocol:

```
overrides {
        dev_loss_tmo 60
        fast_io_fail_tmo 8
        protocol {
                type "scsi:fcp"
                dev_loss_tmo 70
                fast_io_fail_tmo 10
                eh_deadline 360
        }
}
```

   - Settings for path devices, which use the **scsi:iscsi** protocol:

```
overrides {
        dev_loss_tmo 60
        fast_io_fail_tmo 8
        protocol {
                type "scsi:iscsi"
                dev_loss_tmo 60
                fast_io_fail_tmo 120
        }
}
```

   - Settings for path devices, which use all other protocols:

```
overrides {
        dev_loss_tmo 60
        fast_io_fail_tmo 8
        protocol {
                type "<type of protocol>"
                dev_loss_tmo 60
                fast_io_fail_tmo 8
        }
}
```

The **overrides** section can include multiple **protocol** subsections.

IMPORTANT

The **protocol** subsection must include a **type** parameter. The configuration of all paths with a matching **type** parameter is then updated with the rest of the parameters listed in the **protocol** subsection.

Additional resources

- **multipath.conf(5)** man page

5.10. MODIFYING MULTIPATH SETTINGS FOR STORAGE CONTROLLERS

The **devices** section of the **multipath.conf** configuration file sets attributes for individual storage devices. These attributes are used by DM Multipath unless they are overwritten by the attributes specified in the **multipaths** or **overrides** sections of the **multipath.conf** file for paths that contain the device. These attributes override the attributes set in the **defaults** section of the **multipath.conf** file.

Procedure

1. View the information about the default configuration value, including supported devices:

```
# multipathd show config
# multipath -t
```

   Many devices that support multipathing are included by default in a multipath configuration.

2. Optional: If you need to modify the default configuration values, you can overwrite the default values by including an entry in the configuration file for the device that overwrites those values. You can copy the device configuration defaults for the device that the **multipathd show config** command displays and override the values that you want to change.

3. Add a device that is not configured automatically by default to the **devices** section of the configuration file by setting the **vendor** and **product** parameters. Find these values by opening the **/sys/block/*device_name*/device/vendor** and **/sys/block/*device_name*/device/model** files where *device_name* is the device to be multipathed, as mentioned in the following example:

```
# cat /sys/block/sda/device/vendor
WINSYS
# cat /sys/block/sda/device/model
SF2372
```

4. Optional: Specify the additional parameters depending on your specific device:

   active/active device

   Usually there is no need to set additional parameters in this case. If required, you might set **path_grouping_policy** to **multibus**. Other parameters you may need to set are **no_path_retry** and **rr_min_io**.

   active/passive device

   If it automatically switches paths with I/O to the passive path, you need to change the checker function to one that does not send I/O to the path to test if it is working, otherwise,

your device will keep failing over. This means that you have set the **path_checker** to **tur**, which works for all SCSI devices that support the Test Unit Ready command, which most do.

If the device needs a special command to switch paths, then configuring this device for multipath requires a hardware handler kernel module. The current available hardware handler is **emc**. If this is not sufficient for your device, you might not be able to configure the device for multipath.

The following example shows a **device** entry in the multipath configuration file:

```
# }
# device {
#  vendor   "COMPAQ  "
#  product   "MSA1000         "
#  path_grouping_policy multibus
#  path_checker  tur
#  rr_weight  priorities
# }
#}
```

5. Validate the **/etc/multipath.conf** file after modifying the multipath configuration file by running one of the following commands:

   - To display any configuration errors, run:

     ```
     # multipath -t > /dev/null
     ```

   - To display the new configuration with the changes added, run:

     ```
     # multipath -t
     ```

6. Reload the **/etc/multipath.conf** file and reconfigure the **multipathd** daemon for changes to take effect:

   ```
   # service multipathd reload
   ```

Additional resources

- **multipath.conf(5)** and **multipathd(8)** man pages

5.11. SETTING MULTIPATH VALUES FOR ALL DEVICES

Using the **overrides** section of the **multipath.conf** configuration file, you can set a configuration value for all of your devices. This section supports all attributes that are supported by both the **devices** and **defaults** section of the **multipath.conf** configuration file, which is all of the **devices** section attributes except **vendor**, **product**, and **revision**.

DM Multipath uses these attributes for all devices unless they are overwritten by the attributes specified in the **multipaths** section of the **multipath.conf** file for paths that contain the device. These attributes override the attributes set in the **devices** and **defaults** sections of the **multipath.conf** file.

Procedure

1. Override device specific settings. For example, you might want all devices to set **no_path_retry** to **fail**. Use the following command to turn off queueing, when all paths have failed. This overrides any device specific settings.

```
overrides {
        no_path_retry fail
}
```

2. Validate the **/etc/multipath.conf** file after modifying the multipath configuration file by running one of the following commands:

   - To display any configuration errors, run:

```
# multipath -t > /dev/null
```

   - To display the new configuration with the changes added, run:

```
# multipath -t
```

3. Reload the **/etc/multipath.conf** file and reconfigure the **multipathd** daemon for changes to take effect:

```
# service multipathd reload
```

Additional resources

- **multipath.conf(5)** man page

CHAPTER 6. PREVENTING DEVICES FROM MULTIPATHING

You can configure DM Multipath to ignore selected devices when it configures multipath devices. DM Multipath does not group these ignored devices into a multipath device.

6.1. CONDITIONS WHEN DM MULTIPATH CREATES A MULTIPATH DEVICE FOR A PATH

DM Multipath has a set of default rules to determine whether to create a multipath device for a path or whether to ignore the path. You can configure the behavior.

If the **find_multipaths** configuration parameter is set to **off**, multipath always tries to create a multipath device for every path that is not explicitly disabled. If the **find_multipaths** configuration parameter is set to **on**, then multipath creates a device, only if one of following conditions is met:

- There are at least two paths with the same World-Wide Identification (WWID) that are not disabled.
- You manually force the creation of the device by specifying a device with the **multipath** command.
- A path has the same WWID as a multipath device that was previously created even if that multipath device does not currently exist. Whenever a multipath device is created, multipath remembers the WWID of the device so that it automatically creates the device again as soon as it sees a path with that WWID. This allows you to have multipath automatically choose the correct paths to make into multipath devices, without having to disable multipathing on other devices.

If you have previously created a multipath device without using the **find_multipaths** parameter and then you later set the parameter to **on**, you might need to remove the WWIDs of any device you do not want created as a multipath device from the **/etc/multipath/wwids** file. The following example shows a sample **/etc/multipath/wwids** file. The WWIDs are enclosed by slashes (/):

```
# Multipath wwids, Version : 1.0
# NOTE: This file is automatically maintained by multipath and multipathd.
# You should not need to edit this file in normal circumstances.
#
# Valid WWIDs:
/3600d0230000000000e13955cc3757802/
/3600d0230000000000e13955cc3757801/
/3600d0230000000000e13955cc3757800/
/3600d02300069c9ce09d41c31f29d4c00/
/SWINSYS  SF2372        0E13955CC3757802/
/3600d0230000000000e13955cc3757803/
```

In addition to **on** and **off**, you can also set **find_multipaths** to the following values:

strict

Multipath never accepts paths that have not previously been multipathed and are therefore not in the **/etc/multipath/wwids** file.

smart

Multipath always accepts non-disabled devices in **udev** as soon as they appear. If **multipathd** does not create the device within a timeout set with the **find_multipaths_timeout** parameter, it will release its claim on the device.

The built-in default value of **find_multipaths** is **off**. The default **multipath.conf** file created by **mpathconf**, however, will set the value of **find_multipaths** to **on**.

When the **find_multipaths** parameter is set to **on**, disable multipathing only on the devices with multiple paths that you do not want to be multipathed. Because of this, it will generally not be necessary to disable multipathing on devices.

If you add a previously created multipath device to **blacklist**, removing the WWID of that device from the **/etc/multipath/wwids** file by using the **-w** option can help avoid issues with other programs. For example, to remove the device **/dev/sdb** with WWID **3600d0230000000000e13954ed5f89300** from the **/etc/multipath/wwids** file, you can use either of the following methods.

- Removing a multipath device by using the device name.

```
# multipath -w /dev/sdb
wwid '3600d0230000000000e13954ed5f89300' removed
```

- Removing a multipath device by using the WWID of the device.

```
# multipath -w 3600d0230000000000e13954ed5f89300
wwid '3600d0230000000000e13954ed5f89300' removed
```

You can also use the **-W** option to update the **/etc/multipath/wwids** file. This would reset the **/etc/multipath/wwids** file to only include the WWIDs of the current multipath devices. To reset the file, run the following:

```
# multipath -W
successfully reset wwids
```

Additional resources

- **multipath.conf(5)** man page

6.2. CRITERIA FOR DISABLING MULTIPATHING ON CERTAIN DEVICES

You can disable multipathing on devices by any of the following criteria:

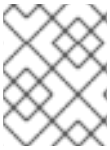
- WWID
- device name
- device type
- property
- protocol

For every device, DM Multipath evaluates these criteria in the following order:

1. **property**
2. **devnode**
3. **device**

4. **protocol**
5. **wwid**

If a device turns out to be disabled by any of the mentioned criteria, DM Multipath excludes it from handling by **multipathd**, and does not evaluate the later criteria. For each criteria, the exception list takes precedence over the list of disabled devices, if a device matches both.



NOTE

By default, a variety of device types are disabled, even after you comment out the initial **blacklist** section of the configuration file.

Additional resources

- Adding exceptions for devices with disabled multipathing

6.3. DISABLING MULTIPATHING BY WWID

You can disable multipathing on individual devices by their World-Wide Identification (WWID).

Procedure

1. Find WWID of a device:

```
# multipathd show paths raw format "%d %w" | grep sdb
sdb 3600508b4001080520001e00011700000
```

2. Disable devices in the **/etc/multipath.conf** configuration file using the **wwid** entry.
The following example shows the lines in the DM Multipath configuration file that disable a device with a WWID of **3600508b4001080520001e00011700000**:

```
blacklist {
        wwid 3600508b4001080520001e00011700000
}
```

3. Validate the **/etc/multipath.conf** file after modifying the multipath configuration file by running one of the following commands:
   - To display any configuration errors, run:

```
# multipath -t > /dev/null
```

   - To display the new configuration with the changes added, run:

```
# multipath -t
```

4. Reload the **/etc/multipath.conf** file and reconfigure the **multipathd** daemon for changes to take effect:

```
# service multipathd reload
```

6.4. DISABLING MULTIPATHING BY DEVICE NAME

You can disable multipathing on device types by device name, so that DM Multipath will not group them into a multipath device.

Procedure

1. Display device information:

```
# udevadm info --query=all -n /dev/mapper/sd*
```

2. Disable devices in the **/etc/multipath.conf** configuration file using the **devnode** entry. The following example shows the lines in the DM Multipath configuration file that disable all SCSI devices, because it disables all **sd*** devices as well:

```
blacklist {
        devnode "^sd[a-z]"
}
```

   You can use a **devnode** entry to disable individual devices rather than all devices of a specific type. However, this is not recommended because unless it is statically mapped by **udev** rules, there is no guarantee that a specific device will have the same name on reboot. For example, a device name could change from **/dev/sda** to **/dev/sdb** on reboot.

   By default, DM Multipath disables all devices that are not SCSI, NVMe, or DASD, using the following **devnode** entry:

```
blacklist {
        devnode "!^(sd[a-z]|dasd[a-z]|nvme[0-9])"
}
```

   The devices that this entry disables do not generally support DM Multipath.

3. Validate the **/etc/multipath.conf** file after modifying the multipath configuration file by running one of the following commands:

   - To display any configuration errors, run:

```
# multipath -t > /dev/null
```

   - To display the new configuration with the changes added, run:

```
# multipath -t
```

4. Reload the **/etc/multipath.conf** file and reconfigure the **multipathd** daemon for changes to take effect:

```
# service multipathd reload
```

Additional resources

- Adding exceptions for devices with disabled multipathing

6.5. DISABLING MULTIPATHING BY DEVICE TYPE

You can disable multipathing on devices by using the device section.

Procedure

1. Display device type:

```
# multipathd show paths raw format "%d %s" | grep sdb
sdb HP,HSV210
```

2. Disable devices in the **/etc/multipath.conf** configuration file using the **device** section. The following example disables multipathing on all IBM DS4200 and HP devices:

```
blacklist {
        device {
                vendor  "IBM"
                product "3S42"       #DS4200 Product 10
        }
        device {
                vendor  "HP"
                product ".*"
        }
}
```

3. Validate the **/etc/multipath.conf** file after modifying the multipath configuration file by running one of the following commands:

   - To display any configuration errors, run:

```
# multipath -t > /dev/null
```

   - To display the new configuration with the changes added, run:

```
# multipath -t
```

4. Reload the **/etc/multipath.conf** file and reconfigure the **multipathd** daemon for changes to take effect:

```
# service multipathd reload
```

6.6. DISABLING MULTIPATHING BY UDEV PROPERTY

You can disable multipathing on devices by their **udev** property parameter.

Procedure

1. Display the **udev** variables for a device:

```
# udevadm info --query=all -n /dev/sdb
```

2. Disable devices in the **/etc/multipath.conf** configuration file using the **property** parameter. This parameter is a regular expression string that matches against the **udev** environment variable name for the devices.
   The following example disables multipathing on all devices with the **udev** property **ID_ATA**:

```
blacklist {
        property "ID_ATA"
}
```

3. Validate the **/etc/multipath.conf** file after modifying the multipath configuration file by running one of the following commands:

   - To display any configuration errors, run:

```
# multipath -t > /dev/null
```

   - To display the new configuration with the changes added, run:

```
# multipath -t
```

4. Reload the **/etc/multipath.conf** file and reconfigure the **multipathd** daemon for changes to take effect:

```
# service multipathd reload
```

6.7. DISABLING MULTIPATHING BY DEVICE PROTOCOL

You can disable multipathing on devices by using device protocol.

Procedure

1. Optional: View the protocol that a path is using:

```
# multipathd show paths raw format "%d %P" | grep sdb
sdb scsi:fcp
```

2. Disable devices in the **/etc/multipath.conf** configuration file using the **protocol** parameter. The protocol parameter takes a regular expression and blacklists all devices with matching protocol strings. For example, to disable multipathing on all nvme devices, use the following:

```
blacklist {
        protocol "nvme"
}
```

   DM Multipath recognizes the following protocol strings:

   - **scsi:fcp**
   - **scsi:spi**
   - **scsi:ssa**
   - **scsi:sbp**

- **scsi:srp**
- **scsi:iscsi**
- **scsi:sas**
- **scsi:adt**
- **scsi:ata**
- **scsi:unspec**
- **ccw**
- **cciss**
- **nvme:pcie**
- **nvme:rdma**
- **nvme:fc**
- **nvme:tcp**
- **nvme:loop**
- **nvme:apple-nvme**
- **nvme:unspec**
- **undef**

3. Validate the **/etc/multipath.conf** file after modifying the multipath configuration file by running one of the following commands:
   - To display any configuration errors, run:

     ```
     # multipath -t > /dev/null
     ```

   - To display the new configuration with the changes added, run:

     ```
     # multipath -t
     ```

4. Reload the **/etc/multipath.conf** file and reconfigure the **multipathd** daemon for changes to take effect:

   ```
   # service multipathd reload
   ```

6.8. ADDING EXCEPTIONS FOR DEVICES WITH DISABLED MULTIPATHING

You can enable multipathing by adding exceptions on devices where multipathing is currently disabled.

Prerequisites

- Multipathing is disabled on certain devices.

Procedure

1. Enable multipathing on the devices using the **blacklist_exceptions** section of the **/etc/multipath.conf** configuration file.
   When specifying devices in the **blacklist_exceptions** section of the configuration file, you must specify the exceptions using the same criteria as they were specified in the **blacklist** section. For example, a WWID exception does not apply to devices disabled by a **devnode** entry, even if the disabled device is associated with that WWID. Similarly, **devnode** exceptions apply only to **devnode** entries, and **device** exceptions apply only to device entries.

   Example 6.1. An exception by WWID

   If you have a large number of devices and want to multipath only one of them with the WWID of **3600d0230000000000e13955cc3757803**, instead of individually disabling each of the devices except the one you want, you could disable all of them, and then enable only the one you want by adding the following lines to the **/etc/multipath.conf** file:

   ```
   blacklist {
         wwid ".*"
   }

   blacklist_exceptions {
         wwid "3600d0230000000000e13955cc3757803"
   }
   ```

   Alternatively, you could use an exclamation mark (**!**) to invert the **blacklist** entry, which disables all devices except the specified WWID:

   ```
   blacklist {
         wwid "!3600d0230000000000e13955cc3757803"
   }
   ```

   Example 6.2. An exception by udev property

   The **property** parameter works differently than the other **blacklist_exception** parameters. The value of the **property** parameter must match the name of a variable in the **udev** database. Otherwise, the device is disabled. Using this parameter, you can disable multipathing on certain SCSI devices, such as USB sticks and local hard drives.

   To enable multipathing only on SCSI devices that could reasonably be multipathed, set this parameter to **(SCSI_IDENT_|ID_WWN)** as in the following example:

   ```
   blacklist_exceptions {
         property "(SCSI_IDENT_|ID_WWN)"
   }
   ```

2. Validate the **/etc/multipath.conf** file after modifying the multipath configuration file by running one of the following commands:

   - To display any configuration errors, run:

```
# multipath -t > /dev/null
```

- To display the new configuration with the changes added, run:

```
# multipath -t
```

3. Reload the **/etc/multipath.conf** file and reconfigure the **multipathd** daemon for changes to take effect:

```
# service multipathd reload
```

CHAPTER 7. MANAGING MULTIPATHED VOLUMES

The following are a few commands provided by DM Multipath, which you can use to manage multipath volumes:

- **multipath**
- **dmsetup**
- **multipathd**

7.1. RESIZING AN ONLINE MULTIPATH DEVICE

If you need to resize an online multipath device, use the following procedure.

Procedure

1. Resize your physical device.
2. Execute the following command to find the paths to the logical unit number (LUN):

```
# multipath -l
```

3. Resize your paths. For SCSI devices, writing a 1 to the **rescan** file for the device causes the SCSI driver to rescan, as in the following command:

```
# echo 1 > /sys/block/path_device/device/rescan
```

Ensure that you run this command for each of the path devices. For example, if your path devices are **sda**, **sdb**, **sde**, and **sdf**, you would run the following commands:

```
# echo 1 > /sys/block/sda/device/rescan
# echo 1 > /sys/block/sdb/device/rescan
# echo 1 > /sys/block/sde/device/rescan
# echo 1 > /sys/block/sdf/device/rescan
```

4. Resize your multipath device:

```
# multipathd resize map multipath_device
```

5. Resize the file system (assuming no LVM or DOS partitions are used):

```
# resize2fs /dev/mapper/mpatha
```

7.2. MOVING A ROOT FILE SYSTEM FROM A SINGLE PATH DEVICE TO A MULTIPATH DEVICE

If you have installed your system on a single-path device and later add another path to the root file system, you will need to move your root file system to a multipathed device. See the following procedure for moving from a single-path to a multipathed device.

Prerequisites

- You have installed the **device-mapper-multipath** package.

Procedure

1. Create the **/etc/multipath.conf** configuration file, load the multipath module, and enable the **multipathd systemd** service:

```
# dnf install device-mapper-multipath
```

2. Execute the following command to create the **/etc/multipath.conf** configuration file, load the multipath module, and set **chkconfig** for the **multipathd** to **on**:

```
# mpathconf --enable
```

3. If the **find_multipaths** configuration parameter is not set to **yes**, edit the **blacklist** and **blacklist_exceptions** sections of the **/etc/multipath.conf** file, as described in Preventing devices from multipathing.

4. In order for multipath to build a multipath device on top of the root device as soon as it is discovered, enter the following command. This command also ensures that **find_multipaths** allows the device, even if it only has one path.

```
# multipath -a root_devname
```

   For example, if the root device is **/dev/sdb**, enter the following command.

```
# multipath -a /dev/sdb
wwid '3600d02300069c9ce09d41c4ac9c53200' added
```

5. Confirm that your configuration file is set up correctly by executing the **multipath** command and search the output for a line of the following format. This indicates that the command failed to create the multipath device.

```
date  wwid: ignoring map
```

   For example, if the WWID of the device is *3600d02300069c9ce09d41c4ac9c53200*, you would see a line in the output such as the following:

```
# multipath
Oct 21 09:37:19 | 3600d02300069c9ce09d41c4ac9c53200: ignoring map
```

6. Rebuild the **initramfs** file system with **multipath**:

```
# dracut --force -H --add multipath
```

7. Shut the machine down.

8. Boot the machine.

9. Make the other paths visible to the machine.

Verification steps

- Check whether the multipath device is created by running the following command:

```
# multipath -l | grep 3600d02300069c9ce09d41c4ac9c53200
mpatha (3600d02300069c9ce09d41c4ac9c53200) dm-0 3PARdata,VV
```

7.3. MOVING A SWAP FILE SYSTEM FROM A SINGLE PATH DEVICE TO A MULTIPATH DEVICE

By default, swap devices are set up as logical volumes. This does not require any special procedure for configuring them as multipath devices as long as you set up multipathing on the physical volumes that constitute the logical volume group. If your swap device is not an LVM volume, however, and it is mounted by device name, you might need to edit the **/etc/fstab** file to switch to the appropriate multipath device name.

Procedure

1. Add the WWID of the device to the **/etc/multipath/wwids** file:

```
# multipath -a swap_devname
```

   For example, if the root device is **/dev/sdb**, enter the following command.

```
# multipath -a /dev/sdb
wwid '3600d02300069c9ce09d41c4ac9c53200' added
```

2. Confirm that your configuration file is set up correctly by executing the **multipath** command and search the output for a line of the following format:

```
date  wwid: ignoring map
```

   This indicates that the command failed to create the multipath device.

   For example, if the WWID of the device is 3600d02300069c9ce09d41c4ac9c53200, you would see a line in the output such as the following:

```
# multipath
Oct 21 09:37:19 | 3600d02300069c9ce09d41c4ac9c53200: ignoring map
```

3. Set up an alias for the swap device in the **/etc/multipath.conf** file:

```
multipaths {
    multipath {
        wwid WWID_of_swap_device
        alias swapdev
    }
}
```

4. Edit the **/etc/fstab** file and replace the old device path to the root device with the multipath device.
   For example, if you had the following entry in the **/etc/fstab** file:

```
/dev/sdb2 swap                swap    defaults        0 0
```

Change the entry to the following:

```
/dev/mapper/swapdev swap          swap    defaults        0 0
```

5. Rebuild the initramfs file system with multipath:

```
# dracut --force -H --add multipath
```

6. Shut the machine down.
7. Boot the machine.
8. Make the other paths visible to the machine.

Verification steps

- Verify if the swap device is on the multipath device:

```
# swapon -s
```

For example:

```
# swapon -s

Filename                Type        Size Used    Priority
/dev/dm-3               partition   4169724 0    -2
```

The file name should match the multipath swap device.

```
# readlink -f /dev/mapper/swapdev
/dev/dm-3
```

7.4. DETERMINING DEVICE MAPPER ENTRIES WITH THE DMSETUP COMMAND

You can use the **dmsetup** command to find out which device mapper entries match the multipathed devices.

Procedure

- Display all the device mapper devices and their major and minor numbers. The minor numbers determine the name of the dm device. For example, a minor number of 3 corresponds to the multipathed device **/dev/dm-3**.

```
# dmsetup ls
mpathd  (253:4)
mpathep1        (253:12)
mpathfp1        (253:11)
mpathb  (253:3)
mpathgp1        (253:14)
mpathhp1        (253:13)
mpatha  (253:2)
```

```
mpathh  (253:9)
mpathg  (253:8)
VolGroup00-LogVol01     (253:1)
mpathf  (253:7)
VolGroup00-LogVol00     (253:0)
mpathe  (253:6)
mpathbp1        (253:10)
mpathd  (253:5)
```

7.5. ADMINISTERING THE MULTIPATHD DAEMON

The **multipathd** commands can be used to administer the **multipathd** daemon.

Procedure

- View the default format for the output of the **multipathd show maps** command:

```
# multipathd show maps
name sysfs uuid
mpathc dm-0 360a98000324669436c2b45666c567942
```

- Some **multipathd** commands include a **format** option followed by a wildcard. Display a list of available wildcards with the following command:

```
# multipathd show wildcards
multipath format wildcards:
%n  name
%w  uuid
%d  sysfs
...
```

- Display the multipath devices that **multipathd** is monitoring. Use wildcards to specify the shown fields:

```
# multipathd show maps format "%n %w %d %s"
name   uuid                             sysfs vend/prod/rev
mpathc 360a98000324669436c2b45666c567942 dm-0  NETAPP,LUN
```

- Display the paths that **multipathd** is monitoring. Use wildcards to specify the shown fields:

```
# multipathd show paths format "%n %w %d %s"
target WWNN        uuid                             dev vend/prod/rev
0x50001fe1500d2250 3600508b4001080520001e00011700000 sdb HP,HSV210
```

- Display data in a raw format:

```
# multipathd show maps raw format "%n %w %d %s"
mpathc 360a98000324669436c2b45666c567942 dm-0 NETAPP,LUN
```

  In raw format, no headers are printed and the fields are not padded to align the columns with the headers. This output can be more easily used for scripting.

Additional resources

- **multipathd**(8) man page

CHAPTER 8. REMOVING STORAGE DEVICES

You can safely remove a storage device from a running system, which helps prevent system memory overload and data loss.

Prerequisites

- Before you remove a storage device, you must ensure that you have enough free system memory due to the increased system memory load during an I/O flush. Use the following commands to view the current memory load and free memory of the system:

```
# vmstat 1 100
# free
```

- Red Hat does not recommend removing a storage device on a system where:
  - Free memory is less than 5% of the total memory in more than 10 samples per 100.
  - Swapping is active (non-zero **si** and **so** columns in the **vmstat** command output).

8.1. SAFE REMOVAL OF STORAGE DEVICES

Safely removing a storage device from a running system requires a top-to-bottom approach. Start from the top layer, which typically is an application or a file system, and work towards the bottom layer, which is the physical device.

You can use storage devices in multiple ways, and they can have different virtual configurations on top of physical devices. For example, you can group multiple instances of a device into a multipath device, make it part of a RAID, or you can make it part of an LVM group. Additionally, devices can be accessed via a file system, or they can be accessed directly such as a "raw" device.

While using the top-to-bottom approach, you must ensure that:

- the device that you want to remove is not in use
- all pending I/O to the device is flushed
- the operating system is not referencing the storage device

8.2. REMOVING BLOCK DEVICES AND ASSOCIATED METADATA

To safely remove a block device from a running system, to help prevent system memory overload and data loss you need to first remove metadata from them. Address each layer in the stack, starting with the file system, and proceed to the disk. These actions prevent putting your system into an inconsistent state.

Use specific commands that may vary depending on what type of devices you are removing:

- **lvremove**, **vgremove** and **pvremove** are specific to LVM.
- For software RAID, run **mdadm** to remove the array. For more information, see Managing RAID.
- For block devices encrypted using LUKS, there are specific additional steps. The following procedure will not work for the block devices encrypted using LUKS. For more information, see Encrypting block devices using LUKS.

WARNING

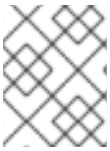
Rescanning the SCSI bus or performing any other action that changes the state of the operating system, without following the procedure documented here can cause delays due to I/O timeouts, devices to be removed unexpectedly, or data loss.

Prerequisites

- You have an existing block device stack containing the file system, the logical volume, and the volume group.
- You ensured that no other applications or services are using the device that you want to remove.
- You backed up the data from the device that you want to remove.
- Optional: If you want to remove a multipath device, and you are unable to access its path devices, disable queueing of the multipath device by running the following command:

```
# multipathd disablequeueing map multipath-device
```

  This enables the I/O of the device to fail, allowing the applications that are using the device to shut down.



NOTE

Removing devices with their metadata one layer at a time ensures no stale signatures remain on the disk.

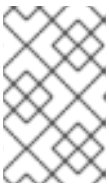
Procedure

1. Unmount the file system:

```
# umount /mnt/mount-point
```

2. Remove the file system:

```
# wipefs -a /dev/vg0/myvol
```



NOTE

If you have added an entry into **/etc/fstab** file to make a persistent association between the file system and a mount point you should also edit **/etc/fstab** at this point to remove that entry.

Continue with the following steps, depending on the type of the device you want to remove:

3. Remove the logical volume (LV) that contained the file system:

```
# lvremove vg0/myvol
```

4. If there are no other logical volumes remaining in the volume group (VG), you can safely remove the VG that contained the device:

```
# vgremove vg0
```

5. Remove the physical volume (PV) metadata from the PV device(s):

```
# pvremove /dev/sdc1
```

```
# wipefs -a /dev/sdc1
```

6. Remove the partitions that contained the PVs:

```
# parted /dev/sdc rm 1
```

NOTE

Follow the next steps only if you want to fully wipe the device.

7. Remove the partition table:

```
# wipefs -a /dev/sdc
```

NOTE

Follow the next steps only if you want to physically remove the device.

- If you are removing a multipath device, execute the following commands:

  a. View all the paths to the device:

```
# multipath -l
```

  The output of this command is required in a later step.

  i. Flush the I/O and remove the multipath device:

```
# multipath -f multipath-device
```

- If the device is not configured as a multipath device, or if the device is configured as a multipath device and you have previously passed I/O to the individual paths, flush any outstanding I/O to all device paths that are used:

```
# blockdev --flushbufs device
```

  This is important for devices accessed directly where the **umount** or **vgreduce** commands do not flush the I/O.

- If you are removing a SCSI device, execute the following commands:

  a. Remove any reference to the path-based name of the device, such as */dev/sd*, */dev/disk/by-path*, or the **major:minor** number, in applications, scripts, or utilities on the

system. This ensures that different devices added in the future are not mistaken for the current device.

b. Remove each path to the device from the SCSI subsystem:

```
# echo 1 > /sys/block/device-name/device/delete
```

Here the ***device-name*** is retrieved from the output of the **multipath -l** command, if the device was previously used as a multipath device.

8. Remove the physical device from a running system. Note that the I/O to other devices does not stop when you remove this device.

Verification

- Verify that the devices you intended to remove are not displaying on the output of **lsblk** command. The following is an example output:

```
# lsblk

NAME    MAJ:MIN RM  SIZE RO TYPE MOUNTPOINT
sda       8:0    0    5G  0 disk
sr0      11:0    1 1024M  0 rom
vda     252:0    0   10G  0 disk
|-vda1 252:1    0    1M  0 part
|-vda2 252:2    0  100M  0 part /boot/efi
`-vda3 252:3    0  9.9G  0 part /
```

Additional resources

- The **multipath(8)**, **pvremove(8)**, **vgremove(8)**, **lvremove(8)**, **wipefs(8)**, **parted(8)**, **blockdev(8)** and **umount(8)** man pages.

CHAPTER 9. TROUBLESHOOTING DM MULTIPATH

If you have trouble implementing a multipath configuration, there are a variety of issues you can check for. The following issues may result in a slow or non-functioning multipath configuration:

The multipath daemon is not running

If you find you have trouble implementing a multipath configuration, ensure that the **multipathd** daemon is running, as described in Configuring DM Multipath. The **multipathd** daemon must be running to use multipathed devices.

Issues with queue_if_no_path feature

If a multipath device is configured with the **features "1 queue_if_no_path"** option, then any process that issues I/O hangs until one or more paths are restored.

9.1. TROUBLESHOOTING ISSUES WITH QUEUE_IF_NO_PATH FEATURE

If a multipath device is configured with the **features "1 queue_if_no_path"** option, then any process that issues I/O hangs until one or more paths are restored. To avoid this, set the **no_path_retry N** parameter in the **/etc/multipath.conf** file, where *N* is the number of times the system should retry a path.

To use the **features "1 queue_if_no_path"** option without the described problem, you can disable the queueing policy at runtime for a particular LUN, for which all paths are unavailable.

Procedure

1. Disable queueing:
   - For a specific device:

     ```
     # multipathd disablequeueing map device
     ```

   - For all devices:

     ```
     # multipathd disablequeueing maps
     ```

     After you disable queueing, it will remain disabled until you restart or reload **multipathd**.
2. Reset queueing to a previous value:
   - For a specific device:

     ```
     # multipathd restorequeueing map device
     ```

   - For all devices:

     ```
     # multipathd restorequeueing maps
     ```

9.2. TROUBLESHOOTING WITH THE MULTIPATHD INTERACTIVE CONSOLE

The **multipathd -k** command is an interactive interface to the **multipathd** daemon. Entering this command brings up an interactive multipath console. After executing this command, you can enter **help** to get a list of available commands and **Ctrl**+**D** to quit.

Use the **multipathd** interactive console to troubleshoot problems you might have with your system.

Procedure

1. Display the multipath configuration, including the default values, before exiting the console:

```
# multipathd -k
multipathd> show config
multipathd> Ctrl+D
```

2. Ensure that multipath picked up all changes to the **multipath.conf** file:

```
# multipathd -k
multipathd> reconfigure
multipathd> Ctrl+D
```

3. Ensure that the path checker is working properly:

```
# multipathd -k
multipathd> show paths
multipathd> Ctrl+D
```

4. You can also run a single **multipathd** interactive command directly from the command line, without starting the interactive console. For example, to check that multipath picks up all changes to the **multipath.conf** file, run the following command:

```
# multipathd reconfigure
```

CHAPTER 10. CONFIGURING MAXIMUM TIME FOR STORAGE ERROR RECOVERY WITH EH_DEADLINE

You can configure the maximum allowed time to recover failed SCSI devices. This configuration guarantees an I/O response time even when storage hardware becomes unresponsive due to a failure.

10.1. THE EH_DEADLINE PARAMETER

The SCSI error handling (EH) mechanism attempts to perform error recovery on failed SCSI devices. The SCSI host object **eh_deadline** parameter enables you to configure the maximum amount of time for the recovery. After the configured time expires, SCSI EH stops and resets the entire host bus adapter (HBA).

Using **eh_deadline** can reduce the time:

- to shut off a failed path,
- to switch a path, or
- to disable a RAID slice.

WARNING

When **eh_deadline** expires, SCSI EH resets the HBA, which affects all target paths on that HBA, not only the failing one. If some of the redundant paths are not available for other reasons, I/O errors might occur. Enable **eh_deadline** only if you have multipath configured on all targets. Also, if your multipath devices are not fully redundant, you should verify that **no_path_retry** is set large enough to allow paths to recover.

The value of the **eh_deadline** parameter is specified in seconds. The default setting is **off**, which disables the time limit and allows all of the error recovery to take place.

Scenarios when eh_deadline is useful

In most scenarios, you do not need to enable **eh_deadline**. Using **eh_deadline** can be useful in certain specific scenarios. For example if a link loss occurs between a Fibre Channel (FC) switch and a target port, and the HBA does not receive Registered State Change Notifications (RSCNs). In such a case, I/O requests and error recovery commands all time out rather than encounter an error. Setting **eh_deadline** in this environment puts an upper limit on the recovery time. That enables the failed I/O to be retried on another available path by DM Multipath.

Under the following conditions, the **eh_deadline** parameter provides no additional benefit, because the I/O and error recovery commands fail immediately, which enables DM Multipath to retry:

- If RSCNs are enabled
- If the HBA does not register the link becoming unavailable

10.2. SETTING THE EH_DEADLINE PARAMETER

This procedure configures the value of the **eh_deadline** parameter to limit the maximum SCSI recovery time.

Procedure

- You can configure **eh_deadline** using either of the following methods:
  - **defaults** section of the **multipath.conf** file
    From the defaults section of the **multipath.conf** file, set the **eh_deadline** parameter to the required number of seconds:

    ```
    # eh_deadline 300
    ```

    NOTE

    From RHEL 8.4, setting the **eh_deadline** parameter using the defaults section of the **multipath.conf** file is the preferred method.

    To turn off the **eh_deadline** parameter with this method, set **eh_deadline** to **off**.

  - **sysfs**
    Write the number of seconds into the **/sys/class/scsi_host/host<host-number>/eh_deadline** files. For example, to set the **eh_deadline** parameter through **sysfs** on SCSI host 6:

    ```
    # echo 300 > /sys/class/scsi_host/host6/eh_deadline
    ```

    To turn off the **eh_deadline** parameter with this method, use echo **off**.

  - Kernel parameter
    Set a default value for all SCSI HBAs using the **scsi_mod.eh_deadline** kernel parameter.

    ```
    # echo 300 > /sys/module/scsi_mod/parameters/eh_deadline
    ```

    To turn off the **eh_deadline** parameter with this method, use echo **-1**.

Additional resources

- How to set eh_deadline and eh_timeout persistently, using a udev rule