NetApp

Configure hosts with FCP and iSCSI

ONTAP SAN Host Utilities

NetApp
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Table of Contents

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Overview

You can configure certain SAN hosts for FCP or iSCSI with ONTAP as the target. First you install the relevant operating system host utility package, which includes the SAN tool kit. You then verify the multipath settings for the NetApp ONTAP LUNs.

AIX and PowerVM/VIOS

Configure AIX 7.3/VIOS 4.x for FCP and iSCSI with ONTAP storage

The AIX Host Utilities software provides management and diagnostic tools for AIX hosts that are connected to ONTAP storage. When you install the AIX Host Utilities on an AIX 7.3/VIOS 4.x host, you can use the Host Utilities to help you manage FCP and iSCSI protocol operations with ONTAP LUNs.

Step 1: Optionally, enable SAN booting

You can configure your host to use SAN booting to simplify deployment and improve scalability. If your configuration doesn't support SAN booting, you can use a local boot.

SAN boot

SAN booting is the process of setting up a SAN-attached disk (a LUN) as a boot device for an AIX/PowerVM host host. You can set up a SAN boot LUN to work in a AIX Multipath I/O (MPIO) environment that is using the FC protocol and running AIX Host Utilities with either the FC or FCoE protocol. The method you use to create a SAN boot LUN and install a new OS image in an AIX MPIO environment depends on the protocol that you are using.

Steps

1. Use the Interoperability Matrix Tool to verify that your AIX OS, protocol, and ONTAP version support SAN booting.

2. Follow the best practices for setting up a SAN boot in the vendor documentation.

Local boot

Perform a local boot by installing the AIX OS on the local hard disk, for example, on an SSD, SATA, or RAID.

Step 2: Install the AIX Host Utilities

NetApp strongly recommends installing the AIX Host Utilities to support ONTAP LUN management and assist technical support with gathering configuration data. The MPIO package from the Host Utilities provides MPIO support for AIX and VIOS.

(i)   Installing the AIX Host Utilities provides additional timeout settings on your AIX host.

Install AIX Host Utilities 8.0.

Step 3: Confirm the multipath configuration for your host

You can use multipathing with AIX and PowerVM to manage ONTAP LUNs.

Multipathing allows you to configure multiple network paths between the host and storage system. If one path fails, traffic continues with the remaining paths. The AIX and PowerVM environments of the Host Utilities use the AIXs native multipathing solution (MPIO).

The Path Control Module (PCM) is responsible for controlling multiple paths for an AIX host. The PCM is a storage vendor supplied code that handles path management and is installed and enabled during the Host Utilities installation.

To ensure that multipathing is configured correctly for your host, verify that you have the NetApp recommended settings configured for your ONTAP LUNs.

Steps

1. Verify that "MPIO NetApp" is available. "MPIO NetApp" is loaded during the AIX Host Utilities installation and becomes available after you reboot the host.

   ```
   lsdev -Cc disk
   ```

   Example output

   ```
   hdisk1 Available 00-00-02 MPIO NetApp FCP Default PCM Disk
   ```

2. The AIX Host Utilities load the following parameter settings for ONTAP LUNs.

Show parameter settings

Parameter	Environment	Value for AIX	Note
algorithm	MPIO	round_robin	Set by Host Utilities
hcheck_cmd	MPIO	inquiry	Set by Host Utilities
hcheck_interval	MPIO	30	Set by Host Utilities
hcheck_mode	MPIO	nonactive	Set by Host Utilities
lun_reset_spt	MPIO / non-MPIO	yes	Set by Host Utilities
max_transfer	MPIO / non-MPIO	FC LUNs: 0x100000 bytes	Set by Host Utilities
qfull_dly	MPIO / non-MPIO	2-second delay	Set by Host Utilities
queue_depth	MPIO / non-MPIO	64	Set by Host Utilities
reserve_policy	MPIO / non-MPIO	no_reserve	Set by Host Utilities
re_timeout (disk)	MPIO / non-MPIO	30 seconds	Uses OS Default values
dyntrk	MPIO / non-MPIO	Yes	Uses OS Default values
fc_err_recov	MPIO / non-MPIO	Fast_fail	Uses OS Default values
q_type	MPIO / non-MPIO	simple	Uses OS Default values
num_cmd_elems	MPIO / non-MPIO	1024 for AIX 3072 for VIOS	FC EN1B, FC EN1C
num_cmd_elems	MPIO / non-MPIO	1024 for AIX	FC EN0G

3. Configure the following settings to optimize I/O operations for FC.

Parameter	AIX versions	AIX OS default value	NetApp recommended value
rw_timeout (disk)	AIX 7.3TL3	NPIV:30 seconds, vSCSI:45 seconds	NPIV:30 seconds, vSCSI:120 seconds
	AIX 7.2TL5	NPIV:30 seconds, vSCSI:45 seconds	NPIV:30 seconds, vSCSI:120 seconds
	VIOS 3.1	30 seconds	30 seconds
	VIOS 4.1	30 seconds	30 seconds

4. Configure the following settings to optimize I/O operations for iSCSI.

Parameter	AIX versions	AIX OS default value	NetApp recommended value
rw_timeout (disk)	AIX 7.3TL3	vSCSI:45 seconds	vSCSI:120 seconds
	AIX 7.2TL5	vSCSI:45 seconds	vSCSI:120 seconds
	VIOS 3.1	120 seconds	30 seconds
	VIOS 4.1	120 seconds	30 seconds
	All AIX7.2 and AIX 7.3 standalone	120 seconds	30 seconds
isw_err_recov (iscsi0)	All AIX7.2 and AIX 7.3 standalone	delayed_fail	fast_fail

5. If your storage configuration includes MetroCluster or SnapMirror active sync, change the default settings:

> **MetroCluster**
>
> By default, the AIX OS enforces a shorter I/O timeout when there are no available paths to a LUN. This might occur in configurations that include single-switch SAN fabric and in MetroCluster configurations that experience unplanned failovers. For additional information and recommended changes to default settings, see the Knowledge Base article What are AIX Host support considerations in a MetroCluster configuration?.
>
> **SnapMirror active sync**
>
> Beginning with ONTAP 9.11.1, SnapMirror active sync is supported for an AIX host. The primary cluster in an AIX configuration is the "active" cluster.
>
> In an AIX configuration, failovers are disruptive. With each failover, you need to perform a re-scan on the host for I/O operations to resume.
>
> Refer to the Knowledge Base article How to configure an AIX host for SnapMirror active sync.

6. Verify the parameter settings and that multiple paths are listed for an ONTAP LUN:

```
lsmpio
```

In the following example for an AFF or FAS system, the PCM is listed for NetApp.

Show example

```
# lsmpio -l hdisk1
name    path_id  status   path_status  parent  connection

hdisk1  0        Enabled  Non          fscsi6
203200a098ba7afe,5b000000000000
hdisk1  1        Enabled  Non          fscsi8
203100a098ba7afe,5b000000000000
hdisk1  2        Enabled  Sel,Opt      fscsi6
203000a098ba7afe,5b000000000000
hdisk1  3        Enabled  Sel,Opt      fscsi8
203800a098ba7afe,5b000000000000
#
lsattr -El hdisk1
PCM             PCM/friend/NetAppDefaultPCM Path Control Module
False
PR_key_value    0x6d0000000002              Persistant Reserve Key
Value           True
algorithm       round_robin                 Algorithm
True
clr_q           no                          Device CLEARS its Queue
on error        True
dist_err_pcnt   0                           Distributed Error Sample
Time            True
dist_tw_width   50                          Distributed Error Sample
Time            True
hcheck_cmd      inquiry                     Health Check Command
True
hcheck_interval 30                          Health Check Interval
True
hcheck_mode     nonactive                   Health Check Mode
True
location                                    Location Label
True
lun_id          0x5b000000000000            Logical Unit Number ID
False
lun_reset_spt   yes                         LUN Level Reset
True
max_transfer    0x100000                    Maximum TRANSFER Size
True
node_name       0x204800a098ba7afe          FC Node Name
False
pvid            none                        Physical volume
identifier                      False
q_err           yes                         Use QERR bit
```

```
True
q_type          simple                          Queuing TYPE
True
qfull_dly       2                               Delay in seconds for
SCSI TASK SET FULL True
queue_depth     64                              Queue DEPTH
True
reassign_to     120                             REASSIGN time out value
True
reserve_policy  PR_shared                       Reserve Policy
True
rw_timeout      30                              READ/WRITE time out
value           True
scsi_id         0xec409                         SCSI ID
False
start_timeout   60                              START unit time out
value           True
timeout_policy  fail_path                       Active/Passive Disk Path
Control Module True
ww_name         0x203200a098ba7afe              FC World Wide Name
False
```

7. Verify the path status for ONTAP LUNs:

```
sanlun lun show
```

The following example outputs show the correct path status for ONTAP LUNs in an ASA, AFF, or FAS configuration.

ASA configurations

An ASA configuration optimizes all paths to a given LUN, keeping them active ("primary"). This improves performance by serving I/O operations through all paths at the same time.

Show example

```
# sanlun lun show -p |grep -p hdisk78
                    ONTAP Path:
vs_aix_clus:/vol/chataix_205p2_vol_en_1_7/jfs_205p2_lun_en
                           LUN: 37
                      LUN Size: 15g
                   Host Device: hdisk78
                          Mode: C
             Multipath Provider: AIX Native
         Multipathing Algorithm: round_robin
------ ------- ------ ------- --------- ----------
host    vserver  AIX                     AIX MPIO
path    path     MPIO   host     vserver    path
state   type     path   adapter  LIF     priority
------ ------- ------ ------- --------- ----------
up      primary  path0  fcs0     fc_aix_1    1
up      primary  path1  fcs0     fc_aix_2    1
up      primary  path2  fcs1     fc_aix_3    1
up      primary  path3  fcs1     fc_aix_4    1
```

AFF or FAS configuration

An AFF or FAS configuration should have two groups of paths with higher and lower priorities. Higher priority Active/Optimized paths are served by the controller where the aggregate is located. Lower priority paths are active but non-optimized because they are served by a different controller. Non-optimized paths are only used when optimized paths aren't available.

The following example displays the correct output for an ONTAP LUN with two Active/Optimized ("primary") paths and two Active/Non-Optimized ("secondary") paths:

Show example

```
# sanlun lun show -p |grep -p hdisk78
                      ONTAP Path:
vs_aix_clus:/vol/chataix_205p2_vol_en_1_7/jfs_205p2_lun_en
                            LUN: 37
                       LUN Size: 15g
                    Host Device: hdisk78
                           Mode: C
             Multipath Provider: AIX Native
          Multipathing Algorithm: round_robin
------- ---------- ------ ------- ---------- ----------
host    vserver    AIX                        AIX MPIO
path    path       MPIO   host    vserver         path
state   type       path   adapter LIF         priority
------- ---------- ------ ------- ---------- ----------
up      secondary  path0  fcs0    fc_aix_1        1
up      primary    path1  fcs0    fc_aix_2        1
up      primary    path2  fcs1    fc_aix_3        1
up      secondary  path3  fcs1    fc_aix_4        1
```

Step 4: Review the known issues

There are no known issues.

What's next?

Learn about using the AIX Host Utilities tool.

Configure AIX 7.2/VIOS 3.1 for FCP and iSCSI with ONTAP storage

The AIX Host Utilities software provides management and diagnostic tools for AIX hosts that are connected to ONTAP storage. When you install the AIX Host Utilities on an AIX 7.2 and/or PowerVM (VIOS 3.1) host, you can use the Host Utilities to help you manage FCP and iSCSI protocol operations with ONTAP LUNs.

Step 1: Optionally, enable SAN booting

You can configure your host to use SAN booting to simplify deployment and improve scalability. If your configuration doesn't support SAN booting, you can use a local boot.

SAN boot

SAN booting is the process of setting up a SAN-attached disk (a LUN) as a boot device for an AIX/PowerVM host host. You can set up a SAN boot LUN to work in a AIX Multipath I/O (MPIO) environment that is using the FC protocol and running AIX Host Utilities with either the FC or FCoE protocol. The method you use to create a SAN boot LUN and install a new OS image in an AIX MPIO environment depends on the protocol that you are using.

Steps

1. Use the Interoperability Matrix Tool to verify that your AIX OS, protocol, and ONTAP version support SAN booting.

2. Follow the best practices for setting up a SAN boot in the vendor documentation.

Local boot

Perform a local boot by installing the AIX OS on the local hard disk, for example, on an SSD, SATA, or RAID.

Step 2: Install the AIX Host Utilities

NetApp strongly recommends installing the AIX Host Utilities to support ONTAP LUN management and assist technical support with gathering configuration data. The MPIO package from the Host Utilities provides MPIO support for AIX and VIOS.

ⓘ   Installing the AIX Host Utilities provides additional timeout settings on your AIX host.

Install AIX Host Utilities 6.1.

Step 3: Confirm the multipath configuration for your host

You can use multipathing with AIX 7.2 and PowerVM to manage ONTAP LUNs.

Multipathing allows you to configure multiple network paths between the host and storage system. If one path fails, traffic continues with the remaining paths. The AIX and PowerVM environments of the Host Utilities use the AIXs native multipathing solution (MPIO).

The Path Control Module (PCM) is responsible for controlling multiple paths for an AIX host. The PCM is a storage vendor supplied code that handles path management and is installed and enabled during the Host Utilities installation.

To ensure that multipathing is configured correctly for your host, verify that you have the NetApp recommended settings configured for your ONTAP LUNs.

1. The AIX Host Utilities load the following parameter settings for ONTAP LUNs.

Show parameter settings

Parameter	Environment	Value for AIX	Note
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hcheck_interval	MPIO	30	Set by Host Utilities
hcheck_mode	MPIO	nonactive	Set by Host Utilities
lun_reset_spt	MPIO / non-MPIO	yes	Set by Host Utilities
max_transfer	MPIO / non-MPIO	FC LUNs: 0x100000 bytes	Set by Host Utilities
qfull_dly	MPIO / non-MPIO	2-second delay	Set by Host Utilities
queue_depth	MPIO / non-MPIO	64	Set by Host Utilities
reserve_policy	MPIO / non-MPIO	no_reserve	Set by Host Utilities
re_timeout (disk)	MPIO / non-MPIO	30 seconds	Uses OS Default values
dyntrk	MPIO / non-MPIO	Yes	Uses OS Default values
fc_err_recov	MPIO / non-MPIO	Fast_fail	Uses OS Default values
q_type	MPIO / non-MPIO	simple	Uses OS Default values
num_cmd_elems	MPIO / non-MPIO	1024 for AIX 3072 for VIOS	FC EN1B, FC EN1C
num_cmd_elems	MPIO / non-MPIO	1024 for AIX	FC EN0G

2. If your storage configuration includes MetroCluster or SnapMirror active sync, change the default settings:

MetroCluster

By default, the AIX OS enforces a shorter I/O timeout when there are no available paths to a LUN. This might occur in configurations that include single-switch SAN fabric and in MetroCluster configurations that experience unplanned failovers. For additional information and recommended changes to default settings, see the Knowledge Base article What are AIX Host support considerations in a MetroCluster configuration?.

SnapMirror active sync

Beginning with ONTAP 9.11.1, SnapMirror active sync is supported for an AIX host. The primary cluster in an AIX configuration is the "active" cluster.

In an AIX configuration, failovers are disruptive. With each failover, you need to perform a re-scan on the host for I/O operations to resume.

Refer to the Knowledge Base article How to configure an AIX host for SnapMirror active sync.

3. Verify the path status for ONTAP LUNs:

```
sanlun lun show
```

The following example outputs show the correct path status for ONTAP LUNs in an ASA, AFF, or FAS configuration.

ASA configurations

An ASA configuration optimizes all paths to a given LUN, keeping them active ("primary"). This improves performance by serving I/O operations through all paths at the same time.

Show example

```
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                          LUN: 37
                     LUN Size: 15g
                  Host Device: hdisk78
                         Mode: C
             Multipath Provider: AIX Native
          Multipathing Algorithm: round_robin
------ ------- ------ ------- --------- ----------
host    vserver  AIX                        AIX MPIO
path    path     MPIO    host     vserver     path
state   type     path    adapter  LIF      priority
------ ------- ------ ------- --------- ----------
up      primary  path0   fcs0     fc_aix_1    1
up      primary  path1   fcs0     fc_aix_2    1
up      primary  path2   fcs1     fc_aix_3    1
up      primary  path3   fcs1     fc_aix_4    1
```

AFF or FAS configuration

An AFF or FAS configuration should have two groups of paths with higher and lower priorities. Higher priority Active/Optimized paths are served by the controller where the aggregate is located. Lower priority paths are active but non-optimized because they are served by a different controller. Non-optimized paths are only used when optimized paths aren't available.

The following example displays the correct output for an ONTAP LUN with two Active/Optimized ("primary") paths and two Active/Non-Optimized ("secondary") paths:

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                        LUN: 37
                   LUN Size: 15g
                Host Device: hdisk78
                       Mode: C
          Multipath Provider: AIX Native
       Multipathing Algorithm: round_robin
------- ---------- ------ ------- ---------- ----------
host    vserver    AIX                       AIX MPIO
path    path       MPIO   host    vserver         path
state   type       path   adapter LIF        priority
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up      primary    path1  fcs0    fc_aix_2        1
up      primary    path2  fcs1    fc_aix_3        1
up      secondary  path3  fcs1    fc_aix_4        1
```

Step 4: Review the known issues

Known issues

The IBM AIX 7.2 and/or PowerVM (VIOS 3.1) with ONTAP storage release has the following known issues:

NetApp Bug ID	Title	Description	Partner ID
1416221	AIX 7200-05-01 encountered I/O disruption on virtual iSCSI disks(VIOS 3.1.1.x) during storage failover	I/O disruption can happen during storage failover operations on AIX 7.2 TL5 hosts on the virtual iSCSI disks mapped through the VIOS 3.1.1.x. By default, the `rw_timeout` value of the virtual iSCSI disks (hdisk) on VIOC will be 45 seconds. If an I/O delay greater than 45 seconds happens during storage failover, an I/O failure might occur. To avoid this situation, refer to the workaround mentioned in the BURT. As per IBM, after applying APAR - IJ34739 (upcoming release) we can dynamically change the rw_timeout value using the `chdev` command.	NA
1414700	AIX 7.2 TL04 encountered I/O disruption on virtual iSCSI disks(VIOS 3.1.1.x) during storage failover	I/O disruption can happen during storage failover operations on AIX 7.2 TL4 hosts on the virtual iSCSI disks mapped through the VIOS 3.1.1.x. By default, the `rw_timeout` value of vSCSI adapter on VIOC is 45 seconds. If an I/O delay of more than 45 seconds happens during a storage failover, I/O failure might occur. To avoid this situation, refer to the workaround mentioned in the BURT.	NA
1307653	I/O issues occur on VIOS 3.1.1.10 during SFO faults and straight I/O	On VIOS 3.1.1, I/O failures might occur on NPIV client disks that are backed by 16 GB or 32 GB FC adapters. Additionally, the `vfchost` driver might stop processing I/O requests from the client. Applying IBM APAR IJ22290 IBM APAR IJ23222 fixes the issue.	NA

What's next?

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Configure AIX 7.1 for FCP and iSCSI with ONTAP storage

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Steps

1. Use the Interoperability Matrix Tool to verify that your AIX OS, protocol, and ONTAP version support SAN booting.

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q_type	MPIO / non-MPIO	simple	Uses OS Default values
num_cmd_elems	MPIO / non-MPIO	1024 for AIX	FC EN1B, FC EN1C
num_cmd_elems	MPIO / non-MPIO	500 for AIX (standalone/physical) 200 for VIOC	FC EN0G

2. If your storage configuration includes MetroCluster or SnapMirror active sync, change the default settings:

MetroCluster

By default, the AIX OS enforces a shorter I/O timeout when there are no available paths to a LUN. This might occur in configurations that include single-switch SAN fabric and in MetroCluster configurations that experience unplanned failovers. For additional information and recommended changes to default settings, see the Knowledge Base article What are AIX Host support considerations in a MetroCluster configuration?.

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3. Verify the path status for ONTAP LUNs:

```
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```

The following example outputs show the correct path status for ONTAP LUNs in an ASA, AFF, or FAS configuration.

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An ASA configuration optimizes all paths to a given LUN, keeping them active ("primary"). This improves performance by serving I/O operations through all paths at the same time.

Show example

```
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                    ONTAP Path:
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                          LUN: 37
                     LUN Size: 15g
                  Host Device: hdisk78
                         Mode: C
            Multipath Provider: AIX Native
         Multipathing Algorithm: round_robin
------ ------- ------ ------- --------- ----------
host    vserver  AIX                        AIX MPIO
path    path     MPIO    host     vserver    path
state   type     path    adapter  LIF        priority
------ ------- ------ ------- --------- ----------
up      primary  path0   fcs0     fc_aix_1    1
up      primary  path1   fcs0     fc_aix_2    1
up      primary  path2   fcs1     fc_aix_3    1
up      primary  path3   fcs1     fc_aix_4    1
```

AFF or FAS configuration

An AFF or FAS configuration should have two groups of paths with higher and lower priorities. Higher priority Active/Optimized paths are served by the controller where the aggregate is located. Lower priority paths are active but non-optimized because they are served by a different controller. Non-optimized paths are only used when optimized paths aren't available.

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Show example

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                  Host Device: hdisk78
                         Mode: C
            Multipath Provider: AIX Native
        Multipathing Algorithm: round_robin
------- ---------- ------ ------- ---------- ----------
host    vserver    AIX                        AIX MPIO
path    path       MPIO   host    vserver         path
state   type       path   adapter LIF        priority
------- ---------- ------ ------- ---------- ----------
up      secondary  path0  fcs0    fc_aix_1        1
up      primary    path1  fcs0    fc_aix_2        1
up      primary    path2  fcs1    fc_aix_3        1
up      secondary  path3  fcs1    fc_aix_4        1
```

Step 4: Review the known issues

The AIX 7.1 with ONTAP storage release has no known issues.

What's next?

Learn about using the AIX Host Utilities tool.

CentOS

CentOS 8

Configure CentOS 8.5 for FCP and iSCSI for ONTAP storage

The Linux Host Utilities software provides management and diagnostic tools for Linux hosts that are connected to ONTAP storage. When you install the Linux Host Utilities on a CentOS 8.5 host, you can use the Host Utilities to help you manage FCP and iSCSI protocol operations with ONTAP LUNs.

ⓘ   You don't need to manually configure Kernel-based Virtual Machine (KVM) settings because ONTAP LUNs are automatically mapped to the hypervisor.

Step 1: Optionally, enable SAN booting

You can configure your host to use SAN booting to simplify deployment and improve scalability.

Before you begin

Use the Interoperability Matrix Tool to verify that your Linux OS, host bus adapter (HBA), HBA firmware, HBA boot BIOS, and ONTAP version support SAN booting.

Steps

1. Create a SAN boot LUN and map it to the host.
2. Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is mapped.

   For information on how to enable the HBA BIOS, see your vendor-specific documentation.

3. Verify that the configuration was successful by rebooting the host and verifying that the OS is up and running.

Step 2: Install the Linux Host Utilities

NetApp strongly recommends installing the Linux Host Utilities to support ONTAP LUN management and assist technical support with gathering configuration data.

Install Linux Host Utilities 8.0.

> ⓘ   Installing the Linux Host Utilities doesn't change any host timeout settings on your Linux host.

Step 3: Confirm the multipath configuration for your host

You can use multipathing with CentOS 8.5 to manage ONTAP LUNs.

To ensure that multipathing is configured correctly for your host, verify that the `/etc/multipath.conf` file is defined and that you have the NetApp recommended settings configured for your ONTAP LUNs.

Steps

1. Verify that the `/etc/multipath.conf` file exits. If the file doesn't exist, create an empty, zero-byte file:

   ```
   touch /etc/multipath.conf
   ```

2. The first time the `multipath.conf` file is created, you might need to enable and start the multipath services to load the recommended settings:

   ```
   chkconfig multipathd on
   ```

   ```
   /etc/init.d/multipathd start
   ```

3. Each time you boot the host, the empty `/etc/multipath.conf` zero-byte file automatically loads the NetApp recommended host multipath parameters as the default settings. You shouldn't need to make changes to the `/etc/multipath.conf` file for your host because the operating system is compiled with

the multipath parameters that recognize and manage ONTAP LUNs correctly.

The following table shows the Linux OS native compiled multipath parameter settings for ONTAP LUNs.

Show parameter settings

Parameter	Setting
detect_prio	yes
dev_loss_tmo	"infinity"
failback	immediate
fast_io_fail_tmo	5
features	"2 pg_init_retries 50"
flush_on_last_del	"yes"
hardware_handler	"0"
no_path_retry	queue
path_checker	"tur"
path_grouping_policy	"group_by_prio"
path_selector	"service-time 0"
polling_interval	5
prio	"ontap"
product	LUN
retain_attached_hw_handler	yes
rr_weight	"uniform"
user_friendly_names	no
vendor	NETAPP

4. Verify the parameter settings and path status for your ONTAP LUNs:

```
multipath -ll
```

The default multipath parameters support ASA, AFF, and FAS configurations. In these configurations, a single ONTAP LUN shouldn't require more than four paths. If there are more than four paths, it might cause issues with the paths during a storage failure.

The following example outputs show the correct parameter settings and path status for ONTAP LUNs in an ASA, AFF, or FAS configuration.

ASA configuration

An ASA configuration optimizes all paths to a given LUN, keeping them active. This improves performance by serving I/O operations through all paths at the same time.

```
multipath -ll
3600a098038303634722b4d59646c4436 dm-28 NETAPP,LUN C-Mode
size=80G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
`-+- policy='service-time 0' prio=50 status=active
  |- 11:0:7:1   sdfi   130:64   active ready running
  |- 11:0:9:1   sdiy  8:288     active ready running
  |- 11:0:10:1  sdml 69:464    active ready running
  |- 11:0:11:1  sdpt  131:304  active ready running
```

AFF or FAS configuration

An AFF or FAS configuration should have two groups of paths with higher and lower priorities. Higher priority Active/Optimized paths are served by the controller where the aggregate is located. Lower priority paths are active but non-optimized because they are served by a different controller. Non-optimized paths are only used when optimized paths aren't available.

The following example displays the output for an ONTAP LUN with two Active/Optimized paths and two Active/Non-Optimized paths:

```
multipath -ll
3600a098038303634722b4d59646c4436 dm-28 NETAPP,LUN C-Mode
size=80G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
|-+- policy='service-time 0' prio=50 status=active
| |- 16:0:6:35 sdwb  69:624  active ready running
| |- 16:0:5:35 sdun  66:752  active ready running
`-+- policy='service-time 0' prio=10 status=enabled
  |- 15:0:0:35 sdaj  66:48   active ready running
  |- 15:0:1:35 sdbx  68:176  active ready running
```

Step 4: Optionally, exclude a device from multipathing

If required, you can exclude a device from multipathing by adding the WWID for the unwanted device to the "blacklist" stanza for the `multipath.conf` file.

Steps

1. Determine the WWID:

```
/lib/udev/scsi_id -gud /dev/sda
```

"sda" is the local SCSI disk that you want to add to the blacklist.

An example WWID is `360030057024d0730239134810c0cb833`.

2. Add the WWID to the "blacklist" stanza:

```
blacklist {
        wwid    360030057024d0730239134810c0cb833
        devnode "^(ram|raw|loop|fd|md|dm-|sr|scd|st)[0-9]*"
        devnode "^hd[a-z]"
        devnode "^cciss.*"
}
```

Step 5: Customize multipath parameters for ONTAP LUNs

If your host is connected to LUNs from other vendors and any of the multipath parameter settings are overridden, you need to correct them by adding stanzas later in the `multipath.conf` file that apply specifically to ONTAP LUNs. If you don't do this, the ONTAP LUNs might not work as expected.

Check your `/etc/multipath.conf` file, especially in the defaults section, for settings that might be overriding the default settings for multipath parameters.

> ⚠️ You shouldn't override the recommended parameter settings for ONTAP LUNs. These settings are required for optimal performance of your host configuration. Contact NetApp support, your OS vendor, or both for more information.

The following example shows how to correct an overridden default. In this example, the `multipath.conf` file defines values for `path_checker` and `no_path_retry` that aren't compatible with ONTAP LUNs, and you can't remove these parameters because ONTAP storage arrays are still attached to the host. Instead, you correct the values for `path_checker` and `no_path_retry` by adding a device stanza to the `multipath.conf` file that applies specifically to the ONTAP LUNs.

Show example

```
defaults {
    path_checker        readsector0
    no_path_retry       fail
}

devices {
    device {
        vendor          "NETAPP"
        product         "LUN"
        no_path_retry   queue
        path_checker    tur
    }
}
```

Step 6: Review the known issues

There are no known issues.

What's next?

- Learn about using the Linux Host Utilities tool.
- Learn about ASM mirroring.

  Automatic Storage Management (ASM) mirroring might require changes to the Linux multipath settings to allow ASM to recognize a problem and switch over to an alternate failure group. Most ASM configurations on ONTAP use external redundancy, which means that data protection is provided by the external array and ASM doesn't mirror data. Some sites use ASM with normal redundancy to provide two-way mirroring, normally across different sites. See Oracle databases on ONTAP for further information.

Configure CentOS 8.4 for FCP and iSCSI for ONTAP storage

The Linux Host Utilities software provides management and diagnostic tools for Linux hosts that are connected to ONTAP storage. When you install the Linux Host Utilities on a CentOS 8.4 host, you can use the Host Utilities to help you manage FCP and iSCSI protocol operations with ONTAP LUNs.

> ⓘ You don't need to manually configure Kernel-based Virtual Machine (KVM) settings because ONTAP LUNs are automatically mapped to the hypervisor.

Step 1: Optionally, enable SAN booting

You can configure your host to use SAN booting to simplify deployment and improve scalability.

Before you begin

Use the Interoperability Matrix Tool to verify that your Linux OS, host bus adapter (HBA), HBA firmware, HBA

boot BIOS, and ONTAP version support SAN booting.

Steps

1. [Create a SAN boot LUN and map it to the host](#).

2. Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is mapped.

   For information on how to enable the HBA BIOS, see your vendor-specific documentation.

3. Verify that the configuration was successful by rebooting the host and verifying that the OS is up and running.

Step 2: Install the Linux Host Utilities

NetApp strongly recommends installing the Linux Host Utilities to support ONTAP LUN management and assist technical support with gathering configuration data.

[Install Linux Host Utilities 8.0](#).

> ⓘ Installing the Linux Host Utilities doesn't change any host timeout settings on your Linux host.

Step 3: Confirm the multipath configuration for your host

You can use multipathing with CentOS 8.4 to manage ONTAP LUNs.

To ensure that multipathing is configured correctly for your host, verify that the `/etc/multipath.conf` file is defined and that you have the NetApp recommended settings configured for your ONTAP LUNs.

Steps

1. Verify that the `/etc/multipath.conf` file exits. If the file doesn't exist, create an empty, zero-byte file:

   ```
   touch /etc/multipath.conf
   ```

2. The first time the `multipath.conf` file is created, you might need to enable and start the multipath services to load the recommended settings:

   ```
   chkconfig multipathd on
   ```

   ```
   /etc/init.d/multipathd start
   ```

3. Each time you boot the host, the empty `/etc/multipath.conf` zero-byte file automatically loads the NetApp recommended host multipath parameters as the default settings. You shouldn't need to make changes to the `/etc/multipath.conf` file for your host because the operating system is compiled with the multipath parameters that recognize and manage ONTAP LUNs correctly.

   The following table shows the Linux OS native compiled multipath parameter settings for ONTAP LUNs.

Show parameter settings

Parameter	Setting
detect_prio	yes
dev_loss_tmo	"infinity"
failback	immediate
fast_io_fail_tmo	5
features	"2 pg_init_retries 50"
flush_on_last_del	"yes"
hardware_handler	"0"
no_path_retry	queue
path_checker	"tur"
path_grouping_policy	"group_by_prio"
path_selector	"service-time 0"
polling_interval	5
prio	"ontap"
product	LUN
retain_attached_hw_handler	yes
rr_weight	"uniform"
user_friendly_names	no
vendor	NETAPP

4. Verify the parameter settings and path status for your ONTAP LUNs:

```
multipath -ll
```

The default multipath parameters support ASA, AFF, and FAS configurations. In these configurations, a single ONTAP LUN shouldn't require more than four paths. If there are more than four paths, it might cause issues with the paths during a storage failure.

The following example outputs show the correct parameter settings and path status for ONTAP LUNs in an ASA, AFF, or FAS configuration.

ASA configuration

An ASA configuration optimizes all paths to a given LUN, keeping them active. This improves performance by serving I/O operations through all paths at the same time.

```
multipath -ll
3600a098038303634722b4d59646c4436 dm-28 NETAPP,LUN C-Mode
size=80G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
`-+- policy='service-time 0' prio=50 status=active
  |- 11:0:7:1    sdfi   130:64   active ready running
  |- 11:0:9:1    sdiy  8:288     active ready running
  |- 11:0:10:1  sdml 69:464     active ready running
  |- 11:0:11:1  sdpt  131:304   active ready running
```

AFF or FAS configuration

An AFF or FAS configuration should have two groups of paths with higher and lower priorities. Higher priority Active/Optimized paths are served by the controller where the aggregate is located. Lower priority paths are active but non-optimized because they are served by a different controller. Non-optimized paths are only used when optimized paths aren't available.

The following example displays the output for an ONTAP LUN with two Active/Optimized paths and two Active/Non-Optimized paths:

```
multipath -ll
3600a098038303634722b4d59646c4436 dm-28 NETAPP,LUN C-Mode
size=80G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
|-+- policy='service-time 0' prio=50 status=active
| |- 16:0:6:35 sdwb  69:624  active ready running
| |- 16:0:5:35 sdun  66:752  active ready running
`-+- policy='service-time 0' prio=10 status=enabled
  |- 15:0:0:35 sdaj  66:48   active ready running
  |- 15:0:1:35 sdbx  68:176  active ready running
```

Step 4: Optionally, exclude a device from multipathing

If required, you can exclude a device from multipathing by adding the WWID for the unwanted device to the "blacklist" stanza for the `multipath.conf` file.

Steps

1. Determine the WWID:

```
/lib/udev/scsi_id -gud /dev/sda
```

"sda" is the local SCSI disk that you want to add to the blacklist.

An example WWID is `360030057024d0730239134810c0cb833`.

2. Add the WWID to the "blacklist" stanza:

```
blacklist {
        wwid    360030057024d0730239134810c0cb833
        devnode "^(ram|raw|loop|fd|md|dm-|sr|scd|st)[0-9]*"
        devnode "^hd[a-z]"
        devnode "^cciss.*"
}
```

Step 5: Customize multipath parameters for ONTAP LUNs

If your host is connected to LUNs from other vendors and any of the multipath parameter settings are overridden, you need to correct them by adding stanzas later in the `multipath.conf` file that apply specifically to ONTAP LUNs. If you don't do this, the ONTAP LUNs might not work as expected.

Check your `/etc/multipath.conf` file, especially in the defaults section, for settings that might be overriding the default settings for multipath parameters.

> ⚠️ You shouldn't override the recommended parameter settings for ONTAP LUNs. These settings are required for optimal performance of your host configuration. Contact NetApp support, your OS vendor, or both for more information.

The following example shows how to correct an overridden default. In this example, the `multipath.conf` file defines values for `path_checker` and `no_path_retry` that aren't compatible with ONTAP LUNs, and you can't remove these parameters because ONTAP storage arrays are still attached to the host. Instead, you correct the values for `path_checker` and `no_path_retry` by adding a device stanza to the `multipath.conf` file that applies specifically to the ONTAP LUNs.

Show example

```
defaults {
    path_checker        readsector0
    no_path_retry       fail
}

devices {
    device {
        vendor          "NETAPP"
        product         "LUN"
        no_path_retry   queue
        path_checker    tur
    }
}
```

Step 6: Review the known issues

There are no known issues.

What's next?

- Learn about using the Linux Host Utilities tool.
- Learn about ASM mirroring.

  Automatic Storage Management (ASM) mirroring might require changes to the Linux multipath settings to allow ASM to recognize a problem and switch over to an alternate failure group. Most ASM configurations on ONTAP use external redundancy, which means that data protection is provided by the external array and ASM doesn't mirror data. Some sites use ASM with normal redundancy to provide two-way mirroring, normally across different sites. See Oracle databases on ONTAP for further information.

Configure CentOS 8.3 for FCP and iSCSI for ONTAP storage

The Linux Host Utilities software provides management and diagnostic tools for Linux hosts that are connected to ONTAP storage. When you install the Linux Host Utilities on a CentOS 8.3 host, you can use the Host Utilities to help you manage FCP and iSCSI protocol operations with ONTAP LUNs.

> ⓘ   You don't need to manually configure Kernel-based Virtual Machine (KVM) settings because ONTAP LUNs are automatically mapped to the hypervisor.

Step 1: Optionally, enable SAN booting

You can configure your host to use SAN booting to simplify deployment and improve scalability.

Before you begin

Use the Interoperability Matrix Tool to verify that your Linux OS, host bus adapter (HBA), HBA firmware, HBA

boot BIOS, and ONTAP version support SAN booting.

Steps

1. [Create a SAN boot LUN and map it to the host](#).

2. Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is mapped.

   For information on how to enable the HBA BIOS, see your vendor-specific documentation.

3. Verify that the configuration was successful by rebooting the host and verifying that the OS is up and running.

Step 2: Install the Linux Host Utilities

NetApp strongly recommends installing the Linux Host Utilities to support ONTAP LUN management and assist technical support with gathering configuration data.

[Install Linux Host Utilities 8.0](#).

> ⓘ Installing the Linux Host Utilities doesn't change any host timeout settings on your Linux host.

Step 3: Confirm the multipath configuration for your host

You can use multipathing with CentOS 8.3 to manage ONTAP LUNs.

To ensure that multipathing is configured correctly for your host, verify that the `/etc/multipath.conf` file is defined and that you have the NetApp recommended settings configured for your ONTAP LUNs.

Steps

1. Verify that the `/etc/multipath.conf` file exits. If the file doesn't exist, create an empty, zero-byte file:

   ```
   touch /etc/multipath.conf
   ```

2. The first time the `multipath.conf` file is created, you might need to enable and start the multipath services to load the recommended settings:

   ```
   chkconfig multipathd on
   ```

   ```
   /etc/init.d/multipathd start
   ```

3. Each time you boot the host, the empty `/etc/multipath.conf` zero-byte file automatically loads the NetApp recommended host multipath parameters as the default settings. You shouldn't need to make changes to the `/etc/multipath.conf` file for your host because the operating system is compiled with the multipath parameters that recognize and manage ONTAP LUNs correctly.

   The following table shows the Linux OS native compiled multipath parameter settings for ONTAP LUNs.

Show parameter settings

Parameter	Setting
detect_prio	yes
dev_loss_tmo	"infinity"
failback	immediate
fast_io_fail_tmo	5
features	"2 pg_init_retries 50"
flush_on_last_del	"yes"
hardware_handler	"0"
no_path_retry	queue
path_checker	"tur"
path_grouping_policy	"group_by_prio"
path_selector	"service-time 0"
polling_interval	5
prio	"ontap"
product	LUN
retain_attached_hw_handler	yes
rr_weight	"uniform"
user_friendly_names	no
vendor	NETAPP

4. Verify the parameter settings and path status for your ONTAP LUNs:

```
multipath -ll
```

The default multipath parameters support ASA, AFF, and FAS configurations. In these configurations, a single ONTAP LUN shouldn't require more than four paths. If there are more than four paths, it might cause issues with the paths during a storage failure.

The following example outputs show the correct parameter settings and path status for ONTAP LUNs in an ASA, AFF, or FAS configuration.

ASA configuration

An ASA configuration optimizes all paths to a given LUN, keeping them active. This improves performance by serving I/O operations through all paths at the same time.

```
multipath -ll
3600a098038303634722b4d59646c4436 dm-28 NETAPP,LUN C-Mode
size=80G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
`-+- policy='service-time 0' prio=50 status=active
  |- 11:0:7:1    sdfi   130:64    active ready running
  |- 11:0:9:1    sdiy  8:288      active ready running
  |- 11:0:10:1  sdml 69:464    active ready running
  |- 11:0:11:1  sdpt   131:304   active ready running
```

AFF or FAS configuration

An AFF or FAS configuration should have two groups of paths with higher and lower priorities. Higher priority Active/Optimized paths are served by the controller where the aggregate is located. Lower priority paths are active but non-optimized because they are served by a different controller. Non-optimized paths are only used when optimized paths aren't available.

The following example displays the output for an ONTAP LUN with two Active/Optimized paths and two Active/Non-Optimized paths:

```
multipath -ll
3600a098038303634722b4d59646c4436 dm-28 NETAPP,LUN C-Mode
size=80G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
|-+- policy='service-time 0' prio=50 status=active
| |- 16:0:6:35 sdwb  69:624  active ready running
| |- 16:0:5:35 sdun  66:752  active ready running
`-+- policy='service-time 0' prio=10 status=enabled
  |- 15:0:0:35 sdaj  66:48    active ready running
  |- 15:0:1:35 sdbx  68:176  active ready running
```

Step 4: Optionally, exclude a device from multipathing

If required, you can exclude a device from multipathing by adding the WWID for the unwanted device to the "blacklist" stanza for the `multipath.conf` file.

Steps

1. Determine the WWID:

```
/lib/udev/scsi_id -gud /dev/sda
```

"sda" is the local SCSI disk that you want to add to the blacklist.

An example WWID is `360030057024d0730239134810c0cb833`.

2. Add the WWID to the "blacklist" stanza:

```
blacklist {
        wwid    360030057024d0730239134810c0cb833
        devnode "^(ram|raw|loop|fd|md|dm-|sr|scd|st)[0-9]*"
        devnode "^hd[a-z]"
        devnode "^cciss.*"
}
```

Step 5: Customize multipath parameters for ONTAP LUNs

If your host is connected to LUNs from other vendors and any of the multipath parameter settings are overridden, you need to correct them by adding stanzas later in the `multipath.conf` file that apply specifically to ONTAP LUNs. If you don't do this, the ONTAP LUNs might not work as expected.

Check your `/etc/multipath.conf` file, especially in the defaults section, for settings that might be overriding the default settings for multipath parameters.

> ⚠ You shouldn't override the recommended parameter settings for ONTAP LUNs. These settings are required for optimal performance of your host configuration. Contact NetApp support, your OS vendor, or both for more information.

The following example shows how to correct an overridden default. In this example, the `multipath.conf` file defines values for `path_checker` and `no_path_retry` that aren't compatible with ONTAP LUNs, and you can't remove these parameters because ONTAP storage arrays are still attached to the host. Instead, you correct the values for `path_checker` and `no_path_retry` by adding a device stanza to the `multipath.conf` file that applies specifically to the ONTAP LUNs.

Show example

```
defaults {
    path_checker        readsector0
    no_path_retry       fail
}

devices {
    device {
        vendor          "NETAPP"
        product         "LUN"
        no_path_retry   queue
        path_checker    tur
    }
}
```

Step 6: Review the known issues

There are no known issues for CentOS 8.3 for FCP and iSCSI with ONTAP storage.

For CentOS Red Hat compatible kernel known issues, see the known issues for Red Hat Enterprise Linux (RHEL) 8.3.

What's next?

- Learn about using the Linux Host Utilities tool.
- Learn about ASM mirroring.

  Automatic Storage Management (ASM) mirroring might require changes to the Linux multipath settings to allow ASM to recognize a problem and switch over to an alternate failure group. Most ASM configurations on ONTAP use external redundancy, which means that data protection is provided by the external array and ASM doesn't mirror data. Some sites use ASM with normal redundancy to provide two-way mirroring, normally across different sites. See Oracle databases on ONTAP for further information.

Configure CentOS 8.2 for FCP and iSCSI for ONTAP storage

The Linux Host Utilities software provides management and diagnostic tools for Linux hosts that are connected to ONTAP storage. When you install the Linux Host Utilities on a CentOS 8.2 host, you can use the Host Utilities to help you manage FCP and iSCSI protocol operations with ONTAP LUNs.

> ⓘ You don't need to manually configure Kernel-based Virtual Machine (KVM) settings because ONTAP LUNs are automatically mapped to the hypervisor.

Step 1: Optionally, enable SAN booting

You can configure your host to use SAN booting to simplify deployment and improve scalability.

Before you begin

Use the Interoperability Matrix Tool to verify that your Linux OS, host bus adapter (HBA), HBA firmware, HBA boot BIOS, and ONTAP version support SAN booting.

Steps

1. Create a SAN boot LUN and map it to the host.

2. Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is mapped.

   For information on how to enable the HBA BIOS, see your vendor-specific documentation.

3. Verify that the configuration was successful by rebooting the host and verifying that the OS is up and running.

Step 2: Install the Linux Host Utilities

NetApp strongly recommends installing the Linux Host Utilities to support ONTAP LUN management and assist technical support with gathering configuration data.

Install Linux Host Utilities 8.0.

> ⓘ | Installing the Linux Host Utilities doesn't change any host timeout settings on your Linux host.

Step 3: Confirm the multipath configuration for your host

You can use multipathing with CentOS 8.2 to manage ONTAP LUNs.

To ensure that multipathing is configured correctly for your host, verify that the `/etc/multipath.conf` file is defined and that you have the NetApp recommended settings configured for your ONTAP LUNs.

Steps

1. Verify that the `/etc/multipath.conf` file exits. If the file doesn't exist, create an empty, zero-byte file:

   ```
   touch /etc/multipath.conf
   ```

2. The first time the `multipath.conf` file is created, you might need to enable and start the multipath services to load the recommended settings:

   ```
   chkconfig multipathd on
   ```

   ```
   /etc/init.d/multipathd start
   ```

3. Each time you boot the host, the empty `/etc/multipath.conf` zero-byte file automatically loads the NetApp recommended host multipath parameters as the default settings. You shouldn't need to make changes to the `/etc/multipath.conf` file for your host because the operating system is compiled with the multipath parameters that recognize and manage ONTAP LUNs correctly.

   The following table shows the Linux OS native compiled multipath parameter settings for ONTAP LUNs.

Show parameter settings

Parameter	Setting
detect_prio	yes
dev_loss_tmo	"infinity"
failback	immediate
fast_io_fail_tmo	5
features	"2 pg_init_retries 50"
flush_on_last_del	"yes"
hardware_handler	"0"
no_path_retry	queue
path_checker	"tur"
path_grouping_policy	"group_by_prio"
path_selector	"service-time 0"
polling_interval	5
prio	"ontap"
product	LUN
retain_attached_hw_handler	yes
rr_weight	"uniform"
user_friendly_names	no
vendor	NETAPP

4. Verify the parameter settings and path status for your ONTAP LUNs:

```
multipath -ll
```

The default multipath parameters support ASA, AFF, and FAS configurations. In these configurations, a single ONTAP LUN shouldn't require more than four paths. If there are more than four paths, it might cause issues with the paths during a storage failure.

The following example outputs show the correct parameter settings and path status for ONTAP LUNs in an ASA, AFF, or FAS configuration.

ASA configuration

An ASA configuration optimizes all paths to a given LUN, keeping them active. This improves performance by serving I/O operations through all paths at the same time.

```
multipath -ll
3600a098038303634722b4d59646c4436 dm-28 NETAPP,LUN C-Mode
size=80G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
`-+- policy='service-time 0' prio=50 status=active
  |- 11:0:7:1   sdfi   130:64   active ready running
  |- 11:0:9:1   sdiy  8:288     active ready running
  |- 11:0:10:1  sdml 69:464   active ready running
  |- 11:0:11:1  sdpt  131:304  active ready running
```

AFF or FAS configuration

An AFF or FAS configuration should have two groups of paths with higher and lower priorities. Higher priority Active/Optimized paths are served by the controller where the aggregate is located. Lower priority paths are active but non-optimized because they are served by a different controller. Non-optimized paths are only used when optimized paths aren't available.

The following example displays the output for an ONTAP LUN with two Active/Optimized paths and two Active/Non-Optimized paths:

```
multipath -ll
3600a098038303634722b4d59646c4436 dm-28 NETAPP,LUN C-Mode
size=80G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
|-+- policy='service-time 0' prio=50 status=active
| |- 16:0:6:35 sdwb  69:624  active ready running
| |- 16:0:5:35 sdun  66:752  active ready running
`-+- policy='service-time 0' prio=10 status=enabled
  |- 15:0:0:35 sdaj  66:48   active ready running
  |- 15:0:1:35 sdbx  68:176  active ready running
```

Step 4: Optionally, exclude a device from multipathing

If required, you can exclude a device from multipathing by adding the WWID for the unwanted device to the "blacklist" stanza for the `multipath.conf` file.

Steps

1. Determine the WWID:

```
/lib/udev/scsi_id -gud /dev/sda
```

"sda" is the local SCSI disk that you want to add to the blacklist.

An example WWID is `360030057024d0730239134810c0cb833`.

2. Add the WWID to the "blacklist" stanza:

```
blacklist {
        wwid    360030057024d0730239134810c0cb833
        devnode "^(ram|raw|loop|fd|md|dm-|sr|scd|st)[0-9]*"
        devnode "^hd[a-z]"
        devnode "^cciss.*"
}
```

Step 5: Customize multipath parameters for ONTAP LUNs

If your host is connected to LUNs from other vendors and any of the multipath parameter settings are overridden, you need to correct them by adding stanzas later in the `multipath.conf` file that apply specifically to ONTAP LUNs. If you don't do this, the ONTAP LUNs might not work as expected.

Check your `/etc/multipath.conf` file, especially in the defaults section, for settings that might be overriding the default settings for multipath parameters.

> ⚠️ You shouldn't override the recommended parameter settings for ONTAP LUNs. These settings are required for optimal performance of your host configuration. Contact NetApp support, your OS vendor, or both for more information.

The following example shows how to correct an overridden default. In this example, the `multipath.conf` file defines values for `path_checker` and `no_path_retry` that aren't compatible with ONTAP LUNs, and you can't remove these parameters because ONTAP storage arrays are still attached to the host. Instead, you correct the values for `path_checker` and `no_path_retry` by adding a device stanza to the `multipath.conf` file that applies specifically to the ONTAP LUNs.

Show example

```
defaults {
    path_checker        readsector0
    no_path_retry       fail
}

devices {
    device {
        vendor          "NETAPP"
        product         "LUN"
        no_path_retry   queue
        path_checker    tur
    }
}
```

Step 6: Review the known issues

There are no known issues for CentOS 8.2 for FCP and iSCSI with ONTAP storage.

For CentOS Red Hat compatible kernel known issues, see the known issues for Red Hat Enterprise Linux (RHEL) 8.2.

What's next?

- Learn about using the Linux Host Utilities tool.
- Learn about ASM mirroring.

  Automatic Storage Management (ASM) mirroring might require changes to the Linux multipath settings to allow ASM to recognize a problem and switch over to an alternate failure group. Most ASM configurations on ONTAP use external redundancy, which means that data protection is provided by the external array and ASM doesn't mirror data. Some sites use ASM with normal redundancy to provide two-way mirroring, normally across different sites. See Oracle databases on ONTAP for further information.

Configure CentOS 8.1 for FCP and iSCSI for ONTAP storage

The Linux Host Utilities software provides management and diagnostic tools for Linux hosts that are connected to ONTAP storage. When you install the Linux Host Utilities on a CentOS 8.1 host, you can use the Host Utilities to help you manage FCP and iSCSI protocol operations with ONTAP LUNs.

> ⓘ You don't need to manually configure Kernel-based Virtual Machine (KVM) settings because ONTAP LUNs are automatically mapped to the hypervisor.

Step 1: Optionally, enable SAN booting

You can configure your host to use SAN booting to simplify deployment and improve scalability.

Before you begin

Use the Interoperability Matrix Tool to verify that your Linux OS, host bus adapter (HBA), HBA firmware, HBA boot BIOS, and ONTAP version support SAN booting.

Steps

1. Create a SAN boot LUN and map it to the host.

2. Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is mapped.

   For information on how to enable the HBA BIOS, see your vendor-specific documentation.

3. Verify that the configuration was successful by rebooting the host and verifying that the OS is up and running.

Step 2: Install the Linux Host Utilities

NetApp strongly recommends installing the Linux Host Utilities to support ONTAP LUN management and assist technical support with gathering configuration data.

Install Linux Host Utilities 8.0.

> (i)   Installing the Linux Host Utilities doesn't change any host timeout settings on your Linux host.

Step 3: Confirm the multipath configuration for your host

You can use multipathing with CentOS 8.1 to manage ONTAP LUNs.

To ensure that multipathing is configured correctly for your host, verify that the `/etc/multipath.conf` file is defined and that you have the NetApp recommended settings configured for your ONTAP LUNs.

Steps

1. Verify that the `/etc/multipath.conf` file exits. If the file doesn't exist, create an empty, zero-byte file:

   ```
   touch /etc/multipath.conf
   ```

2. The first time the `multipath.conf` file is created, you might need to enable and start the multipath services to load the recommended settings:

   ```
   chkconfig multipathd on
   ```

   ```
   /etc/init.d/multipathd start
   ```

3. Each time you boot the host, the empty `/etc/multipath.conf` zero-byte file automatically loads the NetApp recommended host multipath parameters as the default settings. You shouldn't need to make changes to the `/etc/multipath.conf` file for your host because the operating system is compiled with the multipath parameters that recognize and manage ONTAP LUNs correctly.

   The following table shows the Linux OS native compiled multipath parameter settings for ONTAP LUNs.

Show parameter settings

Parameter	Setting
detect_prio	yes
dev_loss_tmo	"infinity"
failback	immediate
fast_io_fail_tmo	5
features	"2 pg_init_retries 50"
flush_on_last_del	"yes"
hardware_handler	"0"
no_path_retry	queue
path_checker	"tur"
path_grouping_policy	"group_by_prio"
path_selector	"service-time 0"
polling_interval	5
prio	"ontap"
product	LUN
retain_attached_hw_handler	yes
rr_weight	"uniform"
user_friendly_names	no
vendor	NETAPP

4. Verify the parameter settings and path status for your ONTAP LUNs:

```
multipath -ll
```

The default multipath parameters support ASA, AFF, and FAS configurations. In these configurations, a single ONTAP LUN shouldn't require more than four paths. If there are more than four paths, it might cause issues with the paths during a storage failure.

The following example outputs show the correct parameter settings and path status for ONTAP LUNs in an ASA, AFF, or FAS configuration.

ASA configuration

An ASA configuration optimizes all paths to a given LUN, keeping them active. This improves performance by serving I/O operations through all paths at the same time.

```
multipath -ll
3600a098038303634722b4d59646c4436 dm-28 NETAPP,LUN C-Mode
size=80G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
`-+- policy='service-time 0' prio=50 status=active
  |- 11:0:7:1    sdfi   130:64    active ready running
  |- 11:0:9:1    sdiy  8:288      active ready running
  |- 11:0:10:1  sdml 69:464    active ready running
  |- 11:0:11:1  sdpt   131:304   active ready running
```

AFF or FAS configuration

An AFF or FAS configuration should have two groups of paths with higher and lower priorities. Higher priority Active/Optimized paths are served by the controller where the aggregate is located. Lower priority paths are active but non-optimized because they are served by a different controller. Non-optimized paths are only used when optimized paths aren't available.

The following example displays the output for an ONTAP LUN with two Active/Optimized paths and two Active/Non-Optimized paths:

```
multipath -ll
3600a098038303634722b4d59646c4436 dm-28 NETAPP,LUN C-Mode
size=80G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
|-+- policy='service-time 0' prio=50 status=active
| |- 16:0:6:35 sdwb  69:624   active ready running
| |- 16:0:5:35 sdun  66:752   active ready running
`-+- policy='service-time 0' prio=10 status=enabled
  |- 15:0:0:35 sdaj  66:48    active ready running
  |- 15:0:1:35 sdbx  68:176   active ready running
```

Step 4: Optionally, exclude a device from multipathing

If required, you can exclude a device from multipathing by adding the WWID for the unwanted device to the "blacklist" stanza for the `multipath.conf` file.

Steps

1. Determine the WWID:

```
/lib/udev/scsi_id -gud /dev/sda
```

"sda" is the local SCSI disk that you want to add to the blacklist.

An example WWID is `360030057024d0730239134810c0cb833`.

2. Add the WWID to the "blacklist" stanza:

```
blacklist {
        wwid    360030057024d0730239134810c0cb833
        devnode "^(ram|raw|loop|fd|md|dm-|sr|scd|st)[0-9]*"
        devnode "^hd[a-z]"
        devnode "^cciss.*"
}
```

Step 5: Customize multipath parameters for ONTAP LUNs

If your host is connected to LUNs from other vendors and any of the multipath parameter settings are overridden, you need to correct them by adding stanzas later in the `multipath.conf` file that apply specifically to ONTAP LUNs. If you don't do this, the ONTAP LUNs might not work as expected.

Check your `/etc/multipath.conf` file, especially in the defaults section, for settings that might be overriding the default settings for multipath parameters.

> ⚠ You shouldn't override the recommended parameter settings for ONTAP LUNs. These settings are required for optimal performance of your host configuration. Contact NetApp support, your OS vendor, or both for more information.

The following example shows how to correct an overridden default. In this example, the `multipath.conf` file defines values for `path_checker` and `no_path_retry` that aren't compatible with ONTAP LUNs, and you can't remove these parameters because ONTAP storage arrays are still attached to the host. Instead, you correct the values for `path_checker` and `no_path_retry` by adding a device stanza to the `multipath.conf` file that applies specifically to the ONTAP LUNs.

Show example

```
defaults {
    path_checker        readsector0
    no_path_retry       fail
}

devices {
    device {
        vendor          "NETAPP"
        product         "LUN"
        no_path_retry   queue
        path_checker    tur
    }
}
```

Step 6: Review the known issues

There are no known issues for CentOS 8.1 for FCP and iSCSI with ONTAP storage.

For CentOS Red Hat compatible kernel known issues, see the known issues for Red Hat Enterprise Linux (RHEL) 8.1.

What's next?

- Learn about using the Linux Host Utilities tool.
- Learn about ASM mirroring.

  Automatic Storage Management (ASM) mirroring might require changes to the Linux multipath settings to allow ASM to recognize a problem and switch over to an alternate failure group. Most ASM configurations on ONTAP use external redundancy, which means that data protection is provided by the external array and ASM doesn't mirror data. Some sites use ASM with normal redundancy to provide two-way mirroring, normally across different sites. See Oracle databases on ONTAP for further information.

Configure CentOS 8.0 for FCP and iSCSI for ONTAP storage

The Linux Host Utilities software provides management and diagnostic tools for Linux hosts that are connected to ONTAP storage. When you install the Linux Host Utilities on a CentOS 8.0 host, you can use the Host Utilities to help you manage FCP and iSCSI protocol operations with ONTAP LUNs.

ⓘ You don't need to manually configure Kernel-based Virtual Machine (KVM) settings because ONTAP LUNs are automatically mapped to the hypervisor.

Step 1: Optionally, enable SAN booting

You can configure your host to use SAN booting to simplify deployment and improve scalability.

Before you begin

Use the Interoperability Matrix Tool to verify that your Linux OS, host bus adapter (HBA), HBA firmware, HBA boot BIOS, and ONTAP version support SAN booting.

Steps

1. Create a SAN boot LUN and map it to the host.

2. Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is mapped.

   For information on how to enable the HBA BIOS, see your vendor-specific documentation.

3. Verify that the configuration was successful by rebooting the host and verifying that the OS is up and running.

Step 2: Install the Linux Host Utilities

NetApp strongly recommends installing the Linux Host Utilities to support ONTAP LUN management and assist technical support with gathering configuration data.

Install Linux Host Utilities 8.0.

> ⓘ   Installing the Linux Host Utilities doesn't change any host timeout settings on your Linux host.

Step 3: Confirm the multipath configuration for your host

You can use multipathing with CentOS 8.0 to manage ONTAP LUNs.

To ensure that multipathing is configured correctly for your host, verify that the `/etc/multipath.conf` file is defined and that you have the NetApp recommended settings configured for your ONTAP LUNs.

Steps

1. Verify that the `/etc/multipath.conf` file exits. If the file doesn't exist, create an empty, zero-byte file:

   ```
   touch /etc/multipath.conf
   ```

2. The first time the `multipath.conf` file is created, you might need to enable and start the multipath services to load the recommended settings:

   ```
   chkconfig multipathd on
   ```

   ```
   /etc/init.d/multipathd start
   ```

3. Each time you boot the host, the empty `/etc/multipath.conf` zero-byte file automatically loads the NetApp recommended host multipath parameters as the default settings. You shouldn't need to make changes to the `/etc/multipath.conf` file for your host because the operating system is compiled with the multipath parameters that recognize and manage ONTAP LUNs correctly.

   The following table shows the Linux OS native compiled multipath parameter settings for ONTAP LUNs.

Show parameter settings

Parameter	Setting
detect_prio	yes
dev_loss_tmo	"infinity"
failback	immediate
fast_io_fail_tmo	5
features	"2 pg_init_retries 50"
flush_on_last_del	"yes"
hardware_handler	"0"
no_path_retry	queue
path_checker	"tur"
path_grouping_policy	"group_by_prio"
path_selector	"service-time 0"
polling_interval	5
prio	"ontap"
product	LUN
retain_attached_hw_handler	yes
rr_weight	"uniform"
user_friendly_names	no
vendor	NETAPP

4. Verify the parameter settings and path status for your ONTAP LUNs:

```
multipath -ll
```

The default multipath parameters support ASA, AFF, and FAS configurations. In these configurations, a single ONTAP LUN shouldn't require more than four paths. If there are more than four paths, it might cause issues with the paths during a storage failure.

The following example outputs show the correct parameter settings and path status for ONTAP LUNs in an ASA, AFF, or FAS configuration.

ASA configuration

An ASA configuration optimizes all paths to a given LUN, keeping them active. This improves performance by serving I/O operations through all paths at the same time.

```
multipath -ll
3600a098038303634722b4d59646c4436 dm-28 NETAPP,LUN C-Mode
size=80G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
`-+- policy='service-time 0' prio=50 status=active
  |- 11:0:7:1    sdfi   130:64    active ready running
  |- 11:0:9:1    sdiy  8:288      active ready running
  |- 11:0:10:1  sdml 69:464    active ready running
  |- 11:0:11:1  sdpt   131:304   active ready running
```

AFF or FAS configuration

An AFF or FAS configuration should have two groups of paths with higher and lower priorities. Higher priority Active/Optimized paths are served by the controller where the aggregate is located. Lower priority paths are active but non-optimized because they are served by a different controller. Non-optimized paths are only used when optimized paths aren't available.

The following example displays the output for an ONTAP LUN with two Active/Optimized paths and two Active/Non-Optimized paths:

```
multipath -ll
3600a098038303634722b4d59646c4436 dm-28 NETAPP,LUN C-Mode
size=80G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
|-+- policy='service-time 0' prio=50 status=active
| |- 16:0:6:35 sdwb   69:624   active ready running
| |- 16:0:5:35 sdun   66:752   active ready running
`-+- policy='service-time 0' prio=10 status=enabled
  |- 15:0:0:35 sdaj   66:48    active ready running
  |- 15:0:1:35 sdbx   68:176   active ready running
```

Step 4: Optionally, exclude a device from multipathing

If required, you can exclude a device from multipathing by adding the WWID for the unwanted device to the "blacklist" stanza for the `multipath.conf` file.

Steps

1. Determine the WWID:

```
/lib/udev/scsi_id -gud /dev/sda
```

"sda" is the local SCSI disk that you want to add to the blacklist.

An example WWID is `360030057024d0730239134810c0cb833`.

2. Add the WWID to the "blacklist" stanza:

```
blacklist {
        wwid    360030057024d0730239134810c0cb833
        devnode "^(ram|raw|loop|fd|md|dm-|sr|scd|st)[0-9]*"
        devnode "^hd[a-z]"
        devnode "^cciss.*"
}
```

Step 5: Customize multipath parameters for ONTAP LUNs

If your host is connected to LUNs from other vendors and any of the multipath parameter settings are overridden, you need to correct them by adding stanzas later in the `multipath.conf` file that apply specifically to ONTAP LUNs. If you don't do this, the ONTAP LUNs might not work as expected.

Check your `/etc/multipath.conf` file, especially in the defaults section, for settings that might be overriding the default settings for multipath parameters.

> (!) You shouldn't override the recommended parameter settings for ONTAP LUNs. These settings are required for optimal performance of your host configuration. Contact NetApp support, your OS vendor, or both for more information.

The following example shows how to correct an overridden default. In this example, the `multipath.conf` file defines values for `path_checker` and `no_path_retry` that aren't compatible with ONTAP LUNs, and you can't remove these parameters because ONTAP storage arrays are still attached to the host. Instead, you correct the values for `path_checker` and `no_path_retry` by adding a device stanza to the `multipath.conf` file that applies specifically to the ONTAP LUNs.

Show example

```
defaults {
    path_checker        readsector0
    no_path_retry       fail
}

devices {
    device {
        vendor          "NETAPP"
        product         "LUN"
        no_path_retry   queue
        path_checker    tur
    }
}
```

Step 6: Review the known issues

There are no known issues for CentOS 8.0 for FCP and iSCSI with ONTAP storage.

For CentOS Red Hat compatible kernel known issues, see the known issues for Red Hat Enterprise Linux (RHEL) 8.0.

What's next?

- Learn about using the Linux Host Utilities tool.
- Learn about ASM mirroring.

  Automatic Storage Management (ASM) mirroring might require changes to the Linux multipath settings to allow ASM to recognize a problem and switch over to an alternate failure group. Most ASM configurations on ONTAP use external redundancy, which means that data protection is provided by the external array and ASM doesn't mirror data. Some sites use ASM with normal redundancy to provide two-way mirroring, normally across different sites. See Oracle databases on ONTAP for further information.

CentOS 7

Configure CentOS 7.9 for FCP and iSCSI for ONTAP storage

The Linux Host Utilities software provides management and diagnostic tools for Linux hosts that are connected to ONTAP storage. When you install the Linux Host Utilities on a CentOS 7.9 host, you can use the Host Utilities to help you manage FCP and iSCSI protocol operations with ONTAP LUNs.

> ⓘ You don't need to manually configure Kernel-based Virtual Machine (KVM) settings because ONTAP LUNs are automatically mapped to the hypervisor.

Step 1: Optionally, enable SAN booting

You can configure your host to use SAN booting to simplify deployment and improve scalability.

Before you begin

Use the Interoperability Matrix Tool to verify that your Linux OS, host bus adapter (HBA), HBA firmware, HBA boot BIOS, and ONTAP version support SAN booting.

Steps

1. Create a SAN boot LUN and map it to the host.

2. Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is mapped.

   For information on how to enable the HBA BIOS, see your vendor-specific documentation.

3. Verify that the configuration was successful by rebooting the host and verifying that the OS is up and running.

Step 2: Install the Linux Host Utilities

NetApp strongly recommends installing the Linux Host Utilities to support ONTAP LUN management and assist technical support with gathering configuration data.

Install Linux Host Utilities 7.1.

> ⓘ   Installing the Linux Host Utilities doesn't change any host timeout settings on your Linux host.

Step 3: Confirm the multipath configuration for your host

You can use multipathing with CentOS 7.9 to manage ONTAP LUNs.

To ensure that multipathing is configured correctly for your host, verify that the `/etc/multipath.conf` file is defined and that you have the NetApp recommended settings configured for your ONTAP LUNs.

Steps

1. Verify that the `/etc/multipath.conf` file exits. If the file doesn't exist, create an empty, zero-byte file:

   ```
   touch /etc/multipath.conf
   ```

2. The first time the `multipath.conf` file is created, you might need to enable and start the multipath services to load the recommended settings:

   ```
   chkconfig multipathd on
   ```

   ```
   /etc/init.d/multipathd start
   ```

3. Each time you boot the host, the empty `/etc/multipath.conf` zero-byte file automatically loads the NetApp recommended host multipath parameters as the default settings. You shouldn't need to make changes to the `/etc/multipath.conf` file for your host because the operating system is compiled with

the multipath parameters that recognize and manage ONTAP LUNs correctly.

The following table shows the Linux OS native compiled multipath parameter settings for ONTAP LUNs.

Show parameter settings

Parameter	Setting
detect_prio	yes
dev_loss_tmo	"infinity"
failback	immediate
fast_io_fail_tmo	5
features	"3 queue_if_no_path pg_init_retries 50"
flush_on_last_del	"yes"
hardware_handler	"0"
no_path_retry	queue
path_checker	"tur"
path_grouping_policy	"group_by_prio"
path_selector	"service-time 0"
polling_interval	5
prio	"ontap"
product	LUN
retain_attached_hw_handler	yes
rr_weight	"uniform"
user_friendly_names	no
vendor	NETAPP

4. Verify the parameter settings and path status for your ONTAP LUNs:

```
multipath -ll
```

The default multipath parameters support ASA, AFF, and FAS configurations. In these configurations, a single ONTAP LUN shouldn't require more than four paths. If there are more than four paths, it might cause issues with the paths during a storage failure.

The following example outputs show the correct parameter settings and path status for ONTAP LUNs in an ASA, AFF, or FAS configuration.

ASA configuration

An ASA configuration optimizes all paths to a given LUN, keeping them active. This improves performance by serving I/O operations through all paths at the same time.

```
multipath -ll
3600a098038303634722b4d59646c4436 dm-28 NETAPP,LUN C-Mode
size=80G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
`-+- policy='service-time 0' prio=50 status=active
  |- 11:0:7:1   sdfi   130:64   active ready running
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  |- 11:0:10:1  sdml 69:464   active ready running
  |- 11:0:11:1  sdpt  131:304  active ready running
```

AFF or FAS configuration

An AFF or FAS configuration should have two groups of paths with higher and lower priorities. Higher priority Active/Optimized paths are served by the controller where the aggregate is located. Lower priority paths are active but non-optimized because they are served by a different controller. Non-optimized paths are only used when optimized paths aren't available.

The following example displays the output for an ONTAP LUN with two Active/Optimized paths and two Active/Non-Optimized paths:

```
multipath -ll
3600a098038303634722b4d59646c4436 dm-28 NETAPP,LUN C-Mode
size=80G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
|-+- policy='service-time 0' prio=50 status=active
| |- 16:0:6:35 sdwb  69:624  active ready running
| |- 16:0:5:35 sdun  66:752  active ready running
`-+- policy='service-time 0' prio=10 status=enabled
  |- 15:0:0:35 sdaj  66:48    active ready running
  |- 15:0:1:35 sdbx  68:176  active ready running
```

Step 4: Optionally, exclude a device from multipathing

If required, you can exclude a device from multipathing by adding the WWID for the unwanted device to the "blacklist" stanza for the `multipath.conf` file.

Steps

1. Determine the WWID:

```
/lib/udev/scsi_id -gud /dev/sda
```

"sda" is the local SCSI disk that you want to add to the blacklist.

An example WWID is `360030057024d0730239134810c0cb833`.

2. Add the WWID to the "blacklist" stanza:

```
blacklist {
        wwid    360030057024d0730239134810c0cb833
        devnode "^(ram|raw|loop|fd|md|dm-|sr|scd|st)[0-9]*"
        devnode "^hd[a-z]"
        devnode "^cciss.*"
}
```

Step 5: Customize multipath parameters for ONTAP LUNs

If your host is connected to LUNs from other vendors and any of the multipath parameter settings are overridden, you need to correct them by adding stanzas later in the `multipath.conf` file that apply specifically to ONTAP LUNs. If you don't do this, the ONTAP LUNs might not work as expected.

Check your `/etc/multipath.conf` file, especially in the defaults section, for settings that might be overriding the default settings for multipath parameters.

> ⚠ You shouldn't override the recommended parameter settings for ONTAP LUNs. These settings are required for optimal performance of your host configuration. Contact NetApp support, your OS vendor, or both for more information.

The following example shows how to correct an overridden default. In this example, the `multipath.conf` file defines values for `path_checker` and `no_path_retry` that aren't compatible with ONTAP LUNs, and you can't remove these parameters because ONTAP storage arrays are still attached to the host. Instead, you correct the values for `path_checker` and `no_path_retry` by adding a device stanza to the `multipath.conf` file that applies specifically to the ONTAP LUNs.

Show example

```
defaults {
    path_checker        readsector0
    no_path_retry       fail
}

devices {
    device {
        vendor          "NETAPP"
        product         "LUN"
        no_path_retry   queue
        path_checker    tur
    }
}
```

Step 6: Review the known issues

The CentOS 7.9 host with ONTAP storage has the following known issues:

NetApp Bug ID	Title	Description
1440718	If you unmap or map a LUN without performing a SCSI rescan, it might lead to data corruption on the host.	When you set the 'disable_changed_wwids' multipath configuration parameter to YES, it disables access to the path device in the event of a WWID change. Multipath will disable access to the path device until the WWID of the path is restored to the WWID of the multipath device. To learn more, see NetApp Knowledge Base: The filesystem corruption on iSCSI LUN on the Oracle Linux 7.

What's next?

- Learn about using the Linux Host Utilities tool.
- Learn about ASM mirroring.

  Automatic Storage Management (ASM) mirroring might require changes to the Linux multipath settings to allow ASM to recognize a problem and switch over to an alternate failure group. Most ASM configurations on ONTAP use external redundancy, which means that data protection is provided by the external array and ASM doesn't mirror data. Some sites use ASM with normal redundancy to provide two-way mirroring, normally across different sites. See Oracle databases on ONTAP for further information.

Configure CentOS 7.8 for FCP and iSCSI for ONTAP storage

The Linux Host Utilities software provides management and diagnostic tools for Linux hosts that are connected to ONTAP storage. When you install the Linux Host Utilities on a CentOS 7.8 host, you can use the Host Utilities to help you manage FCP and iSCSI protocol operations with ONTAP LUNs.

> ⓘ You don't need to manually configure Kernel-based Virtual Machine (KVM) settings because ONTAP LUNs are automatically mapped to the hypervisor.

Step 1: Optionally, enable SAN booting

You can configure your host to use SAN booting to simplify deployment and improve scalability.

Before you begin

Use the Interoperability Matrix Tool to verify that your Linux OS, host bus adapter (HBA), HBA firmware, HBA boot BIOS, and ONTAP version support SAN booting.

Steps

1. Create a SAN boot LUN and map it to the host.

2. Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is mapped.

   For information on how to enable the HBA BIOS, see your vendor-specific documentation.

3. Verify that the configuration was successful by rebooting the host and verifying that the OS is up and running.

Step 2: Install the Linux Host Utilities

NetApp strongly recommends installing the Linux Host Utilities to support ONTAP LUN management and assist technical support with gathering configuration data.

Install Linux Host Utilities 7.1.

> ⓘ Installing the Linux Host Utilities doesn't change any host timeout settings on your Linux host.

Step 3: Confirm the multipath configuration for your host

You can use multipathing with CentOS 7.8 to manage ONTAP LUNs.

To ensure that multipathing is configured correctly for your host, verify that the `/etc/multipath.conf` file is defined and that you have the NetApp recommended settings configured for your ONTAP LUNs.

Steps

1. Verify that the `/etc/multipath.conf` file exits. If the file doesn't exist, create an empty, zero-byte file:

   ```
   touch /etc/multipath.conf
   ```

2. The first time the `multipath.conf` file is created, you might need to enable and start the multipath services to load the recommended settings:

```
chkconfig multipathd on
```

```
/etc/init.d/multipathd start
```

3. Each time you boot the host, the empty `/etc/multipath.conf` zero-byte file automatically loads the NetApp recommended host multipath parameters as the default settings. You shouldn't need to make changes to the `/etc/multipath.conf` file for your host because the operating system is compiled with the multipath parameters that recognize and manage ONTAP LUNs correctly.

The following table shows the Linux OS native compiled multipath parameter settings for ONTAP LUNs.

Show parameter settings

Parameter	Setting
detect_prio	yes
dev_loss_tmo	"infinity"
failback	immediate
fast_io_fail_tmo	5
features	"3 queue_if_no_path pg_init_retries 50"
flush_on_last_del	"yes"
hardware_handler	"0"
no_path_retry	queue
path_checker	"tur"
path_grouping_policy	"group_by_prio"
path_selector	"service-time 0"
polling_interval	5
prio	"ontap"
product	LUN
retain_attached_hw_handler	yes
rr_weight	"uniform"
user_friendly_names	no
vendor	NETAPP

4. Verify the parameter settings and path status for your ONTAP LUNs:

```
multipath -ll
```

The default multipath parameters support ASA, AFF, and FAS configurations. In these configurations, a single ONTAP LUN shouldn't require more than four paths. If there are more than four paths, it might cause issues with the paths during a storage failure.

The following example outputs show the correct parameter settings and path status for ONTAP LUNs in an ASA, AFF, or FAS configuration.

ASA configuration

An ASA configuration optimizes all paths to a given LUN, keeping them active. This improves performance by serving I/O operations through all paths at the same time.

```
multipath -ll
3600a098038303634722b4d59646c4436 dm-28 NETAPP,LUN C-Mode
size=80G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
`-+- policy='service-time 0' prio=50 status=active
  |- 11:0:7:1    sdfi    130:64    active ready running
  |- 11:0:9:1     sdiy  8:288      active ready running
  |- 11:0:10:1  sdml 69:464    active ready running
  |- 11:0:11:1  sdpt   131:304  active ready running
```

AFF or FAS configuration

An AFF or FAS configuration should have two groups of paths with higher and lower priorities. Higher priority Active/Optimized paths are served by the controller where the aggregate is located. Lower priority paths are active but non-optimized because they are served by a different controller. Non-optimized paths are only used when optimized paths aren't available.

The following example displays the output for an ONTAP LUN with two Active/Optimized paths and two Active/Non-Optimized paths:

```
multipath -ll
3600a098038303634722b4d59646c4436 dm-28 NETAPP,LUN C-Mode
size=80G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
|-+- policy='service-time 0' prio=50 status=active
| |- 16:0:6:35 sdwb  69:624  active ready running
| |- 16:0:5:35 sdun  66:752  active ready running
`-+- policy='service-time 0' prio=10 status=enabled
  |- 15:0:0:35 sdaj  66:48    active ready running
  |- 15:0:1:35 sdbx  68:176  active ready running
```

Step 4: Optionally, exclude a device from multipathing

If required, you can exclude a device from multipathing by adding the WWID for the unwanted device to the "blacklist" stanza for the `multipath.conf` file.

Steps

1. Determine the WWID:

   ```
   /lib/udev/scsi_id -gud /dev/sda
   ```

   "sda" is the local SCSI disk that you want to add to the blacklist.

   An example WWID is `360030057024d0730239134810c0cb833`.

2. Add the WWID to the "blacklist" stanza:

   ```
   blacklist {
           wwid    360030057024d0730239134810c0cb833
           devnode "^(ram|raw|loop|fd|md|dm-|sr|scd|st)[0-9]*"
           devnode "^hd[a-z]"
           devnode "^cciss.*"
   }
   ```

Step 5: Customize multipath parameters for ONTAP LUNs

If your host is connected to LUNs from other vendors and any of the multipath parameter settings are overridden, you need to correct them by adding stanzas later in the `multipath.conf` file that apply specifically to ONTAP LUNs. If you don't do this, the ONTAP LUNs might not work as expected.

Check your `/etc/multipath.conf` file, especially in the defaults section, for settings that might be overriding the default settings for multipath parameters.

> ⚠️ You shouldn't override the recommended parameter settings for ONTAP LUNs. These settings are required for optimal performance of your host configuration. Contact NetApp support, your OS vendor, or both for more information.

The following example shows how to correct an overridden default. In this example, the `multipath.conf` file defines values for `path_checker` and `no_path_retry` that aren't compatible with ONTAP LUNs, and you can't remove these parameters because ONTAP storage arrays are still attached to the host. Instead, you correct the values for `path_checker` and `no_path_retry` by adding a device stanza to the `multipath.conf` file that applies specifically to the ONTAP LUNs.

Show example

```
defaults {
    path_checker        readsector0
    no_path_retry       fail
}

devices {
    device {
        vendor          "NETAPP"
        product         "LUN"
        no_path_retry   queue
        path_checker    tur
    }
}
```

Step 6: Review the known issues

The CentOS 7.8 host with ONTAP storage has the following known issues:

NetApp Bug ID	Title	Description
1440718	If you unmap or map a LUN without performing a SCSI rescan, it might lead to data corruption on the host.	When you set the 'disable_changed_wwids' multipath configuration parameter to YES, it disables access to the path device in the event of a WWID change. Multipath will disable access to the path device until the WWID of the path is restored to the WWID of the multipath device. To learn more, see NetApp Knowledge Base: The filesystem corruption on iSCSI LUN on the Oracle Linux 7.

What's next?

- Learn about using the Linux Host Utilities tool.
- Learn about ASM mirroring.

  Automatic Storage Management (ASM) mirroring might require changes to the Linux multipath settings to allow ASM to recognize a problem and switch over to an alternate failure group. Most ASM configurations on ONTAP use external redundancy, which means that data protection is provided by the external array and ASM doesn't mirror data. Some sites use ASM with normal redundancy to provide two-way mirroring, normally across different sites. See Oracle databases on ONTAP for further information.

Configure CentOS 7.7 for FCP and iSCSI for ONTAP storage

The Linux Host Utilities software provides management and diagnostic tools for Linux hosts that are connected to ONTAP storage. When you install the Linux Host Utilities on a CentOS 7.7 host, you can use the Host Utilities to help you manage FCP and iSCSI protocol operations with ONTAP LUNs.

> ⓘ You don't need to manually configure Kernel-based Virtual Machine (KVM) settings because ONTAP LUNs are automatically mapped to the hypervisor.

Step 1: Optionally, enable SAN booting

You can configure your host to use SAN booting to simplify deployment and improve scalability.

Before you begin

Use the Interoperability Matrix Tool to verify that your Linux OS, host bus adapter (HBA), HBA firmware, HBA boot BIOS, and ONTAP version support SAN booting.

Steps

1. Create a SAN boot LUN and map it to the host.

2. Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is mapped.

   For information on how to enable the HBA BIOS, see your vendor-specific documentation.

3. Verify that the configuration was successful by rebooting the host and verifying that the OS is up and running.

Step 2: Install the Linux Host Utilities

NetApp strongly recommends installing the Linux Host Utilities to support ONTAP LUN management and assist technical support with gathering configuration data.

Install Linux Host Utilities 7.1.

> ⓘ Installing the Linux Host Utilities doesn't change any host timeout settings on your Linux host.

Step 3: Confirm the multipath configuration for your host

You can use multipathing with CentOS 7.7 to manage ONTAP LUNs.

To ensure that multipathing is configured correctly for your host, verify that the `/etc/multipath.conf` file is defined and that you have the NetApp recommended settings configured for your ONTAP LUNs.

Steps

1. Verify that the `/etc/multipath.conf` file exits. If the file doesn't exist, create an empty, zero-byte file:

   ```
   touch /etc/multipath.conf
   ```

2. The first time the `multipath.conf` file is created, you might need to enable and start the multipath services to load the recommended settings:

```
chkconfig multipathd on
```

```
/etc/init.d/multipathd start
```

3. Each time you boot the host, the empty `/etc/multipath.conf` zero-byte file automatically loads the NetApp recommended host multipath parameters as the default settings. You shouldn't need to make changes to the `/etc/multipath.conf` file for your host because the operating system is compiled with the multipath parameters that recognize and manage ONTAP LUNs correctly.

The following table shows the Linux OS native compiled multipath parameter settings for ONTAP LUNs.

Show parameter settings

Parameter	Setting
detect_prio	yes
dev_loss_tmo	"infinity"
failback	immediate
fast_io_fail_tmo	5
features	"3 queue_if_no_path pg_init_retries 50"
flush_on_last_del	"yes"
hardware_handler	"0"
no_path_retry	queue
path_checker	"tur"
path_grouping_policy	"group_by_prio"
path_selector	"service-time 0"
polling_interval	5
prio	"ontap"
product	LUN
retain_attached_hw_handler	yes
rr_weight	"uniform"
user_friendly_names	no
vendor	NETAPP

4. Verify the parameter settings and path status for your ONTAP LUNs:

```
multipath -ll
```

The default multipath parameters support ASA, AFF, and FAS configurations. In these configurations, a single ONTAP LUN shouldn't require more than four paths. If there are more than four paths, it might cause issues with the paths during a storage failure.

The following example outputs show the correct parameter settings and path status for ONTAP LUNs in an ASA, AFF, or FAS configuration.

ASA configuration

An ASA configuration optimizes all paths to a given LUN, keeping them active. This improves performance by serving I/O operations through all paths at the same time.

```
multipath -ll
3600a098038303634722b4d59646c4436 dm-28 NETAPP,LUN C-Mode
size=80G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
`-+- policy='service-time 0' prio=50 status=active
  |- 11:0:7:1    sdfi   130:64    active ready running
  |- 11:0:9:1    sdiy  8:288      active ready running
  |- 11:0:10:1  sdml 69:464    active ready running
  |- 11:0:11:1  sdpt   131:304   active ready running
```

AFF or FAS configuration

An AFF or FAS configuration should have two groups of paths with higher and lower priorities. Higher priority Active/Optimized paths are served by the controller where the aggregate is located. Lower priority paths are active but non-optimized because they are served by a different controller. Non-optimized paths are only used when optimized paths aren't available.

The following example displays the output for an ONTAP LUN with two Active/Optimized paths and two Active/Non-Optimized paths:

```
multipath -ll
3600a098038303634722b4d59646c4436 dm-28 NETAPP,LUN C-Mode
size=80G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
|-+- policy='service-time 0' prio=50 status=active
| |- 16:0:6:35 sdwb  69:624  active ready running
| |- 16:0:5:35 sdun  66:752  active ready running
`-+- policy='service-time 0' prio=10 status=enabled
  |- 15:0:0:35 sdaj  66:48    active ready running
  |- 15:0:1:35 sdbx  68:176  active ready running
```

Step 4: Optionally, exclude a device from multipathing

If required, you can exclude a device from multipathing by adding the WWID for the unwanted device to the "blacklist" stanza for the `multipath.conf` file.

Steps

1. Determine the WWID:

```
/lib/udev/scsi_id -gud /dev/sda
```

"sda" is the local SCSI disk that you want to add to the blacklist.

An example WWID is `360030057024d0730239134810c0cb833`.

2. Add the WWID to the "blacklist" stanza:

```
blacklist {
        wwid    360030057024d0730239134810c0cb833
        devnode "^(ram|raw|loop|fd|md|dm-|sr|scd|st)[0-9]*"
        devnode "^hd[a-z]"
        devnode "^cciss.*"
}
```

Step 5: Customize multipath parameters for ONTAP LUNs

If your host is connected to LUNs from other vendors and any of the multipath parameter settings are overridden, you need to correct them by adding stanzas later in the `multipath.conf` file that apply specifically to ONTAP LUNs. If you don't do this, the ONTAP LUNs might not work as expected.

Check your `/etc/multipath.conf` file, especially in the defaults section, for settings that might be overriding the default settings for multipath parameters.

> ⚠️ You shouldn't override the recommended parameter settings for ONTAP LUNs. These settings are required for optimal performance of your host configuration. Contact NetApp support, your OS vendor, or both for more information.

The following example shows how to correct an overridden default. In this example, the `multipath.conf` file defines values for `path_checker` and `no_path_retry` that aren't compatible with ONTAP LUNs, and you can't remove these parameters because ONTAP storage arrays are still attached to the host. Instead, you correct the values for `path_checker` and `no_path_retry` by adding a device stanza to the `multipath.conf` file that applies specifically to the ONTAP LUNs.

Show example

```
defaults {
    path_checker        readsector0
    no_path_retry       fail
}

devices {
    device {
        vendor          "NETAPP"
        product         "LUN"
        no_path_retry   queue
        path_checker    tur
    }
}
```

Step 6: Review the known issues

The CentOS 7.7 host with ONTAP storage has the following known issues:

NetApp Bug ID	Title	Description
1440718	If you unmap or map a LUN without performing a SCSI rescan, it might lead to data corruption on the host.	When you set the 'disable_changed_wwids' multipath configuration parameter to YES, it disables access to the path device in the event of a WWID change. Multipath will disable access to the path device until the WWID of the path is restored to the WWID of the multipath device. To learn more, see NetApp Knowledge Base: The filesystem corruption on iSCSI LUN on the Oracle Linux 7.

What's next?

- Learn about using the Linux Host Utilities tool.
- Learn about ASM mirroring.

  Automatic Storage Management (ASM) mirroring might require changes to the Linux multipath settings to allow ASM to recognize a problem and switch over to an alternate failure group. Most ASM configurations on ONTAP use external redundancy, which means that data protection is provided by the external array and ASM doesn't mirror data. Some sites use ASM with normal redundancy to provide two-way mirroring, normally across different sites. See Oracle databases on ONTAP for further information.

Configure CentOS 7.6 for FCP and iSCSI for ONTAP storage

The Linux Host Utilities software provides management and diagnostic tools for Linux hosts that are connected to ONTAP storage. When you install the Linux Host Utilities on a CentOS 7.6 host, you can use the Host Utilities to help you manage FCP and iSCSI protocol operations with ONTAP LUNs.

> ⓘ You don't need to manually configure Kernel-based Virtual Machine (KVM) settings because ONTAP LUNs are automatically mapped to the hypervisor.

Step 1: Optionally, enable SAN booting

You can configure your host to use SAN booting to simplify deployment and improve scalability.

Before you begin

Use the Interoperability Matrix Tool to verify that your Linux OS, host bus adapter (HBA), HBA firmware, HBA boot BIOS, and ONTAP version support SAN booting.

Steps

1. Create a SAN boot LUN and map it to the host.

2. Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is mapped.

   For information on how to enable the HBA BIOS, see your vendor-specific documentation.

3. Verify that the configuration was successful by rebooting the host and verifying that the OS is up and running.

Step 2: Install the Linux Host Utilities

NetApp strongly recommends installing the Linux Host Utilities to support ONTAP LUN management and assist technical support with gathering configuration data.

Install Linux Host Utilities 7.1.

> ⓘ Installing the Linux Host Utilities doesn't change any host timeout settings on your Linux host.

Step 3: Confirm the multipath configuration for your host

You can use multipathing with CentOS 7.6 to manage ONTAP LUNs.

To ensure that multipathing is configured correctly for your host, verify that the `/etc/multipath.conf` file is defined and that you have the NetApp recommended settings configured for your ONTAP LUNs.

Steps

1. Verify that the `/etc/multipath.conf` file exits. If the file doesn't exist, create an empty, zero-byte file:

   ```
   touch /etc/multipath.conf
   ```

2. The first time the `multipath.conf` file is created, you might need to enable and start the multipath services to load the recommended settings:

```
chkconfig multipathd on
```

```
/etc/init.d/multipathd start
```

3. Each time you boot the host, the empty `/etc/multipath.conf` zero-byte file automatically loads the NetApp recommended host multipath parameters as the default settings. You shouldn't need to make changes to the `/etc/multipath.conf` file for your host because the operating system is compiled with the multipath parameters that recognize and manage ONTAP LUNs correctly.

The following table shows the Linux OS native compiled multipath parameter settings for ONTAP LUNs.

Show parameter settings

Parameter	Setting
detect_prio	yes
dev_loss_tmo	"infinity"
failback	immediate
fast_io_fail_tmo	5
features	"3 queue_if_no_path pg_init_retries 50"
flush_on_last_del	"yes"
hardware_handler	"0"
no_path_retry	queue
path_checker	"tur"
path_grouping_policy	"group_by_prio"
path_selector	"service-time 0"
polling_interval	5
prio	"ontap"
product	LUN
retain_attached_hw_handler	yes
rr_weight	"uniform"
user_friendly_names	no
vendor	NETAPP

4. Verify the parameter settings and path status for your ONTAP LUNs:

```
multipath -ll
```

The default multipath parameters support ASA, AFF, and FAS configurations. In these configurations, a single ONTAP LUN shouldn't require more than four paths. If there are more than four paths, it might cause issues with the paths during a storage failure.

The following example outputs show the correct parameter settings and path status for ONTAP LUNs in an ASA, AFF, or FAS configuration.

ASA configuration

An ASA configuration optimizes all paths to a given LUN, keeping them active. This improves performance by serving I/O operations through all paths at the same time.

```
multipath -ll
3600a098038303634722b4d59646c4436 dm-28 NETAPP,LUN C-Mode
size=80G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
`-+- policy='service-time 0' prio=50 status=active
  |- 11:0:7:1    sdfi    130:64    active ready running
  |- 11:0:9:1     sdiy  8:288      active ready running
  |- 11:0:10:1  sdml 69:464    active ready running
  |- 11:0:11:1  sdpt   131:304  active ready running
```

AFF or FAS configuration

An AFF or FAS configuration should have two groups of paths with higher and lower priorities. Higher priority Active/Optimized paths are served by the controller where the aggregate is located. Lower priority paths are active but non-optimized because they are served by a different controller. Non-optimized paths are only used when optimized paths aren't available.

The following example displays the output for an ONTAP LUN with two Active/Optimized paths and two Active/Non-Optimized paths:

```
multipath -ll
3600a098038303634722b4d59646c4436 dm-28 NETAPP,LUN C-Mode
size=80G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
|-+- policy='service-time 0' prio=50 status=active
| |- 16:0:6:35 sdwb  69:624  active ready running
| |- 16:0:5:35 sdun  66:752  active ready running
`-+- policy='service-time 0' prio=10 status=enabled
  |- 15:0:0:35 sdaj  66:48    active ready running
  |- 15:0:1:35 sdbx  68:176  active ready running
```

Step 4: Optionally, exclude a device from multipathing

If required, you can exclude a device from multipathing by adding the WWID for the unwanted device to the "blacklist" stanza for the `multipath.conf` file.

Steps

1. Determine the WWID:

```
/lib/udev/scsi_id -gud /dev/sda
```

"sda" is the local SCSI disk that you want to add to the blacklist.

An example WWID is `360030057024d0730239134810c0cb833`.

2. Add the WWID to the "blacklist" stanza:

```
blacklist {
        wwid    360030057024d0730239134810c0cb833
        devnode "^(ram|raw|loop|fd|md|dm-|sr|scd|st)[0-9]*"
        devnode "^hd[a-z]"
        devnode "^cciss.*"
}
```

Step 5: Customize multipath parameters for ONTAP LUNs

If your host is connected to LUNs from other vendors and any of the multipath parameter settings are overridden, you need to correct them by adding stanzas later in the `multipath.conf` file that apply specifically to ONTAP LUNs. If you don't do this, the ONTAP LUNs might not work as expected.

Check your `/etc/multipath.conf` file, especially in the defaults section, for settings that might be overriding the default settings for multipath parameters.

> ⚠ You shouldn't override the recommended parameter settings for ONTAP LUNs. These settings are required for optimal performance of your host configuration. Contact NetApp support, your OS vendor, or both for more information.

The following example shows how to correct an overridden default. In this example, the `multipath.conf` file defines values for `path_checker` and `no_path_retry` that aren't compatible with ONTAP LUNs, and you can't remove these parameters because ONTAP storage arrays are still attached to the host. Instead, you correct the values for `path_checker` and `no_path_retry` by adding a device stanza to the `multipath.conf` file that applies specifically to the ONTAP LUNs.

Show example

```
defaults {
    path_checker        readsector0
    no_path_retry       fail
}

devices {
    device {
        vendor          "NETAPP"
        product         "LUN"
        no_path_retry   queue
        path_checker    tur
    }
}
```

Step 6: Review the known issues

The CentOS 7.6 host with ONTAP storage has the following known issues:

NetApp Bug ID	Title	Description
1440718	If you unmap or map a LUN without performing a SCSI rescan, it might lead to data corruption on the host.	When you set the 'disable_changed_wwids' multipath configuration parameter to YES, it disables access to the path device in the event of a WWID change. Multipath will disable access to the path device until the WWID of the path is restored to the WWID of the multipath device. To learn more, see NetApp Knowledge Base: The filesystem corruption on iSCSI LUN on the Oracle Linux 7.

What's next?

- Learn about using the Linux Host Utilities tool.
- Learn about ASM mirroring.

  Automatic Storage Management (ASM) mirroring might require changes to the Linux multipath settings to allow ASM to recognize a problem and switch over to an alternate failure group. Most ASM configurations on ONTAP use external redundancy, which means that data protection is provided by the external array and ASM doesn't mirror data. Some sites use ASM with normal redundancy to provide two-way mirroring, normally across different sites. See Oracle databases on ONTAP for further information.

Configure CentOS 7.5 for FCP and iSCSI for ONTAP storage

The Linux Host Utilities software provides management and diagnostic tools for Linux hosts that are connected to ONTAP storage. When you install the Linux Host Utilities on a CentOS 7.5 host, you can use the Host Utilities to help you manage FCP and iSCSI protocol operations with ONTAP LUNs.

> ⓘ You don't need to manually configure Kernel-based Virtual Machine (KVM) settings because ONTAP LUNs are automatically mapped to the hypervisor.

Step 1: Optionally, enable SAN booting

You can configure your host to use SAN booting to simplify deployment and improve scalability.

Before you begin

Use the Interoperability Matrix Tool to verify that your Linux OS, host bus adapter (HBA), HBA firmware, HBA boot BIOS, and ONTAP version support SAN booting.

Steps

1. Create a SAN boot LUN and map it to the host.

2. Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is mapped.

   For information on how to enable the HBA BIOS, see your vendor-specific documentation.

3. Verify that the configuration was successful by rebooting the host and verifying that the OS is up and running.

Step 2: Install the Linux Host Utilities

NetApp strongly recommends installing the Linux Host Utilities to support ONTAP LUN management and assist technical support with gathering configuration data.

Install Linux Host Utilities 7.1.

> ⓘ Installing the Linux Host Utilities doesn't change any host timeout settings on your Linux host.

Step 3: Confirm the multipath configuration for your host

You can use multipathing with CentOS 7.5 to manage ONTAP LUNs.

To ensure that multipathing is configured correctly for your host, verify that the `/etc/multipath.conf` file is defined and that you have the NetApp recommended settings configured for your ONTAP LUNs.

Steps

1. Verify that the `/etc/multipath.conf` file exits. If the file doesn't exist, create an empty, zero-byte file:

   ```
   touch /etc/multipath.conf
   ```

2. The first time the `multipath.conf` file is created, you might need to enable and start the multipath services to load the recommended settings:

```
chkconfig multipathd on
```

```
/etc/init.d/multipathd start
```

3. Each time you boot the host, the empty `/etc/multipath.conf` zero-byte file automatically loads the NetApp recommended host multipath parameters as the default settings. You shouldn't need to make changes to the `/etc/multipath.conf` file for your host because the operating system is compiled with the multipath parameters that recognize and manage ONTAP LUNs correctly.

The following table shows the Linux OS native compiled multipath parameter settings for ONTAP LUNs.

Show parameter settings

Parameter	Setting
detect_prio	yes
dev_loss_tmo	"infinity"
failback	immediate
fast_io_fail_tmo	5
features	"3 queue_if_no_path pg_init_retries 50"
flush_on_last_del	"yes"
hardware_handler	"0"
no_path_retry	queue
path_checker	"tur"
path_grouping_policy	"group_by_prio"
path_selector	"service-time 0"
polling_interval	5
prio	"ontap"
product	LUN
retain_attached_hw_handler	yes
rr_weight	"uniform"
user_friendly_names	no
vendor	NETAPP

4. Verify the parameter settings and path status for your ONTAP LUNs:

```
multipath -ll
```

The default multipath parameters support ASA, AFF, and FAS configurations. In these configurations, a single ONTAP LUN shouldn't require more than four paths. If there are more than four paths, it might cause issues with the paths during a storage failure.

The following example outputs show the correct parameter settings and path status for ONTAP LUNs in an ASA, AFF, or FAS configuration.

ASA configuration

An ASA configuration optimizes all paths to a given LUN, keeping them active. This improves performance by serving I/O operations through all paths at the same time.

```
multipath -ll
3600a098038303634722b4d59646c4436 dm-28 NETAPP,LUN C-Mode
size=80G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
`-+- policy='service-time 0' prio=50 status=active
  |- 11:0:7:1    sdfi    130:64    active ready running
  |- 11:0:9:1     sdiy  8:288      active ready running
  |- 11:0:10:1  sdml 69:464    active ready running
  |- 11:0:11:1  sdpt   131:304  active ready running
```

AFF or FAS configuration

An AFF or FAS configuration should have two groups of paths with higher and lower priorities. Higher priority Active/Optimized paths are served by the controller where the aggregate is located. Lower priority paths are active but non-optimized because they are served by a different controller. Non-optimized paths are only used when optimized paths aren't available.

The following example displays the output for an ONTAP LUN with two Active/Optimized paths and two Active/Non-Optimized paths:

```
multipath -ll
3600a098038303634722b4d59646c4436 dm-28 NETAPP,LUN C-Mode
size=80G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
|-+- policy='service-time 0' prio=50 status=active
| |- 16:0:6:35 sdwb  69:624  active ready running
| |- 16:0:5:35 sdun  66:752  active ready running
`-+- policy='service-time 0' prio=10 status=enabled
  |- 15:0:0:35 sdaj  66:48    active ready running
  |- 15:0:1:35 sdbx  68:176  active ready running
```

Step 4: Optionally, exclude a device from multipathing

If required, you can exclude a device from multipathing by adding the WWID for the unwanted device to the "blacklist" stanza for the `multipath.conf` file.

Steps

1. Determine the WWID:

```
/lib/udev/scsi_id -gud /dev/sda
```

"sda" is the local SCSI disk that you want to add to the blacklist.

An example WWID is `360030057024d0730239134810c0cb833`.

2. Add the WWID to the "blacklist" stanza:

```
blacklist {
        wwid    360030057024d0730239134810c0cb833
        devnode "^(ram|raw|loop|fd|md|dm-|sr|scd|st)[0-9]*"
        devnode "^hd[a-z]"
        devnode "^cciss.*"
}
```

Step 5: Customize multipath parameters for ONTAP LUNs

If your host is connected to LUNs from other vendors and any of the multipath parameter settings are overridden, you need to correct them by adding stanzas later in the `multipath.conf` file that apply specifically to ONTAP LUNs. If you don't do this, the ONTAP LUNs might not work as expected.

Check your `/etc/multipath.conf` file, especially in the defaults section, for settings that might be overriding the default settings for multipath parameters.

> ⚠️ You shouldn't override the recommended parameter settings for ONTAP LUNs. These settings are required for optimal performance of your host configuration. Contact NetApp support, your OS vendor, or both for more information.

The following example shows how to correct an overridden default. In this example, the `multipath.conf` file defines values for `path_checker` and `no_path_retry` that aren't compatible with ONTAP LUNs, and you can't remove these parameters because ONTAP storage arrays are still attached to the host. Instead, you correct the values for `path_checker` and `no_path_retry` by adding a device stanza to the `multipath.conf` file that applies specifically to the ONTAP LUNs.

Show example

```
defaults {
    path_checker       readsector0
    no_path_retry      fail
}

devices {
    device {
        vendor           "NETAPP"
        product          "LUN"
        no_path_retry    queue
        path_checker     tur
    }
}
```

Step 6: Review the known issues

The CentOS 7.5 host with ONTAP storage has the following known issues:

NetApp Bug ID	Title	Description
1440718	If you unmap or map a LUN without performing a SCSI rescan, it might lead to data corruption on the host.	When you set the 'disable_changed_wwids' multipath configuration parameter to YES, it disables access to the path device in the event of a WWID change. Multipath will disable access to the path device until the WWID of the path is restored to the WWID of the multipath device. To learn more, see NetApp Knowledge Base: The filesystem corruption on iSCSI LUN on the Oracle Linux 7.

What's next?

- Learn about using the Linux Host Utilities tool.
- Learn about ASM mirroring.

  Automatic Storage Management (ASM) mirroring might require changes to the Linux multipath settings to allow ASM to recognize a problem and switch over to an alternate failure group. Most ASM configurations on ONTAP use external redundancy, which means that data protection is provided by the external array and ASM doesn't mirror data. Some sites use ASM with normal redundancy to provide two-way mirroring, normally across different sites. See Oracle databases on ONTAP for further information.

Configure CentOS 7.4 for FCP and iSCSI for ONTAP storage

The Linux Host Utilities software provides management and diagnostic tools for Linux hosts that are connected to ONTAP storage. When you install the Linux Host Utilities on a CentOS 7.4 host, you can use the Host Utilities to help you manage FCP and iSCSI protocol operations with ONTAP LUNs.

> ⓘ You don't need to manually configure Kernel-based Virtual Machine (KVM) settings because ONTAP LUNs are automatically mapped to the hypervisor.

Step 1: Optionally, enable SAN booting

You can configure your host to use SAN booting to simplify deployment and improve scalability.

Before you begin

Use the Interoperability Matrix Tool to verify that your Linux OS, host bus adapter (HBA), HBA firmware, HBA boot BIOS, and ONTAP version support SAN booting.

Steps

1. Create a SAN boot LUN and map it to the host.

2. Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is mapped.

   For information on how to enable the HBA BIOS, see your vendor-specific documentation.

3. Verify that the configuration was successful by rebooting the host and verifying that the OS is up and running.

Step 2: Install the Linux Host Utilities

NetApp strongly recommends installing the Linux Host Utilities to support ONTAP LUN management and assist technical support with gathering configuration data.

Install Linux Host Utilities 7.1.

> ⓘ Installing the Linux Host Utilities doesn't change any host timeout settings on your Linux host.

Step 3: Confirm the multipath configuration for your host

You can use multipathing with CentOS 7.4 to manage ONTAP LUNs.

To ensure that multipathing is configured correctly for your host, verify that the `/etc/multipath.conf` file is defined and that you have the NetApp recommended settings configured for your ONTAP LUNs.

Steps

1. Verify that the `/etc/multipath.conf` file exits. If the file doesn't exist, create an empty, zero-byte file:

   ```
   touch /etc/multipath.conf
   ```

2. The first time the `multipath.conf` file is created, you might need to enable and start the multipath services to load the recommended settings:

```
chkconfig multipathd on
```

```
/etc/init.d/multipathd start
```

3. Each time you boot the host, the empty `/etc/multipath.conf` zero-byte file automatically loads the NetApp recommended host multipath parameters as the default settings. You shouldn't need to make changes to the `/etc/multipath.conf` file for your host because the operating system is compiled with the multipath parameters that recognize and manage ONTAP LUNs correctly.

The following table shows the Linux OS native compiled multipath parameter settings for ONTAP LUNs.

Show parameter settings

Parameter	Setting
detect_prio	yes
dev_loss_tmo	"infinity"
failback	immediate
fast_io_fail_tmo	5
features	"3 queue_if_no_path pg_init_retries 50"
flush_on_last_del	"yes"
hardware_handler	"0"
no_path_retry	queue
path_checker	"tur"
path_grouping_policy	"group_by_prio"
path_selector	"service-time 0"
polling_interval	5
prio	"ontap"
product	LUN
retain_attached_hw_handler	yes
rr_weight	"uniform"
user_friendly_names	no
vendor	NETAPP

4. Verify the parameter settings and path status for your ONTAP LUNs:

```
multipath -ll
```

The default multipath parameters support ASA, AFF, and FAS configurations. In these configurations, a single ONTAP LUN shouldn't require more than four paths. If there are more than four paths, it might cause issues with the paths during a storage failure.

The following example outputs show the correct parameter settings and path status for ONTAP LUNs in an ASA, AFF, or FAS configuration.

ASA configuration

An ASA configuration optimizes all paths to a given LUN, keeping them active. This improves performance by serving I/O operations through all paths at the same time.

```
multipath -ll
3600a098038303634722b4d59646c4436 dm-28 NETAPP,LUN C-Mode
size=80G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
`-+- policy='service-time 0' prio=50 status=active
  |- 11:0:7:1    sdfi   130:64    active ready running
  |- 11:0:9:1    sdiy  8:288      active ready running
  |- 11:0:10:1  sdml 69:464    active ready running
  |- 11:0:11:1  sdpt  131:304  active ready running
```

AFF or FAS configuration

An AFF or FAS configuration should have two groups of paths with higher and lower priorities. Higher priority Active/Optimized paths are served by the controller where the aggregate is located. Lower priority paths are active but non-optimized because they are served by a different controller. Non-optimized paths are only used when optimized paths aren't available.

The following example displays the output for an ONTAP LUN with two Active/Optimized paths and two Active/Non-Optimized paths:

```
multipath -ll
3600a098038303634722b4d59646c4436 dm-28 NETAPP,LUN C-Mode
size=80G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
|-+- policy='service-time 0' prio=50 status=active
| |- 16:0:6:35 sdwb  69:624  active ready running
| |- 16:0:5:35 sdun  66:752  active ready running
`-+- policy='service-time 0' prio=10 status=enabled
  |- 15:0:0:35 sdaj  66:48    active ready running
  |- 15:0:1:35 sdbx  68:176  active ready running
```

Step 4: Optionally, exclude a device from multipathing

If required, you can exclude a device from multipathing by adding the WWID for the unwanted device to the "blacklist" stanza for the `multipath.conf` file.

Steps

1. Determine the WWID:

   ```
   /lib/udev/scsi_id -gud /dev/sda
   ```

   "sda" is the local SCSI disk that you want to add to the blacklist.

   An example WWID is `360030057024d0730239134810c0cb833`.

2. Add the WWID to the "blacklist" stanza:

   ```
   blacklist {
           wwid    360030057024d0730239134810c0cb833
           devnode "^(ram|raw|loop|fd|md|dm-|sr|scd|st)[0-9]*"
           devnode "^hd[a-z]"
           devnode "^cciss.*"
   }
   ```

Step 5: Customize multipath parameters for ONTAP LUNs

If your host is connected to LUNs from other vendors and any of the multipath parameter settings are overridden, you need to correct them by adding stanzas later in the `multipath.conf` file that apply specifically to ONTAP LUNs. If you don't do this, the ONTAP LUNs might not work as expected.

Check your `/etc/multipath.conf` file, especially in the defaults section, for settings that might be overriding the default settings for multipath parameters.

> ⚠️ You shouldn't override the recommended parameter settings for ONTAP LUNs. These settings are required for optimal performance of your host configuration. Contact NetApp support, your OS vendor, or both for more information.

The following example shows how to correct an overridden default. In this example, the `multipath.conf` file defines values for `path_checker` and `no_path_retry` that aren't compatible with ONTAP LUNs, and you can't remove these parameters because ONTAP storage arrays are still attached to the host. Instead, you correct the values for `path_checker` and `no_path_retry` by adding a device stanza to the `multipath.conf` file that applies specifically to the ONTAP LUNs.

Show example

```
defaults {
    path_checker        readsector0
    no_path_retry       fail
}

devices {
    device {
        vendor          "NETAPP"
        product         "LUN"
        no_path_retry   queue
        path_checker    tur
    }
}
```

Step 6: Review the known issues

The CentOS 7.4 host with ONTAP storage has the following known issues:

NetApp Bug ID	Title	Description
1440718	If you unmap or map a LUN without performing a SCSI rescan, it might lead to data corruption on the host.	When you set the 'disable_changed_wwids' multipath configuration parameter to YES, it disables access to the path device in the event of a WWID change. Multipath will disable access to the path device until the WWID of the path is restored to the WWID of the multipath device. To learn more, see NetApp Knowledge Base: The filesystem corruption on iSCSI LUN on the Oracle Linux 7.

What's next?

- Learn about using the Linux Host Utilities tool.
- Learn about ASM mirroring.

  Automatic Storage Management (ASM) mirroring might require changes to the Linux multipath settings to allow ASM to recognize a problem and switch over to an alternate failure group. Most ASM configurations on ONTAP use external redundancy, which means that data protection is provided by the external array and ASM doesn't mirror data. Some sites use ASM with normal redundancy to provide two-way mirroring, normally across different sites. See Oracle databases on ONTAP for further information.

Configure CentOS 7.3 for FCP and iSCSI for ONTAP storage

The Linux Host Utilities software provides management and diagnostic tools for Linux hosts that are connected to ONTAP storage. When you install the Linux Host Utilities on a CentOS 7.3 host, you can use the Host Utilities to help you manage FCP and iSCSI protocol operations with ONTAP LUNs.

ⓘ You don't need to manually configure Kernel-based Virtual Machine (KVM) settings because ONTAP LUNs are automatically mapped to the hypervisor.

Step 1: Optionally, enable SAN booting

You can configure your host to use SAN booting to simplify deployment and improve scalability.

Before you begin

Use the Interoperability Matrix Tool to verify that your Linux OS, host bus adapter (HBA), HBA firmware, HBA boot BIOS, and ONTAP version support SAN booting.

Steps

1. Create a SAN boot LUN and map it to the host.

2. Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is mapped.

   For information on how to enable the HBA BIOS, see your vendor-specific documentation.

3. Verify that the configuration was successful by rebooting the host and verifying that the OS is up and running.

Step 2: Install the Linux Host Utilities

NetApp strongly recommends installing the Linux Host Utilities to support ONTAP LUN management and assist technical support with gathering configuration data.

Install Linux Host Utilities 7.1.

ⓘ Installing the Linux Host Utilities doesn't change any host timeout settings on your Linux host.

Step 3: Confirm the multipath configuration for your host

You can use multipathing with CentOS 7.3 to manage ONTAP LUNs.

To ensure that multipathing is configured correctly for your host, verify that the `/etc/multipath.conf` file is defined and that you have the NetApp recommended settings configured for your ONTAP LUNs.

Steps

1. Verify that the `/etc/multipath.conf` file exits. If the file doesn't exist, create an empty, zero-byte file:

   ```
   touch /etc/multipath.conf
   ```

2. The first time the `multipath.conf` file is created, you might need to enable and start the multipath services to load the recommended settings:

```
chkconfig multipathd on
```

```
/etc/init.d/multipathd start
```

3. Each time you boot the host, the empty `/etc/multipath.conf` zero-byte file automatically loads the NetApp recommended host multipath parameters as the default settings. You shouldn't need to make changes to the `/etc/multipath.conf` file for your host because the operating system is compiled with the multipath parameters that recognize and manage ONTAP LUNs correctly.

The following table shows the Linux OS native compiled multipath parameter settings for ONTAP LUNs.

Show parameter settings

Parameter	Setting
detect_prio	yes
dev_loss_tmo	"infinity"
failback	immediate
fast_io_fail_tmo	5
features	"3 queue_if_no_path pg_init_retries 50"
flush_on_last_del	"yes"
hardware_handler	"0"
no_path_retry	queue
path_checker	"tur"
path_grouping_policy	"group_by_prio"
path_selector	"service-time 0"
polling_interval	5
prio	"ontap"
product	LUN
retain_attached_hw_handler	yes
rr_weight	"uniform"
user_friendly_names	no
vendor	NETAPP

4. Verify the parameter settings and path status for your ONTAP LUNs:

```
multipath -ll
```

The default multipath parameters support ASA, AFF, and FAS configurations. In these configurations, a single ONTAP LUN shouldn't require more than four paths. If there are more than four paths, it might cause issues with the paths during a storage failure.

The following example outputs show the correct parameter settings and path status for ONTAP LUNs in an ASA, AFF, or FAS configuration.

ASA configuration

An ASA configuration optimizes all paths to a given LUN, keeping them active. This improves performance by serving I/O operations through all paths at the same time.

```
multipath -ll
3600a098038303634722b4d59646c4436 dm-28 NETAPP,LUN C-Mode
size=80G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
`-+- policy='service-time 0' prio=50 status=active
  |- 11:0:7:1    sdfi   130:64    active ready running
  |- 11:0:9:1    sdiy  8:288      active ready running
  |- 11:0:10:1  sdml 69:464    active ready running
  |- 11:0:11:1  sdpt   131:304   active ready running
```

AFF or FAS configuration

An AFF or FAS configuration should have two groups of paths with higher and lower priorities. Higher priority Active/Optimized paths are served by the controller where the aggregate is located. Lower priority paths are active but non-optimized because they are served by a different controller. Non-optimized paths are only used when optimized paths aren't available.

The following example displays the output for an ONTAP LUN with two Active/Optimized paths and two Active/Non-Optimized paths:

```
multipath -ll
3600a098038303634722b4d59646c4436 dm-28 NETAPP,LUN C-Mode
size=80G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
|-+- policy='service-time 0' prio=50 status=active
| |- 16:0:6:35 sdwb  69:624  active ready running
| |- 16:0:5:35 sdun  66:752  active ready running
`-+- policy='service-time 0' prio=10 status=enabled
  |- 15:0:0:35 sdaj  66:48    active ready running
  |- 15:0:1:35 sdbx  68:176  active ready running
```

Step 4: Optionally, exclude a device from multipathing

If required, you can exclude a device from multipathing by adding the WWID for the unwanted device to the "blacklist" stanza for the `multipath.conf` file.

Steps

1. Determine the WWID:

```
/lib/udev/scsi_id -gud /dev/sda
```

   "sda" is the local SCSI disk that you want to add to the blacklist.

   An example WWID is `360030057024d0730239134810c0cb833`.

2. Add the WWID to the "blacklist" stanza:

```
blacklist {
        wwid    360030057024d0730239134810c0cb833
        devnode "^(ram|raw|loop|fd|md|dm-|sr|scd|st)[0-9]*"
        devnode "^hd[a-z]"
        devnode "^cciss.*"
}
```

Step 5: Customize multipath parameters for ONTAP LUNs

If your host is connected to LUNs from other vendors and any of the multipath parameter settings are overridden, you need to correct them by adding stanzas later in the `multipath.conf` file that apply specifically to ONTAP LUNs. If you don't do this, the ONTAP LUNs might not work as expected.

Check your `/etc/multipath.conf` file, especially in the defaults section, for settings that might be overriding the default settings for multipath parameters.

> ⚠️ You shouldn't override the recommended parameter settings for ONTAP LUNs. These settings are required for optimal performance of your host configuration. Contact NetApp support, your OS vendor, or both for more information.

The following example shows how to correct an overridden default. In this example, the `multipath.conf` file defines values for `path_checker` and `no_path_retry` that aren't compatible with ONTAP LUNs, and you can't remove these parameters because ONTAP storage arrays are still attached to the host. Instead, you correct the values for `path_checker` and `no_path_retry` by adding a device stanza to the `multipath.conf` file that applies specifically to the ONTAP LUNs.

Show example

```
defaults {
    path_checker        readsector0
    no_path_retry       fail
}

devices {
    device {
        vendor          "NETAPP"
        product         "LUN"
        no_path_retry   queue
        path_checker    tur
    }
}
```

Step 6: Review the known issues

There are no known issues.

What's next?

- Learn about using the Linux Host Utilities tool.

- Learn about ASM mirroring.

  Automatic Storage Management (ASM) mirroring might require changes to the Linux multipath settings to allow ASM to recognize a problem and switch over to an alternate failure group. Most ASM configurations on ONTAP use external redundancy, which means that data protection is provided by the external array and ASM doesn't mirror data. Some sites use ASM with normal redundancy to provide two-way mirroring, normally across different sites. See Oracle databases on ONTAP for further information.

Configure CentOS 7.2 for FCP and iSCSI for ONTAP storage

The Linux Host Utilities software provides management and diagnostic tools for Linux hosts that are connected to ONTAP storage. When you install the Linux Host Utilities on a CentOS 7.2 host, you can use the Host Utilities to help you manage FCP and iSCSI protocol operations with ONTAP LUNs.

> ⓘ   You don't need to manually configure Kernel-based Virtual Machine (KVM) settings because ONTAP LUNs are automatically mapped to the hypervisor.

Step 1: Optionally, enable SAN booting

You can configure your host to use SAN booting to simplify deployment and improve scalability.

Before you begin

Use the Interoperability Matrix Tool to verify that your Linux OS, host bus adapter (HBA), HBA firmware, HBA

boot BIOS, and ONTAP version support SAN booting.

Steps

1. [Create a SAN boot LUN and map it to the host](#).

2. Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is mapped.

   For information on how to enable the HBA BIOS, see your vendor-specific documentation.

3. Verify that the configuration was successful by rebooting the host and verifying that the OS is up and running.

Step 2: Install the Linux Host Utilities

NetApp strongly recommends installing the Linux Host Utilities to support ONTAP LUN management and assist technical support with gathering configuration data.

[Install Linux Host Utilities 7.1](#).

> ℹ️   Installing the Linux Host Utilities doesn't change any host timeout settings on your Linux host.

Step 3: Confirm the multipath configuration for your host

You can use multipathing with CentOS 7.2 to manage ONTAP LUNs.

To ensure that multipathing is configured correctly for your host, verify that the `/etc/multipath.conf` file is defined and that you have the NetApp recommended settings configured for your ONTAP LUNs.

Steps

1. Verify that the `/etc/multipath.conf` file exits. If the file doesn't exist, create an empty, zero-byte file:

   ```
   touch /etc/multipath.conf
   ```

2. The first time the `multipath.conf` file is created, you might need to enable and start the multipath services to load the recommended settings:

   ```
   chkconfig multipathd on
   ```

   ```
   /etc/init.d/multipathd start
   ```

3. Each time you boot the host, the empty `/etc/multipath.conf` zero-byte file automatically loads the NetApp recommended host multipath parameters as the default settings. You shouldn't need to make changes to the `/etc/multipath.conf` file for your host because the operating system is compiled with the multipath parameters that recognize and manage ONTAP LUNs correctly.

   The following table shows the Linux OS native compiled multipath parameter settings for ONTAP LUNs.

Show parameter settings

Parameter	Setting
detect_prio	yes
dev_loss_tmo	"infinity"
failback	immediate
fast_io_fail_tmo	5
features	"3 queue_if_no_path pg_init_retries 50"
flush_on_last_del	"yes"
hardware_handler	"0"
no_path_retry	queue
path_checker	"tur"
path_grouping_policy	"group_by_prio"
path_selector	"service-time 0"
polling_interval	5
prio	"ontap"
product	LUN
retain_attached_hw_handler	yes
rr_weight	"uniform"
user_friendly_names	no
vendor	NETAPP

4. Verify the parameter settings and path status for your ONTAP LUNs:

```
multipath -ll
```

The default multipath parameters support ASA, AFF, and FAS configurations. In these configurations, a single ONTAP LUN shouldn't require more than four paths. If there are more than four paths, it might cause issues with the paths during a storage failure.

The following example outputs show the correct parameter settings and path status for ONTAP LUNs in an ASA, AFF, or FAS configuration.

ASA configuration

An ASA configuration optimizes all paths to a given LUN, keeping them active. This improves performance by serving I/O operations through all paths at the same time.

```
multipath -ll
3600a098038303634722b4d59646c4436 dm-28 NETAPP,LUN C-Mode
size=80G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
`-+- policy='service-time 0' prio=50 status=active
  |- 11:0:7:1    sdfi   130:64   active ready running
  |- 11:0:9:1    sdiy  8:288     active ready running
  |- 11:0:10:1  sdml 69:464   active ready running
  |- 11:0:11:1  sdpt  131:304   active ready running
```

AFF or FAS configuration

An AFF or FAS configuration should have two groups of paths with higher and lower priorities. Higher priority Active/Optimized paths are served by the controller where the aggregate is located. Lower priority paths are active but non-optimized because they are served by a different controller. Non-optimized paths are only used when optimized paths aren't available.

The following example displays the output for an ONTAP LUN with two Active/Optimized paths and two Active/Non-Optimized paths:

```
multipath -ll
3600a098038303634722b4d59646c4436 dm-28 NETAPP,LUN C-Mode
size=80G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
|-+- policy='service-time 0' prio=50 status=active
| |- 16:0:6:35 sdwb  69:624  active ready running
| |- 16:0:5:35 sdun  66:752  active ready running
`-+- policy='service-time 0' prio=10 status=enabled
  |- 15:0:0:35 sdaj  66:48   active ready running
  |- 15:0:1:35 sdbx  68:176  active ready running
```

Step 4: Optionally, exclude a device from multipathing

If required, you can exclude a device from multipathing by adding the WWID for the unwanted device to the "blacklist" stanza for the `multipath.conf` file.

Steps

1. Determine the WWID:

```
/lib/udev/scsi_id -gud /dev/sda
```

"sda" is the local SCSI disk that you want to add to the blacklist.

An example WWID is `360030057024d0730239134810c0cb833`.

2. Add the WWID to the "blacklist" stanza:

```
blacklist {
        wwid    360030057024d0730239134810c0cb833
        devnode "^(ram|raw|loop|fd|md|dm-|sr|scd|st)[0-9]*"
        devnode "^hd[a-z]"
        devnode "^cciss.*"
}
```

Step 5: Customize multipath parameters for ONTAP LUNs

If your host is connected to LUNs from other vendors and any of the multipath parameter settings are overridden, you need to correct them by adding stanzas later in the `multipath.conf` file that apply specifically to ONTAP LUNs. If you don't do this, the ONTAP LUNs might not work as expected.

Check your `/etc/multipath.conf` file, especially in the defaults section, for settings that might be overriding the default settings for multipath parameters.

> ⚠️ You shouldn't override the recommended parameter settings for ONTAP LUNs. These settings are required for optimal performance of your host configuration. Contact NetApp support, your OS vendor, or both for more information.

The following example shows how to correct an overridden default. In this example, the `multipath.conf` file defines values for `path_checker` and `no_path_retry` that aren't compatible with ONTAP LUNs, and you can't remove these parameters because ONTAP storage arrays are still attached to the host. Instead, you correct the values for `path_checker` and `no_path_retry` by adding a device stanza to the `multipath.conf` file that applies specifically to the ONTAP LUNs.

Show example

```
defaults {
    path_checker        readsector0
    no_path_retry       fail
}

devices {
    device {
        vendor          "NETAPP"
        product         "LUN"
        no_path_retry   queue
        path_checker    tur
    }
}
```

Step 6: Review the known issues

There are no known issues.

What's next?

- Learn about using the Linux Host Utilities tool.
- Learn about ASM mirroring.

  Automatic Storage Management (ASM) mirroring might require changes to the Linux multipath settings to allow ASM to recognize a problem and switch over to an alternate failure group. Most ASM configurations on ONTAP use external redundancy, which means that data protection is provided by the external array and ASM doesn't mirror data. Some sites use ASM with normal redundancy to provide two-way mirroring, normally across different sites. See Oracle databases on ONTAP for further information.

Configure CentOS 7.1 for FCP and iSCSI for ONTAP storage

The Linux Host Utilities software provides management and diagnostic tools for Linux hosts that are connected to ONTAP storage. When you install the Linux Host Utilities on a CentOS 7.1 host, you can use the Host Utilities to help you manage FCP and iSCSI protocol operations with ONTAP LUNs.

> ⓘ You don't need to manually configure Kernel-based Virtual Machine (KVM) settings because ONTAP LUNs are automatically mapped to the hypervisor.

Step 1: Optionally, enable SAN booting

You can configure your host to use SAN booting to simplify deployment and improve scalability.

Before you begin

Use the Interoperability Matrix Tool to verify that your Linux OS, host bus adapter (HBA), HBA firmware, HBA

boot BIOS, and ONTAP version support SAN booting.

Steps

1. [Create a SAN boot LUN and map it to the host](#).

2. Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is mapped.

   For information on how to enable the HBA BIOS, see your vendor-specific documentation.

3. Verify that the configuration was successful by rebooting the host and verifying that the OS is up and running.

Step 2: Install the Linux Host Utilities

NetApp strongly recommends installing the Linux Host Utilities to support ONTAP LUN management and assist technical support with gathering configuration data.

[Install Linux Host Utilities 7.1](#).

> ⓘ Installing the Linux Host Utilities doesn't change any host timeout settings on your Linux host.

Step 3: Confirm the multipath configuration for your host

You can use multipathing with CentOS 7.1 to manage ONTAP LUNs.

To ensure that multipathing is configured correctly for your host, verify that the `/etc/multipath.conf` file is defined and that you have the NetApp recommended settings configured for your ONTAP LUNs.

Steps

1. Verify that the `/etc/multipath.conf` file exits. If the file doesn't exist, create an empty, zero-byte file:

   ```
   touch /etc/multipath.conf
   ```

2. The first time the `multipath.conf` file is created, you might need to enable and start the multipath services to load the recommended settings:

   ```
   chkconfig multipathd on
   ```

   ```
   /etc/init.d/multipathd start
   ```

3. Each time you boot the host, the empty `/etc/multipath.conf` zero-byte file automatically loads the NetApp recommended host multipath parameters as the default settings. You shouldn't need to make changes to the `/etc/multipath.conf` file for your host because the operating system is compiled with the multipath parameters that recognize and manage ONTAP LUNs correctly.

   The following table shows the Linux OS native compiled multipath parameter settings for ONTAP LUNs.

Show parameter settings

Parameter	Setting
detect_prio	yes
dev_loss_tmo	"infinity"
failback	immediate
fast_io_fail_tmo	5
features	"3 queue_if_no_path pg_init_retries 50"
flush_on_last_del	"yes"
hardware_handler	"0"
no_path_retry	queue
path_checker	"tur"
path_grouping_policy	"group_by_prio"
path_selector	"service-time 0"
polling_interval	5
prio	"ontap"
product	LUN
retain_attached_hw_handler	yes
rr_weight	"uniform"
user_friendly_names	no
vendor	NETAPP

4. Verify the parameter settings and path status for your ONTAP LUNs:

```
multipath -ll
```

The default multipath parameters support ASA, AFF, and FAS configurations. In these configurations, a single ONTAP LUN shouldn't require more than four paths. If there are more than four paths, it might cause issues with the paths during a storage failure.

The following example outputs show the correct parameter settings and path status for ONTAP LUNs in an ASA, AFF, or FAS configuration.

ASA configuration

An ASA configuration optimizes all paths to a given LUN, keeping them active. This improves performance by serving I/O operations through all paths at the same time.

```
multipath -ll
3600a098038303634722b4d59646c4436 dm-28 NETAPP,LUN C-Mode
size=80G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
`-+- policy='service-time 0' prio=50 status=active
  |- 11:0:7:1    sdfi   130:64    active ready running
  |- 11:0:9:1    sdiy  8:288      active ready running
  |- 11:0:10:1  sdml 69:464    active ready running
  |- 11:0:11:1  sdpt  131:304   active ready running
```

AFF or FAS configuration

An AFF or FAS configuration should have two groups of paths with higher and lower priorities. Higher priority Active/Optimized paths are served by the controller where the aggregate is located. Lower priority paths are active but non-optimized because they are served by a different controller. Non-optimized paths are only used when optimized paths aren't available.

The following example displays the output for an ONTAP LUN with two Active/Optimized paths and two Active/Non-Optimized paths:

```
multipath -ll
3600a098038303634722b4d59646c4436 dm-28 NETAPP,LUN C-Mode
size=80G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
|-+- policy='service-time 0' prio=50 status=active
| |- 16:0:6:35 sdwb   69:624   active ready running
| |- 16:0:5:35 sdun   66:752   active ready running
`-+- policy='service-time 0' prio=10 status=enabled
  |- 15:0:0:35 sdaj   66:48    active ready running
  |- 15:0:1:35 sdbx   68:176   active ready running
```

Step 4: Optionally, exclude a device from multipathing

If required, you can exclude a device from multipathing by adding the WWID for the unwanted device to the "blacklist" stanza for the `multipath.conf` file.

Steps

1. Determine the WWID:

```
/lib/udev/scsi_id -gud /dev/sda
```

"sda" is the local SCSI disk that you want to add to the blacklist.

An example WWID is `360030057024d0730239134810c0cb833`.

2. Add the WWID to the "blacklist" stanza:

```
blacklist {
        wwid    360030057024d0730239134810c0cb833
        devnode "^(ram|raw|loop|fd|md|dm-|sr|scd|st)[0-9]*"
        devnode "^hd[a-z]"
        devnode "^cciss.*"
}
```

Step 5: Customize multipath parameters for ONTAP LUNs

If your host is connected to LUNs from other vendors and any of the multipath parameter settings are overridden, you need to correct them by adding stanzas later in the `multipath.conf` file that apply specifically to ONTAP LUNs. If you don't do this, the ONTAP LUNs might not work as expected.

Check your `/etc/multipath.conf` file, especially in the defaults section, for settings that might be overriding the default settings for multipath parameters.

> ⚠ You shouldn't override the recommended parameter settings for ONTAP LUNs. These settings are required for optimal performance of your host configuration. Contact NetApp support, your OS vendor, or both for more information.

The following example shows how to correct an overridden default. In this example, the `multipath.conf` file defines values for `path_checker` and `no_path_retry` that aren't compatible with ONTAP LUNs, and you can't remove these parameters because ONTAP storage arrays are still attached to the host. Instead, you correct the values for `path_checker` and `no_path_retry` by adding a device stanza to the `multipath.conf` file that applies specifically to the ONTAP LUNs.

Show example

```
defaults {
    path_checker        readsector0
    no_path_retry       fail
}

devices {
    device {
        vendor          "NETAPP"
        product         "LUN"
        no_path_retry   queue
        path_checker    tur
    }
}
```

Step 6: Review the known issues

There are no known issues.

What's next?

- Learn about using the Linux Host Utilities tool.
- Learn about ASM mirroring.

  Automatic Storage Management (ASM) mirroring might require changes to the Linux multipath settings to allow ASM to recognize a problem and switch over to an alternate failure group. Most ASM configurations on ONTAP use external redundancy, which means that data protection is provided by the external array and ASM doesn't mirror data. Some sites use ASM with normal redundancy to provide two-way mirroring, normally across different sites. See Oracle databases on ONTAP for further information.

Configure CentOS 7.0 for FCP and iSCSI for ONTAP storage

The Linux Host Utilities software provides management and diagnostic tools for Linux hosts that are connected to ONTAP storage. When you install the Linux Host Utilities on a CentOS 7.0 host, you can use the Host Utilities to help you manage FCP and iSCSI protocol operations with ONTAP LUNs.

> ⓘ You don't need to manually configure Kernel-based Virtual Machine (KVM) settings because ONTAP LUNs are automatically mapped to the hypervisor.

Step 1: Optionally, enable SAN booting

You can configure your host to use SAN booting to simplify deployment and improve scalability.

Before you begin

Use the Interoperability Matrix Tool to verify that your Linux OS, host bus adapter (HBA), HBA firmware, HBA

boot BIOS, and ONTAP version support SAN booting.

Steps

1. [Create a SAN boot LUN and map it to the host](#).

2. Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is mapped.

   For information on how to enable the HBA BIOS, see your vendor-specific documentation.

3. Verify that the configuration was successful by rebooting the host and verifying that the OS is up and running.

Step 2: Install the Linux Host Utilities

NetApp strongly recommends installing the Linux Host Utilities to support ONTAP LUN management and assist technical support with gathering configuration data.

[Install Linux Host Utilities 7.1](#).

> ⓘ   Installing the Linux Host Utilities doesn't change any host timeout settings on your Linux host.

Step 3: Confirm the multipath configuration for your host

You can use multipathing with CentOS 7.0 to manage ONTAP LUNs.

To ensure that multipathing is configured correctly for your host, verify that the `/etc/multipath.conf` file is defined and that you have the NetApp recommended settings configured for your ONTAP LUNs.

Steps

1. Verify that the `/etc/multipath.conf` file exits. If the file doesn't exist, create an empty, zero-byte file:

   ```
   touch /etc/multipath.conf
   ```

2. The first time the `multipath.conf` file is created, you might need to enable and start the multipath services to load the recommended settings:

   ```
   chkconfig multipathd on
   ```

   ```
   /etc/init.d/multipathd start
   ```

3. Each time you boot the host, the empty `/etc/multipath.conf` zero-byte file automatically loads the NetApp recommended host multipath parameters as the default settings. You shouldn't need to make changes to the `/etc/multipath.conf` file for your host because the operating system is compiled with the multipath parameters that recognize and manage ONTAP LUNs correctly.

   The following table shows the Linux OS native compiled multipath parameter settings for ONTAP LUNs.

Show parameter settings

Parameter	Setting
detect_prio	yes
dev_loss_tmo	"infinity"
failback	immediate
fast_io_fail_tmo	5
features	"3 queue_if_no_path pg_init_retries 50"
flush_on_last_del	"yes"
hardware_handler	"0"
no_path_retry	queue
path_checker	"tur"
path_grouping_policy	"group_by_prio"
path_selector	"service-time 0"
polling_interval	5
prio	"ontap"
product	LUN
retain_attached_hw_handler	yes
rr_weight	"uniform"
user_friendly_names	no
vendor	NETAPP

4. Verify the parameter settings and path status for your ONTAP LUNs:

```
multipath -ll
```

The default multipath parameters support ASA, AFF, and FAS configurations. In these configurations, a single ONTAP LUN shouldn't require more than four paths. If there are more than four paths, it might cause issues with the paths during a storage failure.

The following example outputs show the correct parameter settings and path status for ONTAP LUNs in an ASA, AFF, or FAS configuration.

ASA configuration

An ASA configuration optimizes all paths to a given LUN, keeping them active. This improves performance by serving I/O operations through all paths at the same time.

```
multipath -ll
3600a098038303634722b4d59646c4436 dm-28 NETAPP,LUN C-Mode
size=80G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
`-+- policy='service-time 0' prio=50 status=active
  |- 11:0:7:1    sdfi   130:64    active ready running
  |- 11:0:9:1    sdiy  8:288      active ready running
  |- 11:0:10:1  sdml 69:464    active ready running
  |- 11:0:11:1  sdpt   131:304   active ready running
```

AFF or FAS configuration

An AFF or FAS configuration should have two groups of paths with higher and lower priorities. Higher priority Active/Optimized paths are served by the controller where the aggregate is located. Lower priority paths are active but non-optimized because they are served by a different controller. Non-optimized paths are only used when optimized paths aren't available.

The following example displays the output for an ONTAP LUN with two Active/Optimized paths and two Active/Non-Optimized paths:

```
multipath -ll
3600a098038303634722b4d59646c4436 dm-28 NETAPP,LUN C-Mode
size=80G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
|-+- policy='service-time 0' prio=50 status=active
| |- 16:0:6:35 sdwb   69:624   active ready running
| |- 16:0:5:35 sdun   66:752   active ready running
`-+- policy='service-time 0' prio=10 status=enabled
  |- 15:0:0:35 sdaj   66:48    active ready running
  |- 15:0:1:35 sdbx   68:176   active ready running
```

Step 4: Optionally, exclude a device from multipathing

If required, you can exclude a device from multipathing by adding the WWID for the unwanted device to the "blacklist" stanza for the `multipath.conf` file.

Steps

1. Determine the WWID:

```
/lib/udev/scsi_id -gud /dev/sda
```

"sda" is the local SCSI disk that you want to add to the blacklist.

An example WWID is `360030057024d0730239134810c0cb833`.

2. Add the WWID to the "blacklist" stanza:

```
blacklist {
        wwid    360030057024d0730239134810c0cb833
        devnode "^(ram|raw|loop|fd|md|dm-|sr|scd|st)[0-9]*"
        devnode "^hd[a-z]"
        devnode "^cciss.*"
}
```

Step 5: Customize multipath parameters for ONTAP LUNs

If your host is connected to LUNs from other vendors and any of the multipath parameter settings are overridden, you need to correct them by adding stanzas later in the `multipath.conf` file that apply specifically to ONTAP LUNs. If you don't do this, the ONTAP LUNs might not work as expected.

Check your `/etc/multipath.conf` file, especially in the defaults section, for settings that might be overriding the default settings for multipath parameters.

> ⚠️ You shouldn't override the recommended parameter settings for ONTAP LUNs. These settings are required for optimal performance of your host configuration. Contact NetApp support, your OS vendor, or both for more information.

The following example shows how to correct an overridden default. In this example, the `multipath.conf` file defines values for `path_checker` and `no_path_retry` that aren't compatible with ONTAP LUNs, and you can't remove these parameters because ONTAP storage arrays are still attached to the host. Instead, you correct the values for `path_checker` and `no_path_retry` by adding a device stanza to the `multipath.conf` file that applies specifically to the ONTAP LUNs.

Show example

```
defaults {
    path_checker        readsector0
    no_path_retry       fail
}

devices {
    device {
        vendor          "NETAPP"
        product         "LUN"
        no_path_retry   queue
        path_checker    tur
    }
}
```

Step 6: Review the known issues

There are no known issues.

What's next?

- Learn about using the Linux Host Utilities tool.

- Learn about ASM mirroring.

  Automatic Storage Management (ASM) mirroring might require changes to the Linux multipath settings to allow ASM to recognize a problem and switch over to an alternate failure group. Most ASM configurations on ONTAP use external redundancy, which means that data protection is provided by the external array and ASM doesn't mirror data. Some sites use ASM with normal redundancy to provide two-way mirroring, normally across different sites. See Oracle databases on ONTAP for further information.

CentOS 6

Use CentOS 6.10 with ONTAP

You can use the ONTAP SAN host configuration settings to configure CentOS 6.10 with ONTAP as the target.

Install the Linux Host Utilities

The NetApp Linux Host Utilities software package is available on the NetApp Support Site in a 32-bit and 64-bit .rpm file. If you don't know which file is right for your configuration, use the Interoperability Matrix Tool to verify which one you need.

NetApp strongly recommends installing the Linux Host Utilities, but it's not mandatory. The utilities don't change any settings on your Linux host. The utilities improve management and assist NetApp customer support in gathering information about your configuration.

If you have Linux Host Utilities currently installed, you should either upgrade it to the latest version, or remove it and follow these steps to install the latest version.

Steps

1. Download the 32-bit or 64-bit Linux Host Utilities software package from the NetApp Support Site to your host.

2. Install the software package:

   ```
   rpm -ivh netapp_linux_unified_host_utilities-7-1.x86_64
   ```

> ⓘ You can use the configuration settings provided in this procedure to configure cloud clients connected to Cloud Volumes ONTAP and Amazon FSx for ONTAP.

SAN Toolkit

The toolkit is installed automatically when you install the NetApp Host Utilities package. This kit provides the `sanlun` utility, which helps you manage LUNs and HBAs. The `sanlun` command returns information about the LUNs mapped to your host, multipathing, and information necessary to create initiator groups.

Example

In the following example, the `sanlun lun show` command returns LUN information.

```
# sanlun lun show all
```

Example output:

```
controller(7mode/E-Series)/                  device      host                    lun
vserver(cDOT/FlashRay)    lun-pathname   filename    adapter  protocol  size
Product
-------------------------------------------------------------------------
----------
data_vserver             /vol/vol1/lun1    /dev/sdb    host16     FCP
120.0g  cDOT
data_vserver             /vol/vol1/lun1    /dev/sdc    host15     FCP
120.0g  cDOT
data_vserver             /vol/vol2/lun2    /dev/sdd    host16     FCP
120.0g  cDOT
data_vserver             /vol/vol2/lun2    /dev/sde    host15     FCP
120.0g  cDOT
```

SAN Booting

Before you begin

If you decide to use SAN booting, it must be supported by your configuration. You can use the Interoperability Matrix Tool to verify that your OS, HBA, HBA firmware and the HBA boot BIOS, and ONTAP version are supported.

Steps

1. Map the SAN boot LUN to the host.

2. Verify that multiple paths are available.

   > ℹ️ Multiple paths become available after the host OS is up and running on the paths.

3. Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is mapped.

   For information on how to enable the HBA BIOS, see your vendor-specific documentation.

4. Reboot the host to verify that the boot was successful.

Multipathing

For CentOS 6.10 the `/etc/multipath.conf` file must exist, but you do not need to make specific changes to the file. CentOS 6.10 is compiled with all settings required to recognize and correctly manage ONTAP LUNs.

To Enable ALUA Handler, perform the following steps:

Steps

1. Create a backup of the initrd-image.

2. Append the following parameter value to the kernel for ALUA and non-ALUA to work:
   `rdloaddriver=scsi_dh_alua`

   Example

   ```
   kernel /vmlinuz-2.6.32-358.6.1.el6.x86_64 ro root=/dev/mapper/
   vg_ibmx355021082-lv_root rd_NO_LUKS rd_LVM_LV=vg_ibmx355021082/ lv_root
   LANG=en_US.UTF-8 rd_LVM_LV=vg_ibmx355021082/lv_swap rd_NO_MD
   SYSFONT=latarcyrheb-sun16 crashkernel=auto KEYBOARDTYPE=pc KEYTABLE=us
   rd_NO_DM rhgb quiet rdloaddriver=scsi_dh_alua
   ```

3. Use the `mkinitrd` command to recreate the initrd-image.
   CentOS 6x and later versions use either:
   The command: `mkinitrd -f /boot/ initrd-"uname -r".img uname -r`
   Or
   The command: `dracut -f`

4. Reboot the host.

5. Verify the output of the `cat /proc/cmdline` command to ensure that the setting is complete.

You can use the `multipath -ll` command to verify the settings for your ONTAP LUNs.

The following sections provide example multipath outputs for a LUN mapped to ASA and non-ASA personas.

All SAN Array configurations

All SAN Array (ASA) configurations optimize all paths to a given LUN, keeping them active. This improves performance by serving I/O operations through all paths at the same time.

Example

The following example displays the correct output for an ONTAP LUN.

```
# multipath -ll
3600a0980383034466b2b4a3775474859 dm-3 NETAPP,LUN C-Mode
size=20G features='4 queue_if_no_path pg_init_retries 50
retain_attached_hw_handle' hwhandler='1 alua' wp=rw
|-+- policy='round-robin 0' prio=50 status=active
|- 1:0:8:1  sdb 8:16 active ready running
|- 2:0:8:1  sdd 8:48 active ready running
|- 1:0:9:1  sdc 8:32 active ready running
|- 2:0:9:1  sde 8:64 active ready running
```

> (i) A single LUN shouldn't require more than four paths. Having more than four paths might cause path issues during storage failures.

Non-ASA configurations

For non-ASA configurations, there should be two groups of paths with different priorities. The paths with higher priorities are Active/Optimized. This means they are serviced by the controller where the aggregate is located. The paths with lower priorities are active but non-optimized because they are served from a different controller. The non-optimized paths are only used when optimized paths are not available.

Example

The following example displays the correct output for an ONTAP LUN with two Active/Optimized paths and two Active/Non-Optimized paths.

```
# multipath -ll
3600a0980383034466b2b4a3775474859 dm-3 NETAPP,LUN C-Mode
size=20G features='4 queue_if_no_path pg_init_retries 50
retain_attached_hw_handle' hwhandler='1 alua' wp=rw
|-+- policy='round-robin 0' prio=50 status=active
| |- 1:0:8:1  sdb 8:16 active ready running
| `- 2:0:8:1  sdd 8:48 active ready running
`-+- policy='round-robin 0' prio=10 status=enabled
  |- 1:0:9:1  sdc 8:32 active ready running
  `- 2:0:9:1  sde 8:64 active ready running
```

> (i) A single LUN shouldn't require more than four paths. Having more than four paths might cause path issues during storage failures.

Recommended Settings

The CentOS 6.10 is compiled to recognize ONTAP LUNs and automatically set all configuration parameters correctly for both ASA and non-ASA configuration.

The `multipath.conf` file must exist for the multipath daemon to start. If this file doesn't exist, you can create

an empty, zero-byte file by using the `touch /etc/multipath.conf` command.

The first time you create the `multipath.conf` file, you might need to enable and start the multipath services by using the following commands:

```
chkconfig multipathd on
/etc/init.d/multipathd start
```

You don't need to add anything directly to the `multipath.conf` file unless you have devices that you don't want multipath to manage or you have existing settings that override defaults. To exclude unwanted devices, add the following syntax to the `multipath.conf` file, replacing <DevId> with the worldwide identifier (WWID) string of the device you want to exclude:

```
blacklist {
        wwid <DevId>
        devnode "^(ram|raw|loop|fd|md|dm-|sr|scd|st)[0-9]*"
        devnode "^hd[a-z]"
        devnode "^cciss.*"
}
```

The following example determines the WWID of a device and adds it to the `multipath.conf` file.

Steps

1. Determine the WWID:

```
/lib/udev/scsi_id -gud /dev/sda
```

```
3600a098038314c4a433f5774717a3046
```

`sda` is the local SCSI disk that you want to add to the blacklist.

2. Add the `WWID` to the blacklist stanza in `/etc/multipath.conf`:

```
blacklist {
        wwid    3600a098038314c4a433f5774717a3046
        devnode "^(ram|raw|loop|fd|md|dm-|sr|scd|st)[0-9]*"
        devnode "^hd[a-z]"
        devnode "^cciss.*"
}
```

Always check your `/etc/multipath.conf` file, especially in the defaults section, for legacy settings that might be overriding default settings.

The following table demonstrates the critical `multipathd` parameters for ONTAP LUNs and the required values. If a host is connected to LUNs from other vendors and any of these parameters are overridden, they must be corrected by later stanzas in the `multipath.conf` file that apply specifically to ONTAP LUNs. Without this correction, the ONTAP LUNs might not work as expected. You should only override these defaults in consultation with NetApp, the OS vendor, or both, and only when the impact is fully understood.

Parameter	Setting
detect_prio	yes
dev_loss_tmo	"infinity"
failback	immediate
fast_io_fail_tmo	5
features	"3 queue_if_no_path pg_init_retries 50"
flush_on_last_del	"yes"
hardware_handler	"0"
no_path_retry	queue
path_checker	"tur"
path_grouping_policy	"group_by_prio"
path_selector	"round-robin 0"
polling_interval	5
prio	"ontap"
product	LUN.*
retain_attached_hw_handler	yes
rr_weight	"uniform"
user_friendly_names	no
vendor	NETAPP

Example

The following example shows how to correct an overridden default. In this case, the `multipath.conf` file defines values for `path_checker` and `no_path_retry` that are not compatible with ONTAP LUNs. If they cannot be removed because of other SAN arrays still attached to the host, these parameters can be corrected specifically for ONTAP LUNs with a device stanza.

```
defaults {
    path_checker        readsector0
    no_path_retry        fail
}

devices {
    device {
        vendor          "NETAPP  "
        product          "LUN.*"
        no_path_retry      queue
        path_checker       tur
    }
}
```

Configure KVM settings

You don't need to configure settings for a Kernel-based Virtual Machine because the LUN is mapped to the hypervisor.

ASM mirroring

Automatic Storage Management (ASM) mirroring might require changes to the Linux multipath settings to allow ASM to recognize a problem and switch over to an alternate failure group. Most ASM configurations on ONTAP use external redundancy, which means that data protection is provided by the external array and ASM doesn't mirror data. Some sites use ASM with normal redundancy to provide two-way mirroring, normally across different sites. See Oracle databases on ONTAP for further information.

Known issues

For CentOS (Red Hat compatible kernel) known issues, see the known issues for Red Hat Enterprise Linux (RHEL) 6.10.

Use CentOS 6.9 with ONTAP

You can use the ONTAP SAN host configuration settings to configure CentOS 6.9 with ONTAP as the target.

Install the Linux Host Utilities

The NetApp Linux Host Utilities software package is available on the NetApp Support Site in a 32-bit and 64-bit .rpm file. If you don't know which file is right for your configuration, use the Interoperability Matrix Tool to verify which one you need.

NetApp strongly recommends installing the Linux Host Utilities, but it's not mandatory. The utilities don't change any settings on your Linux host. The utilities improve management and assist NetApp customer support in gathering information about your configuration.

If you have Linux Host Utilities currently installed, you should either upgrade it to the latest version, or remove it and follow these steps to install the latest version.

Steps

1. Download the 32-bit or 64-bit Linux Host Utilities software package from the [NetApp Support Site](#) to your host.

2. Install the software package:

```
rpm -ivh netapp_linux_unified_host_utilities-7-1.x86_64
```

> ⓘ You can use the configuration settings provided in this procedure to configure cloud clients connected to [Cloud Volumes ONTAP](#) and [Amazon FSx for ONTAP](#).

SAN Toolkit

The toolkit is installed automatically when you install the NetApp Host Utilities package. This kit provides the `sanlun` utility, which helps you manage LUNs and HBAs. The `sanlun` command returns information about the LUNs mapped to your host, multipathing, and information necessary to create initiator groups.

Example

In the following example, the `sanlun lun show` command returns LUN information.

```
# sanlun lun show all
```

Example output:

```
controller(7mode/E-Series)/                 device      host                lun
vserver(cDOT/FlashRay)    lun-pathname   filename    adapter  protocol  size
Product
--------------------------------------------------------------------------
----------
data_vserver             /vol/vol1/lun1   /dev/sdb    host16    FCP
120.0g  cDOT
data_vserver             /vol/vol1/lun1   /dev/sdc    host15    FCP
120.0g  cDOT
data_vserver             /vol/vol2/lun2   /dev/sdd    host16    FCP
120.0g  cDOT
data_vserver             /vol/vol2/lun2   /dev/sde    host15    FCP
120.0g  cDOT
```

SAN Booting

Before you begin

If you decide to use SAN booting, it must be supported by your configuration. You can use the [Interoperability Matrix Tool](#) to verify that your OS, HBA, HBA firmware and the HBA boot BIOS, and ONTAP version are supported.

Steps

1. Map the SAN boot LUN to the host.

2. Verify that multiple paths are available.

ⓘ | Multiple paths become available after the host OS is up and running on the paths.

3. Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is mapped.

   For information on how to enable the HBA BIOS, see your vendor-specific documentation.

4. Reboot the host to verify that the boot was successful.

Multipathing

For CentOS 6.9 the `/etc/multipath.conf` file must exist, but you do not need to make specific changes to the file. CentOS 6.9 is compiled with all settings required to recognize and correctly manage ONTAP LUNs.

To Enable ALUA Handler, perform the following steps:

Steps

1. Create a backup of the initrd-image.

2. Append the following parameter value to the kernel for ALUA and non-ALUA to work:
   `rdloaddriver=scsi_dh_alua`

   Example

   ```
   kernel /vmlinuz-2.6.32-358.6.1.el6.x86_64 ro root=/dev/mapper/
   vg_ibmx355021082-lv_root rd_NO_LUKS rd_LVM_LV=vg_ibmx355021082/ lv_root
   LANG=en_US.UTF-8 rd_LVM_LV=vg_ibmx355021082/lv_swap rd_NO_MD
   SYSFONT=latarcyrheb-sun16 crashkernel=auto KEYBOARDTYPE=pc KEYTABLE=us
   rd_NO_DM rhgb quiet rdloaddriver=scsi_dh_alua
   ```

3. Use the `mkinitrd` command to recreate the initrd-image.
   CentOS 6x and later versions use either:
   The command: `mkinitrd -f /boot/ initrd-"uname -r".img uname -r`
   Or
   The command: `dracut -f`

4. Reboot the host.

5. Verify the output of the `cat /proc/cmdline` command to ensure that the setting is complete.

You can use the `multipath -ll` command to verify the settings for your ONTAP LUNs.

The following sections provide example multipath outputs for a LUN mapped to ASA and non-ASA personas.

All SAN Array configurations

All SAN Array (ASA) configurations optimize all paths to a given LUN, keeping them active. This improves performance by serving I/O operations through all paths at the same time.

Example
The following example displays the correct output for an ONTAP LUN.

```
# multipath -ll
3600a0980383034466b2b4a3775474859 dm-3 NETAPP,LUN C-Mode
size=20G features='4 queue_if_no_path pg_init_retries 50
retain_attached_hw_handle' hwhandler='1 alua' wp=rw
|-+- policy='round-robin 0' prio=50 status=active
|- 1:0:8:1  sdb 8:16 active ready running
|- 2:0:8:1  sdd 8:48 active ready running
|- 1:0:9:1  sdc 8:32 active ready running
|- 2:0:9:1  sde 8:64 active ready running
```

> (i) A single LUN shouldn't require more than four paths. Having more than four paths might cause path issues during storage failures.

Non-ASA configurations

For non-ASA configurations, there should be two groups of paths with different priorities. The paths with higher priorities are Active/Optimized. This means they are serviced by the controller where the aggregate is located. The paths with lower priorities are active but non-optimized because they are served from a different controller. The non-optimized paths are only used when optimized paths are not available.

Example

The following example displays the correct output for an ONTAP LUN with two Active/Optimized paths and two Active/Non-Optimized paths.

```
# multipath -ll
3600a0980383034466b2b4a3775474859 dm-3 NETAPP,LUN C-Mode
size=20G features='4 queue_if_no_path pg_init_retries 50
retain_attached_hw_handle' hwhandler='1 alua' wp=rw
|-+- policy='round-robin 0' prio=50 status=active
| |- 1:0:8:1  sdb 8:16 active ready running
| `- 2:0:8:1  sdd 8:48 active ready running
`-+- policy='round-robin 0' prio=10 status=enabled
  |- 1:0:9:1  sdc 8:32 active ready running
  `- 2:0:9:1  sde 8:64 active ready running
```

> (i) A single LUN shouldn't require more than four paths. Having more than four paths might cause path issues during storage failures.

Recommended Settings

The CentOS 6.9 OS is compiled to recognize ONTAP LUNs and automatically set all configuration parameters correctly for both ASA and non-ASA configuration.

The `multipath.conf` file must exist for the multipath daemon to start. If this file doesn't exist, you can create an empty, zero-byte file by using the `touch /etc/multipath.conf` command.

The first time you create the `multipath.conf` file, you might need to enable and start the multipath services by using the following commands:

```
chkconfig multipathd on
/etc/init.d/multipathd start
```

You don't need to add anything directly to the `multipath.conf` file unless you have devices that you don't want multipath to manage or you have existing settings that override defaults. To exclude unwanted devices, add the following syntax to the `multipath.conf` file, replacing <DevId> with the worldwide identifier (WWID) string of the device you want to exclude:

```
blacklist {
        wwid <DevId>
        devnode "^(ram|raw|loop|fd|md|dm-|sr|scd|st)[0-9]*"
        devnode "^hd[a-z]"
        devnode "^cciss.*"
}
```

The following example determines the WWID of a device and adds it to the `multipath.conf` file.

Steps

1. Determine the WWID:

```
/lib/udev/scsi_id -gud /dev/sda
```

```
3600a098038314c4a433f5774717a3046
```

`sda` is the local SCSI disk that you want to add to the blacklist.

2. Add the `WWID` to the blacklist stanza in `/etc/multipath.conf`:

```
blacklist {
        wwid    3600a098038314c4a433f5774717a3046
        devnode "^(ram|raw|loop|fd|md|dm-|sr|scd|st)[0-9]*"
        devnode "^hd[a-z]"
        devnode "^cciss.*"
}
```

Always check your `/etc/multipath.conf` file, especially in the defaults section, for legacy settings that might be overriding default settings.

The following table demonstrates the critical `multipathd` parameters for ONTAP LUNs and the required

values. If a host is connected to LUNs from other vendors and any of these parameters are overridden, they must be corrected by later stanzas in the `multipath.conf` file that apply specifically to ONTAP LUNs. Without this correction, the ONTAP LUNs might not work as expected. You should only override these defaults in consultation with NetApp, the OS vendor, or both, and only when the impact is fully understood.

Parameter	Setting
detect_prio	yes
dev_loss_tmo	"infinity"
failback	immediate
fast_io_fail_tmo	5
features	"3 queue_if_no_path pg_init_retries 50"
flush_on_last_del	"yes"
hardware_handler	"0"
no_path_retry	queue
path_checker	"tur"
path_grouping_policy	"group_by_prio"
path_selector	"round-robin 0"
polling_interval	5
prio	"ontap"
product	LUN.*
retain_attached_hw_handler	yes
rr_weight	"uniform"
user_friendly_names	no
vendor	NETAPP

Example

The following example shows how to correct an overridden default. In this case, the `multipath.conf` file defines values for `path_checker` and `no_path_retry` that are not compatible with ONTAP LUNs. If they cannot be removed because of other SAN arrays still attached to the host, these parameters can be corrected specifically for ONTAP LUNs with a device stanza.

```
defaults {
    path_checker       readsector0
    no_path_retry       fail
}

devices {
    device {
        vendor          "NETAPP  "
        product          "LUN.*"
        no_path_retry     queue
        path_checker      tur
    }
}
```

Configure KVM settings

You don't need to configure settings for a Kernel-based Virtual Machine because the LUN is mapped to the hypervisor.

ASM mirroring

Automatic Storage Management (ASM) mirroring might require changes to the Linux multipath settings to allow ASM to recognize a problem and switch over to an alternate failure group. Most ASM configurations on ONTAP use external redundancy, which means that data protection is provided by the external array and ASM doesn't mirror data. Some sites use ASM with normal redundancy to provide two-way mirroring, normally across different sites. See Oracle databases on ONTAP for further information.

Known issues

For CentOS (Red Hat compatible kernel) known issues, see the known issues for Red Hat Enterprise Linux (RHEL) 6.9.

Use CentOS 6.8 with ONTAP

You can use the ONTAP SAN host configuration settings to configure CentOS 6.8 with ONTAP as the target.

Install the Linux Host Utilities

The NetApp Linux Host Utilities software package is available on the NetApp Support Site in a 32-bit and 64-bit .rpm file. If you don't know which file is right for your configuration, use the Interoperability Matrix Tool to verify which one you need.

NetApp strongly recommends installing the Linux Host Utilities, but it's not mandatory. The utilities don't change any settings on your Linux host. The utilities improve management and assist NetApp customer support in gathering information about your configuration.

If you have Linux Host Utilities currently installed, you should either upgrade it to the latest version, or remove it and follow these steps to install the latest version.

Steps

1. Download the 32-bit or 64-bit Linux Host Utilities software package from the NetApp Support Site to your host.

2. Install the software package:

```
rpm -ivh netapp_linux_unified_host_utilities-7-1.x86_64
```

> ⓘ You can use the configuration settings provided in this procedure to configure cloud clients connected to Cloud Volumes ONTAP and Amazon FSx for ONTAP.

SAN Toolkit

The toolkit is installed automatically when you install the NetApp Host Utilities package. This kit provides the `sanlun` utility, which helps you manage LUNs and HBAs. The `sanlun` command returns information about the LUNs mapped to your host, multipathing, and information necessary to create initiator groups.

Example

In the following example, the `sanlun lun show` command returns LUN information.

```
# sanlun lun show all
```

Example output:

```
controller(7mode/E-Series)/                  device      host                    lun
vserver(cDOT/FlashRay)     lun-pathname   filename    adapter  protocol  size
Product
-------------------------------------------------------------------------
----------
data_vserver            /vol/vol1/lun1   /dev/sdb    host16    FCP
120.0g   cDOT
data_vserver            /vol/vol1/lun1   /dev/sdc    host15    FCP
120.0g   cDOT
data_vserver            /vol/vol2/lun2   /dev/sdd    host16    FCP
120.0g   cDOT
data_vserver            /vol/vol2/lun2   /dev/sde    host15    FCP
120.0g   cDOT
```

SAN Booting

Before you begin

If you decide to use SAN booting, it must be supported by your configuration. You can use the Interoperability Matrix Tool to verify that your OS, HBA, HBA firmware and the HBA boot BIOS, and ONTAP version are supported.

Steps

1. Map the SAN boot LUN to the host.

2. Verify that multiple paths are available.

(i) | Multiple paths become available after the host OS is up and running on the paths.

3. Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is mapped.

   For information on how to enable the HBA BIOS, see your vendor-specific documentation.

4. Reboot the host to verify that the boot was successful.

Multipathing

For CentOS 6.8 the `/etc/multipath.conf` file must exist, but you do not need to make specific changes to the file. CentOS 6.8 is compiled with all settings required to recognize and correctly manage ONTAP LUNs.

To Enable ALUA Handler, perform the following steps:

Steps

1. Create a backup of the initrd-image.

2. Append the following parameter value to the kernel for ALUA and non-ALUA to work:
   `rdloaddriver=scsi_dh_alua`

   Example

   ```
   kernel /vmlinuz-2.6.32-358.6.1.el6.x86_64 ro root=/dev/mapper/
   vg_ibmx355021082-lv_root rd_NO_LUKS rd_LVM_LV=vg_ibmx355021082/ lv_root
   LANG=en_US.UTF-8 rd_LVM_LV=vg_ibmx355021082/lv_swap rd_NO_MD
   SYSFONT=latarcyrheb-sun16 crashkernel=auto KEYBOARDTYPE=pc KEYTABLE=us
   rd_NO_DM rhgb quiet rdloaddriver=scsi_dh_alua
   ```

3. Use the `mkinitrd` command to recreate the initrd-image.
   CentOS 6x and later versions use either:
   The command: `mkinitrd -f /boot/ initrd-"uname -r".img uname -r`
   Or
   The command: `dracut -f`

4. Reboot the host.

5. Verify the output of the `cat /proc/cmdline` command to ensure that the setting is complete.

You can use the `multipath -ll` command to verify the settings for your ONTAP LUNs.

The following sections provide example multipath outputs for a LUN mapped to ASA and non-ASA personas.

All SAN Array configurations

All SAN Array (ASA) configurations optimize all paths to a given LUN, keeping them active. This improves performance by serving I/O operations through all paths at the same time.

Example
The following example displays the correct output for an ONTAP LUN.

```
# multipath -ll
3600a0980383034466b2b4a3775474859 dm-3 NETAPP,LUN C-Mode
size=20G features='4 queue_if_no_path pg_init_retries 50
retain_attached_hw_handle' hwhandler='1 alua' wp=rw
|-+- policy='round-robin 0' prio=50 status=active
|- 1:0:8:1  sdb 8:16 active ready running
|- 2:0:8:1  sdd 8:48 active ready running
|- 1:0:9:1  sdc 8:32 active ready running
|- 2:0:9:1  sde 8:64 active ready running
```

ⓘ A single LUN shouldn't require more than four paths. Having more than four paths might cause
path issues during storage failures.

Non-ASA configurations

For non-ASA configurations, there should be two groups of paths with different priorities. The paths with higher
priorities are Active/Optimized. This means they are serviced by the controller where the aggregate is located.
The paths with lower priorities are active but non-optimized because they are served from a different controller.
The non-optimized paths are only used when optimized paths are not available.

Example

The following example displays the correct output for an ONTAP LUN with two Active/Optimized paths and two
Active/Non-Optimized paths.

```
# multipath -ll
3600a0980383034466b2b4a3775474859 dm-3 NETAPP,LUN C-Mode
size=20G features='4 queue_if_no_path pg_init_retries 50
retain_attached_hw_handle' hwhandler='1 alua' wp=rw
|-+- policy='round-robin 0' prio=50 status=active
| |- 1:0:8:1  sdb 8:16 active ready running
| `- 2:0:8:1  sdd 8:48 active ready running
`-+- policy='round-robin 0' prio=10 status=enabled
  |- 1:0:9:1  sdc 8:32 active ready running
  `- 2:0:9:1  sde 8:64 active ready running
```

ⓘ A single LUN shouldn't require more than four paths. Having more than four paths might cause
path issues during storage failures.

Recommended Settings

The CentOS 6.8 is compiled to recognize ONTAP LUNs and automatically set all configuration parameters
correctly for both ASA and non-ASA configuration.

The `multipath.conf` file must exist for the multipath daemon to start. If this file doesn't exist, you can create
an empty, zero-byte file by using the `touch /etc/multipath.conf` command.

The first time you create the `multipath.conf` file, you might need to enable and start the multipath services by using the following commands:

```
chkconfig multipathd on
/etc/init.d/multipathd start
```

You don't need to add anything directly to the `multipath.conf` file unless you have devices that you don't want multipath to manage or you have existing settings that override defaults. To exclude unwanted devices, add the following syntax to the `multipath.conf` file, replacing <DevId> with the worldwide identifier (WWID) string of the device you want to exclude:

```
blacklist {
        wwid <DevId>
        devnode "^(ram|raw|loop|fd|md|dm-|sr|scd|st)[0-9]*"
        devnode "^hd[a-z]"
        devnode "^cciss.*"
}
```

The following example determines the WWID of a device and adds it to the `multipath.conf` file.

Steps

1. Determine the WWID:

```
/lib/udev/scsi_id -gud /dev/sda
```

```
3600a098038314c4a433f5774717a3046
```

`sda` is the local SCSI disk that you want to add to the blacklist.

2. Add the `WWID` to the blacklist stanza in `/etc/multipath.conf`:

```
blacklist {
        wwid    3600a098038314c4a433f5774717a3046
        devnode "^(ram|raw|loop|fd|md|dm-|sr|scd|st)[0-9]*"
        devnode "^hd[a-z]"
        devnode "^cciss.*"
}
```

Always check your `/etc/multipath.conf` file, especially in the defaults section, for legacy settings that might be overriding default settings.

The following table demonstrates the critical `multipathd` parameters for ONTAP LUNs and the required

values. If a host is connected to LUNs from other vendors and any of these parameters are overridden, they must be corrected by later stanzas in the `multipath.conf` file that apply specifically to ONTAP LUNs. Without this correction, the ONTAP LUNs might not work as expected. You should only override these defaults in consultation with NetApp, the OS vendor, or both, and only when the impact is fully understood.

Parameter	Setting
detect_prio	yes
dev_loss_tmo	"infinity"
failback	immediate
fast_io_fail_tmo	5
features	"3 queue_if_no_path pg_init_retries 50"
flush_on_last_del	"yes"
hardware_handler	"0"
no_path_retry	queue
path_checker	"tur"
path_grouping_policy	"group_by_prio"
path_selector	"round-robin 0"
polling_interval	5
prio	"ontap"
product	LUN.*
retain_attached_hw_handler	yes
rr_weight	"uniform"
user_friendly_names	no
vendor	NETAPP

Example

The following example shows how to correct an overridden default. In this case, the `multipath.conf` file defines values for `path_checker` and `no_path_retry` that are not compatible with ONTAP LUNs. If they cannot be removed because of other SAN arrays still attached to the host, these parameters can be corrected specifically for ONTAP LUNs with a device stanza.

```
defaults {
    path_checker       readsector0
    no_path_retry       fail
}

devices {
    device {
        vendor          "NETAPP  "
        product          "LUN.*"
        no_path_retry     queue
        path_checker      tur
    }
}
```

Configure KVM settings

You don't need to configure settings for a Kernel-based Virtual Machine because the LUN is mapped to the hypervisor.

ASM mirroring

Automatic Storage Management (ASM) mirroring might require changes to the Linux multipath settings to allow ASM to recognize a problem and switch over to an alternate failure group. Most ASM configurations on ONTAP use external redundancy, which means that data protection is provided by the external array and ASM doesn't mirror data. Some sites use ASM with normal redundancy to provide two-way mirroring, normally across different sites. See Oracle databases on ONTAP for further information.

Known issues

For CentOS (Red Hat compatible kernel) known issues, see the known issues for Red Hat Enterprise Linux (RHEL) 6.8.

Use CentOS 6.7 with ONTAP

You can use the ONTAP SAN host configuration settings to configure CentOS 6.7 with ONTAP as the target.

Install the Linux Host Utilities

The NetApp Linux Host Utilities software package is available on the NetApp Support Site in a 32-bit and 64-bit .rpm file. If you don't know which file is right for your configuration, use the Interoperability Matrix Tool to verify which one you need.

NetApp strongly recommends installing the Linux Host Utilities, but it's not mandatory. The utilities don't change any settings on your Linux host. The utilities improve management and assist NetApp customer support in gathering information about your configuration.

If you have Linux Host Utilities currently installed, you should either upgrade it to the latest version, or remove it and follow these steps to install the latest version.

Steps

1. Download the 32-bit or 64-bit Linux Host Utilities software package from the NetApp Support Site to your host.

2. Install the software package:

```
rpm -ivh netapp_linux_unified_host_utilities-7-1.x86_64
```

> ⓘ You can use the configuration settings provided in this procedure to configure cloud clients connected to Cloud Volumes ONTAP and Amazon FSx for ONTAP.

SAN Toolkit

The toolkit is installed automatically when you install the NetApp Host Utilities package. This kit provides the `sanlun` utility, which helps you manage LUNs and HBAs. The `sanlun` command returns information about the LUNs mapped to your host, multipathing, and information necessary to create initiator groups.

Example

In the following example, the `sanlun lun show` command returns LUN information.

```
# sanlun lun show all
```

Example output:

```
controller(7mode/E-Series)/                   device      host                 lun
vserver(cDOT/FlashRay)    lun-pathname   filename    adapter  protocol  size
Product
-------------------------------------------------------------------------
----------
data_vserver            /vol/vol1/lun1   /dev/sdb    host16   FCP
120.0g  cDOT
data_vserver            /vol/vol1/lun1   /dev/sdc    host15   FCP
120.0g  cDOT
data_vserver            /vol/vol2/lun2   /dev/sdd    host16   FCP
120.0g  cDOT
data_vserver            /vol/vol2/lun2   /dev/sde    host15   FCP
120.0g  cDOT
```

SAN Booting

Before you begin

If you decide to use SAN booting, it must be supported by your configuration. You can use the Interoperability Matrix Tool to verify that your OS, HBA, HBA firmware and the HBA boot BIOS, and ONTAP version are supported.

Steps

1. Map the SAN boot LUN to the host.

2. Verify that multiple paths are available.

3. Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is mapped.

   For information on how to enable the HBA BIOS, see your vendor-specific documentation.

4. Reboot the host to verify that the boot was successful.

Multipathing

For CentOS 6.7 the `/etc/multipath.conf` file must exist, but you do not need to make specific changes to the file. CentOS 6.7 is compiled with all settings required to recognize and correctly manage ONTAP LUNs. To Enable ALUA Handler, perform the following steps:

Steps

1. Create a backup of the initrd-image.

2. Append the following parameter value to the kernel for ALUA and non-ALUA to work:
   `rdloaddriver=scsi_dh_alua`

   Example

   ```
   kernel /vmlinuz-2.6.32-358.6.1.el6.x86_64 ro root=/dev/mapper/
   vg_ibmx355021082-lv_root rd_NO_LUKS rd_LVM_LV=vg_ibmx355021082/ lv_root
   LANG=en_US.UTF-8 rd_LVM_LV=vg_ibmx355021082/lv_swap rd_NO_MD
   SYSFONT=latarcyrheb-sun16 crashkernel=auto KEYBOARDTYPE=pc KEYTABLE=us
   rd_NO_DM rhgb quiet rdloaddriver=scsi_dh_alua
   ```

3. Use the `mkinitrd` command to recreate the initrd-image.
   CentOS 6x and later versions use either:
   The command: `mkinitrd -f /boot/ initrd-"uname -r".img uname -r`
   Or
   The command: `dracut -f`

4. Reboot the host.

5. Verify the output of the `cat /proc/cmdline` command to ensure that the setting is complete.

You can use the `multipath -ll` command to verify the settings for your ONTAP LUNs.

The following sections provide example multipath outputs for a LUN mapped to ASA and non-ASA personas.

All SAN Array configurations

All SAN Array (ASA) configurations optimize all paths to a given LUN, keeping them active. This improves performance by serving I/O operations through all paths at the same time.

Example
The following example displays the correct output for an ONTAP LUN.

```
# multipath -ll
3600a0980383034466b2b4a3775474859 dm-3 NETAPP,LUN C-Mode
size=20G features='4 queue_if_no_path pg_init_retries 50
retain_attached_hw_handle' hwhandler='1 alua' wp=rw
|-+- policy='round-robin 0' prio=50 status=active
|- 1:0:8:1  sdb 8:16 active ready running
|- 2:0:8:1  sdd 8:48 active ready running
|- 1:0:9:1  sdc 8:32 active ready running
|- 2:0:9:1  sde 8:64 active ready running
```

ⓘ   A single LUN shouldn't require more than four paths. Having more than four paths might cause
     path issues during storage failures.

Non-ASA configurations

For non-ASA configurations, there should be two groups of paths with different priorities. The paths with higher
priorities are Active/Optimized. This means they are serviced by the controller where the aggregate is located.
The paths with lower priorities are active but non-optimized because they are served from a different controller.
The non-optimized paths are only used when optimized paths are not available.

Example

The following example displays the correct output for an ONTAP LUN with two Active/Optimized paths and two
Active/Non-Optimized paths.

```
# multipath -ll
3600a0980383034466b2b4a3775474859 dm-3 NETAPP,LUN C-Mode
size=20G features='4 queue_if_no_path pg_init_retries 50
retain_attached_hw_handle' hwhandler='1 alua' wp=rw
|-+- policy='round-robin 0' prio=50 status=active
| |- 1:0:8:1  sdb 8:16 active ready running
| `- 2:0:8:1  sdd 8:48 active ready running
`-+- policy='round-robin 0' prio=10 status=enabled
  |- 1:0:9:1  sdc 8:32 active ready running
  `- 2:0:9:1  sde 8:64 active ready running
```

ⓘ   A single LUN shouldn't require more than four paths. Having more than four paths might cause
     path issues during storage failures.

Recommended Settings

The CentOS 6.7 OS is compiled to recognize ONTAP LUNs and automatically set all configuration parameters
correctly for both ASA and non-ASA configuration.

The `multipath.conf` file must exist for the multipath daemon to start. If this file doesn't exist, you can create
an empty, zero-byte file by using the `touch /etc/multipath.conf` command.

The first time you create the `multipath.conf` file, you might need to enable and start the multipath services by using the following commands:

```
chkconfig multipathd on
/etc/init.d/multipathd start
```

You don't need to add anything directly to the `multipath.conf` file unless you have devices that you don't want multipath to manage or you have existing settings that override defaults. To exclude unwanted devices, add the following syntax to the `multipath.conf` file, replacing <DevId> with the worldwide identifier (WWID) string of the device you want to exclude:

```
blacklist {
        wwid <DevId>
        devnode "^(ram|raw|loop|fd|md|dm-|sr|scd|st)[0-9]*"
        devnode "^hd[a-z]"
        devnode "^cciss.*"
}
```

The following example determines the WWID of a device and adds it to the `multipath.conf` file.

Steps

1. Determine the WWID:

   ```
   /lib/udev/scsi_id -gud /dev/sda
   ```

   ```
   3600a098038314c4a433f5774717a3046
   ```

   `sda` is the local SCSI disk that you want to add to the blacklist.

2. Add the `WWID` to the blacklist stanza in `/etc/multipath.conf`:

   ```
   blacklist {
           wwid    3600a098038314c4a433f5774717a3046
           devnode "^(ram|raw|loop|fd|md|dm-|sr|scd|st)[0-9]*"
           devnode "^hd[a-z]"
           devnode "^cciss.*"
   }
   ```

Always check your `/etc/multipath.conf` file, especially in the defaults section, for legacy settings that might be overriding default settings.

The following table demonstrates the critical `multipathd` parameters for ONTAP LUNs and the required

values. If a host is connected to LUNs from other vendors and any of these parameters are overridden, they must be corrected by later stanzas in the `multipath.conf` file that apply specifically to ONTAP LUNs. Without this correction, the ONTAP LUNs might not work as expected. You should only override these defaults in consultation with NetApp, the OS vendor, or both, and only when the impact is fully understood.

Parameter	Setting
detect_prio	yes
dev_loss_tmo	"infinity"
failback	immediate
fast_io_fail_tmo	5
features	"3 queue_if_no_path pg_init_retries 50"
flush_on_last_del	"yes"
hardware_handler	"0"
no_path_retry	queue
path_checker	"tur"
path_grouping_policy	"group_by_prio"
path_selector	"round-robin 0"
polling_interval	5
prio	"ontap"
product	LUN.*
retain_attached_hw_handler	yes
rr_weight	"uniform"
user_friendly_names	no
vendor	NETAPP

Example

The following example shows how to correct an overridden default. In this case, the `multipath.conf` file defines values for `path_checker` and `no_path_retry` that are not compatible with ONTAP LUNs. If they cannot be removed because of other SAN arrays still attached to the host, these parameters can be corrected specifically for ONTAP LUNs with a device stanza.

```
defaults {
    path_checker        readsector0
    no_path_retry        fail
}

devices {
    device {
        vendor            "NETAPP  "
        product            "LUN.*"
        no_path_retry        queue
        path_checker        tur
    }
}
```

Configure KVM settings

You don't need to configure settings for a Kernel-based Virtual Machine because the LUN is mapped to the hypervisor.

ASM mirroring

Automatic Storage Management (ASM) mirroring might require changes to the Linux multipath settings to allow ASM to recognize a problem and switch over to an alternate failure group. Most ASM configurations on ONTAP use external redundancy, which means that data protection is provided by the external array and ASM doesn't mirror data. Some sites use ASM with normal redundancy to provide two-way mirroring, normally across different sites. See Oracle databases on ONTAP for further information.

Known issues

For CentOS (Red Hat compatible kernel) known issues, see the known issues for Red Hat Enterprise Linux (RHEL) 6.7.

Use CentOS 6.6 with ONTAP

You can use the ONTAP SAN host configuration settings to configure CentOS 6.6 with ONTAP as the target.

Install the Linux Host Utilities

The NetApp Linux Host Utilities software package is available on the NetApp Support Site in a 32-bit and 64-bit .rpm file. If you don't know which file is right for your configuration, use the Interoperability Matrix Tool to verify which one you need.

NetApp strongly recommends installing the Linux Host Utilities, but it's not mandatory. The utilities don't change any settings on your Linux host. The utilities improve management and assist NetApp customer support in gathering information about your configuration.

If you have Linux Host Utilities currently installed, you should either upgrade it to the latest version, or remove it and follow these steps to install the latest version.

Steps

1. Download the 32-bit or 64-bit Linux Host Utilities software package from the NetApp Support Site to your host.

2. Install the software package:

```
rpm -ivh netapp_linux_unified_host_utilities-7-1.x86_64
```

> ⓘ You can use the configuration settings provided in this procedure to configure cloud clients connected to Cloud Volumes ONTAP and Amazon FSx for ONTAP.

SAN Toolkit

The toolkit is installed automatically when you install the NetApp Host Utilities package. This kit provides the `sanlun` utility, which helps you manage LUNs and HBAs. The `sanlun` command returns information about the LUNs mapped to your host, multipathing, and information necessary to create initiator groups.

Example

In the following example, the `sanlun lun show` command returns LUN information.

```
# sanlun lun show all
```

Example output:

```
controller(7mode/E-Series)/                 device      host                    lun
vserver(cDOT/FlashRay)    lun-pathname   filename    adapter   protocol   size
Product
-----------------------------------------------------------------------------
----------
data_vserver              /vol/vol1/lun1   /dev/sdb    host16    FCP
120.0g   cDOT
data_vserver              /vol/vol1/lun1   /dev/sdc    host15    FCP
120.0g   cDOT
data_vserver              /vol/vol2/lun2   /dev/sdd    host16    FCP
120.0g   cDOT
data_vserver              /vol/vol2/lun2   /dev/sde    host15    FCP
120.0g   cDOT
```

SAN Booting

Before you begin

If you decide to use SAN booting, it must be supported by your configuration. You can use the Interoperability Matrix Tool to verify that your OS, HBA, HBA firmware and the HBA boot BIOS, and ONTAP version are supported.

Steps

1. Map the SAN boot LUN to the host.

2. Verify that multiple paths are available.

i | Multiple paths become available after the host OS is up and running on the paths.

3. Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is mapped.

   For information on how to enable the HBA BIOS, see your vendor-specific documentation.

4. Reboot the host to verify that the boot was successful.

Multipathing

For CentOS 6.6 the `/etc/multipath.conf` file must exist, but you do not need to make specific changes to the file. CentOS 6.6 is compiled with all settings required to recognize and correctly manage ONTAP LUNs. To Enable ALUA Handler, perform the following steps:

Steps

1. Create a backup of the initrd-image.

2. Append the following parameter value to the kernel for ALUA and non-ALUA to work:
   `rdloaddriver=scsi_dh_alua`

   Example

   ```
   kernel /vmlinuz-2.6.32-358.6.1.el6.x86_64 ro root=/dev/mapper/
   vg_ibmx355021082-lv_root rd_NO_LUKS rd_LVM_LV=vg_ibmx355021082/ lv_root
   LANG=en_US.UTF-8 rd_LVM_LV=vg_ibmx355021082/lv_swap rd_NO_MD
   SYSFONT=latarcyrheb-sun16 crashkernel=auto KEYBOARDTYPE=pc KEYTABLE=us
   rd_NO_DM rhgb quiet rdloaddriver=scsi_dh_alua
   ```

3. Use the `mkinitrd` command to recreate the initrd-image.
   CentOS 6x and later versions use either:
   The command: `mkinitrd -f /boot/ initrd-"uname -r".img uname -r`
   Or
   The command: `dracut -f`

4. Reboot the host.

5. Verify the output of the `cat /proc/cmdline` command to ensure that the setting is complete.

You can use the `multipath -ll` command to verify the settings for your ONTAP LUNs.

The following sections provide example multipath outputs for a LUN mapped to ASA and non-ASA personas.

All SAN Array configurations

All SAN Array (ASA) configurations optimize all paths to a given LUN, keeping them active. This improves performance by serving I/O operations through all paths at the same time.

Example
The following example displays the correct output for an ONTAP LUN.

```
# multipath -ll
3600a0980383034466b2b4a3775474859 dm-3 NETAPP,LUN C-Mode
size=20G features='4 queue_if_no_path pg_init_retries 50
retain_attached_hw_handle' hwhandler='1 alua' wp=rw
|-+- policy='round-robin 0' prio=50 status=active
|- 1:0:8:1  sdb 8:16 active ready running
|- 2:0:8:1  sdd 8:48 active ready running
|- 1:0:9:1  sdc 8:32 active ready running
|- 2:0:9:1  sde 8:64 active ready running
```

> ⓘ A single LUN shouldn't require more than four paths. Having more than four paths might cause path issues during storage failures.

Non-ASA configurations

For non-ASA configurations, there should be two groups of paths with different priorities. The paths with higher priorities are Active/Optimized. This means they are serviced by the controller where the aggregate is located. The paths with lower priorities are active but non-optimized because they are served from a different controller. The non-optimized paths are only used when optimized paths are not available.

Example

The following example displays the correct output for an ONTAP LUN with two Active/Optimized paths and two Active/Non-Optimized paths.

```
# multipath -ll
3600a0980383034466b2b4a3775474859 dm-3 NETAPP,LUN C-Mode
size=20G features='4 queue_if_no_path pg_init_retries 50
retain_attached_hw_handle' hwhandler='1 alua' wp=rw
|-+- policy='round-robin 0' prio=50 status=active
| |- 1:0:8:1  sdb 8:16 active ready running
| `- 2:0:8:1  sdd 8:48 active ready running
`-+- policy='round-robin 0' prio=10 status=enabled
  |- 1:0:9:1  sdc 8:32 active ready running
  `- 2:0:9:1  sde 8:64 active ready running
```

> ⓘ A single LUN shouldn't require more than four paths. Having more than four paths might cause path issues during storage failures.

Recommended Settings

The CentOS 6.6 OS is compiled to recognize ONTAP LUNs and automatically set all configuration parameters correctly for both ASA and non-ASA configuration.

The `multipath.conf` file must exist for the multipath daemon to start. If this file doesn't exist, you can create an empty, zero-byte file by using the `touch /etc/multipath.conf` command.

The first time you create the `multipath.conf` file, you might need to enable and start the multipath services by using the following commands:

```
chkconfig multipathd on
/etc/init.d/multipathd start
```

You don't need to add anything directly to the `multipath.conf` file unless you have devices that you don't want multipath to manage or you have existing settings that override defaults. To exclude unwanted devices, add the following syntax to the `multipath.conf` file, replacing <DevId> with the worldwide identifier (WWID) string of the device you want to exclude:

```
blacklist {
        wwid <DevId>
        devnode "^(ram|raw|loop|fd|md|dm-|sr|scd|st)[0-9]*"
        devnode "^hd[a-z]"
        devnode "^cciss.*"
}
```

The following example determines the WWID of a device and adds it to the `multipath.conf` file.

Steps

1. Determine the WWID:

   ```
   /lib/udev/scsi_id -gud /dev/sda
   ```

   ```
   3600a098038314c4a433f5774717a3046
   ```

   `sda` is the local SCSI disk that you want to add to the blacklist.

2. Add the `WWID` to the blacklist stanza in `/etc/multipath.conf`:

   ```
   blacklist {
           wwid    3600a098038314c4a433f5774717a3046
           devnode "^(ram|raw|loop|fd|md|dm-|sr|scd|st)[0-9]*"
           devnode "^hd[a-z]"
           devnode "^cciss.*"
   }
   ```

Always check your `/etc/multipath.conf` file, especially in the defaults section, for legacy settings that might be overriding default settings.

The following table demonstrates the critical `multipathd` parameters for ONTAP LUNs and the required

values. If a host is connected to LUNs from other vendors and any of these parameters are overridden, they must be corrected by later stanzas in the `multipath.conf` file that apply specifically to ONTAP LUNs. Without this correction, the ONTAP LUNs might not work as expected. You should only override these defaults in consultation with NetApp, the OS vendor, or both, and only when the impact is fully understood.

Parameter	Setting
detect_prio	yes
dev_loss_tmo	"infinity"
failback	immediate
fast_io_fail_tmo	5
features	"3 queue_if_no_path pg_init_retries 50"
flush_on_last_del	"yes"
hardware_handler	"0"
no_path_retry	queue
path_checker	"tur"
path_grouping_policy	"group_by_prio"
path_selector	"round-robin 0"
polling_interval	5
prio	"ontap"
product	LUN.*
retain_attached_hw_handler	yes
rr_weight	"uniform"
user_friendly_names	no
vendor	NETAPP

Example

The following example shows how to correct an overridden default. In this case, the `multipath.conf` file defines values for `path_checker` and `no_path_retry` that are not compatible with ONTAP LUNs. If they cannot be removed because of other SAN arrays still attached to the host, these parameters can be corrected specifically for ONTAP LUNs with a device stanza.

```
defaults {
    path_checker        readsector0
    no_path_retry        fail
}

devices {
    device {
        vendor          "NETAPP  "
        product          "LUN.*"
        no_path_retry      queue
        path_checker       tur
    }
}
```

Configure KVM settings

You don't need to configure settings for a Kernel-based Virtual Machine because the LUN is mapped to the hypervisor.

ASM mirroring

Automatic Storage Management (ASM) mirroring might require changes to the Linux multipath settings to allow ASM to recognize a problem and switch over to an alternate failure group. Most ASM configurations on ONTAP use external redundancy, which means that data protection is provided by the external array and ASM doesn't mirror data. Some sites use ASM with normal redundancy to provide two-way mirroring, normally across different sites. See Oracle databases on ONTAP for further information.

Known issues

For CentOS (Red Hat compatible kernel) known issues, see the known issues for Red Hat Enterprise Linux (RHEL) 6.6.

Use CentOS 6.5 with ONTAP

You can use the ONTAP SAN host configuration settings to configure CentOS 6.5 with ONTAP as the target.

Install the Linux Host Utilities

The NetApp Linux Host Utilities software package is available on the NetApp Support Site in a 32-bit and 64-bit .rpm file. If you don't know which file is right for your configuration, use the Interoperability Matrix Tool to verify which one you need.

NetApp strongly recommends installing the Linux Host Utilities, but it's not mandatory. The utilities don't change any settings on your Linux host. The utilities improve management and assist NetApp customer support in gathering information about your configuration.

If you have Linux Host Utilities currently installed, you should either upgrade it to the latest version, or remove it and follow these steps to install the latest version.

Steps

1. Download the 32-bit or 64-bit Linux Host Utilities software package from the NetApp Support Site to your host.

2. Install the software package:

```
rpm -ivh netapp_linux_unified_host_utilities-7-1.x86_64
```

ⓘ You can use the configuration settings provided in this procedure to configure cloud clients connected to Cloud Volumes ONTAP and Amazon FSx for ONTAP.

SAN Toolkit

The toolkit is installed automatically when you install the NetApp Host Utilities package. This kit provides the `sanlun` utility, which helps you manage LUNs and HBAs. The `sanlun` command returns information about the LUNs mapped to your host, multipathing, and information necessary to create initiator groups.

Example

In the following example, the `sanlun lun show` command returns LUN information.

```
# sanlun lun show all
```

Example output:

```
controller(7mode/E-Series)/                 device     host                    lun
vserver(cDOT/FlashRay)    lun-pathname    filename    adapter  protocol  size
Product
--------------------------------------------------------------------------
----------
data_vserver              /vol/vol1/lun1    /dev/sdb    host16    FCP
120.0g  cDOT
data_vserver              /vol/vol1/lun1    /dev/sdc    host15    FCP
120.0g  cDOT
data_vserver              /vol/vol2/lun2    /dev/sdd    host16    FCP
120.0g  cDOT
data_vserver              /vol/vol2/lun2    /dev/sde    host15    FCP
120.0g  cDOT
```

SAN Booting

Before you begin

If you decide to use SAN booting, it must be supported by your configuration. You can use the Interoperability Matrix Tool to verify that your OS, HBA, HBA firmware and the HBA boot BIOS, and ONTAP version are supported.

Steps

1. Map the SAN boot LUN to the host.

2. Verify that multiple paths are available.

ⓘ	Multiple paths become available after the host OS is up and running on the paths.

3. Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is mapped.

   For information on how to enable the HBA BIOS, see your vendor-specific documentation.

4. Reboot the host to verify that the boot was successful.

Multipathing

For CentOS 6.5 the `/etc/multipath.conf` file must exist, but you do not need to make specific changes to the file. CentOS 6.5 is compiled with all settings required to recognize and correctly manage ONTAP LUNs.

To Enable ALUA Handler, perform the following steps:

Steps

1. Create a backup of the initrd-image.

2. Append the following parameter value to the kernel for ALUA and non-ALUA to work:
   `rdloaddriver=scsi_dh_alua`

   Example

   ```
   kernel /vmlinuz-2.6.32-358.6.1.el6.x86_64 ro root=/dev/mapper/
   vg_ibmx355021082-lv_root rd_NO_LUKS rd_LVM_LV=vg_ibmx355021082/ lv_root
   LANG=en_US.UTF-8 rd_LVM_LV=vg_ibmx355021082/lv_swap rd_NO_MD
   SYSFONT=latarcyrheb-sun16 crashkernel=auto KEYBOARDTYPE=pc KEYTABLE=us
   rd_NO_DM rhgb quiet rdloaddriver=scsi_dh_alua
   ```

3. Use the `mkinitrd` command to recreate the initrd-image.
   CentOS 6x and later versions use either:
   The command: `mkinitrd -f /boot/ initrd-"uname -r".img uname -r`
   Or
   The command: `dracut -f`

4. Reboot the host.

5. Verify the output of the `cat /proc/cmdline` command to ensure that the setting is complete.

You can use the `multipath -ll` command to verify the settings for your ONTAP LUNs.

The following sections provide example multipath outputs for a LUN mapped to ASA and non-ASA personas.

All SAN Array configurations

All SAN Array (ASA) configurations optimize all paths to a given LUN, keeping them active. This improves performance by serving I/O operations through all paths at the same time.

Example
The following example displays the correct output for an ONTAP LUN.

```
# multipath -ll
3600a0980383034466b2b4a3775474859 dm-3 NETAPP,LUN C-Mode
size=20G features='4 queue_if_no_path pg_init_retries 50
retain_attached_hw_handle' hwhandler='1 alua' wp=rw
|-+- policy='round-robin 0' prio=50 status=active
|- 1:0:8:1  sdb 8:16 active ready running
|- 2:0:8:1  sdd 8:48 active ready running
|- 1:0:9:1  sdc 8:32 active ready running
|- 2:0:9:1  sde 8:64 active ready running
```

> ⓘ A single LUN shouldn't require more than four paths. Having more than four paths might cause path issues during storage failures.

Non-ASA configurations

For non-ASA configurations, there should be two groups of paths with different priorities. The paths with higher priorities are Active/Optimized. This means they are serviced by the controller where the aggregate is located. The paths with lower priorities are active but non-optimized because they are served from a different controller. The non-optimized paths are only used when optimized paths are not available.

Example

The following example displays the correct output for an ONTAP LUN with two Active/Optimized paths and two Active/Non-Optimized paths.

```
# multipath -ll
3600a0980383034466b2b4a3775474859 dm-3 NETAPP,LUN C-Mode
size=20G features='4 queue_if_no_path pg_init_retries 50
retain_attached_hw_handle' hwhandler='1 alua' wp=rw
|-+- policy='round-robin 0' prio=50 status=active
| |- 1:0:8:1  sdb 8:16 active ready running
| `- 2:0:8:1  sdd 8:48 active ready running
`-+- policy='round-robin 0' prio=10 status=enabled
  |- 1:0:9:1  sdc 8:32 active ready running
  `- 2:0:9:1  sde 8:64 active ready running
```

> ⓘ A single LUN shouldn't require more than four paths. Having more than four paths might cause path issues during storage failures.

Recommended Settings

The CentOS 6.5 OS is compiled to recognize ONTAP LUNs and automatically set all configuration parameters correctly for both ASA and non-ASA configuration.

The `multipath.conf` file must exist for the multipath daemon to start. If this file doesn't exist, you can create an empty, zero-byte file by using the `touch /etc/multipath.conf` command.

The first time you create the `multipath.conf` file, you might need to enable and start the multipath services by using the following commands:

```
chkconfig multipathd on
/etc/init.d/multipathd start
```

You don't need to add anything directly to the `multipath.conf` file unless you have devices that you don't want multipath to manage or you have existing settings that override defaults. To exclude unwanted devices, add the following syntax to the `multipath.conf` file, replacing <DevId> with the worldwide identifier (WWID) string of the device you want to exclude:

```
blacklist {
        wwid <DevId>
        devnode "^(ram|raw|loop|fd|md|dm-|sr|scd|st)[0-9]*"
        devnode "^hd[a-z]"
        devnode "^cciss.*"
}
```

The following example determines the WWID of a device and adds it to the `multipath.conf` file.

Steps

1. Determine the WWID:

```
/lib/udev/scsi_id -gud /dev/sda
```

```
3600a098038314c4a433f5774717a3046
```

`sda` is the local SCSI disk that you want to add to the blacklist.

2. Add the `WWID` to the blacklist stanza in `/etc/multipath.conf`:

```
blacklist {
        wwid    3600a098038314c4a433f5774717a3046
        devnode "^(ram|raw|loop|fd|md|dm-|sr|scd|st)[0-9]*"
        devnode "^hd[a-z]"
        devnode "^cciss.*"
}
```

Always check your `/etc/multipath.conf` file, especially in the defaults section, for legacy settings that might be overriding default settings.

The following table demonstrates the critical `multipathd` parameters for ONTAP LUNs and the required

values. If a host is connected to LUNs from other vendors and any of these parameters are overridden, they must be corrected by later stanzas in the `multipath.conf` file that apply specifically to ONTAP LUNs. Without this correction, the ONTAP LUNs might not work as expected. You should only override these defaults in consultation with NetApp, the OS vendor, or both, and only when the impact is fully understood.

Parameter	Setting
detect_prio	yes
dev_loss_tmo	"infinity"
failback	immediate
fast_io_fail_tmo	5
features	"3 queue_if_no_path pg_init_retries 50"
flush_on_last_del	"yes"
hardware_handler	"0"
no_path_retry	queue
path_checker	"tur"
path_grouping_policy	"group_by_prio"
path_selector	"round-robin 0"
polling_interval	5
prio	"ontap"
product	LUN.*
retain_attached_hw_handler	yes
rr_weight	"uniform"
user_friendly_names	no
vendor	NETAPP

Example

The following example shows how to correct an overridden default. In this case, the `multipath.conf` file defines values for `path_checker` and `no_path_retry` that are not compatible with ONTAP LUNs. If they cannot be removed because of other SAN arrays still attached to the host, these parameters can be corrected specifically for ONTAP LUNs with a device stanza.

```
defaults {
    path_checker        readsector0
    no_path_retry        fail
}

devices {
    device {
        vendor          "NETAPP  "
        product          "LUN.*"
        no_path_retry      queue
        path_checker       tur
    }
}
```

Configure KVM settings

You don't need to configure settings for a Kernel-based Virtual Machine because the LUN is mapped to the hypervisor.

ASM mirroring

Automatic Storage Management (ASM) mirroring might require changes to the Linux multipath settings to allow ASM to recognize a problem and switch over to an alternate failure group. Most ASM configurations on ONTAP use external redundancy, which means that data protection is provided by the external array and ASM doesn't mirror data. Some sites use ASM with normal redundancy to provide two-way mirroring, normally across different sites. See Oracle databases on ONTAP for further information.

Known issues

For CentOS (Red Hat compatible kernel) known issues, see the known issues for Red Hat Enterprise Linux (RHEL) 6.5.

Use CentOS 6.4 with ONTAP

You can use the ONTAP SAN host configuration settings to configure CentOS 6.4 with ONTAP as the target.

Install the Linux Host Utilities

The NetApp Linux Host Utilities software package is available on the NetApp Support Site in a 32-bit and 64-bit .rpm file. If you don't know which file is right for your configuration, use the Interoperability Matrix Tool to verify which one you need.

NetApp strongly recommends installing the Linux Host Utilities, but it's not mandatory. The utilities don't change any settings on your Linux host. The utilities improve management and assist NetApp customer support in gathering information about your configuration.

If you have Linux Host Utilities currently installed, you should either upgrade it to the latest version, or remove it and follow these steps to install the latest version.

Steps

1. Download the 32-bit or 64-bit Linux Host Utilities software package from the NetApp Support Site to your host.

2. Install the software package:

```
rpm -ivh netapp_linux_unified_host_utilities-7-1.x86_64
```

> ⓘ You can use the configuration settings provided in this procedure to configure cloud clients connected to Cloud Volumes ONTAP and Amazon FSx for ONTAP.

SAN Toolkit

The toolkit is installed automatically when you install the NetApp Host Utilities package. This kit provides the `sanlun` utility, which helps you manage LUNs and HBAs. The `sanlun` command returns information about the LUNs mapped to your host, multipathing, and information necessary to create initiator groups.

Example

In the following example, the `sanlun lun show` command returns LUN information.

```
# sanlun lun show all
```

Example output:

```
controller(7mode/E-Series)/                device    host                lun
vserver(cDOT/FlashRay)    lun-pathname   filename   adapter  protocol  size
Product
-------------------------------------------------------------------------
----------
data_vserver           /vol/vol1/lun1   /dev/sdb   host16   FCP
120.0g  cDOT
data_vserver           /vol/vol1/lun1   /dev/sdc   host15   FCP
120.0g  cDOT
data_vserver           /vol/vol2/lun2   /dev/sdd   host16   FCP
120.0g  cDOT
data_vserver           /vol/vol2/lun2   /dev/sde   host15   FCP
120.0g  cDOT
```

SAN Booting

Before you begin

If you decide to use SAN booting, it must be supported by your configuration. You can use the Interoperability Matrix Tool to verify that your OS, HBA, HBA firmware and the HBA boot BIOS, and ONTAP version are supported.

Steps

1. Map the SAN boot LUN to the host.

2. Verify that multiple paths are available.

Multiple paths become available after the host OS is up and running on the paths.

3. Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is mapped.

   For information on how to enable the HBA BIOS, see your vendor-specific documentation.

4. Reboot the host to verify that the boot was successful.

Multipathing

For CentOS 6.4 the `/etc/multipath.conf` file must exist, but you do not need to make specific changes to the file. CentOS 6.4 is compiled with all settings required to recognize and correctly manage ONTAP LUNs.

To Enable ALUA Handler, perform the following steps:

Steps

1. Create a backup of the initrd-image.

2. Append the following parameter value to the kernel for ALUA and non-ALUA to work:
   `rdloaddriver=scsi_dh_alua`

   Example

   ```
   kernel /vmlinuz-2.6.32-358.6.1.el6.x86_64 ro root=/dev/mapper/
   vg_ibmx355021082-lv_root rd_NO_LUKS rd_LVM_LV=vg_ibmx355021082/ lv_root
   LANG=en_US.UTF-8 rd_LVM_LV=vg_ibmx355021082/lv_swap rd_NO_MD
   SYSFONT=latarcyrheb-sun16 crashkernel=auto KEYBOARDTYPE=pc KEYTABLE=us
   rd_NO_DM rhgb quiet rdloaddriver=scsi_dh_alua
   ```

3. Use the `mkinitrd` command to recreate the initrd-image.
   CentOS 6x and later versions use either:
   The command: `mkinitrd -f /boot/ initrd-"uname -r".img uname -r`
   Or
   The command: `dracut -f`

4. Reboot the host.

5. Verify the output of the `cat /proc/cmdline` command to ensure that the setting is complete.

You can use the `multipath -ll` command to verify the settings for your ONTAP LUNs.

The following sections provide example multipath outputs for a LUN mapped to ASA and non-ASA personas.

All SAN Array configurations

All SAN Array (ASA) configurations optimize all paths to a given LUN, keeping them active. This improves performance by serving I/O operations through all paths at the same time.

Example
The following example displays the correct output for an ONTAP LUN.

```
# multipath -ll
3600a0980383034466b2b4a3775474859 dm-3 NETAPP,LUN C-Mode
size=20G features='4 queue_if_no_path pg_init_retries 50
retain_attached_hw_handle' hwhandler='1 alua' wp=rw
|-+- policy='round-robin 0' prio=50 status=active
|- 1:0:8:1  sdb 8:16 active ready running
|- 2:0:8:1  sdd 8:48 active ready running
|- 1:0:9:1  sdc 8:32 active ready running
|- 2:0:9:1  sde 8:64 active ready running
```

> (i) A single LUN shouldn't require more than four paths. Having more than four paths might cause path issues during storage failures.

Non-ASA configurations

For non-ASA configurations, there should be two groups of paths with different priorities. The paths with higher priorities are Active/Optimized. This means they are serviced by the controller where the aggregate is located. The paths with lower priorities are active but non-optimized because they are served from a different controller. The non-optimized paths are only used when optimized paths are not available.

Example

The following example displays the correct output for an ONTAP LUN with two Active/Optimized paths and two Active/Non-Optimized paths.

```
# multipath -ll
3600a0980383034466b2b4a3775474859 dm-3 NETAPP,LUN C-Mode
size=20G features='4 queue_if_no_path pg_init_retries 50
retain_attached_hw_handle' hwhandler='1 alua' wp=rw
|-+- policy='round-robin 0' prio=50 status=active
| |- 1:0:8:1  sdb 8:16 active ready running
| `- 2:0:8:1  sdd 8:48 active ready running
`-+- policy='round-robin 0' prio=10 status=enabled
  |- 1:0:9:1  sdc 8:32 active ready running
  `- 2:0:9:1  sde 8:64 active ready running
```

> (i) A single LUN shouldn't require more than four paths. Having more than four paths might cause path issues during storage failures.

Recommended Settings

The CentOS 6.4 OS is compiled to recognize ONTAP LUNs and automatically set all configuration parameters correctly for both ASA and non-ASA configuration.

The `multipath.conf` file must exist for the multipath daemon to start. If this file doesn't exist, you can create an empty, zero-byte file by using the `touch /etc/multipath.conf` command.

The first time you create the `multipath.conf` file, you might need to enable and start the multipath services by using the following commands:

```
chkconfig multipathd on
/etc/init.d/multipathd start
```

You don't need to add anything directly to the `multipath.conf` file unless you have devices that you don't want multipath to manage or you have existing settings that override defaults. To exclude unwanted devices, add the following syntax to the `multipath.conf` file, replacing <DevId> with the worldwide identifier (WWID) string of the device you want to exclude:

```
blacklist {
        wwid <DevId>
        devnode "^(ram|raw|loop|fd|md|dm-|sr|scd|st)[0-9]*"
        devnode "^hd[a-z]"
        devnode "^cciss.*"
}
```

The following example determines the WWID of a device and adds it to the `multipath.conf` file.

Steps

1. Determine the WWID:

    ```
    /lib/udev/scsi_id -gud /dev/sda
    ```

    ```
    3600a098038314c4a433f5774717a3046
    ```

    `sda` is the local SCSI disk that you want to add to the blacklist.

2. Add the `WWID` to the blacklist stanza in `/etc/multipath.conf`:

    ```
    blacklist {
            wwid    3600a098038314c4a433f5774717a3046
            devnode "^(ram|raw|loop|fd|md|dm-|sr|scd|st)[0-9]*"
            devnode "^hd[a-z]"
            devnode "^cciss.*"
    }
    ```

Always check your `/etc/multipath.conf` file, especially in the defaults section, for legacy settings that might be overriding default settings.

The following table demonstrates the critical `multipathd` parameters for ONTAP LUNs and the required

values. If a host is connected to LUNs from other vendors and any of these parameters are overridden, they must be corrected by later stanzas in the `multipath.conf` file that apply specifically to ONTAP LUNs. Without this correction, the ONTAP LUNs might not work as expected. You should only override these defaults in consultation with NetApp, the OS vendor, or both, and only when the impact is fully understood.

Parameter	Setting
detect_prio	yes
dev_loss_tmo	"infinity"
failback	immediate
fast_io_fail_tmo	5
features	"3 queue_if_no_path pg_init_retries 50"
flush_on_last_del	"yes"
hardware_handler	"0"
no_path_retry	queue
path_checker	"tur"
path_grouping_policy	"group_by_prio"
path_selector	"round-robin 0"
polling_interval	5
prio	"ontap"
product	LUN.*
retain_attached_hw_handler	yes
rr_weight	"uniform"
user_friendly_names	no
vendor	NETAPP

Example

The following example shows how to correct an overridden default. In this case, the `multipath.conf` file defines values for `path_checker` and `no_path_retry` that are not compatible with ONTAP LUNs. If they cannot be removed because of other SAN arrays still attached to the host, these parameters can be corrected specifically for ONTAP LUNs with a device stanza.

```
defaults {
    path_checker        readsector0
    no_path_retry        fail
}

devices {
    device {
        vendor          "NETAPP  "
        product          "LUN.*"
        no_path_retry      queue
        path_checker       tur
    }
}
```

Configure KVM settings

You don't need to configure settings for a Kernel-based Virtual Machine because the LUN is mapped to the hypervisor.

ASM mirroring

Automatic Storage Management (ASM) mirroring might require changes to the Linux multipath settings to allow ASM to recognize a problem and switch over to an alternate failure group. Most ASM configurations on ONTAP use external redundancy, which means that data protection is provided by the external array and ASM doesn't mirror data. Some sites use ASM with normal redundancy to provide two-way mirroring, normally across different sites. See Oracle databases on ONTAP for further information.

Known issues

For CentOS (Red Hat compatible kernel) known issues, see the known issues for Red Hat Enterprise Linux (RHEL) 6.4.

Citrix

Configure Citrix Xenserver 8.4 for FCP and iSCSI with ONTAP storage

Configure Citrix Hypervisor 8.4 for multipathing and with specific parameters and settings for FCP and iSCSI protocol operations with ONTAP storage.

ⓘ   The Linux Host Utilities software package doesn't support Citrix Hypervisor operating systems.

Step 1: Optionally, enable SAN booting

You can configure your host to use SAN booting to simplify deployment and improve scalability.

Before you begin

Use the Interoperability Matrix Tool to verify that your Linux OS, host bus adapter (HBA), HBA firmware, HBA boot BIOS, and ONTAP version support SAN booting.

Steps

1. Create a SAN boot LUN and map it to the host.

2. Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is mapped.

   For information on how to enable the HBA BIOS, see your vendor-specific documentation.

3. Verify that the configuration was successful by rebooting the host and verifying that the OS is up and running.

Step 2: Confirm the multipath configuration for your host

You can use multipathing with Citrix Hypervisor 8.4 to manage ONTAP LUNs.

To ensure that multipathing is configured correctly for your host, verify that the `/etc/multipath.conf` file is defined and that you have the NetApp recommended settings configured for your ONTAP LUNs.

Steps

1. Verify that the `/etc/multipath.conf` file exists. If the file doesn't exist, create an empty, zero-byte file:

   ```
   touch /etc/multipath.conf
   ```

2. The first time the `multipath.conf` file is created, you might need to enable and start the multipath services to load the recommended settings:

   ```
   systemctl enable multipathd
   ```

   ```
   systemctl start multipathd
   ```

3. Each time you boot the host, the empty `/etc/multipath.conf` zero-byte file automatically loads the NetApp recommended host multipath parameters as the default settings. You shouldn't need to make changes to the `/etc/multipath.conf` file for your host because the host operating system is compiled with the multipath parameters that recognize and manage ONTAP LUNs correctly.

   The following table shows the native Linux OS compiled multipath parameter settings for ONTAP LUNs.

Show parameter settings

Parameter	Setting
detect_prio	yes
dev_loss_tmo	"infinity"
failback	immediate
fast_io_fail_tmo	5
features	"3 queue_if_no_path pg_init_retries 50"
flush_on_last_del	"yes"
hardware_handler	"0"
no_path_retry	queue
path_checker	"tur"
path_grouping_policy	"group_by_prio"
path_selector	"service-time 0"
polling_interval	5
prio	"ontap"
product	LUN
retain_attached_hw_handler	yes
rr_weight	"uniform"
user_friendly_names	no
vendor	NETAPP

4. Verify the parameter settings and path status for your ONTAP LUNs:

```
/sbin/mpathutil list
```

The default multipath parameters support ASA, AFF, and FAS configurations. In these configurations, a single ONTAP LUN shouldn't require more than four paths. If there are more than four paths, it might cause issues with the paths during a storage failure.

The following example outputs show the correct parameter settings and path status for ONTAP LUNs in an ASA, AFF, or FAS configuration.

ASA configuration

An ASA configuration optimizes all paths to a given LUN, keeping them active. This improves performance by serving I/O operations through all paths at the same time.

```
/usr/sbin/mpathutil status
show topology
create: 3600a098038315045572b5930646f4b63 dm-1 NETAPP  ,LUN C-Mode
size=9.0G features='4 queue_if_no_path pg_init_retries 50
retain_attached_hw_handle' hwhandler='1 alua' wp=rw
`-+- policy='service-time 0' prio=50 status=active
  |- 15:0:0:0  sdb  8:16    active ready running
  |- 15:0:1:0  sdc  8:32    active ready running
  |- 16:0:0:0  sdcf 69:48   active ready running
  `- 16:0:1:0  sdcg 69:64   active ready running
```

AFF or FAS configuration

An AFF or FAS configuration should have two groups of paths with higher and lower priorities. Higher priority Active/Optimized paths are served by the controller where the aggregate is located. Lower priority paths are active but non-optimized because they are served by a different controller. Non-optimized paths are only used when optimized paths aren't available.

The following example displays the output for an ONTAP LUN with two Active/Optimized paths and two Active/Non-Optimized paths:

```
/usr/sbin/mpathutil status
show topology
create: 3600a098038315045572b5930646f4b63 dm-1 NETAPP  ,LUN C-Mode
size=9.0G features='4 queue_if_no_path pg_init_retries 50
retain_attached_hw_handle' hwhandler='1 alua' wp=rw
|-+- policy='service-time 0' prio=50 status=active
  |- 15:0:0:0  sdb  8:16    active ready running
  `- 15:0:1:0  sdc  8:32    active ready running
`-+- policy='service-time 0' prio=50 status=active
    |- 16:0:0:0  sdcf 69:48   active ready running
    `- 16:0:1:0  sdcg 69:64   active ready running
```

Step 3: Optionally, exclude a device from multipathing

If required, you can exclude a device from multipathing by adding the WWID for the unwanted device to the "blacklist" stanza for the `multipath.conf` file.

Steps

1. Determine the WWID:

```
/lib/udev/scsi_id -gud /dev/sda
```

"sda" is the local SCSI disk that you want to add to the blacklist.

An example WWID is `360030057024d0730239134810c0cb833`.

2. Add the WWID to the "blacklist" stanza:

```
blacklist {
        wwid   360030057024d0730239134810c0cb833
        devnode "^(ram|raw|loop|fd|md|dm-|sr|scd|st)[0-9]*"
        devnode "^hd[a-z]"
        devnode "^cciss.*"
}
```

Step 4: Customize multipath parameters for ONTAP LUNs

If your host is connected to LUNs from other vendors and any of the multipath parameter settings are overridden, you need to correct them by adding stanzas later in the `multipath.conf` file that apply specifically to ONTAP LUNs. If you don't do this, the ONTAP LUNs might not work as expected.

Check your `/etc/multipath.conf` file, especially in the defaults section, for settings that might be overriding the default settings for multipath parameters.

> ⚠ You shouldn't override the recommended parameter settings for ONTAP LUNs. These settings are required for optimal performance of your host configuration. Contact NetApp support, your OS vendor, or both for more information.

The following example shows how to correct an overridden default. In this example, the `multipath.conf` file defines values for `path_checker` and `no_path_retry` that aren't compatible with ONTAP LUNs, and you can't remove these parameters because ONTAP storage arrays are still attached to the host. Instead, you correct the values for `path_checker` and `no_path_retry` by adding a device stanza to the `multipath.conf` file that applies specifically to the ONTAP LUNs.

Show example

```
defaults {
    path_checker       readsector0
    no_path_retry      fail
}

devices {
    device {
        vendor          "NETAPP"
        product         "LUN"
        no_path_retry   queue
        path_checker    tur
    }
}
```

Step 5: Review the known issues

There are no known issues.

Configure Citrix Hypervisor 8.2 for FCP and iSCSI with ONTAP storage

Configure Citrix Hypervisor 8.2 for multipathing and with specific parameters and settings for FCP and iSCSI protocol operations with ONTAP storage.

ⓘ The Linux Host Utilities software package doesn't support Citrix Hypervisor operating systems.

Step 1: Optionally, enable SAN booting

You can configure your host to use SAN booting to simplify deployment and improve scalability.

Before you begin

Use the Interoperability Matrix Tool to verify that your Linux OS, host bus adapter (HBA), HBA firmware, HBA boot BIOS, and ONTAP version support SAN booting.

Steps

1. Create a SAN boot LUN and map it to the host.

2. Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is mapped.

   For information on how to enable the HBA BIOS, see your vendor-specific documentation.

3. Verify that the configuration was successful by rebooting the host and verifying that the OS is up and running.

Step 2: Confirm the multipath configuration for your host

You can use multipathing with Citrix Hypervisor 8.2 to manage ONTAP LUNs.

To ensure that multipathing is configured correctly for your host, verify that the `/etc/multipath.conf` file is defined and that you have the NetApp recommended settings configured for your ONTAP LUNs.

Steps

1. Verify that the `/etc/multipath.conf` file exists. If the file doesn't exist, create an empty, zero-byte file:

   ```
   touch /etc/multipath.conf
   ```

2. The first time the `multipath.conf` file is created, you might need to enable and start the multipath services to load the recommended settings:

   ```
   systemctl enable multipathd
   ```

   ```
   systemctl start multipathd
   ```

3. Each time you boot the host, the empty `/etc/multipath.conf` zero-byte file automatically loads the NetApp recommended host multipath parameters as the default settings. You shouldn't need to make changes to the `/etc/multipath.conf` file for your host because the host operating system is compiled with the multipath parameters that recognize and manage ONTAP LUNs correctly.

   The following table shows the native Linux OS compiled multipath parameter settings for ONTAP LUNs.

Show parameter settings

Parameter	Setting
detect_prio	yes
dev_loss_tmo	"infinity"
failback	immediate
fast_io_fail_tmo	5
features	"3 queue_if_no_path pg_init_retries 50"
flush_on_last_del	"yes"
hardware_handler	"0"
no_path_retry	queue
path_checker	"tur"
path_grouping_policy	"group_by_prio"
path_selector	"service-time 0"
polling_interval	5
prio	"ontap"
product	LUN
retain_attached_hw_handler	yes
rr_weight	"uniform"
user_friendly_names	no
vendor	NETAPP

4. Verify the parameter settings and path status for your ONTAP LUNs:

```
/sbin/mpathutil list
```

The default multipath parameters support ASA, AFF, and FAS configurations. In these configurations, a single ONTAP LUN shouldn't require more than four paths. If there are more than four paths, it might cause issues with the paths during a storage failure.

The following example outputs show the correct parameter settings and path status for ONTAP LUNs in an ASA, AFF, or FAS configuration.

ASA configuration

An ASA configuration optimizes all paths to a given LUN, keeping them active. This improves performance by serving I/O operations through all paths at the same time.

```
/usr/sbin/mpathutil status
show topology
create: 3600a098038315045572b5930646f4b63 dm-1 NETAPP  ,LUN C-Mode
size=9.0G features='4 queue_if_no_path pg_init_retries 50
retain_attached_hw_handle' hwhandler='1 alua' wp=rw
`-+- policy='service-time 0' prio=50 status=active
  |- 15:0:0:0  sdb  8:16    active ready running
  |- 15:0:1:0  sdc  8:32    active ready running
  |- 16:0:0:0  sdcf 69:48   active ready running
  `- 16:0:1:0  sdcg 69:64   active ready running
```

AFF or FAS configuration

An AFF or FAS configuration should have two groups of paths with higher and lower priorities. Higher priority Active/Optimized paths are served by the controller where the aggregate is located. Lower priority paths are active but non-optimized because they are served by a different controller. Non-optimized paths are only used when optimized paths aren't available.

The following example displays the output for an ONTAP LUN with two Active/Optimized paths and two Active/Non-Optimized paths:

```
/usr/sbin/mpathutil status
show topology
create: 3600a098038315045572b5930646f4b63 dm-1 NETAPP  ,LUN C-Mode
size=9.0G features='4 queue_if_no_path pg_init_retries 50
retain_attached_hw_handle' hwhandler='1 alua' wp=rw
|-+- policy='service-time 0' prio=50 status=active
  |- 15:0:0:0  sdb  8:16    active ready running
  `- 15:0:1:0  sdc  8:32    active ready running
`-+- policy='service-time 0' prio=50 status=active
    |- 16:0:0:0  sdcf 69:48   active ready running
    `- 16:0:1:0  sdcg 69:64   active ready running
```

Step 3: Optionally, exclude a device from multipathing

If required, you can exclude a device from multipathing by adding the WWID for the unwanted device to the "blacklist" stanza for the `multipath.conf` file.

Steps

1. Determine the WWID:

```
/lib/udev/scsi_id -gud /dev/sda
```

"sda" is the local SCSI disk that you want to add to the blacklist.

An example WWID is `360030057024d0730239134810c0cb833`.

2. Add the WWID to the "blacklist" stanza:

```
blacklist {
        wwid    360030057024d0730239134810c0cb833
        devnode "^(ram|raw|loop|fd|md|dm-|sr|scd|st)[0-9]*"
        devnode "^hd[a-z]"
        devnode "^cciss.*"
}
```

Step 4: Customize multipath parameters for ONTAP LUNs

If your host is connected to LUNs from other vendors and any of the multipath parameter settings are overridden, you need to correct them by adding stanzas later in the `multipath.conf` file that apply specifically to ONTAP LUNs. If you don't do this, the ONTAP LUNs might not work as expected.

Check your `/etc/multipath.conf` file, especially in the defaults section, for settings that might be overriding the default settings for multipath parameters.

> ⚠️ You shouldn't override the recommended parameter settings for ONTAP LUNs. These settings are required for optimal performance of your host configuration. Contact NetApp support, your OS vendor, or both for more information.

The following example shows how to correct an overridden default. In this example, the `multipath.conf` file defines values for `path_checker` and `no_path_retry` that aren't compatible with ONTAP LUNs, and you can't remove these parameters because ONTAP storage arrays are still attached to the host. Instead, you correct the values for `path_checker` and `no_path_retry` by adding a device stanza to the `multipath.conf` file that applies specifically to the ONTAP LUNs.

Show example

```
defaults {
    path_checker        readsector0
    no_path_retry       fail
}

devices {
    device {
        vendor          "NETAPP"
        product         "LUN"
        no_path_retry   queue
        path_checker    tur
    }
}
```

Step 5: Review the known issues

There are no known issues.

ESXi

Use VMware vSphere 8.x with ONTAP

You can configure ONTAP SAN host settings for the VMware vSphere 8.x release with FC, FCoE, and iSCSI protocols.

Hypervisor SAN booting

Before you begin

If you decide to use SAN booting, it must be supported by your configuration. You can use the Interoperability Matrix Tool to verify that your OS, HBA, HBA firmware and the HBA boot BIOS, and ONTAP version are supported.

Steps

1. Map the SAN boot LUN to the host.

2. Verify that multiple paths are available.

    > ⓘ Multiple paths become available after the host OS is up and running on the paths.

3. Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is mapped.

    For information on how to enable the HBA BIOS, see your vendor-specific documentation.

4. Reboot the host to verify that the boot was successful.

Multipathing

ESXi provides an extensible multipathing module called Native Multipathing Plug-In (NMP) that manages the sub-plugins, Storage Array Type Plugins (SATPs), and Path Selection Plugins (PSPs). By default, these SATP rules are available in ESXi.

For ONTAP storage, the "VMW_SATP_ALUA" plugin is used by default with "VMW_PSP_RR" as a path selection policy (PSP). You can run the following command to confirm the PSP:

```
`esxcli storage nmp satp rule list -s VMW_SATP_ALUA`
```

Example output:

```
Name                Device  Vendor    Model         Driver  Transport  Options
----------------------------------------------------------------------------
-------
VMW_SATP_ALUA           LSI       INF-01-00
reset_on_attempted_reserve  system
VMW_SATP_ALUA           NETAPP
reset_on_attempted_reserve  system

Rule Group  Claim Options  Default PSP  PSP Options     Description
----------------------------------------------------------------
tpgs_on       VMW_PSP_MRU                    NetApp E-Series arrays with
ALUA support
tpgs_on       VMW_PSP_RR                     NetApp arrays with ALUA
support
```

Non-ASA configurations

For non-ASA configurations, there should be two groups of paths with different priorities. The paths with higher priorities are Active/Optimized. This means they are serviced by the controller where the aggregate is located. The paths with lower priorities are active but non-optimized because they are served from a different controller. The non-optimized paths are only used when optimized paths are not available.

Example

The following example displays the correct output for an ONTAP LUN with two Active/Optimized paths and two Active/Non-Optimized paths.

```
# esxcli storage nmp device list -d naa.600a098038314869372454524439585
```

Example output:

```
naa.600a098038314869372454524439855
    Device Display Name: NETAPP Fibre Channel Disk
(naa.600a098038314869372454524439855)
    Storage Array Type: VMW_SATP_ALUA
    Storage Array Type Device Config: {implicit_support=on;
explicit_support=off; explicit_allow=on; alua_followover=on;
action_OnRetryErrors=off;
{TPG_id=1000,TPG_state=ANO}{TPG_id=1001,TPG_state=AO}}
    Path Selection Policy: VMW_PSP_RR
    Path Selection Policy Device Config:
{policy=rr,iops=1000,bytes=10485760,useANO=0; lastPathIndex=1:
NumIOsPending=0,numBytesPending=0}
    Path Selection Policy Device Custom Config:
    Working Paths: vmhba4:C0:T0:L11, vmhba3:C0:T0:L11
    Is USB: false
```

```
# esxcli storage nmp path list -d naa.600a098038314869372454524439855
```

Example output:

```
fc.20000024ff7f4a51:21000024ff7f4a51-fc.2009d039ea3ab21f:2003d039ea3ab21f-
naa.600a098038314869372454524439855
    Runtime Name: vmhba4:C0:T0:L11
    Device: naa.600a098038314869372454524439855
    Device Display Name: NETAPP Fibre Channel Disk
(naa.600a098038314869372454524439855)
    Group State: active
    Array Priority: 0
    Storage Array Type Path Config: {TPG_id=1001,
TPG_state=AO,RTP_id=4,RTP_health=UP}
    Path Selection Policy Path Config: PSP VMW_PSP_RR does not support path
configuration.

fc.20000024ff7f4a50:21000024ff7f4a50-fc.2009d039ea3ab21f:2002d039ea3ab21f-
naa.600a098038314869372454524439855
    Runtime Name: vmhba3:C0:T0:L11
    Device: naa.600a098038314869372454524439855
    Device Display Name: NETAPP Fibre Channel Disk
(naa.600a098038314869372454524439855)
    Group State: active
    Array Priority: 0
    Storage Array Type Path Config: {TPG_id=1001,
TPG_state=AO,RTP_id=3,RTP_health=UP}
```

```
    Path Selection Policy Path Config: PSP VMW_PSP_RR does not support path
configuration.

fc.20000024ff7f4a51:21000024ff7f4a51-fc.2009d039ea3ab21f:2001d039ea3ab21f-
naa.600a098038314869372454524439585
    Runtime Name: vmhba4:C0:T3:L11
    Device: naa.600a098038314869372454524439585
    Device Display Name: NETAPP Fibre Channel Disk
(naa.600a098038314869372454524439585)
    Group State: active unoptimized
    Array Priority: 0
    Storage Array Type Path Config: {TPG_id=1000,
TPG_state=ANO,RTP_id=2,RTP_health=UP}
    Path Selection Policy Path Config: PSP VMW_PSP_RR does not support path
configuration.

fc.20000024ff7f4a50:21000024ff7f4a50-fc.2009d039ea3ab21f:2000d039ea3ab21f-
naa.600a098038314869372454524439585
    Runtime Name: vmhba3:C0:T3:L11
    Device: naa.600a098038314869372454524439585
    Device Display Name: NETAPP Fibre Channel Disk
(naa.600a098038314869372454524439585)
    Group State: active unoptimized
    Array Priority: 0
    Storage Array Type Path Config: {TPG_id=1000,
TPG_state=ANO,RTP_id=1,RTP_health=UP}
    Path Selection Policy Path Config: PSP VMW_PSP_RR does not support path
configuration.
```

All SAN Array configurations

All SAN Array (ASA) configurations optimize all paths to a given LUN, keeping them active. This improves performance by serving I/O operations through all paths at the same time.

Example

The following example displays the correct output for an ONTAP LUN.

```
esxcli storage nmp device list -d naa.600a098038304759563f4e7837574453
```

Example output:

```
naa.600a098038314962485d543078486c7a
    Device Display Name: NETAPP Fibre Channel Disk
(naa.600a098038314962485d543078486c7a)
    Storage Array Type: VMW_SATP_ALUA
    Storage Array Type Device Config: {implicit_support=on;
explicit_support=off; explicit_allow=on; alua_followover=on;
action_OnRetryErrors=off;
{TPG_id=1001,TPG_state=AO}{TPG_id=1000,TPG_state=AO}}
    Path Selection Policy: VMW_PSP_RR
    Path Selection Policy Device Config:
{policy=rr,iops=1000,bytes=10485760,useANO=0; lastPathIndex=3:
NumIOsPending=0,numBytesPending=0}
    Path Selection Policy Device Custom Config:
    Working Paths: vmhba4:C0:T0:L14, vmhba4:C0:T1:L14, vmhba3:C0:T0:L14,
vmhba3:C0:T1:L14
    Is USB: false
```

```
# esxcli storage nmp path list -d naa.600a098038314962485d543078486c7a
```

Example output:

```
fc.200034800d756a75:210034800d756a75-fc.2018d039ea936319:2015d039ea936319-
naa.600a098038314962485d543078486c7a
    Runtime Name: vmhba4:C0:T0:L14
    Device: naa.600a098038314962485d543078486c7a
    Device Display Name: NETAPP Fibre Channel Disk
(naa.600a098038314962485d543078486c7a)
    Group State: active
    Array Priority: 0
    Storage Array Type Path Config: {TPG_id=1000,
TPG_state=AO,RTP_id=2,RTP_health=UP}
    Path Selection Policy Path Config: PSP VMW_PSP_RR does not support path
configuration.

fc.200034800d756a75:210034800d756a75-fc.2018d039ea936319:2017d039ea936319-
naa.600a098038314962485d543078486c7a
    Runtime Name: vmhba4:C0:T1:L14
    Device: naa.600a098038314962485d543078486c7a
    Device Display Name: NETAPP Fibre Channel Disk
(naa.600a098038314962485d543078486c7a)
    Group State: active
    Array Priority: 0
    Storage Array Type Path Config: {TPG_id=1001,
```

```
TPG_state=AO,RTP_id=4,RTP_health=UP}
    Path Selection Policy Path Config: PSP VMW_PSP_RR does not support path
configuration.

fc.200034800d756a74:210034800d756a74-fc.2018d039ea936319:2014d039ea936319-
naa.600a098038314962485d543078486c7a
    Runtime Name: vmhba3:C0:T0:L14
    Device: naa.600a098038314962485d543078486c7a
    Device Display Name: NETAPP Fibre Channel Disk
(naa.600a098038314962485d543078486c7a)
    Group State: active
    Array Priority: 0
    Storage Array Type Path Config: {TPG_id=1000,
TPG_state=AO,RTP_id=1,RTP_health=UP}
    Path Selection Policy Path Config: PSP VMW_PSP_RR does not support path
configuration.

fc.200034800d756a74:210034800d756a74-fc.2018d039ea936319:2016d039ea936319-
naa.600a098038314962485d543078486c7a
    Runtime Name: vmhba3:C0:T1:L14
    Device: naa.600a098038314962485d543078486c7a
    Device Display Name: NETAPP Fibre Channel Disk
(naa.600a098038314962485d543078486c7a)
    Group State: active
    Array Priority: 0
    Storage Array Type Path Config: {TPG_id=1001,
TPG_state=AO,RTP_id=3,RTP_health=UP}
    Path Selection Policy Path Config: PSP VMW_PSP_RR does not support path
configuration.
```

vVol

Virtual Volumes (vVols) are a VMware object type that corresponds to a Virtual Machine (VM) disk, its snapshots, and fast clones.

ONTAP tools for VMware vSphere includes the VASA Provider for ONTAP, which provides the integration point for a VMware vCenter to leverage vVols based storage. When you deploy the ONTAP tools Open Virtualization Appliance (OVA), it is automatically registered with the vCenter server and enables the VASA Provider.

When you create a vVols datastore using the vCenter UI, it guides you to create FlexVols as backup storage for the datastore. vVols within vVols datastores are accessed by ESXi hosts using a protocol endpoint (PE). In SAN environments, one 4MB LUN is created on each FlexVol in the datastore for use as a PE. A SAN PE is an administrative logical unit (ALU). vVols are subsidiary logical units (SLUs).

Standard requirements and best practices for SAN environments apply when using vVols, including (but not limited to) the following:

- Create at least one SAN LIF on each node per SVM you intend to use. The best practice is to create at least two per node, but no more than necessary.

- Eliminate any single point of failure. Use multiple VMkernel network interfaces on different network subnets that use NIC teaming when multiple virtual switches are used, or use multiple physical NICs connected to multiple physical switches to provide HA and increased throughput.

- Configure zoning, VLANs, or both as required for host connectivity.

- Verify that all required initiators are logged into the target LIFs on the desired SVM.

> ⓘ You must deploy ONTAP tools for VMware vSphere to enable the VASA Provider. The VASA Provider will manage all of your iGroup settings for you, therefore there is no need to create or manage iGroups in a vVols environment.

NetApp does not recommend changing any vVols settings from default at this time.

Refer to the Interoperability Matrix Tool for specific versions of ONTAP tools, or legacy VASA Provider for your specific versions of vSphere and ONTAP.

For detailed information on provisioning and managing vVols, refer to the ONTAP tools for VMware vSphere documentation, VMware vSphere with ONTAP, and Virtual Volumes (vVols) with ONTAP tools 10.

Recommended settings

ATS locking

ATS locking is **mandatory** for VAAI compatible storage and upgraded VMFS5 and is required for proper interoperability and optimal VMFS shared storage I/O performance with ONTAP LUNs. Refer to VMware documentation for details on enabling ATS locking.

Settings	Default	ONTAP Recommended	Description
HardwareAcceleratedLocking	1	1	Helps enable the use of Atomic Test and Set (ATS) locking
Disk IOPs	1000	1	IOPS limit: The Round Robin PSP defaults to an IOPS limit of 1000. In this default case, a new path is used after 1000 I/O operations are issued.
Disk/QFullSampleSize	0	32	The count of QUEUE FULL or BUSY conditions it takes before ESXi starts throttling.

> ⓘ Enable `Space-alloc` setting for all the LUNs mapped to VMware vSphere for `UNMAP` to work. For more details, refer to ONTAP Documentation.

Guest OS timeouts

You can manually configure the virtual machines with the recommended guest OS tunings. After tuning updates, you must reboot the guest for the updates to take effect.

GOS timeout values:

Guest OS Type	Timeouts
Linux variants	disk timeout = 60
Windows	disk timeout = 60
Solaris	disk timeout = 60 busy retry = 300 not ready retry = 300 reset retry = 30 max.throttle = 32 min.throttle = 8

Validate the vSphere tunable

You can use the following command to verify the `HardwareAcceleratedLocking` setting.

`esxcli system settings advanced list --option /VMFS3/HardwareAcceleratedLocking`

```
    Path: /VMFS3/HardwareAcceleratedLocking
    Type: integer
    Int Value: 1
    Default Int Value: 1
    Min Value: 0
    Max Value: 1
    String Value:
    Default String Value:
    Valid Characters:
    Description: Enable hardware accelerated VMFS locking (requires
 compliant hardware). Please see http://kb.vmware.com/kb/2094604 before
 disabling this option.
```

Validate the disk IOPs setting

You can use the following command to verify the IOPs setting.

`esxcli storage nmp device list -d naa.600a098038304731783f506670553355`

```
naa.600a098038304731783f506670553355
    Device Display Name: NETAPP Fibre Channel Disk
(naa.600a098038304731783f506670553355)
    Storage Array Type: VMW_SATP_ALUA
    Storage Array Type Device Config: {implicit_support=on;
explicit_support=off; explicit_allow=on; alua_followover=on;
action_OnRetryErrors=off;
{TPG_id=1000,TPG_state=ANO}{TPG_id=1001,TPG_state=AO}}
    Path Selection Policy: VMW_PSP_RR
    Path Selection Policy Device Config: {policy=rr,
iops=1,bytes=10485760,useANO=0; lastPathIndex=0:
NumIOsPending=0,numBytesPending=0}
    Path Selection Policy Device Custom Config:
    Working Paths: vmhba4:C0:T0:L82, vmhba3:C0:T0:L82
    Is USB: false
```

Validate the QFullSampleSize

You can use the following command to verify the QFullSampleSize.

```
esxcli system settings advanced list --option /Disk/QFullSampleSize
```

```
    Path: /Disk/QFullSampleSize
    Type: integer
    Int Value: 32
    Default Int Value: 0
    Min Value: 0
    Max Value: 64
    String Value:
    Default String Value:
    Valid Characters:
    Description: Default I/O samples to monitor for detecting non-transient
queue full condition. Should be nonzero to enable queue depth throttling.
Device specific QFull options will take precedence over this value if set.
```

Known issues

The VMware vSphere 8.x with ONTAP release has the following known issues:

NetApp Bug ID	Title	Description
1543660	I/O error occurs when Linux VMs using vNVMe adapters encounter a long all paths down (APD) window	Linux VMs running vSphere 8.x and later and using virtual NVMe (vNVME) adapters encounter an I/O error because the vNVMe retry operation is disabled by default. To avoid a disruption on Linux VMs running older kernels during an all paths down (APD) or a heavy I/O load, VMware has introduced a tunable "VSCSIDisableNvmeRetry" to disable the vNVMe retry operation.

Related information

- VMware vSphere with ONTAP
- VMware vSphere 5.x, 6.x and 7.x support with NetApp MetroCluster (2031038)
- NetApp ONTAP with NetApp SnapMirror active sync with VMware vSphere Metro Storage Cluster (vMSC)

Use VMware vSphere 7.x with ONTAP

You can use ONTAP SAN host configuration settings for the vSphere 7.x release with FC, FCoE and iSCSI protocols.

Hypervisor SAN Booting

Before you begin

If you decide to use SAN booting, it must be supported by your configuration. You can use the Interoperability Matrix Tool to verify that your OS, HBA, HBA firmware and the HBA boot BIOS, and ONTAP version are supported.

Steps

1. Map the SAN boot LUN to the host.

2. Verify that multiple paths are available.

   > ⓘ Multiple paths become available after the host OS is up and running on the paths.

3. Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is mapped.

   For information on how to enable the HBA BIOS, see your vendor-specific documentation.

4. Reboot the host to verify that the boot was successful.

Multipathing

ESXi provides an extensible multipathing module called Native Multipathing Plug-In (NMP) that manages the sub-plugins, Storage Array Type Plugins (SATPs), and Path Selection Plugins (PSPs). These SATP rules are available by default in ESXi.

For ONTAP storage, the "VMW_SATP_ALUA" plugin is used by default with "VMW_PSP_RR" as a path selection policy (PSP). You can run the following command to confirm the PSP.

```
esxcli storage nmp satp rule list -s VMW_SATP_ALUA
```

```
Name              Device  Vendor    Model         Driver  Transport  Options
------------      ------  --------  ------------  ------  ---------
--------------------------
VMW_SATP_ALUA             NETAPP
reset_on_attempted_reserve


Rule Group  Claim Options  Default PSP  PSP Options     Description
 ----------  ------------   -----------  --------------  -----------
system      tpgs_on        VMW_PSP_RR                   NetApp arrays with
ALUA support
```

Non-ASA configurations

For non-ASA configurations, there should be two groups of paths with different priorities. The paths with higher priorities are Active/Optimized. This means they are serviced by the controller where the aggregate is located. The paths with lower priorities are active but non-optimized because they are served from a different controller. The non-optimized paths are only used when optimized paths are not available.

Example

The following example displays the correct output for an ONTAP LUN with two Active/Optimized paths and two Active/Non-Optimized paths.

```
esxcli storage nmp device list -d naa.600a098038313530772b4d673979372f
```

```
naa.600a098038313530772b4d673979372f
   Device Display Name: NETAPP Fibre Channel Disk
(naa.600a098038313530772b4d673979372f)
   Storage Array Type: VMW_SATP_ALUA
   Storage Array Type Device Config: {implicit_support=on;
explicit_support=off; explicit_allow=on; alua_followover=on;
action_OnRetryErrors=off;
{TPG_id=1000,TPG_state=AO}{TPG_id=1001,TPG_state=ANO}}
   Path Selection Policy: VMW_PSP_RR
   Path Selection Policy Device Config:
{policy=rr,iops=1,bytes=10485760,useANO=0; lastPathIndex=1:
NumIOsPending=0,numBytesPending=0}
   Path Selection Policy Device Custom Config:
   Working Paths: vmhba3:C0:T3:L21, vmhba4:C0:T2:L21
   Is USB: false
```

```
esxcli storage nmp path list -d naa.600a098038313530772b4d673979372f
```

```
fc.20000090fae0ec8e:10000090fae0ec8e-fc.201000a098dfe3d1:200b00a098dfe3d1-
naa.600a098038313530772b4d673979372f
    Runtime Name: vmhba3:C0:T2:L21
    Device: naa.600a098038313530772b4d673979372f
    Device Display Name: NETAPP Fibre Channel Disk
(naa.600a098038313530772b4d673979372f)
    Group State: active unoptimized
    Array Priority: 0
    Storage Array Type Path Config:
{TPG_id=1001,TPG_state=ANO,RTP_id=29,RTP_health=UP}
    Path Selection Policy Path Config: PSP VMW_PSP_RR does not support path
configuration.

fc.20000090fae0ec8e:10000090fae0ec8e-fc.201000a098dfe3d1:200700a098dfe3d1-
naa.600a098038313530772b4d673979372f
    Runtime Name: vmhba3:C0:T3:L21
    Device: naa.600a098038313530772b4d673979372f
    Device Display Name: NETAPP Fibre Channel Disk
(naa.600a098038313530772b4d673979372f)
    Group State: active
    Array Priority: 0
    Storage Array Type Path Config:
{TPG_id=1000,TPG_state=AO,RTP_id=25,RTP_health=UP}
    Path Selection Policy Path Config: PSP VMW_PSP_RR does not support path
configuration.

fc.20000090fae0ec8f:10000090fae0ec8f-fc.201000a098dfe3d1:200800a098dfe3d1-
naa.600a098038313530772b4d673979372f
    Runtime Name: vmhba4:C0:T2:L21
    Device: naa.600a098038313530772b4d673979372f
    Device Display Name: NETAPP Fibre Channel Disk
(naa.600a098038313530772b4d673979372f)
    Group State: active
    Array Priority: 0
    Storage Array Type Path Config:
{TPG_id=1000,TPG_state=AO,RTP_id=26,RTP_health=UP}
    Path Selection Policy Path Config: PSP VMW_PSP_RR does not support path
configuration.

fc.20000090fae0ec8f:10000090fae0ec8f-fc.201000a098dfe3d1:200c00a098dfe3d1-
naa.600a098038313530772b4d673979372f
    Runtime Name: vmhba4:C0:T3:L21
    Device: naa.600a098038313530772b4d673979372f
    Device Display Name: NETAPP Fibre Channel Disk
(naa.600a098038313530772b4d673979372f)
    Group State: active unoptimized
```

```
   Array Priority: 0
   Storage Array Type Path Config:
{TPG_id=1001,TPG_state=ANO,RTP_id=30,RTP_health=UP}
   Path Selection Policy Path Config: PSP VMW_PSP_RR does not support path
configuration.
```

All SAN Array configurations

All SAN Array (ASA) configurations optimize all paths to a given LUN, keeping them active. This improves performance by serving I/O operations through all paths at the same time.

Example

The following example displays the correct output for an ONTAP LUN.

esxcli storage nmp device list -d naa.600a098038304759563f4e7837574453

```
naa.600a098038304759563f4e7837574453
   Device Display Name: NETAPP Fibre Channel Disk
(naa.600a098038304759563f4e7837574453)
   Storage Array Type: VMW_SATP_ALUA
   Storage Array Type Device Config: {implicit_support=on;
explicit_support=off; explicit_allow=on; alua_followover=on;
action_OnRetryErrors=off;
{TPG_id=1001,TPG_state=AO}{TPG_id=1000,TPG_state=AO}}
   Path Selection Policy: VMW_PSP_RR
   Path Selection Policy Device Config:
{policy=rr,iops=1,bytes=10485760,useANO=0; lastPathIndex=2:
NumIOsPending=0,numBytesPending=0}
   Path Selection Policy Device Custom Config:
   Working Paths: vmhba4:C0:T0:L9, vmhba3:C0:T1:L9, vmhba3:C0:T0:L9,
vmhba4:C0:T1:L9
   Is USB: false
```

esxcli storage nmp device list -d naa.600a098038304759563f4e7837574453

```
fc.20000024ff171d37:21000024ff171d37-fc.202300a098ea5e27:204a00a098ea5e27-
naa.600a098038304759563f4e7837574453
   Runtime Name: vmhba4:C0:T0:L9
   Device: naa.600a098038304759563f4e7837574453
   Device Display Name: NETAPP Fibre Channel Disk
(naa.600a098038304759563f4e7837574453)
   Group State: active
   Array Priority: 0
   Storage Array Type Path Config:
{TPG_id=1000,TPG_state=AO,RTP_id=6,RTP_health=UP}
```

```
    Path Selection Policy Path Config: PSP VMW_PSP_RR does not support path
configuration.

fc.20000024ff171d36:21000024ff171d36-fc.202300a098ea5e27:201d00a098ea5e27-
naa.600a098038304759563f4e7837574453
    Runtime Name: vmhba3:C0:T1:L9
    Device: naa.600a098038304759563f4e7837574453
    Device Display Name: NETAPP Fibre Channel Disk
(naa.600a098038304759563f4e7837574453)
    Group State: active
    Array Priority: 0
    Storage Array Type Path Config:
{TPG_id=1001,TPG_state=AO,RTP_id=3,RTP_health=UP}
    Path Selection Policy Path Config: PSP VMW_PSP_RR does not support path
configuration.

fc.20000024ff171d36:21000024ff171d36-fc.202300a098ea5e27:201b00a098ea5e27-
naa.600a098038304759563f4e7837574453
    Runtime Name: vmhba3:C0:T0:L9
    Device: naa.600a098038304759563f4e7837574453
    Device Display Name: NETAPP Fibre Channel Disk
(naa.600a098038304759563f4e7837574453)
    Group State: active
    Array Priority: 0
    Storage Array Type Path Config:
{TPG_id=1000,TPG_state=AO,RTP_id=1,RTP_health=UP}
    Path Selection Policy Path Config: PSP VMW_PSP_RR does not support path
configuration.

fc.20000024ff171d37:21000024ff171d37-fc.202300a098ea5e27:201e00a098ea5e27-
naa.600a098038304759563f4e7837574453
    Runtime Name: vmhba4:C0:T1:L9
    Device: naa.600a098038304759563f4e7837574453
    Device Display Name: NETAPP Fibre Channel Disk
(naa.600a098038304759563f4e7837574453)
    Group State: active
    Array Priority: 0
    Storage Array Type Path Config:
{TPG_id=1001,TPG_state=AO,RTP_id=4,RTP_health=UP}
    Path Selection Policy Path Config: PSP VMW_PSP_RR does not support path
configuration.
```

vVol

Virtual Volumes (vVols) are a VMware object type that corresponds to a Virtual Machine (VM) disk, and its snapshots and fast-clones.

ONTAP tools for VMware vSphere includes the VASA Provider for ONTAP, which provides the integration point for a VMware vCenter to leverage vVols based storage. When you deploy the ONTAP tools OVA, it is automatically registered with the vCenter server and enables the VASA Provider.

When you create a vVols datastore using the vCenter UI, it guides you to create FlexVols as backup storage for the datastore. vVols within a vVols datastores are access by ESXi hosts using a protocol endpoint (PE). In SAN environments, one 4MB LUN is created on each FlexVol in the datastore for use as a PE. A SAN PE is an administrative logical unit (ALU). vVols are subsidiary logical units (SLUs).

Standard requirements and best practices for SAN environments apply when using vVols, including (but not limited to) the following:

1. Create at least one SAN LIF on each node per SVM you intend to use. The best practice is to create at least two per node, but no more than necessary.

2. Eliminate any single point of failure. use multiple VMkernel network interfaces on different network subnets that use NIC teaming when multiple virtual switches are used. Or use multiple physical NICs connected to multiple physical switches to provide HA and increased throughput.

3. Configure zoning and/or VLANs as required for host connectivity.

4. Ensure all required initiators are logged into the target LIFs on the desired SVM.

> ⓘ You must deploy ONTAP tools for VMware vSphere to enabled the VASA Provider. The VASA Provider will manage all of your igroup settings for you, so there is no need to create or manage igroups in a vVols environment.

NetApp does not recommend changing any vVols settings from the default at this time.

Refer to the Interoperability Matrix Tool for specific versions of ONTAP tools, or legacy VASA Provider for your specific versions of vSphere and ONTAP.

For detailed information on provisioning and managing vVols, refer to the ONTAP tools for VMware vSphere documentation as well as VMware vSphere with ONTAP and Virtual Volumes (vVols) with ONTAP tools 10.

Recommended Settings

ATS Locking

ATS locking is **mandatory** for VAAI compatible storage and upgraded VMFS5, and is required for proper interoperability and optimal VMFS shared storage I/O performance with ONTAP LUNs. Refer to VMware documentation for details on enabling ATS locking.

Settings	Default	ONTAP Recommended	Description
HardwareAcceleratedLocking	1	1	Helps enable the use of Atomic Test and Set (ATS) locking
Disk IOPs	1000	1	IOPS limit: The Round Robin PSP defaults to an IOPS limit of 1000. In this default case, a new path is used after 1000 I/O operations are issued.

Settings	Default	ONTAP Recommended	Description
Disk/QFullSampleSize	0	32	The count of QUEUE FULL or BUSY conditions it takes before ESXi starts throttling.

> ⓘ Enable Space-alloc setting for all the LUN's mapped to VMware vSphere for UNMAP to work. For More details, refer to ONTAP Documentation.

Guest OS timeouts

You can manually configure the virtual machines with the recommended guest OS tunings. After tuning updates, you must reboot the guest for the updates to take effect.

GOS timeout values:

Guest OS Type	Timeouts
Linux variants	disk timeout = 60
Windows	disk timeout = 60
Solaris	disk timeout = 60 busy retry = 300 not ready retry = 300 reset retry = 30 max.throttle = 32 min.throttle = 8

Validating the vSphere tunable

Use the following command to verify the HardwareAcceleratedLocking setting.

esxcli system settings advanced list --option /VMFS3/HardwareAcceleratedLocking

```
    Path: /VMFS3/HardwareAcceleratedLocking
    Type: integer
    Int Value: 1
    Default Int Value: 1
    Min Value: 0
    Max Value: 1
    String Value:
    Default String Value:
    Valid Characters:
    Description: Enable hardware accelerated VMFS locking (requires
 compliant hardware). Please see http://kb.vmware.com/kb/2094604 before
 disabling this option.
```

Validate the disk IOPs setting

Use the following command to verify the IOPs setting.

esxcli storage nmp device list -d naa.600a098038304731783f506670553355

```
naa.600a098038304731783f506670553355
    Device Display Name: NETAPP Fibre Channel Disk
(naa.600a098038304731783f506670553355)
    Storage Array Type: VMW_SATP_ALUA
    Storage Array Type Device Config: {implicit_support=on;
explicit_support=off; explicit_allow=on; alua_followover=on;
action_OnRetryErrors=off;
{TPG_id=1000,TPG_state=ANO}{TPG_id=1001,TPG_state=AO}}
    Path Selection Policy: VMW_PSP_RR
    Path Selection Policy Device Config:
{policy=rr,iops=1,bytes=10485760,useANO=0; lastPathIndex=0:
NumIOsPending=0,numBytesPending=0}
    Path Selection Policy Device Custom Config:
    Working Paths: vmhba4:C0:T0:L82, vmhba3:C0:T0:L82
    Is USB: false
```

Validating the QFullSampleSize

Use the following command to verify the QFullSampleSize

esxcli system settings advanced list --option /Disk/QFullSampleSize

```
    Path: /Disk/QFullSampleSize
    Type: integer
    Int Value: 32
    Default Int Value: 0
    Min Value: 0
    Max Value: 64
    String Value:
    Default String Value:
    Valid Characters:
    Description: Default I/O samples to monitor for detecting non-transient
queue full condition. Should be nonzero to enable queue depth throttling.
Device specific QFull options will take precedence over this value if set.
```

Known issues

There are no known issues for the VMware vSphere 7.x with ONTAP release.

Related information

- VMware vSphere with ONTAP
- VMware vSphere 5.x, 6.x and 7.x support with NetApp MetroCluster (2031038)
- NetApp ONTAP with NetApp SnapMirror active sync with VMware vSphere Metro Storage Cluster (vMSC)

Use VMware vSphere 6.5 and 6.7 with ONTAP

You can use ONTAP SAN host configuration settings for the vSphere 6.5.x and 6.7.x releases with FC, FCoE and iSCSI protocols.

Hypervisor SAN Booting

Before you begin

If you decide to use SAN booting, it must be supported by your configuration. You can use the Interoperability Matrix Tool to verify that your OS, HBA, HBA firmware and the HBA boot BIOS, and ONTAP version are supported.

Steps

1. Map the SAN boot LUN to the host.

2. Verify that multiple paths are available.

   > ℹ️ Multiple paths become available after the host OS is up and running on the paths.

3. Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is mapped.

   For information on how to enable the HBA BIOS, see your vendor-specific documentation.

4. Reboot the host to verify that the boot was successful.

Multipathing

ESXi provides an extensible multipathing module called Native Multipathing Plug-In (NMP) that manages the sub-plugins, Storage Array Type Plugins (SATPs), and Path Selection Plugins (PSPs). These SATP rules are available by default in ESXi.

For ONTAP storage, the "VMW_SATP_ALUA" plugin is used by default with "VMW_PSP_RR" as a path selection policy (PSP). You can run the following command to confirm the PSP:

```
esxcli storage nmp satp rule list -s VMW_SATP_ALUA
```

```
Name              Device  Vendor   Model    Driver  Transport  Options
-------------     ------  ------   -------  ------  ---------  -------
VMW_SATP_ALUA             LSI      INF-01-00
reset_on_attempted_reserve
VMW_SATP_ALUA             NETAPP
reset_on_attempted_reserve


Rule Group  Claim Options  Default PSP  PSP Options  Description
----------  -------------  -----------  -----------  ------------
system         tpgs_on        VMW_PSP_MRU          NetApp E-Series arrays
with ALUA support
system         tpgs_on        MW_PSP_RR          NetApp arrays with ALUA
support
```

All SAN Array configurations

All SAN Array (ASA) configurations optimize all paths to a given LUN, keeping them active. This improves performance by serving I/O operations through all paths at the same time.

Example

The following example displays the correct output for an ONTAP LUN.

esxcli storage nmp device list -d naa.600a098038304759563f4e7837574453

```
fc.20000024ff171d37:21000024ff171d37-fc.202300a098ea5e27:204a00a098ea5e27-
naa.600a098038304759563f4e7837574453
   Runtime Name: vmhba4:C0:T0:L9
   Device: naa.600a098038304759563f4e7837574453
   Device Display Name: NETAPP Fibre Channel Disk
(naa.600a098038304759563f4e7837574453)
   Group State: active
   Array Priority: 0
   Storage Array Type Path Config:
{TPG_id=1000,TPG_state=AO,RTP_id=6,RTP_health=UP}
   Path Selection Policy Path Config: PSP VMW_PSP_RR does not support path
configuration.

fc.20000024ff171d36:21000024ff171d36-fc.202300a098ea5e27:201d00a098ea5e27-
naa.600a098038304759563f4e7837574453
   Runtime Name: vmhba3:C0:T1:L9
   Device: naa.600a098038304759563f4e7837574453
   Device Display Name: NETAPP Fibre Channel Disk
(naa.600a098038304759563f4e7837574453)
   Group State: active
   Array Priority: 0
   Storage Array Type Path Config:
```

```
{TPG_id=1001,TPG_state=AO,RTP_id=3,RTP_health=UP}
    Path Selection Policy Path Config: PSP VMW_PSP_RR does not support path
configuration.

fc.20000024ff171d36:21000024ff171d36-fc.202300a098ea5e27:201b00a098ea5e27-
naa.600a098038304759563f4e7837574453
    Runtime Name: vmhba3:C0:T0:L9
    Device: naa.600a098038304759563f4e7837574453
    Device Display Name: NETAPP Fibre Channel Disk
(naa.600a098038304759563f4e7837574453)
    Group State: active
    Array Priority: 0
    Storage Array Type Path Config:
{TPG_id=1000,TPG_state=AO,RTP_id=1,RTP_health=UP}
    Path Selection Policy Path Config: PSP VMW_PSP_RR does not support path
configuration.

fc.20000024ff171d37:21000024ff171d37-fc.202300a098ea5e27:201e00a098ea5e27-
naa.600a098038304759563f4e7837574453
    Runtime Name: vmhba4:C0:T1:L9
    Device: naa.600a098038304759563f4e7837574453
    Device Display Name: NETAPP Fibre Channel Disk
(naa.600a098038304759563f4e7837574453)
    Group State: active
    Array Priority: 0
    Storage Array Type Path Config:
{TPG_id=1001,TPG_state=AO,RTP_id=4,RTP_health=UP}
    Path Selection Policy Path Config: PSP VMW_PSP_RR does not support path
configuration.
```

In the above example, LUN has been mapped from NetApp storage with 4 paths (4 active-optimized).

Non-ASA configurations

For non-ASA configurations, there should be two groups of paths with different priorities. The paths with higher priorities are Active/Optimized. This means they are serviced by the controller where the aggregate is located. The paths with lower priorities are active but non-optimized because they are served from a different controller. The non-optimized paths are only used when optimized paths are not available.

Example

The following example displays the correct output for an ONTAP LUN with two Active/Optimized paths and two Active/Non-Optimized paths.

`esxcli storage nmp path list -d naa.600a098038313530772b4d673979372f`

```
fc.20000090fae0ec8e:10000090fae0ec8e-fc.201000a098dfe3d1:200b00a098dfe3d1-
naa.600a098038313530772b4d673979372f
```

```
    Runtime Name: vmhba3:C0:T2:L21
    Device: naa.600a098038313530772b4d673979372f
    Device Display Name: NETAPP Fibre Channel Disk
(naa.600a098038313530772b4d673979372f)
    Group State: active unoptimized
    Array Priority: 0
    Storage Array Type Path Config:
{TPG_id=1001,TPG_state=ANO,RTP_id=29,RTP_health=UP}
    Path Selection Policy Path Config: PSP VMW_PSP_RR does not support path
configuration.

fc.20000090fae0ec8e:10000090fae0ec8e-fc.201000a098dfe3d1:200700a098dfe3d1-
naa.600a098038313530772b4d673979372f
    Runtime Name: vmhba3:C0:T3:L21
    Device: naa.600a098038313530772b4d673979372f
    Device Display Name: NETAPP Fibre Channel Disk
(naa.600a098038313530772b4d673979372f)
    Group State: active
    Array Priority: 0
    Storage Array Type Path Config:
{TPG_id=1000,TPG_state=AO,RTP_id=25,RTP_health=UP}
    Path Selection Policy Path Config: PSP VMW_PSP_RR does not support path
configuration.

fc.20000090fae0ec8f:10000090fae0ec8f-fc.201000a098dfe3d1:200800a098dfe3d1-
naa.600a098038313530772b4d673979372f
    Runtime Name: vmhba4:C0:T2:L21
    Device: naa.600a098038313530772b4d673979372f
    Device Display Name: NETAPP Fibre Channel Disk
(naa.600a098038313530772b4d673979372f)
    Group State: active
    Array Priority: 0
    Storage Array Type Path Config:
{TPG_id=1000,TPG_state=AO,RTP_id=26,RTP_health=UP}
    Path Selection Policy Path Config: PSP VMW_PSP_RR does not support path
configuration.

fc.20000090fae0ec8f:10000090fae0ec8f-fc.201000a098dfe3d1:200c00a098dfe3d1-
naa.600a098038313530772b4d673979372f
    Runtime Name: vmhba4:C0:T3:L21
    Device: naa.600a098038313530772b4d673979372f
    Device Display Name: NETAPP Fibre Channel Disk
(naa.600a098038313530772b4d673979372f)
    Group State: active unoptimized
    Array Priority: 0
    Storage Array Type Path Config:
```

```
{TPG_id=1001,TPG_state=ANO,RTP_id=30,RTP_health=UP}
    Path Selection Policy Path Config: PSP VMW_PSP_RR does not support path
configuration.
```

In the above example, LUN has been mapped from NetApp storage with 4 paths (2 active-optimized and 2 active-unoptimized).

vVol

Virtual Volumes (vVols) are a VMware object type that corresponds to a Virtual Machine (VM) disk, and its snapshots and fast clones.

ONTAP tools for VMware vSphere includes the VASA Provider for ONTAP, which provides the integration point for a VMware vCenter to leverage vVols based storage. When you deploy the ONTAP tools OVA, it is automatically registered with the vCenter server and enables the VASA Provider.

When you create a vVols datastore using the vCenter UI, it guides you to create FlexVols as backup storage for the datastore. vVols within a vVols datastores are accessed by ESXi hosts using a protocol endpoint (PE). In SAN environments, one 4MB LUN is created on each FlexVol volume volume volume in the datastore for use as a PE. A SAN PE is an administrative logical unit (ALU); vVols are subsidiary logical units (SLUs).

Standard requirements and best practices for SAN environments apply when using vVols, including (but not limited to) the following:

1. Create at least one SAN LIF on each node per SVM you intend to use. The best practice is to create at least two per node, but no more than necessary.
2. Eliminate any single point of failure. Use multiple VMkernel network interfaces on different network subnets that use NIC teaming when multiple virtual switches are used or use multiple physical NICs connected to multiple physical switches to provide HA and increased throughput.
3. Configure zoning and/or VLANs as required for host connectivity.
4. Ensure all required initiators are logged into the target LIFs on the desired SVM.

> ⓘ You must deploy ONTAP tools for VMware vSphere to enable the VASA Provider. The VASA Provider will manage all of your igroup settings for you, so there is no need to create or manage iGroups in a vVols environment.

NetApp doesn't recommend changing any vVols settings from default at this time.

Refer to the Interoperability Matrix Tool for specific versions of ONTAP tools, or legacy VASA Provider for your specific versions of vSphere and ONTAP.

For detailed information on provisioning and managing vVols, refer to the ONTAP tools for VMware vSphere documentation as well as VMware vSphere with ONTAP and Virtual Volumes (vVols) with ONTAP tools 10.

Recommended Settings

ATS Locking

ATS locking is **mandatory** for VAAI compatible storage and upgraded VMFS5 and is required for proper interoperability and optimal VMFS shared storage I/O performance with ONTAP LUNs. Refer to VMware documentation for details on enabling ATS locking.

Settings	Default	ONTAP Recommended	Description
HardwareAcceleratedLocking	1	1	Helps enable the use of Atomic Test and Set (ATS) locking
Disk IOPs	1000	1	IOPS limit: The Round Robin PSP defaults to an IOPS limit of 1000. In this default case, a new path is used after 1000 I/O operations are issued.
Disk/QFullSampleSize	0	32	The count of QUEUE FULL or BUSY conditions it takes before ESXi starts throttling.

> (i) Enable Space-alloc setting for all the LUN's mapped to VMware vSphere for UNMAP to work. For more details, refer to ONTAP Documentation.

Guest OS timeouts

You can manually configure the virtual machines with the recommended guest OS tunings. After tuning updates, you must reboot the guest for the updates to take effect.

GOS timeout values:

Guest OS Type	Timeouts
Linux variants	disk timeout = 60
Windows	disk timeout = 60
Solaris	disk timeout = 60 busy retry = 300 not ready retry = 300 reset retry = 30 max.throttle = 32 min.throttle = 8

Validate the vSphere tunable

Use the following command to verify the `HardwareAcceleratedLocking` setting:

esxcli system settings advanced list --option /VMFS3/HardwareAcceleratedLocking

```
    Path: /VMFS3/HardwareAcceleratedLocking
    Type: integer
    Int Value: 1
    Default Int Value: 1
    Min Value: 0
    Max Value: 1
    String Value:
    Default String Value:
    Valid Characters:
    Description: Enable hardware accelerated VMFS locking (requires
compliant hardware). Please see http://kb.vmware.com/kb/2094604 before
disabling this option.
```

Validate the disk IOPs setting

Use the following command to verify the IOPs setting:

esxcli storage nmp device list -d naa.600a098038304731783f506670553355

```
naa.600a098038304731783f506670553355
    Device Display Name: NETAPP Fibre Channel Disk
(naa.600a098038304731783f506670553355)
    Storage Array Type: VMW_SATP_ALUA
    Storage Array Type Device Config: {implicit_support=on;
explicit_support=off; explicit_allow=on; alua_followover=on;
action_OnRetryErrors=off;
{TPG_id=1000,TPG_state=ANO}{TPG_id=1001,TPG_state=AO}}
    Path Selection Policy: VMW_PSP_RR
    Path Selection Policy Device Config:
{policy=rr,iops=1,bytes=10485760,useANO=0; lastPathIndex=0:
NumIOsPending=0,numBytesPending=0}
    Path Selection Policy Device Custom Config:
    Working Paths: vmhba4:C0:T0:L82, vmhba3:C0:T0:L82
    Is USB: false
```

Validate the QFullSampleSize

Use the following command to verify the QFullSampleSize:

esxcli system settings advanced list --option /Disk/QFullSampleSize

```
    Path: /Disk/QFullSampleSize
    Type: integer
    Int Value: 32
    Default Int Value: 0
    Min Value: 0
    Max Value: 64
    String Value:
    Default String Value:
    Valid Characters:
    Description: Default I/O samples to monitor for detecting non-transient
queue full condition. Should be nonzero to enable queue depth throttling.
Device specific QFull options will take precedence over this value if set.
```

Known issues

The VMware vSphere 6.5 and 6.7 with ONTAP release has the following known issues:

OS version	NetApp Bug ID	Title	Description
ESXi 6.5 and ESXi 6.7.x	1413424	WFC RDM luns fails during testing	Windows failover clustering raw device mapping between Windows Virtual Machines like Windows 2019, Windows 2016, and Windows 2012 across VMWare ESXi host failed during storage failover testing on all the 7-mode, C-cmode cluster controllers.
ESXi 6.5.x and ESXi 6.7.x	1256473	PLOGI issue seen during testing on Emulex adapters	

Related information

- [VMware vSphere with ONTAP](#)
- [VMware vSphere 5.x, 6.x and 7.x support with NetApp MetroCluster (2031038)](#)
- [NetApp ONTAP with NetApp SnapMirror active sync with VMware vSphere Metro Storage Cluster (vMSC)](#)

HP-UX

Configure HP-UX 11i v3 for FCP and iSCSI with ONTAP storage

The HP-UX Host Utilities software provides management and diagnostic tools for HP-UX hosts that are connected to ONTAP storage. When you install the HP-UX Host Utilities on a HP-UX 11i v3 host, you can use the Host Utilities to help you manage FCP and iSCSI protocol operations with ONTAP LUNs.

Step 1: Optionally, enable SAN booting

Configure your host to use SAN booting to simplify deployment and improve scalability. SAN booting is the process of setting up a SAN-attached disk (a LUN) as a boot device for a HP-UX host. The Host Utilities support SAN booting with FC and FCoE protocols in HP-UX environments.

Steps

1. Use the Interoperability Matrix Tool to verify that your Linux OS, host bus adapter (HBA), HBA firmware, HBA boot BIOS, and ONTAP version support SAN booting.

2. Follow the best practices for setting up a SAN boot in the HP-UX vendor documentation.

Step 2: Install the HP-UX Host Utilities

NetApp strongly recommends installing the HP-UX Host Utilities to support ONTAP LUN management and assist technical support with gathering configuration data.

Install HP-UX Host Utilities 6.0

Step 3: Confirm the multipath configuration for your host

Use multipathing with HP-UX 11i v3 to manage ONTAP LUNs. Multipathing allows you to configure multiple network paths between the host and storage system. If one path fails, traffic continues on the remaining paths.

After installing HP-UX Host Utilities, verify that you have the NetApp recommended settings configured for your ONTAP LUNs.

About this task

The HP-UX Host Utilities support Native Microsoft Multipath I/O (MPIO) and Veritas Dynamic Multipathing. The following steps are for the Native MPIO solution.

Steps

1. When you install the HP-UX Host Utilities, the following recommended default settings are automatically loaded for ONTAP LUNs.

   Show parameter settings

Parameter	Uses Default Value
transient_secs	120
leg_mpath_enable	TRUE
max_q_depth	8
path_fail_secs	120
load_bal_policy	Round_robin
lua_enabled	TRUE
esd_secs	30

2. Verify the parameter settings and path status for your ONTAP LUNs:

```
sanlun lun show
```

The default multipath parameters support ASA, AFF, and FAS configurations. The following example outputs show the correct parameter settings and path status for ONTAP LUNs in an ASA, AFF, or FAS configuration.

ASA configuration

An ASA configuration optimizes all paths to a given LUN, keeping them active. This improves performance by serving I/O operations through all paths at the same time.

```
# sanlun lun show -p vs39:/vol/hpux_vol_1_1/hpux_lun

                  ONTAP Path: vs39:/vol/hpux_vol_1_1/hpux_lun
                         LUN: 2
                    LUN Size: 30g
                 Host Device: /dev/rdisk/disk25
                        Mode: C
           Multipath Provider: None
-------- ---------- -------------------- ------- --------------
host     vserver    /dev/dsk
path     path       filename             host    vserver
state    type       or hardware path     adapter LIF
-------- ---------- -------------------- ------- --------------
up       primary    /dev/dsk/c4t0d2      fcd0    248_1c_hp
up       primary    /dev/dsk/c6t0d2      fcd0    246_1c_hp
up       primary    /dev/dsk/c10t0d2     fcd1    246_1d_hp
up       primary    /dev/dsk/c8t0d2      fcd1    248_1d_hp
```

AFF or FAS configuration

An AFF or FAS configuration should have two groups of paths with higher and lower priorities. Higher priority Active/Optimized paths are served by the controller where the aggregate is located. Lower priority paths are active but non-optimized because they are served by a different controller. Non-optimized paths are only used when optimized paths aren't available.

The following example displays the output for an ONTAP LUN with two Active/Optimized paths and two Active/Non-Optimized paths:

```
# sanlun lun show -p vs39:/vol/vol24_3_0/lun24_0
                    ONTAP Path: vs39:/vol/vol24_3_0/lun24_0
                          LUN: 37
                     LUN Size: 15g
                  Host Device: /dev/rdisk/disk942
                         Mode: C
              Multipath Policy: A/A
            Multipath Provider: Native
------- ---------- ------ ------- ---------- ----------
--------------
host    vserver    /dev/dsk                              HP A/A
path    path       filename         host     vserver    path
failover
state   type       or hardware path adapter    LIF       priority
------- ---------- ------ ------- ---------- ----------
--------------
up         primary    /dev/dsk/c39t4d5   fcd0     hpux_3     0
up         primary    /dev/dsk/c41t4d5   fcd1     hpux_4     0
up         secondary  /dev/dsk/c40t4d5   fcd0     hpux_3     1
up         secondary  /dev/dsk/c42t4d5   fcd1     hpux_4     1
```

Step 4: Review the known issues

The HP-UX 11i v3 with ONTAP storage release has the following known issues:

NetApp Bug ID	Title	Description	Partner ID
1447287	AUFO event on the isolated master cluster in SnapMirror active sync configuration causes temporary disruption on the HP-UX host	This issue occurs when there is an automatic unplanned failover (AUFO) event on the isolated master cluster in the SnapMirror active sync configuration. It might take more than 120 seconds for I/O to resume on the HP-UX host, but this might not cause any I/O disruption or error messages. This issue causes dual event failure because the connection between the primary and the secondary cluster is lost and the connection between the primary cluster and the mediator is also lost. This is considered a rare event, unlike other AUFO events.	NA
1344935	HP-UX 11.31 Host intermittently reporting path status incorrectly on ASA setup.	Path reporting issues with ASA configuration.	NA
1306354	HP-UX LVM creation sends I/O of block size above 1MB	SCSI Maximum Transfer Length of 1MB is enforced in ONTAP All SAN Array. To restrict the Maximum Transfer Length from HP-UX hosts when connected to ONTAP All SAN Array, it is required to set the Maximum I/O size allowed by the HP-UX SCSI subsystem to 1MB.

Refer HP-UX vendor documentation for details. | NA |

What's next

Learn about using the HP-UX Host Utilities tool.

Oracle Linux

Oracle Linux 9

Configure Oracle Linux 9.5 for FCP and iSCSI with ONTAP storage

The Linux Host Utilities software provides management and diagnostic tools for Linux hosts that are connected to ONTAP storage. When you install the Linux Host Utilities on an Oracle Linux 9.5 host, you can use the Host Utilities to help you manage FCP and iSCSI protocol operations with ONTAP LUNs.

> ⓘ You don't need to configure Kernel-based Virtual Machine (KVM) settings because ONTAP LUNs are automatically mapped to the KVM hypervisor.

Step 1: Optionally, enable SAN booting

You can configure your host to use SAN booting to simplify deployment and improve scalability.

Before you begin

Use the Interoperability Matrix Tool to verify that your Linux OS, host bus adapter (HBA), HBA firmware, HBA boot BIOS, and ONTAP version support SAN booting.

Steps

1. Create a SAN boot LUN and map it to the host.
2. Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is mapped.

   For information on how to enable the HBA BIOS, see your vendor-specific documentation.

3. Verify that the configuration was successful by rebooting the host and verifying that the OS is up and running.

Step 2: Install the Linux Host Utilities

NetApp strongly recommends installing the Linux Host Utilities to support ONTAP LUN management and assist technical support with gathering configuration data.

Install Linux Host Utilities 8.0.

> ⓘ Installing the Linux Host Utilities doesn't change any host timeout settings on your Linux host.

Step 3: Confirm the multipath configuration for your host

You can use multipathing with Oracle Linux 9.5 to manage ONTAP LUNs.

To ensure that multipathing is configured correctly for your host, verify that the `/etc/multipath.conf` file is defined and that you have the NetApp recommended settings configured for your ONTAP LUNs.

Steps

1. Verify that the `/etc/multipath.conf` file exits. If the file doesn't exist, create an empty, zero-byte file:

```
touch /etc/multipath.conf
```

2. The first time the `multipath.conf` file is created, you might need to enable and start the multipath services to load the recommended settings:

```
systemctl enable multipathd
```

```
systemctl start multipathd
```

3. Each time you boot the host, the empty `/etc/multipath.conf` zero-byte file automatically loads the NetApp recommended host multipath parameters as the default settings. You shouldn't need to make changes to the `/etc/multipath.conf` file for your host because the operating system is compiled with the multipath parameters that recognize and manage ONTAP LUNs correctly.

The following table shows the Linux OS native compiled multipath parameter settings for ONTAP LUNs.

Show parameter settings

Parameter	Setting
detect_prio	yes
dev_loss_tmo	"infinity"
failback	immediate
fast_io_fail_tmo	5
features	"2 pg_init_retries 50"
flush_on_last_del	"yes"
hardware_handler	"0"
no_path_retry	queue
path_checker	"tur"
path_grouping_policy	"group_by_prio"
path_selector	"service-time 0"
polling_interval	5
prio	"ontap"
product	LUN
retain_attached_hw_handler	yes
rr_weight	"uniform"
user_friendly_names	no
vendor	NETAPP

4. Verify the parameter settings and path status for your ONTAP LUNs:

```
multipath -ll
```

The default multipath parameters support ASA, AFF, and FAS configurations. In these configurations, a single ONTAP LUN shouldn't require more than four paths. If there are more than four paths, it might cause issues with the paths during a storage failure.

The following example outputs show the correct parameter settings and path status for ONTAP LUNs in an ASA, AFF, or FAS configuration.

ASA configuration

An ASA configuration optimizes all paths to a given LUN, keeping them active. This improves performance by serving I/O operations through all paths at the same time.

Show example

```
multipath -ll
3600a098038303634722b4d59646c4436 dm-28 NETAPP,LUN C-Mode
size=10G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
|-+- policy='service-time 0' prio=50 status=active
  |- 11:0:7:6   sdbz 68:208  active ready running
  |- 11:0:11:6  sddn 71:80   active ready running
  |- 11:0:15:6  sdfb 129:208 active ready running
  |- 12:0:1:6   sdgp 132:80  active ready running
```

AFF or FAS configuration

An AFF or FAS configuration should have two groups of paths with higher and lower priorities. Higher priority Active/Optimized paths are served by the controller where the aggregate is located. Lower priority paths are active but non-optimized because they are served by a different controller. Non-optimized paths are only used when optimized paths aren't available.

The following example displays the output for an ONTAP LUN with two Active/Optimized paths and two Active/Non-Optimized paths:

Show example

```
multipath -ll
3600a0980383036347ffb4d59646c4436 dm-28 NETAPP,LUN C-Mode
size=10G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
|-+- policy='service-time 0' prio=50 status=active
| |- 16:0:6:35 sdwb  69:624  active ready running
| |- 16:0:5:35 sdun  66:752  active ready running
`-+- policy='service-time 0' prio=10 status=enabled
  |- 15:0:0:35 sdaj  66:48   active ready running
  |- 15:0:1:35 sdbx  68:176  active ready running
```

Step 4: Optionally, exclude a device from multipathing

If required, you can exclude a device from multipathing by adding the WWID for the unwanted device to the "blacklist" stanza for the `multipath.conf` file.

Steps

1. Determine the WWID:

   ```
   /lib/udev/scsi_id -gud /dev/sda
   ```

   "sda" is the local SCSI disk that you want to add to the blacklist.

   An example WWID is `360030057024d0730239134810c0cb833`.

2. Add the WWID to the "blacklist" stanza:

   ```
   blacklist {
             wwid    360030057024d0730239134810c0cb833
           devnode "^(ram|raw|loop|fd|md|dm-|sr|scd|st)[0-9]*"
           devnode "^hd[a-z]"
           devnode "^cciss.*"
   }
   ```

Step 5: Customize multipath parameters for ONTAP LUNs

If your host is connected to LUNs from other vendors and any of the multipath parameter settings are overridden, you need to correct them by adding stanzas later in the `multipath.conf` file that apply specifically to ONTAP LUNs. If you don't do this, the ONTAP LUNs might not work as expected.

Check your `/etc/multipath.conf` file, especially in the defaults section, for settings that might be overriding the default settings for multipath parameters.

> ⚠️ You shouldn't override the recommended parameter settings for ONTAP LUNs. These settings are required for optimal performance of your host configuration. Contact NetApp support, your OS vendor, or both for more information.

The following example shows how to correct an overridden default. In this example, the `multipath.conf` file defines values for `path_checker` and `no_path_retry` that aren't compatible with ONTAP LUNs, and you can't remove these parameters because ONTAP storage arrays are still attached to the host. Instead, you correct the values for `path_checker` and `no_path_retry` by adding a device stanza to the `multipath.conf` file that applies specifically to the ONTAP LUNs.

Show example

```
defaults {
    path_checker        readsector0
    no_path_retry       fail
}

devices {
    device {
        vendor          "NETAPP"
        product         "LUN"
        no_path_retry   queue
        path_checker    tur
    }
}
```

Step 6: Review the known issues

There are no known issues.

What's next?

- Learn about using the Linux Host Utilities tool.
- Learn about ASM mirroring.

  Automatic Storage Management (ASM) mirroring might require changes to the Linux multipath settings to allow ASM to recognize a problem and switch over to an alternate failure group. Most ASM configurations on ONTAP use external redundancy, which means that data protection is provided by the external array and ASM doesn't mirror data. Some sites use ASM with normal redundancy to provide two-way mirroring, normally across different sites. See Oracle databases on ONTAP for further information.

Configure Oracle Linux 9.4 for FCP and iSCSI with ONTAP storage

The Linux Host Utilities software provides management and diagnostic tools for Linux hosts that are connected to ONTAP storage. When you install the Linux Host Utilities on an Oracle Linux 9.4 host, you can use the Host Utilities to help you manage FCP and iSCSI protocol operations with ONTAP LUNs.

ⓘ You don't need to manually configure Kernel-based Virtual Machine (KVM) settings because ONTAP LUNs are automatically mapped to the hypervisor.

Step 1: Optionally, enable SAN booting

You can configure your host to use SAN booting to simplify deployment and improve scalability.

Before you begin

Use the Interoperability Matrix Tool to verify that your Linux OS, host bus adapter (HBA), HBA firmware, HBA

boot BIOS, and ONTAP version support SAN booting.

Steps

1. [Create a SAN boot LUN and map it to the host](#).

2. Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is mapped.

   For information on how to enable the HBA BIOS, see your vendor-specific documentation.

3. Verify that the configuration was successful by rebooting the host and verifying that the OS is up and running.

Step 2: Install the Linux Host Utilities

NetApp strongly recommends installing the Linux Host Utilities to support ONTAP LUN management and assist technical support with gathering configuration data.

[Install Linux Host Utilities 8.0](#).

> ℹ️ Installing the Linux Host Utilities doesn't change any host timeout settings on your Linux host.

Step 3: Confirm the multipath configuration for your host

You can use multipathing with Oracle Linux 9.4 to manage ONTAP LUNs.

> ℹ️ You can use the [recommended settings for Red Hat Enterprise Linux (RHEL) 9.4](#) to configure Red Hat Compatible Kernel for Oracle Linux 9.4.

To ensure that multipathing is configured correctly for your host, verify that the `/etc/multipath.conf` file is defined and that you have the NetApp recommended settings configured for your ONTAP LUNs.

Steps

1. Verify that the `/etc/multipath.conf` file exits. If the file doesn't exist, create an empty, zero-byte file:

   ```
   touch /etc/multipath.conf
   ```

2. The first time the `multipath.conf` file is created, you might need to enable and start the multipath services to load the recommended settings:

   ```
   systemctl enable multipathd
   ```

   ```
   systemctl start multipathd
   ```

3. Each time you boot the host, the empty `/etc/multipath.conf` zero-byte file automatically loads the NetApp recommended host multipath parameters as the default settings. You shouldn't need to make changes to the `/etc/multipath.conf` file for your host because the operating system is compiled with the multipath parameters that recognize and manage ONTAP LUNs correctly.

The following table shows the Linux OS native compiled multipath parameter settings for ONTAP LUNs.

Show parameter settings

Parameter	Setting
detect_prio	yes
dev_loss_tmo	"infinity"
failback	immediate
fast_io_fail_tmo	5
features	"2 pg_init_retries 50"
flush_on_last_del	"yes"
hardware_handler	"0"
no_path_retry	queue
path_checker	"tur"
path_grouping_policy	"group_by_prio"
path_selector	"service-time 0"
polling_interval	5
prio	"ontap"
product	LUN
retain_attached_hw_handler	yes
rr_weight	"uniform"
user_friendly_names	no
vendor	NETAPP

4. Verify the parameter settings and path status for your ONTAP LUNs:

```
multipath -ll
```

The default multipath parameters support ASA, AFF, and FAS configurations. In these configurations, a single ONTAP LUN shouldn't require more than four paths. If there are more than four paths, it might cause issues with the paths during a storage failure.

The following example outputs show the correct parameter settings and path status for ONTAP LUNs in an ASA, AFF, or FAS configuration.

ASA configuration

An ASA configuration optimizes all paths to a given LUN, keeping them active. This improves performance by serving I/O operations through all paths at the same time.

Show example

```
multipath -ll
3600a098038303634722b4d59646c4436 dm-28 NETAPP,LUN C-Mode
size=10G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
|-+- policy='service-time 0' prio=50 status=active
  |- 11:0:7:6   sdbz 68:208  active ready running
  |- 11:0:11:6  sddn 71:80   active ready running
  |- 11:0:15:6  sdfb 129:208 active ready running
  |- 12:0:1:6   sdgp 132:80  active ready running
```

AFF or FAS configuration

An AFF or FAS configuration should have two groups of paths with higher and lower priorities. Higher priority Active/Optimized paths are served by the controller where the aggregate is located. Lower priority paths are active but non-optimized because they are served by a different controller. Non-optimized paths are only used when optimized paths aren't available.

The following example displays the output for an ONTAP LUN with two Active/Optimized paths and two Active/Non-Optimized paths:

Show example

```
multipath -ll
3600a0980383036347ffb4d59646c4436 dm-28 NETAPP,LUN C-Mode
size=10G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
|-+- policy='service-time 0' prio=50 status=active
| |- 16:0:6:35 sdwb  69:624  active ready running
| |- 16:0:5:35 sdun  66:752  active ready running
`-+- policy='service-time 0' prio=10 status=enabled
  |- 15:0:0:35 sdaj  66:48   active ready running
  |- 15:0:1:35 sdbx  68:176  active ready running
```

Step 4: Optionally, exclude a device from multipathing

If required, you can exclude a device from multipathing by adding the WWID for the unwanted device to the "blacklist" stanza for the `multipath.conf` file.

Steps

1. Determine the WWID:

   ```
   /lib/udev/scsi_id -gud /dev/sda
   ```

   "sda" is the local SCSI disk that you want to add to the blacklist.

   An example WWID is `360030057024d0730239134810c0cb833`.

2. Add the WWID to the "blacklist" stanza:

   ```
   blacklist {
           wwid    360030057024d0730239134810c0cb833
           devnode "^(ram|raw|loop|fd|md|dm-|sr|scd|st)[0-9]*"
           devnode "^hd[a-z]"
           devnode "^cciss.*"
   }
   ```

Step 5: Customize multipath parameters for ONTAP LUNs

If your host is connected to LUNs from other vendors and any of the multipath parameter settings are overridden, you need to correct them by adding stanzas later in the `multipath.conf` file that apply specifically to ONTAP LUNs. If you don't do this, the ONTAP LUNs might not work as expected.

Check your `/etc/multipath.conf` file, especially in the defaults section, for settings that might be overriding the default settings for multipath parameters.

> ⚠️ You shouldn't override the recommended parameter settings for ONTAP LUNs. These settings are required for optimal performance of your host configuration. Contact NetApp support, your OS vendor, or both for more information.

The following example shows how to correct an overridden default. In this example, the `multipath.conf` file defines values for `path_checker` and `no_path_retry` that aren't compatible with ONTAP LUNs, and you can't remove these parameters because ONTAP storage arrays are still attached to the host. Instead, you correct the values for `path_checker` and `no_path_retry` by adding a device stanza to the `multipath.conf` file that applies specifically to the ONTAP LUNs.

Show example

```
defaults {
    path_checker        readsector0
    no_path_retry       fail
}

devices {
    device {
        vendor          "NETAPP"
        product         "LUN"
        no_path_retry   queue
        path_checker    tur
    }
}
```

Step 6: Review the known issues

There are no known issues.

What's next?

- Learn about using the Linux Host Utilities tool.

- Learn about ASM mirroring.

  Automatic Storage Management (ASM) mirroring might require changes to the Linux multipath settings to allow ASM to recognize a problem and switch over to an alternate failure group. Most ASM configurations on ONTAP use external redundancy, which means that data protection is provided by the external array and ASM doesn't mirror data. Some sites use ASM with normal redundancy to provide two-way mirroring, normally across different sites. See Oracle databases on ONTAP for further information.

Configure Oracle Linux 9.3 for FCP and iSCSI with ONTAP storage

The Linux Host Utilities software provides management and diagnostic tools for Linux hosts that are connected to ONTAP storage. When you install the Linux Host Utilities on an Oracle Linux 9.3 host, you can use the Host Utilities to help you manage FCP and iSCSI protocol operations with ONTAP LUNs.

ⓘ You don't need to manually configure Kernel-based Virtual Machine (KVM) settings because ONTAP LUNs are automatically mapped to the hypervisor.

Step 1: Optionally, enable SAN booting

You can configure your host to use SAN booting to simplify deployment and improve scalability.

Before you begin

Use the Interoperability Matrix Tool to verify that your Linux OS, host bus adapter (HBA), HBA firmware, HBA

boot BIOS, and ONTAP version support SAN booting.

Steps

1. [Create a SAN boot LUN and map it to the host](#).

2. Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is mapped.

   For information on how to enable the HBA BIOS, see your vendor-specific documentation.

3. Verify that the configuration was successful by rebooting the host and verifying that the OS is up and running.

Step 2: Install the Linux Host Utilities

NetApp strongly recommends installing the Linux Host Utilities to support ONTAP LUN management and assist technical support with gathering configuration data.

[Install Linux Host Utilities 8.0](#).

> ⓘ Installing the Linux Host Utilities doesn't change any host timeout settings on your Linux host.

Step 3: Confirm the multipath configuration for your host

You can use multipathing with Oracle Linux 9.3 to manage ONTAP LUNs.

> ⓘ You can use the [recommended settings for Red Hat Enterprise Linux (RHEL) 9.3](#) to configure Red Hat Compatible Kernel for Oracle Linux 9.3.

To ensure that multipathing is configured correctly for your host, verify that the `/etc/multipath.conf` file is defined and that you have the NetApp recommended settings configured for your ONTAP LUNs.

Steps

1. Verify that the `/etc/multipath.conf` file exits. If the file doesn't exist, create an empty, zero-byte file:

   ```
   touch /etc/multipath.conf
   ```

2. The first time the `multipath.conf` file is created, you might need to enable and start the multipath services to load the recommended settings:

   ```
   systemctl enable multipathd
   ```

   ```
   systemctl start multipathd
   ```

3. Each time you boot the host, the empty `/etc/multipath.conf` zero-byte file automatically loads the NetApp recommended host multipath parameters as the default settings. You shouldn't need to make changes to the `/etc/multipath.conf` file for your host because the operating system is compiled with the multipath parameters that recognize and manage ONTAP LUNs correctly.

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flush_on_last_del	"yes"
hardware_handler	"0"
no_path_retry	queue
path_checker	"tur"
path_grouping_policy	"group_by_prio"
path_selector	"service-time 0"
polling_interval	5
prio	"ontap"
product	LUN
retain_attached_hw_handler	yes
rr_weight	"uniform"
user_friendly_names	no
vendor	NETAPP

4. Verify the parameter settings and path status for your ONTAP LUNs:

```
multipath -ll
```

The default multipath parameters support ASA, AFF, and FAS configurations. In these configurations, a single ONTAP LUN shouldn't require more than four paths. If there are more than four paths, it might cause issues with the paths during a storage failure.

The following example outputs show the correct parameter settings and path status for ONTAP LUNs in an ASA, AFF, or FAS configuration.

ASA configuration

An ASA configuration optimizes all paths to a given LUN, keeping them active. This improves performance by serving I/O operations through all paths at the same time.

Show example

```
multipath -ll
3600a098038303634722b4d59646c4436 dm-28 NETAPP,LUN C-Mode
size=10G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
|-+- policy='service-time 0' prio=50 status=active
  |- 11:0:7:6    sdbz 68:208   active ready running
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```

AFF or FAS configuration

An AFF or FAS configuration should have two groups of paths with higher and lower priorities. Higher priority Active/Optimized paths are served by the controller where the aggregate is located. Lower priority paths are active but non-optimized because they are served by a different controller. Non-optimized paths are only used when optimized paths aren't available.

The following example displays the output for an ONTAP LUN with two Active/Optimized paths and two Active/Non-Optimized paths:

Show example

```
multipath -ll
3600a0980383036347ffb4d59646c4436 dm-28 NETAPP,LUN C-Mode
size=10G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
|-+- policy='service-time 0' prio=50 status=active
| |- 16:0:6:35 sdwb  69:624  active ready running
| |- 16:0:5:35 sdun  66:752  active ready running
`-+- policy='service-time 0' prio=10 status=enabled
  |- 15:0:0:35 sdaj  66:48   active ready running
  |- 15:0:1:35 sdbx  68:176  active ready running
```

Step 4: Optionally, exclude a device from multipathing

If required, you can exclude a device from multipathing by adding the WWID for the unwanted device to the "blacklist" stanza for the `multipath.conf` file.

Steps

1. Determine the WWID:

   ```
   /lib/udev/scsi_id -gud /dev/sda
   ```

   "sda" is the local SCSI disk that you want to add to the blacklist.

   An example WWID is `360030057024d0730239134810c0cb833`.

2. Add the WWID to the "blacklist" stanza:

   ```
   blacklist {
           wwid    360030057024d0730239134810c0cb833
           devnode "^(ram|raw|loop|fd|md|dm-|sr|scd|st)[0-9]*"
           devnode "^hd[a-z]"
           devnode "^cciss.*"
   }
   ```

Step 5: Customize multipath parameters for ONTAP LUNs

If your host is connected to LUNs from other vendors and any of the multipath parameter settings are overridden, you need to correct them by adding stanzas later in the `multipath.conf` file that apply specifically to ONTAP LUNs. If you don't do this, the ONTAP LUNs might not work as expected.

Check your `/etc/multipath.conf` file, especially in the defaults section, for settings that might be overriding the default settings for multipath parameters.

> ⚠️ You shouldn't override the recommended parameter settings for ONTAP LUNs. These settings are required for optimal performance of your host configuration. Contact NetApp support, your OS vendor, or both for more information.

The following example shows how to correct an overridden default. In this example, the `multipath.conf` file defines values for `path_checker` and `no_path_retry` that aren't compatible with ONTAP LUNs, and you can't remove these parameters because ONTAP storage arrays are still attached to the host. Instead, you correct the values for `path_checker` and `no_path_retry` by adding a device stanza to the `multipath.conf` file that applies specifically to the ONTAP LUNs.

Show example

```
defaults {
    path_checker        readsector0
    no_path_retry       fail
}

devices {
    device {
        vendor          "NETAPP"
        product         "LUN"
        no_path_retry   queue
        path_checker    tur
    }
}
```

Step 6: Review the known issues

The Oracle Linux 9.3 with ONTAP storage release has the following known issue:

NetApp Bug ID	Title	Description

1508554	SAN LUN utility with Emulex HBA needs symbolic links from library packages	When you execute the Linux Host Utilities CLI command - "sanlun fcp show adapter -v" on a SAN host, the command fails with an error message displaying that the library dependencies required for an host bus adapter (HBA) discovery cannot be located:
		
		`[root@hostname ~]# sanlun fcp show adapter -v`
		`Unable to locate /usr/lib64/libHBAAPI.so library`
		`Make sure the package installing the library is installed & loaded`

What's next?

- Learn about using the Linux Host Utilities tool.

- Learn about ASM mirroring.

  Automatic Storage Management (ASM) mirroring might require changes to the Linux multipath settings to

allow ASM to recognize a problem and switch over to an alternate failure group. Most ASM configurations on ONTAP use external redundancy, which means that data protection is provided by the external array and ASM doesn't mirror data. Some sites use ASM with normal redundancy to provide two-way mirroring, normally across different sites. See Oracle databases on ONTAP for further information.

Configure Oracle Linux 9.2 for FCP and iSCSI with ONTAP storage

The Linux Host Utilities software provides management and diagnostic tools for Linux hosts that are connected to ONTAP storage. When you install the Linux Host Utilities on an Oracle Linux 9.2 host, you can use the Host Utilities to help you manage FCP and iSCSI protocol operations with ONTAP LUNs.

> ⓘ You don't need to manually configure Kernel-based Virtual Machine (KVM) settings because ONTAP LUNs are automatically mapped to the hypervisor.

Step 1: Optionally, enable SAN booting

You can configure your host to use SAN booting to simplify deployment and improve scalability.

Before you begin

Use the Interoperability Matrix Tool to verify that your Linux OS, host bus adapter (HBA), HBA firmware, HBA boot BIOS, and ONTAP version support SAN booting.

Steps

1. Create a SAN boot LUN and map it to the host.

2. Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is mapped.

   For information on how to enable the HBA BIOS, see your vendor-specific documentation.

3. Verify that the configuration was successful by rebooting the host and verifying that the OS is up and running.

Step 2: Install the Linux Host Utilities

NetApp strongly recommends installing the Linux Host Utilities to support ONTAP LUN management and assist technical support with gathering configuration data.

Install Linux Host Utilities 8.0.

> ⓘ Installing the Linux Host Utilities doesn't change any host timeout settings on your Linux host.

Step 3: Confirm the multipath configuration for your host

You can use multipathing with Oracle Linux 9.2 to manage ONTAP LUNs.

> ⓘ You can use the recommended settings for Red Hat Enterprise Linux (RHEL) 9.2 to configure Red Hat Compatible Kernel for Oracle Linux 9.2.

To ensure that multipathing is configured correctly for your host, verify that the `/etc/multipath.conf` file is defined and that you have the NetApp recommended settings configured for your ONTAP LUNs.

Steps

1. Verify that the `/etc/multipath.conf` file exits. If the file doesn't exist, create an empty, zero-byte file:

   ```
   touch /etc/multipath.conf
   ```

2. The first time the `multipath.conf` file is created, you might need to enable and start the multipath services to load the recommended settings:

   ```
   systemctl enable multipathd
   ```

   ```
   systemctl start multipathd
   ```

3. Each time you boot the host, the empty `/etc/multipath.conf` zero-byte file automatically loads the NetApp recommended host multipath parameters as the default settings. You shouldn't need to make changes to the `/etc/multipath.conf` file for your host because the operating system is compiled with the multipath parameters that recognize and manage ONTAP LUNs correctly.

   The following table shows the Linux OS native compiled multipath parameter settings for ONTAP LUNs.

Show parameter settings

Parameter	Setting
detect_prio	yes
dev_loss_tmo	"infinity"
failback	immediate
fast_io_fail_tmo	5
features	"2 pg_init_retries 50"
flush_on_last_del	"yes"
hardware_handler	"0"
no_path_retry	queue
path_checker	"tur"
path_grouping_policy	"group_by_prio"
path_selector	"service-time 0"
polling_interval	5
prio	"ontap"
product	LUN
retain_attached_hw_handler	yes
rr_weight	"uniform"
user_friendly_names	no
vendor	NETAPP

4. Verify the parameter settings and path status for your ONTAP LUNs:

```
multipath -ll
```

The default multipath parameters support ASA, AFF, and FAS configurations. In these configurations, a single ONTAP LUN shouldn't require more than four paths. If there are more than four paths, it might cause issues with the paths during a storage failure.

The following example outputs show the correct parameter settings and path status for ONTAP LUNs in an ASA, AFF, or FAS configuration.

ASA configuration

An ASA configuration optimizes all paths to a given LUN, keeping them active. This improves performance by serving I/O operations through all paths at the same time.

Show example

```
multipath -ll
3600a098038303634722b4d59646c4436 dm-28 NETAPP,LUN C-Mode
size=10G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
|-+- policy='service-time 0' prio=50 status=active
  |- 11:0:7:6    sdbz 68:208  active ready running
  |- 11:0:11:6   sddn 71:80   active ready running
  |- 11:0:15:6   sdfb 129:208 active ready running
  |- 12:0:1:6    sdgp 132:80  active ready running
```

AFF or FAS configuration

An AFF or FAS configuration should have two groups of paths with higher and lower priorities. Higher priority Active/Optimized paths are served by the controller where the aggregate is located. Lower priority paths are active but non-optimized because they are served by a different controller. Non-optimized paths are only used when optimized paths aren't available.

The following example displays the output for an ONTAP LUN with two Active/Optimized paths and two Active/Non-Optimized paths:

Show example

```
multipath -ll
3600a0980383036347ffb4d59646c4436 dm-28 NETAPP,LUN C-Mode
size=10G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
|-+- policy='service-time 0' prio=50 status=active
| |- 16:0:6:35 sdwb  69:624  active ready running
| |- 16:0:5:35 sdun  66:752  active ready running
`-+- policy='service-time 0' prio=10 status=enabled
  |- 15:0:0:35 sdaj  66:48   active ready running
  |- 15:0:1:35 sdbx  68:176  active ready running
```

Step 4: Optionally, exclude a device from multipathing

If required, you can exclude a device from multipathing by adding the WWID for the unwanted device to the "blacklist" stanza for the `multipath.conf` file.

Steps

1. Determine the WWID:

   ```
   /lib/udev/scsi_id -gud /dev/sda
   ```

   "sda" is the local SCSI disk that you want to add to the blacklist.

   An example WWID is `360030057024d0730239134810c0cb833`.

2. Add the WWID to the "blacklist" stanza:

   ```
   blacklist {
           wwid    360030057024d0730239134810c0cb833
           devnode "^(ram|raw|loop|fd|md|dm-|sr|scd|st)[0-9]*"
           devnode "^hd[a-z]"
           devnode "^cciss.*"
   }
   ```

Step 5: Customize multipath parameters for ONTAP LUNs

If your host is connected to LUNs from other vendors and any of the multipath parameter settings are overridden, you need to correct them by adding stanzas later in the `multipath.conf` file that apply specifically to ONTAP LUNs. If you don't do this, the ONTAP LUNs might not work as expected.

Check your `/etc/multipath.conf` file, especially in the defaults section, for settings that might be overriding the default settings for multipath parameters.

> ⚠️ You shouldn't override the recommended parameter settings for ONTAP LUNs. These settings are required for optimal performance of your host configuration. Contact NetApp support, your OS vendor, or both for more information.

The following example shows how to correct an overridden default. In this example, the `multipath.conf` file defines values for `path_checker` and `no_path_retry` that aren't compatible with ONTAP LUNs, and you can't remove these parameters because ONTAP storage arrays are still attached to the host. Instead, you correct the values for `path_checker` and `no_path_retry` by adding a device stanza to the `multipath.conf` file that applies specifically to the ONTAP LUNs.

Show example

```
defaults {
    path_checker        readsector0
    no_path_retry       fail
}

devices {
    device {
        vendor          "NETAPP"
        product         "LUN"
        no_path_retry   queue
        path_checker    tur
    }
}
```

Step 6: Review the known issues

The Oracle Linux 9.2 with ONTAP storage release has the following known issues:

NetApp Bug ID	Title	Description
1508554	SAN LUN utility with Emulex HBA needs symbolic links from library packages	When you execute the Linux Host Utilities CLI command - "sanlun fcp show adapter -v" on a SAN host, the command fails with an error message displaying that the library dependencies required for an host bus adapter (HBA) discovery cannot be located: ```[root@hostname ~]# sanlun fcp show adapter -v Unable to locate /usr/lib64/libHBAAPI.so library Make sure the package installing the library is installed & loaded```

What's next?

- Learn about using the Linux Host Utilities tool.
- Learn about ASM mirroring.

  Automatic Storage Management (ASM) mirroring might require changes to the Linux multipath settings to

allow ASM to recognize a problem and switch over to an alternate failure group. Most ASM configurations on ONTAP use external redundancy, which means that data protection is provided by the external array and ASM doesn't mirror data. Some sites use ASM with normal redundancy to provide two-way mirroring, normally across different sites. See Oracle databases on ONTAP for further information.

Configure Oracle Linux 9.1 for FCP and iSCSI with ONTAP storage

The Linux Host Utilities software provides management and diagnostic tools for Linux hosts that are connected to ONTAP storage. When you install the Linux Host Utilities on an Oracle Linux 9.1 host, you can use the Host Utilities to help you manage FCP and iSCSI protocol operations with ONTAP LUNs.

> ⓘ You don't need to manually configure Kernel-based Virtual Machine (KVM) settings because ONTAP LUNs are automatically mapped to the hypervisor.

Step 1: Optionally, enable SAN booting

You can configure your host to use SAN booting to simplify deployment and improve scalability.

Before you begin

Use the Interoperability Matrix Tool to verify that your Linux OS, host bus adapter (HBA), HBA firmware, HBA boot BIOS, and ONTAP version support SAN booting.

Steps

1. Create a SAN boot LUN and map it to the host.

2. Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is mapped.

   For information on how to enable the HBA BIOS, see your vendor-specific documentation.

3. Verify that the configuration was successful by rebooting the host and verifying that the OS is up and running.

Step 2: Install the Linux Host Utilities

NetApp strongly recommends installing the Linux Host Utilities to support ONTAP LUN management and assist technical support with gathering configuration data.

Install Linux Host Utilities 8.0.

> ⓘ Installing the Linux Host Utilities doesn't change any host timeout settings on your Linux host.

Step 3: Confirm the multipath configuration for your host

You can use multipathing with Oracle Linux 9.1 to manage ONTAP LUNs.

> ⓘ You can use the recommended settings for Red Hat Enterprise Linux (RHEL) 9.1 to configure Red Hat Compatible Kernel for Oracle Linux 9.1.

To ensure that multipathing is configured correctly for your host, verify that the `/etc/multipath.conf` file is defined and that you have the NetApp recommended settings configured for your ONTAP LUNs.

Steps

1. Verify that the `/etc/multipath.conf` file exits. If the file doesn't exist, create an empty, zero-byte file:

   ```
   touch /etc/multipath.conf
   ```

2. The first time the `multipath.conf` file is created, you might need to enable and start the multipath services to load the recommended settings:

   ```
   systemctl enable multipathd
   ```

   ```
   systemctl start multipathd
   ```

3. Each time you boot the host, the empty `/etc/multipath.conf` zero-byte file automatically loads the NetApp recommended host multipath parameters as the default settings. You shouldn't need to make changes to the `/etc/multipath.conf` file for your host because the operating system is compiled with the multipath parameters that recognize and manage ONTAP LUNs correctly.

   The following table shows the Linux OS native compiled multipath parameter settings for ONTAP LUNs.

Show parameter settings

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fast_io_fail_tmo	5
features	"2 pg_init_retries 50"
flush_on_last_del	"yes"
hardware_handler	"0"
no_path_retry	queue
path_checker	"tur"
path_grouping_policy	"group_by_prio"
path_selector	"service-time 0"
polling_interval	5
prio	"ontap"
product	LUN
retain_attached_hw_handler	yes
rr_weight	"uniform"
user_friendly_names	no
vendor	NETAPP

4. Verify the parameter settings and path status for your ONTAP LUNs:

```
multipath -ll
```

The default multipath parameters support ASA, AFF, and FAS configurations. In these configurations, a single ONTAP LUN shouldn't require more than four paths. If there are more than four paths, it might cause issues with the paths during a storage failure.

The following example outputs show the correct parameter settings and path status for ONTAP LUNs in an ASA, AFF, or FAS configuration.

ASA configuration

An ASA configuration optimizes all paths to a given LUN, keeping them active. This improves performance by serving I/O operations through all paths at the same time.

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```
multipath -ll
3600a098038303634722b4d59646c4436 dm-28 NETAPP,LUN C-Mode
size=10G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
|-+- policy='service-time 0' prio=50 status=active
  |- 11:0:7:6   sdbz 68:208  active ready running
  |- 11:0:11:6  sddn 71:80   active ready running
  |- 11:0:15:6  sdfb 129:208 active ready running
  |- 12:0:1:6   sdgp 132:80  active ready running
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AFF or FAS configuration

An AFF or FAS configuration should have two groups of paths with higher and lower priorities. Higher priority Active/Optimized paths are served by the controller where the aggregate is located. Lower priority paths are active but non-optimized because they are served by a different controller. Non-optimized paths are only used when optimized paths aren't available.

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Show example

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hwhandler='1 alua' wp=rw
|-+- policy='service-time 0' prio=50 status=active
| |- 16:0:6:35 sdwb  69:624  active ready running
| |- 16:0:5:35 sdun  66:752  active ready running
`-+- policy='service-time 0' prio=10 status=enabled
  |- 15:0:0:35 sdaj  66:48   active ready running
  |- 15:0:1:35 sdbx  68:176  active ready running
```

Step 4: Optionally, exclude a device from multipathing

If required, you can exclude a device from multipathing by adding the WWID for the unwanted device to the "blacklist" stanza for the `multipath.conf` file.

Steps

1. Determine the WWID:

   ```
   /lib/udev/scsi_id -gud /dev/sda
   ```

   "sda" is the local SCSI disk that you want to add to the blacklist.

   An example WWID is `360030057024d0730239134810c0cb833`.

2. Add the WWID to the "blacklist" stanza:

   ```
   blacklist {
           wwid   360030057024d0730239134810c0cb833
           devnode "^(ram|raw|loop|fd|md|dm-|sr|scd|st)[0-9]*"
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   }
   ```

Step 5: Customize multipath parameters for ONTAP LUNs

If your host is connected to LUNs from other vendors and any of the multipath parameter settings are overridden, you need to correct them by adding stanzas later in the `multipath.conf` file that apply specifically to ONTAP LUNs. If you don't do this, the ONTAP LUNs might not work as expected.

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The following example shows how to correct an overridden default. In this example, the `multipath.conf` file defines values for `path_checker` and `no_path_retry` that aren't compatible with ONTAP LUNs, and you can't remove these parameters because ONTAP storage arrays are still attached to the host. Instead, you correct the values for `path_checker` and `no_path_retry` by adding a device stanza to the `multipath.conf` file that applies specifically to the ONTAP LUNs.

Show example

```
defaults {
    path_checker        readsector0
    no_path_retry       fail
}

devices {
    device {
        vendor          "NETAPP"
        product         "LUN"
        no_path_retry   queue
        path_checker    tur
    }
}
```

Step 6: Review the known issues

The Oracle Linux 9.1 with NetApp ONTAP storage release has the following known issues:

NetApp Bug ID	Title	Description

1508554	SAN LUN utility with Emulex HBA needs symbolic links from library packages	When you execute the Linux Host Utilities CLI command - "sanlun fcp show adapter -v" on a SAN host, the command fails with an error message displaying that the library dependencies required for a host bus adapter (HBA) discovery cannot be located:
		
		`[root@hostname ~]# sanlun fcp show adapter -v`
		`Unable to locate /usr/lib64/libHBAAPI.so library`
		`Make sure the package installing the library is installed & loaded`

What's next?

- Learn about using the Linux Host Utilities tool.
- Learn about ASM mirroring.

  Automatic Storage Management (ASM) mirroring might require changes to the Linux multipath settings to

allow ASM to recognize a problem and switch over to an alternate failure group. Most ASM configurations on ONTAP use external redundancy, which means that data protection is provided by the external array and ASM doesn't mirror data. Some sites use ASM with normal redundancy to provide two-way mirroring, normally across different sites. See Oracle databases on ONTAP for further information.

Configure Oracle Linux 9.0 for FCP and iSCSI with ONTAP storage

The Linux Host Utilities software provides management and diagnostic tools for Linux hosts that are connected to ONTAP storage. When you install the Linux Host Utilities on an Oracle Linux 9.0 host, you can use the Host Utilities to help you manage FCP and iSCSI protocol operations with ONTAP LUNs.

> (i) You don't need to manually configure Kernel-based Virtual Machine (KVM) settings because ONTAP LUNs are automatically mapped to the hypervisor.

Step 1: Optionally, enable SAN booting

You can configure your host to use SAN booting to simplify deployment and improve scalability.

Before you begin
Use the Interoperability Matrix Tool to verify that your Linux OS, host bus adapter (HBA), HBA firmware, HBA boot BIOS, and ONTAP version support SAN booting.

Steps
1. Create a SAN boot LUN and map it to the host.
2. Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is mapped.

   For information on how to enable the HBA BIOS, see your vendor-specific documentation.

3. Verify that the configuration was successful by rebooting the host and verifying that the OS is up and running.

Step 2: Install the Linux Host Utilities

NetApp strongly recommends installing the Linux Host Utilities to support ONTAP LUN management and assist technical support with gathering configuration data.

Install Linux Host Utilities 8.0.

> (i) Installing the Linux Host Utilities doesn't change any host timeout settings on your Linux host.

Step 3: Confirm the multipath configuration for your host

You can use multipathing with Oracle Linux 9.0 to manage ONTAP LUNs.

> (i) You can use the recommended settings for Red Hat Enterprise Linux (RHEL) 9.0 to configure Red Hat Compatible Kernel for Oracle Linux 9.0.

To ensure that multipathing is configured correctly for your host, verify that the `/etc/multipath.conf` file is defined and that you have the NetApp recommended settings configured for your ONTAP LUNs.

Steps

1. Verify that the `/etc/multipath.conf` file exits. If the file doesn't exist, create an empty, zero-byte file:

   ```
   touch /etc/multipath.conf
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2. The first time the `multipath.conf` file is created, you might need to enable and start the multipath services to load the recommended settings:

   ```
   systemctl enable multipathd
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```

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Show example

```
defaults {
    path_checker        readsector0
    no_path_retry       fail
}

devices {
    device {
        vendor          "NETAPP"
        product         "LUN"
        no_path_retry   queue
        path_checker    tur
    }
}
```

Step 6: Review the known issues

The Oracle Linux 9.0 with NetApp ONTAP storage release has the following known issues:

NetApp Bug ID	Title	Description
1508554	SAN LUN utility with Emulex HBA needs symbolic links from library packages	When you execute the Linux Host Utilities CLI command - "sanlun fcp show adapter -v" on a SAN host, the command fails with an error message displaying that the library dependencies required for a host bus adapter (HBA) discovery cannot be located: ```[root@hostname ~]# sanlun fcp show adapter -v Unable to locate /usr/lib64/libHBAAPI.so library Make sure the package installing the library is installed & loaded```

What's next?

- Learn about using the Linux Host Utilities tool.

- Learn about ASM mirroring.

  Automatic Storage Management (ASM) mirroring might require changes to the Linux multipath settings to

allow ASM to recognize a problem and switch over to an alternate failure group. Most ASM configurations on ONTAP use external redundancy, which means that data protection is provided by the external array and ASM doesn't mirror data. Some sites use ASM with normal redundancy to provide two-way mirroring, normally across different sites. See Oracle databases on ONTAP for further information.

Oracle Linux 8

Configure Oracle Linux 8.10 for FCP and iSCSI with ONTAP storage

The Linux Host Utilities software provides management and diagnostic tools for Linux hosts that are connected to ONTAP storage. When you install the Linux Host Utilities on an Oracle Linux 8.10 host, you can use the Host Utilities to help you manage FCP and iSCSI protocol operations with ONTAP LUNs.

> ⓘ You don't need to manually configure Kernel-based Virtual Machine (KVM) settings because ONTAP LUNs are automatically mapped to the hypervisor.

Step 1: Optionally, enable SAN booting

You can configure your host to use SAN booting to simplify deployment and improve scalability.

Before you begin

Use the Interoperability Matrix Tool to verify that your Linux OS, host bus adapter (HBA), HBA firmware, HBA boot BIOS, and ONTAP version support SAN booting.

Steps

1. Create a SAN boot LUN and map it to the host.
2. Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is mapped.

   For information on how to enable the HBA BIOS, see your vendor-specific documentation.

3. Verify that the configuration was successful by rebooting the host and verifying that the OS is up and running.

Step 2: Install the Linux Host Utilities

NetApp strongly recommends installing the Linux Host Utilities to support ONTAP LUN management and assist technical support with gathering configuration data.

Install Linux Host Utilities 8.0.

> ⓘ Installing the Linux Host Utilities doesn't change any host timeout settings on your Linux host.

Step 3: Confirm the multipath configuration for your host

You can use multipathing with Oracle Linux 8.10 to manage ONTAP LUNs.

> ⓘ You can use the recommended settings for Red Hat Enterprise Linux (RHEL) 8.10 to configure Red Hat Compatible Kernel for Oracle Linux 8.10.

To ensure that multipathing is configured correctly for your host, verify that the `/etc/multipath.conf` file is

defined and that you have the NetApp recommended settings configured for your ONTAP LUNs.

Steps

1. Verify that the `/etc/multipath.conf` file exits. If the file doesn't exist, create an empty, zero-byte file:

   ```
   touch /etc/multipath.conf
   ```

2. The first time the `multipath.conf` file is created, you might need to enable and start the multipath services to load the recommended settings:

   ```
   chkconfig multipathd on
   ```

   ```
   /etc/init.d/multipathd start
   ```

3. Each time you boot the host, the empty `/etc/multipath.conf` zero-byte file automatically loads the NetApp recommended host multipath parameters as the default settings. You shouldn't need to make changes to the `/etc/multipath.conf` file for your host because the operating system is compiled with the multipath parameters that recognize and manage ONTAP LUNs correctly.

   The following table shows the Linux OS native compiled multipath parameter settings for ONTAP LUNs.

Show parameter settings

Parameter	Setting
detect_prio	yes
dev_loss_tmo	"infinity"
failback	immediate
fast_io_fail_tmo	5
features	"2 pg_init_retries 50"
flush_on_last_del	"yes"
hardware_handler	"0"
no_path_retry	queue
path_checker	"tur"
path_grouping_policy	"group_by_prio"
path_selector	"service-time 0"
polling_interval	5
prio	"ontap"
product	LUN
retain_attached_hw_handler	yes
rr_weight	"uniform"
user_friendly_names	no
vendor	NETAPP

4. Verify the parameter settings and path status for your ONTAP LUNs:

```
multipath -ll
```

The default multipath parameters support ASA, AFF, and FAS configurations. In these configurations, a single ONTAP LUN shouldn't require more than four paths. If there are more than four paths, it might cause issues with the paths during a storage failure.

The following example outputs show the correct parameter settings and path status for ONTAP LUNs in an ASA, AFF, or FAS configuration.

ASA configuration

An ASA configuration optimizes all paths to a given LUN, keeping them active. This improves performance by serving I/O operations through all paths at the same time.

Show example

```
multipath -ll
3600a098038303634722b4d59646c4436 dm-28 NETAPP,LUN C-Mode
size=10G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
|-+- policy='service-time 0' prio=50 status=active
  |- 11:0:7:6   sdbz 68:208  active ready running
  |- 11:0:11:6  sddn 71:80   active ready running
  |- 11:0:15:6  sdfb 129:208 active ready running
  |- 12:0:1:6   sdgp 132:80  active ready running
```

AFF or FAS configuration

An AFF or FAS configuration should have two groups of paths with higher and lower priorities. Higher priority Active/Optimized paths are served by the controller where the aggregate is located. Lower priority paths are active but non-optimized because they are served by a different controller. Non-optimized paths are only used when optimized paths aren't available.

The following example displays the output for an ONTAP LUN with two Active/Optimized paths and two Active/Non-Optimized paths:

Show example

```
multipath -ll
3600a0980383036347ffb4d59646c4436 dm-28 NETAPP,LUN C-Mode
size=10G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
|-+- policy='service-time 0' prio=50 status=active
| |- 16:0:6:35 sdwb  69:624  active ready running
| |- 16:0:5:35 sdun  66:752  active ready running
`-+- policy='service-time 0' prio=10 status=enabled
  |- 15:0:0:35 sdaj  66:48   active ready running
  |- 15:0:1:35 sdbx  68:176  active ready running
```

Step 4: Optionally, exclude a device from multipathing

If required, you can exclude a device from multipathing by adding the WWID for the unwanted device to the "blacklist" stanza for the `multipath.conf` file.

Steps

1. Determine the WWID:

   ```
   /lib/udev/scsi_id -gud /dev/sda
   ```

   "sda" is the local SCSI disk that you want to add to the blacklist.

   An example WWID is `360030057024d0730239134810c0cb833`.

2. Add the WWID to the "blacklist" stanza:

   ```
   blacklist {
            wwid    360030057024d0730239134810c0cb833
            devnode "^(ram|raw|loop|fd|md|dm-|sr|scd|st)[0-9]*"
            devnode "^hd[a-z]"
            devnode "^cciss.*"
   }
   ```

Step 5: Customize multipath parameters for ONTAP LUNs

If your host is connected to LUNs from other vendors and any of the multipath parameter settings are overridden, you need to correct them by adding stanzas later in the `multipath.conf` file that apply specifically to ONTAP LUNs. If you don't do this, the ONTAP LUNs might not work as expected.

Check your `/etc/multipath.conf` file, especially in the defaults section, for settings that might be overriding the default settings for multipath parameters.

> ⚠️ You shouldn't override the recommended parameter settings for ONTAP LUNs. These settings are required for optimal performance of your host configuration. Contact NetApp support, your OS vendor, or both for more information.

The following example shows how to correct an overridden default. In this example, the `multipath.conf` file defines values for `path_checker` and `no_path_retry` that aren't compatible with ONTAP LUNs, and you can't remove these parameters because ONTAP storage arrays are still attached to the host. Instead, you correct the values for `path_checker` and `no_path_retry` by adding a device stanza to the `multipath.conf` file that applies specifically to the ONTAP LUNs.

Show example

```
defaults {
    path_checker        readsector0
    no_path_retry       fail
}

devices {
    device {
        vendor          "NETAPP"
        product         "LUN"
        no_path_retry   queue
        path_checker    tur
    }
}
```

Step 6: Review the known issues

There are no known issues.

What's next?

- Learn about using the Linux Host Utilities tool.
- Learn about ASM mirroring.

  Automatic Storage Management (ASM) mirroring might require changes to the Linux multipath settings to allow ASM to recognize a problem and switch over to an alternate failure group. Most ASM configurations on ONTAP use external redundancy, which means that data protection is provided by the external array and ASM doesn't mirror data. Some sites use ASM with normal redundancy to provide two-way mirroring, normally across different sites. See Oracle databases on ONTAP for further information.

Configure Oracle Linux 8.9 for FCP and iSCSI with ONTAP storage

The Linux Host Utilities software provides management and diagnostic tools for Linux hosts that are connected to ONTAP storage. When you install the Linux Host Utilities on an Oracle Linux 8.9 host, you can use the Host Utilities to help you manage FCP and iSCSI protocol operations with ONTAP LUNs.

ⓘ | You don't need to manually configure Kernel-based Virtual Machine (KVM) settings because ONTAP LUNs are automatically mapped to the hypervisor.

Step 1: Optionally, enable SAN booting

You can configure your host to use SAN booting to simplify deployment and improve scalability.

Before you begin

Use the Interoperability Matrix Tool to verify that your Linux OS, host bus adapter (HBA), HBA firmware, HBA

boot BIOS, and ONTAP version support SAN booting.

Steps

1. [Create a SAN boot LUN and map it to the host](#).

2. Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is mapped.

   For information on how to enable the HBA BIOS, see your vendor-specific documentation.

3. Verify that the configuration was successful by rebooting the host and verifying that the OS is up and running.

Step 2: Install the Linux Host Utilities

NetApp strongly recommends installing the Linux Host Utilities to support ONTAP LUN management and assist technical support with gathering configuration data.

[Install Linux Host Utilities 8.0](#).

> ⓘ Installing the Linux Host Utilities doesn't change any host timeout settings on your Linux host.

Step 3: Confirm the multipath configuration for your host

You can use multipathing with Oracle Linux 8.9 to manage ONTAP LUNs.

> ⓘ You can use the [recommended settings for Red Hat Enterprise Linux (RHEL) 8.9](#) to configure Red Hat Compatible Kernel for Oracle Linux 8.9.

To ensure that multipathing is configured correctly for your host, verify that the `/etc/multipath.conf` file is defined and that you have the NetApp recommended settings configured for your ONTAP LUNs.

Steps

1. Verify that the `/etc/multipath.conf` file exits. If the file doesn't exist, create an empty, zero-byte file:

   ```
   touch /etc/multipath.conf
   ```

2. The first time the `multipath.conf` file is created, you might need to enable and start the multipath services to load the recommended settings:

   ```
   chkconfig multipathd on
   ```

   ```
   /etc/init.d/multipathd start
   ```

3. Each time you boot the host, the empty `/etc/multipath.conf` zero-byte file automatically loads the NetApp recommended host multipath parameters as the default settings. You shouldn't need to make changes to the `/etc/multipath.conf` file for your host because the operating system is compiled with the multipath parameters that recognize and manage ONTAP LUNs correctly.

The following table shows the Linux OS native compiled multipath parameter settings for ONTAP LUNs.

Show parameter settings

Parameter	Setting
detect_prio	yes
dev_loss_tmo	"infinity"
failback	immediate
fast_io_fail_tmo	5
features	"2 pg_init_retries 50"
flush_on_last_del	"yes"
hardware_handler	"0"
no_path_retry	queue
path_checker	"tur"
path_grouping_policy	"group_by_prio"
path_selector	"service-time 0"
polling_interval	5
prio	"ontap"
product	LUN
retain_attached_hw_handler	yes
rr_weight	"uniform"
user_friendly_names	no
vendor	NETAPP

4. Verify the parameter settings and path status for your ONTAP LUNs:

```
multipath -ll
```

The default multipath parameters support ASA, AFF, and FAS configurations. In these configurations, a single ONTAP LUN shouldn't require more than four paths. If there are more than four paths, it might cause issues with the paths during a storage failure.

The following example outputs show the correct parameter settings and path status for ONTAP LUNs in an ASA, AFF, or FAS configuration.

ASA configuration

An ASA configuration optimizes all paths to a given LUN, keeping them active. This improves performance by serving I/O operations through all paths at the same time.

Show example

```
multipath -ll
3600a098038303634722b4d59646c4436 dm-28 NETAPP,LUN C-Mode
size=10G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
|-+- policy='service-time 0' prio=50 status=active
  |- 11:0:7:6   sdbz 68:208  active ready running
  |- 11:0:11:6  sddn 71:80   active ready running
  |- 11:0:15:6  sdfb 129:208 active ready running
  |- 12:0:1:6   sdgp 132:80  active ready running
```

AFF or FAS configuration

An AFF or FAS configuration should have two groups of paths with higher and lower priorities. Higher priority Active/Optimized paths are served by the controller where the aggregate is located. Lower priority paths are active but non-optimized because they are served by a different controller. Non-optimized paths are only used when optimized paths aren't available.

The following example displays the output for an ONTAP LUN with two Active/Optimized paths and two Active/Non-Optimized paths:

Show example

```
multipath -ll
3600a0980383036347ffb4d59646c4436 dm-28 NETAPP,LUN C-Mode
size=10G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
|-+- policy='service-time 0' prio=50 status=active
| |- 16:0:6:35 sdwb  69:624  active ready running
| |- 16:0:5:35 sdun  66:752  active ready running
`-+- policy='service-time 0' prio=10 status=enabled
  |- 15:0:0:35 sdaj  66:48   active ready running
  |- 15:0:1:35 sdbx  68:176  active ready running
```

Step 4: Optionally, exclude a device from multipathing

If required, you can exclude a device from multipathing by adding the WWID for the unwanted device to the "blacklist" stanza for the `multipath.conf` file.

Steps

1. Determine the WWID:

   ```
   /lib/udev/scsi_id -gud /dev/sda
   ```

   "sda" is the local SCSI disk that you want to add to the blacklist.

   An example WWID is `360030057024d0730239134810c0cb833`.

2. Add the WWID to the "blacklist" stanza:

   ```
   blacklist {
           wwid   360030057024d0730239134810c0cb833
           devnode "^(ram|raw|loop|fd|md|dm-|sr|scd|st)[0-9]*"
           devnode "^hd[a-z]"
           devnode "^cciss.*"
   }
   ```

Step 5: Customize multipath parameters for ONTAP LUNs

If your host is connected to LUNs from other vendors and any of the multipath parameter settings are overridden, you need to correct them by adding stanzas later in the `multipath.conf` file that apply specifically to ONTAP LUNs. If you don't do this, the ONTAP LUNs might not work as expected.

Check your `/etc/multipath.conf` file, especially in the defaults section, for settings that might be overriding the default settings for multipath parameters.

> ⚠️ You shouldn't override the recommended parameter settings for ONTAP LUNs. These settings are required for optimal performance of your host configuration. Contact NetApp support, your OS vendor, or both for more information.

The following example shows how to correct an overridden default. In this example, the `multipath.conf` file defines values for `path_checker` and `no_path_retry` that aren't compatible with ONTAP LUNs, and you can't remove these parameters because ONTAP storage arrays are still attached to the host. Instead, you correct the values for `path_checker` and `no_path_retry` by adding a device stanza to the `multipath.conf` file that applies specifically to the ONTAP LUNs.

Show example

```
defaults {
    path_checker        readsector0
    no_path_retry       fail
}

devices {
    device {
        vendor          "NETAPP"
        product         "LUN"
        no_path_retry   queue
        path_checker    tur
    }
}
```

Step 6: Review the known issues

There are no known issues.

What's next?

- Learn about using the Linux Host Utilities tool.
- Learn about ASM mirroring.

  Automatic Storage Management (ASM) mirroring might require changes to the Linux multipath settings to allow ASM to recognize a problem and switch over to an alternate failure group. Most ASM configurations on ONTAP use external redundancy, which means that data protection is provided by the external array and ASM doesn't mirror data. Some sites use ASM with normal redundancy to provide two-way mirroring, normally across different sites. See Oracle databases on ONTAP for further information.

Configure Oracle Linux 8.8 for FCP and iSCSI with ONTAP storage

The Linux Host Utilities software provides management and diagnostic tools for Linux hosts that are connected to ONTAP storage. When you install the Linux Host Utilities on an Oracle Linux 8.8 host, you can use the Host Utilities to help you manage FCP and iSCSI protocol operations with ONTAP LUNs.

ⓘ You don't need to manually configure Kernel-based Virtual Machine (KVM) settings because ONTAP LUNs are automatically mapped to the hypervisor.

Step 1: Optionally, enable SAN booting

You can configure your host to use SAN booting to simplify deployment and improve scalability.

Before you begin

Use the Interoperability Matrix Tool to verify that your Linux OS, host bus adapter (HBA), HBA firmware, HBA

boot BIOS, and ONTAP version support SAN booting.

Steps

1. [Create a SAN boot LUN and map it to the host](#).

2. Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is mapped.

   For information on how to enable the HBA BIOS, see your vendor-specific documentation.

3. Verify that the configuration was successful by rebooting the host and verifying that the OS is up and running.

Step 2: Install the Linux Host Utilities

NetApp strongly recommends installing the Linux Host Utilities to support ONTAP LUN management and assist technical support with gathering configuration data.

[Install Linux Host Utilities 8.0](#).

> ⓘ Installing the Linux Host Utilities doesn't change any host timeout settings on your Linux host.

Step 3: Confirm the multipath configuration for your host

You can use multipathing with Oracle Linux 8.8 to manage ONTAP LUNs.

> ⓘ You can use the [recommended settings for Red Hat Enterprise Linux (RHEL) 8.8](#) to configure Red Hat Compatible Kernel for Oracle Linux 8.8.

To ensure that multipathing is configured correctly for your host, verify that the `/etc/multipath.conf` file is defined and that you have the NetApp recommended settings configured for your ONTAP LUNs.

Steps

1. Verify that the `/etc/multipath.conf` file exits. If the file doesn't exist, create an empty, zero-byte file:

   ```
   touch /etc/multipath.conf
   ```

2. The first time the `multipath.conf` file is created, you might need to enable and start the multipath services to load the recommended settings:

   ```
   chkconfig multipathd on
   ```

   ```
   /etc/init.d/multipathd start
   ```

3. Each time you boot the host, the empty `/etc/multipath.conf` zero-byte file automatically loads the NetApp recommended host multipath parameters as the default settings. You shouldn't need to make changes to the `/etc/multipath.conf` file for your host because the operating system is compiled with the multipath parameters that recognize and manage ONTAP LUNs correctly.

The following table shows the Linux OS native compiled multipath parameter settings for ONTAP LUNs.

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path_checker	"tur"
path_grouping_policy	"group_by_prio"
path_selector	"service-time 0"
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prio	"ontap"
product	LUN
retain_attached_hw_handler	yes
rr_weight	"uniform"
user_friendly_names	no
vendor	NETAPP

4. Verify the parameter settings and path status for your ONTAP LUNs:

```
multipath -ll
```

The default multipath parameters support ASA, AFF, and FAS configurations. In these configurations, a single ONTAP LUN shouldn't require more than four paths. If there are more than four paths, it might cause issues with the paths during a storage failure.

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An AFF or FAS configuration should have two groups of paths with higher and lower priorities. Higher priority Active/Optimized paths are served by the controller where the aggregate is located. Lower priority paths are active but non-optimized because they are served by a different controller. Non-optimized paths are only used when optimized paths aren't available.

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Show example

```
multipath -ll
3600a0980383036347ffb4d59646c4436 dm-28 NETAPP,LUN C-Mode
size=10G features='3 queue_if_no_path pg_init_retries 50'
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|-+- policy='service-time 0' prio=50 status=active
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`-+- policy='service-time 0' prio=10 status=enabled
  |- 15:0:0:35 sdaj  66:48   active ready running
  |- 15:0:1:35 sdbx  68:176  active ready running
```

Step 4: Optionally, exclude a device from multipathing

If required, you can exclude a device from multipathing by adding the WWID for the unwanted device to the "blacklist" stanza for the `multipath.conf` file.

Steps

1. Determine the WWID:

   ```
   /lib/udev/scsi_id -gud /dev/sda
   ```

   "sda" is the local SCSI disk that you want to add to the blacklist.

   An example WWID is `360030057024d0730239134810c0cb833`.

2. Add the WWID to the "blacklist" stanza:

   ```
   blacklist {
           wwid    360030057024d0730239134810c0cb833
           devnode "^(ram|raw|loop|fd|md|dm-|sr|scd|st)[0-9]*"
           devnode "^hd[a-z]"
           devnode "^cciss.*"
   }
   ```

Step 5: Customize multipath parameters for ONTAP LUNs

If your host is connected to LUNs from other vendors and any of the multipath parameter settings are overridden, you need to correct them by adding stanzas later in the `multipath.conf` file that apply specifically to ONTAP LUNs. If you don't do this, the ONTAP LUNs might not work as expected.

Check your `/etc/multipath.conf` file, especially in the defaults section, for settings that might be overriding the default settings for multipath parameters.

> ⚠️ You shouldn't override the recommended parameter settings for ONTAP LUNs. These settings are required for optimal performance of your host configuration. Contact NetApp support, your OS vendor, or both for more information.

The following example shows how to correct an overridden default. In this example, the `multipath.conf` file defines values for `path_checker` and `no_path_retry` that aren't compatible with ONTAP LUNs, and you can't remove these parameters because ONTAP storage arrays are still attached to the host. Instead, you correct the values for `path_checker` and `no_path_retry` by adding a device stanza to the `multipath.conf` file that applies specifically to the ONTAP LUNs.

Show example

```
defaults {
    path_checker        readsector0
    no_path_retry       fail
}

devices {
    device {
        vendor          "NETAPP"
        product         "LUN"
        no_path_retry   queue
        path_checker    tur
    }
}
```

Step 6: Review the known issues

There are no known issues.

What's next?

- Learn about using the Linux Host Utilities tool.
- Learn about ASM mirroring.

  Automatic Storage Management (ASM) mirroring might require changes to the Linux multipath settings to allow ASM to recognize a problem and switch over to an alternate failure group. Most ASM configurations on ONTAP use external redundancy, which means that data protection is provided by the external array and ASM doesn't mirror data. Some sites use ASM with normal redundancy to provide two-way mirroring, normally across different sites. See Oracle databases on ONTAP for further information.

Configure Oracle Linux 8.7 for FCP and iSCSI with ONTAP storage

The Linux Host Utilities software provides management and diagnostic tools for Linux hosts that are connected to ONTAP storage. When you install the Linux Host Utilities on an Oracle Linux 8.7 host, you can use the Host Utilities to help you manage FCP and iSCSI protocol operations with ONTAP LUNs.

> ⓘ You don't need to manually configure Kernel-based Virtual Machine (KVM) settings because ONTAP LUNs are automatically mapped to the hypervisor.

Step 1: Optionally, enable SAN booting

You can configure your host to use SAN booting to simplify deployment and improve scalability.

Before you begin

Use the Interoperability Matrix Tool to verify that your Linux OS, host bus adapter (HBA), HBA firmware, HBA

boot BIOS, and ONTAP version support SAN booting.

Steps

1. [Create a SAN boot LUN and map it to the host](#).

2. Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is mapped.

   For information on how to enable the HBA BIOS, see your vendor-specific documentation.

3. Verify that the configuration was successful by rebooting the host and verifying that the OS is up and running.

Step 2: Install the Linux Host Utilities

NetApp strongly recommends installing the Linux Host Utilities to support ONTAP LUN management and assist technical support with gathering configuration data.

[Install Linux Host Utilities 8.0](#).

> ⓘ   Installing the Linux Host Utilities doesn't change any host timeout settings on your Linux host.

Step 3: Confirm the multipath configuration for your host

You can use multipathing with Oracle Linux 8.7 to manage ONTAP LUNs.

> ⓘ   You can use the [recommended settings for Red Hat Enterprise Linux (RHEL) 8.7](#) to configure Red Hat Compatible Kernel for Oracle Linux 8.7.

To ensure that multipathing is configured correctly for your host, verify that the `/etc/multipath.conf` file is defined and that you have the NetApp recommended settings configured for your ONTAP LUNs.

Steps

1. Verify that the `/etc/multipath.conf` file exits. If the file doesn't exist, create an empty, zero-byte file:

   ```
   touch /etc/multipath.conf
   ```

2. The first time the `multipath.conf` file is created, you might need to enable and start the multipath services to load the recommended settings:

   ```
   chkconfig multipathd on
   ```

   ```
   /etc/init.d/multipathd start
   ```

3. Each time you boot the host, the empty `/etc/multipath.conf` zero-byte file automatically loads the NetApp recommended host multipath parameters as the default settings. You shouldn't need to make changes to the `/etc/multipath.conf` file for your host because the operating system is compiled with the multipath parameters that recognize and manage ONTAP LUNs correctly.

The following table shows the Linux OS native compiled multipath parameter settings for ONTAP LUNs.

Show parameter settings

Parameter	Setting
detect_prio	yes
dev_loss_tmo	"infinity"
failback	immediate
fast_io_fail_tmo	5
features	"2 pg_init_retries 50"
flush_on_last_del	"yes"
hardware_handler	"0"
no_path_retry	queue
path_checker	"tur"
path_grouping_policy	"group_by_prio"
path_selector	"service-time 0"
polling_interval	5
prio	"ontap"
product	LUN
retain_attached_hw_handler	yes
rr_weight	"uniform"
user_friendly_names	no
vendor	NETAPP

4. Verify the parameter settings and path status for your ONTAP LUNs:

```
multipath -ll
```

The default multipath parameters support ASA, AFF, and FAS configurations. In these configurations, a single ONTAP LUN shouldn't require more than four paths. If there are more than four paths, it might cause issues with the paths during a storage failure.

The following example outputs show the correct parameter settings and path status for ONTAP LUNs in an ASA, AFF, or FAS configuration.

ASA configuration

An ASA configuration optimizes all paths to a given LUN, keeping them active. This improves performance by serving I/O operations through all paths at the same time.

Show example

```
multipath -ll
3600a098038303634722b4d59646c4436 dm-28 NETAPP,LUN C-Mode
size=10G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
|-+- policy='service-time 0' prio=50 status=active
  |- 11:0:7:6   sdbz 68:208  active ready running
  |- 11:0:11:6  sddn 71:80   active ready running
  |- 11:0:15:6  sdfb 129:208 active ready running
  |- 12:0:1:6   sdgp 132:80  active ready running
```

AFF or FAS configuration

An AFF or FAS configuration should have two groups of paths with higher and lower priorities. Higher priority Active/Optimized paths are served by the controller where the aggregate is located. Lower priority paths are active but non-optimized because they are served by a different controller. Non-optimized paths are only used when optimized paths aren't available.

The following example displays the output for an ONTAP LUN with two Active/Optimized paths and two Active/Non-Optimized paths:

Show example

```
multipath -ll
3600a0980383036347ffb4d59646c4436 dm-28 NETAPP,LUN C-Mode
size=10G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
|-+- policy='service-time 0' prio=50 status=active
| |- 16:0:6:35 sdwb  69:624  active ready running
| |- 16:0:5:35 sdun  66:752  active ready running
`-+- policy='service-time 0' prio=10 status=enabled
  |- 15:0:0:35 sdaj  66:48   active ready running
  |- 15:0:1:35 sdbx  68:176  active ready running
```

Step 4: Optionally, exclude a device from multipathing

If required, you can exclude a device from multipathing by adding the WWID for the unwanted device to the "blacklist" stanza for the `multipath.conf` file.

Steps

1. Determine the WWID:

   ```
   /lib/udev/scsi_id -gud /dev/sda
   ```

   "sda" is the local SCSI disk that you want to add to the blacklist.

   An example WWID is `360030057024d0730239134810c0cb833`.

2. Add the WWID to the "blacklist" stanza:

   ```
   blacklist {
           wwid   360030057024d0730239134810c0cb833
           devnode "^(ram|raw|loop|fd|md|dm-|sr|scd|st)[0-9]*"
           devnode "^hd[a-z]"
           devnode "^cciss.*"
   }
   ```

Step 5: Customize multipath parameters for ONTAP LUNs

If your host is connected to LUNs from other vendors and any of the multipath parameter settings are overridden, you need to correct them by adding stanzas later in the `multipath.conf` file that apply specifically to ONTAP LUNs. If you don't do this, the ONTAP LUNs might not work as expected.

Check your `/etc/multipath.conf` file, especially in the defaults section, for settings that might be overriding the default settings for multipath parameters.

> ⚠️ You shouldn't override the recommended parameter settings for ONTAP LUNs. These settings are required for optimal performance of your host configuration. Contact NetApp support, your OS vendor, or both for more information.

The following example shows how to correct an overridden default. In this example, the `multipath.conf` file defines values for `path_checker` and `no_path_retry` that aren't compatible with ONTAP LUNs, and you can't remove these parameters because ONTAP storage arrays are still attached to the host. Instead, you correct the values for `path_checker` and `no_path_retry` by adding a device stanza to the `multipath.conf` file that applies specifically to the ONTAP LUNs.

Show example

```
defaults {
    path_checker        readsector0
    no_path_retry       fail
}

devices {
    device {
        vendor          "NETAPP"
        product         "LUN"
        no_path_retry   queue
        path_checker    tur
    }
}
```

Step 6: Review the known issues

There are no known issues.

What's next?

- Learn about using the Linux Host Utilities tool.
- Learn about ASM mirroring.

  Automatic Storage Management (ASM) mirroring might require changes to the Linux multipath settings to allow ASM to recognize a problem and switch over to an alternate failure group. Most ASM configurations on ONTAP use external redundancy, which means that data protection is provided by the external array and ASM doesn't mirror data. Some sites use ASM with normal redundancy to provide two-way mirroring, normally across different sites. See Oracle databases on ONTAP for further information.

Configure Oracle Linux 8.6 for FCP and iSCSI with ONTAP storage

The Linux Host Utilities software provides management and diagnostic tools for Linux hosts that are connected to ONTAP storage. When you install the Linux Host Utilities on an Oracle Linux 8.6 host, you can use the Host Utilities to help you manage FCP and iSCSI protocol operations with ONTAP LUNs.

> ⓘ You don't need to manually configure Kernel-based Virtual Machine (KVM) settings because ONTAP LUNs are automatically mapped to the hypervisor.

Step 1: Optionally, enable SAN booting

You can configure your host to use SAN booting to simplify deployment and improve scalability.

Before you begin

Use the Interoperability Matrix Tool to verify that your Linux OS, host bus adapter (HBA), HBA firmware, HBA

boot BIOS, and ONTAP version support SAN booting.

Steps

1. [Create a SAN boot LUN and map it to the host](#).

2. Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is mapped.

   For information on how to enable the HBA BIOS, see your vendor-specific documentation.

3. Verify that the configuration was successful by rebooting the host and verifying that the OS is up and running.

Step 2: Install the Linux Host Utilities

NetApp strongly recommends installing the Linux Host Utilities to support ONTAP LUN management and assist technical support with gathering configuration data.

[Install Linux Host Utilities 8.0](#).

> ⓘ   Installing the Linux Host Utilities doesn't change any host timeout settings on your Linux host.

Step 3: Confirm the multipath configuration for your host

You can use multipathing with Oracle Linux 8.6 to manage ONTAP LUNs.

> ⓘ   You can use the [recommended settings for Red Hat Enterprise Linux (RHEL) 8.6](#) to configure Red Hat Compatible Kernel for Oracle Linux 8.6.

To ensure that multipathing is configured correctly for your host, verify that the `/etc/multipath.conf` file is defined and that you have the NetApp recommended settings configured for your ONTAP LUNs.

Steps

1. Verify that the `/etc/multipath.conf` file exits. If the file doesn't exist, create an empty, zero-byte file:

   ```
   touch /etc/multipath.conf
   ```

2. The first time the `multipath.conf` file is created, you might need to enable and start the multipath services to load the recommended settings:

   ```
   chkconfig multipathd on
   ```

   ```
   /etc/init.d/multipathd start
   ```

3. Each time you boot the host, the empty `/etc/multipath.conf` zero-byte file automatically loads the NetApp recommended host multipath parameters as the default settings. You shouldn't need to make changes to the `/etc/multipath.conf` file for your host because the operating system is compiled with the multipath parameters that recognize and manage ONTAP LUNs correctly.

The following table shows the Linux OS native compiled multipath parameter settings for ONTAP LUNs.

Show parameter settings

Parameter	Setting
detect_prio	yes
dev_loss_tmo	"infinity"
failback	immediate
fast_io_fail_tmo	5
features	"2 pg_init_retries 50"
flush_on_last_del	"yes"
hardware_handler	"0"
no_path_retry	queue
path_checker	"tur"
path_grouping_policy	"group_by_prio"
path_selector	"service-time 0"
polling_interval	5
prio	"ontap"
product	LUN
retain_attached_hw_handler	yes
rr_weight	"uniform"
user_friendly_names	no
vendor	NETAPP

4. Verify the parameter settings and path status for your ONTAP LUNs:

```
multipath -ll
```

The default multipath parameters support ASA, AFF, and FAS configurations. In these configurations, a single ONTAP LUN shouldn't require more than four paths. If there are more than four paths, it might cause issues with the paths during a storage failure.

The following example outputs show the correct parameter settings and path status for ONTAP LUNs in an ASA, AFF, or FAS configuration.

ASA configuration

An ASA configuration optimizes all paths to a given LUN, keeping them active. This improves performance by serving I/O operations through all paths at the same time.

Show example

```
multipath -ll
3600a098038303634722b4d59646c4436 dm-28 NETAPP,LUN C-Mode
size=10G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
|-+- policy='service-time 0' prio=50 status=active
  |- 11:0:7:6   sdbz 68:208  active ready running
  |- 11:0:11:6  sddn 71:80   active ready running
  |- 11:0:15:6  sdfb 129:208 active ready running
  |- 12:0:1:6   sdgp 132:80  active ready running
```

AFF or FAS configuration

An AFF or FAS configuration should have two groups of paths with higher and lower priorities. Higher priority Active/Optimized paths are served by the controller where the aggregate is located. Lower priority paths are active but non-optimized because they are served by a different controller. Non-optimized paths are only used when optimized paths aren't available.

The following example displays the output for an ONTAP LUN with two Active/Optimized paths and two Active/Non-Optimized paths:

Show example

```
multipath -ll
3600a0980383036347ffb4d59646c4436 dm-28 NETAPP,LUN C-Mode
size=10G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
|-+- policy='service-time 0' prio=50 status=active
| |- 16:0:6:35 sdwb  69:624  active ready running
| |- 16:0:5:35 sdun  66:752  active ready running
`-+- policy='service-time 0' prio=10 status=enabled
  |- 15:0:0:35 sdaj  66:48   active ready running
  |- 15:0:1:35 sdbx  68:176  active ready running
```

Step 4: Optionally, exclude a device from multipathing

If required, you can exclude a device from multipathing by adding the WWID for the unwanted device to the "blacklist" stanza for the `multipath.conf` file.

Steps

1. Determine the WWID:

```
/lib/udev/scsi_id -gud /dev/sda
```

"sda" is the local SCSI disk that you want to add to the blacklist.

An example WWID is `360030057024d0730239134810c0cb833`.

2. Add the WWID to the "blacklist" stanza:

```
blacklist {
        wwid    360030057024d0730239134810c0cb833
        devnode "^(ram|raw|loop|fd|md|dm-|sr|scd|st)[0-9]*"
        devnode "^hd[a-z]"
        devnode "^cciss.*"
}
```

Step 5: Customize multipath parameters for ONTAP LUNs

If your host is connected to LUNs from other vendors and any of the multipath parameter settings are overridden, you need to correct them by adding stanzas later in the `multipath.conf` file that apply specifically to ONTAP LUNs. If you don't do this, the ONTAP LUNs might not work as expected.

Check your `/etc/multipath.conf` file, especially in the defaults section, for settings that might be overriding the default settings for multipath parameters.

> ⚠️ You shouldn't override the recommended parameter settings for ONTAP LUNs. These settings are required for optimal performance of your host configuration. Contact NetApp support, your OS vendor, or both for more information.

The following example shows how to correct an overridden default. In this example, the `multipath.conf` file defines values for `path_checker` and `no_path_retry` that aren't compatible with ONTAP LUNs, and you can't remove these parameters because ONTAP storage arrays are still attached to the host. Instead, you correct the values for `path_checker` and `no_path_retry` by adding a device stanza to the `multipath.conf` file that applies specifically to the ONTAP LUNs.

Show example

```
defaults {
    path_checker        readsector0
    no_path_retry       fail
}

devices {
    device {
        vendor          "NETAPP"
        product         "LUN"
        no_path_retry   queue
        path_checker    tur
    }
}
```

Step 6: Review the known issues

There are no known issues.

> ℹ️   For Oracle Linux RHCK known issues, see the known issues section in the corresponding Red
>   Hat Enterprise Linux release documentation.

What's next?

- Learn about using the Linux Host Utilities tool.

- Learn about ASM mirroring.

  Automatic Storage Management (ASM) mirroring might require changes to the Linux multipath settings to
  allow ASM to recognize a problem and switch over to an alternate failure group. Most ASM configurations
  on ONTAP use external redundancy, which means that data protection is provided by the external array
  and ASM doesn't mirror data. Some sites use ASM with normal redundancy to provide two-way mirroring,
  normally across different sites. See Oracle databases on ONTAP for further information.

Configure Oracle Linux 8.5 for FCP and iSCSI with ONTAP storage

The Linux Host Utilities software provides management and diagnostic tools for Linux
hosts that are connected to ONTAP storage. When you install the Linux Host Utilities on
an Oracle Linux 8.5 host, you can use the Host Utilities to help you manage FCP and
iSCSI protocol operations with ONTAP LUNs.

> ℹ️   You don't need to manually configure Kernel-based Virtual Machine (KVM) settings because
>   ONTAP LUNs are automatically mapped to the hypervisor.

Step 1: Optionally, enable SAN booting

You can configure your host to use SAN booting to simplify deployment and improve scalability.

Before you begin

Use the Interoperability Matrix Tool to verify that your Linux OS, host bus adapter (HBA), HBA firmware, HBA boot BIOS, and ONTAP version support SAN booting.

Steps

1. Create a SAN boot LUN and map it to the host.

2. Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is mapped.

   For information on how to enable the HBA BIOS, see your vendor-specific documentation.

3. Verify that the configuration was successful by rebooting the host and verifying that the OS is up and running.

Step 2: Install the Linux Host Utilities

NetApp strongly recommends installing the Linux Host Utilities to support ONTAP LUN management and assist technical support with gathering configuration data.

Install Linux Host Utilities 8.0.

> ⓘ Installing the Linux Host Utilities doesn't change any host timeout settings on your Linux host.

Step 3: Confirm the multipath configuration for your host

You can use multipathing with Oracle Linux 8.5 to manage ONTAP LUNs.

> ⓘ You can use the recommended settings for Red Hat Enterprise Linux (RHEL) 8.5 to configure Red Hat Compatible Kernel for Oracle Linux 8.5.

To ensure that multipathing is configured correctly for your host, verify that the `/etc/multipath.conf` file is defined and that you have the NetApp recommended settings configured for your ONTAP LUNs.

Steps

1. Verify that the `/etc/multipath.conf` file exits. If the file doesn't exist, create an empty, zero-byte file:

   ```
   touch /etc/multipath.conf
   ```

2. The first time the `multipath.conf` file is created, you might need to enable and start the multipath services to load the recommended settings:

   ```
   chkconfig multipathd on
   ```

   ```
   /etc/init.d/multipathd start
   ```

3. Each time you boot the host, the empty `/etc/multipath.conf` zero-byte file automatically loads the NetApp recommended host multipath parameters as the default settings. You shouldn't need to make changes to the `/etc/multipath.conf` file for your host because the operating system is compiled with the multipath parameters that recognize and manage ONTAP LUNs correctly.

The following table shows the Linux OS native compiled multipath parameter settings for ONTAP LUNs.

Show parameter settings

Parameter	Setting
detect_prio	yes
dev_loss_tmo	"infinity"
failback	immediate
fast_io_fail_tmo	5
features	"2 pg_init_retries 50"
flush_on_last_del	"yes"
hardware_handler	"0"
no_path_retry	queue
path_checker	"tur"
path_grouping_policy	"group_by_prio"
path_selector	"service-time 0"
polling_interval	5
prio	"ontap"
product	LUN
retain_attached_hw_handler	yes
rr_weight	"uniform"
user_friendly_names	no
vendor	NETAPP

4. Verify the parameter settings and path status for your ONTAP LUNs:

```
multipath -ll
```

The default multipath parameters support ASA, AFF, and FAS configurations. In these configurations, a single ONTAP LUN shouldn't require more than four paths. If there are more than four paths, it might cause issues with the paths during a storage failure.

The following example outputs show the correct parameter settings and path status for ONTAP LUNs in an ASA, AFF, or FAS configuration.

ASA configuration

An ASA configuration optimizes all paths to a given LUN, keeping them active. This improves performance by serving I/O operations through all paths at the same time.

Show example

```
multipath -ll
3600a098038303634722b4d59646c4436 dm-28 NETAPP,LUN C-Mode
size=10G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
|-+- policy='service-time 0' prio=50 status=active
  |- 11:0:7:6   sdbz 68:208  active ready running
  |- 11:0:11:6  sddn 71:80   active ready running
  |- 11:0:15:6  sdfb 129:208 active ready running
  |- 12:0:1:6   sdgp 132:80  active ready running
```

AFF or FAS configuration

An AFF or FAS configuration should have two groups of paths with higher and lower priorities. Higher priority Active/Optimized paths are served by the controller where the aggregate is located. Lower priority paths are active but non-optimized because they are served by a different controller. Non-optimized paths are only used when optimized paths aren't available.

The following example displays the output for an ONTAP LUN with two Active/Optimized paths and two Active/Non-Optimized paths:

Show example

```
multipath -ll
3600a0980383036347ffb4d59646c4436 dm-28 NETAPP,LUN C-Mode
size=10G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
|-+- policy='service-time 0' prio=50 status=active
| |- 16:0:6:35 sdwb  69:624  active ready running
| |- 16:0:5:35 sdun  66:752  active ready running
`-+- policy='service-time 0' prio=10 status=enabled
  |- 15:0:0:35 sdaj  66:48   active ready running
  |- 15:0:1:35 sdbx  68:176  active ready running
```

Step 4: Optionally, exclude a device from multipathing

If required, you can exclude a device from multipathing by adding the WWID for the unwanted device to the "blacklist" stanza for the `multipath.conf` file.

Steps

1. Determine the WWID:

   ```
   /lib/udev/scsi_id -gud /dev/sda
   ```

   "sda" is the local SCSI disk that you want to add to the blacklist.

   An example WWID is `360030057024d0730239134810c0cb833`.

2. Add the WWID to the "blacklist" stanza:

   ```
   blacklist {
           wwid    360030057024d0730239134810c0cb833
           devnode "^(ram|raw|loop|fd|md|dm-|sr|scd|st)[0-9]*"
           devnode "^hd[a-z]"
           devnode "^cciss.*"
   }
   ```

Step 5: Customize multipath parameters for ONTAP LUNs

If your host is connected to LUNs from other vendors and any of the multipath parameter settings are overridden, you need to correct them by adding stanzas later in the `multipath.conf` file that apply specifically to ONTAP LUNs. If you don't do this, the ONTAP LUNs might not work as expected.

Check your `/etc/multipath.conf` file, especially in the defaults section, for settings that might be overriding the default settings for multipath parameters.

> ⚠️ You shouldn't override the recommended parameter settings for ONTAP LUNs. These settings are required for optimal performance of your host configuration. Contact NetApp support, your OS vendor, or both for more information.

The following example shows how to correct an overridden default. In this example, the `multipath.conf` file defines values for `path_checker` and `no_path_retry` that aren't compatible with ONTAP LUNs, and you can't remove these parameters because ONTAP storage arrays are still attached to the host. Instead, you correct the values for `path_checker` and `no_path_retry` by adding a device stanza to the `multipath.conf` file that applies specifically to the ONTAP LUNs.

Show example

```
defaults {
    path_checker        readsector0
    no_path_retry       fail
}

devices {
    device {
        vendor          "NETAPP"
        product         "LUN"
        no_path_retry   queue
        path_checker    tur
    }
}
```

Step 6: Review the known issues

There are no known issues.

> (i) For Oracle Linux RHCK known issues, see the known issues section in the corresponding Red
> Hat Enterprise Linux release documentation.

What's next?

- Learn about using the Linux Host Utilities tool.

- Learn about ASM mirroring.

  Automatic Storage Management (ASM) mirroring might require changes to the Linux multipath settings to
  allow ASM to recognize a problem and switch over to an alternate failure group. Most ASM configurations
  on ONTAP use external redundancy, which means that data protection is provided by the external array
  and ASM doesn't mirror data. Some sites use ASM with normal redundancy to provide two-way mirroring,
  normally across different sites. See Oracle databases on ONTAP for further information.

Configure Oracle Linux 8.4 for FCP and iSCSI with ONTAP storage

The Linux Host Utilities software provides management and diagnostic tools for Linux
hosts that are connected to ONTAP storage. When you install the Linux Host Utilities on
an Oracle Linux 8.4 host, you can use the Host Utilities to help you manage FCP and
iSCSI protocol operations with ONTAP LUNs.

> (i) You don't need to manually configure Kernel-based Virtual Machine (KVM) settings because
> ONTAP LUNs are automatically mapped to the hypervisor.

Step 1: Optionally, enable SAN booting

You can configure your host to use SAN booting to simplify deployment and improve scalability.

Before you begin

Use the Interoperability Matrix Tool to verify that your Linux OS, host bus adapter (HBA), HBA firmware, HBA boot BIOS, and ONTAP version support SAN booting.

Steps

1. Create a SAN boot LUN and map it to the host.

2. Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is mapped.

   For information on how to enable the HBA BIOS, see your vendor-specific documentation.

3. Verify that the configuration was successful by rebooting the host and verifying that the OS is up and running.

Step 2: Install the Linux Host Utilities

NetApp strongly recommends installing the Linux Host Utilities to support ONTAP LUN management and assist technical support with gathering configuration data.

Install Linux Host Utilities 8.0.

> ⓘ Installing the Linux Host Utilities doesn't change any host timeout settings on your Linux host.

Step 3: Confirm the multipath configuration for your host

You can use multipathing with Oracle Linux 8.4 to manage ONTAP LUNs.

> ⓘ You can use the recommended settings for Red Hat Enterprise Linux (RHEL) 8.4 to configure Red Hat Compatible Kernel for Oracle Linux 8.4.

To ensure that multipathing is configured correctly for your host, verify that the `/etc/multipath.conf` file is defined and that you have the NetApp recommended settings configured for your ONTAP LUNs.

Steps

1. Verify that the `/etc/multipath.conf` file exits. If the file doesn't exist, create an empty, zero-byte file:

   ```
   touch /etc/multipath.conf
   ```

2. The first time the `multipath.conf` file is created, you might need to enable and start the multipath services to load the recommended settings:

   ```
   chkconfig multipathd on
   ```

   ```
   /etc/init.d/multipathd start
   ```

3. Each time you boot the host, the empty `/etc/multipath.conf` zero-byte file automatically loads the NetApp recommended host multipath parameters as the default settings. You shouldn't need to make changes to the `/etc/multipath.conf` file for your host because the operating system is compiled with the multipath parameters that recognize and manage ONTAP LUNs correctly.

The following table shows the Linux OS native compiled multipath parameter settings for ONTAP LUNs.

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flush_on_last_del	"yes"
hardware_handler	"0"
no_path_retry	queue
path_checker	"tur"
path_grouping_policy	"group_by_prio"
path_selector	"service-time 0"
polling_interval	5
prio	"ontap"
product	LUN
retain_attached_hw_handler	yes
rr_weight	"uniform"
user_friendly_names	no
vendor	NETAPP

4. Verify the parameter settings and path status for your ONTAP LUNs:

```
multipath -ll
```

The default multipath parameters support ASA, AFF, and FAS configurations. In these configurations, a single ONTAP LUN shouldn't require more than four paths. If there are more than four paths, it might cause issues with the paths during a storage failure.

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Show example

```
multipath -ll
3600a098038303634722b4d59646c4436 dm-28 NETAPP,LUN C-Mode
size=10G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
|-+- policy='service-time 0' prio=50 status=active
  |- 11:0:7:6    sdbz 68:208  active ready running
  |- 11:0:11:6   sddn 71:80   active ready running
  |- 11:0:15:6   sdfb 129:208 active ready running
  |- 12:0:1:6    sdgp 132:80  active ready running
```

AFF or FAS configuration

An AFF or FAS configuration should have two groups of paths with higher and lower priorities. Higher priority Active/Optimized paths are served by the controller where the aggregate is located. Lower priority paths are active but non-optimized because they are served by a different controller. Non-optimized paths are only used when optimized paths aren't available.

The following example displays the output for an ONTAP LUN with two Active/Optimized paths and two Active/Non-Optimized paths:

Show example

```
multipath -ll
3600a0980383036347ffb4d59646c4436 dm-28 NETAPP,LUN C-Mode
size=10G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
|-+- policy='service-time 0' prio=50 status=active
| |- 16:0:6:35 sdwb  69:624  active ready running
| |- 16:0:5:35 sdun  66:752  active ready running
`-+- policy='service-time 0' prio=10 status=enabled
  |- 15:0:0:35 sdaj  66:48   active ready running
  |- 15:0:1:35 sdbx  68:176  active ready running
```

Step 4: Optionally, exclude a device from multipathing

If required, you can exclude a device from multipathing by adding the WWID for the unwanted device to the "blacklist" stanza for the `multipath.conf` file.

Steps

1. Determine the WWID:

   ```
   /lib/udev/scsi_id -gud /dev/sda
   ```

   "sda" is the local SCSI disk that you want to add to the blacklist.

   An example WWID is `360030057024d0730239134810c0cb833`.

2. Add the WWID to the "blacklist" stanza:

   ```
   blacklist {
           wwid   360030057024d0730239134810c0cb833
           devnode "^(ram|raw|loop|fd|md|dm-|sr|scd|st)[0-9]*"
           devnode "^hd[a-z]"
           devnode "^cciss.*"
   }
   ```

Step 5: Customize multipath parameters for ONTAP LUNs

If your host is connected to LUNs from other vendors and any of the multipath parameter settings are overridden, you need to correct them by adding stanzas later in the `multipath.conf` file that apply specifically to ONTAP LUNs. If you don't do this, the ONTAP LUNs might not work as expected.

Check your `/etc/multipath.conf` file, especially in the defaults section, for settings that might be overriding the default settings for multipath parameters.

> ⚠ You shouldn't override the recommended parameter settings for ONTAP LUNs. These settings are required for optimal performance of your host configuration. Contact NetApp support, your OS vendor, or both for more information.

The following example shows how to correct an overridden default. In this example, the `multipath.conf` file defines values for `path_checker` and `no_path_retry` that aren't compatible with ONTAP LUNs, and you can't remove these parameters because ONTAP storage arrays are still attached to the host. Instead, you correct the values for `path_checker` and `no_path_retry` by adding a device stanza to the `multipath.conf` file that applies specifically to the ONTAP LUNs.

```
defaults {
    path_checker       readsector0
    no_path_retry      fail
}

devices {
    device {
        vendor          "NETAPP"
        product         "LUN"
        no_path_retry   queue
        path_checker    tur
    }
}
```

Step 6: Review the known issues

There are no known issues.

What's next?

- [Learn about using the Linux Host Utilities tool](#).
- Learn about ASM mirroring.

  Automatic Storage Management (ASM) mirroring might require changes to the Linux multipath settings to allow ASM to recognize a problem and switch over to an alternate failure group. Most ASM configurations on ONTAP use external redundancy, which means that data protection is provided by the external array and ASM doesn't mirror data. Some sites use ASM with normal redundancy to provide two-way mirroring, normally across different sites. See [Oracle databases on ONTAP](#) for further information.

Configure Oracle Linux 8.3 for FCP and iSCSI with ONTAP storage

The Linux Host Utilities software provides management and diagnostic tools for Linux hosts that are connected to ONTAP storage. When you install the Linux Host Utilities on an Oracle Linux 8.3 host, you can use the Host Utilities to help you manage FCP and iSCSI protocol operations with ONTAP LUNs.

ⓘ | You don't need to manually configure Kernel-based Virtual Machine (KVM) settings because ONTAP LUNs are automatically mapped to the hypervisor.

Step 1: Optionally, enable SAN booting

You can configure your host to use SAN booting to simplify deployment and improve scalability.

Before you begin

Use the [Interoperability Matrix Tool](#) to verify that your Linux OS, host bus adapter (HBA), HBA firmware, HBA

boot BIOS, and ONTAP version support SAN booting.

Steps

1. [Create a SAN boot LUN and map it to the host](#).

2. Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is mapped.

   For information on how to enable the HBA BIOS, see your vendor-specific documentation.

3. Verify that the configuration was successful by rebooting the host and verifying that the OS is up and running.

Step 2: Install the Linux Host Utilities

NetApp strongly recommends installing the Linux Host Utilities to support ONTAP LUN management and assist technical support with gathering configuration data.

[Install Linux Host Utilities 8.0](#).

> ⓘ Installing the Linux Host Utilities doesn't change any host timeout settings on your Linux host.

Step 3: Confirm the multipath configuration for your host

You can use multipathing with Oracle Linux 8.3 to manage ONTAP LUNs.

> ⓘ You can use the [recommended settings for Red Hat Enterprise Linux (RHEL) 8.3](#) to configure Red Hat Compatible Kernel for Oracle Linux 8.3.

To ensure that multipathing is configured correctly for your host, verify that the `/etc/multipath.conf` file is defined and that you have the NetApp recommended settings configured for your ONTAP LUNs.

Steps

1. Verify that the `/etc/multipath.conf` file exits. If the file doesn't exist, create an empty, zero-byte file:

   ```
   touch /etc/multipath.conf
   ```

2. The first time the `multipath.conf` file is created, you might need to enable and start the multipath services to load the recommended settings:

   ```
   chkconfig multipathd on
   ```

   ```
   /etc/init.d/multipathd start
   ```

3. Each time you boot the host, the empty `/etc/multipath.conf` zero-byte file automatically loads the NetApp recommended host multipath parameters as the default settings. You shouldn't need to make changes to the `/etc/multipath.conf` file for your host because the operating system is compiled with the multipath parameters that recognize and manage ONTAP LUNs correctly.

The following table shows the Linux OS native compiled multipath parameter settings for ONTAP LUNs.

Show parameter settings

Parameter	Setting
detect_prio	yes
dev_loss_tmo	"infinity"
failback	immediate
fast_io_fail_tmo	5
features	"2 pg_init_retries 50"
flush_on_last_del	"yes"
hardware_handler	"0"
no_path_retry	queue
path_checker	"tur"
path_grouping_policy	"group_by_prio"
path_selector	"service-time 0"
polling_interval	5
prio	"ontap"
product	LUN
retain_attached_hw_handler	yes
rr_weight	"uniform"
user_friendly_names	no
vendor	NETAPP

4. Verify the parameter settings and path status for your ONTAP LUNs:

```
multipath -ll
```

The default multipath parameters support ASA, AFF, and FAS configurations. In these configurations, a single ONTAP LUN shouldn't require more than four paths. If there are more than four paths, it might cause issues with the paths during a storage failure.

The following example outputs show the correct parameter settings and path status for ONTAP LUNs in an ASA, AFF, or FAS configuration.

ASA configuration

An ASA configuration optimizes all paths to a given LUN, keeping them active. This improves performance by serving I/O operations through all paths at the same time.

Show example

```
multipath -ll
3600a098038303634722b4d59646c4436 dm-28 NETAPP,LUN C-Mode
size=10G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
|-+- policy='service-time 0' prio=50 status=active
  |- 11:0:7:6   sdbz 68:208  active ready running
  |- 11:0:11:6  sddn 71:80   active ready running
  |- 11:0:15:6  sdfb 129:208 active ready running
  |- 12:0:1:6   sdgp 132:80  active ready running
```

AFF or FAS configuration

An AFF or FAS configuration should have two groups of paths with higher and lower priorities. Higher priority Active/Optimized paths are served by the controller where the aggregate is located. Lower priority paths are active but non-optimized because they are served by a different controller. Non-optimized paths are only used when optimized paths aren't available.

The following example displays the output for an ONTAP LUN with two Active/Optimized paths and two Active/Non-Optimized paths:

Show example

```
multipath -ll
3600a0980383036347ffb4d59646c4436 dm-28 NETAPP,LUN C-Mode
size=10G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
|-+- policy='service-time 0' prio=50 status=active
| |- 16:0:6:35 sdwb  69:624  active ready running
| |- 16:0:5:35 sdun  66:752  active ready running
`-+- policy='service-time 0' prio=10 status=enabled
  |- 15:0:0:35 sdaj  66:48   active ready running
  |- 15:0:1:35 sdbx  68:176  active ready running
```

Step 4: Optionally, exclude a device from multipathing

If required, you can exclude a device from multipathing by adding the WWID for the unwanted device to the "blacklist" stanza for the `multipath.conf` file.

Steps

1. Determine the WWID:

    ```
    /lib/udev/scsi_id -gud /dev/sda
    ```

    "sda" is the local SCSI disk that you want to add to the blacklist.

    An example WWID is `360030057024d0730239134810c0cb833`.

2. Add the WWID to the "blacklist" stanza:

    ```
    blacklist {
            wwid    360030057024d0730239134810c0cb833
            devnode "^(ram|raw|loop|fd|md|dm-|sr|scd|st)[0-9]*"
            devnode "^hd[a-z]"
            devnode "^cciss.*"
    }
    ```

Step 5: Customize multipath parameters for ONTAP LUNs

If your host is connected to LUNs from other vendors and any of the multipath parameter settings are overridden, you need to correct them by adding stanzas later in the `multipath.conf` file that apply specifically to ONTAP LUNs. If you don't do this, the ONTAP LUNs might not work as expected.

Check your `/etc/multipath.conf` file, especially in the defaults section, for settings that might be overriding the default settings for multipath parameters.

> ⚠️ You shouldn't override the recommended parameter settings for ONTAP LUNs. These settings are required for optimal performance of your host configuration. Contact NetApp support, your OS vendor, or both for more information.

The following example shows how to correct an overridden default. In this example, the `multipath.conf` file defines values for `path_checker` and `no_path_retry` that aren't compatible with ONTAP LUNs, and you can't remove these parameters because ONTAP storage arrays are still attached to the host. Instead, you correct the values for `path_checker` and `no_path_retry` by adding a device stanza to the `multipath.conf` file that applies specifically to the ONTAP LUNs.

```
defaults {
    path_checker        readsector0
    no_path_retry       fail
}

devices {
    device {
        vendor          "NETAPP"
        product         "LUN"
        no_path_retry   queue
        path_checker    tur
    }
}
```

Step 6: Review the known issues

There are no known issues.

What's next?

- Learn about using the Linux Host Utilities tool.
- Learn about ASM mirroring.

  Automatic Storage Management (ASM) mirroring might require changes to the Linux multipath settings to allow ASM to recognize a problem and switch over to an alternate failure group. Most ASM configurations on ONTAP use external redundancy, which means that data protection is provided by the external array and ASM doesn't mirror data. Some sites use ASM with normal redundancy to provide two-way mirroring, normally across different sites. See Oracle databases on ONTAP for further information.

Configure Oracle Linux 8.2 for FCP and iSCSI with ONTAP storage

The Linux Host Utilities software provides management and diagnostic tools for Linux hosts that are connected to ONTAP storage. When you install the Linux Host Utilities on an Oracle Linux 8.2 host, you can use the Host Utilities to help you manage FCP and iSCSI protocol operations with ONTAP LUNs.

ⓘ You don't need to manually configure Kernel-based Virtual Machine (KVM) settings because ONTAP LUNs are automatically mapped to the hypervisor.

Step 1: Optionally, enable SAN booting

You can configure your host to use SAN booting to simplify deployment and improve scalability.

Before you begin

Use the Interoperability Matrix Tool to verify that your Linux OS, host bus adapter (HBA), HBA firmware, HBA

boot BIOS, and ONTAP version support SAN booting.

Steps

1. [Create a SAN boot LUN and map it to the host](#).

2. Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is mapped.

   For information on how to enable the HBA BIOS, see your vendor-specific documentation.

3. Verify that the configuration was successful by rebooting the host and verifying that the OS is up and running.

Step 2: Install the Linux Host Utilities

NetApp strongly recommends installing the Linux Host Utilities to support ONTAP LUN management and assist technical support with gathering configuration data.

[Install Linux Host Utilities 8.0](#).

> ⓘ | Installing the Linux Host Utilities doesn't change any host timeout settings on your Linux host.

Step 3: Confirm the multipath configuration for your host

You can use multipathing with Oracle Linux 8.2 to manage ONTAP LUNs.

> ⓘ | You can use the [recommended settings for Red Hat Enterprise Linux (RHEL) 8.2](#) to configure Red Hat Compatible Kernel for Oracle Linux 8.2.

To ensure that multipathing is configured correctly for your host, verify that the `/etc/multipath.conf` file is defined and that you have the NetApp recommended settings configured for your ONTAP LUNs.

Steps

1. Verify that the `/etc/multipath.conf` file exits. If the file doesn't exist, create an empty, zero-byte file:

   ```
   touch /etc/multipath.conf
   ```

2. The first time the `multipath.conf` file is created, you might need to enable and start the multipath services to load the recommended settings:

   ```
   chkconfig multipathd on
   ```

   ```
   /etc/init.d/multipathd start
   ```

3. Each time you boot the host, the empty `/etc/multipath.conf` zero-byte file automatically loads the NetApp recommended host multipath parameters as the default settings. You shouldn't need to make changes to the `/etc/multipath.conf` file for your host because the operating system is compiled with the multipath parameters that recognize and manage ONTAP LUNs correctly.

The following table shows the Linux OS native compiled multipath parameter settings for ONTAP LUNs.

Show parameter settings

Parameter	Setting
detect_prio	yes
dev_loss_tmo	"infinity"
failback	immediate
fast_io_fail_tmo	5
features	"2 pg_init_retries 50"
flush_on_last_del	"yes"
hardware_handler	"0"
no_path_retry	queue
path_checker	"tur"
path_grouping_policy	"group_by_prio"
path_selector	"service-time 0"
polling_interval	5
prio	"ontap"
product	LUN
retain_attached_hw_handler	yes
rr_weight	"uniform"
user_friendly_names	no
vendor	NETAPP

4. Verify the parameter settings and path status for your ONTAP LUNs:

```
multipath -ll
```

The default multipath parameters support ASA, AFF, and FAS configurations. In these configurations, a single ONTAP LUN shouldn't require more than four paths. If there are more than four paths, it might cause issues with the paths during a storage failure.

The following example outputs show the correct parameter settings and path status for ONTAP LUNs in an ASA, AFF, or FAS configuration.

ASA configuration

An ASA configuration optimizes all paths to a given LUN, keeping them active. This improves performance by serving I/O operations through all paths at the same time.

Show example

```
multipath -ll
3600a098038303634722b4d59646c4436 dm-28 NETAPP,LUN C-Mode
size=10G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
|-+- policy='service-time 0' prio=50 status=active
  |- 11:0:7:6   sdbz 68:208  active ready running
  |- 11:0:11:6  sddn 71:80   active ready running
  |- 11:0:15:6  sdfb 129:208 active ready running
  |- 12:0:1:6   sdgp 132:80  active ready running
```

AFF or FAS configuration

An AFF or FAS configuration should have two groups of paths with higher and lower priorities. Higher priority Active/Optimized paths are served by the controller where the aggregate is located. Lower priority paths are active but non-optimized because they are served by a different controller. Non-optimized paths are only used when optimized paths aren't available.

The following example displays the output for an ONTAP LUN with two Active/Optimized paths and two Active/Non-Optimized paths:

Show example

```
multipath -ll
3600a0980383036347ffb4d59646c4436 dm-28 NETAPP,LUN C-Mode
size=10G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
|-+- policy='service-time 0' prio=50 status=active
| |- 16:0:6:35 sdwb  69:624  active ready running
| |- 16:0:5:35 sdun  66:752  active ready running
`-+- policy='service-time 0' prio=10 status=enabled
  |- 15:0:0:35 sdaj  66:48   active ready running
  |- 15:0:1:35 sdbx  68:176  active ready running
```

Step 4: Optionally, exclude a device from multipathing

If required, you can exclude a device from multipathing by adding the WWID for the unwanted device to the "blacklist" stanza for the `multipath.conf` file.

Steps

1. Determine the WWID:

   ```
   /lib/udev/scsi_id -gud /dev/sda
   ```

   "sda" is the local SCSI disk that you want to add to the blacklist.

   An example WWID is `360030057024d0730239134810c0cb833`.

2. Add the WWID to the "blacklist" stanza:

   ```
   blacklist {
           wwid    360030057024d0730239134810c0cb833
           devnode "^(ram|raw|loop|fd|md|dm-|sr|scd|st)[0-9]*"
           devnode "^hd[a-z]"
           devnode "^cciss.*"
   }
   ```

Step 5: Customize multipath parameters for ONTAP LUNs

If your host is connected to LUNs from other vendors and any of the multipath parameter settings are overridden, you need to correct them by adding stanzas later in the `multipath.conf` file that apply specifically to ONTAP LUNs. If you don't do this, the ONTAP LUNs might not work as expected.

Check your `/etc/multipath.conf` file, especially in the defaults section, for settings that might be overriding the default settings for multipath parameters.

> ⚠️ You shouldn't override the recommended parameter settings for ONTAP LUNs. These settings are required for optimal performance of your host configuration. Contact NetApp support, your OS vendor, or both for more information.

The following example shows how to correct an overridden default. In this example, the `multipath.conf` file defines values for `path_checker` and `no_path_retry` that aren't compatible with ONTAP LUNs, and you can't remove these parameters because ONTAP storage arrays are still attached to the host. Instead, you correct the values for `path_checker` and `no_path_retry` by adding a device stanza to the `multipath.conf` file that applies specifically to the ONTAP LUNs.

Show example

```
defaults {
    path_checker        readsector0
    no_path_retry       fail
}

devices {
    device {
        vendor          "NETAPP"
        product         "LUN"
        no_path_retry   queue
        path_checker    tur
    }
}
```

Step 6: Review the known issues

There are no known issues.

What's next?

- Learn about using the Linux Host Utilities tool.
- Learn about ASM mirroring.

  Automatic Storage Management (ASM) mirroring might require changes to the Linux multipath settings to allow ASM to recognize a problem and switch over to an alternate failure group. Most ASM configurations on ONTAP use external redundancy, which means that data protection is provided by the external array and ASM doesn't mirror data. Some sites use ASM with normal redundancy to provide two-way mirroring, normally across different sites. See Oracle databases on ONTAP for further information.

Configure Oracle Linux 8.1 for FCP and iSCSI with ONTAP storage

The Linux Host Utilities software provides management and diagnostic tools for Linux hosts that are connected to ONTAP storage. When you install the Linux Host Utilities on an Oracle Linux 8.1 host, you can use the Host Utilities to help you manage FCP and iSCSI protocol operations with ONTAP LUNs.

> ⓘ You don't need to manually configure Kernel-based Virtual Machine (KVM) settings because ONTAP LUNs are automatically mapped to the hypervisor.

Step 1: Optionally, enable SAN booting

You can configure your host to use SAN booting to simplify deployment and improve scalability.

Before you begin

Use the Interoperability Matrix Tool to verify that your Linux OS, host bus adapter (HBA), HBA firmware, HBA

boot BIOS, and ONTAP version support SAN booting.

Steps

1. Create a SAN boot LUN and map it to the host.

2. Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is mapped.

   For information on how to enable the HBA BIOS, see your vendor-specific documentation.

3. Verify that the configuration was successful by rebooting the host and verifying that the OS is up and running.

Step 2: Install the Linux Host Utilities

NetApp strongly recommends installing the Linux Host Utilities to support ONTAP LUN management and assist technical support with gathering configuration data.

Install Linux Host Utilities 8.0.

> ⓘ Installing the Linux Host Utilities doesn't change any host timeout settings on your Linux host.

Step 3: Confirm the multipath configuration for your host

You can use multipathing with Oracle Linux 8.1 to manage ONTAP LUNs.

> ⓘ You can use the recommended settings for Red Hat Enterprise Linux (RHEL) 8.1 to configure
> Red Hat Compatible Kernel for Oracle Linux 8.1.

To ensure that multipathing is configured correctly for your host, verify that the `/etc/multipath.conf` file is defined and that you have the NetApp recommended settings configured for your ONTAP LUNs.

Steps

1. Verify that the `/etc/multipath.conf` file exits. If the file doesn't exist, create an empty, zero-byte file:

   ```
   touch /etc/multipath.conf
   ```

2. The first time the `multipath.conf` file is created, you might need to enable and start the multipath services to load the recommended settings:

   ```
   chkconfig multipathd on
   ```

   ```
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3. Each time you boot the host, the empty `/etc/multipath.conf` zero-byte file automatically loads the NetApp recommended host multipath parameters as the default settings. You shouldn't need to make changes to the `/etc/multipath.conf` file for your host because the operating system is compiled with the multipath parameters that recognize and manage ONTAP LUNs correctly.

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hardware_handler	"0"
no_path_retry	queue
path_checker	"tur"
path_grouping_policy	"group_by_prio"
path_selector	"service-time 0"
polling_interval	5
prio	"ontap"
product	LUN
retain_attached_hw_handler	yes
rr_weight	"uniform"
user_friendly_names	no
vendor	NETAPP

4. Verify the parameter settings and path status for your ONTAP LUNs:

```
multipath -ll
```

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Show example

```
multipath -ll
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size=10G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
|-+- policy='service-time 0' prio=50 status=active
  |- 11:0:7:6   sdbz 68:208  active ready running
  |- 11:0:11:6  sddn 71:80   active ready running
  |- 11:0:15:6  sdfb 129:208 active ready running
  |- 12:0:1:6   sdgp 132:80  active ready running
```

AFF or FAS configuration

An AFF or FAS configuration should have two groups of paths with higher and lower priorities. Higher priority Active/Optimized paths are served by the controller where the aggregate is located. Lower priority paths are active but non-optimized because they are served by a different controller. Non-optimized paths are only used when optimized paths aren't available.

The following example displays the output for an ONTAP LUN with two Active/Optimized paths and two Active/Non-Optimized paths:

Show example

```
multipath -ll
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size=10G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
|-+- policy='service-time 0' prio=50 status=active
| |- 16:0:6:35 sdwb  69:624  active ready running
| |- 16:0:5:35 sdun  66:752  active ready running
`-+- policy='service-time 0' prio=10 status=enabled
  |- 15:0:0:35 sdaj  66:48   active ready running
  |- 15:0:1:35 sdbx  68:176  active ready running
```

Step 4: Optionally, exclude a device from multipathing

If required, you can exclude a device from multipathing by adding the WWID for the unwanted device to the "blacklist" stanza for the `multipath.conf` file.

Steps

1. Determine the WWID:

```
/lib/udev/scsi_id -gud /dev/sda
```

"sda" is the local SCSI disk that you want to add to the blacklist.

An example WWID is `360030057024d0730239134810c0cb833`.

2. Add the WWID to the "blacklist" stanza:

```
blacklist {
        wwid    360030057024d0730239134810c0cb833
        devnode "^(ram|raw|loop|fd|md|dm-|sr|scd|st)[0-9]*"
        devnode "^hd[a-z]"
        devnode "^cciss.*"
}
```

Step 5: Customize multipath parameters for ONTAP LUNs

If your host is connected to LUNs from other vendors and any of the multipath parameter settings are overridden, you need to correct them by adding stanzas later in the `multipath.conf` file that apply specifically to ONTAP LUNs. If you don't do this, the ONTAP LUNs might not work as expected.

Check your `/etc/multipath.conf` file, especially in the defaults section, for settings that might be overriding the default settings for multipath parameters.

> ⚠️ You shouldn't override the recommended parameter settings for ONTAP LUNs. These settings are required for optimal performance of your host configuration. Contact NetApp support, your OS vendor, or both for more information.

The following example shows how to correct an overridden default. In this example, the `multipath.conf` file defines values for `path_checker` and `no_path_retry` that aren't compatible with ONTAP LUNs, and you can't remove these parameters because ONTAP storage arrays are still attached to the host. Instead, you correct the values for `path_checker` and `no_path_retry` by adding a device stanza to the `multipath.conf` file that applies specifically to the ONTAP LUNs.

Show example

```
defaults {
    path_checker        readsector0
    no_path_retry       fail
}

devices {
    device {
        vendor          "NETAPP"
        product         "LUN"
        no_path_retry   queue
        path_checker    tur
    }
}
```

Step 6: Review the known issues

There are no known issues.

What's next?

- Learn about using the Linux Host Utilities tool.

- Learn about ASM mirroring.

  Automatic Storage Management (ASM) mirroring might require changes to the Linux multipath settings to allow ASM to recognize a problem and switch over to an alternate failure group. Most ASM configurations on ONTAP use external redundancy, which means that data protection is provided by the external array and ASM doesn't mirror data. Some sites use ASM with normal redundancy to provide two-way mirroring, normally across different sites. See Oracle databases on ONTAP for further information.

Configure Oracle Linux 8.0 for FCP and iSCSI with ONTAP storage

The Linux Host Utilities software provides management and diagnostic tools for Linux hosts that are connected to ONTAP storage. When you install the Linux Host Utilities on an Oracle Linux 8.0 host, you can use the Host Utilities to help you manage FCP and iSCSI protocol operations with ONTAP LUNs.

ⓘ You don't need to manually configure Kernel-based Virtual Machine (KVM) settings because ONTAP LUNs are automatically mapped to the hypervisor.

Step 1: Optionally, enable SAN booting

You can configure your host to use SAN booting to simplify deployment and improve scalability.

Before you begin

Use the Interoperability Matrix Tool to verify that your Linux OS, host bus adapter (HBA), HBA firmware, HBA

boot BIOS, and ONTAP version support SAN booting.

Steps

1. [Create a SAN boot LUN and map it to the host](#).

2. Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is mapped.

   For information on how to enable the HBA BIOS, see your vendor-specific documentation.

3. Verify that the configuration was successful by rebooting the host and verifying that the OS is up and running.

Step 2: Install the Linux Host Utilities

NetApp strongly recommends installing the Linux Host Utilities to support ONTAP LUN management and assist technical support with gathering configuration data.

[Install Linux Host Utilities 8.0](#).

> ⓘ   Installing the Linux Host Utilities doesn't change any host timeout settings on your Linux host.

Step 3: Confirm the multipath configuration for your host

You can use multipathing with Oracle Linux 8.0 to manage ONTAP LUNs.

> ⓘ   You can use the [recommended settings for Red Hat Enterprise Linux (RHEL) 8.0](#) to configure Red Hat Compatible Kernel for Oracle Linux 8.0.

To ensure that multipathing is configured correctly for your host, verify that the `/etc/multipath.conf` file is defined and that you have the NetApp recommended settings configured for your ONTAP LUNs.

Steps

1. Verify that the `/etc/multipath.conf` file exits. If the file doesn't exist, create an empty, zero-byte file:

   ```
   touch /etc/multipath.conf
   ```

2. The first time the `multipath.conf` file is created, you might need to enable and start the multipath services to load the recommended settings:

   ```
   chkconfig multipathd on
   ```

   ```
   /etc/init.d/multipathd start
   ```

3. Each time you boot the host, the empty `/etc/multipath.conf` zero-byte file automatically loads the NetApp recommended host multipath parameters as the default settings. You shouldn't need to make changes to the `/etc/multipath.conf` file for your host because the operating system is compiled with the multipath parameters that recognize and manage ONTAP LUNs correctly.

The following table shows the Linux OS native compiled multipath parameter settings for ONTAP LUNs.

Show parameter settings

Parameter	Setting
detect_prio	yes
dev_loss_tmo	"infinity"
failback	immediate
fast_io_fail_tmo	5
features	"2 pg_init_retries 50"
flush_on_last_del	"yes"
hardware_handler	"0"
no_path_retry	queue
path_checker	"tur"
path_grouping_policy	"group_by_prio"
path_selector	"service-time 0"
polling_interval	5
prio	"ontap"
product	LUN
retain_attached_hw_handler	yes
rr_weight	"uniform"
user_friendly_names	no
vendor	NETAPP

4. Verify the parameter settings and path status for your ONTAP LUNs:

```
multipath -ll
```

The default multipath parameters support ASA, AFF, and FAS configurations. In these configurations, a single ONTAP LUN shouldn't require more than four paths. If there are more than four paths, it might cause issues with the paths during a storage failure.

The following example outputs show the correct parameter settings and path status for ONTAP LUNs in an ASA, AFF, or FAS configuration.

ASA configuration

An ASA configuration optimizes all paths to a given LUN, keeping them active. This improves performance by serving I/O operations through all paths at the same time.

Show example

```
multipath -ll
3600a098038303634722b4d59646c4436 dm-28 NETAPP,LUN C-Mode
size=10G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
|-+- policy='service-time 0' prio=50 status=active
  |- 11:0:7:6   sdbz 68:208  active ready running
  |- 11:0:11:6  sddn 71:80   active ready running
  |- 11:0:15:6  sdfb 129:208 active ready running
  |- 12:0:1:6   sdgp 132:80  active ready running
```

AFF or FAS configuration

An AFF or FAS configuration should have two groups of paths with higher and lower priorities. Higher priority Active/Optimized paths are served by the controller where the aggregate is located. Lower priority paths are active but non-optimized because they are served by a different controller. Non-optimized paths are only used when optimized paths aren't available.

The following example displays the output for an ONTAP LUN with two Active/Optimized paths and two Active/Non-Optimized paths:

Show example

```
multipath -ll
3600a0980383036347ffb4d59646c4436 dm-28 NETAPP,LUN C-Mode
size=10G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
|-+- policy='service-time 0' prio=50 status=active
| |- 16:0:6:35 sdwb  69:624  active ready running
| |- 16:0:5:35 sdun  66:752  active ready running
`-+- policy='service-time 0' prio=10 status=enabled
  |- 15:0:0:35 sdaj  66:48   active ready running
  |- 15:0:1:35 sdbx  68:176  active ready running
```

Step 4: Optionally, exclude a device from multipathing

If required, you can exclude a device from multipathing by adding the WWID for the unwanted device to the "blacklist" stanza for the `multipath.conf` file.

Steps

1. Determine the WWID:

   ```
   /lib/udev/scsi_id -gud /dev/sda
   ```

   "sda" is the local SCSI disk that you want to add to the blacklist.

   An example WWID is `360030057024d0730239134810c0cb833`.

2. Add the WWID to the "blacklist" stanza:

   ```
   blacklist {
           wwid    360030057024d0730239134810c0cb833
           devnode "^(ram|raw|loop|fd|md|dm-|sr|scd|st)[0-9]*"
           devnode "^hd[a-z]"
           devnode "^cciss.*"
   }
   ```

Step 5: Customize multipath parameters for ONTAP LUNs

If your host is connected to LUNs from other vendors and any of the multipath parameter settings are overridden, you need to correct them by adding stanzas later in the `multipath.conf` file that apply specifically to ONTAP LUNs. If you don't do this, the ONTAP LUNs might not work as expected.

Check your `/etc/multipath.conf` file, especially in the defaults section, for settings that might be overriding the default settings for multipath parameters.

> ⚠️ You shouldn't override the recommended parameter settings for ONTAP LUNs. These settings are required for optimal performance of your host configuration. Contact NetApp support, your OS vendor, or both for more information.

The following example shows how to correct an overridden default. In this example, the `multipath.conf` file defines values for `path_checker` and `no_path_retry` that aren't compatible with ONTAP LUNs, and you can't remove these parameters because ONTAP storage arrays are still attached to the host. Instead, you correct the values for `path_checker` and `no_path_retry` by adding a device stanza to the `multipath.conf` file that applies specifically to the ONTAP LUNs.

Show example

```
defaults {
    path_checker      readsector0
    no_path_retry     fail
}

devices {
    device {
        vendor          "NETAPP"
        product         "LUN"
        no_path_retry   queue
        path_checker    tur
    }
}
```

Step 6: Review the known issues

There are no known issues.

What's next?

- Learn about using the Linux Host Utilities tool.

- Learn about ASM mirroring.

  Automatic Storage Management (ASM) mirroring might require changes to the Linux multipath settings to allow ASM to recognize a problem and switch over to an alternate failure group. Most ASM configurations on ONTAP use external redundancy, which means that data protection is provided by the external array and ASM doesn't mirror data. Some sites use ASM with normal redundancy to provide two-way mirroring, normally across different sites. See Oracle databases on ONTAP for further information.

Oracle Linux 7

Configure Oracle Linux 7.9 for FCP and iSCSI with ONTAP storage

The Linux Host Utilities software provides management and diagnostic tools for Linux hosts that are connected to ONTAP storage. When you install the Linux Host Utilities on an Oracle Linux 7.9 host, you can use the Host Utilities to help you manage FCP and iSCSI protocol operations with ONTAP LUNs.

> ⓘ You don't need to manually configure Kernel-based Virtual Machine (KVM) settings because ONTAP LUNs are automatically mapped to the hypervisor.

Step 1: Optionally, enable SAN booting

You can configure your host to use SAN booting to simplify deployment and improve scalability.

Before you begin

Use the Interoperability Matrix Tool to verify that your Linux OS, host bus adapter (HBA), HBA firmware, HBA boot BIOS, and ONTAP version support SAN booting.

Steps

1. Create a SAN boot LUN and map it to the host.

2. Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is mapped.

   For information on how to enable the HBA BIOS, see your vendor-specific documentation.

3. Verify that the configuration was successful by rebooting the host and verifying that the OS is up and running.

Step 2: Install the Linux Host Utilities

NetApp strongly recommends installing the Linux Host Utilities to support ONTAP LUN management and assist technical support with gathering configuration data.

Install Linux Host Utilities 7.1.

> ⓘ Installing the Linux Host Utilities doesn't change any host timeout settings on your Linux host.

Step 3: Confirm the multipath configuration for your host

You can use multipathing with Oracle Linux 7.9 to manage ONTAP LUNs.

> ⓘ You can use the recommended settings for Red Hat Enterprise Linux (RHEL) 7.9 to configure Red Hat Compatible Kernel for Oracle Linux 7.9.

To ensure that multipathing is configured correctly for your host, verify that the `/etc/multipath.conf` file is defined and that you have the NetApp recommended settings configured for your ONTAP LUNs.

Steps

1. Verify that the `/etc/multipath.conf` file exits. If the file doesn't exist, create an empty, zero-byte file:

   ```
   touch /etc/multipath.conf
   ```

2. The first time the `multipath.conf` file is created, you might need to enable and start the multipath services to load the recommended settings:

   ```
   chkconfig multipathd on
   ```

   ```
   /etc/init.d/multipathd start
   ```

3. Each time you boot the host, the empty `/etc/multipath.conf` zero-byte file automatically loads the NetApp recommended host multipath parameters as the default settings. You shouldn't need to make changes to the `/etc/multipath.conf` file for your host because the operating system is compiled with

the multipath parameters that recognize and manage ONTAP LUNs correctly.

The following table shows the Linux OS native compiled multipath parameter settings for ONTAP LUNs.

Show parameter settings

Parameter	Setting
detect_prio	yes
dev_loss_tmo	"infinity"
failback	immediate
fast_io_fail_tmo	5
features	"2 pg_init_retries 50"
flush_on_last_del	"yes"
hardware_handler	"0"
no_path_retry	queue
path_checker	"tur"
path_grouping_policy	"group_by_prio"
path_selector	"service-time 0"
polling_interval	5
prio	"ontap"
product	LUN
retain_attached_hw_handler	yes
rr_weight	"uniform"
user_friendly_names	no
vendor	NETAPP

4. Verify the parameter settings and path status for your ONTAP LUNs:

```
multipath -ll
```

The default multipath parameters support ASA, AFF, and FAS configurations. In these configurations, a single ONTAP LUN shouldn't require more than four paths. If there are more than four paths, it might cause issues with the paths during a storage failure.

The following example outputs show the correct parameter settings and path status for ONTAP LUNs in an ASA, AFF, or FAS configuration.

ASA configuration

An ASA configuration optimizes all paths to a given LUN, keeping them active. This improves performance by serving I/O operations through all paths at the same time.

Show example

```
multipath -ll
3600a098038303634722b4d59646c4436 dm-28 NETAPP,LUN C-Mode
size=10G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
|-+- policy='service-time 0' prio=50 status=active
  |- 11:0:7:6   sdbz 68:208  active ready running
  |- 11:0:11:6  sddn 71:80   active ready running
  |- 11:0:15:6  sdfb 129:208 active ready running
  |- 12:0:1:6   sdgp 132:80  active ready running
```

AFF or FAS configuration

An AFF or FAS configuration should have two groups of paths with higher and lower priorities. Higher priority Active/Optimized paths are served by the controller where the aggregate is located. Lower priority paths are active but non-optimized because they are served by a different controller. Non-optimized paths are only used when optimized paths aren't available.

The following example displays the output for an ONTAP LUN with two Active/Optimized paths and two Active/Non-Optimized paths:

Show example

```
multipath -ll
3600a0980383036347ffb4d59646c4436 dm-28 NETAPP,LUN C-Mode
size=10G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
|-+- policy='service-time 0' prio=50 status=active
| |- 16:0:6:35 sdwb  69:624  active ready running
| |- 16:0:5:35 sdun  66:752  active ready running
`-+- policy='service-time 0' prio=10 status=enabled
  |- 15:0:0:35 sdaj  66:48   active ready running
  |- 15:0:1:35 sdbx  68:176  active ready running
```

Step 4: Optionally, exclude a device from multipathing

If required, you can exclude a device from multipathing by adding the WWID for the unwanted device to the "blacklist" stanza for the `multipath.conf` file.

Steps

1. Determine the WWID:

```
/lib/udev/scsi_id -gud /dev/sda
```

"sda" is the local SCSI disk that you want to add to the blacklist.

An example WWID is `360030057024d0730239134810c0cb833`.

2. Add the WWID to the "blacklist" stanza:

```
blacklist {
        wwid   360030057024d0730239134810c0cb833
        devnode "^(ram|raw|loop|fd|md|dm-|sr|scd|st)[0-9]*"
        devnode "^hd[a-z]"
        devnode "^cciss.*"
}
```

Step 5: Customize multipath parameters for ONTAP LUNs

If your host is connected to LUNs from other vendors and any of the multipath parameter settings are overridden, you need to correct them by adding stanzas later in the `multipath.conf` file that apply specifically to ONTAP LUNs. If you don't do this, the ONTAP LUNs might not work as expected.

Check your `/etc/multipath.conf` file, especially in the defaults section, for settings that might be overriding the default settings for multipath parameters.

> ⚠️ You shouldn't override the recommended parameter settings for ONTAP LUNs. These settings are required for optimal performance of your host configuration. Contact NetApp support, your OS vendor, or both for more information.

The following example shows how to correct an overridden default. In this example, the `multipath.conf` file defines values for `path_checker` and `no_path_retry` that aren't compatible with ONTAP LUNs, and you can't remove these parameters because ONTAP storage arrays are still attached to the host. Instead, you correct the values for `path_checker` and `no_path_retry` by adding a device stanza to the `multipath.conf` file that applies specifically to the ONTAP LUNs.

Show example

```
defaults {
    path_checker        readsector0
    no_path_retry       fail
}

devices {
    device {
        vendor          "NETAPP"
        product         "LUN"
        no_path_retry   queue
        path_checker    tur
    }
}
```

Step 6: Review the known issues

The Oracle Linux 7.9 host with ONTAP storage has the following known issues:

NetApp Bug ID	Title	Description
1440718	If you unmap or map a LUN without performing a SCSI rescan, it might lead to data corruption on the host	When you set the `disable_changed_wwids` multipath configuration parameter to YES, it disables access to the path device in the event of a worldwide identifier (WWID) change. Multipath disables access to the path device until the WWID of the path is restored to the WWID of the multipath device. See the NetApp Knowledge Base: The filesystem corruption on iSCSI LUN on the Oracle Linux 7 for more information.

What's next?

- Learn about using the Linux Host Utilities tool.

- Learn about ASM mirroring.

  Automatic Storage Management (ASM) mirroring might require changes to the Linux multipath settings to allow ASM to recognize a problem and switch over to an alternate failure group. Most ASM configurations on ONTAP use external redundancy, which means that data protection is provided by the external array and ASM doesn't mirror data. Some sites use ASM with normal redundancy to provide two-way mirroring, normally across different sites. See Oracle databases on ONTAP for further information.

Configure Oracle Linux 7.8 for FCP and iSCSI with ONTAP storage

The Linux Host Utilities software provides management and diagnostic tools for Linux hosts that are connected to ONTAP storage. When you install the Linux Host Utilities on an Oracle Linux 7.8 host, you can use the Host Utilities to help you manage FCP and iSCSI protocol operations with ONTAP LUNs.

> ℹ️ You don't need to manually configure Kernel-based Virtual Machine (KVM) settings because ONTAP LUNs are automatically mapped to the hypervisor.

Step 1: Optionally, enable SAN booting

You can configure your host to use SAN booting to simplify deployment and improve scalability.

Before you begin

Use the Interoperability Matrix Tool to verify that your Linux OS, host bus adapter (HBA), HBA firmware, HBA boot BIOS, and ONTAP version support SAN booting.

Steps

1. Create a SAN boot LUN and map it to the host.

2. Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is mapped.

   For information on how to enable the HBA BIOS, see your vendor-specific documentation.

3. Verify that the configuration was successful by rebooting the host and verifying that the OS is up and running.

Step 2: Install the Linux Host Utilities

NetApp strongly recommends installing the Linux Host Utilities to support ONTAP LUN management and assist technical support with gathering configuration data.

Install Linux Host Utilities 7.1.

> ℹ️ Installing the Linux Host Utilities doesn't change any host timeout settings on your Linux host.

Step 3: Confirm the multipath configuration for your host

You can use multipathing with Oracle Linux 7.8 to manage ONTAP LUNs.

> ℹ️ You can use the recommended settings for Red Hat Enterprise Linux (RHEL) 7.8 to configure Red Hat Compatible Kernel for Oracle Linux 7.8.

To ensure that multipathing is configured correctly for your host, verify that the `/etc/multipath.conf` file is defined and that you have the NetApp recommended settings configured for your ONTAP LUNs.

Steps

1. Verify that the `/etc/multipath.conf` file exits. If the file doesn't exist, create an empty, zero-byte file:

   ```
   touch /etc/multipath.conf
   ```

2. The first time the `multipath.conf` file is created, you might need to enable and start the multipath services to load the recommended settings:

```
chkconfig multipathd on
```

```
/etc/init.d/multipathd start
```

3. Each time you boot the host, the empty `/etc/multipath.conf` zero-byte file automatically loads the NetApp recommended host multipath parameters as the default settings. You shouldn't need to make changes to the `/etc/multipath.conf` file for your host because the operating system is compiled with the multipath parameters that recognize and manage ONTAP LUNs correctly.

   The following table shows the Linux OS native compiled multipath parameter settings for ONTAP LUNs.

   Show parameter settings

Parameter	Setting
detect_prio	yes
dev_loss_tmo	"infinity"
failback	immediate
fast_io_fail_tmo	5
features	"2 pg_init_retries 50"
flush_on_last_del	"yes"
hardware_handler	"0"
no_path_retry	queue
path_checker	"tur"
path_grouping_policy	"group_by_prio"
path_selector	"service-time 0"
polling_interval	5
prio	"ontap"
product	LUN
retain_attached_hw_handler	yes
rr_weight	"uniform"
user_friendly_names	no
vendor	NETAPP

4. Verify the parameter settings and path status for your ONTAP LUNs:

```
multipath -ll
```

The default multipath parameters support AFF and FAS configurations. In these configurations, a single ONTAP LUN shouldn't require more than four paths. If there are more than four paths, it might cause issues with the paths during a storage failure.

An AFF or FAS configuration should have two groups of paths with higher and lower priorities. Higher priority Active/Optimized paths are served by the controller where the aggregate is located. Lower priority paths are active but non-optimized because they are served by a different controller. Non-optimized paths are only used when optimized paths aren't available.

The following example outputs show the correct parameter settings and path status for ONTAP LUNs in an AFF or FAS configuration with two Active/Optimized paths and two Active/Non-Optimized paths:

Show example

```
multipath -ll
3600a0980383036347ffb4d59646c4436 dm-28 NETAPP,LUN C-Mode
size=10G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
|-+- policy='service-time 0' prio=50 status=active
| |- 16:0:6:35 sdwb  69:624  active ready running
| |- 16:0:5:35 sdun  66:752  active ready running
`-+- policy='service-time 0' prio=10 status=enabled
  |- 15:0:0:35 sdaj  66:48   active ready running
  |- 15:0:1:35 sdbx  68:176  active ready running
```

Step 4: Optionally, exclude a device from multipathing

If required, you can exclude a device from multipathing by adding the WWID for the unwanted device to the "blacklist" stanza for the `multipath.conf` file.

Steps

1. Determine the WWID:

   ```
   /lib/udev/scsi_id -gud /dev/sda
   ```

   "sda" is the local SCSI disk that you want to add to the blacklist.

   An example WWID is `360030057024d0730239134810c0cb833`.

2. Add the WWID to the "blacklist" stanza:

```
blacklist {
        wwid    360030057024d0730239134810c0cb833
        devnode "^(ram|raw|loop|fd|md|dm-|sr|scd|st)[0-9]*"
        devnode "^hd[a-z]"
        devnode "^cciss.*"
}
```

Step 5: Customize multipath parameters for ONTAP LUNs

If your host is connected to LUNs from other vendors and any of the multipath parameter settings are overridden, you need to correct them by adding stanzas later in the `multipath.conf` file that apply specifically to ONTAP LUNs. If you don't do this, the ONTAP LUNs might not work as expected.

Check your `/etc/multipath.conf` file, especially in the defaults section, for settings that might be overriding the default settings for multipath parameters.

> ⚠ You shouldn't override the recommended parameter settings for ONTAP LUNs. These settings are required for optimal performance of your host configuration. Contact NetApp support, your OS vendor, or both for more information.

The following example shows how to correct an overridden default. In this example, the `multipath.conf` file defines values for `path_checker` and `no_path_retry` that aren't compatible with ONTAP LUNs, and you can't remove these parameters because ONTAP storage arrays are still attached to the host. Instead, you correct the values for `path_checker` and `no_path_retry` by adding a device stanza to the `multipath.conf` file that applies specifically to the ONTAP LUNs.

Show example

```
defaults {
    path_checker        readsector0
    no_path_retry       fail
}

devices {
    device {
        vendor          "NETAPP"
        product         "LUN"
        no_path_retry   queue
        path_checker    tur
    }
}
```

Step 6: Review the known issues

The Oracle Linux 7.8 host with ONTAP storage has the following known issues:

NetApp Bug ID	Title	Description
1440718	If you unmap or map a LUN without performing a SCSI rescan, it might lead to data corruption on the host.	When you set the 'disable_changed_wwids' multipath configuration parameter to YES, it disables access to the path device in the event of a WWID change. Multipath will disable access to the path device until the WWID of the path is restored to the WWID of the multipath device. To learn more, see NetApp Knowledge Base: The filesystem corruption on iSCSI LUN on the Oracle Linux 7.
1311575	I/O delays observed due to Read/Write operations failed to switch through secondary paths during storage failover with Qlogic QLE2672(16G)	I/O operations might fail to resume through secondary paths during storage failover operations on Oracle Linux 7.7 kernel (5.4.17-2011.0.7.el7uek.x86_6) with QLogic QLE2672 16G HBA. If I/O progress stops due to blocked primary paths during storage failover, the I/O operation might not resume through secondary paths causing an I/O delay. The I/O operation resumes only after primary paths come online after the completion of the storage failover giveback operation.
1311576	I/O delays observed due to Read/Write operation failing to switch through secondary paths during storage failover with Emulex LPe16002(16G)	I/O operations might fail to resume through secondary paths during storage failover operations on Oracle Linux 7.7 kernel (5.4.17-2011.0.7.el7uek.x86_6) with Emulex LPe16002 16G HBA. If I/O progress stops due to blocked primary paths during storage failover, the I/O operation might not resume through secondary paths causing an I/O delay. The I/O operation resumes only after primary paths come online after the completion of the storage failover giveback operation.

NetApp Bug ID	Title	Description
1246134	I/O delays observed and reports are moving to blocked, NOT PRESENT state during storage failover with Emulex LPe16002(16G)	During storage failover operations on the Oracle Linux 7.6 with the UEK5U2 kernel running with an Emulex LPe16002B-M6 16G Fibre Channel (FC) host bus adapter (HBA), I/O progress might stop due to reports getting blocked. The storage failover operation reports change from "online" state to "blocked" state, causing a delay in read and write operations. After the operation is completed successfully, the reports fail to move back to "online" state and continue to remain in "blocked" state.
1246327	I/O delays observed and Rports are moving to blocked, NOT PRESENT state during storage failover with Qlogic QLE2672(16G) and QLE2742(32G)	Fibre Channel (FC) remote ports might be blocked on Red Hat Enterprise Linux (RHEL) 7.6 with the QLogic QLE2672 16G host during storage failover operations. Because the logical interfaces go down when a storage node is down, the remote ports set the storage node status to blocked. I/O progress might stop due to the blocked ports if you are running both a QLogic QLE2672 16G host and a QLE2742 32GB Fibre Channel (FC) host bus adapter (HBA). When the storage node returns to its optimal state, the logical interfaces also come up and the remote ports should be online. However, the remote ports might still be blocked. This blocked state registers as failed faulty to LUNS at the multipath layer. You can verify the state of the remote ports with the following command: # cat /sys/class/fc_remote_ports/rport-*/port_stat You should see the following output: Blocked Blocked Blocked Blocked Online Online

What's next?

- Learn about using the Linux Host Utilities tool.

- Learn about ASM mirroring.

  Automatic Storage Management (ASM) mirroring might require changes to the Linux multipath settings to allow ASM to recognize a problem and switch over to an alternate failure group. Most ASM configurations on ONTAP use external redundancy, which means that data protection is provided by the external array and ASM doesn't mirror data. Some sites use ASM with normal redundancy to provide two-way mirroring, normally across different sites. See Oracle databases on ONTAP for further information.

Configure Oracle Linux 7.7 for FCP and iSCSI with ONTAP storage

The Linux Host Utilities software provides management and diagnostic tools for Linux hosts that are connected to ONTAP storage. When you install the Linux Host Utilities on an Oracle Linux 7.7 host, you can use the Host Utilities to help you manage FCP and iSCSI protocol operations with ONTAP LUNs.

> ⓘ You don't need to manually configure Kernel-based Virtual Machine (KVM) settings because ONTAP LUNs are automatically mapped to the hypervisor.

Step 1: Optionally, enable SAN booting

You can configure your host to use SAN booting to simplify deployment and improve scalability.

Before you begin

Use the Interoperability Matrix Tool to verify that your Linux OS, host bus adapter (HBA), HBA firmware, HBA boot BIOS, and ONTAP version support SAN booting.

Steps

1. Create a SAN boot LUN and map it to the host.

2. Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is mapped.

   For information on how to enable the HBA BIOS, see your vendor-specific documentation.

3. Verify that the configuration was successful by rebooting the host and verifying that the OS is up and running.

Step 2: Install the Linux Host Utilities

NetApp strongly recommends installing the Linux Host Utilities to support ONTAP LUN management and assist technical support with gathering configuration data.

Install Linux Host Utilities 7.1.

> ⓘ Installing the Linux Host Utilities doesn't change any host timeout settings on your Linux host.

Step 3: Confirm the multipath configuration for your host

You can use multipathing with Oracle Linux 7.7 to manage ONTAP LUNs.

ⓘ You can use the recommended settings for Red Hat Enterprise Linux (RHEL) 7.7 to configure Red Hat Compatible Kernel for Oracle Linux 7.7.

To ensure that multipathing is configured correctly for your host, verify that the `/etc/multipath.conf` file is defined and that you have the NetApp recommended settings configured for your ONTAP LUNs.

Steps

1. Verify that the `/etc/multipath.conf` file exits. If the file doesn't exist, create an empty, zero-byte file:

```
touch /etc/multipath.conf
```

2. The first time the `multipath.conf` file is created, you might need to enable and start the multipath services to load the recommended settings:

```
chkconfig multipathd on
```

```
/etc/init.d/multipathd start
```

3. Each time you boot the host, the empty `/etc/multipath.conf` zero-byte file automatically loads the NetApp recommended host multipath parameters as the default settings. You shouldn't need to make changes to the `/etc/multipath.conf` file for your host because the operating system is compiled with the multipath parameters that recognize and manage ONTAP LUNs correctly.

   The following table shows the Linux OS native compiled multipath parameter settings for ONTAP LUNs.

Show parameter settings

Parameter	Setting
detect_prio	yes
dev_loss_tmo	"infinity"
failback	immediate
fast_io_fail_tmo	5
features	"2 pg_init_retries 50"
flush_on_last_del	"yes"
hardware_handler	"0"
no_path_retry	queue
path_checker	"tur"
path_grouping_policy	"group_by_prio"
path_selector	"service-time 0"
polling_interval	5
prio	"ontap"
product	LUN
retain_attached_hw_handler	yes
rr_weight	"uniform"
user_friendly_names	no
vendor	NETAPP

4. Verify the parameter settings and path status for your ONTAP LUNs:

```
multipath -ll
```

The default multipath parameters support AFF and FAS configurations. In these configurations, a single ONTAP LUN shouldn't require more than four paths. If there are more than four paths, it might cause issues with the paths during a storage failure.

An AFF or FAS configuration should have two groups of paths with higher and lower priorities. Higher priority Active/Optimized paths are served by the controller where the aggregate is located. Lower priority paths are active but non-optimized because they are served by a different controller. Non-optimized paths are only used when optimized paths aren't available.

The following example outputs show the correct parameter settings and path status for ONTAP LUNs in an AFF or FAS configuration with two Active/Optimized paths and two Active/Non-Optimized paths:

Show example

```
multipath -ll
3600a0980383036347ffb4d59646c4436 dm-28 NETAPP,LUN C-Mode
size=10G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
|-+- policy='service-time 0' prio=50 status=active
| |- 16:0:6:35 sdwb  69:624   active ready running
| |- 16:0:5:35 sdun  66:752   active ready running
`-+- policy='service-time 0' prio=10 status=enabled
  |- 15:0:0:35 sdaj  66:48    active ready running
  |- 15:0:1:35 sdbx  68:176   active ready running
```

Step 4: Optionally, exclude a device from multipathing

If required, you can exclude a device from multipathing by adding the WWID for the unwanted device to the
"blacklist" stanza for the `multipath.conf` file.

Steps

1. Determine the WWID:

   ```
   /lib/udev/scsi_id -gud /dev/sda
   ```

   "sda" is the local SCSI disk that you want to add to the blacklist.

   An example WWID is `360030057024d0730239134810c0cb833`.

2. Add the WWID to the "blacklist" stanza:

   ```
   blacklist {
           wwid    360030057024d0730239134810c0cb833
           devnode "^(ram|raw|loop|fd|md|dm-|sr|scd|st)[0-9]*"
           devnode "^hd[a-z]"
           devnode "^cciss.*"
   }
   ```

Step 5: Customize multipath parameters for ONTAP LUNs

If your host is connected to LUNs from other vendors and any of the multipath parameter settings are
overridden, you need to correct them by adding stanzas later in the `multipath.conf` file that apply
specifically to ONTAP LUNs. If you don't do this, the ONTAP LUNs might not work as expected.

Check your `/etc/multipath.conf` file, especially in the defaults section, for settings that might be
overriding the default settings for multipath parameters.

> ⚠ You shouldn't override the recommended parameter settings for ONTAP LUNs. These settings
> are required for optimal performance of your host configuration. Contact NetApp support, your
> OS vendor, or both for more information.

The following example shows how to correct an overridden default. In this example, the `multipath.conf` file
defines values for `path_checker` and `no_path_retry` that aren't compatible with ONTAP LUNs, and you
can't remove these parameters because ONTAP storage arrays are still attached to the host. Instead, you
correct the values for `path_checker` and `no_path_retry` by adding a device stanza to the
`multipath.conf` file that applies specifically to the ONTAP LUNs.

Show example

```
defaults {
    path_checker        readsector0
    no_path_retry       fail
}

devices {
    device {
        vendor          "NETAPP"
        product         "LUN"
        no_path_retry   queue
        path_checker    tur
    }
}
```

Step 6: Review the known issues

The Oracle Linux 7.7 host with ONTAP storage has the following known issues:

NetApp Bug ID	Title	Description
1440718	If you unmap or map a LUN without performing a SCSI rescan, it might lead to data corruption on the host.	When you set the 'disable_changed_wwids' multipath configuration parameter to YES, it disables access to the path device in the event of a WWID change. Multipath will disable access to the path device until the WWID of the path is restored to the WWID of the multipath device. To learn more, see NetApp Knowledge Base: The filesystem corruption on iSCSI LUN on the Oracle Linux 7.

NetApp Bug ID	Title	Description
1311575	I/O delays observed due to Read/Write operations failed to switch through secondary paths during storage failover with Qlogic QLE2672(16G)	I/O operations might fail to resume through secondary paths during storage failover operations on Oracle Linux 7.7 kernel (5.4.17-2011.0.7.el7uek.x86_6) with QLogic QLE2672 16G HBA. If I/O progress stops due to blocked primary paths during storage failover, the I/O operation might not resume through secondary paths causing an I/O delay. The I/O operation resumes only after primary paths come online after the completion of the storage failover giveback operation.
1311576	I/O delays observed due to Read/Write operation failing to switch through secondary paths during storage failover with Emulex LPe16002(16G)	I/O operations might fail to resume through secondary paths during storage failover operations on Oracle Linux 7.7 kernel (5.4.17-2011.0.7.el7uek.x86_6) with Emulex LPe16002 16G HBA. If I/O progress stops due to blocked primary paths during storage failover, the I/O operation might not resume through secondary paths causing an I/O delay. The I/O operation resumes only after primary paths come online after the completion of the storage failover giveback operation.
1246134	I/O delays observed and reports are moving to blocked, NOT PRESENT state during storage failover with Emulex LPe16002(16G)	During storage failover operations on the Oracle Linux 7.6 with the UEK5U2 kernel running with an Emulex LPe16002B-M6 16G Fibre Channel (FC) host bus adapter (HBA), I/O progress might stop due to reports getting blocked. The storage failover operation reports change from "online" state to "blocked" state, causing a delay in read and write operations. After the operation is completed successfully, the reports fail to move back to "online" state and continue to remain in "blocked" state.

NetApp Bug ID	Title	Description
1246327	I/O delays observed and Rports are moving to blocked, NOT PRESENT state during storage failover with Qlogic QLE2672(16G) and QLE2742(32G)	Fibre Channel (FC) remote ports might be blocked on Red Hat Enterprise Linux (RHEL) 7.6 with the QLogic QLE2672 16G host during storage failover operations. Because the logical interfaces go down when a storage node is down, the remote ports set the storage node status to blocked. I/O progress might stop due to the blocked ports if you are running both a QLogic QLE2672 16G host and a QLE2742 32GB Fibre Channel (FC) host bus adapter (HBA). When the storage node returns to its optimal state, the logical interfaces also come up and the remote ports should be online. However, the remote ports might still be blocked. This blocked state registers as failed faulty to LUNS at the multipath layer. You can verify the state of the remote ports with the following command: # cat /sys/class/fc_remote_ports/rport-*/port_stat You should see the following output: Blocked Blocked Blocked Blocked Online Online

What's next?

- [Learn about using the Linux Host Utilities tool](#).

- Learn about ASM mirroring.

  Automatic Storage Management (ASM) mirroring might require changes to the Linux multipath settings to allow ASM to recognize a problem and switch over to an alternate failure group. Most ASM configurations on ONTAP use external redundancy, which means that data protection is provided by the external array and ASM doesn't mirror data. Some sites use ASM with normal redundancy to provide two-way mirroring, normally across different sites. See [Oracle databases on ONTAP](#) for further information.

Configure Oracle Linux 7.6 for FCP and iSCSI with ONTAP storage

The Linux Host Utilities software provides management and diagnostic tools for Linux

hosts that are connected to ONTAP storage. When you install the Linux Host Utilities on an Oracle Linux 7.6 host, you can use the Host Utilities to help you manage FCP and iSCSI protocol operations with ONTAP LUNs.

> ⓘ You don't need to manually configure Kernel-based Virtual Machine (KVM) settings because ONTAP LUNs are automatically mapped to the hypervisor.

Step 1: Optionally, enable SAN booting

You can configure your host to use SAN booting to simplify deployment and improve scalability.

Before you begin

Use the Interoperability Matrix Tool to verify that your Linux OS, host bus adapter (HBA), HBA firmware, HBA boot BIOS, and ONTAP version support SAN booting.

Steps

1. Create a SAN boot LUN and map it to the host.
2. Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is mapped.

   For information on how to enable the HBA BIOS, see your vendor-specific documentation.

3. Verify that the configuration was successful by rebooting the host and verifying that the OS is up and running.

Step 2: Install the Linux Host Utilities

NetApp strongly recommends installing the Linux Host Utilities to support ONTAP LUN management and assist technical support with gathering configuration data.

Install Linux Host Utilities 7.1.

> ⓘ Installing the Linux Host Utilities doesn't change any host timeout settings on your Linux host.

Step 3: Confirm the multipath configuration for your host

You can use multipathing with Oracle Linux 7.6 to manage ONTAP LUNs.

> ⓘ You can use the recommended settings for Red Hat Enterprise Linux (RHEL) 7.6 to configure Red Hat Compatible Kernel for Oracle Linux 7.6.

To ensure that multipathing is configured correctly for your host, verify that the `/etc/multipath.conf` file is defined and that you have the NetApp recommended settings configured for your ONTAP LUNs.

Steps

1. Verify that the `/etc/multipath.conf` file exits. If the file doesn't exist, create an empty, zero-byte file:

   ```
   touch /etc/multipath.conf
   ```

2. The first time the `multipath.conf` file is created, you might need to enable and start the multipath services to load the recommended settings:

```
chkconfig multipathd on
```

```
/etc/init.d/multipathd start
```

3. Each time you boot the host, the empty `/etc/multipath.conf` zero-byte file automatically loads the NetApp recommended host multipath parameters as the default settings. You shouldn't need to make changes to the `/etc/multipath.conf` file for your host because the operating system is compiled with the multipath parameters that recognize and manage ONTAP LUNs correctly.

The following table shows the Linux OS native compiled multipath parameter settings for ONTAP LUNs.

Show parameter settings

Parameter	Setting
detect_prio	yes
dev_loss_tmo	"infinity"
failback	immediate
fast_io_fail_tmo	5
features	"2 pg_init_retries 50"
flush_on_last_del	"yes"
hardware_handler	"0"
no_path_retry	queue
path_checker	"tur"
path_grouping_policy	"group_by_prio"
path_selector	"service-time 0"
polling_interval	5
prio	"ontap"
product	LUN
retain_attached_hw_handler	yes
rr_weight	"uniform"
user_friendly_names	no
vendor	NETAPP

4. Verify the parameter settings and path status for your ONTAP LUNs:

```
multipath -ll
```

The default multipath parameters support AFF and FAS configurations. In these configurations, a single ONTAP LUN shouldn't require more than four paths. If there are more than four paths, it might cause issues with the paths during a storage failure.

An AFF or FAS configuration should have two groups of paths with higher and lower priorities. Higher priority Active/Optimized paths are served by the controller where the aggregate is located. Lower priority paths are active but non-optimized because they are served by a different controller. Non-optimized paths are only used when optimized paths aren't available.

The following example outputs show the correct parameter settings and path status for ONTAP LUNs in an AFF or FAS configuration with two Active/Optimized paths and two Active/Non-Optimized paths:

Show example

```
multipath -ll
3600a0980383036347ffb4d59646c4436 dm-28 NETAPP,LUN C-Mode
size=10G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
|-+- policy='service-time 0' prio=50 status=active
| |- 16:0:6:35 sdwb  69:624  active ready running
| |- 16:0:5:35 sdun  66:752  active ready running
`-+- policy='service-time 0' prio=10 status=enabled
  |- 15:0:0:35 sdaj  66:48   active ready running
  |- 15:0:1:35 sdbx  68:176  active ready running
```

Step 4: Optionally, exclude a device from multipathing

If required, you can exclude a device from multipathing by adding the WWID for the unwanted device to the "blacklist" stanza for the `multipath.conf` file.

Steps

1. Determine the WWID:

   ```
   /lib/udev/scsi_id -gud /dev/sda
   ```

   "sda" is the local SCSI disk that you want to add to the blacklist.

   An example WWID is `360030057024d0730239134810c0cb833`.

2. Add the WWID to the "blacklist" stanza:

```
blacklist {
        wwid    360030057024d0730239134810c0cb833
        devnode "^(ram|raw|loop|fd|md|dm-|sr|scd|st)[0-9]*"
        devnode "^hd[a-z]"
        devnode "^cciss.*"
}
```

Step 5: Customize multipath parameters for ONTAP LUNs

If your host is connected to LUNs from other vendors and any of the multipath parameter settings are overridden, you need to correct them by adding stanzas later in the `multipath.conf` file that apply specifically to ONTAP LUNs. If you don't do this, the ONTAP LUNs might not work as expected.

Check your `/etc/multipath.conf` file, especially in the defaults section, for settings that might be overriding the default settings for multipath parameters.

> ⚠️ You shouldn't override the recommended parameter settings for ONTAP LUNs. These settings are required for optimal performance of your host configuration. Contact NetApp support, your OS vendor, or both for more information.

The following example shows how to correct an overridden default. In this example, the `multipath.conf` file defines values for `path_checker` and `no_path_retry` that aren't compatible with ONTAP LUNs, and you can't remove these parameters because ONTAP storage arrays are still attached to the host. Instead, you correct the values for `path_checker` and `no_path_retry` by adding a device stanza to the `multipath.conf` file that applies specifically to the ONTAP LUNs.

Show example

```
defaults {
    path_checker        readsector0
    no_path_retry       fail
}

devices {
    device {
        vendor          "NETAPP"
        product         "LUN"
        no_path_retry   queue
        path_checker    tur
    }
}
```

Step 6: Review the known issues

The Oracle Linux 7.6 host with ONTAP storage has the following known issues:

NetApp Bug ID	Title	Description
1440718	If you unmap or map a LUN without performing a SCSI rescan, it might lead to data corruption on the host.	When you set the 'disable_changed_wwids' multipath configuration parameter to YES, it disables access to the path device in the event of a WWID change. Multipath will disable access to the path device until the WWID of the path is restored to the WWID of the multipath device. To learn more, see NetApp Knowledge Base: The filesystem corruption on iSCSI LUN on the Oracle Linux 7.
1202736	LUNs might not be available during host discovery due to "Not Present" state of remote ports on a OL7U6 host with QLogic QLE2742 adapter	During host discovery, the status of Fibre Channel (FC) remote ports on a OL7U6 host with a QLogic QLE2742 adapter might enter into "Not Present" state. Remote ports with a "Not Present" state might cause paths to LUNs to become unavailable. During storage failover, the path redundancy might be reduced and result in an I/O outage. You can check the remote port status by entering the following command: # cat /sys/class/fc_remote_ports/rport-*/port_state The following is an example of the output that is displayed: Online Online Not Present Online Online

NetApp Bug ID	Title	Description
1204078	Kernel disruption occurs on Oracle Linux 7.6 running with Qlogic(QLE2672) 16GB FC HBA during storage failover operations	During storage failover operations on the Oracle Linux 7.6 with a Qlogic QLE2672 Fibre Channel (FC) host bus adapter (HBA), a kernel disruption occurs due to a panic in the kernel. The kernel panic causes Oracle Linux 7.6 to reboot, which leads to an application disruption. If the kdump mechanism is enabled, the kernel panic generates a vmcore file located in the /var/crash/ directory. You can analyze the vmcore file to determine the cause of the panic. After the kernel disruption, you can reboot the host OS and recover the operating system, and then you can restart any applications as required.
1204351	Kernel disruption might occur on Oracle Linux 7.6 running with Qlogic(QLE2742) 32GB FC HBA during storage failover operations	During storage failover operations on the Oracle Linux 7.6 with a Qlogic QLE2742 Fibre Channel (FC) host bus adapter (HBA), a kernel disruption might occur due to a panic in the kernel. The kernel panic causes Oracle Linux 7.6 to reboot, which leads to an application disruption. If the kdump mechanism is enabled, the kernel panic generates a vmcore file located in the /var/crash/ directory. You can analyze the vmcore file to determine the cause of the panic. After the kernel disruption, you can reboot the host OS and recover the operating system, and then you can restart any applications as required.

NetApp Bug ID	Title	Description
1204352	Kernel disruption might occur on Oracle Linux 7.6 running with Emulex (LPe32002-M2)32GB FC HBA during storage failover operations	During storage failover operations on the Oracle Linux 7.6 with an Emulex LPe32002-M2 Fibre Channel (FC) host bus adapter (HBA), a kernel disruption might occur due to a panic in the kernel. The kernel panic causes Oracle Linux 7.6 to reboot, which leads to an application disruption. If the kdump mechanism is enabled, the kernel panic generates a vmcore file located in the /var/crash/ directory. You can analyze the vmcore file to determine the cause of the panic. After the kernel disruption, you can reboot the host OS and recover the operating system, and then you can restart any applications as required.
11246134	No I/O progress on Oracle Linux 7.6 with UEK5U2 kernel, running with an Emulex LPe16002B-M6 16G FC HBA during storage failover operations	During storage failover operations on the Oracle Linux 7.6 with the UEK5U2 kernel running with an Emulex LPe16002B-M6 16G Fibre Channel (FC) host bus adapter (HBA), I/O progress might stop due to reports getting blocked. The storage failover operation reports change from an "online" state to a "blocked" state, causing a delay in read and write operations. After the operation has completed successfully, the reports fail to move back to an "online" state and continue to remain in a "blocked" state.

NetApp Bug ID	Title	Description
[1246327](#)	Remote port status on QLogic QLE2672 16G host blocked during storage failover operations	Fibre Channel (FC) remote ports might be blocked on Red Hat Enterprise Linux (RHEL) 7.6 with the QLogic QLE2672 16G host during storage failover operations. Because the logical interfaces go down when a storage node is down, the remote ports set the storage node status to blocked. I/O progress might stop due to the blocked ports if you are running both a QLogic QLE2672 16G host and a QLE2742 32GB Fibre Channel (FC) host bus adapter (HBA). When the storage node returns to its optimal state, the logical interfaces also come up and the remote ports should be online. However, the remote ports might still be blocked. This blocked state registers as failed faulty to LUNS at the multipath layer. You can verify the state of the remote ports with the following command: # cat /sys/class/fc_remote_ports/rport-*/port_stat You should see the following output: Blocked Blocked Blocked Blocked Online Online

What's next?

- [Learn about using the Linux Host Utilities tool](#).
- Learn about ASM mirroring.

  Automatic Storage Management (ASM) mirroring might require changes to the Linux multipath settings to allow ASM to recognize a problem and switch over to an alternate failure group. Most ASM configurations on ONTAP use external redundancy, which means that data protection is provided by the external array and ASM doesn't mirror data. Some sites use ASM with normal redundancy to provide two-way mirroring, normally across different sites. See [Oracle databases on ONTAP](#) for further information.

Configure Oracle Linux 7.5 for FCP and iSCSI with ONTAP storage

The Linux Host Utilities software provides management and diagnostic tools for Linux

hosts that are connected to ONTAP storage. When you install the Linux Host Utilities on an Oracle Linux 7.5 host, you can use the Host Utilities to help you manage FCP and iSCSI protocol operations with ONTAP LUNs.

> ⓘ You don't need to manually configure Kernel-based Virtual Machine (KVM) settings because ONTAP LUNs are automatically mapped to the hypervisor.

Step 1: Optionally, enable SAN booting

You can configure your host to use SAN booting to simplify deployment and improve scalability.

Before you begin

Use the Interoperability Matrix Tool to verify that your Linux OS, host bus adapter (HBA), HBA firmware, HBA boot BIOS, and ONTAP version support SAN booting.

Steps

1. Create a SAN boot LUN and map it to the host.

2. Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is mapped.

   For information on how to enable the HBA BIOS, see your vendor-specific documentation.

3. Verify that the configuration was successful by rebooting the host and verifying that the OS is up and running.

Step 2: Install the Linux Host Utilities

NetApp strongly recommends installing the Linux Host Utilities to support ONTAP LUN management and assist technical support with gathering configuration data.

Install Linux Host Utilities 7.1.

> ⓘ Installing the Linux Host Utilities doesn't change any host timeout settings on your Linux host.

Step 3: Confirm the multipath configuration for your host

You can use multipathing with Oracle Linux 7.5 to manage ONTAP LUNs.

> ⓘ You can use the recommended settings for Red Hat Enterprise Linux (RHEL) 7.5 to configure Red Hat Compatible Kernel for Oracle Linux 7.5.

To ensure that multipathing is configured correctly for your host, verify that the `/etc/multipath.conf` file is defined and that you have the NetApp recommended settings configured for your ONTAP LUNs.

Steps

1. Verify that the `/etc/multipath.conf` file exits. If the file doesn't exist, create an empty, zero-byte file:

   ```
   touch /etc/multipath.conf
   ```

2. The first time the `multipath.conf` file is created, you might need to enable and start the multipath services to load the recommended settings:

```
chkconfig multipathd on
```

```
/etc/init.d/multipathd start
```

3. Each time you boot the host, the empty `/etc/multipath.conf` zero-byte file automatically loads the NetApp recommended host multipath parameters as the default settings. You shouldn't need to make changes to the `/etc/multipath.conf` file for your host because the operating system is compiled with the multipath parameters that recognize and manage ONTAP LUNs correctly.

The following table shows the Linux OS native compiled multipath parameter settings for ONTAP LUNs.

Show parameter settings

Parameter	Setting
detect_prio	yes
dev_loss_tmo	"infinity"
failback	immediate
fast_io_fail_tmo	5
features	"2 pg_init_retries 50"
flush_on_last_del	"yes"
hardware_handler	"0"
no_path_retry	queue
path_checker	"tur"
path_grouping_policy	"group_by_prio"
path_selector	"service-time 0"
polling_interval	5
prio	"ontap"
product	LUN
retain_attached_hw_handler	yes
rr_weight	"uniform"
user_friendly_names	no
vendor	NETAPP

4. Verify the parameter settings and path status for your ONTAP LUNs:

```
multipath -ll
```

The default multipath parameters support AFF and FAS configurations. In these configurations, a single ONTAP LUN shouldn't require more than four paths. If there are more than four paths, it might cause issues with the paths during a storage failure.

An AFF or FAS configuration should have two groups of paths with higher and lower priorities. Higher priority Active/Optimized paths are served by the controller where the aggregate is located. Lower priority paths are active but non-optimized because they are served by a different controller. Non-optimized paths are only used when optimized paths aren't available.

The following example outputs show the correct parameter settings and path status for ONTAP LUNs in an AFF or FAS configuration with two Active/Optimized paths and two Active/Non-Optimized paths:

Show example

```
multipath -ll
3600a0980383036347ffb4d59646c4436 dm-28 NETAPP,LUN C-Mode
size=10G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
|-+- policy='service-time 0' prio=50 status=active
| |- 16:0:6:35 sdwb  69:624  active ready running
| |- 16:0:5:35 sdun  66:752  active ready running
`-+- policy='service-time 0' prio=10 status=enabled
  |- 15:0:0:35 sdaj  66:48   active ready running
  |- 15:0:1:35 sdbx  68:176  active ready running
```

Step 4: Optionally, exclude a device from multipathing

If required, you can exclude a device from multipathing by adding the WWID for the unwanted device to the "blacklist" stanza for the `multipath.conf` file.

Steps

1. Determine the WWID:

   ```
   /lib/udev/scsi_id -gud /dev/sda
   ```

   "sda" is the local SCSI disk that you want to add to the blacklist.

   An example WWID is `360030057024d0730239134810c0cb833`.

2. Add the WWID to the "blacklist" stanza:

```
blacklist {
        wwid    360030057024d0730239134810c0cb833
        devnode "^(ram|raw|loop|fd|md|dm-|sr|scd|st)[0-9]*"
        devnode "^hd[a-z]"
        devnode "^cciss.*"
}
```

Step 5: Customize multipath parameters for ONTAP LUNs

If your host is connected to LUNs from other vendors and any of the multipath parameter settings are overridden, you need to correct them by adding stanzas later in the `multipath.conf` file that apply specifically to ONTAP LUNs. If you don't do this, the ONTAP LUNs might not work as expected.

Check your `/etc/multipath.conf` file, especially in the defaults section, for settings that might be overriding the default settings for multipath parameters.

> ⚠ You shouldn't override the recommended parameter settings for ONTAP LUNs. These settings are required for optimal performance of your host configuration. Contact NetApp support, your OS vendor, or both for more information.

The following example shows how to correct an overridden default. In this example, the `multipath.conf` file defines values for `path_checker` and `no_path_retry` that aren't compatible with ONTAP LUNs, and you can't remove these parameters because ONTAP storage arrays are still attached to the host. Instead, you correct the values for `path_checker` and `no_path_retry` by adding a device stanza to the `multipath.conf` file that applies specifically to the ONTAP LUNs.

Show example

```
defaults {
    path_checker        readsector0
    no_path_retry       fail
}

devices {
    device {
        vendor          "NETAPP"
        product         "LUN"
        no_path_retry   queue
        path_checker    tur
    }
}
```

Step 6: Review the known issues

The Oracle Linux 7.5 host with ONTAP storage has the following known issues:

NetApp Bug ID	Title	Description
1440718	If you unmap or map a LUN without performing a SCSI rescan, it might lead to data corruption on the host.	When you set the 'disable_changed_wwids' multipath configuration parameter to YES, it disables access to the path device in the event of a WWID change. Multipath will disable access to the path device until the WWID of the path is restored to the WWID of the multipath device. To learn more, see NetApp Knowledge Base: The filesystem corruption on iSCSI LUN on the Oracle Linux 7.
1177239	Kernel disruption observed on OL7.5 with Qlogic QLE2672 16G FC during storage failover operations	During storage failover operations on Oracle Linux 7 (OL7.5) with kernel 4.1.12-112.16.4.el7uek.x86_64 and the Qlogic QLE2672 HBA, you might observe kernel disruption. This prompts a reboot of the operating system which causes an application disruption. If kdump is configured, the kernel disruption creates a vmcore file in the /var/crash/ directory. This disruption can be observed in the module "kmem_cache_alloc+118," which is logged in the vmcore file and identified with the string "exception RIP: kmem_cache_alloc+118." After a kernel disruption, you can recover by rebooting the host operating system and restarting the application.

What's next?

- Learn about using the Linux Host Utilities tool.
- Learn about ASM mirroring.

   Automatic Storage Management (ASM) mirroring might require changes to the Linux multipath settings to allow ASM to recognize a problem and switch over to an alternate failure group. Most ASM configurations on ONTAP use external redundancy, which means that data protection is provided by the external array and ASM doesn't mirror data. Some sites use ASM with normal redundancy to provide two-way mirroring, normally across different sites. See Oracle databases on ONTAP for further information.

Configure Oracle Linux 7.4 for FCP and iSCSI with ONTAP storage

The Linux Host Utilities software provides management and diagnostic tools for Linux hosts that are connected to ONTAP storage. When you install the Linux Host Utilities on

an Oracle Linux 7.4 host, you can use the Host Utilities to help you manage FCP and iSCSI protocol operations with ONTAP LUNs.

> ⓘ You don't need to manually configure Kernel-based Virtual Machine (KVM) settings because ONTAP LUNs are automatically mapped to the hypervisor.

Step 1: Optionally, enable SAN booting

You can configure your host to use SAN booting to simplify deployment and improve scalability.

Before you begin

Use the Interoperability Matrix Tool to verify that your Linux OS, host bus adapter (HBA), HBA firmware, HBA boot BIOS, and ONTAP version support SAN booting.

Steps

1. Create a SAN boot LUN and map it to the host.

2. Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is mapped.

   For information on how to enable the HBA BIOS, see your vendor-specific documentation.

3. Verify that the configuration was successful by rebooting the host and verifying that the OS is up and running.

Step 2: Install the Linux Host Utilities

NetApp strongly recommends installing the Linux Host Utilities to support ONTAP LUN management and assist technical support with gathering configuration data.

Install Linux Host Utilities 7.1.

> ⓘ Installing the Linux Host Utilities doesn't change any host timeout settings on your Linux host.

Step 3: Confirm the multipath configuration for your host

You can use multipathing with Oracle Linux 7.4 to manage ONTAP LUNs.

> ⓘ You can use the recommended settings for Red Hat Enterprise Linux (RHEL) 7.4 to configure Red Hat Compatible Kernel for Oracle Linux 7.4.

To ensure that multipathing is configured correctly for your host, verify that the `/etc/multipath.conf` file is defined and that you have the NetApp recommended settings configured for your ONTAP LUNs.

Steps

1. Verify that the `/etc/multipath.conf` file exits. If the file doesn't exist, create an empty, zero-byte file:

   ```
   touch /etc/multipath.conf
   ```

2. The first time the `multipath.conf` file is created, you might need to enable and start the multipath services to load the recommended settings:

```
chkconfig multipathd on
```

```
/etc/init.d/multipathd start
```

3. Each time you boot the host, the empty `/etc/multipath.conf` zero-byte file automatically loads the NetApp recommended host multipath parameters as the default settings. You shouldn't need to make changes to the `/etc/multipath.conf` file for your host because the operating system is compiled with the multipath parameters that recognize and manage ONTAP LUNs correctly.

The following table shows the Linux OS native compiled multipath parameter settings for ONTAP LUNs.

Show parameter settings

Parameter	Setting
detect_prio	yes
dev_loss_tmo	"infinity"
failback	immediate
fast_io_fail_tmo	5
features	"2 pg_init_retries 50"
flush_on_last_del	"yes"
hardware_handler	"0"
no_path_retry	queue
path_checker	"tur"
path_grouping_policy	"group_by_prio"
path_selector	"service-time 0"
polling_interval	5
prio	"ontap"
product	LUN
retain_attached_hw_handler	yes
rr_weight	"uniform"
user_friendly_names	no
vendor	NETAPP

4. Verify the parameter settings and path status for your ONTAP LUNs:

```
multipath -ll
```

The default multipath parameters support AFF and FAS configurations. In these configurations, a single ONTAP LUN shouldn't require more than four paths. If there are more than four paths, it might cause issues with the paths during a storage failure.

An AFF or FAS configuration should have two groups of paths with higher and lower priorities. Higher priority Active/Optimized paths are served by the controller where the aggregate is located. Lower priority paths are active but non-optimized because they are served by a different controller. Non-optimized paths are only used when optimized paths aren't available.

The following example outputs show the correct parameter settings and path status for ONTAP LUNs in an AFF or FAS configuration with two Active/Optimized paths and two Active/Non-Optimized paths:

Show example

```
multipath -ll
3600a0980383036347ffb4d59646c4436 dm-28 NETAPP,LUN C-Mode
size=10G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
|-+- policy='service-time 0' prio=50 status=active
| |- 16:0:6:35 sdwb  69:624  active ready running
| |- 16:0:5:35 sdun  66:752  active ready running
`-+- policy='service-time 0' prio=10 status=enabled
  |- 15:0:0:35 sdaj  66:48   active ready running
  |- 15:0:1:35 sdbx  68:176  active ready running
```

Step 4: Optionally, exclude a device from multipathing

If required, you can exclude a device from multipathing by adding the WWID for the unwanted device to the "blacklist" stanza for the `multipath.conf` file.

Steps

1. Determine the WWID:

   ```
   /lib/udev/scsi_id -gud /dev/sda
   ```

   "sda" is the local SCSI disk that you want to add to the blacklist.

   An example WWID is `360030057024d0730239134810c0cb833`.

2. Add the WWID to the "blacklist" stanza:

```
blacklist {
        wwid    360030057024d0730239134810c0cb833
        devnode "^(ram|raw|loop|fd|md|dm-|sr|scd|st)[0-9]*"
        devnode "^hd[a-z]"
        devnode "^cciss.*"
}
```

Step 5: Customize multipath parameters for ONTAP LUNs

If your host is connected to LUNs from other vendors and any of the multipath parameter settings are overridden, you need to correct them by adding stanzas later in the `multipath.conf` file that apply specifically to ONTAP LUNs. If you don't do this, the ONTAP LUNs might not work as expected.

Check your `/etc/multipath.conf` file, especially in the defaults section, for settings that might be overriding the default settings for multipath parameters.

> ⚠️ You shouldn't override the recommended parameter settings for ONTAP LUNs. These settings are required for optimal performance of your host configuration. Contact NetApp support, your OS vendor, or both for more information.

The following example shows how to correct an overridden default. In this example, the `multipath.conf` file defines values for `path_checker` and `no_path_retry` that aren't compatible with ONTAP LUNs, and you can't remove these parameters because ONTAP storage arrays are still attached to the host. Instead, you correct the values for `path_checker` and `no_path_retry` by adding a device stanza to the `multipath.conf` file that applies specifically to the ONTAP LUNs.

Show example

```
defaults {
    path_checker        readsector0
    no_path_retry       fail
}

devices {
    device {
        vendor          "NETAPP"
        product         "LUN"
        no_path_retry   queue
        path_checker    tur
    }
}
```

Step 6: Review the known issues

The Oracle Linux 7.4 host with ONTAP storage has the following known issues:

NetApp Bug ID	Title	Description
1440718	If you unmap or map a LUN without performing a SCSI rescan, it might lead to data corruption on the host.	When you set the 'disable_changed_wwids' multipath configuration parameter to YES, it disables access to the path device in the event of a WWID change. Multipath will disable access to the path device until the WWID of the path is restored to the WWID of the multipath device. To learn more, see NetApp Knowledge Base: The filesystem corruption on iSCSI LUN on the Oracle Linux 7.
1109468	Firmware dumps observed on an OL7.4 Hypervisor with QLE8362 card	During storage failover operations on an OL7.4 Hypervisor with QLE8362 card, the firmware dumps are observed occasionally. The firmware dumps might result in an I/O outage on the host, which might go up to 500 seconds. After the adapter completes the firmware dump, the I/O operation resumes in the normal manner. No further recovery procedure is required on the host. To indicate the firmware dump, the following message is displayed in the /var/log/message file: qla2xxx [0000:0c:00.3]-d001:8: Firmware dump saved to temp buffer (8/ffffc90008901000), dump status flags (0x3f)

What's next?

- Learn about using the Linux Host Utilities tool.
- Learn about ASM mirroring.

  Automatic Storage Management (ASM) mirroring might require changes to the Linux multipath settings to allow ASM to recognize a problem and switch over to an alternate failure group. Most ASM configurations on ONTAP use external redundancy, which means that data protection is provided by the external array and ASM doesn't mirror data. Some sites use ASM with normal redundancy to provide two-way mirroring, normally across different sites. See Oracle databases on ONTAP for further information.

Configure Oracle Linux 7.3 for FCP and iSCSI with ONTAP storage

The Linux Host Utilities software provides management and diagnostic tools for Linux hosts that are connected to ONTAP storage. When you install the Linux Host Utilities on an Oracle Linux 7.3 host, you can use the Host Utilities to help you manage FCP and iSCSI protocol operations with ONTAP LUNs.

> ⓘ   You don't need to manually configure Kernel-based Virtual Machine (KVM) settings because ONTAP LUNs are automatically mapped to the hypervisor.

Step 1: Optionally, enable SAN booting

You can configure your host to use SAN booting to simplify deployment and improve scalability.

Before you begin

Use the Interoperability Matrix Tool to verify that your Linux OS, host bus adapter (HBA), HBA firmware, HBA boot BIOS, and ONTAP version support SAN booting.

Steps

1. Create a SAN boot LUN and map it to the host.

2. Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is mapped.

   For information on how to enable the HBA BIOS, see your vendor-specific documentation.

3. Verify that the configuration was successful by rebooting the host and verifying that the OS is up and running.

Step 2: Install the Linux Host Utilities

NetApp strongly recommends installing the Linux Host Utilities to support ONTAP LUN management and assist technical support with gathering configuration data.

Install Linux Host Utilities 7.1.

> ⓘ   Installing the Linux Host Utilities doesn't change any host timeout settings on your Linux host.

Step 3: Confirm the multipath configuration for your host

You can use multipathing with Oracle Linux 7.3 to manage ONTAP LUNs.

> ⓘ   You can use the recommended settings for Red Hat Enterprise Linux (RHEL) 7.3 to configure Red Hat Compatible Kernel for Oracle Linux 7.3.

To ensure that multipathing is configured correctly for your host, verify that the `/etc/multipath.conf` file is defined and that you have the NetApp recommended settings configured for your ONTAP LUNs.

Steps

1. Verify that the `/etc/multipath.conf` file exits. If the file doesn't exist, create an empty, zero-byte file:

   ```
   touch /etc/multipath.conf
   ```

2. The first time the `multipath.conf` file is created, you might need to enable and start the multipath services to load the recommended settings:

   ```
   chkconfig multipathd on
   ```

```
/etc/init.d/multipathd start
```

3. Each time you boot the host, the empty `/etc/multipath.conf` zero-byte file automatically loads the NetApp recommended host multipath parameters as the default settings. You shouldn't need to make changes to the `/etc/multipath.conf` file for your host because the operating system is compiled with the multipath parameters that recognize and manage ONTAP LUNs correctly.

   The following table shows the Linux OS native compiled multipath parameter settings for ONTAP LUNs.

   Show parameter settings

Parameter	Setting
detect_prio	yes
dev_loss_tmo	"infinity"
failback	immediate
fast_io_fail_tmo	5
features	"2 pg_init_retries 50"
flush_on_last_del	"yes"
hardware_handler	"0"
no_path_retry	queue
path_checker	"tur"
path_grouping_policy	"group_by_prio"
path_selector	"service-time 0"
polling_interval	5
prio	"ontap"
product	LUN
retain_attached_hw_handler	yes
rr_weight	"uniform"
user_friendly_names	no
vendor	NETAPP

4. Verify the parameter settings and path status for your ONTAP LUNs:

```
multipath -ll
```

The default multipath parameters support AFF and FAS configurations. In these configurations, a single ONTAP LUN shouldn't require more than four paths. If there are more than four paths, it might cause issues with the paths during a storage failure.

An AFF or FAS configuration should have two groups of paths with higher and lower priorities. Higher priority Active/Optimized paths are served by the controller where the aggregate is located. Lower priority paths are active but non-optimized because they are served by a different controller. Non-optimized paths are only used when optimized paths aren't available.

The following example outputs show the correct parameter settings and path status for ONTAP LUNs in an AFF or FAS configuration with two Active/Optimized paths and two Active/Non-Optimized paths:

Show example

```
multipath -ll
3600a0980383036347ffb4d59646c4436 dm-28 NETAPP,LUN C-Mode
size=10G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
|-+- policy='service-time 0' prio=50 status=active
| |- 16:0:6:35 sdwb  69:624   active ready running
| |- 16:0:5:35 sdun  66:752   active ready running
`-+- policy='service-time 0' prio=10 status=enabled
  |- 15:0:0:35 sdaj  66:48    active ready running
  |- 15:0:1:35 sdbx  68:176   active ready running
```

Step 4: Optionally, exclude a device from multipathing

If required, you can exclude a device from multipathing by adding the WWID for the unwanted device to the "blacklist" stanza for the `multipath.conf` file.

Steps

1. Determine the WWID:

```
/lib/udev/scsi_id -gud /dev/sda
```

"sda" is the local SCSI disk that you want to add to the blacklist.

An example WWID is `360030057024d0730239134810c0cb833`.

2. Add the WWID to the "blacklist" stanza:

```
blacklist {
        wwid    360030057024d0730239134810c0cb833
        devnode "^(ram|raw|loop|fd|md|dm-|sr|scd|st)[0-9]*"
        devnode "^hd[a-z]"
        devnode "^cciss.*"
}
```

Step 5: Customize multipath parameters for ONTAP LUNs

If your host is connected to LUNs from other vendors and any of the multipath parameter settings are overridden, you need to correct them by adding stanzas later in the `multipath.conf` file that apply specifically to ONTAP LUNs. If you don't do this, the ONTAP LUNs might not work as expected.

Check your `/etc/multipath.conf` file, especially in the defaults section, for settings that might be overriding the default settings for multipath parameters.

> ⚠️ You shouldn't override the recommended parameter settings for ONTAP LUNs. These settings are required for optimal performance of your host configuration. Contact NetApp support, your OS vendor, or both for more information.

The following example shows how to correct an overridden default. In this example, the `multipath.conf` file defines values for `path_checker` and `no_path_retry` that aren't compatible with ONTAP LUNs, and you can't remove these parameters because ONTAP storage arrays are still attached to the host. Instead, you correct the values for `path_checker` and `no_path_retry` by adding a device stanza to the `multipath.conf` file that applies specifically to the ONTAP LUNs.

Show example

```
defaults {
    path_checker        readsector0
    no_path_retry       fail
}

devices {
    device {
        vendor          "NETAPP"
        product         "LUN"
        no_path_retry   queue
        path_checker    tur
    }
}
```

Step 6: Review the known issues

There are no known issues.

What's next?

- Learn about using the Linux Host Utilities tool.

- Learn about ASM mirroring.

  Automatic Storage Management (ASM) mirroring might require changes to the Linux multipath settings to allow ASM to recognize a problem and switch over to an alternate failure group. Most ASM configurations on ONTAP use external redundancy, which means that data protection is provided by the external array and ASM doesn't mirror data. Some sites use ASM with normal redundancy to provide two-way mirroring, normally across different sites. See Oracle databases on ONTAP for further information.

Configure Oracle Linux 7.2 for FCP and iSCSI with ONTAP storage

The Linux Host Utilities software provides management and diagnostic tools for Linux hosts that are connected to ONTAP storage. When you install the Linux Host Utilities on an Oracle Linux 7.2 host, you can use the Host Utilities to help you manage FCP and iSCSI protocol operations with ONTAP LUNs.

> ℹ️ You don't need to manually configure Kernel-based Virtual Machine (KVM) settings because ONTAP LUNs are automatically mapped to the hypervisor.

Step 1: Optionally, enable SAN booting

You can configure your host to use SAN booting to simplify deployment and improve scalability.

Before you begin

Use the Interoperability Matrix Tool to verify that your Linux OS, host bus adapter (HBA), HBA firmware, HBA boot BIOS, and ONTAP version support SAN booting.

Steps

1. Create a SAN boot LUN and map it to the host.

2. Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is mapped.

   For information on how to enable the HBA BIOS, see your vendor-specific documentation.

3. Verify that the configuration was successful by rebooting the host and verifying that the OS is up and running.

Step 2: Install the Linux Host Utilities

NetApp strongly recommends installing the Linux Host Utilities to support ONTAP LUN management and assist technical support with gathering configuration data.

Install Linux Host Utilities 7.1.

> ℹ️ Installing the Linux Host Utilities doesn't change any host timeout settings on your Linux host.

Step 3: Confirm the multipath configuration for your host

You can use multipathing with Oracle Linux 7.2 to manage ONTAP LUNs. Oracle Linux 7.2 supports Unbreakable Enterprise Kernel (UEK) R3 and UEK R4. The OS boots with UEK R3 kernel by default

> ℹ️ You can use the recommended settings for Red Hat Enterprise Linux (RHEL) 7.2 to configure Red Hat Compatible Kernel for Oracle Linux 7.2.

Steps

Depending on your configuration, select the UEK 3 or UEK 4 tab.

UEK 3

The settings for Oracle Linux UEK 3 with and without ALUA update automatically. After the settings update, you need to enable "ALUA Handler":

1. Create a backup of the initrd-image.

2. Append the following parameter value to the kernel for ALUA and non-ALUA to work:

```
rdloaddriver=scsi_dh_alua
```

Example output

```
kernel /vmlinuz-3.8.13-68.1.2.el6uek.x86_64 ro
root=/dev/mapper/vg_ibmx3550m421096-lv_root
rd_NO_LUKSrd_LVM_LV=vg_ibmx3550m421096/lv_root LANG=en_US.UTF-8
rd_NO_MDSYSFONT=latarcyrheb-sun16 crashkernel=256M KEYBOARDTYPE=pc
KEYTABLE=us rd_LVM_LV=vg_ibmx3550m421096/lv_swap rd_NO_DM rhgb quiet
rdloaddriver=scsi_dh_alua
```

3. Recreate the initrd-image:

```
dracut -f
```

4. Reboot the host.

5. Review the output of the `cat /proc/cmdline` command to verify that the setting is complete.

UEK 4

For Oracle Linux UEK 4, verify that the `/etc/multipath.conf` file is defined and that the NetApp recommended settings are configured for your ONTAP LUNs.

1. Verify that the `/etc/multipath.conf` file exits. If the file doesn't exist, create an empty, zero-byte file:

```
touch /etc/multipath.conf
```

2. The first time the `multipath.conf` file is created, you might need to enable and start the multipath services to load the recommended settings:

```
chkconfig multipathd on
```

```
/etc/init.d/multipathd start
```

3. Each time you boot the host, the empty `/etc/multipath.conf` zero-byte file automatically loads the NetApp recommended host multipath parameters as the default settings. You shouldn't need to make changes to the `/etc/multipath.conf` file for your host because the operating system is compiled with the multipath parameters that recognize and manage ONTAP LUNs correctly.

Show parameter settings

Parameter	Setting
detect_prio	yes
dev_loss_tmo	"infinity"
failback	immediate
fast_io_fail_tmo	5
features	"2 pg_init_retries 50"
flush_on_last_del	"yes"
hardware_handler	"0"
no_path_retry	queue
path_checker	"tur"
path_grouping_policy	"group_by_prio"
path_selector	"service-time 0"
polling_interval	5
prio	"ontap"
product	LUN
retain_attached_hw_handler	yes
rr_weight	"uniform"
user_friendly_names	no
vendor	NETAPP

4. Verify the parameter settings and path status for your ONTAP LUNs:

```
multipath -ll
```

The default multipath parameters support AFF and FAS configurations. In these configurations, a single ONTAP LUN shouldn't require more than four paths. If there are more than four paths, it might cause issues with the paths during a storage failure.

An AFF or FAS configuration should have two groups of paths with higher and lower priorities. Higher priority Active/Optimized paths are served by the controller where the aggregate is located. Lower priority paths are active but non-optimized because they are served by a different controller. Non-optimized paths are only used when optimized paths aren't available.

The following example outputs show the correct parameter settings and path status for ONTAP LUNs

in an AFF or FAS configuration with two Active/Optimized paths and two Active/Non-Optimized paths:

Show example

```
multipath -ll
3600a0980383036347ffb4d59646c4436 dm-28 NETAPP,LUN C-Mode
size=10G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
|-+- policy='service-time 0' prio=50 status=active
| |- 16:0:6:35 sdwb  69:624  active ready running
| |- 16:0:5:35 sdun  66:752  active ready running
`-+- policy='service-time 0' prio=10 status=enabled
  |- 15:0:0:35 sdaj  66:48   active ready running
  |- 15:0:1:35 sdbx  68:176  active ready running
```

Step 4: Optionally, exclude a device from multipathing

If required, you can exclude a device from multipathing by adding the WWID for the unwanted device to the "blacklist" stanza for the `multipath.conf` file.

Steps

1. Determine the WWID:

   ```
   /lib/udev/scsi_id -gud /dev/sda
   ```

   "sda" is the local SCSI disk that you want to add to the blacklist.

   An example WWID is `360030057024d0730239134810c0cb833`.

2. Add the WWID to the "blacklist" stanza:

   ```
   blacklist {
           wwid   360030057024d0730239134810c0cb833
           devnode "^(ram|raw|loop|fd|md|dm-|sr|scd|st)[0-9]*"
           devnode "^hd[a-z]"
           devnode "^cciss.*"
   }
   ```

Step 5: Customize multipath parameters for ONTAP LUNs

If your host is connected to LUNs from other vendors and any of the multipath parameter settings are overridden, you need to correct them by adding stanzas later in the `multipath.conf` file that apply specifically to ONTAP LUNs. If you don't do this, the ONTAP LUNs might not work as expected.

Check your `/etc/multipath.conf` file, especially in the defaults section, for settings that might be overriding the default settings for multipath parameters.

> ⚠️ You shouldn't override the recommended parameter settings for ONTAP LUNs. These settings are required for optimal performance of your host configuration. Contact NetApp support, your OS vendor, or both for more information.

The following example shows how to correct an overridden default. In this example, the `multipath.conf` file defines values for `path_checker` and `no_path_retry` that aren't compatible with ONTAP LUNs, and you can't remove these parameters because ONTAP storage arrays are still attached to the host. Instead, you correct the values for `path_checker` and `no_path_retry` by adding a device stanza to the `multipath.conf` file that applies specifically to the ONTAP LUNs.

Show example

```
defaults {
    path_checker        readsector0
    no_path_retry       fail
}

devices {
    device {
        vendor          "NETAPP"
        product         "LUN"
        no_path_retry   queue
        path_checker    tur
    }
}
```

Step 6: Review the known issues

There are no known issues.

What's next?

- Learn about using the Linux Host Utilities tool.
- Learn about ASM mirroring.

  Automatic Storage Management (ASM) mirroring might require changes to the Linux multipath settings to allow ASM to recognize a problem and switch over to an alternate failure group. Most ASM configurations on ONTAP use external redundancy, which means that data protection is provided by the external array and ASM doesn't mirror data. Some sites use ASM with normal redundancy to provide two-way mirroring, normally across different sites. See Oracle databases on ONTAP for further information.

Configure Oracle Linux 7.1 for FCP and iSCSI with ONTAP storage

The Linux Host Utilities software provides management and diagnostic tools for Linux hosts that are connected to ONTAP storage. When you install the Linux Host Utilities on

an Oracle Linux 7.1 host, you can use the Host Utilities to help you manage FCP and iSCSI protocol operations with ONTAP LUNs.

> ⓘ You don't need to manually configure Kernel-based Virtual Machine (KVM) settings because ONTAP LUNs are automatically mapped to the hypervisor.

Step 1: Optionally, enable SAN booting

You can configure your host to use SAN booting to simplify deployment and improve scalability.

Before you begin

Use the Interoperability Matrix Tool to verify that your Linux OS, host bus adapter (HBA), HBA firmware, HBA boot BIOS, and ONTAP version support SAN booting.

Steps

1. Create a SAN boot LUN and map it to the host.

2. Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is mapped.

   For information on how to enable the HBA BIOS, see your vendor-specific documentation.

3. Verify that the configuration was successful by rebooting the host and verifying that the OS is up and running.

Step 2: Install the Linux Host Utilities

NetApp strongly recommends installing the Linux Host Utilities to support ONTAP LUN management and assist technical support with gathering configuration data.

Install Linux Host Utilities 7.1.

> ⓘ Installing the Linux Host Utilities doesn't change any host timeout settings on your Linux host.

Step 3: Confirm the multipath configuration for your host

You can use multipathing with Oracle Linux 7.1 to manage ONTAP LUNs. Oracle Linux 7.1 supports Unbreakable Enterprise Kernel (UEK) R3 and UEK R4. The OS boots with UEK R3 kernel by default.

> ⓘ You can use the recommended settings for Red Hat Enterprise Linux (RHEL) 7.1 to configure Red Hat Compatible Kernel for Oracle Linux 7.1.

Steps

Depending on your configuration, select the UEK 3 or UEK 4 tab.

UEK 3

The settings for Oracle Linux UEK 3 with and without ALUA update automatically. After the settings update, you need to enable "ALUA Handler":

1. Create a backup of the initrd-image.

2. Append the following parameter value to the kernel for ALUA and non-ALUA to work:

```
rdloaddriver=scsi_dh_alua
```

Example output

```
kernel /vmlinuz-3.8.13-68.1.2.el6uek.x86_64 ro
root=/dev/mapper/vg_ibmx3550m421096-lv_root
rd_NO_LUKSrd_LVM_LV=vg_ibmx3550m421096/lv_root LANG=en_US.UTF-8
rd_NO_MDSYSFONT=latarcyrheb-sun16 crashkernel=256M KEYBOARDTYPE=pc
KEYTABLE=us rd_LVM_LV=vg_ibmx3550m421096/lv_swap rd_NO_DM rhgb quiet
rdloaddriver=scsi_dh_alua
```

3. Recreate the initrd-image:

```
dracut -f
```

4. Reboot the host.

5. Review the output of the `cat /proc/cmdline` command to verify that the setting is complete.

UEK 4

For Oracle Linux UEK 4, verify that the `/etc/multipath.conf` file is defined and that the NetApp recommended settings are configured for your ONTAP LUNs.

1. Verify that the `/etc/multipath.conf` file exits. If the file doesn't exist, create an empty, zero-byte file:

```
touch /etc/multipath.conf
```

2. The first time the `multipath.conf` file is created, you might need to enable and start the multipath services to load the recommended settings:

```
chkconfig multipathd on
```

```
/etc/init.d/multipathd start
```

3. Each time you boot the host, the empty `/etc/multipath.conf` zero-byte file automatically loads the NetApp recommended host multipath parameters as the default settings. You shouldn't need to make changes to the `/etc/multipath.conf` file for your host because the operating system is compiled with the multipath parameters that recognize and manage ONTAP LUNs correctly.

Show parameter settings

Parameter	Setting
detect_prio	yes
dev_loss_tmo	"infinity"
failback	immediate
fast_io_fail_tmo	5
features	"2 pg_init_retries 50"
flush_on_last_del	"yes"
hardware_handler	"0"
no_path_retry	queue
path_checker	"tur"
path_grouping_policy	"group_by_prio"
path_selector	"service-time 0"
polling_interval	5
prio	"ontap"
product	LUN
retain_attached_hw_handler	yes
rr_weight	"uniform"
user_friendly_names	no
vendor	NETAPP

4. Verify the parameter settings and path status for your ONTAP LUNs:

```
multipath -ll
```

The default multipath parameters support AFF and FAS configurations. In these configurations, a single ONTAP LUN shouldn't require more than four paths. If there are more than four paths, it might cause issues with the paths during a storage failure.

An AFF or FAS configuration should have two groups of paths with higher and lower priorities. Higher priority Active/Optimized paths are served by the controller where the aggregate is located. Lower priority paths are active but non-optimized because they are served by a different controller. Non-optimized paths are only used when optimized paths aren't available.

The following example outputs show the correct parameter settings and path status for ONTAP LUNs

in an AFF or FAS configuration with two Active/Optimized paths and two Active/Non-Optimized paths:

Show example

```
multipath -ll
3600a0980383036347ffb4d59646c4436 dm-28 NETAPP,LUN C-Mode
size=10G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
|-+- policy='service-time 0' prio=50 status=active
| |- 16:0:6:35 sdwb  69:624  active ready running
| |- 16:0:5:35 sdun  66:752  active ready running
`-+- policy='service-time 0' prio=10 status=enabled
  |- 15:0:0:35 sdaj  66:48   active ready running
  |- 15:0:1:35 sdbx  68:176  active ready running
```

Step 4: Optionally, exclude a device from multipathing

If required, you can exclude a device from multipathing by adding the WWID for the unwanted device to the "blacklist" stanza for the `multipath.conf` file.

Steps

1. Determine the WWID:

   ```
   /lib/udev/scsi_id -gud /dev/sda
   ```

   "sda" is the local SCSI disk that you want to add to the blacklist.

   An example WWID is `360030057024d0730239134810c0cb833`.

2. Add the WWID to the "blacklist" stanza:

   ```
   blacklist {
           wwid   360030057024d0730239134810c0cb833
         devnode "^(ram|raw|loop|fd|md|dm-|sr|scd|st)[0-9]*"
         devnode "^hd[a-z]"
         devnode "^cciss.*"
   }
   ```

Step 5: Customize multipath parameters for ONTAP LUNs

If your host is connected to LUNs from other vendors and any of the multipath parameter settings are overridden, you need to correct them by adding stanzas later in the `multipath.conf` file that apply specifically to ONTAP LUNs. If you don't do this, the ONTAP LUNs might not work as expected.

Check your `/etc/multipath.conf` file, especially in the defaults section, for settings that might be overriding the default settings for multipath parameters.

> ⚠️ You shouldn't override the recommended parameter settings for ONTAP LUNs. These settings are required for optimal performance of your host configuration. Contact NetApp support, your OS vendor, or both for more information.

The following example shows how to correct an overridden default. In this example, the `multipath.conf` file defines values for `path_checker` and `no_path_retry` that aren't compatible with ONTAP LUNs, and you can't remove these parameters because ONTAP storage arrays are still attached to the host. Instead, you correct the values for `path_checker` and `no_path_retry` by adding a device stanza to the `multipath.conf` file that applies specifically to the ONTAP LUNs.

Show example

```
defaults {
    path_checker        readsector0
    no_path_retry       fail
}

devices {
    device {
        vendor          "NETAPP"
        product         "LUN"
        no_path_retry   queue
        path_checker    tur
    }
}
```

Step 6: Review the known issues

There are no known issues.

What's next?

- Learn about using the Linux Host Utilities tool.
- Learn about ASM mirroring.

  Automatic Storage Management (ASM) mirroring might require changes to the Linux multipath settings to allow ASM to recognize a problem and switch over to an alternate failure group. Most ASM configurations on ONTAP use external redundancy, which means that data protection is provided by the external array and ASM doesn't mirror data. Some sites use ASM with normal redundancy to provide two-way mirroring, normally across different sites. See Oracle databases on ONTAP for further information.

Configure Oracle Linux 7.0 for FCP and iSCSI with ONTAP storage

The Linux Host Utilities software provides management and diagnostic tools for Linux hosts that are connected to ONTAP storage. When you install the Linux Host Utilities on

an Oracle Linux 7.0 host, you can use the Host Utilities to help you manage FCP and iSCSI protocol operations with ONTAP LUNs.

> ⓘ You don't need to manually configure Kernel-based Virtual Machine (KVM) settings because ONTAP LUNs are automatically mapped to the hypervisor.

Step 1: Optionally, enable SAN booting

You can configure your host to use SAN booting to simplify deployment and improve scalability.

Before you begin

Use the Interoperability Matrix Tool to verify that your Linux OS, host bus adapter (HBA), HBA firmware, HBA boot BIOS, and ONTAP version support SAN booting.

Steps

1. Create a SAN boot LUN and map it to the host.

2. Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is mapped.

   For information on how to enable the HBA BIOS, see your vendor-specific documentation.

3. Verify that the configuration was successful by rebooting the host and verifying that the OS is up and running.

Step 2: Install the Linux Host Utilities

NetApp strongly recommends installing the Linux Host Utilities to support ONTAP LUN management and assist technical support with gathering configuration data.

Install Linux Host Utilities 7.1.

> ⓘ Installing the Linux Host Utilities doesn't change any host timeout settings on your Linux host.

Step 3: Confirm the multipath configuration for your host

You can use multipathing with Oracle Linux 7.0 to manage ONTAP LUNs. Oracle Linux 7.0 supports Unbreakable Enterprise Kernel (UEK) R3 and UEK R4. The OS boots with UEK R3 kernel by default

> ⓘ You can use the recommended settings for Red Hat Enterprise Linux (RHEL) 7.0 to configure Red Hat Compatible Kernel for Oracle Linux 7.0.

Steps

Depending on your configuration, select the UEK 3 or UEK 4 tab.

UEK 3

The settings for Oracle Linux UEK 3 with and without ALUA update automatically. After the settings update, you need to enable "ALUA Handler":

1. Create a backup of the initrd-image.

2. Append the following parameter value to the kernel for ALUA and non-ALUA to work:

```
rdloaddriver=scsi_dh_alua
```

Example output

```
kernel /vmlinuz-3.8.13-68.1.2.el6uek.x86_64 ro
root=/dev/mapper/vg_ibmx3550m421096-lv_root
rd_NO_LUKSrd_LVM_LV=vg_ibmx3550m421096/lv_root LANG=en_US.UTF-8
rd_NO_MDSYSFONT=latarcyrheb-sun16 crashkernel=256M KEYBOARDTYPE=pc
KEYTABLE=us rd_LVM_LV=vg_ibmx3550m421096/lv_swap rd_NO_DM rhgb quiet
rdloaddriver=scsi_dh_alua
```

3. Recreate the initrd-image:

```
dracut -f
```

4. Reboot the host.

5. Review the output of the `cat /proc/cmdline` command to verify that the setting is complete.

UEK 4

For Oracle Linux UEK 4, verify that the `/etc/multipath.conf` file is defined and that the NetApp recommended settings are configured for your ONTAP LUNs.

1. Verify that the `/etc/multipath.conf` file exits. If the file doesn't exist, create an empty, zero-byte file:

```
touch /etc/multipath.conf
```

2. The first time the `multipath.conf` file is created, you might need to enable and start the multipath services to load the recommended settings:

```
chkconfig multipathd on
```

```
/etc/init.d/multipathd start
```

3. Each time you boot the host, the empty `/etc/multipath.conf` zero-byte file automatically loads the NetApp recommended host multipath parameters as the default settings. You shouldn't need to make changes to the `/etc/multipath.conf` file for your host because the operating system is compiled with the multipath parameters that recognize and manage ONTAP LUNs correctly.

Show parameter settings

Parameter	Setting
detect_prio	yes
dev_loss_tmo	"infinity"
failback	immediate
fast_io_fail_tmo	5
features	"2 pg_init_retries 50"
flush_on_last_del	"yes"
hardware_handler	"0"
no_path_retry	queue
path_checker	"tur"
path_grouping_policy	"group_by_prio"
path_selector	"service-time 0"
polling_interval	5
prio	"ontap"
product	LUN
retain_attached_hw_handler	yes
rr_weight	"uniform"
user_friendly_names	no
vendor	NETAPP

4. Verify the parameter settings and path status for your ONTAP LUNs:

```
multipath -ll
```

The default multipath parameters support AFF and FAS configurations. In these configurations, a single ONTAP LUN shouldn't require more than four paths. If there are more than four paths, it might cause issues with the paths during a storage failure.

An AFF or FAS configuration should have two groups of paths with higher and lower priorities. Higher priority Active/Optimized paths are served by the controller where the aggregate is located. Lower priority paths are active but non-optimized because they are served by a different controller. Non-optimized paths are only used when optimized paths aren't available.

The following example outputs show the correct parameter settings and path status for ONTAP LUNs

in an AFF or FAS configuration with two Active/Optimized paths and two Active/Non-Optimized paths:

Show example

```
multipath -ll
3600a0980383036347ffb4d59646c4436 dm-28 NETAPP,LUN C-Mode
size=10G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
|-+- policy='service-time 0' prio=50 status=active
| |- 16:0:6:35 sdwb  69:624  active ready running
| |- 16:0:5:35 sdun  66:752  active ready running
`-+- policy='service-time 0' prio=10 status=enabled
  |- 15:0:0:35 sdaj  66:48   active ready running
  |- 15:0:1:35 sdbx  68:176  active ready running
```

Step 4: Optionally, exclude a device from multipathing

If required, you can exclude a device from multipathing by adding the WWID for the unwanted device to the "blacklist" stanza for the `multipath.conf` file.

Steps

1. Determine the WWID:

   ```
   /lib/udev/scsi_id -gud /dev/sda
   ```

   "sda" is the local SCSI disk that you want to add to the blacklist.

   An example WWID is `360030057024d0730239134810c0cb833`.

2. Add the WWID to the "blacklist" stanza:

   ```
   blacklist {
           wwid   360030057024d0730239134810c0cb833
         devnode "^(ram|raw|loop|fd|md|dm-|sr|scd|st)[0-9]*"
         devnode "^hd[a-z]"
         devnode "^cciss.*"
   }
   ```

Step 5: Customize multipath parameters for ONTAP LUNs

If your host is connected to LUNs from other vendors and any of the multipath parameter settings are overridden, you need to correct them by adding stanzas later in the `multipath.conf` file that apply specifically to ONTAP LUNs. If you don't do this, the ONTAP LUNs might not work as expected.

Check your `/etc/multipath.conf` file, especially in the defaults section, for settings that might be overriding the default settings for multipath parameters.

> ⚠️ You shouldn't override the recommended parameter settings for ONTAP LUNs. These settings are required for optimal performance of your host configuration. Contact NetApp support, your OS vendor, or both for more information.

The following example shows how to correct an overridden default. In this example, the `multipath.conf` file defines values for `path_checker` and `no_path_retry` that aren't compatible with ONTAP LUNs, and you can't remove these parameters because ONTAP storage arrays are still attached to the host. Instead, you correct the values for `path_checker` and `no_path_retry` by adding a device stanza to the `multipath.conf` file that applies specifically to the ONTAP LUNs.

Show example

```
defaults {
    path_checker        readsector0
    no_path_retry       fail
}

devices {
    device {
        vendor          "NETAPP"
        product         "LUN"
        no_path_retry   queue
        path_checker    tur
    }
}
```

Step 6: Review the known issues

The Oracle Linux 7.0 host with ONTAP storage has the following known issues:

NetApp Bug ID	Title	Description
901558	OL7.0 : Host loses all paths to the lun and hangs due to "RSCN timeout" error on OL 7.0 UEK r3U5 Beta on Emulex 8G(LPe12002) host	You might observe that the Emulex 8G(LPe12002) host hangs and there is a high I/O outage during storage failover operations with I/O. You might observe paths not recovering, which is a result of the RSCN timeout, due to which the host loses all the paths and hangs. Probability of hitting this issue is high.

NetApp Bug ID	Title	Description
901557	OL 7.0: High I/O outage observed on QLogic 8G FC (QLE2562) SAN host during storage failover operations with I/O	You might observe high I/O outage on QLogic 8G FC (QLE2562) host during storage failover operations with I/O. Aborts and Device resets manifests as I/O outage on the host. Probability of hitting this I/O outage is high.
894766	OL7.0: Dracut fails to include scsi_dh_alua.ko module in initramfs on UEKR3U5 alpha	The scsi_dh_alua module might not load even after adding the parameter "rdloaddriver=scsi_dh_alua" in the kernel command line and creating Dracut. As a result, ALUA is not enabled for NetApp LUNs as recommended.
894796	Anaconda displays an iSCSI login failure message although logins are successful during OL 7.0 OS installation	When you are installing OL 7.0, the anaconda installation screen displays that iSCSI login to multiple target IPs have failed though the iSCSI logins are successful. Anaconda displays following error message: "Node Login Failed" You will observe this error only when you select multiple target IPs for iSCSI login. You can continue the OS installation by clicking the "ok" button. This bug does not hamper either the iSCSI or the OL 7.0 OS installation.
894771	OL7.0 : Anaconda does not add bootdev argument in kernel cmd line to set IP address for iSCSI SANboot OS install	Anaconda does not add a bootdev argument in the kernel command line where you set the IPv4 address during the OL 7.0 OS installation on an iSCSI multipath'd LUN. Owing to this, you cannot assign IP addresses to any of the Ethernet interfaces that were configured to establish iSCSI sessions with the storage subsystem during the OL 7.0 boot. Since iSCSI sessions are not established, the root LUN is not discovered when the OS boots and hence the OS boot fails.

NetApp Bug ID	Title	Description
916501	Qlogic 10G FCoE (QLE8152) host kernel crash observed during storage failover operations with I/O	You might observe a kernel crash in Qlogic driver module on 10G FCoE Qlogic (QLE8152) host. The crash occurs during storage failover operations with I/O. Probability of hitting this crash is high which leads to longer I/O outage on the host.

What's next?

- Learn about using the Linux Host Utilities tool.

- Learn about ASM mirroring.

  Automatic Storage Management (ASM) mirroring might require changes to the Linux multipath settings to allow ASM to recognize a problem and switch over to an alternate failure group. Most ASM configurations on ONTAP use external redundancy, which means that data protection is provided by the external array and ASM doesn't mirror data. Some sites use ASM with normal redundancy to provide two-way mirroring, normally across different sites. See Oracle databases on ONTAP for further information.

Oracle Linux 6

Use Oracle Linux 6.10 with ONTAP

You can use the ONTAP SAN host configuration settings to configure Oracle Linux 6.10 with ONTAP as the target.

Install the Linux Host Utilities

The NetApp Linux Host Utilities software package is available on the NetApp Support Site in a 32-bit and 64-bit .rpm file. If you don't know which file is right for your configuration, use the Interoperability Matrix Tool to verify which one you need.

NetApp strongly recommends installing the Linux Host Utilities, but it's not mandatory. The utilities don't change any settings on your Linux host. The utilities improve management and assist NetApp customer support in gathering information about your configuration.

If you have Linux Host Utilities currently installed, you should either upgrade it to the latest version, or remove it and follow these steps to install the latest version.

Steps

1. Download the 32-bit or 64-bit Linux Host Utilities software package from the NetApp Support Site to your host.

2. Install the software package:

   ```
   rpm -ivh netapp_linux_unified_host_utilities-7-1.x86_64
   ```

> You can use the configuration settings provided in this procedure to configure cloud clients connected to Cloud Volumes ONTAP and Amazon FSx for ONTAP.

SAN Toolkit

The toolkit is installed automatically when you install the NetApp Host Utilities package. This kit provides the `sanlun` utility, which helps you manage LUNs and HBAs. The `sanlun` command returns information about the LUNs mapped to your host, multipathing, and information necessary to create initiator groups.

Example

In the following example, the `sanlun lun show` command returns LUN information.

```
# sanlun lun show all
```

Example output:

```
controller(7mode/E-Series)/                 device      host                    lun
vserver(cDOT/FlashRay)    lun-pathname    filename    adapter   protocol   size
Product
-------------------------------------------------------------------------
----------
data_vserver              /vol/vol1/lun1   /dev/sdb    host16    FCP
120.0g  cDOT
data_vserver              /vol/vol1/lun1   /dev/sdc    host15    FCP
120.0g  cDOT
data_vserver              /vol/vol2/lun2   /dev/sdd    host16    FCP
120.0g  cDOT
data_vserver              /vol/vol2/lun2   /dev/sde    host15    FCP
120.0g  cDOT
```

SAN Booting

Before you begin

If you decide to use SAN booting, it must be supported by your configuration. You can use the Interoperability Matrix Tool to verify that your OS, HBA, HBA firmware and the HBA boot BIOS, and ONTAP version are supported.

Steps

1. Map the SAN boot LUN to the host.

2. Verify that multiple paths are available.

   > ⓘ Multiple paths become available after the host OS is up and running on the paths.

3. Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is mapped.

   For information on how to enable the HBA BIOS, see your vendor-specific documentation.

4. Reboot the host to verify that the boot was successful.

Multipathing

For Oracle Linux 6.10 the /etc/multipath.conf file must exist, but you do not need to make specific changes to the file. Oracle Linux 6.10 is compiled with all settings required to recognize and correctly manage ONTAP LUNs.
To Enable ALUA Handler, perform the following steps:

Steps

1. Create a backup of the initrd-image.

2. Append the following parameter value to the kernel for ALUA and non-ALUA to work:
   `rdloaddriver=scsi_dh_alua`

   Example

   ```
   kernel /vmlinuz-3.8.13-68.1.2.el6uek.x86_64 ro
   root=/dev/mapper/vg_ibmx3550m421096-lv_root
   rd_NO_LUKSrd_LVM_LV=vg_ibmx3550m421096/lv_root LANG=en_US.UTF-8
   rd_NO_MDSYSFONT=latarcyrheb-sun16 crashkernel=256M KEYBOARDTYPE=pc
   KEYTABLE=us rd_LVM_LV=vg_ibmx3550m421096/lv_swap rd_NO_DM rhgb quiet
   rdloaddriver=scsi_dh_alua
   ```

3. Use the `mkinitrd` command to recreate the initrd-image.
   Oracle 6x and later versions use either:
   The command: `mkinitrd -f /boot/ initrd-"uname -r".img uname -r`
   Or
   The command: `dracut -f`

4. Reboot the host.

5. Verify the output of the `cat /proc/cmdline` command to ensure that the setting is complete.
   You can use the `multipath -ll` command to verify the settings for your ONTAP LUNs.
   There should be two groups of paths with different priorities. The paths with higher priorities are Active/Optimized. This means they are serviced by the controller where the aggregate is located. The paths with lower priorities are active but non-optimized because they are served from a different controller. The non-optimized paths are only used when optimized paths are not available.

Example

The following example displays the correct output for an ONTAP LUN with two Active/Optimized paths and two Active/Non-Optimized paths:

```
# multipath -ll
3600a09803831347657244e527766394e dm-5 NETAPP,LUN C-Mode
size=80G features='4 queue_if_no_path pg_init_retries 50
retain_attached_hw_handle' hwhandler='1 alua' wp=rw
|-+- policy='round-robin 0' prio=50 status=active
| |- 0:0:26:37 sdje 8:384   active ready running
| |- 0:0:25:37 sdik 135:64  active ready running
`-+- policy='round-robin 0' prio=10 status=enabled
  |- 0:0:18:37 sdda 70:128  active ready running
  |- 0:0:19:37 sddu 71:192  active ready running
```

> ⓘ A single LUN shouldn't require more than four paths. Having more than four paths might cause path issues during storage failures.

Recommended Settings

The Oracle Linux 6.10 OS is compiled to recognize ONTAP LUNs and automatically set all configuration parameters correctly.

The `multipath.conf` file must exist for the multipath daemon to start. If this file doesn't exist, you can create an empty, zero-byte file by using the `touch /etc/multipath.conf` command.

The first time you create the `multipath.conf` file, you might need to enable and start the multipath services by using the following commands:

```
# chkconfig multipathd on
# /etc/init.d/multipathd start
```

There is no requirement to add devices directly to the `multipath.conf` file, unless you have devices that you do not want multipath to manage or you have existing settings that override defaults. To exclude the unwanted devices, you add the following syntax to the `multipath.conf` file, replacing <DevId> with the WWID string of the device you want to exclude:

```
blacklist {
        wwid <DevId>
        devnode "^(ram|raw|loop|fd|md|dm-|sr|scd|st)[0-9]*"
        devnode "^hd[a-z]"
        devnode "^cciss.*"
}
```

Example

In the following example, `sda` is the local SCSI disk that you want to add to the blacklist.

Steps

1. Run the following command to determine the WWID:

```
# /lib/udev/scsi_id -gud /dev/sda
360030057024d0730239134810c0cb833
```

2. Add this WWID to the "blacklist" stanza in `/etc/multipath.conf`:

```
blacklist {
     wwid    360030057024d0730239134810c0cb833
     devnode "^(ram|raw|loop|fd|md|dm-|sr|scd|st)[0-9]*"
     devnode "^hd[a-z]"
     devnode "^cciss.*"
}
```

You should always check your `/etc/multipath.conf` file, especially in the defaults section, for legacy settings that might be overriding default settings.

The following table demonstrates the critical `multipathd` parameters for ONTAP LUNs and the required values. If a host is connected to LUNs from other vendors and any of these parameters are overridden, they must be corrected by later stanzas in the `multipath.conf` file that apply specifically to ONTAP LUNs. Without this correction, the ONTAP LUNs might not work as expected. You should only override these defaults in consultation with NetApp, the OS vendor, or both, and only when the impact is fully understood.

Parameter	Setting
detect_prio	yes
dev_loss_tmo	"infinity"
failback	immediate
fast_io_fail_tmo	5
features	"3 queue_if_no_path pg_init_retries 50"
flush_on_last_del	"yes"
hardware_handler	"0"
no_path_retry	queue
path_checker	"tur"
path_grouping_policy	"group_by_prio"
path_selector	"round-robin 0"
polling_interval	5
prio	"ontap"
product	LUN.*
retain_attached_hw_handler	yes
rr_weight	"uniform"

Parameter	Setting
user_friendly_names	no
vendor	NETAPP

Example

The following example shows how to correct an overridden default. In this case, the `multipath.conf` file defines values for `path_checker` and `detect_prio` that are not compatible with ONTAP LUNs.
If they cannot be removed because of other SAN arrays still attached to the host, these parameters can be corrected specifically for ONTAP LUNs with a device stanza.

```
defaults {
 path_checker readsector0
 detect_prio no
 }
devices {
 device {
 vendor "NETAPP "
 product "LUN.*"
 path_checker tur
 detect_prio yes
 }
}
```

> ⓘ To configure Oracle Linux 6.10 Red Hat Compatible Kernel (RHCK), use the recommended settings for Red Hat Enterprise Linux (RHEL) 6.10.

Known issues

There are no known issues for the Oracle Linux 6.10 with ONTAP release.

> ⓘ For Oracle Linux RHCK known issues, see the known issues for RHEL 6.10.

Use Oracle Linux 6.9 with ONTAP

You can use the ONTAP SAN host configuration settings to configure Oracle Linux 6.9 with ONTAP as the target.

Install the Linux Host Utilities

The NetApp Linux Host Utilities software package is available on the NetApp Support Site in a 32-bit and 64-bit .rpm file. If you don't know which file is right for your configuration, use the Interoperability Matrix Tool to verify which one you need.

NetApp strongly recommends installing the Linux Host Utilities, but it's not mandatory. The utilities don't change any settings on your Linux host. The utilities improve management and assist NetApp customer support in gathering information about your configuration.

If you have Linux Host Utilities currently installed, you should either upgrade it to the latest version, or remove it and follow these steps to install the latest version.

Steps

1. Download the 32-bit or 64-bit Linux Host Utilities software package from the NetApp Support Site to your host.

2. Install the software package:

```
rpm -ivh netapp_linux_unified_host_utilities-7-1.x86_64
```

SAN Toolkit

The toolkit is installed automatically when you install the NetApp Host Utilities package. This kit provides the `sanlun` utility, which helps you manage LUNs and HBAs. The `sanlun` command returns information about the LUNs mapped to your host, multipathing, and information necessary to create initiator groups.

Example

In the following example, the `sanlun lun show` command returns LUN information.

```
# sanlun lun show all
```

Example output:

```
controller(7mode/E-Series)/                device      host                lun
vserver(cDOT/FlashRay)    lun-pathname   filename    adapter   protocol  size
Product
--------------------------------------------------------------------------
----------
data_vserver              /vol/vol1/lun1   /dev/sdb    host16    FCP
120.0g  cDOT
data_vserver              /vol/vol1/lun1   /dev/sdc    host15    FCP
120.0g  cDOT
data_vserver              /vol/vol2/lun2   /dev/sdd    host16    FCP
120.0g  cDOT
data_vserver              /vol/vol2/lun2   /dev/sde    host15    FCP
120.0g  cDOT
```

SAN Booting

Before you begin

If you decide to use SAN booting, it must be supported by your configuration. You can use the Interoperability Matrix Tool to verify that your OS, HBA, HBA firmware and the HBA boot BIOS, and ONTAP version are supported.

Steps

1. Map the SAN boot LUN to the host.

2. Verify that multiple paths are available.

ℹ️ Multiple paths become available after the host OS is up and running on the paths.

3. Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is mapped.

   For information on how to enable the HBA BIOS, see your vendor-specific documentation.

4. Reboot the host to verify that the boot was successful.

Multipathing

For Oracle Linux 6.9 the /etc/multipath.conf file must exist, but you do not need to make specific changes to the file. Oracle Linux 6.9 is compiled with all settings required to recognize and correctly manage ONTAP LUNs. To Enable ALUA Handler, perform the following steps:

Steps

1. Create a backup of the initrd-image.

2. Append the following parameter value to the kernel for ALUA and non-ALUA to work:
   `rdloaddriver=scsi_dh_alua`

   Example

   ```
   kernel /vmlinuz-3.8.13-68.1.2.el6uek.x86_64 ro
   root=/dev/mapper/vg_ibmx3550m421096-lv_root
   rd_NO_LUKSrd_LVM_LV=vg_ibmx3550m421096/lv_root LANG=en_US.UTF-8
   rd_NO_MDSYSFONT=latarcyrheb-sun16 crashkernel=256M KEYBOARDTYPE=pc
   KEYTABLE=us rd_LVM_LV=vg_ibmx3550m421096/lv_swap rd_NO_DM rhgb quiet
   rdloaddriver=scsi_dh_alua
   ```

3. Use the `mkinitrd` command to recreate the initrd-image.
   Oracle 6x and later versions use either:
   The command: `mkinitrd -f /boot/ initrd-"uname -r".img uname -r`
   Or
   The command: `dracut -f`

4. Reboot the host.

5. Verify the output of the `cat /proc/cmdline` command to ensure that the setting is complete.
   You can use the `multipath -ll` command to verify the settings for your ONTAP LUNs.
   There should be two groups of paths with different priorities. The paths with higher priorities are Active/Optimized. This means they are serviced by the controller where the aggregate is located. The paths with lower priorities are active but non-optimized because they are served from a different controller. The non-optimized paths are only used when optimized paths are not available.

Example

The following example displays the correct output for an ONTAP LUN with two Active/Optimized paths and two Active/Non-Optimized paths:

```
# multipath -ll
3600a09803831347657244e527766394e dm-5 NETAPP,LUN C-Mode
size=80G features='4 queue_if_no_path pg_init_retries 50
retain_attached_hw_handle' hwhandler='1 alua' wp=rw
|-+- policy='round-robin 0' prio=50 status=active
| |- 0:0:26:37 sdje 8:384   active ready running
| |- 0:0:25:37 sdik 135:64  active ready running
|-+- policy='round-robin 0' prio=10 status=enabled
  |- 0:0:18:37 sdda 70:128  active ready running
  |- 0:0:19:37 sddu 71:192  active ready running
```

> (i) A single LUN shouldn't require more than four paths. Having more than four paths might cause path issues during storage failures.

Recommended Settings

The Oracle Linux 6.9 OS is compiled to recognize ONTAP LUNs and automatically set all configuration parameters correctly.

The `multipath.conf` file must exist for the multipath daemon to start. If this file doesn't exist, you can create an empty, zero-byte file by using the `touch /etc/multipath.conf` command.

The first time you create the `multipath.conf` file, you might need to enable and start the multipath services by using the following commands:

```
# chkconfig multipathd on
# /etc/init.d/multipathd start
```

There is no requirement to add devices directly to the `multipath.conf` file, unless you have devices that you do not want multipath to manage or you have existing settings that override defaults. To exclude the unwanted devices, you add the following syntax to the `multipath.conf` file, replacing <DevId> with the WWID string of the device you want to exclude:

```
blacklist {
        wwid <DevId>
        devnode "^(ram|raw|loop|fd|md|dm-|sr|scd|st)[0-9]*"
        devnode "^hd[a-z]"
        devnode "^cciss.*"
}
```

Example

In the following example, `sda` is the local SCSI disk that you want to add to the blacklist.

Steps

1. Run the following command to determine the WWID:

```
# /lib/udev/scsi_id -gud /dev/sda
360030057024d0730239134810c0cb833
```

2. Add this WWID to the "blacklist" stanza in `/etc/multipath.conf`:

```
blacklist {
     wwid   360030057024d0730239134810c0cb833
     devnode "^(ram|raw|loop|fd|md|dm-|sr|scd|st)[0-9]*"
     devnode "^hd[a-z]"
     devnode "^cciss.*"
}
```

You should always check your `/etc/multipath.conf` file, especially in the defaults section, for legacy settings that might be overriding default settings.

The following table demonstrates the critical `multipathd` parameters for ONTAP LUNs and the required values. If a host is connected to LUNs from other vendors and any of these parameters are overridden, they must be corrected by later stanzas in the `multipath.conf` file that apply specifically to ONTAP LUNs. Without this correction, the ONTAP LUNs might not work as expected. You should only override these defaults in consultation with NetApp, the OS vendor, or both, and only when the impact is fully understood.

Parameter	Setting
detect_prio	yes
dev_loss_tmo	"infinity"
failback	immediate
fast_io_fail_tmo	5
features	"3 queue_if_no_path pg_init_retries 50"
flush_on_last_del	"yes"
hardware_handler	"0"
no_path_retry	queue
path_checker	"tur"
path_grouping_policy	"group_by_prio"
path_selector	"round-robin 0"
polling_interval	5
prio	"ontap"
product	LUN.*
retain_attached_hw_handler	yes
rr_weight	"uniform"

Parameter	Setting
user_friendly_names	no
vendor	NETAPP

Example

The following example shows how to correct an overridden default. In this case, the `multipath.conf` file defines values for `path_checker` and `detect_prio` that are not compatible with ONTAP LUNs. If they cannot be removed because of other SAN arrays still attached to the host, these parameters can be corrected specifically for ONTAP LUNs with a device stanza.

```
defaults {
 path_checker readsector0
 detect_prio no
 }
devices {
 device {
 vendor "NETAPP "
 product "LUN.*"
 path_checker tur
 detect_prio yes
 }
}
```

> (i) To configure Oracle Linux 6.9 Red Hat Compatible Kernel (RHCK), use the recommended settings for Red Hat Enterprise Linux (RHEL) 6.9.

ASM mirroring

Automatic Storage Management (ASM) mirroring might require changes to the Linux multipath settings to allow ASM to recognize a problem and switch over to an alternate failure group. Most ASM configurations on ONTAP use external redundancy, which means that data protection is provided by the external array and ASM doesn't mirror data. Some sites use ASM with normal redundancy to provide two-way mirroring, normally across different sites. See Oracle databases on ONTAP for further information.

Known issues

The Oracle Linux 6.9 with ONTAP release has the following known issues:

NetApp Bug ID	Title	Description
1082780	Firmware dumps are observed occasionally on OL6.9 hypervisor with the QLE8362 card	During storage failover operations on OL6.9 hypervisor with QLE8362 card, the firmware dumps are observed occasionally. The firmware dumps might result in an I/O outage on the host which might go up to a thousand seconds. After the adapter completes the firmware dump, the I/O operation resumes in the normal manner. No further recovery procedure is required on the host. To indicate the firmware dump, the following message is displayed in the /var/log/message file: qla2xxx [0000:0c:00.3]-d001:3: Firmware dump saved to temp buffer (3/ffffc90008901000), dump status flags (0x3f).

ⓘ   For Oracle Linux RHCK known issues, see the known issues for RHEL 6.9.

Use Oracle Linux 6.8 with ONTAP

You can use the ONTAP SAN host configuration settings to configure Oracle Linux 6.8 with ONTAP as the target.

Install the Linux Host Utilities

The NetApp Linux Host Utilities software package is available on the NetApp Support Site in a 32-bit and 64-bit .rpm file. If you don't know which file is right for your configuration, use the Interoperability Matrix Tool to verify which one you need.

NetApp strongly recommends installing the Linux Host Utilities, but it's not mandatory. The utilities don't change any settings on your Linux host. The utilities improve management and assist NetApp customer support in gathering information about your configuration.

If you have Linux Host Utilities currently installed, you should either upgrade it to the latest version, or remove it and follow these steps to install the latest version.

Steps

1. Download the 32-bit or 64-bit Linux Host Utilities software package from the NetApp Support Site to your host.

2. Install the software package:

```
rpm -ivh netapp_linux_unified_host_utilities-7-1.x86_64
```

SAN Toolkit

The toolkit is installed automatically when you install the NetApp Host Utilities package. This kit provides the

`sanlun` utility, which helps you manage LUNs and HBAs. The `sanlun` command returns information about the LUNs mapped to your host, multipathing, and information necessary to create initiator groups.

Example

In the following example, the `sanlun lun show` command returns LUN information.

```
# sanlun lun show all
```

Example output:

```
controller(7mode/E-Series)/                 device     host                lun
vserver(cDOT/FlashRay)     lun-pathname   filename   adapter  protocol  size
Product
-------------------------------------------------------------------------
----------
data_vserver               /vol/vol1/lun1   /dev/sdb   host16   FCP
120.0g  cDOT
data_vserver               /vol/vol1/lun1   /dev/sdc   host15   FCP
120.0g  cDOT
data_vserver               /vol/vol2/lun2   /dev/sdd   host16   FCP
120.0g  cDOT
data_vserver               /vol/vol2/lun2   /dev/sde   host15   FCP
120.0g  cDOT
```

SAN Booting

Before you begin

If you decide to use SAN booting, it must be supported by your configuration. You can use the Interoperability Matrix Tool to verify that your OS, HBA, HBA firmware and the HBA boot BIOS, and ONTAP version are supported.

Steps

1. Map the SAN boot LUN to the host.

2. Verify that multiple paths are available.

   ⓘ | Multiple paths become available after the host OS is up and running on the paths.

3. Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is mapped.

   For information on how to enable the HBA BIOS, see your vendor-specific documentation.

4. Reboot the host to verify that the boot was successful.

Multipathing

For Oracle Linux 6.8 the /etc/multipath.conf file must exist, but you do not need to make specific changes to the file. Oracle Linux 6.8 is compiled with all settings required to recognize and correctly manage ONTAP LUNs.

To Enable ALUA Handler, perform the following steps:

Steps

1. Create a backup of the initrd-image.

2. Append the following parameter value to the kernel for ALUA and non-ALUA to work:
   `rdloaddriver=scsi_dh_alua`

   Example

   ```
   kernel /vmlinuz-3.8.13-68.1.2.el6uek.x86_64 ro
   root=/dev/mapper/vg_ibmx3550m421096-lv_root
   rd_NO_LUKSrd_LVM_LV=vg_ibmx3550m421096/lv_root LANG=en_US.UTF-8
   rd_NO_MDSYSFONT=latarcyrheb-sun16 crashkernel=256M KEYBOARDTYPE=pc
   KEYTABLE=us rd_LVM_LV=vg_ibmx3550m421096/lv_swap rd_NO_DM rhgb quiet
   rdloaddriver=scsi_dh_alua
   ```

3. Use the `mkinitrd` command to recreate the initrd-image.
   Oracle 6x and later versions use either:
   The command: `mkinitrd -f /boot/ initrd-"uname -r".img uname -r`
   Or
   The command: `dracut -f`

4. Reboot the host.

5. Verify the output of the `cat /proc/cmdline` command to ensure that the setting is complete.
   You can use the `multipath -ll` command to verify the settings for your ONTAP LUNs.
   There should be two groups of paths with different priorities. The paths with higher priorities are
   Active/Optimized. This means they are serviced by the controller where the aggregate is located. The
   paths with lower priorities are active but non-optimized because they are served from a different controller.
   The non-optimized paths are only used when optimized paths are not available.

Example

The following example displays the correct output for an ONTAP LUN with two Active/Optimized paths and two
Active/Non-Optimized paths:

```
# multipath -ll
3600a09803831347657244e527766394e dm-5 NETAPP,LUN C-Mode
size=80G features='4 queue_if_no_path pg_init_retries 50
retain_attached_hw_handle' hwhandler='1 alua' wp=rw
|-+- policy='round-robin 0' prio=50 status=active
| |- 0:0:26:37 sdje 8:384   active ready running
| |- 0:0:25:37 sdik 135:64  active ready running
|-+- policy='round-robin 0' prio=10 status=enabled
  |- 0:0:18:37 sdda 70:128  active ready running
  |- 0:0:19:37 sddu 71:192  active ready running
```

ⓘ A single LUN shouldn't require more than four paths. Having more than four paths might cause
    path issues during storage failures.

Recommended Settings

The Oracle Linux 6.8 OS is compiled to recognize ONTAP LUNs and automatically set all configuration parameters correctly.

The `multipath.conf` file must exist for the multipath daemon to start. If this file doesn't exist, you can create an empty, zero-byte file by using the `touch /etc/multipath.conf` command.

The first time you create the `multipath.conf` file, you might need to enable and start the multipath services by using the following commands:

```
# chkconfig multipathd on
# /etc/init.d/multipathd start
```

There is no requirement to add devices directly to the `multipath.conf` file, unless you have devices that you do not want multipath to manage or you have existing settings that override defaults. To exclude the unwanted devices, you add the following syntax to the `multipath.conf` file, replacing <DevId> with the WWID string of the device you want to exclude:

```
blacklist {
        wwid <DevId>
        devnode "^(ram|raw|loop|fd|md|dm-|sr|scd|st)[0-9]*"
        devnode "^hd[a-z]"
        devnode "^cciss.*"
}
```

Example

In the following example, `sda` is the local SCSI disk that you want to add to the blacklist.

Steps

1. Run the following command to determine the WWID:

   ```
   # /lib/udev/scsi_id -gud /dev/sda
   360030057024d0730239134810c0cb833
   ```

2. Add this WWID to the "blacklist" stanza in `/etc/multipath.conf`:

   ```
   blacklist {
         wwid    360030057024d0730239134810c0cb833
         devnode "^(ram|raw|loop|fd|md|dm-|sr|scd|st)[0-9]*"
         devnode "^hd[a-z]"
         devnode "^cciss.*"
   }
   ```

You should always check your `/etc/multipath.conf` file, especially in the defaults section, for legacy settings that might be overriding default settings.

The following table demonstrates the critical `multipathd` parameters for ONTAP LUNs and the required values. If a host is connected to LUNs from other vendors and any of these parameters are overridden, they must be corrected by later stanzas in the `multipath.conf` file that apply specifically to ONTAP LUNs. Without this correction, the ONTAP LUNs might not work as expected. You should only override these defaults in consultation with NetApp, the OS vendor, or both, and only when the impact is fully understood.

Parameter	Setting
detect_prio	yes
dev_loss_tmo	"infinity"
failback	immediate
fast_io_fail_tmo	5
features	"3 queue_if_no_path pg_init_retries 50"
flush_on_last_del	"yes"
hardware_handler	"0"
no_path_retry	queue
path_checker	"tur"
path_grouping_policy	"group_by_prio"
path_selector	"round-robin 0"
polling_interval	5
prio	"ontap"
product	LUN.*
retain_attached_hw_handler	yes
rr_weight	"uniform"
user_friendly_names	no
vendor	NETAPP

Example

The following example shows how to correct an overridden default. In this case, the `multipath.conf` file defines values for `path_checker` and `detect_prio` that are not compatible with ONTAP LUNs.
If they cannot be removed because of other SAN arrays still attached to the host, these parameters can be corrected specifically for ONTAP LUNs with a device stanza.

```
defaults {
 path_checker readsector0
 detect_prio no
 }
devices {
 device {
 vendor "NETAPP "
 product "LUN.*"
 path_checker tur
 detect_prio yes
 }
}
```

> (i) To configure Oracle Linux 6.8 Red Hat Compatible Kernel (RHCK), use the recommended settings for Red Hat Enterprise Linux (RHEL) 6.8.

ASM mirroring

Automatic Storage Management (ASM) mirroring might require changes to the Linux multipath settings to allow ASM to recognize a problem and switch over to an alternate failure group. Most ASM configurations on ONTAP use external redundancy, which means that data protection is provided by the external array and ASM doesn't mirror data. Some sites use ASM with normal redundancy to provide two-way mirroring, normally across different sites. See Oracle databases on ONTAP for further information.

Known issues

There are no known issues for the Oracle Linux 6.8 with ONTAP release.

> (i) For Oracle Linux RHCK known issues, see the known issues for RHEL 6.8.

Use Oracle Linux 6.7 with ONTAP

You can use the ONTAP SAN host configuration settings to configure Oracle Linux 6.7 with ONTAP as the target.

Install the Linux Host Utilities

The NetApp Linux Host Utilities software package is available on the NetApp Support Site in a 32-bit and 64-bit .rpm file. If you don't know which file is right for your configuration, use the Interoperability Matrix Tool to verify which one you need.

NetApp strongly recommends installing the Linux Host Utilities, but it's not mandatory. The utilities don't change any settings on your Linux host. The utilities improve management and assist NetApp customer support in gathering information about your configuration.

If you have Linux Host Utilities currently installed, you should either upgrade it to the latest version, or remove it and follow these steps to install the latest version.

Steps

1. Download the 32-bit or 64-bit Linux Host Utilities software package from the NetApp Support Site to your host.

2. Install the software package:

```
rpm -ivh netapp_linux_unified_host_utilities-7-1.x86_64
```

SAN Toolkit

The toolkit is installed automatically when you install the NetApp Host Utilities package. This kit provides the `sanlun` utility, which helps you manage LUNs and HBAs. The `sanlun` command returns information about the LUNs mapped to your host, multipathing, and information necessary to create initiator groups.

Example

In the following example, the `sanlun lun show` command returns LUN information.

```
# sanlun lun show all
```

Example output:

```
controller(7mode/E-Series)/              device      host                 lun
vserver(cDOT/FlashRay)    lun-pathname   filename    adapter  protocol  size
Product
--------------------------------------------------------------------------
----------
data_vserver              /vol/vol1/lun1   /dev/sdb   host16    FCP
120.0g  cDOT
data_vserver              /vol/vol1/lun1   /dev/sdc   host15    FCP
120.0g  cDOT
data_vserver              /vol/vol2/lun2   /dev/sdd   host16    FCP
120.0g  cDOT
data_vserver              /vol/vol2/lun2   /dev/sde   host15    FCP
120.0g  cDOT
```

SAN Booting

Before you begin

If you decide to use SAN booting, it must be supported by your configuration. You can use the Interoperability Matrix Tool to verify that your OS, HBA, HBA firmware and the HBA boot BIOS, and ONTAP version are supported.

Steps

1. Map the SAN boot LUN to the host.

2. Verify that multiple paths are available.

   > ⓘ   Multiple paths become available after the host OS is up and running on the paths.

3. Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is mapped.

   For information on how to enable the HBA BIOS, see your vendor-specific documentation.

4. Reboot the host to verify that the boot was successful.

Multipathing

For Oracle Linux 6.7 the /etc/multipath.conf file must exist, but you do not need to make specific changes to the file. Oracle Linux 6.7 is compiled with all settings required to recognize and correctly manage ONTAP LUNs. To Enable ALUA Handler, perform the following steps:

Steps

1. Create a backup of the initrd-image.

2. Append the following parameter value to the kernel for ALUA and non-ALUA to work:
   `rdloaddriver=scsi_dh_alua`

   Example

   ```
   kernel /vmlinuz-3.8.13-68.1.2.el6uek.x86_64 ro
   root=/dev/mapper/vg_ibmx3550m421096-lv_root
   rd_NO_LUKSrd_LVM_LV=vg_ibmx3550m421096/lv_root LANG=en_US.UTF-8
   rd_NO_MDSYSFONT=latarcyrheb-sun16 crashkernel=256M KEYBOARDTYPE=pc
   KEYTABLE=us rd_LVM_LV=vg_ibmx3550m421096/lv_swap rd_NO_DM rhgb quiet
   rdloaddriver=scsi_dh_alua
   ```

3. Use the `mkinitrd` command to recreate the initrd-image.
   Oracle 6x and later versions use either:
   The command: `mkinitrd -f /boot/ initrd-"uname -r".img uname -r`
   Or
   The command: `dracut -f`

4. Reboot the host.

5. Verify the output of the `cat /proc/cmdline` command to ensure that the setting is complete.
   You can use the `multipath -ll` command to verify the settings for your ONTAP LUNs.
   There should be two groups of paths with different priorities. The paths with higher priorities are Active/Optimized. This means they are serviced by the controller where the aggregate is located. The paths with lower priorities are active but non-optimized because they are served from a different controller. The non-optimized paths are only used when optimized paths are not available.

Example

The following example displays the correct output for an ONTAP LUN with two Active/Optimized paths and two Active/Non-Optimized paths:

```
# multipath -ll
3600a09803831347657244e527766394e dm-5 NETAPP,LUN C-Mode
size=80G features='4 queue_if_no_path pg_init_retries 50
retain_attached_hw_handle' hwhandler='1 alua' wp=rw
|-+- policy='round-robin 0' prio=50 status=active
| |- 0:0:26:37 sdje 8:384   active ready running
| |- 0:0:25:37 sdik 135:64  active ready running
|-+- policy='round-robin 0' prio=10 status=enabled
  |- 0:0:18:37 sdda 70:128  active ready running
  |- 0:0:19:37 sddu 71:192  active ready running
```

ⓘ   A single LUN shouldn't require more than four paths. Having more than four paths might cause
    path issues during storage failures.

Recommended Settings

The Oracle Linux 6.7 OS is compiled to recognize ONTAP LUNs and automatically set all configuration
parameters correctly.

The `multipath.conf` file must exist for the multipath daemon to start. If this file doesn't exist, you can create
an empty, zero-byte file by using the `touch /etc/multipath.conf` command.

The first time you create the `multipath.conf` file, you might need to enable and start the multipath services
by using the following commands:

```
# chkconfig multipathd on
# /etc/init.d/multipathd start
```

There is no requirement to add devices directly to the `multipath.conf` file, unless you have devices that you
do not want multipath to manage or you have existing settings that override defaults. To exclude the unwanted
devices, you add the following syntax to the `multipath.conf` file, replacing <DevId> with the WWID string of
the device you want to exclude:

```
blacklist {
        wwid <DevId>
        devnode "^(ram|raw|loop|fd|md|dm-|sr|scd|st)[0-9]*"
        devnode "^hd[a-z]"
        devnode "^cciss.*"
}
```

Example

In the following example, `sda` is the local SCSI disk that you want to add to the blacklist.

Steps

1. Run the following command to determine the WWID:

```
# /lib/udev/scsi_id -gud /dev/sda
360030057024d0730239134810c0cb833
```

2. Add this WWID to the "blacklist" stanza in `/etc/multipath.conf`:

```
blacklist {
      wwid   360030057024d0730239134810c0cb833
      devnode "^(ram|raw|loop|fd|md|dm-|sr|scd|st)[0-9]*"
      devnode "^hd[a-z]"
      devnode "^cciss.*"
}
```

You should always check your `/etc/multipath.conf` file, especially in the defaults section, for legacy settings that might be overriding default settings.

The following table demonstrates the critical `multipathd` parameters for ONTAP LUNs and the required values. If a host is connected to LUNs from other vendors and any of these parameters are overridden, they must be corrected by later stanzas in the `multipath.conf` file that apply specifically to ONTAP LUNs. Without this correction, the ONTAP LUNs might not work as expected. You should only override these defaults in consultation with NetApp, the OS vendor, or both, and only when the impact is fully understood.

Parameter	Setting
detect_prio	yes
dev_loss_tmo	"infinity"
failback	immediate
fast_io_fail_tmo	5
features	"3 queue_if_no_path pg_init_retries 50"
flush_on_last_del	"yes"
hardware_handler	"0"
no_path_retry	queue
path_checker	"tur"
path_grouping_policy	"group_by_prio"
path_selector	"round-robin 0"
polling_interval	5
prio	"ontap"
product	LUN.*
retain_attached_hw_handler	yes
rr_weight	"uniform"

Parameter	Setting
user_friendly_names	no
vendor	NETAPP

Example

The following example shows how to correct an overridden default. In this case, the `multipath.conf` file defines values for `path_checker` and `detect_prio` that are not compatible with ONTAP LUNs. If they cannot be removed because of other SAN arrays still attached to the host, these parameters can be corrected specifically for ONTAP LUNs with a device stanza.

```
defaults {
 path_checker readsector0
 detect_prio no
 }
devices {
 device {
 vendor "NETAPP "
 product "LUN.*"
 path_checker tur
 detect_prio yes
 }
}
```

> ⓘ To configure Oracle Linux 6.7 Red Hat Compatible Kernel (RHCK), use the recommended settings for Red Hat Enterprise Linux (RHEL) 6.7.

ASM mirroring

Automatic Storage Management (ASM) mirroring might require changes to the Linux multipath settings to allow ASM to recognize a problem and switch over to an alternate failure group. Most ASM configurations on ONTAP use external redundancy, which means that data protection is provided by the external array and ASM doesn't mirror data. Some sites use ASM with normal redundancy to provide two-way mirroring, normally across different sites. See Oracle databases on ONTAP for further information.

Known issues

There are no known issues for the Oracle Linux 6.7 with ONTAP release.

> ⓘ For Oracle Linux RHCK known issues, see the known issues for RHEL 6.7.

Use Oracle Linux 6.6 with ONTAP

You can use the ONTAP SAN host configuration settings to configure Oracle Linux 6.6 with ONTAP as the target.

Install the Linux Host Utilities

The NetApp Linux Host Utilities software package is available on the NetApp Support Site in a 32-bit and 64-bit .rpm file. If you don't know which file is right for your configuration, use the Interoperability Matrix Tool to verify which one you need.

NetApp strongly recommends installing the Linux Host Utilities, but it's not mandatory. The utilities don't change any settings on your Linux host. The utilities improve management and assist NetApp customer support in gathering information about your configuration.

If you have Linux Host Utilities currently installed, you should either upgrade it to the latest version, or remove it and follow these steps to install the latest version.

Steps

1. Download the 32-bit or 64-bit Linux Host Utilities software package from the NetApp Support Site to your host.

2. Install the software package:

   ```
   rpm -ivh netapp_linux_unified_host_utilities-7-1.x86_64
   ```

SAN Toolkit

The toolkit is installed automatically when you install the NetApp Host Utilities package. This kit provides the `sanlun` utility, which helps you manage LUNs and HBAs. The `sanlun` command returns information about the LUNs mapped to your host, multipathing, and information necessary to create initiator groups.

Example

In the following example, the `sanlun lun show` command returns LUN information.

```
# sanlun lun show all
```

Example output:

```
controller(7mode/E-Series)/                 device      host                lun
vserver(cDOT/FlashRay)    lun-pathname    filename    adapter   protocol  size
Product
-------------------------------------------------------------------------
----------
data_vserver           /vol/vol1/lun1    /dev/sdb    host16    FCP
120.0g  cDOT
data_vserver           /vol/vol1/lun1    /dev/sdc    host15    FCP
120.0g  cDOT
data_vserver           /vol/vol2/lun2    /dev/sdd    host16    FCP
120.0g  cDOT
data_vserver           /vol/vol2/lun2    /dev/sde    host15    FCP
120.0g  cDOT
```

SAN Booting

Before you begin

If you decide to use SAN booting, it must be supported by your configuration. You can use the Interoperability Matrix Tool to verify that your OS, HBA, HBA firmware and the HBA boot BIOS, and ONTAP version are supported.

Steps

1. Map the SAN boot LUN to the host.

2. Verify that multiple paths are available.

   > ℹ️   Multiple paths become available after the host OS is up and running on the paths.

3. Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is mapped.

   For information on how to enable the HBA BIOS, see your vendor-specific documentation.

4. Reboot the host to verify that the boot was successful.

Multipathing

For Oracle Linux 6.6 the /etc/multipath.conf file must exist, but you do not need to make specific changes to the file. Oracle Linux 6.6 is compiled with all settings required to recognize and correctly manage ONTAP LUNs. To Enable ALUA Handler, perform the following steps:

Steps

1. Create a backup of the initrd-image.

2. Append the following parameter value to the kernel for ALUA and non-ALUA to work:
   `rdloaddriver=scsi_dh_alua`

   Example

   ```
   kernel /vmlinuz-3.8.13-68.1.2.el6uek.x86_64 ro
   root=/dev/mapper/vg_ibmx3550m421096-lv_root
   rd_NO_LUKSrd_LVM_LV=vg_ibmx3550m421096/lv_root LANG=en_US.UTF-8
   rd_NO_MDSYSFONT=latarcyrheb-sun16 crashkernel=256M KEYBOARDTYPE=pc
   KEYTABLE=us rd_LVM_LV=vg_ibmx3550m421096/lv_swap rd_NO_DM rhgb quiet
   rdloaddriver=scsi_dh_alua
   ```

3. Use the `mkinitrd` command to recreate the initrd-image.
   Oracle 6x and later versions use either:
   The command: `mkinitrd -f /boot/ initrd-"uname -r".img uname -r`
   Or
   The command: `dracut -f`

4. Reboot the host.

5. Verify the output of the `cat /proc/cmdline` command to ensure that the setting is complete.
   You can use the `multipath -ll` command to verify the settings for your ONTAP LUNs.
   There should be two groups of paths with different priorities. The paths with higher priorities are Active/Optimized. This means they are serviced by the controller where the aggregate is located. The paths with lower priorities are active but non-optimized because they are served from a different controller.

The non-optimized paths are only used when optimized paths are not available.

Example

The following example displays the correct output for an ONTAP LUN with two Active/Optimized paths and two Active/Non-Optimized paths:

```
# multipath -ll
3600a09803831347657244e527766394e dm-5 NETAPP,LUN C-Mode
size=80G features='4 queue_if_no_path pg_init_retries 50
retain_attached_hw_handle' hwhandler='1 alua' wp=rw
|-+- policy='round-robin 0' prio=50 status=active
| |- 0:0:26:37 sdje 8:384   active ready running
| |- 0:0:25:37 sdik 135:64  active ready running
|-+- policy='round-robin 0' prio=10 status=enabled
  |- 0:0:18:37 sdda 70:128  active ready running
  |- 0:0:19:37 sddu 71:192  active ready running
```

> ⓘ A single LUN shouldn't require more than four paths. Having more than four paths might cause path issues during storage failures.

Recommended Settings

The Oracle Linux 6.6 OS is compiled to recognize ONTAP LUNs and automatically set all configuration parameters correctly.

The `multipath.conf` file must exist for the multipath daemon to start. If this file doesn't exist, you can create an empty, zero-byte file by using the `touch /etc/multipath.conf` command.

The first time you create the `multipath.conf` file, you might need to enable and start the multipath services by using the following commands:

```
# chkconfig multipathd on
# /etc/init.d/multipathd start
```

There is no requirement to add devices directly to the `multipath.conf` file, unless you have devices that you do not want multipath to manage or you have existing settings that override defaults. To exclude the unwanted devices, you add the following syntax to the `multipath.conf` file, replacing <DevId> with the WWID string of the device you want to exclude:

```
blacklist {
        wwid <DevId>
        devnode "^(ram|raw|loop|fd|md|dm-|sr|scd|st)[0-9]*"
        devnode "^hd[a-z]"
        devnode "^cciss.*"
}
```

Example

In the following example, `sda` is the local SCSI disk that you want to add to the blacklist.

Steps

1. Run the following command to determine the WWID:

```
# /lib/udev/scsi_id -gud /dev/sda
360030057024d0730239134810c0cb833
```

2. Add this WWID to the "blacklist" stanza in `/etc/multipath.conf`:

```
blacklist {
     wwid    360030057024d0730239134810c0cb833
     devnode "^(ram|raw|loop|fd|md|dm-|sr|scd|st)[0-9]*"
     devnode "^hd[a-z]"
     devnode "^cciss.*"
}
```

You should always check your `/etc/multipath.conf` file, especially in the defaults section, for legacy settings that might be overriding default settings.

The following table demonstrates the critical `multipathd` parameters for ONTAP LUNs and the required values. If a host is connected to LUNs from other vendors and any of these parameters are overridden, they must be corrected by later stanzas in the `multipath.conf` file that apply specifically to ONTAP LUNs. Without this correction, the ONTAP LUNs might not work as expected. You should only override these defaults in consultation with NetApp, the OS vendor, or both, and only when the impact is fully understood.

Parameter	Setting
detect_prio	yes
dev_loss_tmo	"infinity"
failback	immediate
fast_io_fail_tmo	5
features	"3 queue_if_no_path pg_init_retries 50"
flush_on_last_del	"yes"
hardware_handler	"0"
no_path_retry	queue
path_checker	"tur"
path_grouping_policy	"group_by_prio"
path_selector	"round-robin 0"
polling_interval	5

Parameter	Setting
prio	"ontap"
product	LUN.*
retain_attached_hw_handler	yes
rr_weight	"uniform"
user_friendly_names	no
vendor	NETAPP

Example

The following example shows how to correct an overridden default. In this case, the `multipath.conf` file defines values for `path_checker` and `detect_prio` that are not compatible with ONTAP LUNs.
If they cannot be removed because of other SAN arrays still attached to the host, these parameters can be corrected specifically for ONTAP LUNs with a device stanza.

```
defaults {
 path_checker readsector0
 detect_prio no
 }
devices {
 device {
 vendor "NETAPP "
 product "LUN.*"
 path_checker tur
 detect_prio yes
 }
}
```

ⓘ To configure Oracle Linux 6.6 Red Hat Compatible Kernel (RHCK), use the recommended settings for Red Hat Enterprise Linux (RHEL) 6.6.

ASM mirroring

Automatic Storage Management (ASM) mirroring might require changes to the Linux multipath settings to allow ASM to recognize a problem and switch over to an alternate failure group. Most ASM configurations on ONTAP use external redundancy, which means that data protection is provided by the external array and ASM doesn't mirror data. Some sites use ASM with normal redundancy to provide two-way mirroring, normally across different sites. See Oracle databases on ONTAP for further information.

Known issues

There are no known issues for the Oracle Linux 6.6 with ONTAP release.

ⓘ For Oracle Linux RHCK known issues, see the known issues for RHEL 6.6.

Use Oracle Linux 6.5 with ONTAP

You can use the ONTAP SAN host configuration settings to configure Oracle Linux 6.5 with ONTAP as the target.

Install the Linux Host Utilities

The NetApp Linux Host Utilities software package is available on the NetApp Support Site in a 32-bit and 64-bit .rpm file. If you don't know which file is right for your configuration, use the Interoperability Matrix Tool to verify which one you need.

NetApp strongly recommends installing the Linux Host Utilities, but it's not mandatory. The utilities don't change any settings on your Linux host. The utilities improve management and assist NetApp customer support in gathering information about your configuration.

If you have Linux Host Utilities currently installed, you should either upgrade it to the latest version, or remove it and follow these steps to install the latest version.

Steps

1. Download the 32-bit or 64-bit Linux Host Utilities software package from the NetApp Support Site to your host.

2. Install the software package:

   ```
   rpm -ivh netapp_linux_unified_host_utilities-7-1.x86_64
   ```

SAN Toolkit

The toolkit is installed automatically when you install the NetApp Host Utilities package. This kit provides the `sanlun` utility, which helps you manage LUNs and HBAs. The `sanlun` command returns information about the LUNs mapped to your host, multipathing, and information necessary to create initiator groups.

Example

In the following example, the `sanlun lun show` command returns LUN information.

```
# sanlun lun show all
```

Example output:

```
controller(7mode/E-Series)/                 device      host                    lun
vserver(cDOT/FlashRay)    lun-pathname    filename     adapter  protocol   size
Product
----------------------------------------------------------------------
----------
data_vserver              /vol/vol1/lun1   /dev/sdb    host16   FCP
120.0g  cDOT
data_vserver              /vol/vol1/lun1   /dev/sdc    host15   FCP
120.0g  cDOT
data_vserver              /vol/vol2/lun2   /dev/sdd    host16   FCP
120.0g  cDOT
data_vserver              /vol/vol2/lun2   /dev/sde    host15   FCP
120.0g  cDOT
```

SAN Booting

Before you begin

If you decide to use SAN booting, it must be supported by your configuration. You can use the Interoperability Matrix Tool to verify that your OS, HBA, HBA firmware and the HBA boot BIOS, and ONTAP version are supported.

Steps

1. Map the SAN boot LUN to the host.

2. Verify that multiple paths are available.

   > ⓘ Multiple paths become available after the host OS is up and running on the paths.

3. Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is mapped.

   For information on how to enable the HBA BIOS, see your vendor-specific documentation.

4. Reboot the host to verify that the boot was successful.

Multipathing

For Oracle Linux 6.5 the /etc/multipath.conf file must exist, but you do not need to make specific changes to the file. Oracle Linux 6.5 is compiled with all settings required to recognize and correctly manage ONTAP LUNs. To Enable ALUA Handler, perform the following steps:

Steps

1. Create a backup of the initrd-image.

2. Append the following parameter value to the kernel for ALUA and non-ALUA to work:
   `rdloaddriver=scsi_dh_alua`

Example

```
kernel /vmlinuz-3.8.13-68.1.2.el6uek.x86_64 ro
root=/dev/mapper/vg_ibmx3550m421096-lv_root
rd_NO_LUKSrd_LVM_LV=vg_ibmx3550m421096/lv_root LANG=en_US.UTF-8
rd_NO_MDSYSFONT=latarcyrheb-sun16 crashkernel=256M KEYBOARDTYPE=pc
KEYTABLE=us rd_LVM_LV=vg_ibmx3550m421096/lv_swap rd_NO_DM rhgb quiet
rdloaddriver=scsi_dh_alua
```

3. Use the `mkinitrd` command to recreate the initrd-image.
   Oracle 6x and later versions use either:
   The command: `mkinitrd -f /boot/ initrd-"uname -r".img uname -r`
   Or
   The command: `dracut -f`

4. Reboot the host.

5. Verify the output of the `cat /proc/cmdline` command to ensure that the setting is complete.
   You can use the `multipath -ll` command to verify the settings for your ONTAP LUNs.
   There should be two groups of paths with different priorities. The paths with higher priorities are
   Active/Optimized. This means they are serviced by the controller where the aggregate is located. The
   paths with lower priorities are active but non-optimized because they are served from a different controller.
   The non-optimized paths are only used when optimized paths are not available.

Example

The following example displays the correct output for an ONTAP LUN with two Active/Optimized paths and two
Active/Non-Optimized paths:

```
# multipath -ll
3600a09803831347657244e527766394e dm-5 NETAPP,LUN C-Mode
size=80G features='4 queue_if_no_path pg_init_retries 50
retain_attached_hw_handle' hwhandler='1 alua' wp=rw
|-+- policy='round-robin 0' prio=50 status=active
| |- 0:0:26:37 sdje 8:384   active ready running
| |- 0:0:25:37 sdik 135:64  active ready running
|-+- policy='round-robin 0' prio=10 status=enabled
  |- 0:0:18:37 sdda 70:128  active ready running
  |- 0:0:19:37 sddu 71:192  active ready running
```

> ⓘ A single LUN shouldn't require more than four paths. Having more than four paths might cause
> path issues during storage failures.

Recommended Settings

The Oracle Linux 6.5 OS is compiled to recognize ONTAP LUNs and automatically set all configuration
parameters correctly.

The `multipath.conf` file must exist for the multipath daemon to start. If this file doesn't exist, you can create
an empty, zero-byte file by using the `touch /etc/multipath.conf` command.

The first time you create the `multipath.conf` file, you might need to enable and start the multipath services by using the following commands:

```
# chkconfig multipathd on
# /etc/init.d/multipathd start
```

There is no requirement to add devices directly to the `multipath.conf` file, unless you have devices that you do not want multipath to manage or you have existing settings that override defaults. To exclude the unwanted devices, you add the following syntax to the `multipath.conf` file, replacing <DevId> with the WWID string of the device you want to exclude:

```
blacklist {
        wwid <DevId>
        devnode "^(ram|raw|loop|fd|md|dm-|sr|scd|st)[0-9]*"
        devnode "^hd[a-z]"
        devnode "^cciss.*"
}
```

Example

In the following example, `sda` is the local SCSI disk that you want to add to the blacklist.

Steps

1. Run the following command to determine the WWID:

   ```
   # /lib/udev/scsi_id -gud /dev/sda
   360030057024d0730239134810c0cb833
   ```

2. Add this WWID to the "blacklist" stanza in `/etc/multipath.conf`:

   ```
   blacklist {
        wwid   360030057024d0730239134810c0cb833
        devnode "^(ram|raw|loop|fd|md|dm-|sr|scd|st)[0-9]*"
        devnode "^hd[a-z]"
        devnode "^cciss.*"
   }
   ```

You should always check your `/etc/multipath.conf` file, especially in the defaults section, for legacy settings that might be overriding default settings.

The following table demonstrates the critical `multipathd` parameters for ONTAP LUNs and the required values. If a host is connected to LUNs from other vendors and any of these parameters are overridden, they must be corrected by later stanzas in the `multipath.conf` file that apply specifically to ONTAP LUNs. Without this correction, the ONTAP LUNs might not work as expected. You should only override these defaults in consultation with NetApp, the OS vendor, or both, and only when the impact is fully understood.

Parameter	Setting
detect_prio	yes
dev_loss_tmo	"infinity"
failback	immediate
fast_io_fail_tmo	5
features	"3 queue_if_no_path pg_init_retries 50"
flush_on_last_del	"yes"
hardware_handler	"0"
no_path_retry	queue
path_checker	"tur"
path_grouping_policy	"group_by_prio"
path_selector	"round-robin 0"
polling_interval	5
prio	"ontap"
product	LUN.*
retain_attached_hw_handler	yes
rr_weight	"uniform"
user_friendly_names	no
vendor	NETAPP

Example

The following example shows how to correct an overridden default. In this case, the `multipath.conf` file defines values for `path_checker` and `detect_prio` that are not compatible with ONTAP LUNs.
If they cannot be removed because of other SAN arrays still attached to the host, these parameters can be corrected specifically for ONTAP LUNs with a device stanza.

```
defaults {
 path_checker readsector0
 detect_prio no
 }
devices {
 device {
 vendor "NETAPP "
 product "LUN.*"
 path_checker tur
 detect_prio yes
 }
}
```

(i) To configure Oracle Linux 6.5 Red Hat Compatible Kernel (RHCK), use the recommended settings for Red Hat Enterprise Linux (RHEL) 6.5.

ASM mirroring

Automatic Storage Management (ASM) mirroring might require changes to the Linux multipath settings to allow ASM to recognize a problem and switch over to an alternate failure group. Most ASM configurations on ONTAP use external redundancy, which means that data protection is provided by the external array and ASM doesn't mirror data. Some sites use ASM with normal redundancy to provide two-way mirroring, normally across different sites. See Oracle databases on ONTAP for further information.

Known issues

There are no known issues for the Oracle Linux 6.5 with ONTAP release.

(i) For Oracle Linux RHCK known issues, see the known issues for RHEL 6.5.

Use Oracle Linux 6.4 with ONTAP

You can use the ONTAP SAN host configuration settings to configure Oracle Linux 6.4 with ONTAP as the target.

Install the Linux Host Utilities

The NetApp Linux Host Utilities software package is available on the NetApp Support Site in a 32-bit and 64-bit .rpm file. If you don't know which file is right for your configuration, use the Interoperability Matrix Tool to verify which one you need.

NetApp strongly recommends installing the Linux Host Utilities, but it's not mandatory. The utilities don't change any settings on your Linux host. The utilities improve management and assist NetApp customer support in gathering information about your configuration.

If you have Linux Host Utilities currently installed, you should either upgrade it to the latest version, or remove it and follow these steps to install the latest version.

Steps

1. Download the 32-bit or 64-bit Linux Host Utilities software package from the NetApp Support Site to your host.

2. Install the software package:

   ```
   rpm -ivh netapp_linux_unified_host_utilities-7-1.x86_64
   ```

SAN Toolkit

The toolkit is installed automatically when you install the NetApp Host Utilities package. This kit provides the `sanlun` utility, which helps you manage LUNs and HBAs. The `sanlun` command returns information about the LUNs mapped to your host, multipathing, and information necessary to create initiator groups.

Example

In the following example, the `sanlun lun show` command returns LUN information.

```
# sanlun lun show all
```

Example output:

```
controller(7mode/E-Series)/              device     host                lun
vserver(cDOT/FlashRay)    lun-pathname  filename   adapter  protocol  size
Product
-------------------------------------------------------------------------
----------
data_vserver              /vol/vol1/lun1   /dev/sdb   host16   FCP
120.0g  cDOT
data_vserver              /vol/vol1/lun1   /dev/sdc   host15   FCP
120.0g  cDOT
data_vserver              /vol/vol2/lun2   /dev/sdd   host16   FCP
120.0g  cDOT
data_vserver              /vol/vol2/lun2   /dev/sde   host15   FCP
120.0g  cDOT
```

SAN Booting

Before you begin

If you decide to use SAN booting, it must be supported by your configuration. You can use the Interoperability Matrix Tool to verify that your OS, HBA, HBA firmware and the HBA boot BIOS, and ONTAP version are supported.

Steps

1. Map the SAN boot LUN to the host.

2. Verify that multiple paths are available.

   > ℹ️   Multiple paths become available after the host OS is up and running on the paths.

3. Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is mapped.

   For information on how to enable the HBA BIOS, see your vendor-specific documentation.

4. Reboot the host to verify that the boot was successful.

Multipathing

For Oracle Linux 6.4 the /etc/multipath.conf file must exist, but you do not need to make specific changes to the file. Oracle Linux 6.4 is compiled with all settings required to recognize and correctly manage ONTAP LUNs. To Enable ALUA Handler, perform the following steps:

Steps

1. Create a backup of the initrd-image.

2. Append the following parameter value to the kernel for ALUA and non-ALUA to work:
   `rdloaddriver=scsi_dh_alua`

Example

```
kernel /vmlinuz-3.8.13-68.1.2.el6uek.x86_64 ro
root=/dev/mapper/vg_ibmx3550m421096-lv_root
rd_NO_LUKSrd_LVM_LV=vg_ibmx3550m421096/lv_root LANG=en_US.UTF-8
rd_NO_MDSYSFONT=latarcyrheb-sun16 crashkernel=256M KEYBOARDTYPE=pc
KEYTABLE=us rd_LVM_LV=vg_ibmx3550m421096/lv_swap rd_NO_DM rhgb quiet
rdloaddriver=scsi_dh_alua
```

3. Use the `mkinitrd` command to recreate the initrd-image.
   Oracle 6x and later versions use either:
   The command: `mkinitrd -f /boot/ initrd-"uname -r".img uname -r`
   Or
   The command: `dracut -f`

4. Reboot the host.

5. Verify the output of the `cat /proc/cmdline` command to ensure that the setting is complete.
   You can use the `multipath -ll` command to verify the settings for your ONTAP LUNs.
   There should be two groups of paths with different priorities. The paths with higher priorities are Active/Optimized. This means they are serviced by the controller where the aggregate is located. The paths with lower priorities are active but non-optimized because they are served from a different controller. The non-optimized paths are only used when optimized paths are not available.

Example

The following example displays the correct output for an ONTAP LUN with two Active/Optimized paths and two Active/Non-Optimized paths:

```
# multipath -ll
3600a09803831347657244e527766394e dm-5 NETAPP,LUN C-Mode
size=80G features='4 queue_if_no_path pg_init_retries 50
retain_attached_hw_handle' hwhandler='1 alua' wp=rw
|-+- policy='round-robin 0' prio=50 status=active
| |- 0:0:26:37 sdje 8:384   active ready running
| |- 0:0:25:37 sdik 135:64  active ready running
|-+- policy='round-robin 0' prio=10 status=enabled
  |- 0:0:18:37 sdda 70:128  active ready running
  |- 0:0:19:37 sddu 71:192  active ready running
```

> ⓘ A single LUN shouldn't require more than four paths. Having more than four paths might cause path issues during storage failures.

Recommended Settings

The Oracle Linux 6.4 OS is compiled to recognize ONTAP LUNs and automatically set all configuration parameters correctly.

The `multipath.conf` file must exist for the multipath daemon to start. If this file doesn't exist, you can create an empty, zero-byte file by using the `touch /etc/multipath.conf` command.

The first time you create the `multipath.conf` file, you might need to enable and start the multipath services by using the following commands:

```
# chkconfig multipathd on
# /etc/init.d/multipathd start
```

There is no requirement to add devices directly to the `multipath.conf` file, unless you have devices that you do not want multipath to manage or you have existing settings that override defaults. To exclude the unwanted devices, you add the following syntax to the `multipath.conf` file, replacing <DevId> with the WWID string of the device you want to exclude:

```
blacklist {
        wwid <DevId>
        devnode "^(ram|raw|loop|fd|md|dm-|sr|scd|st)[0-9]*"
        devnode "^hd[a-z]"
        devnode "^cciss.*"
}
```

Example

In the following example, `sda` is the local SCSI disk that you want to add to the blacklist.

Steps

1. Run the following command to determine the WWID:

   ```
   # /lib/udev/scsi_id -gud /dev/sda
   360030057024d0730239134810c0cb833
   ```

2. Add this WWID to the "blacklist" stanza in `/etc/multipath.conf`:

   ```
   blacklist {
         wwid   360030057024d0730239134810c0cb833
         devnode "^(ram|raw|loop|fd|md|dm-|sr|scd|st)[0-9]*"
         devnode "^hd[a-z]"
         devnode "^cciss.*"
   }
   ```

You should always check your `/etc/multipath.conf` file, especially in the defaults section, for legacy settings that might be overriding default settings.

The following table demonstrates the critical `multipathd` parameters for ONTAP LUNs and the required values. If a host is connected to LUNs from other vendors and any of these parameters are overridden, they must be corrected by later stanzas in the `multipath.conf` file that apply specifically to ONTAP LUNs. Without this correction, the ONTAP LUNs might not work as expected. You should only override these defaults in consultation with NetApp, the OS vendor, or both, and only when the impact is fully understood.

Parameter	Setting
detect_prio	yes
dev_loss_tmo	"infinity"
failback	immediate
fast_io_fail_tmo	5
features	"3 queue_if_no_path pg_init_retries 50"
flush_on_last_del	"yes"
hardware_handler	"0"
no_path_retry	queue
path_checker	"tur"
path_grouping_policy	"group_by_prio"
path_selector	"round-robin 0"
polling_interval	5
prio	"ontap"
product	LUN.*
retain_attached_hw_handler	yes
rr_weight	"uniform"
user_friendly_names	no
vendor	NETAPP

Example

The following example shows how to correct an overridden default. In this case, the `multipath.conf` file defines values for `path_checker` and `detect_prio` that are not compatible with ONTAP LUNs.
If they cannot be removed because of other SAN arrays still attached to the host, these parameters can be corrected specifically for ONTAP LUNs with a device stanza.

```
defaults {
 path_checker readsector0
 detect_prio no
 }
devices {
 device {
 vendor "NETAPP "
 product "LUN.*"
 path_checker tur
 detect_prio yes
 }
}
```

(i) To configure Oracle Linux 6.4 Red Hat Compatible Kernel (RHCK), use the recommended settings for Red Hat Enterprise Linux (RHEL) 6.4.

ASM mirroring

Automatic Storage Management (ASM) mirroring might require changes to the Linux multipath settings to allow ASM to recognize a problem and switch over to an alternate failure group. Most ASM configurations on ONTAP use external redundancy, which means that data protection is provided by the external array and ASM doesn't mirror data. Some sites use ASM with normal redundancy to provide two-way mirroring, normally across different sites. See Oracle databases on ONTAP for further information.

Known issues

The Oracle Linux 6.4 with ONTAP release has the following known issues:

NetApp Bug ID	Title	Description
713555	QLogic adapter resets are seen on OL 6.4 and OL 5.9 with UEK2 on controller faults such as takeover/giveback, and reboot	QLogic adapter resets are seen on OL6.4 hosts with UEK2 (kernel-uek-2.6.39-400.17.1.el6uek) or OL5.9 hosts with UEK2 (kernel-uek-2.6.39 400.17.1.el5uek) when controller faults happen (such as takeover, giveback, and reboots). These resets are intermittent. When these adapter resets happen, a prolonged I/O outage (sometimes, more than 10 minutes) might occur until the adapter resets succeed and the paths' status are updated by dm-multipath. In /var/log/messages, messages similar to the following are seen when this bug is hit: kernel: qla2xxx [0000:11:00.0]-8018:0: ADAPTER RESET ISSUED nexus=0:2:13. This is observed with the kernel version: On OL6.4: kernel-uek-2.6.39-400.17.1.el6uek On OL5.9: kernel-uek-2.6.39-400.17.1.el5uek

NetApp Bug ID	Title	Description
715217	Delay in path recovery on OL 6.4 or OL 5.9 hosts with UEK2 might result in delayed I/O resumption on controller or fabric faults	When a controller fault (storage failover or giveback, reboots and so on) or a fabric fault (FC port disable or enable) occurs with I/O on Oracle Linux 6.4 or Oracle Linux 5.9 hosts with UEK2 Kernel, the path recovery by DM-Multipath takes a long time (4mins. to 10 mins). Sometimes, during the paths recovering to active state, the following lpfc driver errors are also seen: kernel: sd 0:0:8:3: [sdlt] Result: hostbyte=DID_ERROR driverbyte=DRIVER_OK Due to this delay in path recovery during fault events, the I/O resumption also delays. OL 6.4 Versions: device-mapper-1.02.77-9.el6 device-mapper-multipath-0.4.9-64.0.1.el6 kernel-uek-2.6.39-400.17.1.el6uek OL 5.9 Versions: device-mapper-1.02.77-9.el5 device-mapper-multipath-0.4.9-64.0.1.el5 kernel-uek-2.6.39-400.17.1.el5uek

NetApp Bug ID	Title	Description
[709911](#)	DM Multipath on OL 6.4 and OL 5.9 iSCSI with UEK2 kernel takes long time to update LUN path status after storage faults	On systems running Oracle Linux 6 Update4 and Oracle Linux 5 Update9 iSCSI with Unbreakable Enterprise Kernel Release 2 (UEK2), a problem has been seen during storage fault events where DM Multipath (DMMP) takes around 15 minutes to update the path status of Device Mapper (DM) devices (LUNs). If you run the "multipath -ll" command during this interval, the path status is shown as "failed ready running" for that DM device (LUN). The path status is eventually updated as "active ready running." This issue is seen with following version: Oracle Linux 6 Update 4: UEK2 Kernel: 2.6.39-400.17.1.el6uek.x86_64 Multipath: device-mapper-multipath-0.4.9-64.0.1.el6.x86_64 iSCSI: iscsi-initiator-utils-6.2.0.873-2.0.1.el6.x86_64 Oracle Linux 5 Update 9: UEK2 Kernel: 2.6.39-400.17.1.el5uek Multipath: device-mapper-multipath-0.4.9-64.0.1.el5.x86_64 iSCSI: iscsi-initiator-utils-6.2.0.872-16.0.1.el5.x86_64

NetApp Bug ID	Title	Description
	DM Multipath on OL 6.4 and OL 5.9	

NetApp Bug ID	Title	Description
[739909](#)	The SG_IO ioctl system call fails on dm-multipath devices after an FC fault on OL6.x and OL5.x hosts with UEK2	A problem is seen on Oracle Linux 6.x hosts with UEK2 kernel and Oracle Linux 5.x hosts with UEK2 kernel. The sg_* commands on a multipath device fail with EAGAIN error code (errno) after a fabric fault that makes all the paths in the active path group go down. This problem is seen only when there is no I/O occurring to the multipath devices. The following is an example: # sg_inq -v /dev/mapper/3600a0980417649373 03f436c75324370 inquiry cdb: 12 00 00 00 24 00 ioctl(SG_IO v3) failed with os_err (errno) = 11 inquiry: pass through os error: Resource temporarily unavailable HDIO_GET_IDENTITY ioctl failed: Resource temporarily unavailable [11] Both SCSI INQUIRY and fetching ATA information failed on /dev/mapper/3600a0980417649373 03f436c75324370 # This problem occurs because the path group switchover to other active groups is not activated during ioctl() calls when no I/O is occurring on the DM-Multipath device. The problem has been observed on the following versions of the kernel-uek and device-mapper-multipath packages: OL6.4 versions: kernel-uek-2.6.39-400.17.1.el6uek device-mapper-multipath-0.4.9-64.0.1.el6 OL5.9 versions: kernel-uek-2.6.39-400.17.1.el5uek device-mapper-multipath-0.4.9-64.0.1.el5

ⓘ   For Oracle Linux RHCK known issues, see the [known issues](#) for RHEL 6.4.

RHEL

RHEL 10

Configure RHEL 10 for FCP and iSCSI with ONTAP storage

The Linux Host Utilities software provides management and diagnostic tools for Linux hosts that are connected to ONTAP storage. When you install the Linux Host Utilities on a Red Hat Enterprise Linux (RHEL) 10 host, you can use the Host Utilities to help you manage FCP and iSCSI protocol operations with ONTAP LUNs.

> ℹ️ You don't need to manually configure Kernel-based Virtual Machine (KVM) settings because ONTAP LUNs are automatically mapped to the hypervisor.

Step 1: Optionally, enable SAN booting

You can configure your host to use SAN booting to simplify deployment and improve scalability.

Before you begin

Use the Interoperability Matrix Tool to verify that your Linux OS, host bus adapter (HBA), HBA firmware, HBA boot BIOS, and ONTAP version support SAN booting.

Steps

1. Create a SAN boot LUN and map it to the host.
2. Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is mapped.

   For information on how to enable the HBA BIOS, see your vendor-specific documentation.
3. Verify that the configuration was successful by rebooting the host and verifying that the OS is up and running.

Step 2: Install the Linux Host Utilities

NetApp strongly recommends installing the Linux Host Utilities to support ONTAP LUN management and assist technical support with gathering configuration data.

Install Linux Host Utilities 8.0.

> ℹ️ Installing the Linux Host Utilities doesn't change any host timeout settings on your Linux host.

Step 3: Confirm the multipath configuration for your host

You can use multipathing with RHEL 10 to manage ONTAP LUNs.

To ensure that multipathing is configured correctly for your host, verify that the `/etc/multipath.conf` file is defined and that you have the NetApp recommended settings configured for your ONTAP LUNs.

Steps

1. Verify that the `/etc/multipath.conf` file exits. If the file doesn't exist, create an empty, zero-byte file:

```
touch /etc/multipath.conf
```

2. The first time the `multipath.conf` file is created, you might need to enable and start the multipath services to load the recommended settings:

```
systemctl enable multipathd
```

```
systemctl start multipathd
```

3. Each time you boot the host, the empty `/etc/multipath.conf` zero-byte file automatically loads the NetApp recommended host multipath parameters as the default settings. You shouldn't need to make changes to the `/etc/multipath.conf` file for your host because the operating system is compiled with the multipath parameters that recognize and manage ONTAP LUNs correctly.

The following table shows the Linux OS native compiled multipath parameter settings for ONTAP LUNs.

Show parameter settings

Parameter	Setting
detect_prio	yes
dev_loss_tmo	"infinity"
failback	immediate
fast_io_fail_tmo	5
features	"2 pg_init_retries 50"
flush_on_last_del	"yes"
hardware_handler	"0"
no_path_retry	queue
path_checker	"tur"
path_grouping_policy	"group_by_prio"
path_selector	"service-time 0"
polling_interval	5
prio	"ontap"
product	LUN
retain_attached_hw_handler	yes
rr_weight	"uniform"
user_friendly_names	no
vendor	NETAPP

4. Verify the parameter settings and path status for your ONTAP LUNs:

```
multipath -ll
```

The default multipath parameters support ASA, AFF, and FAS configurations. In these configurations, a single ONTAP LUN shouldn't require more than four paths. If there are more than four paths, it might cause issues with the paths during a storage failure.

The following example outputs show the correct parameter settings and path status for ONTAP LUNs in an ASA, AFF, or FAS configuration.

ASA configuration

An ASA configuration optimizes all paths to a given LUN, keeping them active. This improves performance by serving I/O operations through all paths at the same time.

```
# multipath -ll
3600a098038314e535a24584e4b496252 dm-32 NETAPP,LUN C-Mode
size=10G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
`-+- policy='service-time 0' prio=50 status=active
  |- 11:0:0:41 sdan 66:112  active ready running
  |- 11:0:1:41 sdcb 68:240  active ready running
  |- 14:0:2:41 sdfd 129:240 active ready running
  `- 14:0:0:41 sddp 71:112  active ready running
```

AFF or FAS configuration

An AFF or FAS configuration should have two groups of paths with higher and lower priorities. Higher priority Active/Optimized paths are served by the controller where the aggregate is located. Lower priority paths are active but non-optimized because they are served by a different controller. Non-optimized paths are only used when optimized paths aren't available.

The following example displays the output for an ONTAP LUN with two Active/Optimized paths and two Active/Non-Optimized paths:

```
# multipath -ll
3600a0980383149764b5d567257516273 dm-0 NETAPP,LUN C-Mode
size=150G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
|-+- policy='service-time 0' prio=50 status=active
| |- 16:0:3:0  sdcg 69:64  active ready running
| `- 10:0:0:0  sdb  8:16   active ready running
`-+- policy='service-time 0' prio=10 status=enabled
  |- 10:0:1:0  sdc  8:32   active ready running
  `- 16:0:2:0  sdcf 69:48  active ready running
```

Step 4: Optionally, exclude a device from multipathing

If required, you can exclude a device from multipathing by adding the WWID for the unwanted device to the "blacklist" stanza for the `multipath.conf` file.

Steps

1. Determine the WWID:

   ```
   /lib/udev/scsi_id -gud /dev/sda
   ```

   "sda" is the local SCSI disk that you want to add to the blacklist.

   An example WWID is `360030057024d0730239134810c0cb833`.

2. Add the WWID to the "blacklist" stanza:

   ```
   blacklist {
           wwid    360030057024d0730239134810c0cb833
           devnode "^(ram|raw|loop|fd|md|dm-|sr|scd|st)[0-9]*"
           devnode "^hd[a-z]"
           devnode "^cciss.*"
   }
   ```

Step 5: Customize multipath parameters for ONTAP LUNs

If your host is connected to LUNs from other vendors and any of the multipath parameter settings are overridden, you need to correct them by adding stanzas later in the `multipath.conf` file that apply specifically to ONTAP LUNs. If you don't do this, the ONTAP LUNs might not work as expected.

Check your `/etc/multipath.conf` file, especially in the defaults section, for settings that might be overriding the default settings for multipath parameters.

> ⚠️ You shouldn't override the recommended parameter settings for ONTAP LUNs. These settings are required for optimal performance of your host configuration. Contact NetApp support, your OS vendor, or both for more information.

The following example shows how to correct an overridden default. In this example, the `multipath.conf` file defines values for `path_checker` and `no_path_retry` that aren't compatible with ONTAP LUNs, and you can't remove these parameters because ONTAP storage arrays are still attached to the host. Instead, you correct the values for `path_checker` and `no_path_retry` by adding a device stanza to the `multipath.conf` file that applies specifically to the ONTAP LUNs.

Show example

```
defaults {
    path_checker        readsector0
    no_path_retry       fail
}

devices {
    device {
        vendor          "NETAPP"
        product         "LUN"
        no_path_retry   queue
        path_checker    tur
    }
}
```

Step 6: Review the known issues

There are no known issues.

What's next?

- Learn about using the Linux Host Utilities tool.
- Learn about ASM mirroring.

  Automatic Storage Management (ASM) mirroring might require changes to the Linux multipath settings to allow ASM to recognize a problem and switch over to an alternate failure group. Most ASM configurations on ONTAP use external redundancy, which means that data protection is provided by the external array and ASM doesn't mirror data. Some sites use ASM with normal redundancy to provide two-way mirroring, normally across different sites. See Oracle databases on ONTAP for further information.

RHEL 9

Configure RHEL 9.6 for FCP and iSCSI with ONTAP storage

The Linux Host Utilities software provides management and diagnostic tools for Linux hosts that are connected to ONTAP storage. When you install the Linux Host Utilities on a Red Hat Enterprise Linux (RHEL) 9.6 host, you can use the Host Utilities to help you manage FCP and iSCSI protocol operations with ONTAP LUNs.

ⓘ   You don't need to manually configure Kernel-based Virtual Machine (KVM) settings because ONTAP LUNs are automatically mapped to the hypervisor.

Step 1: Optionally, enable SAN booting

You can configure your host to use SAN booting to simplify deployment and improve scalability.

Before you begin

Use the Interoperability Matrix Tool to verify that your Linux OS, host bus adapter (HBA), HBA firmware, HBA boot BIOS, and ONTAP version support SAN booting.

Steps

1. Create a SAN boot LUN and map it to the host.

2. Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is mapped.

   For information on how to enable the HBA BIOS, see your vendor-specific documentation.

3. Verify that the configuration was successful by rebooting the host and verifying that the OS is up and running.

Step 2: Install the Linux Host Utilities

NetApp strongly recommends installing the Linux Host Utilities to support ONTAP LUN management and assist technical support with gathering configuration data.

Install Linux Host Utilities 8.0.

> ⓘ   Installing the Linux Host Utilities doesn't change any host timeout settings on your Linux host.

Step 3: Confirm the multipath configuration for your host

You can use multipathing with RHEL 9.6 to manage ONTAP LUNs.

To ensure that multipathing is configured correctly for your host, verify that the `/etc/multipath.conf` file is defined and that you have the NetApp recommended settings configured for your ONTAP LUNs.

Steps

1. Verify that the `/etc/multipath.conf` file exits. If the file doesn't exist, create an empty, zero-byte file:

   ```
   touch /etc/multipath.conf
   ```

2. The first time the `multipath.conf` file is created, you might need to enable and start the multipath services to load the recommended settings:

   ```
   systemctl enable multipathd
   ```

   ```
   systemctl start multipathd
   ```

3. Each time you boot the host, the empty `/etc/multipath.conf` zero-byte file automatically loads the NetApp recommended host multipath parameters as the default settings. You shouldn't need to make changes to the `/etc/multipath.conf` file for your host because the operating system is compiled with the multipath parameters that recognize and manage ONTAP LUNs correctly.

   The following table shows the Linux OS native compiled multipath parameter settings for ONTAP LUNs.

Show parameter settings

Parameter	Setting
detect_prio	yes
dev_loss_tmo	"infinity"
failback	immediate
fast_io_fail_tmo	5
features	"2 pg_init_retries 50"
flush_on_last_del	"yes"
hardware_handler	"0"
no_path_retry	queue
path_checker	"tur"
path_grouping_policy	"group_by_prio"
path_selector	"service-time 0"
polling_interval	5
prio	"ontap"
product	LUN
retain_attached_hw_handler	yes
rr_weight	"uniform"
user_friendly_names	no
vendor	NETAPP

4. Verify the parameter settings and path status for your ONTAP LUNs:

```
multipath -ll
```

The default multipath parameters support ASA, AFF, and FAS configurations. In these configurations, a single ONTAP LUN shouldn't require more than four paths. If there are more than four paths, it might cause issues with the paths during a storage failure.

The following example outputs show the correct parameter settings and path status for ONTAP LUNs in an ASA, AFF, or FAS configuration.

ASA configuration

An ASA configuration optimizes all paths to a given LUN, keeping them active. This improves performance by serving I/O operations through all paths at the same time.

Show example

```
multipath -ll
3600a098038314c4a433f577471797958 dm-2 NETAPP,LUN C-Mode
size=180G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
`-+- policy='service-time 0' prio=50 status=active
  |- 14:0:0:0  sdc  8:32   active ready running
  |- 17:0:0:0  sdas 66:192 active ready running
  |- 14:0:3:0  sdar 66:176 active ready running
  `- 17:0:3:0  sdch 69:80  active ready running
```

AFF or FAS configuration

An AFF or FAS configuration should have two groups of paths with higher and lower priorities. Higher priority Active/Optimized paths are served by the controller where the aggregate is located. Lower priority paths are active but non-optimized because they are served by a different controller. Non-optimized paths are only used when optimized paths aren't available.

The following example displays the output for an ONTAP LUN with two Active/Optimized paths and two Active/Non-Optimized paths:

Show example

```
multipath -ll
3600a0980383149764b5d567257516273 dm-0 NETAPP,LUN C-Mode
size=150G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
|-+- policy='service-time 0' prio=50 status=active
| |- 16:0:3:0  sdcg 69:64  active ready running
| `- 10:0:0:0  sdb  8:16   active ready running
`-+- policy='service-time 0' prio=10 status=enabled
  |- 10:0:1:0  sdc  8:32   active ready running
  `- 16:0:2:0  sdcf 69:48  active ready running
```

Step 4: Optionally, exclude a device from multipathing

If required, you can exclude a device from multipathing by adding the WWID for the unwanted device to the "blacklist" stanza for the `multipath.conf` file.

Steps

1. Determine the WWID:

   ```
   /lib/udev/scsi_id -gud /dev/sda
   ```

   "sda" is the local SCSI disk that you want to add to the blacklist.

   An example WWID is `360030057024d0730239134810c0cb833`.

2. Add the WWID to the "blacklist" stanza:

   ```
   blacklist {
           wwid    360030057024d0730239134810c0cb833
           devnode "^(ram|raw|loop|fd|md|dm-|sr|scd|st)[0-9]*"
           devnode "^hd[a-z]"
           devnode "^cciss.*"
   }
   ```

Step 5: Customize multipath parameters for ONTAP LUNs

If your host is connected to LUNs from other vendors and any of the multipath parameter settings are overridden, you need to correct them by adding stanzas later in the `multipath.conf` file that apply specifically to ONTAP LUNs. If you don't do this, the ONTAP LUNs might not work as expected.

Check your `/etc/multipath.conf` file, especially in the defaults section, for settings that might be overriding the default settings for multipath parameters.

> ⚠ You shouldn't override the recommended parameter settings for ONTAP LUNs. These settings are required for optimal performance of your host configuration. Contact NetApp support, your OS vendor, or both for more information.

The following example shows how to correct an overridden default. In this example, the `multipath.conf` file defines values for `path_checker` and `no_path_retry` that aren't compatible with ONTAP LUNs, and you can't remove these parameters because ONTAP storage arrays are still attached to the host. Instead, you correct the values for `path_checker` and `no_path_retry` by adding a device stanza to the `multipath.conf` file that applies specifically to the ONTAP LUNs.

```
defaults {
    path_checker        readsector0
    no_path_retry       fail
}

devices {
    device {
        vendor          "NETAPP"
        product         "LUN"
        no_path_retry   queue
        path_checker    tur
    }
}
```

Step 6: Review the known issues

There are no known issues.

What's next?

- [Learn about using the Linux Host Utilities tool](#).
- Learn about ASM mirroring.

  Automatic Storage Management (ASM) mirroring might require changes to the Linux multipath settings to allow ASM to recognize a problem and switch over to an alternate failure group. Most ASM configurations on ONTAP use external redundancy, which means that data protection is provided by the external array and ASM doesn't mirror data. Some sites use ASM with normal redundancy to provide two-way mirroring, normally across different sites. See [Oracle databases on ONTAP](#) for further information.

Configure RHEL 9.5 for FCP and iSCSI with ONTAP storage

The Linux Host Utilities software provides management and diagnostic tools for Linux hosts that are connected to ONTAP storage. When you install the Linux Host Utilities on a Red Hat Enterprise Linux (RHEL) 9.5 host, you can use the Host Utilities to help you manage FCP and iSCSI protocol operations with ONTAP LUNs.

> ⓘ You don't need to manually configure Kernel-based Virtual Machine (KVM) settings because ONTAP LUNs are automatically mapped to the hypervisor.

Step 1: Optionally, enable SAN booting

You can configure your host to use SAN booting to simplify deployment and improve scalability.

Before you begin

Use the [Interoperability Matrix Tool](#) to verify that your Linux OS, host bus adapter (HBA), HBA firmware, HBA

boot BIOS, and ONTAP version support SAN booting.

Steps

1. [Create a SAN boot LUN and map it to the host](#).

2. Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is mapped.

   For information on how to enable the HBA BIOS, see your vendor-specific documentation.

3. Verify that the configuration was successful by rebooting the host and verifying that the OS is up and running.

Step 2: Install the Linux Host Utilities

NetApp strongly recommends installing the Linux Host Utilities to support ONTAP LUN management and assist technical support with gathering configuration data.

[Install Linux Host Utilities 8.0](#).

> ⓘ   Installing the Linux Host Utilities doesn't change any host timeout settings on your Linux host.

Step 3: Confirm the multipath configuration for your host

You can use multipathing with RHEL 9.5 to manage ONTAP LUNs.

To ensure that multipathing is configured correctly for your host, verify that the `/etc/multipath.conf` file is defined and that you have the NetApp recommended settings configured for your ONTAP LUNs.

Steps

1. Verify that the `/etc/multipath.conf` file exits. If the file doesn't exist, create an empty, zero-byte file:

   ```
   touch /etc/multipath.conf
   ```

2. The first time the `multipath.conf` file is created, you might need to enable and start the multipath services to load the recommended settings:

   ```
   systemctl enable multipathd
   ```

   ```
   systemctl start multipathd
   ```

3. Each time you boot the host, the empty `/etc/multipath.conf` zero-byte file automatically loads the NetApp recommended host multipath parameters as the default settings. You shouldn't need to make changes to the `/etc/multipath.conf` file for your host because the operating system is compiled with the multipath parameters that recognize and manage ONTAP LUNs correctly.

   The following table shows the Linux OS native compiled multipath parameter settings for ONTAP LUNs.

Show parameter settings

Parameter	Setting
detect_prio	yes
dev_loss_tmo	"infinity"
failback	immediate
fast_io_fail_tmo	5
features	"2 pg_init_retries 50"
flush_on_last_del	"yes"
hardware_handler	"0"
no_path_retry	queue
path_checker	"tur"
path_grouping_policy	"group_by_prio"
path_selector	"service-time 0"
polling_interval	5
prio	"ontap"
product	LUN
retain_attached_hw_handler	yes
rr_weight	"uniform"
user_friendly_names	no
vendor	NETAPP

4. Verify the parameter settings and path status for your ONTAP LUNs:

```
multipath -ll
```

The default multipath parameters support ASA, AFF, and FAS configurations. In these configurations, a single ONTAP LUN shouldn't require more than four paths. If there are more than four paths, it might cause issues with the paths during a storage failure.

The following example outputs show the correct parameter settings and path status for ONTAP LUNs in an ASA, AFF, or FAS configuration.

ASA configuration

An ASA configuration optimizes all paths to a given LUN, keeping them active. This improves performance by serving I/O operations through all paths at the same time.

Show example

```
multipath -ll
3600a098038314c4a433f577471797958 dm-2 NETAPP,LUN C-Mode
size=180G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
`-+- policy='service-time 0' prio=50 status=active
  |- 14:0:0:0  sdc  8:32   active ready running
  |- 17:0:0:0  sdas 66:192 active ready running
  |- 14:0:3:0  sdar 66:176 active ready running
  `- 17:0:3:0  sdch 69:80  active ready running
```

AFF or FAS configuration

An AFF or FAS configuration should have two groups of paths with higher and lower priorities. Higher priority Active/Optimized paths are served by the controller where the aggregate is located. Lower priority paths are active but non-optimized because they are served by a different controller. Non-optimized paths are only used when optimized paths aren't available.

The following example displays the output for an ONTAP LUN with two Active/Optimized paths and two Active/Non-Optimized paths:

Show example

```
multipath -ll
3600a0980383149764b5d567257516273 dm-0 NETAPP,LUN C-Mode
size=150G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
|-+- policy='service-time 0' prio=50 status=active
| |- 16:0:3:0  sdcg 69:64  active ready running
| `- 10:0:0:0  sdb  8:16   active ready running
`-+- policy='service-time 0' prio=10 status=enabled
  |- 10:0:1:0  sdc  8:32   active ready running
  `- 16:0:2:0  sdcf 69:48  active ready running
```

Step 4: Optionally, exclude a device from multipathing

If required, you can exclude a device from multipathing by adding the WWID for the unwanted device to the "blacklist" stanza for the `multipath.conf` file.

Steps

1. Determine the WWID:

   ```
   /lib/udev/scsi_id -gud /dev/sda
   ```

   "sda" is the local SCSI disk that you want to add to the blacklist.

   An example WWID is `360030057024d0730239134810c0cb833`.

2. Add the WWID to the "blacklist" stanza:

   ```
   blacklist {
           wwid    360030057024d0730239134810c0cb833
           devnode "^(ram|raw|loop|fd|md|dm-|sr|scd|st)[0-9]*"
           devnode "^hd[a-z]"
           devnode "^cciss.*"
   }
   ```

Step 5: Customize multipath parameters for ONTAP LUNs

If your host is connected to LUNs from other vendors and any of the multipath parameter settings are overridden, you need to correct them by adding stanzas later in the `multipath.conf` file that apply specifically to ONTAP LUNs. If you don't do this, the ONTAP LUNs might not work as expected.

Check your `/etc/multipath.conf` file, especially in the defaults section, for settings that might be overriding the default settings for multipath parameters.

> ⚠️ You shouldn't override the recommended parameter settings for ONTAP LUNs. These settings are required for optimal performance of your host configuration. Contact NetApp support, your OS vendor, or both for more information.

The following example shows how to correct an overridden default. In this example, the `multipath.conf` file defines values for `path_checker` and `no_path_retry` that aren't compatible with ONTAP LUNs, and you can't remove these parameters because ONTAP storage arrays are still attached to the host. Instead, you correct the values for `path_checker` and `no_path_retry` by adding a device stanza to the `multipath.conf` file that applies specifically to the ONTAP LUNs.

Show example

```
defaults {
    path_checker        readsector0
    no_path_retry       fail
}

devices {
    device {
        vendor          "NETAPP"
        product         "LUN"
        no_path_retry   queue
        path_checker    tur
    }
}
```

Step 6: Review the known issues

There are no known issues.

What's next?

- Learn about using the Linux Host Utilities tool.

- Learn about ASM mirroring.

  Automatic Storage Management (ASM) mirroring might require changes to the Linux multipath settings to allow ASM to recognize a problem and switch over to an alternate failure group. Most ASM configurations on ONTAP use external redundancy, which means that data protection is provided by the external array and ASM doesn't mirror data. Some sites use ASM with normal redundancy to provide two-way mirroring, normally across different sites. See Oracle databases on ONTAP for further information.

Configure RHEL 9.4 for FCP and iSCSI with ONTAP storage

The Linux Host Utilities software provides management and diagnostic tools for Linux hosts that are connected to ONTAP storage. When you install the Linux Host Utilities on a Red Hat Enterprise Linux (RHEL) 9.4 host, you can use the Host Utilities to help you manage FCP and iSCSI protocol operations with ONTAP LUNs.

> ⓘ You don't need to manually configure Kernel-based Virtual Machine (KVM) settings because ONTAP LUNs are automatically mapped to the hypervisor.

Step 1: Optionally, enable SAN booting

You can configure your host to use SAN booting to simplify deployment and improve scalability.

Before you begin

Use the Interoperability Matrix Tool to verify that your Linux OS, host bus adapter (HBA), HBA firmware, HBA

boot BIOS, and ONTAP version support SAN booting.

Steps

1. [Create a SAN boot LUN and map it to the host](#).

2. Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is mapped.

   For information on how to enable the HBA BIOS, see your vendor-specific documentation.

3. Verify that the configuration was successful by rebooting the host and verifying that the OS is up and running.

Step 2: Install the Linux Host Utilities

NetApp strongly recommends installing the Linux Host Utilities to support ONTAP LUN management and assist technical support with gathering configuration data.

[Install Linux Host Utilities 8.0](#).

> ℹ️ Installing the Linux Host Utilities doesn't change any host timeout settings on your Linux host.

Step 3: Confirm the multipath configuration for your host

You can use multipathing with RHEL 9.4 to manage ONTAP LUNs.

To ensure that multipathing is configured correctly for your host, verify that the `/etc/multipath.conf` file is defined and that you have the NetApp recommended settings configured for your ONTAP LUNs.

Steps

1. Verify that the `/etc/multipath.conf` file exits. If the file doesn't exist, create an empty, zero-byte file:

   ```
   touch /etc/multipath.conf
   ```

2. The first time the `multipath.conf` file is created, you might need to enable and start the multipath services to load the recommended settings:

   ```
   systemctl enable multipathd
   ```

   ```
   systemctl start multipathd
   ```

3. Each time you boot the host, the empty `/etc/multipath.conf` zero-byte file automatically loads the NetApp recommended host multipath parameters as the default settings. You shouldn't need to make changes to the `/etc/multipath.conf` file for your host because the operating system is compiled with the multipath parameters that recognize and manage ONTAP LUNs correctly.

   The following table shows the Linux OS native compiled multipath parameter settings for ONTAP LUNs.

Show parameter settings

Parameter	Setting
detect_prio	yes
dev_loss_tmo	"infinity"
failback	immediate
fast_io_fail_tmo	5
features	"2 pg_init_retries 50"
flush_on_last_del	"yes"
hardware_handler	"0"
no_path_retry	queue
path_checker	"tur"
path_grouping_policy	"group_by_prio"
path_selector	"service-time 0"
polling_interval	5
prio	"ontap"
product	LUN
retain_attached_hw_handler	yes
rr_weight	"uniform"
user_friendly_names	no
vendor	NETAPP

4. Verify the parameter settings and path status for your ONTAP LUNs:

```
multipath -ll
```

The default multipath parameters support ASA, AFF, and FAS configurations. In these configurations, a single ONTAP LUN shouldn't require more than four paths. If there are more than four paths, it might cause issues with the paths during a storage failure.

The following example outputs show the correct parameter settings and path status for ONTAP LUNs in an ASA, AFF, or FAS configuration.

ASA configuration

An ASA configuration optimizes all paths to a given LUN, keeping them active. This improves performance by serving I/O operations through all paths at the same time.

Show example

```
multipath -ll
3600a098038314c4a433f577471797958 dm-2 NETAPP,LUN C-Mode
size=180G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
`-+- policy='service-time 0' prio=50 status=active
  |- 14:0:0:0  sdc  8:32   active ready running
  |- 17:0:0:0  sdas 66:192 active ready running
  |- 14:0:3:0  sdar 66:176 active ready running
  `- 17:0:3:0  sdch 69:80  active ready running
```

AFF or FAS configuration

An AFF or FAS configuration should have two groups of paths with higher and lower priorities. Higher priority Active/Optimized paths are served by the controller where the aggregate is located. Lower priority paths are active but non-optimized because they are served by a different controller. Non-optimized paths are only used when optimized paths aren't available.

The following example displays the output for an ONTAP LUN with two Active/Optimized paths and two Active/Non-Optimized paths:

Show example

```
multipath -ll
3600a0980383149764b5d567257516273 dm-0 NETAPP,LUN C-Mode
size=150G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
|-+- policy='service-time 0' prio=50 status=active
| |- 16:0:3:0  sdcg 69:64  active ready running
| `- 10:0:0:0  sdb  8:16   active ready running
`-+- policy='service-time 0' prio=10 status=enabled
  |- 10:0:1:0  sdc  8:32   active ready running
  `- 16:0:2:0  sdcf 69:48  active ready running
```

Step 4: Optionally, exclude a device from multipathing

If required, you can exclude a device from multipathing by adding the WWID for the unwanted device to the "blacklist" stanza for the `multipath.conf` file.

Steps

1. Determine the WWID:

   ```
   /lib/udev/scsi_id -gud /dev/sda
   ```

   "sda" is the local SCSI disk that you want to add to the blacklist.

   An example WWID is `360030057024d0730239134810c0cb833`.

2. Add the WWID to the "blacklist" stanza:

   ```
   blacklist {
            wwid   360030057024d0730239134810c0cb833
            devnode "^(ram|raw|loop|fd|md|dm-|sr|scd|st)[0-9]*"
            devnode "^hd[a-z]"
            devnode "^cciss.*"
   }
   ```

Step 5: Customize multipath parameters for ONTAP LUNs

If your host is connected to LUNs from other vendors and any of the multipath parameter settings are overridden, you need to correct them by adding stanzas later in the `multipath.conf` file that apply specifically to ONTAP LUNs. If you don't do this, the ONTAP LUNs might not work as expected.

Check your `/etc/multipath.conf` file, especially in the defaults section, for settings that might be overriding the default settings for multipath parameters.

> ⚠️ You shouldn't override the recommended parameter settings for ONTAP LUNs. These settings are required for optimal performance of your host configuration. Contact NetApp support, your OS vendor, or both for more information.

The following example shows how to correct an overridden default. In this example, the `multipath.conf` file defines values for `path_checker` and `no_path_retry` that aren't compatible with ONTAP LUNs, and you can't remove these parameters because ONTAP storage arrays are still attached to the host. Instead, you correct the values for `path_checker` and `no_path_retry` by adding a device stanza to the `multipath.conf` file that applies specifically to the ONTAP LUNs.

Show example

```
defaults {
    path_checker        readsector0
    no_path_retry       fail
}

devices {
    device {
        vendor          "NETAPP"
        product         "LUN"
        no_path_retry   queue
        path_checker    tur
    }
}
```

Step 6: Review the known issues

There are no known issues.

What's next?

- Learn about using the Linux Host Utilities tool.
- Learn about ASM mirroring.

  Automatic Storage Management (ASM) mirroring might require changes to the Linux multipath settings to allow ASM to recognize a problem and switch over to an alternate failure group. Most ASM configurations on ONTAP use external redundancy, which means that data protection is provided by the external array and ASM doesn't mirror data. Some sites use ASM with normal redundancy to provide two-way mirroring, normally across different sites. See Oracle databases on ONTAP for further information.

Configure RHEL 9.3 for FCP and iSCSI with ONTAP storage

The Linux Host Utilities software provides management and diagnostic tools for Linux hosts that are connected to ONTAP storage. When you install the Linux Host Utilities on a Red Hat Enterprise Linux (RHEL) 9.3 host, you can use the Host Utilities to help you manage FCP and iSCSI protocol operations with ONTAP LUNs.

> ⓘ You don't need to manually configure Kernel-based Virtual Machine (KVM) settings because ONTAP LUNs are automatically mapped to the hypervisor.

Step 1: Optionally, enable SAN booting

You can configure your host to use SAN booting to simplify deployment and improve scalability.

Before you begin

Use the Interoperability Matrix Tool to verify that your Linux OS, host bus adapter (HBA), HBA firmware, HBA

boot BIOS, and ONTAP version support SAN booting.

Steps

1. [Create a SAN boot LUN and map it to the host](#).

2. Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is mapped.

   For information on how to enable the HBA BIOS, see your vendor-specific documentation.

3. Verify that the configuration was successful by rebooting the host and verifying that the OS is up and running.

Step 2: Install the Linux Host Utilities

NetApp strongly recommends installing the Linux Host Utilities to support ONTAP LUN management and assist technical support with gathering configuration data.

[Install Linux Host Utilities 8.0](#).

> ℹ️   Installing the Linux Host Utilities doesn't change any host timeout settings on your Linux host.

Step 3: Confirm the multipath configuration for your host

You can use multipathing with RHEL 9.3 to manage ONTAP LUNs.

To ensure that multipathing is configured correctly for your host, verify that the `/etc/multipath.conf` file is defined and that you have the NetApp recommended settings configured for your ONTAP LUNs.

Steps

1. Verify that the `/etc/multipath.conf` file exits. If the file doesn't exist, create an empty, zero-byte file:

   ```
   touch /etc/multipath.conf
   ```

2. The first time the `multipath.conf` file is created, you might need to enable and start the multipath services to load the recommended settings:

   ```
   systemctl enable multipathd
   ```

   ```
   systemctl start multipathd
   ```

3. Each time you boot the host, the empty `/etc/multipath.conf` zero-byte file automatically loads the NetApp recommended host multipath parameters as the default settings. You shouldn't need to make changes to the `/etc/multipath.conf` file for your host because the operating system is compiled with the multipath parameters that recognize and manage ONTAP LUNs correctly.

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flush_on_last_del	"yes"
hardware_handler	"0"
no_path_retry	queue
path_checker	"tur"
path_grouping_policy	"group_by_prio"
path_selector	"service-time 0"
polling_interval	5
prio	"ontap"
product	LUN
retain_attached_hw_handler	yes
rr_weight	"uniform"
user_friendly_names	no
vendor	NETAPP

4. Verify the parameter settings and path status for your ONTAP LUNs:

```
multipath -ll
```

The default multipath parameters support ASA, AFF, and FAS configurations. In these configurations, a single ONTAP LUN shouldn't require more than four paths. If there are more than four paths, it might cause issues with the paths during a storage failure.

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ASA configuration

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Show example

```
multipath -ll
3600a098038314c4a433f577471797958 dm-2 NETAPP,LUN C-Mode
size=180G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
`-+- policy='service-time 0' prio=50 status=active
  |- 14:0:0:0  sdc  8:32   active ready running
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  |- 14:0:3:0  sdar 66:176 active ready running
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AFF or FAS configuration

An AFF or FAS configuration should have two groups of paths with higher and lower priorities. Higher priority Active/Optimized paths are served by the controller where the aggregate is located. Lower priority paths are active but non-optimized because they are served by a different controller. Non-optimized paths are only used when optimized paths aren't available.

The following example displays the output for an ONTAP LUN with two Active/Optimized paths and two Active/Non-Optimized paths:

Show example

```
multipath -ll
3600a0980383149764b5d567257516273 dm-0 NETAPP,LUN C-Mode
size=150G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
|-+- policy='service-time 0' prio=50 status=active
| |- 16:0:3:0  sdcg 69:64  active ready running
| `- 10:0:0:0  sdb  8:16   active ready running
`-+- policy='service-time 0' prio=10 status=enabled
  |- 10:0:1:0  sdc  8:32   active ready running
  `- 16:0:2:0  sdcf 69:48  active ready running
```

Step 4: Optionally, exclude a device from multipathing

If required, you can exclude a device from multipathing by adding the WWID for the unwanted device to the "blacklist" stanza for the `multipath.conf` file.

Steps

1. Determine the WWID:

```
/lib/udev/scsi_id -gud /dev/sda
```

"sda" is the local SCSI disk that you want to add to the blacklist.

An example WWID is `360030057024d0730239134810c0cb833`.

2. Add the WWID to the "blacklist" stanza:

```
blacklist {
        wwid    360030057024d0730239134810c0cb833
        devnode "^(ram|raw|loop|fd|md|dm-|sr|scd|st)[0-9]*"
        devnode "^hd[a-z]"
        devnode "^cciss.*"
}
```

Step 5: Customize multipath parameters for ONTAP LUNs

If your host is connected to LUNs from other vendors and any of the multipath parameter settings are overridden, you need to correct them by adding stanzas later in the `multipath.conf` file that apply specifically to ONTAP LUNs. If you don't do this, the ONTAP LUNs might not work as expected.

Check your `/etc/multipath.conf` file, especially in the defaults section, for settings that might be overriding the default settings for multipath parameters.

> ⚠️ You shouldn't override the recommended parameter settings for ONTAP LUNs. These settings are required for optimal performance of your host configuration. Contact NetApp support, your OS vendor, or both for more information.

The following example shows how to correct an overridden default. In this example, the `multipath.conf` file defines values for `path_checker` and `no_path_retry` that aren't compatible with ONTAP LUNs, and you can't remove these parameters because ONTAP storage arrays are still attached to the host. Instead, you correct the values for `path_checker` and `no_path_retry` by adding a device stanza to the `multipath.conf` file that applies specifically to the ONTAP LUNs.

Show example

```
defaults {
    path_checker        readsector0
    no_path_retry       fail
}

devices {
    device {
        vendor          "NETAPP"
        product         "LUN"
        no_path_retry   queue
        path_checker    tur
    }
}
```

Step 6: Review the known issues

The RHEL 9.3 with ONTAP storage release has the following known issues:

NetApp Bug ID	Title	Description	JIRA ID
1508554	NetApp Linux Host Utilities CLI requires additional library package dependencies to support Emulex host bus adapter (HBA) adapter discovery	In RHEL 9.x, the NetApp Linux SAN Host Utilities CLI `sanlun fcp show adapter -v` fails because the library package dependencies to support Emulex host bus adapter (HBA) discovery cannot be found.	Not applicable
1593771	A Red Hat Enterprise Linux 9.3 QLogic SAN host encounters loss of partial multipaths during storage mobility operations	During the ONTAP storage controller takeover operation, half of the multipaths are expected to go down or switch to a failover mode and then recover to full path count during the giveback workflow. However, with a Red Hat Enterprise Linux (RHEL) 9.3 QLogic host, only partial multipaths are recovered after a storage failover giveback operation.	RHEL 17811

What's next?

- Learn about using the Linux Host Utilities tool.
- Learn about ASM mirroring.

  Automatic Storage Management (ASM) mirroring might require changes to the Linux multipath settings to allow ASM to recognize a problem and switch over to an alternate failure group. Most ASM configurations on ONTAP use external redundancy, which means that data protection is provided by the external array

and ASM doesn't mirror data. Some sites use ASM with normal redundancy to provide two-way mirroring, normally across different sites. See Oracle databases on ONTAP for further information.

Configure RHEL 9.2 for FCP and iSCSI with ONTAP storage

The Linux Host Utilities software provides management and diagnostic tools for Linux hosts that are connected to ONTAP storage. When you install the Linux Host Utilities on a Red Hat Enterprise Linux (RHEL) 9.2 host, you can use the Host Utilities to help you manage FCP and iSCSI protocol operations with ONTAP LUNs.

> ⓘ You don't need to manually configure Kernel-based Virtual Machine (KVM) settings because ONTAP LUNs are automatically mapped to the hypervisor.

Step 1: Optionally, enable SAN booting

You can configure your host to use SAN booting to simplify deployment and improve scalability.

Before you begin

Use the Interoperability Matrix Tool to verify that your Linux OS, host bus adapter (HBA), HBA firmware, HBA boot BIOS, and ONTAP version support SAN booting.

Steps

1. Create a SAN boot LUN and map it to the host.

2. Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is mapped.

   For information on how to enable the HBA BIOS, see your vendor-specific documentation.

3. Verify that the configuration was successful by rebooting the host and verifying that the OS is up and running.

Step 2: Install the Linux Host Utilities

NetApp strongly recommends installing the Linux Host Utilities to support ONTAP LUN management and assist technical support with gathering configuration data.

Install Linux Host Utilities 8.0.

> ⓘ Installing the Linux Host Utilities doesn't change any host timeout settings on your Linux host.

Step 3: Confirm the multipath configuration for your host

You can use multipathing with RHEL 9.2 to manage ONTAP LUNs.

To ensure that multipathing is configured correctly for your host, verify that the `/etc/multipath.conf` file is defined and that you have the NetApp recommended settings configured for your ONTAP LUNs.

Steps

1. Verify that the `/etc/multipath.conf` file exits. If the file doesn't exist, create an empty, zero-byte file:

```
touch /etc/multipath.conf
```

2. The first time the `multipath.conf` file is created, you might need to enable and start the multipath services to load the recommended settings:

```
systemctl enable multipathd
```

```
systemctl start multipathd
```

3. Each time you boot the host, the empty `/etc/multipath.conf` zero-byte file automatically loads the NetApp recommended host multipath parameters as the default settings. You shouldn't need to make changes to the `/etc/multipath.conf` file for your host because the operating system is compiled with the multipath parameters that recognize and manage ONTAP LUNs correctly.

The following table shows the Linux OS native compiled multipath parameter settings for ONTAP LUNs.

Show parameter settings

Parameter	Setting
detect_prio	yes
dev_loss_tmo	"infinity"
failback	immediate
fast_io_fail_tmo	5
features	"2 pg_init_retries 50"
flush_on_last_del	"yes"
hardware_handler	"0"
no_path_retry	queue
path_checker	"tur"
path_grouping_policy	"group_by_prio"
path_selector	"service-time 0"
polling_interval	5
prio	"ontap"
product	LUN
retain_attached_hw_handler	yes
rr_weight	"uniform"
user_friendly_names	no
vendor	NETAPP

4. Verify the parameter settings and path status for your ONTAP LUNs:

```
multipath -ll
```

The default multipath parameters support ASA, AFF, and FAS configurations. In these configurations, a single ONTAP LUN shouldn't require more than four paths. If there are more than four paths, it might cause issues with the paths during a storage failure.

The following example outputs show the correct parameter settings and path status for ONTAP LUNs in an ASA, AFF, or FAS configuration.

ASA configuration

An ASA configuration optimizes all paths to a given LUN, keeping them active. This improves performance by serving I/O operations through all paths at the same time.

Show example

```
multipath -ll
3600a098038314c4a433f577471797958 dm-2 NETAPP,LUN C-Mode
size=180G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
`-+- policy='service-time 0' prio=50 status=active
  |- 14:0:0:0  sdc  8:32   active ready running
  |- 17:0:0:0  sdas 66:192 active ready running
  |- 14:0:3:0  sdar 66:176 active ready running
  `- 17:0:3:0  sdch 69:80  active ready running
```

AFF or FAS configuration

An AFF or FAS configuration should have two groups of paths with higher and lower priorities. Higher priority Active/Optimized paths are served by the controller where the aggregate is located. Lower priority paths are active but non-optimized because they are served by a different controller. Non-optimized paths are only used when optimized paths aren't available.

The following example displays the output for an ONTAP LUN with two Active/Optimized paths and two Active/Non-Optimized paths:

Show example

```
multipath -ll
3600a0980383149764b5d567257516273 dm-0 NETAPP,LUN C-Mode
size=150G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
|-+- policy='service-time 0' prio=50 status=active
| |- 16:0:3:0  sdcg 69:64  active ready running
| `- 10:0:0:0  sdb  8:16   active ready running
`-+- policy='service-time 0' prio=10 status=enabled
  |- 10:0:1:0  sdc  8:32   active ready running
  `- 16:0:2:0  sdcf 69:48  active ready running
```

Step 4: Optionally, exclude a device from multipathing

If required, you can exclude a device from multipathing by adding the WWID for the unwanted device to the "blacklist" stanza for the `multipath.conf` file.

Steps

1. Determine the WWID:

   ```
   /lib/udev/scsi_id -gud /dev/sda
   ```

   "sda" is the local SCSI disk that you want to add to the blacklist.

   An example WWID is `360030057024d0730239134810c0cb833`.

2. Add the WWID to the "blacklist" stanza:

   ```
   blacklist {
           wwid    360030057024d0730239134810c0cb833
           devnode "^(ram|raw|loop|fd|md|dm-|sr|scd|st)[0-9]*"
           devnode "^hd[a-z]"
           devnode "^cciss.*"
   }
   ```

Step 5: Customize multipath parameters for ONTAP LUNs

If your host is connected to LUNs from other vendors and any of the multipath parameter settings are overridden, you need to correct them by adding stanzas later in the `multipath.conf` file that apply specifically to ONTAP LUNs. If you don't do this, the ONTAP LUNs might not work as expected.

Check your `/etc/multipath.conf` file, especially in the defaults section, for settings that might be overriding the default settings for multipath parameters.

> ⚠️ You shouldn't override the recommended parameter settings for ONTAP LUNs. These settings are required for optimal performance of your host configuration. Contact NetApp support, your OS vendor, or both for more information.

The following example shows how to correct an overridden default. In this example, the `multipath.conf` file defines values for `path_checker` and `no_path_retry` that aren't compatible with ONTAP LUNs, and you can't remove these parameters because ONTAP storage arrays are still attached to the host. Instead, you correct the values for `path_checker` and `no_path_retry` by adding a device stanza to the `multipath.conf` file that applies specifically to the ONTAP LUNs.

Show example

```
defaults {
    path_checker       readsector0
    no_path_retry      fail
}

devices {
    device {
        vendor          "NETAPP"
        product         "LUN"
        no_path_retry   queue
        path_checker    tur
    }
}
```

Step 6: Review the known issues

The RHEL 9.2 with ONTAP storage release has the following known issue:

NetApp Bug ID	Title	Description
1508554	NetApp Linux Host Utilities CLI requires additional library package dependencies to support Emulex HBA adapter discovery	In RHEL 9.2, the NetApp Linux SAN Host Utilities CLI `sanlun fcp show adapter -v` fails because the library package dependencies to support HBA discovery cannot be found.
1537359	A Red Hat Linux 9.2 SAN booted host with Emulex HBA encounters stalled tasks leading to kernel disruption	During a storage failover giveback operation, a Red Hat Linux 9.2 SAN booted host with an Emulex host bus adapter (HBA) encounters stalled tasks leading to kernel disruption. The kernel disruption causes the operating system to reboot and if `kdump` is configured, it generates the `vmcore` file under the `/var/crash/` directory. The issue is being triaged with the `lpfc` driver but it cannot be reproduced consistently.

What's next?

- Learn about using the Linux Host Utilities tool.

- Learn about ASM mirroring.

  Automatic Storage Management (ASM) mirroring might require changes to the Linux multipath settings to allow ASM to recognize a problem and switch over to an alternate failure group. Most ASM configurations on ONTAP use external redundancy, which means that data protection is provided by the external array and ASM doesn't mirror data. Some sites use ASM with normal redundancy to provide two-way mirroring,

normally across different sites. See Oracle databases on ONTAP for further information.

Configure RHEL 9.1 for FCP and iSCSI with ONTAP storage

The Linux Host Utilities software provides management and diagnostic tools for Linux hosts that are connected to ONTAP storage. When you install the Linux Host Utilities on a Red Hat Enterprise Linux (RHEL) 9.1 host, you can use the Host Utilities to help you manage FCP and iSCSI protocol operations with ONTAP LUNs.

> **(i)** You don't need to manually configure Kernel-based Virtual Machine (KVM) settings because ONTAP LUNs are automatically mapped to the hypervisor.

Step 1: Optionally, enable SAN booting

You can configure your host to use SAN booting to simplify deployment and improve scalability.

Before you begin
Use the Interoperability Matrix Tool to verify that your Linux OS, host bus adapter (HBA), HBA firmware, HBA boot BIOS, and ONTAP version support SAN booting.

Steps
1. Create a SAN boot LUN and map it to the host.
2. Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is mapped.

   For information on how to enable the HBA BIOS, see your vendor-specific documentation.

3. Verify that the configuration was successful by rebooting the host and verifying that the OS is up and running.

Step 2: Install the Linux Host Utilities

NetApp strongly recommends installing the Linux Host Utilities to support ONTAP LUN management and assist technical support with gathering configuration data.

Install Linux Host Utilities 8.0.

> **(i)** Installing the Linux Host Utilities doesn't change any host timeout settings on your Linux host.

Step 3: Confirm the multipath configuration for your host

You can use multipathing with RHEL 9.1 to manage ONTAP LUNs.

To ensure that multipathing is configured correctly for your host, verify that the `/etc/multipath.conf` file is defined and that you have the NetApp recommended settings configured for your ONTAP LUNs.

Steps
1. Verify that the `/etc/multipath.conf` file exits. If the file doesn't exist, create an empty, zero-byte file:

```
touch /etc/multipath.conf
```

2. The first time the `multipath.conf` file is created, you might need to enable and start the multipath services to load the recommended settings:

```
systemctl enable multipathd
```

```
systemctl start multipathd
```

3. Each time you boot the host, the empty `/etc/multipath.conf` zero-byte file automatically loads the NetApp recommended host multipath parameters as the default settings. You shouldn't need to make changes to the `/etc/multipath.conf` file for your host because the operating system is compiled with the multipath parameters that recognize and manage ONTAP LUNs correctly.

The following table shows the Linux OS native compiled multipath parameter settings for ONTAP LUNs.

Show parameter settings

Parameter	Setting
detect_prio	yes
dev_loss_tmo	"infinity"
failback	immediate
fast_io_fail_tmo	5
features	"2 pg_init_retries 50"
flush_on_last_del	"yes"
hardware_handler	"0"
no_path_retry	queue
path_checker	"tur"
path_grouping_policy	"group_by_prio"
path_selector	"service-time 0"
polling_interval	5
prio	"ontap"
product	LUN
retain_attached_hw_handler	yes
rr_weight	"uniform"
user_friendly_names	no
vendor	NETAPP

4. Verify the parameter settings and path status for your ONTAP LUNs:

```
multipath -ll
```

The default multipath parameters support ASA, AFF, and FAS configurations. In these configurations, a single ONTAP LUN shouldn't require more than four paths. If there are more than four paths, it might cause issues with the paths during a storage failure.

The following example outputs show the correct parameter settings and path status for ONTAP LUNs in an ASA, AFF, or FAS configuration.

ASA configuration

An ASA configuration optimizes all paths to a given LUN, keeping them active. This improves performance by serving I/O operations through all paths at the same time.

Show example

```
multipath -ll
3600a098038314c4a433f577471797958 dm-2 NETAPP,LUN C-Mode
size=180G features='3 queue_if_no_path pg_init_retries 50'
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`-+- policy='service-time 0' prio=50 status=active
  |- 14:0:0:0  sdc  8:32   active ready running
  |- 17:0:0:0  sdas 66:192 active ready running
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```

AFF or FAS configuration

An AFF or FAS configuration should have two groups of paths with higher and lower priorities. Higher priority Active/Optimized paths are served by the controller where the aggregate is located. Lower priority paths are active but non-optimized because they are served by a different controller. Non-optimized paths are only used when optimized paths aren't available.

The following example displays the output for an ONTAP LUN with two Active/Optimized paths and two Active/Non-Optimized paths:

Show example

```
multipath -ll
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size=150G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
|-+- policy='service-time 0' prio=50 status=active
| |- 16:0:3:0  sdcg 69:64  active ready running
| `- 10:0:0:0  sdb  8:16   active ready running
`-+- policy='service-time 0' prio=10 status=enabled
  |- 10:0:1:0  sdc  8:32   active ready running
  `- 16:0:2:0  sdcf 69:48  active ready running
```

Step 4: Optionally, exclude a device from multipathing

If required, you can exclude a device from multipathing by adding the WWID for the unwanted device to the "blacklist" stanza for the `multipath.conf` file.

Steps

1. Determine the WWID:

   ```
   /lib/udev/scsi_id -gud /dev/sda
   ```

   "sda" is the local SCSI disk that you want to add to the blacklist.

   An example WWID is `360030057024d0730239134810c0cb833`.

2. Add the WWID to the "blacklist" stanza:

   ```
   blacklist {
           wwid    360030057024d0730239134810c0cb833
           devnode "^(ram|raw|loop|fd|md|dm-|sr|scd|st)[0-9]*"
           devnode "^hd[a-z]"
           devnode "^cciss.*"
   }
   ```

Step 5: Customize multipath parameters for ONTAP LUNs

If your host is connected to LUNs from other vendors and any of the multipath parameter settings are overridden, you need to correct them by adding stanzas later in the `multipath.conf` file that apply specifically to ONTAP LUNs. If you don't do this, the ONTAP LUNs might not work as expected.

Check your `/etc/multipath.conf` file, especially in the defaults section, for settings that might be overriding the default settings for multipath parameters.

> ⚠️ You shouldn't override the recommended parameter settings for ONTAP LUNs. These settings are required for optimal performance of your host configuration. Contact NetApp support, your OS vendor, or both for more information.

The following example shows how to correct an overridden default. In this example, the `multipath.conf` file defines values for `path_checker` and `no_path_retry` that aren't compatible with ONTAP LUNs, and you can't remove these parameters because ONTAP storage arrays are still attached to the host. Instead, you correct the values for `path_checker` and `no_path_retry` by adding a device stanza to the `multipath.conf` file that applies specifically to the ONTAP LUNs.

Show example

```
defaults {
    path_checker        readsector0
    no_path_retry       fail
}

devices {
    device {
        vendor          "NETAPP"
        product         "LUN"
        no_path_retry   queue
        path_checker    tur
    }
}
```

Step 6: Review the known issues

The RHEL 9.1 with ONTAP storage release has the following known issue:

NetApp Bug ID	Title	Description
1508554	NetApp Linux Host Utilities CLI requires additional library package dependencies to support Emulex HBA adapter discovery	In RHEL 9.1, the NetApp Linux SAN Host Utilities CLI `sanlun fcp show adapter -v` fails because the library package dependencies to support HBA discovery cannot be found.

What's next?

- Learn about using the Linux Host Utilities tool.
- Learn about ASM mirroring.

  Automatic Storage Management (ASM) mirroring might require changes to the Linux multipath settings to allow ASM to recognize a problem and switch over to an alternate failure group. Most ASM configurations on ONTAP use external redundancy, which means that data protection is provided by the external array and ASM doesn't mirror data. Some sites use ASM with normal redundancy to provide two-way mirroring, normally across different sites. See Oracle databases on ONTAP for further information.

Configure RHEL 9.0 for FCP and iSCSI with ONTAP storage

The Linux Host Utilities software provides management and diagnostic tools for Linux hosts that are connected to ONTAP storage. When you install the Linux Host Utilities on a Red Hat Enterprise Linux (RHEL) 9.0 host, you can use the Host Utilities to help you manage FCP and iSCSI protocol operations with ONTAP LUNs.

> ℹ️ You don't need to manually configure Kernel-based Virtual Machine (KVM) settings because ONTAP LUNs are automatically mapped to the hypervisor.

Step 1: Optionally, enable SAN booting

You can configure your host to use SAN booting to simplify deployment and improve scalability.

Before you begin

Use the Interoperability Matrix Tool to verify that your Linux OS, host bus adapter (HBA), HBA firmware, HBA boot BIOS, and ONTAP version support SAN booting.

Steps

1. Create a SAN boot LUN and map it to the host.

2. Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is mapped.

   For information on how to enable the HBA BIOS, see your vendor-specific documentation.

3. Verify that the configuration was successful by rebooting the host and verifying that the OS is up and running.

Step 2: Install the Linux Host Utilities

NetApp strongly recommends installing the Linux Host Utilities to support ONTAP LUN management and assist technical support with gathering configuration data.

Install Linux Host Utilities 8.0.

> ℹ️ Installing the Linux Host Utilities doesn't change any host timeout settings on your Linux host.

Step 3: Confirm the multipath configuration for your host

You can use multipathing with RHEL 9.0 to manage ONTAP LUNs.

To ensure that multipathing is configured correctly for your host, verify that the `/etc/multipath.conf` file is defined and that you have the NetApp recommended settings configured for your ONTAP LUNs.

Steps

1. Verify that the `/etc/multipath.conf` file exits. If the file doesn't exist, create an empty, zero-byte file:

   ```
   touch /etc/multipath.conf
   ```

2. The first time the `multipath.conf` file is created, you might need to enable and start the multipath services to load the recommended settings:

   ```
   systemctl enable multipathd
   ```

   ```
   systemctl start multipathd
   ```

3. Each time you boot the host, the empty `/etc/multipath.conf` zero-byte file automatically loads the NetApp recommended host multipath parameters as the default settings. You shouldn't need to make changes to the `/etc/multipath.conf` file for your host because the operating system is compiled with the multipath parameters that recognize and manage ONTAP LUNs correctly.

The following table shows the Linux OS native compiled multipath parameter settings for ONTAP LUNs.

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flush_on_last_del	"yes"
hardware_handler	"0"
no_path_retry	queue
path_checker	"tur"
path_grouping_policy	"group_by_prio"
path_selector	"service-time 0"
polling_interval	5
prio	"ontap"
product	LUN
retain_attached_hw_handler	yes
rr_weight	"uniform"
user_friendly_names	no
vendor	NETAPP

4. Verify the parameter settings and path status for your ONTAP LUNs:

```
multipath -ll
```

The default multipath parameters support ASA, AFF, and FAS configurations. In these configurations, a single ONTAP LUN shouldn't require more than four paths. If there are more than four paths, it might cause issues with the paths during a storage failure.

The following example outputs show the correct parameter settings and path status for ONTAP LUNs in an ASA, AFF, or FAS configuration.

ASA configuration

An ASA configuration optimizes all paths to a given LUN, keeping them active. This improves performance by serving I/O operations through all paths at the same time.

Show example

```
multipath -ll
3600a098038314c4a433f577471797958 dm-2 NETAPP,LUN C-Mode
size=180G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
`-+- policy='service-time 0' prio=50 status=active
  |- 14:0:0:0  sdc  8:32   active ready running
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  |- 14:0:3:0  sdar 66:176 active ready running
  `- 17:0:3:0  sdch 69:80  active ready running
```

AFF or FAS configuration

An AFF or FAS configuration should have two groups of paths with higher and lower priorities. Higher priority Active/Optimized paths are served by the controller where the aggregate is located. Lower priority paths are active but non-optimized because they are served by a different controller. Non-optimized paths are only used when optimized paths aren't available.

The following example displays the output for an ONTAP LUN with two Active/Optimized paths and two Active/Non-Optimized paths:

Show example

```
multipath -ll
3600a0980383149764b5d567257516273 dm-0 NETAPP,LUN C-Mode
size=150G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
|-+- policy='service-time 0' prio=50 status=active
| |- 16:0:3:0  sdcg 69:64  active ready running
| `- 10:0:0:0  sdb  8:16   active ready running
`-+- policy='service-time 0' prio=10 status=enabled
  |- 10:0:1:0  sdc  8:32   active ready running
  `- 16:0:2:0  sdcf 69:48  active ready running
```

Step 4: Optionally, exclude a device from multipathing

If required, you can exclude a device from multipathing by adding the WWID for the unwanted device to the "blacklist" stanza for the `multipath.conf` file.

Steps

1. Determine the WWID:

```
/lib/udev/scsi_id -gud /dev/sda
```

"sda" is the local SCSI disk that you want to add to the blacklist.

An example WWID is `360030057024d0730239134810c0cb833`.

2. Add the WWID to the "blacklist" stanza:

```
blacklist {
        wwid   360030057024d0730239134810c0cb833
        devnode "^(ram|raw|loop|fd|md|dm-|sr|scd|st)[0-9]*"
        devnode "^hd[a-z]"
        devnode "^cciss.*"
}
```

Step 5: Customize multipath parameters for ONTAP LUNs

If your host is connected to LUNs from other vendors and any of the multipath parameter settings are overridden, you need to correct them by adding stanzas later in the `multipath.conf` file that apply specifically to ONTAP LUNs. If you don't do this, the ONTAP LUNs might not work as expected.

Check your `/etc/multipath.conf` file, especially in the defaults section, for settings that might be overriding the default settings for multipath parameters.

> ⚠️ You shouldn't override the recommended parameter settings for ONTAP LUNs. These settings are required for optimal performance of your host configuration. Contact NetApp support, your OS vendor, or both for more information.

The following example shows how to correct an overridden default. In this example, the `multipath.conf` file defines values for `path_checker` and `no_path_retry` that aren't compatible with ONTAP LUNs, and you can't remove these parameters because ONTAP storage arrays are still attached to the host. Instead, you correct the values for `path_checker` and `no_path_retry` by adding a device stanza to the `multipath.conf` file that applies specifically to the ONTAP LUNs.

Show example

```
defaults {
    path_checker        readsector0
    no_path_retry       fail
}

devices {
    device {
        vendor          "NETAPP"
        product         "LUN"
        no_path_retry   queue
        path_checker    tur
    }
}
```

Step 6: Review the known issues

There are no known issues.

What's next?

- Learn about using the Linux Host Utilities tool.
- Learn about ASM mirroring.

  Automatic Storage Management (ASM) mirroring might require changes to the Linux multipath settings to allow ASM to recognize a problem and switch over to an alternate failure group. Most ASM configurations on ONTAP use external redundancy, which means that data protection is provided by the external array and ASM doesn't mirror data. Some sites use ASM with normal redundancy to provide two-way mirroring, normally across different sites. See Oracle databases on ONTAP for further information.

RHEL 8

Configure RHEL 8.10 for FCP and iSCSI with ONTAP storage

The Linux Host Utilities software provides management and diagnostic tools for Linux hosts that are connected to ONTAP storage. When you install the Linux Host Utilities on a Red Hat Enterprise Linux (RHEL) 8.10 host, you can use the Host Utilities to help you manage FCP and iSCSI protocol operations with ONTAP LUNs.

> ⓘ You don't need to manually configure Kernel-based Virtual Machine (KVM) settings because ONTAP LUNs are automatically mapped to the hypervisor.

Step 1: Optionally, enable SAN booting

You can configure your host to use SAN booting to simplify deployment and improve scalability.

Before you begin

Use the Interoperability Matrix Tool to verify that your Linux OS, host bus adapter (HBA), HBA firmware, HBA boot BIOS, and ONTAP version support SAN booting.

Steps

1. Create a SAN boot LUN and map it to the host.

2. Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is mapped.

   For information on how to enable the HBA BIOS, see your vendor-specific documentation.

3. Verify that the configuration was successful by rebooting the host and verifying that the OS is up and running.

Step 2: Install the Linux Host Utilities

NetApp strongly recommends installing the Linux Host Utilities to support ONTAP LUN management and assist technical support with gathering configuration data.

Install Linux Host Utilities 8.0.

> ⓘ Installing the Linux Host Utilities doesn't change any host timeout settings on your Linux host.

Step 3: Confirm the multipath configuration for your host

You can use multipathing with RHEL 8.10 to manage ONTAP LUNs.

To ensure that multipathing is configured correctly for your host, verify that the `/etc/multipath.conf` file is defined and that you have the NetApp recommended settings configured for your ONTAP LUNs.

Steps

1. Verify that the `/etc/multipath.conf` file exits. If the file doesn't exist, create an empty, zero-byte file:

   ```
   touch /etc/multipath.conf
   ```

2. The first time the `multipath.conf` file is created, you might need to enable and start the multipath services to load the recommended settings:

   ```
   systemctl enable multipathd
   ```

   ```
   systemctl start multipathd
   ```

3. Each time you boot the host, the empty `/etc/multipath.conf` zero-byte file automatically loads the NetApp recommended host multipath parameters as the default settings. You shouldn't need to make changes to the `/etc/multipath.conf` file for your host because the operating system is compiled with the multipath parameters that recognize and manage ONTAP LUNs correctly.

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path_checker	"tur"
path_grouping_policy	"group_by_prio"
path_selector	"service-time 0"
polling_interval	5
prio	"ontap"
product	LUN
retain_attached_hw_handler	yes
rr_weight	"uniform"
user_friendly_names	no
vendor	NETAPP

4. Verify the parameter settings and path status for your ONTAP LUNs:

```
multipath -ll
```

The default multipath parameters support ASA, AFF, and FAS configurations. In these configurations, a single ONTAP LUN shouldn't require more than four paths. If there are more than four paths, it might cause issues with the paths during a storage failure.

The following example outputs show the correct parameter settings and path status for ONTAP LUNs in an ASA, AFF, or FAS configuration.

ASA configuration

An ASA configuration optimizes all paths to a given LUN, keeping them active. This improves performance by serving I/O operations through all paths at the same time.

Show example

```
multipath -ll
3600a098038314c4a433f577471797958 dm-2 NETAPP,LUN C-Mode
size=180G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
`-+- policy='service-time 0' prio=50 status=active
  |- 14:0:0:0  sdc  8:32   active ready running
  |- 17:0:0:0  sdas 66:192 active ready running
  |- 14:0:3:0  sdar 66:176 active ready running
  `- 17:0:3:0  sdch 69:80  active ready running
```

AFF or FAS configuration

An AFF or FAS configuration should have two groups of paths with higher and lower priorities. Higher priority Active/Optimized paths are served by the controller where the aggregate is located. Lower priority paths are active but non-optimized because they are served by a different controller. Non-optimized paths are only used when optimized paths aren't available.

The following example displays the output for an ONTAP LUN with two Active/Optimized paths and two Active/Non-Optimized paths:

Show example

```
multipath -ll
3600a0980383149764b5d567257516273 dm-0 NETAPP,LUN C-Mode
size=150G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
|-+- policy='service-time 0' prio=50 status=active
| |- 16:0:3:0  sdcg 69:64  active ready running
| `- 10:0:0:0  sdb  8:16   active ready running
`-+- policy='service-time 0' prio=10 status=enabled
  |- 10:0:1:0  sdc  8:32   active ready running
  `- 16:0:2:0  sdcf 69:48  active ready running
```

Step 4: Optionally, exclude a device from multipathing

If required, you can exclude a device from multipathing by adding the WWID for the unwanted device to the "blacklist" stanza for the `multipath.conf` file.

Steps

1. Determine the WWID:

   ```
   /lib/udev/scsi_id -gud /dev/sda
   ```

   "sda" is the local SCSI disk that you want to add to the blacklist.

   An example WWID is `360030057024d0730239134810c0cb833`.

2. Add the WWID to the "blacklist" stanza:

   ```
   blacklist {
           wwid    360030057024d0730239134810c0cb833
           devnode "^(ram|raw|loop|fd|md|dm-|sr|scd|st)[0-9]*"
           devnode "^hd[a-z]"
           devnode "^cciss.*"
   }
   ```

Step 5: Customize multipath parameters for ONTAP LUNs

If your host is connected to LUNs from other vendors and any of the multipath parameter settings are overridden, you need to correct them by adding stanzas later in the `multipath.conf` file that apply specifically to ONTAP LUNs. If you don't do this, the ONTAP LUNs might not work as expected.

Check your `/etc/multipath.conf` file, especially in the defaults section, for settings that might be overriding the default settings for multipath parameters.

> ⚠️ You shouldn't override the recommended parameter settings for ONTAP LUNs. These settings are required for optimal performance of your host configuration. Contact NetApp support, your OS vendor, or both for more information.

The following example shows how to correct an overridden default. In this example, the `multipath.conf` file defines values for `path_checker` and `no_path_retry` that aren't compatible with ONTAP LUNs, and you can't remove these parameters because ONTAP storage arrays are still attached to the host. Instead, you correct the values for `path_checker` and `no_path_retry` by adding a device stanza to the `multipath.conf` file that applies specifically to the ONTAP LUNs.

Show example

```
defaults {
    path_checker        readsector0
    no_path_retry       fail
}

devices {
    device {
        vendor          "NETAPP"
        product         "LUN"
        no_path_retry   queue
        path_checker    tur
    }
}
```

Step 6: Review the known issues

There are no known issues.

What's next?

- Learn about using the Linux Host Utilities tool.
- Learn about ASM mirroring.

  Automatic Storage Management (ASM) mirroring might require changes to the Linux multipath settings to allow ASM to recognize a problem and switch over to an alternate failure group. Most ASM configurations on ONTAP use external redundancy, which means that data protection is provided by the external array and ASM doesn't mirror data. Some sites use ASM with normal redundancy to provide two-way mirroring, normally across different sites. See Oracle databases on ONTAP for further information.

Configure RHEL 8.9 for FCP and iSCSI with ONTAP storage

The Linux Host Utilities software provides management and diagnostic tools for Linux hosts that are connected to ONTAP storage. When you install the Linux Host Utilities on a Red Hat Enterprise Linux (RHEL) 8.9 host, you can use the Host Utilities to help you manage FCP and iSCSI protocol operations with ONTAP LUNs.

> ⓘ You don't need to manually configure Kernel-based Virtual Machine (KVM) settings because ONTAP LUNs are automatically mapped to the hypervisor.

Step 1: Optionally, enable SAN booting

You can configure your host to use SAN booting to simplify deployment and improve scalability.

Before you begin

Use the Interoperability Matrix Tool to verify that your Linux OS, host bus adapter (HBA), HBA firmware, HBA

boot BIOS, and ONTAP version support SAN booting.

Steps

1. [Create a SAN boot LUN and map it to the host](#).

2. Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is mapped.

   For information on how to enable the HBA BIOS, see your vendor-specific documentation.

3. Verify that the configuration was successful by rebooting the host and verifying that the OS is up and running.

Step 2: Install the Linux Host Utilities

NetApp strongly recommends installing the Linux Host Utilities to support ONTAP LUN management and assist technical support with gathering configuration data.

[Install Linux Host Utilities 8.0](#).

> ⓘ Installing the Linux Host Utilities doesn't change any host timeout settings on your Linux host.

Step 3: Confirm the multipath configuration for your host

You can use multipathing with RHEL 8.9 to manage ONTAP LUNs.

To ensure that multipathing is configured correctly for your host, verify that the `/etc/multipath.conf` file is defined and that you have the NetApp recommended settings configured for your ONTAP LUNs.

Steps

1. Verify that the `/etc/multipath.conf` file exits. If the file doesn't exist, create an empty, zero-byte file:

   ```
   touch /etc/multipath.conf
   ```

2. The first time the `multipath.conf` file is created, you might need to enable and start the multipath services to load the recommended settings:

   ```
   systemctl enable multipathd
   ```

   ```
   systemctl start multipathd
   ```

3. Each time you boot the host, the empty `/etc/multipath.conf` zero-byte file automatically loads the NetApp recommended host multipath parameters as the default settings. You shouldn't need to make changes to the `/etc/multipath.conf` file for your host because the operating system is compiled with the multipath parameters that recognize and manage ONTAP LUNs correctly.

   The following table shows the Linux OS native compiled multipath parameter settings for ONTAP LUNs.

Show parameter settings

Parameter	Setting
detect_prio	yes
dev_loss_tmo	"infinity"
failback	immediate
fast_io_fail_tmo	5
features	"2 pg_init_retries 50"
flush_on_last_del	"yes"
hardware_handler	"0"
no_path_retry	queue
path_checker	"tur"
path_grouping_policy	"group_by_prio"
path_selector	"service-time 0"
polling_interval	5
prio	"ontap"
product	LUN
retain_attached_hw_handler	yes
rr_weight	"uniform"
user_friendly_names	no
vendor	NETAPP

4. Verify the parameter settings and path status for your ONTAP LUNs:

```
multipath -ll
```

The default multipath parameters support ASA, AFF, and FAS configurations. In these configurations, a single ONTAP LUN shouldn't require more than four paths. If there are more than four paths, it might cause issues with the paths during a storage failure.

The following example outputs show the correct parameter settings and path status for ONTAP LUNs in an ASA, AFF, or FAS configuration.

ASA configuration

An ASA configuration optimizes all paths to a given LUN, keeping them active. This improves performance by serving I/O operations through all paths at the same time.

Show example

```
multipath -ll
3600a098038314c4a433f577471797958 dm-2 NETAPP,LUN C-Mode
size=180G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
`-+- policy='service-time 0' prio=50 status=active
  |- 14:0:0:0  sdc  8:32   active ready running
  |- 17:0:0:0  sdas 66:192 active ready running
  |- 14:0:3:0  sdar 66:176 active ready running
  `- 17:0:3:0  sdch 69:80  active ready running
```

AFF or FAS configuration

An AFF or FAS configuration should have two groups of paths with higher and lower priorities. Higher priority Active/Optimized paths are served by the controller where the aggregate is located. Lower priority paths are active but non-optimized because they are served by a different controller. Non-optimized paths are only used when optimized paths aren't available.

The following example displays the output for an ONTAP LUN with two Active/Optimized paths and two Active/Non-Optimized paths:

Show example

```
multipath -ll
3600a0980383149764b5d567257516273 dm-0 NETAPP,LUN C-Mode
size=150G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
|-+- policy='service-time 0' prio=50 status=active
| |- 16:0:3:0  sdcg 69:64  active ready running
| `- 10:0:0:0  sdb  8:16   active ready running
`-+- policy='service-time 0' prio=10 status=enabled
  |- 10:0:1:0  sdc  8:32   active ready running
  `- 16:0:2:0  sdcf 69:48  active ready running
```

Step 4: Optionally, exclude a device from multipathing

If required, you can exclude a device from multipathing by adding the WWID for the unwanted device to the "blacklist" stanza for the `multipath.conf` file.

Steps

1. Determine the WWID:

   ```
   /lib/udev/scsi_id -gud /dev/sda
   ```

   "sda" is the local SCSI disk that you want to add to the blacklist.

   An example WWID is `360030057024d0730239134810c0cb833`.

2. Add the WWID to the "blacklist" stanza:

   ```
   blacklist {
           wwid    360030057024d0730239134810c0cb833
           devnode "^(ram|raw|loop|fd|md|dm-|sr|scd|st)[0-9]*"
           devnode "^hd[a-z]"
           devnode "^cciss.*"
   }
   ```

Step 5: Customize multipath parameters for ONTAP LUNs

If your host is connected to LUNs from other vendors and any of the multipath parameter settings are overridden, you need to correct them by adding stanzas later in the `multipath.conf` file that apply specifically to ONTAP LUNs. If you don't do this, the ONTAP LUNs might not work as expected.

Check your `/etc/multipath.conf` file, especially in the defaults section, for settings that might be overriding the default settings for multipath parameters.

> ⚠️ You shouldn't override the recommended parameter settings for ONTAP LUNs. These settings are required for optimal performance of your host configuration. Contact NetApp support, your OS vendor, or both for more information.

The following example shows how to correct an overridden default. In this example, the `multipath.conf` file defines values for `path_checker` and `no_path_retry` that aren't compatible with ONTAP LUNs, and you can't remove these parameters because ONTAP storage arrays are still attached to the host. Instead, you correct the values for `path_checker` and `no_path_retry` by adding a device stanza to the `multipath.conf` file that applies specifically to the ONTAP LUNs.

Show example

```
defaults {
    path_checker        readsector0
    no_path_retry       fail
}

devices {
    device {
        vendor          "NETAPP"
        product         "LUN"
        no_path_retry   queue
        path_checker    tur
    }
}
```

Step 6: Review the known issues

There are no known issues.

What's next?

- Learn about using the Linux Host Utilities tool.

- Learn about ASM mirroring.

  Automatic Storage Management (ASM) mirroring might require changes to the Linux multipath settings to allow ASM to recognize a problem and switch over to an alternate failure group. Most ASM configurations on ONTAP use external redundancy, which means that data protection is provided by the external array and ASM doesn't mirror data. Some sites use ASM with normal redundancy to provide two-way mirroring, normally across different sites. See Oracle databases on ONTAP for further information.

Configure RHEL 8.8 for FCP and iSCSI with ONTAP storage

The Linux Host Utilities software provides management and diagnostic tools for Linux hosts that are connected to ONTAP storage. When you install the Linux Host Utilities on a Red Hat Enterprise Linux (RHEL) 8.8 host, you can use the Host Utilities to help you manage FCP and iSCSI protocol operations with ONTAP LUNs.

> ⓘ You don't need to manually configure Kernel-based Virtual Machine (KVM) settings because ONTAP LUNs are automatically mapped to the hypervisor.

Step 1: Optionally, enable SAN booting

You can configure your host to use SAN booting to simplify deployment and improve scalability.

Before you begin

Use the Interoperability Matrix Tool to verify that your Linux OS, host bus adapter (HBA), HBA firmware, HBA

boot BIOS, and ONTAP version support SAN booting.

Steps

1. Create a SAN boot LUN and map it to the host.

2. Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is mapped.

   For information on how to enable the HBA BIOS, see your vendor-specific documentation.

3. Verify that the configuration was successful by rebooting the host and verifying that the OS is up and running.

Step 2: Install the Linux Host Utilities

NetApp strongly recommends installing the Linux Host Utilities to support ONTAP LUN management and assist technical support with gathering configuration data.

Install Linux Host Utilities 8.0.

> (i)   Installing the Linux Host Utilities doesn't change any host timeout settings on your Linux host.

Step 3: Confirm the multipath configuration for your host

You can use multipathing with RHEL 8.8 to manage ONTAP LUNs.

To ensure that multipathing is configured correctly for your host, verify that the `/etc/multipath.conf` file is defined and that you have the NetApp recommended settings configured for your ONTAP LUNs.

Steps

1. Verify that the `/etc/multipath.conf` file exits. If the file doesn't exist, create an empty, zero-byte file:

   ```
   touch /etc/multipath.conf
   ```

2. The first time the `multipath.conf` file is created, you might need to enable and start the multipath services to load the recommended settings:

   ```
   systemctl enable multipathd
   ```

   ```
   systemctl start multipathd
   ```

3. Each time you boot the host, the empty `/etc/multipath.conf` zero-byte file automatically loads the NetApp recommended host multipath parameters as the default settings. You shouldn't need to make changes to the `/etc/multipath.conf` file for your host because the operating system is compiled with the multipath parameters that recognize and manage ONTAP LUNs correctly.

   The following table shows the Linux OS native compiled multipath parameter settings for ONTAP LUNs.

Show parameter settings

Parameter	Setting
detect_prio	yes
dev_loss_tmo	"infinity"
failback	immediate
fast_io_fail_tmo	5
features	"2 pg_init_retries 50"
flush_on_last_del	"yes"
hardware_handler	"0"
no_path_retry	queue
path_checker	"tur"
path_grouping_policy	"group_by_prio"
path_selector	"service-time 0"
polling_interval	5
prio	"ontap"
product	LUN
retain_attached_hw_handler	yes
rr_weight	"uniform"
user_friendly_names	no
vendor	NETAPP

4. Verify the parameter settings and path status for your ONTAP LUNs:

```
multipath -ll
```

The default multipath parameters support ASA, AFF, and FAS configurations. In these configurations, a single ONTAP LUN shouldn't require more than four paths. If there are more than four paths, it might cause issues with the paths during a storage failure.

The following example outputs show the correct parameter settings and path status for ONTAP LUNs in an ASA, AFF, or FAS configuration.

ASA configuration

An ASA configuration optimizes all paths to a given LUN, keeping them active. This improves performance by serving I/O operations through all paths at the same time.

Show example

```
multipath -ll
3600a098038314c4a433f577471797958 dm-2 NETAPP,LUN C-Mode
size=180G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
`-+- policy='service-time 0' prio=50 status=active
  |- 14:0:0:0  sdc  8:32   active ready running
  |- 17:0:0:0  sdas 66:192 active ready running
  |- 14:0:3:0  sdar 66:176 active ready running
  `- 17:0:3:0  sdch 69:80  active ready running
```

AFF or FAS configuration

An AFF or FAS configuration should have two groups of paths with higher and lower priorities. Higher priority Active/Optimized paths are served by the controller where the aggregate is located. Lower priority paths are active but non-optimized because they are served by a different controller. Non-optimized paths are only used when optimized paths aren't available.

The following example displays the output for an ONTAP LUN with two Active/Optimized paths and two Active/Non-Optimized paths:

Show example

```
multipath -ll
3600a0980383149764b5d567257516273 dm-0 NETAPP,LUN C-Mode
size=150G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
|-+- policy='service-time 0' prio=50 status=active
| |- 16:0:3:0  sdcg 69:64  active ready running
| `- 10:0:0:0  sdb  8:16   active ready running
`-+- policy='service-time 0' prio=10 status=enabled
  |- 10:0:1:0  sdc  8:32   active ready running
  `- 16:0:2:0  sdcf 69:48  active ready running
```

Step 4: Optionally, exclude a device from multipathing

If required, you can exclude a device from multipathing by adding the WWID for the unwanted device to the "blacklist" stanza for the `multipath.conf` file.

Steps

1. Determine the WWID:

   ```
   /lib/udev/scsi_id -gud /dev/sda
   ```

   "sda" is the local SCSI disk that you want to add to the blacklist.

   An example WWID is `360030057024d0730239134810c0cb833`.

2. Add the WWID to the "blacklist" stanza:

   ```
   blacklist {
           wwid    360030057024d0730239134810c0cb833
           devnode "^(ram|raw|loop|fd|md|dm-|sr|scd|st)[0-9]*"
           devnode "^hd[a-z]"
           devnode "^cciss.*"
   }
   ```

Step 5: Customize multipath parameters for ONTAP LUNs

If your host is connected to LUNs from other vendors and any of the multipath parameter settings are overridden, you need to correct them by adding stanzas later in the `multipath.conf` file that apply specifically to ONTAP LUNs. If you don't do this, the ONTAP LUNs might not work as expected.

Check your `/etc/multipath.conf` file, especially in the defaults section, for settings that might be overriding the default settings for multipath parameters.

> ⚠️ You shouldn't override the recommended parameter settings for ONTAP LUNs. These settings are required for optimal performance of your host configuration. Contact NetApp support, your OS vendor, or both for more information.

The following example shows how to correct an overridden default. In this example, the `multipath.conf` file defines values for `path_checker` and `no_path_retry` that aren't compatible with ONTAP LUNs, and you can't remove these parameters because ONTAP storage arrays are still attached to the host. Instead, you correct the values for `path_checker` and `no_path_retry` by adding a device stanza to the `multipath.conf` file that applies specifically to the ONTAP LUNs.

Show example

```
defaults {
    path_checker        readsector0
    no_path_retry       fail
}

devices {
    device {
        vendor          "NETAPP"
        product         "LUN"
        no_path_retry   queue
        path_checker    tur
    }
}
```

Step 6: Review the known issues

There are no known issues.

What's next?

- Learn about using the Linux Host Utilities tool.

- Learn about ASM mirroring.

  Automatic Storage Management (ASM) mirroring might require changes to the Linux multipath settings to allow ASM to recognize a problem and switch over to an alternate failure group. Most ASM configurations on ONTAP use external redundancy, which means that data protection is provided by the external array and ASM doesn't mirror data. Some sites use ASM with normal redundancy to provide two-way mirroring, normally across different sites. See Oracle databases on ONTAP for further information.

Configure RHEL 8.7 for FCP and iSCSI with ONTAP storage

The Linux Host Utilities software provides management and diagnostic tools for Linux hosts that are connected to ONTAP storage. When you install the Linux Host Utilities on a Red Hat Enterprise Linux (RHEL) 8.7 host, you can use the Host Utilities to help you manage FCP and iSCSI protocol operations with ONTAP LUNs.

> ⓘ   You don't need to manually configure Kernel-based Virtual Machine (KVM) settings because ONTAP LUNs are automatically mapped to the hypervisor.

Step 1: Optionally, enable SAN booting

You can configure your host to use SAN booting to simplify deployment and improve scalability.

Before you begin

Use the Interoperability Matrix Tool to verify that your Linux OS, host bus adapter (HBA), HBA firmware, HBA

boot BIOS, and ONTAP version support SAN booting.

Steps

1. [Create a SAN boot LUN and map it to the host](#).

2. Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is mapped.

   For information on how to enable the HBA BIOS, see your vendor-specific documentation.

3. Verify that the configuration was successful by rebooting the host and verifying that the OS is up and running.

Step 2: Install the Linux Host Utilities

NetApp strongly recommends installing the Linux Host Utilities to support ONTAP LUN management and assist technical support with gathering configuration data.

[Install Linux Host Utilities 8.0](#).

> ⓘ   Installing the Linux Host Utilities doesn't change any host timeout settings on your Linux host.

Step 3: Confirm the multipath configuration for your host

You can use multipathing with RHEL 8.7 to manage ONTAP LUNs.

To ensure that multipathing is configured correctly for your host, verify that the `/etc/multipath.conf` file is defined and that you have the NetApp recommended settings configured for your ONTAP LUNs.

Steps

1. Verify that the `/etc/multipath.conf` file exits. If the file doesn't exist, create an empty, zero-byte file:

   ```
   touch /etc/multipath.conf
   ```

2. The first time the `multipath.conf` file is created, you might need to enable and start the multipath services to load the recommended settings:

   ```
   systemctl enable multipathd
   ```

   ```
   systemctl start multipathd
   ```

3. Each time you boot the host, the empty `/etc/multipath.conf` zero-byte file automatically loads the NetApp recommended host multipath parameters as the default settings. You shouldn't need to make changes to the `/etc/multipath.conf` file for your host because the operating system is compiled with the multipath parameters that recognize and manage ONTAP LUNs correctly.

   The following table shows the Linux OS native compiled multipath parameter settings for ONTAP LUNs.

Show parameter settings

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hardware_handler	"0"
no_path_retry	queue
path_checker	"tur"
path_grouping_policy	"group_by_prio"
path_selector	"service-time 0"
polling_interval	5
prio	"ontap"
product	LUN
retain_attached_hw_handler	yes
rr_weight	"uniform"
user_friendly_names	no
vendor	NETAPP

4. Verify the parameter settings and path status for your ONTAP LUNs:

```
multipath -ll
```

The default multipath parameters support ASA, AFF, and FAS configurations. In these configurations, a single ONTAP LUN shouldn't require more than four paths. If there are more than four paths, it might cause issues with the paths during a storage failure.

The following example outputs show the correct parameter settings and path status for ONTAP LUNs in an ASA, AFF, or FAS configuration.

ASA configuration

An ASA configuration optimizes all paths to a given LUN, keeping them active. This improves performance by serving I/O operations through all paths at the same time.

Show example

```
multipath -ll
3600a098038314c4a433f577471797958 dm-2 NETAPP,LUN C-Mode
size=180G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
`-+- policy='service-time 0' prio=50 status=active
  |- 14:0:0:0  sdc  8:32   active ready running
  |- 17:0:0:0  sdas 66:192 active ready running
  |- 14:0:3:0  sdar 66:176 active ready running
  `- 17:0:3:0  sdch 69:80  active ready running
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AFF or FAS configuration

An AFF or FAS configuration should have two groups of paths with higher and lower priorities. Higher priority Active/Optimized paths are served by the controller where the aggregate is located. Lower priority paths are active but non-optimized because they are served by a different controller. Non-optimized paths are only used when optimized paths aren't available.

The following example displays the output for an ONTAP LUN with two Active/Optimized paths and two Active/Non-Optimized paths:

Show example

```
multipath -ll
3600a0980383149764b5d567257516273 dm-0 NETAPP,LUN C-Mode
size=150G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
|-+- policy='service-time 0' prio=50 status=active
| |- 16:0:3:0  sdcg 69:64  active ready running
| `- 10:0:0:0  sdb  8:16   active ready running
`-+- policy='service-time 0' prio=10 status=enabled
  |- 10:0:1:0  sdc  8:32   active ready running
  `- 16:0:2:0  sdcf 69:48  active ready running
```

Step 4: Optionally, exclude a device from multipathing

If required, you can exclude a device from multipathing by adding the WWID for the unwanted device to the "blacklist" stanza for the `multipath.conf` file.

Steps

1. Determine the WWID:

   ```
   /lib/udev/scsi_id -gud /dev/sda
   ```

   "sda" is the local SCSI disk that you want to add to the blacklist.

   An example WWID is `360030057024d0730239134810c0cb833`.

2. Add the WWID to the "blacklist" stanza:

   ```
   blacklist {
           wwid    360030057024d0730239134810c0cb833
           devnode "^(ram|raw|loop|fd|md|dm-|sr|scd|st)[0-9]*"
           devnode "^hd[a-z]"
           devnode "^cciss.*"
   }
   ```

Step 5: Customize multipath parameters for ONTAP LUNs

If your host is connected to LUNs from other vendors and any of the multipath parameter settings are overridden, you need to correct them by adding stanzas later in the `multipath.conf` file that apply specifically to ONTAP LUNs. If you don't do this, the ONTAP LUNs might not work as expected.

Check your `/etc/multipath.conf` file, especially in the defaults section, for settings that might be overriding the default settings for multipath parameters.

> ⚠️ You shouldn't override the recommended parameter settings for ONTAP LUNs. These settings are required for optimal performance of your host configuration. Contact NetApp support, your OS vendor, or both for more information.

The following example shows how to correct an overridden default. In this example, the `multipath.conf` file defines values for `path_checker` and `no_path_retry` that aren't compatible with ONTAP LUNs, and you can't remove these parameters because ONTAP storage arrays are still attached to the host. Instead, you correct the values for `path_checker` and `no_path_retry` by adding a device stanza to the `multipath.conf` file that applies specifically to the ONTAP LUNs.

Show example

```
defaults {
    path_checker        readsector0
    no_path_retry       fail
}

devices {
    device {
        vendor          "NETAPP"
        product         "LUN"
        no_path_retry   queue
        path_checker    tur
    }
}
```

Step 6: Review the known issues

There are no known issues.

What's next?

- Learn about using the Linux Host Utilities tool.
- Learn about ASM mirroring.

  Automatic Storage Management (ASM) mirroring might require changes to the Linux multipath settings to allow ASM to recognize a problem and switch over to an alternate failure group. Most ASM configurations on ONTAP use external redundancy, which means that data protection is provided by the external array and ASM doesn't mirror data. Some sites use ASM with normal redundancy to provide two-way mirroring, normally across different sites. See Oracle databases on ONTAP for further information.

Configure RHEL 8.6 for FCP and iSCSI with ONTAP storage

The Linux Host Utilities software provides management and diagnostic tools for Linux hosts that are connected to ONTAP storage. When you install the Linux Host Utilities on a Red Hat Enterprise Linux (RHEL) 8.6 host, you can use the Host Utilities to help you manage FCP and iSCSI protocol operations with ONTAP LUNs.

> ⓘ You don't need to manually configure Kernel-based Virtual Machine (KVM) settings because ONTAP LUNs are automatically mapped to the hypervisor.

Step 1: Optionally, enable SAN booting

You can configure your host to use SAN booting to simplify deployment and improve scalability.

Before you begin

Use the Interoperability Matrix Tool to verify that your Linux OS, host bus adapter (HBA), HBA firmware, HBA

boot BIOS, and ONTAP version support SAN booting.

Steps

1. [Create a SAN boot LUN and map it to the host](#).

2. Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is mapped.

   For information on how to enable the HBA BIOS, see your vendor-specific documentation.

3. Verify that the configuration was successful by rebooting the host and verifying that the OS is up and running.

Step 2: Install the Linux Host Utilities

NetApp strongly recommends installing the Linux Host Utilities to support ONTAP LUN management and assist technical support with gathering configuration data.

[Install Linux Host Utilities 8.0](#).

> ⓘ   Installing the Linux Host Utilities doesn't change any host timeout settings on your Linux host.

Step 3: Confirm the multipath configuration for your host

You can use multipathing with RHEL 8.6 to manage ONTAP LUNs.

To ensure that multipathing is configured correctly for your host, verify that the `/etc/multipath.conf` file is defined and that you have the NetApp recommended settings configured for your ONTAP LUNs.

Steps

1. Verify that the `/etc/multipath.conf` file exits. If the file doesn't exist, create an empty, zero-byte file:

   ```
   touch /etc/multipath.conf
   ```

2. The first time the `multipath.conf` file is created, you might need to enable and start the multipath services to load the recommended settings:

   ```
   systemctl enable multipathd
   ```

   ```
   systemctl start multipathd
   ```

3. Each time you boot the host, the empty `/etc/multipath.conf` zero-byte file automatically loads the NetApp recommended host multipath parameters as the default settings. You shouldn't need to make changes to the `/etc/multipath.conf` file for your host because the operating system is compiled with the multipath parameters that recognize and manage ONTAP LUNs correctly.

   The following table shows the Linux OS native compiled multipath parameter settings for ONTAP LUNs.

Show parameter settings

Parameter	Setting
detect_prio	yes
dev_loss_tmo	"infinity"
failback	immediate
fast_io_fail_tmo	5
features	"2 pg_init_retries 50"
flush_on_last_del	"yes"
hardware_handler	"0"
no_path_retry	queue
path_checker	"tur"
path_grouping_policy	"group_by_prio"
path_selector	"service-time 0"
polling_interval	5
prio	"ontap"
product	LUN
retain_attached_hw_handler	yes
rr_weight	"uniform"
user_friendly_names	no
vendor	NETAPP

4. Verify the parameter settings and path status for your ONTAP LUNs:

```
multipath -ll
```

The default multipath parameters support ASA, AFF, and FAS configurations. In these configurations, a single ONTAP LUN shouldn't require more than four paths. If there are more than four paths, it might cause issues with the paths during a storage failure.

The following example outputs show the correct parameter settings and path status for ONTAP LUNs in an ASA, AFF, or FAS configuration.

ASA configuration

An ASA configuration optimizes all paths to a given LUN, keeping them active. This improves performance by serving I/O operations through all paths at the same time.

Show example

```
multipath -ll
3600a098038314c4a433f577471797958 dm-2 NETAPP,LUN C-Mode
size=180G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
`-+- policy='service-time 0' prio=50 status=active
  |- 14:0:0:0  sdc  8:32   active ready running
  |- 17:0:0:0  sdas 66:192 active ready running
  |- 14:0:3:0  sdar 66:176 active ready running
  `- 17:0:3:0  sdch 69:80  active ready running
```

AFF or FAS configuration

An AFF or FAS configuration should have two groups of paths with higher and lower priorities. Higher priority Active/Optimized paths are served by the controller where the aggregate is located. Lower priority paths are active but non-optimized because they are served by a different controller. Non-optimized paths are only used when optimized paths aren't available.

The following example displays the output for an ONTAP LUN with two Active/Optimized paths and two Active/Non-Optimized paths:

Show example

```
multipath -ll
3600a0980383149764b5d567257516273 dm-0 NETAPP,LUN C-Mode
size=150G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
|-+- policy='service-time 0' prio=50 status=active
| |- 16:0:3:0  sdcg 69:64  active ready running
| `- 10:0:0:0  sdb  8:16   active ready running
`-+- policy='service-time 0' prio=10 status=enabled
  |- 10:0:1:0  sdc  8:32   active ready running
  `- 16:0:2:0  sdcf 69:48  active ready running
```

Step 4: Optionally, exclude a device from multipathing

If required, you can exclude a device from multipathing by adding the WWID for the unwanted device to the "blacklist" stanza for the `multipath.conf` file.

Steps

1. Determine the WWID:

   ```
   /lib/udev/scsi_id -gud /dev/sda
   ```

   "sda" is the local SCSI disk that you want to add to the blacklist.

   An example WWID is `360030057024d0730239134810c0cb833`.

2. Add the WWID to the "blacklist" stanza:

   ```
   blacklist {
           wwid   360030057024d0730239134810c0cb833
           devnode "^(ram|raw|loop|fd|md|dm-|sr|scd|st)[0-9]*"
           devnode "^hd[a-z]"
           devnode "^cciss.*"
   }
   ```

Step 5: Customize multipath parameters for ONTAP LUNs

If your host is connected to LUNs from other vendors and any of the multipath parameter settings are overridden, you need to correct them by adding stanzas later in the `multipath.conf` file that apply specifically to ONTAP LUNs. If you don't do this, the ONTAP LUNs might not work as expected.

Check your `/etc/multipath.conf` file, especially in the defaults section, for settings that might be overriding the default settings for multipath parameters.

> ⚠️ You shouldn't override the recommended parameter settings for ONTAP LUNs. These settings are required for optimal performance of your host configuration. Contact NetApp support, your OS vendor, or both for more information.

The following example shows how to correct an overridden default. In this example, the `multipath.conf` file defines values for `path_checker` and `no_path_retry` that aren't compatible with ONTAP LUNs, and you can't remove these parameters because ONTAP storage arrays are still attached to the host. Instead, you correct the values for `path_checker` and `no_path_retry` by adding a device stanza to the `multipath.conf` file that applies specifically to the ONTAP LUNs.

Show example

```
defaults {
    path_checker        readsector0
    no_path_retry       fail
}

devices {
    device {
        vendor          "NETAPP"
        product         "LUN"
        no_path_retry   queue
        path_checker    tur
    }
}
```

Step 6: Review the known issues

There are no known issues.

What's next?

- Learn about using the Linux Host Utilities tool.
- Learn about ASM mirroring.

  Automatic Storage Management (ASM) mirroring might require changes to the Linux multipath settings to allow ASM to recognize a problem and switch over to an alternate failure group. Most ASM configurations on ONTAP use external redundancy, which means that data protection is provided by the external array and ASM doesn't mirror data. Some sites use ASM with normal redundancy to provide two-way mirroring, normally across different sites. See Oracle databases on ONTAP for further information.

Configure RHEL 8.5 for FCP and iSCSI with ONTAP storage

The Linux Host Utilities software provides management and diagnostic tools for Linux hosts that are connected to ONTAP storage. When you install the Linux Host Utilities on a Red Hat Enterprise Linux (RHEL) 8.5 host, you can use the Host Utilities to help you manage FCP and iSCSI protocol operations with ONTAP LUNs.

ⓘ You don't need to manually configure Kernel-based Virtual Machine (KVM) settings because ONTAP LUNs are automatically mapped to the hypervisor.

Step 1: Optionally, enable SAN booting

You can configure your host to use SAN booting to simplify deployment and improve scalability.

Before you begin

Use the Interoperability Matrix Tool to verify that your Linux OS, host bus adapter (HBA), HBA firmware, HBA

boot BIOS, and ONTAP version support SAN booting.

Steps

1. [Create a SAN boot LUN and map it to the host](#).

2. Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is mapped.

   For information on how to enable the HBA BIOS, see your vendor-specific documentation.

3. Verify that the configuration was successful by rebooting the host and verifying that the OS is up and running.

Step 2: Install the Linux Host Utilities

NetApp strongly recommends installing the Linux Host Utilities to support ONTAP LUN management and assist technical support with gathering configuration data.

[Install Linux Host Utilities 8.0](#).

> ℹ️ Installing the Linux Host Utilities doesn't change any host timeout settings on your Linux host.

Step 3: Confirm the multipath configuration for your host

You can use multipathing with RHEL 8.5 to manage ONTAP LUNs.

To ensure that multipathing is configured correctly for your host, verify that the `/etc/multipath.conf` file is defined and that you have the NetApp recommended settings configured for your ONTAP LUNs.

Steps

1. Verify that the `/etc/multipath.conf` file exits. If the file doesn't exist, create an empty, zero-byte file:

   ```
   touch /etc/multipath.conf
   ```

2. The first time the `multipath.conf` file is created, you might need to enable and start the multipath services to load the recommended settings:

   ```
   systemctl enable multipathd
   ```

   ```
   systemctl start multipathd
   ```

3. Each time you boot the host, the empty `/etc/multipath.conf` zero-byte file automatically loads the NetApp recommended host multipath parameters as the default settings. You shouldn't need to make changes to the `/etc/multipath.conf` file for your host because the operating system is compiled with the multipath parameters that recognize and manage ONTAP LUNs correctly.

   The following table shows the Linux OS native compiled multipath parameter settings for ONTAP LUNs.

Show parameter settings

Parameter	Setting
detect_prio	yes
dev_loss_tmo	"infinity"
failback	immediate
fast_io_fail_tmo	5
features	"2 pg_init_retries 50"
flush_on_last_del	"yes"
hardware_handler	"0"
no_path_retry	queue
path_checker	"tur"
path_grouping_policy	"group_by_prio"
path_selector	"service-time 0"
polling_interval	5
prio	"ontap"
product	LUN
retain_attached_hw_handler	yes
rr_weight	"uniform"
user_friendly_names	no
vendor	NETAPP

4. Verify the parameter settings and path status for your ONTAP LUNs:

```
multipath -ll
```

The default multipath parameters support ASA, AFF, and FAS configurations. In these configurations, a single ONTAP LUN shouldn't require more than four paths. If there are more than four paths, it might cause issues with the paths during a storage failure.

The following example outputs show the correct parameter settings and path status for ONTAP LUNs in an ASA, AFF, or FAS configuration.

ASA configuration

An ASA configuration optimizes all paths to a given LUN, keeping them active. This improves performance by serving I/O operations through all paths at the same time.

Show example

```
multipath -ll
3600a098038314c4a433f577471797958 dm-2 NETAPP,LUN C-Mode
size=180G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
`-+- policy='service-time 0' prio=50 status=active
  |- 14:0:0:0  sdc  8:32   active ready running
  |- 17:0:0:0  sdas 66:192 active ready running
  |- 14:0:3:0  sdar 66:176 active ready running
  `- 17:0:3:0  sdch 69:80  active ready running
```

AFF or FAS configuration

An AFF or FAS configuration should have two groups of paths with higher and lower priorities. Higher priority Active/Optimized paths are served by the controller where the aggregate is located. Lower priority paths are active but non-optimized because they are served by a different controller. Non-optimized paths are only used when optimized paths aren't available.

The following example displays the output for an ONTAP LUN with two Active/Optimized paths and two Active/Non-Optimized paths:

Show example

```
multipath -ll
3600a0980383149764b5d567257516273 dm-0 NETAPP,LUN C-Mode
size=150G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
|-+- policy='service-time 0' prio=50 status=active
| |- 16:0:3:0  sdcg 69:64  active ready running
| `- 10:0:0:0  sdb  8:16   active ready running
`-+- policy='service-time 0' prio=10 status=enabled
  |- 10:0:1:0  sdc  8:32   active ready running
  `- 16:0:2:0  sdcf 69:48  active ready running
```

Step 4: Optionally, exclude a device from multipathing

If required, you can exclude a device from multipathing by adding the WWID for the unwanted device to the "blacklist" stanza for the `multipath.conf` file.

Steps

1. Determine the WWID:

   ```
   /lib/udev/scsi_id -gud /dev/sda
   ```

   "sda" is the local SCSI disk that you want to add to the blacklist.

   An example WWID is `360030057024d0730239134810c0cb833`.

2. Add the WWID to the "blacklist" stanza:

   ```
   blacklist {
           wwid    360030057024d0730239134810c0cb833
           devnode "^(ram|raw|loop|fd|md|dm-|sr|scd|st)[0-9]*"
           devnode "^hd[a-z]"
           devnode "^cciss.*"
   }
   ```

Step 5: Customize multipath parameters for ONTAP LUNs

If your host is connected to LUNs from other vendors and any of the multipath parameter settings are overridden, you need to correct them by adding stanzas later in the `multipath.conf` file that apply specifically to ONTAP LUNs. If you don't do this, the ONTAP LUNs might not work as expected.

Check your `/etc/multipath.conf` file, especially in the defaults section, for settings that might be overriding the default settings for multipath parameters.

> ⚠️ You shouldn't override the recommended parameter settings for ONTAP LUNs. These settings are required for optimal performance of your host configuration. Contact NetApp support, your OS vendor, or both for more information.

The following example shows how to correct an overridden default. In this example, the `multipath.conf` file defines values for `path_checker` and `no_path_retry` that aren't compatible with ONTAP LUNs, and you can't remove these parameters because ONTAP storage arrays are still attached to the host. Instead, you correct the values for `path_checker` and `no_path_retry` by adding a device stanza to the `multipath.conf` file that applies specifically to the ONTAP LUNs.

Show example

```
defaults {
    path_checker        readsector0
    no_path_retry       fail
}

devices {
    device {
        vendor          "NETAPP"
        product         "LUN"
        no_path_retry   queue
        path_checker    tur
    }
}
```

Step 6: Review the known issues

There are no known issues.

What's next?

- [Learn about using the Linux Host Utilities tool](#).

- Learn about ASM mirroring.

  Automatic Storage Management (ASM) mirroring might require changes to the Linux multipath settings to allow ASM to recognize a problem and switch over to an alternate failure group. Most ASM configurations on ONTAP use external redundancy, which means that data protection is provided by the external array and ASM doesn't mirror data. Some sites use ASM with normal redundancy to provide two-way mirroring, normally across different sites. See [Oracle databases on ONTAP](#) for further information.

Configure RHEL 8.4 for FCP and iSCSI with ONTAP storage

The Linux Host Utilities software provides management and diagnostic tools for Linux hosts that are connected to ONTAP storage. When you install the Linux Host Utilities on a Red Hat Enterprise Linux (RHEL) 8.4 host, you can use the Host Utilities to help you manage FCP and iSCSI protocol operations with ONTAP LUNs.

> (i) You don't need to manually configure Kernel-based Virtual Machine (KVM) settings because ONTAP LUNs are automatically mapped to the hypervisor.

Step 1: Optionally, enable SAN booting

You can configure your host to use SAN booting to simplify deployment and improve scalability.

Before you begin

Use the [Interoperability Matrix Tool](#) to verify that your Linux OS, host bus adapter (HBA), HBA firmware, HBA

boot BIOS, and ONTAP version support SAN booting.

Steps

1. [Create a SAN boot LUN and map it to the host](#).

2. Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is mapped.

   For information on how to enable the HBA BIOS, see your vendor-specific documentation.

3. Verify that the configuration was successful by rebooting the host and verifying that the OS is up and running.

Step 2: Install the Linux Host Utilities

NetApp strongly recommends installing the Linux Host Utilities to support ONTAP LUN management and assist technical support with gathering configuration data.

[Install Linux Host Utilities 8.0](#).

> ⓘ   Installing the Linux Host Utilities doesn't change any host timeout settings on your Linux host.

Step 3: Confirm the multipath configuration for your host

You can use multipathing with RHEL 8.4 to manage ONTAP LUNs.

To ensure that multipathing is configured correctly for your host, verify that the `/etc/multipath.conf` file is defined and that you have the NetApp recommended settings configured for your ONTAP LUNs.

Steps

1. Verify that the `/etc/multipath.conf` file exits. If the file doesn't exist, create an empty, zero-byte file:

   ```
   touch /etc/multipath.conf
   ```

2. The first time the `multipath.conf` file is created, you might need to enable and start the multipath services to load the recommended settings:

   ```
   systemctl enable multipathd
   ```

   ```
   systemctl start multipathd
   ```

3. Each time you boot the host, the empty `/etc/multipath.conf` zero-byte file automatically loads the NetApp recommended host multipath parameters as the default settings. You shouldn't need to make changes to the `/etc/multipath.conf` file for your host because the operating system is compiled with the multipath parameters that recognize and manage ONTAP LUNs correctly.

   The following table shows the Linux OS native compiled multipath parameter settings for ONTAP LUNs.

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features	"2 pg_init_retries 50"
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hardware_handler	"0"
no_path_retry	queue
path_checker	"tur"
path_grouping_policy	"group_by_prio"
path_selector	"service-time 0"
polling_interval	5
prio	"ontap"
product	LUN
retain_attached_hw_handler	yes
rr_weight	"uniform"
user_friendly_names	no
vendor	NETAPP

4. Verify the parameter settings and path status for your ONTAP LUNs:

```
multipath -ll
```

The default multipath parameters support ASA, AFF, and FAS configurations. In these configurations, a single ONTAP LUN shouldn't require more than four paths. If there are more than four paths, it might cause issues with the paths during a storage failure.

The following example outputs show the correct parameter settings and path status for ONTAP LUNs in an ASA, AFF, or FAS configuration.

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  |- 14:0:0:0  sdc  8:32   active ready running
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AFF or FAS configuration

An AFF or FAS configuration should have two groups of paths with higher and lower priorities. Higher priority Active/Optimized paths are served by the controller where the aggregate is located. Lower priority paths are active but non-optimized because they are served by a different controller. Non-optimized paths are only used when optimized paths aren't available.

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Show example

```
multipath -ll
3600a0980383149764b5d567257516273 dm-0 NETAPP,LUN C-Mode
size=150G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
|-+- policy='service-time 0' prio=50 status=active
| |- 16:0:3:0  sdcg 69:64  active ready running
| `- 10:0:0:0  sdb  8:16   active ready running
`-+- policy='service-time 0' prio=10 status=enabled
  |- 10:0:1:0  sdc  8:32   active ready running
  `- 16:0:2:0  sdcf 69:48  active ready running
```

Step 4: Optionally, exclude a device from multipathing

If required, you can exclude a device from multipathing by adding the WWID for the unwanted device to the "blacklist" stanza for the `multipath.conf` file.

Steps

1. Determine the WWID:

   ```
   /lib/udev/scsi_id -gud /dev/sda
   ```

   "sda" is the local SCSI disk that you want to add to the blacklist.

   An example WWID is `360030057024d0730239134810c0cb833`.

2. Add the WWID to the "blacklist" stanza:

   ```
   blacklist {
           wwid    360030057024d0730239134810c0cb833
           devnode "^(ram|raw|loop|fd|md|dm-|sr|scd|st)[0-9]*"
           devnode "^hd[a-z]"
           devnode "^cciss.*"
   }
   ```

Step 5: Customize multipath parameters for ONTAP LUNs

If your host is connected to LUNs from other vendors and any of the multipath parameter settings are overridden, you need to correct them by adding stanzas later in the `multipath.conf` file that apply specifically to ONTAP LUNs. If you don't do this, the ONTAP LUNs might not work as expected.

Check your `/etc/multipath.conf` file, especially in the defaults section, for settings that might be overriding the default settings for multipath parameters.

> ⚠️ You shouldn't override the recommended parameter settings for ONTAP LUNs. These settings are required for optimal performance of your host configuration. Contact NetApp support, your OS vendor, or both for more information.

The following example shows how to correct an overridden default. In this example, the `multipath.conf` file defines values for `path_checker` and `no_path_retry` that aren't compatible with ONTAP LUNs, and you can't remove these parameters because ONTAP storage arrays are still attached to the host. Instead, you correct the values for `path_checker` and `no_path_retry` by adding a device stanza to the `multipath.conf` file that applies specifically to the ONTAP LUNs.

Show example

```
defaults {
    path_checker        readsector0
    no_path_retry       fail
}

devices {
    device {
        vendor          "NETAPP"
        product         "LUN"
        no_path_retry   queue
        path_checker    tur
    }
}
```

Step 6: Review the known issues

There are no known issues.

What's next?

- Learn about using the Linux Host Utilities tool.

- Learn about ASM mirroring.

  Automatic Storage Management (ASM) mirroring might require changes to the Linux multipath settings to allow ASM to recognize a problem and switch over to an alternate failure group. Most ASM configurations on ONTAP use external redundancy, which means that data protection is provided by the external array and ASM doesn't mirror data. Some sites use ASM with normal redundancy to provide two-way mirroring, normally across different sites. See Oracle databases on ONTAP for further information.

Configure RHEL 8.3 for FCP and iSCSI with ONTAP storage

The Linux Host Utilities software provides management and diagnostic tools for Linux hosts that are connected to ONTAP storage. When you install the Linux Host Utilities on a Red Hat Enterprise Linux (RHEL) 8.3 host, you can use the Host Utilities to help you manage FCP and iSCSI protocol operations with ONTAP LUNs.

> ⓘ You don't need to manually configure Kernel-based Virtual Machine (KVM) settings because ONTAP LUNs are automatically mapped to the hypervisor.

Step 1: Optionally, enable SAN booting

You can configure your host to use SAN booting to simplify deployment and improve scalability.

Before you begin

Use the Interoperability Matrix Tool to verify that your Linux OS, host bus adapter (HBA), HBA firmware, HBA

boot BIOS, and ONTAP version support SAN booting.

Steps

1. [Create a SAN boot LUN and map it to the host](#).

2. Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is mapped.

   For information on how to enable the HBA BIOS, see your vendor-specific documentation.

3. Verify that the configuration was successful by rebooting the host and verifying that the OS is up and running.

Step 2: Install the Linux Host Utilities

NetApp strongly recommends installing the Linux Host Utilities to support ONTAP LUN management and assist technical support with gathering configuration data.

[Install Linux Host Utilities 8.0](#).

> ⓘ   Installing the Linux Host Utilities doesn't change any host timeout settings on your Linux host.

Step 3: Confirm the multipath configuration for your host

You can use multipathing with RHEL 8.3 to manage ONTAP LUNs.

To ensure that multipathing is configured correctly for your host, verify that the `/etc/multipath.conf` file is defined and that you have the NetApp recommended settings configured for your ONTAP LUNs.

Steps

1. Verify that the `/etc/multipath.conf` file exits. If the file doesn't exist, create an empty, zero-byte file:

   ```
   touch /etc/multipath.conf
   ```

2. The first time the `multipath.conf` file is created, you might need to enable and start the multipath services to load the recommended settings:

   ```
   systemctl enable multipathd
   ```

   ```
   systemctl start multipathd
   ```

3. Each time you boot the host, the empty `/etc/multipath.conf` zero-byte file automatically loads the NetApp recommended host multipath parameters as the default settings. You shouldn't need to make changes to the `/etc/multipath.conf` file for your host because the operating system is compiled with the multipath parameters that recognize and manage ONTAP LUNs correctly.

   The following table shows the Linux OS native compiled multipath parameter settings for ONTAP LUNs.

Show parameter settings

Parameter	Setting
detect_prio	yes
dev_loss_tmo	"infinity"
failback	immediate
fast_io_fail_tmo	5
features	"2 pg_init_retries 50"
flush_on_last_del	"yes"
hardware_handler	"0"
no_path_retry	queue
path_checker	"tur"
path_grouping_policy	"group_by_prio"
path_selector	"service-time 0"
polling_interval	5
prio	"ontap"
product	LUN
retain_attached_hw_handler	yes
rr_weight	"uniform"
user_friendly_names	no
vendor	NETAPP

4. Verify the parameter settings and path status for your ONTAP LUNs:

```
multipath -ll
```

The default multipath parameters support ASA, AFF, and FAS configurations. In these configurations, a single ONTAP LUN shouldn't require more than four paths. If there are more than four paths, it might cause issues with the paths during a storage failure.

The following example outputs show the correct parameter settings and path status for ONTAP LUNs in an ASA, AFF, or FAS configuration.

ASA configuration

An ASA configuration optimizes all paths to a given LUN, keeping them active. This improves performance by serving I/O operations through all paths at the same time.

Show example

```
multipath -ll
3600a098038314c4a433f577471797958 dm-2 NETAPP,LUN C-Mode
size=180G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
`-+- policy='service-time 0' prio=50 status=active
  |- 14:0:0:0  sdc  8:32   active ready running
  |- 17:0:0:0  sdas 66:192 active ready running
  |- 14:0:3:0  sdar 66:176 active ready running
  `- 17:0:3:0  sdch 69:80  active ready running
```

AFF or FAS configuration

An AFF or FAS configuration should have two groups of paths with higher and lower priorities. Higher priority Active/Optimized paths are served by the controller where the aggregate is located. Lower priority paths are active but non-optimized because they are served by a different controller. Non-optimized paths are only used when optimized paths aren't available.

The following example displays the output for an ONTAP LUN with two Active/Optimized paths and two Active/Non-Optimized paths:

Show example

```
multipath -ll
3600a0980383149764b5d567257516273 dm-0 NETAPP,LUN C-Mode
size=150G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
|-+- policy='service-time 0' prio=50 status=active
| |- 16:0:3:0  sdcg 69:64  active ready running
| `- 10:0:0:0  sdb  8:16   active ready running
`-+- policy='service-time 0' prio=10 status=enabled
  |- 10:0:1:0  sdc  8:32   active ready running
  `- 16:0:2:0  sdcf 69:48  active ready running
```

Step 4: Optionally, exclude a device from multipathing

If required, you can exclude a device from multipathing by adding the WWID for the unwanted device to the "blacklist" stanza for the `multipath.conf` file.

Steps

1. Determine the WWID:

   ```
   /lib/udev/scsi_id -gud /dev/sda
   ```

   "sda" is the local SCSI disk that you want to add to the blacklist.

   An example WWID is `360030057024d0730239134810c0cb833`.

2. Add the WWID to the "blacklist" stanza:

   ```
   blacklist {
            wwid    360030057024d0730239134810c0cb833
            devnode "^(ram|raw|loop|fd|md|dm-|sr|scd|st)[0-9]*"
            devnode "^hd[a-z]"
            devnode "^cciss.*"
   }
   ```

Step 5: Customize multipath parameters for ONTAP LUNs

If your host is connected to LUNs from other vendors and any of the multipath parameter settings are overridden, you need to correct them by adding stanzas later in the `multipath.conf` file that apply specifically to ONTAP LUNs. If you don't do this, the ONTAP LUNs might not work as expected.

Check your `/etc/multipath.conf` file, especially in the defaults section, for settings that might be overriding the default settings for multipath parameters.

> ⚠️ You shouldn't override the recommended parameter settings for ONTAP LUNs. These settings are required for optimal performance of your host configuration. Contact NetApp support, your OS vendor, or both for more information.

The following example shows how to correct an overridden default. In this example, the `multipath.conf` file defines values for `path_checker` and `no_path_retry` that aren't compatible with ONTAP LUNs, and you can't remove these parameters because ONTAP storage arrays are still attached to the host. Instead, you correct the values for `path_checker` and `no_path_retry` by adding a device stanza to the `multipath.conf` file that applies specifically to the ONTAP LUNs.

Show example

```
defaults {
    path_checker        readsector0
    no_path_retry       fail
}

devices {
    device {
        vendor          "NETAPP"
        product         "LUN"
        no_path_retry   queue
        path_checker    tur
    }
}
```

Step 6: Review the known issues

There are no known issues.

What's next?

- Learn about using the Linux Host Utilities tool.
- Learn about ASM mirroring.

  Automatic Storage Management (ASM) mirroring might require changes to the Linux multipath settings to allow ASM to recognize a problem and switch over to an alternate failure group. Most ASM configurations on ONTAP use external redundancy, which means that data protection is provided by the external array and ASM doesn't mirror data. Some sites use ASM with normal redundancy to provide two-way mirroring, normally across different sites. See Oracle databases on ONTAP for further information.

Configure RHEL 8.2 for FCP and iSCSI with ONTAP storage

The Linux Host Utilities software provides management and diagnostic tools for Linux hosts that are connected to ONTAP storage. When you install the Linux Host Utilities on a Red Hat Enterprise Linux (RHEL) 8.2 host, you can use the Host Utilities to help you manage FCP and iSCSI protocol operations with ONTAP LUNs.

> ⓘ You don't need to manually configure Kernel-based Virtual Machine (KVM) settings because ONTAP LUNs are automatically mapped to the hypervisor.

Step 1: Optionally, enable SAN booting

You can configure your host to use SAN booting to simplify deployment and improve scalability.

Before you begin

Use the Interoperability Matrix Tool to verify that your Linux OS, host bus adapter (HBA), HBA firmware, HBA

boot BIOS, and ONTAP version support SAN booting.

Steps

1. Create a SAN boot LUN and map it to the host.

2. Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is mapped.

   For information on how to enable the HBA BIOS, see your vendor-specific documentation.

3. Verify that the configuration was successful by rebooting the host and verifying that the OS is up and running.

Step 2: Install the Linux Host Utilities

NetApp strongly recommends installing the Linux Host Utilities to support ONTAP LUN management and assist technical support with gathering configuration data.

Install Linux Host Utilities 8.0.

> ⓘ   Installing the Linux Host Utilities doesn't change any host timeout settings on your Linux host.

Step 3: Confirm the multipath configuration for your host

You can use multipathing with RHEL 8.2 to manage ONTAP LUNs.

To ensure that multipathing is configured correctly for your host, verify that the `/etc/multipath.conf` file is defined and that you have the NetApp recommended settings configured for your ONTAP LUNs.

Steps

1. Verify that the `/etc/multipath.conf` file exits. If the file doesn't exist, create an empty, zero-byte file:

   ```
   touch /etc/multipath.conf
   ```

2. The first time the `multipath.conf` file is created, you might need to enable and start the multipath services to load the recommended settings:

   ```
   systemctl enable multipathd
   ```

   ```
   systemctl start multipathd
   ```

3. Each time you boot the host, the empty `/etc/multipath.conf` zero-byte file automatically loads the NetApp recommended host multipath parameters as the default settings. You shouldn't need to make changes to the `/etc/multipath.conf` file for your host because the operating system is compiled with the multipath parameters that recognize and manage ONTAP LUNs correctly.

   The following table shows the Linux OS native compiled multipath parameter settings for ONTAP LUNs.

Show parameter settings

Parameter	Setting
detect_prio	yes
dev_loss_tmo	"infinity"
failback	immediate
fast_io_fail_tmo	5
features	"2 pg_init_retries 50"
flush_on_last_del	"yes"
hardware_handler	"0"
no_path_retry	queue
path_checker	"tur"
path_grouping_policy	"group_by_prio"
path_selector	"service-time 0"
polling_interval	5
prio	"ontap"
product	LUN
retain_attached_hw_handler	yes
rr_weight	"uniform"
user_friendly_names	no
vendor	NETAPP

4. Verify the parameter settings and path status for your ONTAP LUNs:

```
multipath -ll
```

The default multipath parameters support ASA, AFF, and FAS configurations. In these configurations, a single ONTAP LUN shouldn't require more than four paths. If there are more than four paths, it might cause issues with the paths during a storage failure.

The following example outputs show the correct parameter settings and path status for ONTAP LUNs in an ASA, AFF, or FAS configuration.

ASA configuration

An ASA configuration optimizes all paths to a given LUN, keeping them active. This improves performance by serving I/O operations through all paths at the same time.

Show example

```
multipath -ll
3600a098038314c4a433f577471797958 dm-2 NETAPP,LUN C-Mode
size=180G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
`-+- policy='service-time 0' prio=50 status=active
  |- 14:0:0:0  sdc  8:32   active ready running
  |- 17:0:0:0  sdas 66:192 active ready running
  |- 14:0:3:0  sdar 66:176 active ready running
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```

AFF or FAS configuration

An AFF or FAS configuration should have two groups of paths with higher and lower priorities. Higher priority Active/Optimized paths are served by the controller where the aggregate is located. Lower priority paths are active but non-optimized because they are served by a different controller. Non-optimized paths are only used when optimized paths aren't available.

The following example displays the output for an ONTAP LUN with two Active/Optimized paths and two Active/Non-Optimized paths:

Show example

```
multipath -ll
3600a0980383149764b5d567257516273 dm-0 NETAPP,LUN C-Mode
size=150G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
|-+- policy='service-time 0' prio=50 status=active
| |- 16:0:3:0  sdcg 69:64  active ready running
| `- 10:0:0:0  sdb  8:16   active ready running
`-+- policy='service-time 0' prio=10 status=enabled
  |- 10:0:1:0  sdc  8:32   active ready running
  `- 16:0:2:0  sdcf 69:48  active ready running
```

Step 4: Optionally, exclude a device from multipathing

If required, you can exclude a device from multipathing by adding the WWID for the unwanted device to the "blacklist" stanza for the `multipath.conf` file.

Steps

1. Determine the WWID:

   ```
   /lib/udev/scsi_id -gud /dev/sda
   ```

   "sda" is the local SCSI disk that you want to add to the blacklist.

   An example WWID is `360030057024d0730239134810c0cb833`.

2. Add the WWID to the "blacklist" stanza:

   ```
   blacklist {
           wwid    360030057024d0730239134810c0cb833
           devnode "^(ram|raw|loop|fd|md|dm-|sr|scd|st)[0-9]*"
           devnode "^hd[a-z]"
           devnode "^cciss.*"
   }
   ```

Step 5: Customize multipath parameters for ONTAP LUNs

If your host is connected to LUNs from other vendors and any of the multipath parameter settings are overridden, you need to correct them by adding stanzas later in the `multipath.conf` file that apply specifically to ONTAP LUNs. If you don't do this, the ONTAP LUNs might not work as expected.

Check your `/etc/multipath.conf` file, especially in the defaults section, for settings that might be overriding the default settings for multipath parameters.

> ⚠️ You shouldn't override the recommended parameter settings for ONTAP LUNs. These settings are required for optimal performance of your host configuration. Contact NetApp support, your OS vendor, or both for more information.

The following example shows how to correct an overridden default. In this example, the `multipath.conf` file defines values for `path_checker` and `no_path_retry` that aren't compatible with ONTAP LUNs, and you can't remove these parameters because ONTAP storage arrays are still attached to the host. Instead, you correct the values for `path_checker` and `no_path_retry` by adding a device stanza to the `multipath.conf` file that applies specifically to the ONTAP LUNs.

Show example

```
defaults {
    path_checker        readsector0
    no_path_retry       fail
}

devices {
    device {
        vendor          "NETAPP"
        product         "LUN"
        no_path_retry   queue
        path_checker    tur
    }
}
```

Step 6: Review the known issues

There are no known issues.

What's next?

- Learn about using the Linux Host Utilities tool.
- Learn about ASM mirroring.

  Automatic Storage Management (ASM) mirroring might require changes to the Linux multipath settings to allow ASM to recognize a problem and switch over to an alternate failure group. Most ASM configurations on ONTAP use external redundancy, which means that data protection is provided by the external array and ASM doesn't mirror data. Some sites use ASM with normal redundancy to provide two-way mirroring, normally across different sites. See Oracle databases on ONTAP for further information.

Configure RHEL 8.1 for FCP and iSCSI with ONTAP storage

The Linux Host Utilities software provides management and diagnostic tools for Linux hosts that are connected to ONTAP storage. When you install the Linux Host Utilities on a Red Hat Enterprise Linux (RHEL) 8.1 host, you can use the Host Utilities to support managing FCP and iSCSI protocol operations with ONTAP LUNs.

> ⓘ You don't need to manually configure Kernel-based Virtual Machine (KVM) settings because
>   ONTAP LUNs are automatically mapped to the hypervisor.

Step 1: Optionally, enable SAN booting

You can configure your host to use SAN booting to simplify deployment and improve scalability.

Before you begin

Use the Interoperability Matrix Tool to verify that your Linux OS, host bus adapter (HBA), HBA firmware, HBA

boot BIOS, and ONTAP version support SAN booting.

Steps

1. [Create a SAN boot LUN and map it to the host](#).

2. Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is mapped.

   For information on how to enable the HBA BIOS, see your vendor-specific documentation.

3. Verify that the configuration was successful by rebooting the host and verifying that the OS is up and running.

Step 2: Install the Linux Host Utilities

NetApp strongly recommends installing the Linux Host Utilities to support ONTAP LUN management and assist technical support with gathering configuration data.

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> ⓘ | Installing the Linux Host Utilities doesn't change any host timeout settings on your Linux host.

Step 3: Confirm the multipath configuration for your host

You can use multipathing with RHEL 8.1 to manage ONTAP LUNs.

To ensure that multipathing is configured correctly for your host, verify that the `/etc/multipath.conf` file is defined and that you have the NetApp recommended settings configured for your ONTAP LUNs.

Steps

1. Verify that the `/etc/multipath.conf` file exits. If the file doesn't exist, create an empty, zero-byte file:

   ```
   touch /etc/multipath.conf
   ```

2. The first time the `multipath.conf` file is created, you might need to enable and start the multipath services to load the recommended settings:

   ```
   systemctl enable multipathd
   ```

   ```
   systemctl start multipathd
   ```

3. Each time you boot the host, the empty `/etc/multipath.conf` zero-byte file automatically loads the NetApp recommended host multipath parameters as the default settings. You shouldn't need to make changes to the `/etc/multipath.conf` file for your host because the operating system is compiled with the multipath parameters that recognize and manage ONTAP LUNs correctly.

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hardware_handler	"0"
no_path_retry	queue
path_checker	"tur"
path_grouping_policy	"group_by_prio"
path_selector	"service-time 0"
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prio	"ontap"
product	LUN
retain_attached_hw_handler	yes
rr_weight	"uniform"
user_friendly_names	no
vendor	NETAPP

4. Verify the parameter settings and path status for your ONTAP LUNs:

```
multipath -ll
```

The default multipath parameters support ASA, AFF, and FAS configurations. In these configurations, a single ONTAP LUN shouldn't require more than four paths. If there are more than four paths, it might cause issues with the paths during a storage failure.

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```
multipath -ll
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size=150G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
|-+- policy='service-time 0' prio=50 status=active
| |- 16:0:3:0  sdcg 69:64  active ready running
| `- 10:0:0:0  sdb  8:16   active ready running
`-+- policy='service-time 0' prio=10 status=enabled
  |- 10:0:1:0  sdc  8:32   active ready running
  `- 16:0:2:0  sdcf 69:48  active ready running
```

Step 4: Optionally, exclude a device from multipathing

If required, you can exclude a device from multipathing by adding the WWID for the unwanted device to the "blacklist" stanza for the `multipath.conf` file.

Steps

1. Determine the WWID:

   ```
   /lib/udev/scsi_id -gud /dev/sda
   ```

   "sda" is the local SCSI disk that you want to add to the blacklist.

   An example WWID is `360030057024d0730239134810c0cb833`.

2. Add the WWID to the "blacklist" stanza:

   ```
   blacklist {
           wwid    360030057024d0730239134810c0cb833
           devnode "^(ram|raw|loop|fd|md|dm-|sr|scd|st)[0-9]*"
           devnode "^hd[a-z]"
           devnode "^cciss.*"
   }
   ```

Step 5: Customize multipath parameters for ONTAP LUNs

If your host is connected to LUNs from other vendors and any of the multipath parameter settings are overridden, you need to correct them by adding stanzas later in the `multipath.conf` file that apply specifically to ONTAP LUNs. If you don't do this, the ONTAP LUNs might not work as expected.

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Show example

```
defaults {
    path_checker       readsector0
    no_path_retry      fail
}

devices {
    device {
        vendor          "NETAPP"
        product         "LUN"
        no_path_retry   queue
        path_checker    tur
    }
}
```

Step 6: Review the known issues

The RHEL 8.1 with ONTAP storage release has the following known issues:

NetApp Bug ID	Title	Description
1275843	Kernel disruption might occur on Red Hat Enterprise Linux 8.1 with QLogic QLE2672 16GB FC HBA during storage failover operation	Kernel disruption might occur during storage failover operations on the Red Hat Enterprise Linux 8.1 kernel with a QLogic QLE2672 Fibre Channel (FC) host bus adapter (HBA). The kernel disruption causes Red Hat Enterprise Linux 8.1 to reboot, leading to application disruption. If the kdump mechanism is enabled, the kernel disruption generates a vmcore file located in the/var/crash/ directory. You can check the vmcore file to determine the cause of the disruption.A storage failover with the QLogic QLE2672 HBA event affects the "kmem_cache_alloc+131" module. You can locate the event in the vmcore file by finding the following string: " [exception RIP: kmem_cache_alloc+131]"After the kernel disruption, reboot the Host OS and recover the operating system. Then restart the applications

NetApp Bug ID	Title	Description
1275838	Kernel disruption occurs on Red Hat Enterprise Linux 8.1 with QLogic QLE2742 32GB FC HBA during storage failover operations	Kernel disruption occurs during storage failover operations on the Red Hat Enterprise Linux 8.1 kernel with a QLogic QLE2742 Fibre Channel (FC) host bus adapter (HBA). The kernel disruption causes Red Hat Enterprise Linux 8.1 to reboot, leading to application disruption. If the kdump mechanism is enabled, the kernel disruption generates a vmcore file located in the/var/crash/ directory. You can check the vmcore file to determine the cause of the disruption. A storage failover with the QLogic QLE2742 HBA event affects the "kmem_cache_alloc+131"module. You can locate the event in the vmcore file by finding the following string: " [exception RIP: kmem_cache_alloc+131]"After the kernel disruption, reboot the Host OS and recover the operating system. Then restart the applications.
1266250	Login to multiple paths fails during the Red Hat Enterprise Linux 8.1 installation on iSCSI SAN LUN	You cannot login to multiple paths during the Red Hat Enterprise Linux 8.1 installation on iSCSI SAN LUN multipath devices. Installation is not possible on multipath iSCSI device and the multipath service is not enabled on the SAN boot device.

What's next?

- Learn about using the Linux Host Utilities tool.
- Learn about ASM mirroring.

  Automatic Storage Management (ASM) mirroring might require changes to the Linux multipath settings to allow ASM to recognize a problem and switch over to an alternate failure group. Most ASM configurations on ONTAP use external redundancy, which means that data protection is provided by the external array and ASM doesn't mirror data. Some sites use ASM with normal redundancy to provide two-way mirroring, normally across different sites. See Oracle databases on ONTAP for further information.

Configure RHEL 8.0 for FCP and iSCSI with ONTAP storage

The Linux Host Utilities software provides management and diagnostic tools for Linux hosts that are connected to ONTAP storage. When you install the Linux Host Utilities on a Red Hat Enterprise Linux (RHEL) 8.0 host, you can use the Host Utilities to help you manage FCP and iSCSI protocol operations with ONTAP LUNs.

Step 1: Optionally, enable SAN booting

You can configure your host to use SAN booting to simplify deployment and improve scalability.

Before you begin

Use the Interoperability Matrix Tool to verify that your Linux OS, host bus adapter (HBA), HBA firmware, HBA boot BIOS, and ONTAP version support SAN booting.

Steps

1. Create a SAN boot LUN and map it to the host.

2. Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is mapped.

   For information on how to enable the HBA BIOS, see your vendor-specific documentation.

3. Verify that the configuration was successful by rebooting the host and verifying that the OS is up and running.

Step 2: Install the Linux Host Utilities

NetApp strongly recommends installing the Linux Host Utilities to support ONTAP LUN management and assist technical support with gathering configuration data.

Install Linux Host Utilities 8.0.

> ℹ️ Installing the Linux Host Utilities doesn't change any host timeout settings on your Linux host.

Step 3: Confirm the multipath configuration for your host

You can use multipathing with RHEL 8.0 to manage ONTAP LUNs.

To ensure that multipathing is configured correctly for your host, verify that the `/etc/multipath.conf` file is defined and that you have the NetApp recommended settings configured for your ONTAP LUNs.

Steps

1. Verify that the `/etc/multipath.conf` file exits. If the file doesn't exist, create an empty, zero-byte file:

   ```
   touch /etc/multipath.conf
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2. The first time the `multipath.conf` file is created, you might need to enable and start the multipath services to load the recommended settings:

   ```
   systemctl enable multipathd
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   systemctl start multipathd
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fast_io_fail_tmo	5
features	"2 pg_init_retries 50"
flush_on_last_del	"yes"
hardware_handler	"0"
no_path_retry	queue
path_checker	"tur"
path_grouping_policy	"group_by_prio"
path_selector	"service-time 0"
polling_interval	5
prio	"ontap"
product	LUN
retain_attached_hw_handler	yes
rr_weight	"uniform"
user_friendly_names	no
vendor	NETAPP

4. Verify the parameter settings and path status for your ONTAP LUNs:

```
multipath -ll
```

The default multipath parameters support ASA, AFF, and FAS configurations. In these configurations, a single ONTAP LUN shouldn't require more than four paths. If there are more than four paths, it might cause issues with the paths during a storage failure.

The following example outputs show the correct parameter settings and path status for ONTAP LUNs in an ASA, AFF, or FAS configuration.

ASA configuration

An ASA configuration optimizes all paths to a given LUN, keeping them active. This improves performance by serving I/O operations through all paths at the same time.

Show example

```
multipath -ll
3600a098038314c4a433f577471797958 dm-2 NETAPP,LUN C-Mode
size=180G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
`-+- policy='service-time 0' prio=50 status=active
  |- 14:0:0:0  sdc  8:32   active ready running
  |- 17:0:0:0  sdas 66:192 active ready running
  |- 14:0:3:0  sdar 66:176 active ready running
  `- 17:0:3:0  sdch 69:80  active ready running
```

AFF or FAS configuration

An AFF or FAS configuration should have two groups of paths with higher and lower priorities. Higher priority Active/Optimized paths are served by the controller where the aggregate is located. Lower priority paths are active but non-optimized because they are served by a different controller. Non-optimized paths are only used when optimized paths aren't available.

The following example displays the output for an ONTAP LUN with two Active/Optimized paths and two Active/Non-Optimized paths:

Show example

```
multipath -ll
3600a0980383149764b5d567257516273 dm-0 NETAPP,LUN C-Mode
size=150G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
|-+- policy='service-time 0' prio=50 status=active
| |- 16:0:3:0  sdcg 69:64  active ready running
| `- 10:0:0:0  sdb  8:16   active ready running
`-+- policy='service-time 0' prio=10 status=enabled
  |- 10:0:1:0  sdc  8:32   active ready running
  `- 16:0:2:0  sdcf 69:48  active ready running
```

Step 4: Optionally, exclude a device from multipathing

If required, you can exclude a device from multipathing by adding the WWID for the unwanted device to the "blacklist" stanza for the `multipath.conf` file.

Steps

1. Determine the WWID:

```
/lib/udev/scsi_id -gud /dev/sda
```

"sda" is the local SCSI disk that you want to add to the blacklist.

An example WWID is `360030057024d0730239134810c0cb833`.

2. Add the WWID to the "blacklist" stanza:

```
blacklist {
        wwid   360030057024d0730239134810c0cb833
        devnode "^(ram|raw|loop|fd|md|dm-|sr|scd|st)[0-9]*"
        devnode "^hd[a-z]"
        devnode "^cciss.*"
}
```

Step 5: Customize multipath parameters for ONTAP LUNs

If your host is connected to LUNs from other vendors and any of the multipath parameter settings are overridden, you need to correct them by adding stanzas later in the `multipath.conf` file that apply specifically to ONTAP LUNs. If you don't do this, the ONTAP LUNs might not work as expected.

Check your `/etc/multipath.conf` file, especially in the defaults section, for settings that might be overriding the default settings for multipath parameters.

> ⚠️ You shouldn't override the recommended parameter settings for ONTAP LUNs. These settings are required for optimal performance of your host configuration. Contact NetApp support, your OS vendor, or both for more information.

The following example shows how to correct an overridden default. In this example, the `multipath.conf` file defines values for `path_checker` and `no_path_retry` that aren't compatible with ONTAP LUNs, and you can't remove these parameters because ONTAP storage arrays are still attached to the host. Instead, you correct the values for `path_checker` and `no_path_retry` by adding a device stanza to the `multipath.conf` file that applies specifically to the ONTAP LUNs.

Show example

```
defaults {
    path_checker        readsector0
    no_path_retry       fail
}

devices {
    device {
        vendor          "NETAPP"
        product         "LUN"
        no_path_retry   queue
        path_checker    tur
    }
}
```

Step 6: Review the known issues

The RHEL 8.0 with ONTAP storage release has the following known issues:

NetApp Bug ID	Title	Description
1238719	Kernel disruption on RHEL8 with QLogic QLE2672 16GB FC during storage failover operations	Kernel disruption might occur during storage failover operations on a Red Hat Enterprise Linux (RHEL) 8 kernel with a QLogic QLE2672 host bus adapter (HBA). The kernel disruption causes the operating system to reboot. The reboot causes application disruption and generates the vmcore file under the /var/crash/directory if kdump is configured. Use the vmcore file to identify the cause of the failure. In this case, the disruption is in the "kmem_cache_alloc+160" module. It is logged in the vmcore file with the following string: "[exception RIP: kmem_cache_alloc+160]". Reboot the host OS to recover the operating system and then restart the application.

NetApp Bug ID	Title	Description
1226783	RHEL8 OS boots up to "emergency mode" when more than 204 SCSI devices are mapped on all Fibre Channel (FC) host bus adapters (HBA)	If a host is mapped with more than 204 SCSI devices during an operating systemreboot process, the RHEL8 OS fails to boot up to "normal mode" and enters "emergency mode". This results in most of the host services becoming unavailable.
1230882	Creating a partition on an iSCSI multipath device during the RHEL8 installation is not feasible.	iSCSI SAN LUN multipath devices are not listed in disk selection during RHEL 8 installation. Consequently, the multipath service is not enabled on the SAN boot device.
1235998	The "rescan-scsi-bus.sh -a" command does not scan more than 328 devices	If a Red Hat Enterprise Linux 8 host maps with more than 328 SCSI devices, the host OS command "rescan-scsi-bus.sh -a" only scans 328 devices. The host does not discover any remaining mapped devices.
1231087	Remote ports transit to a blocked state on RHEL8 with Emulex LPe16002 16GB FC during storage failover operations	Remote ports transit to a blocked state on RHEL8 with Emulex LPe16002 16GB Fibre Channel (FC) during storage failover operations. When the storage node returns to an optimal state, the LIFs also come up and the remote port state should read "online". Occasionally, the remote port state might continue to read as "blocked" or "not present". This state can lead to a "failed faulty" path to LUNs at the multipath layer
1231098	Remote ports transit to blocked state on RHEL8 with Emulex LPe32002 32GB FC during storage failover operations	Remote ports transit to a blocked state on RHEL8 with Emulex LPe32002 32GBFibre Channel (FC) during storage failover operations. When the storage node returns to an optimal state, the LIFs also come up and the remote port state should read "online". Occasionally, the remote port state might continue to read as "blocked" or "not present". This state can lead to a "failed faulty" path to LUNs at the multipath layer.

What's next?

- [Learn about using the Linux Host Utilities tool](#).
- Learn about ASM mirroring.

  Automatic Storage Management (ASM) mirroring might require changes to the Linux multipath settings to allow ASM to recognize a problem and switch over to an alternate failure group. Most ASM configurations on ONTAP use external redundancy, which means that data protection is provided by the external array and ASM doesn't mirror data. Some sites use ASM with normal redundancy to provide two-way mirroring, normally across different sites. See [Oracle databases on ONTAP](#) for further information.

RHEL 7

Configure RHEL 7.9 for FCP and iSCSI with ONTAP storage

The Linux Host Utilities software provides management and diagnostic tools for Linux hosts that are connected to ONTAP storage. When you install the Linux Host Utilities on a Red Hat Enterprise Linux (RHEL) 7.9 host, you can use the Host Utilities to help you manage FCP and iSCSI protocol operations with ONTAP LUNs.

> (i) You don't need to manually configure Kernel-based Virtual Machine (KVM) settings because ONTAP LUNs are automatically mapped to the hypervisor.

Step 1: Optionally, enable SAN booting

You can configure your host to use SAN booting to simplify deployment and improve scalability.

Before you begin

Use the [Interoperability Matrix Tool](#) to verify that your Linux OS, host bus adapter (HBA), HBA firmware, HBA boot BIOS, and ONTAP version support SAN booting.

Steps

1. [Create a SAN boot LUN and map it to the host](#).
2. Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is mapped.

   For information on how to enable the HBA BIOS, see your vendor-specific documentation.

3. Verify that the configuration was successful by rebooting the host and verifying that the OS is up and running.

Step 2: Install the Linux Host Utilities

NetApp strongly recommends installing the Linux Host Utilities to support ONTAP LUN management and assist technical support with gathering configuration data.

[Install Linux Host Utilities 7.1](#).

> (i) Installing the Linux Host Utilities doesn't change any host timeout settings on your Linux host.

Step 3: Confirm the multipath configuration for your host

You can use multipathing with RHEL 7.9 to manage ONTAP LUNs.

To ensure that multipathing is configured correctly for your host, verify that the `/etc/multipath.conf` file is defined and that you have the NetApp recommended settings configured for your ONTAP LUNs.

Steps

1. Verify that the `/etc/multipath.conf` file exists:

   ```
   ls /etc/multipath.conf
   ```

   If the file doesn't exist, create an empty, zero-byte file:

   ```
   touch /etc/multipath.conf
   ```

2. The first time the `multipath.conf` file is created, you might need to enable and start the multipath services to load the recommended settings:

   ```
   systemctl enable multipathd
   ```

   ```
   systemctl start multipathd
   ```

3. Each time you boot the host, the empty `/etc/multipath.conf` zero-byte file automatically loads the NetApp recommended host multipath parameters as the default settings. You shouldn't need to make changes to the `/etc/multipath.conf` file for your host because the host operating system is compiled with the multipath parameters that recognize and manage ONTAP LUNs correctly.

   The following table shows the native Linux OS compiled multipath parameter settings for ONTAP LUNs.

Show parameter settings

Parameter	Setting
detect_prio	yes
dev_loss_tmo	"infinity"
failback	immediate
fast_io_fail_tmo	5
features	"3 queue_if_no_path pg_init_retries 50"
flush_on_last_del	"yes"
hardware_handler	"0"
no_path_retry	queue
path_checker	"tur"
path_grouping_policy	"group_by_prio"
path_selector	"service-time 0"
polling_interval	5
prio	"ontap"
product	LUN.*
retain_attached_hw_handler	yes
rr_weight	"uniform"
user_friendly_names	no
vendor	NETAPP

4. Verify the parameter settings and path status for your ONTAP LUNs:

```
multipath -ll
```

The default multipath parameters support ASA, AFF, and FAS configurations. In these configurations, a single ONTAP LUN shouldn't require more than four paths. If there are more than four paths, it might cause issues with the paths during a storage failure.

The following example outputs show the correct parameter settings and path status for ONTAP LUNs in an ASA, AFF, or FAS configuration.

ASA configuration

An ASA configuration optimizes all paths to a given LUN, keeping them active. This improves performance by serving I/O operations through all paths at the same time.

```
# multipath -ll
3600a09803831347657244e527766394e dm-5 NETAPP,LUN C-Mode
size=80G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
`-+- policy='service-time 0' prio=50 status=active
  |- 3:0:7:9   sdco 69:192  active ready running
  |- 3:0:8:9   sddi 71:0    active ready running
  |- 14:0:8:9  sdjq 65:320  active ready running
  `- 14:0:7:9  sdiw 8:256   active ready running
```

AFF or FAS configuration

An AFF or FAS configuration should have two groups of paths with higher and lower priorities. Higher priority Active/Optimized paths are served by the controller where the aggregate is located. Lower priority paths are active but non-optimized because they are served by a different controller. Non-optimized paths are only used when optimized paths aren't available.

The following example displays the output for an ONTAP LUN with two Active/Optimized paths and two Active/Non-Optimized paths:

```
# multipath -ll
3600a09803831347657244e527766394e dm-5 NETAPP,LUN C-Mode
size=80G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
|-+- policy='service-time 0' prio=50 status=active
| |- 3:0:3:0   sdd  8:48    active ready running
| |- 3:0:4:0   sdx  65:112  active ready running
`-+- policy='service-time 0' prio=10 status=enabled
  |- 14:0:2:0  sdfk 130:96  active ready running
  `- 14:0:5:0  sdgz 132:240 active ready running
```

Step 4: Optionally, exclude a device from multipathing

If required, you can exclude a device from multipathing by adding the WWID for the unwanted device to the "blacklist" stanza for the `multipath.conf` file.

Steps

1. Determine the WWID:

```
/lib/udev/scsi_id -gud /dev/sda
```

"sda" is the local SCSI disk that you want to add to the blacklist.

An example WWID is `360030057024d0730239134810c0cb833`.

2. Add the WWID to the "blacklist" stanza:

```
blacklist {
        wwid    360030057024d0730239134810c0cb833
        devnode "^(ram|raw|loop|fd|md|dm-|sr|scd|st)[0-9]*"
        devnode "^hd[a-z]"
        devnode "^cciss.*"
}
```

Step 5: Customize multipath parameters for ONTAP LUNs

If your host is connected to LUNs from other vendors and any of the multipath parameter settings are overridden, you need to correct them by adding stanzas later in the `multipath.conf` file that apply specifically to ONTAP LUNs. If you don't do this, the ONTAP LUNs might not work as expected.

Check your `/etc/multipath.conf` file, especially in the defaults section, for settings that might be overriding the default settings for multipath parameters.

> ⚠ You shouldn't override the recommended parameter settings for ONTAP LUNs. These settings are required for optimal performance of your host configuration. Contact NetApp support, your OS vendor, or both for more information.

The following example shows how to correct an overridden default. In this example, the `multipath.conf` file defines values for `path_checker` and `no_path_retry` that aren't compatible with ONTAP LUNs, and you can't remove these parameters because ONTAP storage arrays are still attached to the host. Instead, you correct the values for `path_checker` and `no_path_retry` by adding a device stanza to the `multipath.conf` file that applies specifically to the ONTAP LUNs.

Show example

```
defaults {
    path_checker        readsector0
    no_path_retry       fail
}

devices {
    device {
        vendor          "NETAPP"
        product         "LUN"
        no_path_retry   queue
        path_checker    tur
    }
}
```

Step 6: Review the known issues

The RHEL 7.9 with ONTAP storage release has the following known issue:

NetApp Bug ID	Title	Description
1440718	If you unmap or map a LUN without performing a SCSI rescan, it might lead to data corruption on the host.	When you set the 'disable_changed_wwids' multipath configuration parameter to YES, it disables access to the path device in the event of a WWID change. Multipath will disable access to the path device until the WWID of the path is restored to the WWID of the multipath device. To learn more, see NetApp Knowledge Base: The filesystem corruption on iSCSI LUN on the Oracle Linux 7.

What's next?

- Learn about using the Linux Host Utilities tool.
- Learn about ASM mirroring.

  Automatic Storage Management (ASM) mirroring might require changes to the Linux multipath settings to allow ASM to recognize a problem and switch over to an alternate failure group. Most ASM configurations on ONTAP use external redundancy, which means that data protection is provided by the external array and ASM doesn't mirror data. Some sites use ASM with normal redundancy to provide two-way mirroring, normally across different sites. See Oracle databases on ONTAP for further information.

Configure RHEL 7.8 for FCP and iSCSI with ONTAP storage

The Linux Host Utilities software provides management and diagnostic tools for Linux hosts that are connected to ONTAP storage. When you install the Linux Host Utilities on a Red Hat Enterprise Linux (RHEL) 7.8 host, you can use the Host Utilities to help you manage FCP and iSCSI protocol operations with ONTAP LUNs.

> ⓘ You don't need to manually configure Kernel-based Virtual Machine (KVM) settings because ONTAP LUNs are automatically mapped to the hypervisor.

Step 1: Optionally, enable SAN booting

You can configure your host to use SAN booting to simplify deployment and improve scalability.

Before you begin

Use the Interoperability Matrix Tool to verify that your Linux OS, host bus adapter (HBA), HBA firmware, HBA boot BIOS, and ONTAP version support SAN booting.

Steps

1. Create a SAN boot LUN and map it to the host.

2. Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is mapped.

   For information on how to enable the HBA BIOS, see your vendor-specific documentation.

3. Verify that the configuration was successful by rebooting the host and verifying that the OS is up and running.

Step 2: Install the Linux Host Utilities

NetApp strongly recommends installing the Linux Host Utilities to support ONTAP LUN management and assist technical support with gathering configuration data.

Install Linux Host Utilities 7.1.

> ⓘ Installing the Linux Host Utilities doesn't change any host timeout settings on your Linux host.

Step 3: Confirm the multipath configuration for your host

You can use multipathing with RHEL 7.8 to manage ONTAP LUNs.

To ensure that multipathing is configured correctly for your host, verify that the `/etc/multipath.conf` file is defined and that you have the NetApp recommended settings configured for your ONTAP LUNs.

Steps

1. Verify that the `/etc/multipath.conf` file exists:

   ```
   ls /etc/multipath.conf
   ```

   If the file doesn't exist, create an empty, zero-byte file:

```
touch /etc/multipath.conf
```

2. The first time the `multipath.conf` file is created, you might need to enable and start the multipath services to load the recommended settings:

```
systemctl enable multipathd
```

```
systemctl start multipathd
```

3. Each time you boot the host, the empty `/etc/multipath.conf` zero-byte file automatically loads the NetApp recommended host multipath parameters as the default settings. You shouldn't need to make changes to the `/etc/multipath.conf` file for your host because the host operating system is compiled with the multipath parameters that recognize and manage ONTAP LUNs correctly.

The following table shows the native Linux OS compiled multipath parameter settings for ONTAP LUNs.

Show parameter settings

Parameter	Setting
detect_prio	yes
dev_loss_tmo	"infinity"
failback	immediate
fast_io_fail_tmo	5
features	"3 queue_if_no_path pg_init_retries 50"
flush_on_last_del	"yes"
hardware_handler	"0"
no_path_retry	queue
path_checker	"tur"
path_grouping_policy	"group_by_prio"
path_selector	"service-time 0"
polling_interval	5
prio	"ontap"
product	LUN.*
retain_attached_hw_handler	yes
rr_weight	"uniform"
user_friendly_names	no
vendor	NETAPP

4. Verify the parameter settings and path status for your ONTAP LUNs:

```
multipath -ll
```

The default multipath parameters support ASA, AFF, and FAS configurations. In these configurations, a single ONTAP LUN shouldn't require more than four paths. If there are more than four paths, it might cause issues with the paths during a storage failure.

The following example outputs show the correct parameter settings and path status for ONTAP LUNs in an ASA, AFF, or FAS configuration.

ASA configuration

An ASA configuration optimizes all paths to a given LUN, keeping them active. This improves performance by serving I/O operations through all paths at the same time.

```
# multipath -ll
3600a09803831347657244e527766394e dm-5 NETAPP,LUN C-Mode
size=80G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
`-+- policy='service-time 0' prio=50 status=active
  |- 3:0:7:9    sdco 69:192   active ready running
  |- 3:0:8:9    sddi 71:0     active ready running
  |- 14:0:8:9   sdjq 65:320   active ready running
  `- 14:0:7:9   sdiw 8:256    active ready running
```

AFF or FAS configuration

An AFF or FAS configuration should have two groups of paths with higher and lower priorities. Higher priority Active/Optimized paths are served by the controller where the aggregate is located. Lower priority paths are active but non-optimized because they are served by a different controller. Non-optimized paths are only used when optimized paths aren't available.

The following example displays the output for an ONTAP LUN with two Active/Optimized paths and two Active/Non-Optimized paths:

```
# multipath -ll
3600a09803831347657244e527766394e dm-5 NETAPP,LUN C-Mode
size=80G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
|-+- policy='service-time 0' prio=50 status=active
| |- 3:0:3:0    sdd  8:48     active ready running
| |- 3:0:4:0    sdx  65:112   active ready running
`-+- policy='service-time 0' prio=10 status=enabled
  |- 14:0:2:0   sdfk 130:96   active ready running
  `- 14:0:5:0   sdgz 132:240  active ready running
```

Step 4: Optionally, exclude a device from multipathing

If required, you can exclude a device from multipathing by adding the WWID for the unwanted device to the "blacklist" stanza for the `multipath.conf` file.

Steps

1. Determine the WWID:

   ```
   /lib/udev/scsi_id -gud /dev/sda
   ```

   "sda" is the local SCSI disk that you want to add to the blacklist.

   An example WWID is `360030057024d0730239134810c0cb833`.

2. Add the WWID to the "blacklist" stanza:

   ```
   blacklist {
           wwid    360030057024d0730239134810c0cb833
           devnode "^(ram|raw|loop|fd|md|dm-|sr|scd|st)[0-9]*"
           devnode "^hd[a-z]"
           devnode "^cciss.*"
   }
   ```

Step 5: Customize multipath parameters for ONTAP LUNs

If your host is connected to LUNs from other vendors and any of the multipath parameter settings are overridden, you need to correct them by adding stanzas later in the `multipath.conf` file that apply specifically to ONTAP LUNs. If you don't do this, the ONTAP LUNs might not work as expected.

Check your `/etc/multipath.conf` file, especially in the defaults section, for settings that might be overriding the default settings for multipath parameters.

> ⚠️ You shouldn't override the recommended parameter settings for ONTAP LUNs. These settings are required for optimal performance of your host configuration. Contact NetApp support, your OS vendor, or both for more information.

The following example shows how to correct an overridden default. In this example, the `multipath.conf` file defines values for `path_checker` and `no_path_retry` that aren't compatible with ONTAP LUNs, and you can't remove these parameters because ONTAP storage arrays are still attached to the host. Instead, you correct the values for `path_checker` and `no_path_retry` by adding a device stanza to the `multipath.conf` file that applies specifically to the ONTAP LUNs.

Show example

```
defaults {
    path_checker      readsector0
    no_path_retry     fail
}

devices {
    device {
        vendor          "NETAPP"
        product         "LUN"
        no_path_retry   queue
        path_checker    tur
    }
}
```

Step 6: Review the known issues

The RHEL 7.8 with ONTAP storage release has the following known issue:

NetApp Bug ID	Title	Description
1440718	If you unmap or map a LUN without performing a SCSI rescan, it might lead to data corruption on the host.	When you set the 'disable_changed_wwids' multipath configuration parameter to YES, it disables access to the path device in the event of a WWID change. Multipath will disable access to the path device until the WWID of the path is restored to the WWID of the multipath device. To learn more, see NetApp Knowledge Base: The filesystem corruption on iSCSI LUN on the Oracle Linux 7.

What's next?

- Learn about using the Linux Host Utilities tool.

- Learn about ASM mirroring.

  Automatic Storage Management (ASM) mirroring might require changes to the Linux multipath settings to allow ASM to recognize a problem and switch over to an alternate failure group. Most ASM configurations on ONTAP use external redundancy, which means that data protection is provided by the external array and ASM doesn't mirror data. Some sites use ASM with normal redundancy to provide two-way mirroring, normally across different sites. See Oracle databases on ONTAP for further information.

Configure RHEL 7.7 for FCP and iSCSI with ONTAP storage

The Linux Host Utilities software provides management and diagnostic tools for Linux hosts that are connected to ONTAP storage. When you install the Linux Host Utilities on a Red Hat Enterprise Linux (RHEL) 7.7 host, you can use the Host Utilities to help you manage FCP and iSCSI protocol operations with ONTAP LUNs.

> (i) You don't need to manually configure Kernel-based Virtual Machine (KVM) settings because ONTAP LUNs are automatically mapped to the hypervisor.

Step 1: Optionally, enable SAN booting

You can configure your host to use SAN booting to simplify deployment and improve scalability.

Before you begin

Use the Interoperability Matrix Tool to verify that your Linux OS, host bus adapter (HBA), HBA firmware, HBA boot BIOS, and ONTAP version support SAN booting.

Steps

1. Create a SAN boot LUN and map it to the host.

2. Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is mapped.

   For information on how to enable the HBA BIOS, see your vendor-specific documentation.

3. Verify that the configuration was successful by rebooting the host and verifying that the OS is up and running.

Step 2: Install the Linux Host Utilities

NetApp strongly recommends installing the Linux Host Utilities to support ONTAP LUN management and assist technical support with gathering configuration data.

Install Linux Host Utilities 7.1.

> (i) Installing the Linux Host Utilities doesn't change any host timeout settings on your Linux host.

Step 3: Confirm the multipath configuration for your host

You can use multipathing with RHEL 7.7 to manage ONTAP LUNs.

To ensure that multipathing is configured correctly for your host, verify that the `/etc/multipath.conf` file is defined and that you have the NetApp recommended settings configured for your ONTAP LUNs.

Steps

1. Verify that the `/etc/multipath.conf` file exists:

   ```
   ls /etc/multipath.conf
   ```

   If the file doesn't exist, create an empty, zero-byte file:

```
touch /etc/multipath.conf
```

2. The first time the `multipath.conf` file is created, you might need to enable and start the multipath services to load the recommended settings:

```
systemctl enable multipathd
```

```
systemctl start multipathd
```

3. Each time you boot the host, the empty `/etc/multipath.conf` zero-byte file automatically loads the NetApp recommended host multipath parameters as the default settings. You shouldn't need to make changes to the `/etc/multipath.conf` file for your host because the host operating system is compiled with the multipath parameters that recognize and manage ONTAP LUNs correctly.

The following table shows the native Linux OS compiled multipath parameter settings for ONTAP LUNs.

Show parameter settings

Parameter	Setting
detect_prio	yes
dev_loss_tmo	"infinity"
failback	immediate
fast_io_fail_tmo	5
features	"3 queue_if_no_path pg_init_retries 50"
flush_on_last_del	"yes"
hardware_handler	"0"
no_path_retry	queue
path_checker	"tur"
path_grouping_policy	"group_by_prio"
path_selector	"service-time 0"
polling_interval	5
prio	"ontap"
product	LUN.*
retain_attached_hw_handler	yes
rr_weight	"uniform"
user_friendly_names	no
vendor	NETAPP

4. Verify the parameter settings and path status for your ONTAP LUNs:

```
multipath -ll
```

The default multipath parameters support ASA, AFF, and FAS configurations. In these configurations, a single ONTAP LUN shouldn't require more than four paths. If there are more than four paths, it might cause issues with the paths during a storage failure.

The following example outputs show the correct parameter settings and path status for ONTAP LUNs in an ASA, AFF, or FAS configuration.

ASA configuration

An ASA configuration optimizes all paths to a given LUN, keeping them active. This improves performance by serving I/O operations through all paths at the same time.

```
# multipath -ll
3600a09803831347657244e527766394e dm-5 NETAPP,LUN C-Mode
size=80G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
`-+- policy='service-time 0' prio=50 status=active
  |- 3:0:7:9    sdco 69:192   active ready running
  |- 3:0:8:9    sddi 71:0     active ready running
  |- 14:0:8:9   sdjq 65:320   active ready running
  `- 14:0:7:9   sdiw 8:256    active ready running
```

AFF or FAS configuration

An AFF or FAS configuration should have two groups of paths with higher and lower priorities. Higher priority Active/Optimized paths are served by the controller where the aggregate is located. Lower priority paths are active but non-optimized because they are served by a different controller. Non-optimized paths are only used when optimized paths aren't available.

The following example displays the output for an ONTAP LUN with two Active/Optimized paths and two Active/Non-Optimized paths:

```
# multipath -ll
3600a09803831347657244e527766394e dm-5 NETAPP,LUN C-Mode
size=80G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
|-+- policy='service-time 0' prio=50 status=active
| |- 3:0:3:0    sdd  8:48     active ready running
| |- 3:0:4:0    sdx  65:112   active ready running
`-+- policy='service-time 0' prio=10 status=enabled
  |- 14:0:2:0   sdfk 130:96   active ready running
  `- 14:0:5:0   sdgz 132:240  active ready running
```

Step 4: Optionally, exclude a device from multipathing

If required, you can exclude a device from multipathing by adding the WWID for the unwanted device to the "blacklist" stanza for the `multipath.conf` file.

Steps

1. Determine the WWID:

   ```
   /lib/udev/scsi_id -gud /dev/sda
   ```

   "sda" is the local SCSI disk that you want to add to the blacklist.

   An example WWID is `360030057024d0730239134810c0cb833`.

2. Add the WWID to the "blacklist" stanza:

   ```
   blacklist {
           wwid    360030057024d0730239134810c0cb833
           devnode "^(ram|raw|loop|fd|md|dm-|sr|scd|st)[0-9]*"
           devnode "^hd[a-z]"
           devnode "^cciss.*"
   }
   ```

Step 5: Customize multipath parameters for ONTAP LUNs

If your host is connected to LUNs from other vendors and any of the multipath parameter settings are overridden, you need to correct them by adding stanzas later in the `multipath.conf` file that apply specifically to ONTAP LUNs. If you don't do this, the ONTAP LUNs might not work as expected.

Check your `/etc/multipath.conf` file, especially in the defaults section, for settings that might be overriding the default settings for multipath parameters.

> ⚠ You shouldn't override the recommended parameter settings for ONTAP LUNs. These settings are required for optimal performance of your host configuration. Contact NetApp support, your OS vendor, or both for more information.

The following example shows how to correct an overridden default. In this example, the `multipath.conf` file defines values for `path_checker` and `no_path_retry` that aren't compatible with ONTAP LUNs, and you can't remove these parameters because ONTAP storage arrays are still attached to the host. Instead, you correct the values for `path_checker` and `no_path_retry` by adding a device stanza to the `multipath.conf` file that applies specifically to the ONTAP LUNs.

Show example

```
defaults {
    path_checker        readsector0
    no_path_retry       fail
}

devices {
    device {
        vendor          "NETAPP"
        product         "LUN"
        no_path_retry   queue
        path_checker    tur
    }
}
```

Step 6: Review the known issues

The RHEL 7.7 with ONTAP storage release has the following known issues:

NetApp Bug ID	Title	Description
1440718	If you unmap or map a LUN without performing a SCSI rescan, it might lead to data corruption on the host.	When you set the 'disable_changed_wwids' multipath configuration parameter to YES, it disables access to the path device in the event of a WWID change. Multipath will disable access to the path device until the WWID of the path is restored to the WWID of the multipath device. To learn more, see NetApp Knowledge Base: The filesystem corruption on iSCSI LUN on the Oracle Linux 7.
1258856	Remote ports transit to a blocked state on RHEL7U7 with Emulex LPe16002 16GB FC during storage failover operations	Remote ports might transit to a blocked state on a RHEL 7.7 host with a LPe16002 16GB FC adapter during storage failover operations. When the storage node returns to an optimal state, the LIFs also come up and the remote port state should read "online". Occasionally, the remote port state might continue to read as "blocked" or "not present". This state can lead to a "failed faulty" path to LUNs at the multipath layer.

NetApp Bug ID	Title	Description
1261474	Remote ports transit to blocked state on RHEL7U7 with Emulex LPe32002 32GB FC	Remote ports might transit to a blocked state on a RHEL 7.7 host with LPe32002 32GB FC adapter during storage failover operations. When the storage node returns to an optimal state, the LIFs also come up and the remote port state should read "online". Occasionally, the remote port state might continue to read as "blocked" or "not present". This state can lead to a "failed faulty" path to LUNs at the multipath layer.

What's next?

- Learn about using the Linux Host Utilities tool.

- Learn about ASM mirroring.

  Automatic Storage Management (ASM) mirroring might require changes to the Linux multipath settings to allow ASM to recognize a problem and switch over to an alternate failure group. Most ASM configurations on ONTAP use external redundancy, which means that data protection is provided by the external array and ASM doesn't mirror data. Some sites use ASM with normal redundancy to provide two-way mirroring, normally across different sites. See Oracle databases on ONTAP for further information.

Configure RHEL 7.6 for FCP and iSCSI with ONTAP storage

The Linux Host Utilities software provides management and diagnostic tools for Linux hosts that are connected to ONTAP storage. When you install the Linux Host Utilities on a Red Hat Enterprise Linux (RHEL) 7.6 host, you can use the Host Utilities to help you manage FCP and iSCSI protocol operations with ONTAP LUNs.

> ⓘ You don't need to manually configure Kernel-based Virtual Machine (KVM) settings because ONTAP LUNs are automatically mapped to the hypervisor.

Step 1: Optionally, enable SAN booting

You can configure your host to use SAN booting to simplify deployment and improve scalability.

Before you begin

Use the Interoperability Matrix Tool to verify that your Linux OS, host bus adapter (HBA), HBA firmware, HBA boot BIOS, and ONTAP version support SAN booting.

Steps

1. Create a SAN boot LUN and map it to the host.

2. Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is mapped.

   For information on how to enable the HBA BIOS, see your vendor-specific documentation.

3. Verify that the configuration was successful by rebooting the host and verifying that the OS is up and running.

Step 2: Install the Linux Host Utilities

NetApp strongly recommends installing the Linux Host Utilities to support ONTAP LUN management and assist technical support with gathering configuration data.

Install Linux Host Utilities 7.1.

> ⓘ   Installing the Linux Host Utilities doesn't change any host timeout settings on your Linux host.

Step 3: Confirm the multipath configuration for your host

You can use multipathing with RHEL 7.6 to manage ONTAP LUNs.

To ensure that multipathing is configured correctly for your host, verify that the `/etc/multipath.conf` file is defined and that you have the NetApp recommended settings configured for your ONTAP LUNs.

Steps

1. Verify that the `/etc/multipath.conf` file exists:

```
ls /etc/multipath.conf
```

If the file doesn't exist, create an empty, zero-byte file:

```
touch /etc/multipath.conf
```

2. The first time the `multipath.conf` file is created, you might need to enable and start the multipath services to load the recommended settings:

```
systemctl enable multipathd
```

```
systemctl start multipathd
```

3. Each time you boot the host, the empty `/etc/multipath.conf` zero-byte file automatically loads the NetApp recommended host multipath parameters as the default settings. You shouldn't need to make changes to the `/etc/multipath.conf` file for your host because the host operating system is compiled with the multipath parameters that recognize and manage ONTAP LUNs correctly.

The following table shows the native Linux OS compiled multipath parameter settings for ONTAP LUNs.

Show parameter settings

Parameter	Setting
detect_prio	yes
dev_loss_tmo	"infinity"
failback	immediate
fast_io_fail_tmo	5
features	"3 queue_if_no_path pg_init_retries 50"
flush_on_last_del	"yes"
hardware_handler	"0"
no_path_retry	queue
path_checker	"tur"
path_grouping_policy	"group_by_prio"
path_selector	"service-time 0"
polling_interval	5
prio	"ontap"
product	LUN.*
retain_attached_hw_handler	yes
rr_weight	"uniform"
user_friendly_names	no
vendor	NETAPP

4. Verify the parameter settings and path status for your ONTAP LUNs:

```
multipath -ll
```

The default multipath parameters support ASA, AFF, and FAS configurations. In these configurations, a single ONTAP LUN shouldn't require more than four paths. If there are more than four paths, it might cause issues with the paths during a storage failure.

The following example outputs show the correct parameter settings and path status for ONTAP LUNs in an ASA, AFF, or FAS configuration.

ASA configuration

An ASA configuration optimizes all paths to a given LUN, keeping them active. This improves performance by serving I/O operations through all paths at the same time.

```
# multipath -ll
3600a09803831347657244e527766394e dm-5 NETAPP,LUN C-Mode
size=80G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
`-+- policy='service-time 0' prio=50 status=active
  |- 3:0:7:9    sdco 69:192  active ready running
  |- 3:0:8:9    sddi 71:0    active ready running
  |- 14:0:8:9   sdjq 65:320  active ready running
  `- 14:0:7:9   sdiw 8:256   active ready running
```

AFF or FAS configuration

An AFF or FAS configuration should have two groups of paths with higher and lower priorities. Higher priority Active/Optimized paths are served by the controller where the aggregate is located. Lower priority paths are active but non-optimized because they are served by a different controller. Non-optimized paths are only used when optimized paths aren't available.

The following example displays the output for an ONTAP LUN with two Active/Optimized paths and two Active/Non-Optimized paths:

```
# multipath -ll
3600a09803831347657244e527766394e dm-5 NETAPP,LUN C-Mode
size=80G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
|-+- policy='service-time 0' prio=50 status=active
| |- 3:0:3:0    sdd  8:48    active ready running
| |- 3:0:4:0    sdx  65:112  active ready running
`-+- policy='service-time 0' prio=10 status=enabled
  |- 14:0:2:0   sdfk 130:96  active ready running
  `- 14:0:5:0   sdgz 132:240 active ready running
```

Step 4: Optionally, exclude a device from multipathing

If required, you can exclude a device from multipathing by adding the WWID for the unwanted device to the "blacklist" stanza for the `multipath.conf` file.

Steps

1. Determine the WWID:

```
/lib/udev/scsi_id -gud /dev/sda
```

"sda" is the local SCSI disk that you want to add to the blacklist.

An example WWID is `360030057024d0730239134810c0cb833`.

2. Add the WWID to the "blacklist" stanza:

```
blacklist {
        wwid    360030057024d0730239134810c0cb833
        devnode "^(ram|raw|loop|fd|md|dm-|sr|scd|st)[0-9]*"
        devnode "^hd[a-z]"
        devnode "^cciss.*"
}
```

Step 5: Customize multipath parameters for ONTAP LUNs

If your host is connected to LUNs from other vendors and any of the multipath parameter settings are overridden, you need to correct them by adding stanzas later in the `multipath.conf` file that apply specifically to ONTAP LUNs. If you don't do this, the ONTAP LUNs might not work as expected.

Check your `/etc/multipath.conf` file, especially in the defaults section, for settings that might be overriding the default settings for multipath parameters.

> ⚠️ You shouldn't override the recommended parameter settings for ONTAP LUNs. These settings are required for optimal performance of your host configuration. Contact NetApp support, your OS vendor, or both for more information.

The following example shows how to correct an overridden default. In this example, the `multipath.conf` file defines values for `path_checker` and `no_path_retry` that aren't compatible with ONTAP LUNs, and you can't remove these parameters because ONTAP storage arrays are still attached to the host. Instead, you correct the values for `path_checker` and `no_path_retry` by adding a device stanza to the `multipath.conf` file that applies specifically to the ONTAP LUNs.

Show example

```
defaults {
    path_checker        readsector0
    no_path_retry       fail
}

devices {
    device {
        vendor          "NETAPP"
        product         "LUN"
        no_path_retry   queue
        path_checker    tur
    }
}
```

Step 6: Review the known issues

The RHEL 7.6 with ONTAP storage release has the following known issues:

NetApp Bug ID	Title	Description
1440718	If you unmap or map a LUN without performing a SCSI rescan, it might lead to data corruption on the host.	When you set the 'disable_changed_wwids' multipath configuration parameter to YES, it disables access to the path device in the event of a WWID change. Multipath will disable access to the path device until the WWID of the path is restored to the WWID of the multipath device. To learn more, see NetApp Knowledge Base: The filesystem corruption on iSCSI LUN on the Oracle Linux 7.
1186754	Remote ports status on RHEL7U6 with QLogic QLE2742 host might be in blocked during host discovery	During host discovery, FC remote port status on RHEL7U6 host with a QLogic QLE2742 adapter might enter a blocked state. These blocked remote ports might result in the paths to LUNs becoming unavailable. During storage failover, the path redundancy might be reduced and result in I/O outage. You can check the remote port status by entering the following command:# cat /sys/class/fc_remote_ports/rport-*/port_state

NetApp Bug ID	Title	Description
1190698	Remote port status on RHEL7U6 with QLogic QLE2672 host might be in blocked during storage failover operations	FC remote ports might be blocked on Red Hat Enterprise Linux (RHEL) 7U6 with the QLogic QLE2672 host during storage failover operations. Because the logical interfaces go down when a storage node is down, the remote ports set the storage node status to blocked. When the storage node returns to its optimal state, the logical interfaces also come up and the remote ports should be online. However, the remote portsmight still be blocked. This blocked state registers as failed faulty to LUNS at the multipath layer. You can verify the remote ports state with the following command:# cat /sys/class/fc_remote_ports/rport-*/port_state

What's next?

- Learn about using the Linux Host Utilities tool.
- Learn about ASM mirroring.

  Automatic Storage Management (ASM) mirroring might require changes to the Linux multipath settings to allow ASM to recognize a problem and switch over to an alternate failure group. Most ASM configurations on ONTAP use external redundancy, which means that data protection is provided by the external array and ASM doesn't mirror data. Some sites use ASM with normal redundancy to provide two-way mirroring, normally across different sites. See Oracle databases on ONTAP for further information.

Configure RHEL 7.5 for FCP and iSCSI with ONTAP storage

The Linux Host Utilities software provides management and diagnostic tools for Linux hosts that are connected to ONTAP storage. When you install the Linux Host Utilities on a Red Hat Enterprise Linux (RHEL) 7.5 host, you can use the Host Utilities to help you manage FCP and iSCSI protocol operations with ONTAP LUNs.

> ⓘ You don't need to manually configure Kernel-based Virtual Machine (KVM) settings because ONTAP LUNs are automatically mapped to the hypervisor.

Step 1: Optionally, enable SAN booting

You can configure your host to use SAN booting to simplify deployment and improve scalability.

Before you begin

Use the Interoperability Matrix Tool to verify that your Linux OS, host bus adapter (HBA), HBA firmware, HBA boot BIOS, and ONTAP version support SAN booting.

Steps

1. Create a SAN boot LUN and map it to the host.

2. Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is mapped.

   For information on how to enable the HBA BIOS, see your vendor-specific documentation.

3. Verify that the configuration was successful by rebooting the host and verifying that the OS is up and running.

Step 2: Install the Linux Host Utilities

NetApp strongly recommends installing the Linux Host Utilities to support ONTAP LUN management and assist technical support with gathering configuration data.

Install Linux Host Utilities 7.1.

> ℹ️   Installing the Linux Host Utilities doesn't change any host timeout settings on your Linux host.

Step 3: Confirm the multipath configuration for your host

You can use multipathing with RHEL 7.5 to manage ONTAP LUNs.

To ensure that multipathing is configured correctly for your host, verify that the `/etc/multipath.conf` file is defined and that you have the NetApp recommended settings configured for your ONTAP LUNs.

Steps

1. Verify that the `/etc/multipath.conf` file exists:

   ```
   ls /etc/multipath.conf
   ```

   If the file doesn't exist, create an empty, zero-byte file:

   ```
   touch /etc/multipath.conf
   ```

2. The first time the `multipath.conf` file is created, you might need to enable and start the multipath services to load the recommended settings:

   ```
   systemctl enable multipathd
   ```

   ```
   systemctl start multipathd
   ```

3. Each time you boot the host, the empty `/etc/multipath.conf` zero-byte file automatically loads the NetApp recommended host multipath parameters as the default settings. You shouldn't need to make changes to the `/etc/multipath.conf` file for your host because the host operating system is compiled with the multipath parameters that recognize and manage ONTAP LUNs correctly.

The following table shows the native Linux OS compiled multipath parameter settings for ONTAP LUNs.

Show parameter settings

Parameter	Setting
detect_prio	yes
dev_loss_tmo	"infinity"
failback	immediate
fast_io_fail_tmo	5
features	"3 queue_if_no_path pg_init_retries 50"
flush_on_last_del	"yes"
hardware_handler	"0"
no_path_retry	queue
path_checker	"tur"
path_grouping_policy	"group_by_prio"
path_selector	"service-time 0"
polling_interval	5
prio	"ontap"
product	LUN.*
retain_attached_hw_handler	yes
rr_weight	"uniform"
user_friendly_names	no
vendor	NETAPP

4. Verify the parameter settings and path status for your ONTAP LUNs:

```
multipath -ll
```

The default multipath parameters support ASA, AFF, and FAS configurations. In these configurations, a single ONTAP LUN shouldn't require more than four paths. If there are more than four paths, it might cause issues with the paths during a storage failure.

The following example outputs show the correct parameter settings and path status for ONTAP LUNs in an ASA, AFF, or FAS configuration.

ASA configuration

An ASA configuration optimizes all paths to a given LUN, keeping them active. This improves performance by serving I/O operations through all paths at the same time.

```
# multipath -ll
3600a09803831347657244e527766394e dm-5 NETAPP,LUN C-Mode
size=80G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
`-+- policy='service-time 0' prio=50 status=active
  |- 3:0:7:9    sdco 69:192  active ready running
  |- 3:0:8:9    sddi 71:0    active ready running
  |- 14:0:8:9   sdjq 65:320  active ready running
  `- 14:0:7:9   sdiw 8:256   active ready running
```

AFF or FAS configuration

An AFF or FAS configuration should have two groups of paths with higher and lower priorities. Higher priority Active/Optimized paths are served by the controller where the aggregate is located. Lower priority paths are active but non-optimized because they are served by a different controller. Non-optimized paths are only used when optimized paths aren't available.

The following example displays the output for an ONTAP LUN with two Active/Optimized paths and two Active/Non-Optimized paths:

```
# multipath -ll
3600a09803831347657244e527766394e dm-5 NETAPP,LUN C-Mode
size=80G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
|-+- policy='service-time 0' prio=50 status=active
| |- 3:0:3:0    sdd  8:48    active ready running
| |- 3:0:4:0    sdx  65:112  active ready running
`-+- policy='service-time 0' prio=10 status=enabled
  |- 14:0:2:0   sdfk 130:96  active ready running
  `- 14:0:5:0   sdgz 132:240 active ready running
```

Step 4: Optionally, exclude a device from multipathing

If required, you can exclude a device from multipathing by adding the WWID for the unwanted device to the "blacklist" stanza for the `multipath.conf` file.

Steps

1. Determine the WWID:

```
/lib/udev/scsi_id -gud /dev/sda
```

"sda" is the local SCSI disk that you want to add to the blacklist.

An example WWID is `360030057024d0730239134810c0cb833`.

2. Add the WWID to the "blacklist" stanza:

```
blacklist {
        wwid    360030057024d0730239134810c0cb833
        devnode "^(ram|raw|loop|fd|md|dm-|sr|scd|st)[0-9]*"
        devnode "^hd[a-z]"
        devnode "^cciss.*"
}
```

Step 5: Customize multipath parameters for ONTAP LUNs

If your host is connected to LUNs from other vendors and any of the multipath parameter settings are overridden, you need to correct them by adding stanzas later in the `multipath.conf` file that apply specifically to ONTAP LUNs. If you don't do this, the ONTAP LUNs might not work as expected.

Check your `/etc/multipath.conf` file, especially in the defaults section, for settings that might be overriding the default settings for multipath parameters.

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The following example shows how to correct an overridden default. In this example, the `multipath.conf` file defines values for `path_checker` and `no_path_retry` that aren't compatible with ONTAP LUNs, and you can't remove these parameters because ONTAP storage arrays are still attached to the host. Instead, you correct the values for `path_checker` and `no_path_retry` by adding a device stanza to the `multipath.conf` file that applies specifically to the ONTAP LUNs.

Show example

```
defaults {
    path_checker        readsector0
    no_path_retry       fail
}

devices {
    device {
        vendor          "NETAPP"
        product         "LUN"
        no_path_retry   queue
        path_checker    tur
    }
}
```

Step 6: Review the known issues

The RHEL 7.5 with ONTAP storage release has the following known issues:

NetApp Bug ID	Title	Description
1440718	If you unmap or map a LUN without performing a SCSI rescan, it might lead to data corruption on the host.	When you set the 'disable_changed_wwids' multipath configuration parameter to YES, it disables access to the path device in the event of a WWID change. Multipath will disable access to the path device until the WWID of the path is restored to the WWID of the multipath device. To learn more, see NetApp Knowledge Base: The filesystem corruption on iSCSI LUN on the Oracle Linux 7.

NetApp Bug ID	Title	Description
1139053	Kernel disruption occurs on RHEL7.5 with QLogic QLE2672 16GB FC during storage failover operations	During storage failover operations on the RHEL7U5 kernel with QLogic QLE2672 16GB fibre channel host bus adapter, the kernel disruption occurs due to a panic in the kernel. The kernel panic causes RHEL 7.5 to reboot, which leads to an application disruption. The kernel panic generates the vmcore file under the /var/crash/directory if kdump is configured. The vmcore file is used to understand the cause of the failure. In this case, the panic was observed in the "get_next_timer_interrupt+440" module which is logged in the vmcore file with the following string: " [exception RIP: get_next_timer_interrupt+440]" After the kernel disruption, you can recover the operating system by rebooting the host operating system and restarting the application as required.
1138536	Kernel disruption occurs on RHEL7U5 with QLogic QLE2742 32GB FC during storage failover operations	During storage failover operations on the Red Hat Enterprise Linux (RHEL) RHEL7U5 kernel with QLogic QLE2742 HBA, kernel disruption occurs due to a panic in the kernel. The kernel panic leads to a reboot of the operating system, causing an application disruption. The kernel panic generates the vmcore file under the /var/crash/ directory if kdump is configured. When the kernel panics, you can use the vmcore file to investigate the reason for the failure. The following example shows a panic in the bget_next_timer_interrupt+440b module. The panic is logged in the vmcore file with the following string: " [exception RIP: get_next_timer_interrupt+440]" You can recover the operating system by rebooting the host OS and restarting the application as required.

NetApp Bug ID	Title	Description
[1148090](#)	Kernel disruption occurs on RHEL 7.5 with QLogic QLE2742 32GB FC HBA during storage failover operations	During storage failover operations on the Red Hat Enterprise Linux (RHEL) 7.5 kernel with a QLogic QLE2742 Fibre Channel (FC) host bus adapter (HBA), a kernel disruption occurs due to a panic in the kernel. The kernel panic causes RHEL 7.5 to reboot, which leads to an application disruption. If the kdump mechanism is enabled, the kernel panic generates a vmcore file located in the /var/crash/ directory. You can analyze the vmcore file to determine the cause of the panic. In this instance, when storage failover with the QLogic QLE2742 HBA event occurs, the "native_queued_spin_lock_slowpath+464" module is affected. You can locate the event in the vmcore file by finding the following string: " [exception RIP: native_queued_spin_lock_slowpath+464]" After the kernel disruption, you can reboot the Host OS and recover the operating system, and then you can restart the applications as required.

NetApp Bug ID	Title	Description
1146898	Kernel disruption occurs on RHEL 7.5 with Emulex HBAs during storage failover operations	During storage failover operations on a Red Hat Enterprise Linux (RHEL) 7.5 system with Emulex LPe32002-M2 32-GB FC host bus adapters (HBAs), a disruption in the kernel occurs. The kernel disruption causes a reboot of the operating system, which in turn causes an application disruption. If you configure kdump, the kernel disruption generates the vmcore file under the /var/crash/ directory. You can use the vmcore file to determine the cause of the failure. In the following example, you can see the disruption in the "lpfc_hba_clean_txcmplq+368" module. This disruption is logged in the vmcore file with the following string: " [exception RIP: lpfc_hba_clean_txcmplq+368]" After the kernel disruption, reboot the host OS to recover the operating system. Restart the application as required.

What's next?

- Learn about using the Linux Host Utilities tool.
- Learn about ASM mirroring.

  Automatic Storage Management (ASM) mirroring might require changes to the Linux multipath settings to allow ASM to recognize a problem and switch over to an alternate failure group. Most ASM configurations on ONTAP use external redundancy, which means that data protection is provided by the external array and ASM doesn't mirror data. Some sites use ASM with normal redundancy to provide two-way mirroring, normally across different sites. See Oracle databases on ONTAP for further information.

Configure RHEL 7.4 for FCP and iSCSI with ONTAP storage

The Linux Host Utilities software provides management and diagnostic tools for Linux hosts that are connected to ONTAP storage. When you install the Linux Host Utilities on a Red Hat Enterprise Linux (RHEL) 7.4 host, you can use the Host Utilities to help you manage FCP and iSCSI protocol operations with ONTAP LUNs.

ⓘ You don't need to manually configure Kernel-based Virtual Machine (KVM) settings because ONTAP LUNs are automatically mapped to the hypervisor.

Step 1: Optionally, enable SAN booting

You can configure your host to use SAN booting to simplify deployment and improve scalability.

Before you begin

Use the Interoperability Matrix Tool to verify that your Linux OS, host bus adapter (HBA), HBA firmware, HBA boot BIOS, and ONTAP version support SAN booting.

Steps

1. Create a SAN boot LUN and map it to the host.

2. Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is mapped.

   For information on how to enable the HBA BIOS, see your vendor-specific documentation.

3. Verify that the configuration was successful by rebooting the host and verifying that the OS is up and running.

Step 2: Install the Linux Host Utilities

NetApp strongly recommends installing the Linux Host Utilities to support ONTAP LUN management and assist technical support with gathering configuration data.

Install Linux Host Utilities 7.1.

> ⓘ | Installing the Linux Host Utilities doesn't change any host timeout settings on your Linux host.

Step 3: Confirm the multipath configuration for your host

You can use multipathing with RHEL 7.4 to manage ONTAP LUNs.

To ensure that multipathing is configured correctly for your host, verify that the `/etc/multipath.conf` file is defined and that you have the NetApp recommended settings configured for your ONTAP LUNs.

Steps

1. Verify that the `/etc/multipath.conf` file exists:

   ```
   ls /etc/multipath.conf
   ```

   If the file doesn't exist, create an empty, zero-byte file:

   ```
   touch /etc/multipath.conf
   ```

2. The first time the `multipath.conf` file is created, you might need to enable and start the multipath services to load the recommended settings:

   ```
   systemctl enable multipathd
   ```

   ```
   systemctl start multipathd
   ```

3. Each time you boot the host, the empty `/etc/multipath.conf` zero-byte file automatically loads the

NetApp recommended host multipath parameters as the default settings. You shouldn't need to make changes to the `/etc/multipath.conf` file for your host because the host operating system is compiled with the multipath parameters that recognize and manage ONTAP LUNs correctly.

The following table shows the native Linux OS compiled multipath parameter settings for ONTAP LUNs.

Show parameter settings

Parameter	Setting
detect_prio	yes
dev_loss_tmo	"infinity"
failback	immediate
fast_io_fail_tmo	5
features	"3 queue_if_no_path pg_init_retries 50"
flush_on_last_del	"yes"
hardware_handler	"0"
no_path_retry	queue
path_checker	"tur"
path_grouping_policy	"group_by_prio"
path_selector	"service-time 0"
polling_interval	5
prio	"ontap"
product	LUN.*
retain_attached_hw_handler	yes
rr_weight	"uniform"
user_friendly_names	no
vendor	NETAPP

4. Verify the parameter settings and path status for your ONTAP LUNs:

```
multipath -ll
```

The default multipath parameters support ASA, AFF, and FAS configurations. In these configurations, a single ONTAP LUN shouldn't require more than four paths. If there are more than four paths, it might cause issues with the paths during a storage failure.

The following example outputs show the correct parameter settings and path status for ONTAP LUNs in an ASA, AFF, or FAS configuration.

ASA configuration

An ASA configuration optimizes all paths to a given LUN, keeping them active. This improves performance by serving I/O operations through all paths at the same time.

```
# multipath -ll
3600a09803831347657244e527766394e dm-5 NETAPP,LUN C-Mode
size=80G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
`-+- policy='service-time 0' prio=50 status=active
  |- 3:0:7:9    sdco 69:192  active ready running
  |- 3:0:8:9    sddi 71:0    active ready running
  |- 14:0:8:9   sdjq 65:320  active ready running
  `- 14:0:7:9   sdiw 8:256   active ready running
```

AFF or FAS configuration

An AFF or FAS configuration should have two groups of paths with higher and lower priorities. Higher priority Active/Optimized paths are served by the controller where the aggregate is located. Lower priority paths are active but non-optimized because they are served by a different controller. Non-optimized paths are only used when optimized paths aren't available.

The following example displays the output for an ONTAP LUN with two Active/Optimized paths and two Active/Non-Optimized paths:

```
# multipath -ll
3600a09803831347657244e527766394e dm-5 NETAPP,LUN C-Mode
size=80G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
|-+- policy='service-time 0' prio=50 status=active
| |- 3:0:3:0    sdd  8:48    active ready running
| |- 3:0:4:0    sdx  65:112  active ready running
`-+- policy='service-time 0' prio=10 status=enabled
  |- 14:0:2:0   sdfk 130:96  active ready running
  `- 14:0:5:0   sdgz 132:240 active ready running
```

Step 4: Optionally, exclude a device from multipathing

If required, you can exclude a device from multipathing by adding the WWID for the unwanted device to the "blacklist" stanza for the `multipath.conf` file.

Steps

1. Determine the WWID:

```
/lib/udev/scsi_id -gud /dev/sda
```

"sda" is the local SCSI disk that you want to add to the blacklist.

An example WWID is `360030057024d0730239134810c0cb833`.

2. Add the WWID to the "blacklist" stanza:

```
blacklist {
        wwid    360030057024d0730239134810c0cb833
        devnode "^(ram|raw|loop|fd|md|dm-|sr|scd|st)[0-9]*"
        devnode "^hd[a-z]"
        devnode "^cciss.*"
}
```

Step 5: Customize multipath parameters for ONTAP LUNs

If your host is connected to LUNs from other vendors and any of the multipath parameter settings are overridden, you need to correct them by adding stanzas later in the `multipath.conf` file that apply specifically to ONTAP LUNs. If you don't do this, the ONTAP LUNs might not work as expected.

Check your `/etc/multipath.conf` file, especially in the defaults section, for settings that might be overriding the default settings for multipath parameters.

> ⚠ You shouldn't override the recommended parameter settings for ONTAP LUNs. These settings are required for optimal performance of your host configuration. Contact NetApp support, your OS vendor, or both for more information.

The following example shows how to correct an overridden default. In this example, the `multipath.conf` file defines values for `path_checker` and `no_path_retry` that aren't compatible with ONTAP LUNs, and you can't remove these parameters because ONTAP storage arrays are still attached to the host. Instead, you correct the values for `path_checker` and `no_path_retry` by adding a device stanza to the `multipath.conf` file that applies specifically to the ONTAP LUNs.

Show example

```
defaults {
    path_checker        readsector0
    no_path_retry       fail
}

devices {
    device {
        vendor          "NETAPP"
        product         "LUN"
        no_path_retry   queue
        path_checker    tur
    }
}
```

Step 6: Review the known issues

The RHEL 7.4 with ONTAP storage release has the following known issue:

NetApp Bug ID	Title	Description
1440718	If you unmap or map a LUN without performing a SCSI rescan, it might lead to data corruption on the host.	When you set the 'disable_changed_wwids' multipath configuration parameter to YES, it disables access to the path device in the event of a WWID change. Multipath will disable access to the path device until the WWID of the path is restored to the WWID of the multipath device. To learn more, see NetApp Knowledge Base: The filesystem corruption on iSCSI LUN on the Oracle Linux 7.

What's next?

- Learn about using the Linux Host Utilities tool.
- Learn about ASM mirroring.

  Automatic Storage Management (ASM) mirroring might require changes to the Linux multipath settings to allow ASM to recognize a problem and switch over to an alternate failure group. Most ASM configurations on ONTAP use external redundancy, which means that data protection is provided by the external array and ASM doesn't mirror data. Some sites use ASM with normal redundancy to provide two-way mirroring, normally across different sites. See Oracle databases on ONTAP for further information.

Configure RHEL 7.3 for FCP and iSCSI with ONTAP storage

The Linux Host Utilities software provides management and diagnostic tools for Linux hosts that are connected to ONTAP storage. When you install the Linux Host Utilities on a Red Hat Enterprise Linux (RHEL) 7.3 host, you can use the Host Utilities to help you manage FCP and iSCSI protocol operations with ONTAP LUNs.

> ⓘ You don't need to manually configure Kernel-based Virtual Machine (KVM) settings because ONTAP LUNs are automatically mapped to the hypervisor.

Step 1: Optionally, enable SAN booting

You can configure your host to use SAN booting to simplify deployment and improve scalability.

Before you begin

Use the Interoperability Matrix Tool to verify that your Linux OS, host bus adapter (HBA), HBA firmware, HBA boot BIOS, and ONTAP version support SAN booting.

Steps

1. Create a SAN boot LUN and map it to the host.

2. Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is mapped.

   For information on how to enable the HBA BIOS, see your vendor-specific documentation.

3. Verify that the configuration was successful by rebooting the host and verifying that the OS is up and running.

Step 2: Install the Linux Host Utilities

NetApp strongly recommends installing the Linux Host Utilities to support ONTAP LUN management and assist technical support with gathering configuration data.

Install Linux Host Utilities 7.1.

> ⓘ Installing the Linux Host Utilities doesn't change any host timeout settings on your Linux host.

Step 3: Confirm the multipath configuration for your host

You can use multipathing with RHEL 7.3 to manage ONTAP LUNs.

To ensure that multipathing is configured correctly for your host, verify that the `/etc/multipath.conf` file is defined and that you have the NetApp recommended settings configured for your ONTAP LUNs.

Steps

1. Verify that the `/etc/multipath.conf` file exists:

   ```
   ls /etc/multipath.conf
   ```

   If the file doesn't exist, create an empty, zero-byte file:

```
touch /etc/multipath.conf
```

2. The first time the `multipath.conf` file is created, you might need to enable and start the multipath services to load the recommended settings:

```
systemctl enable multipathd
```

```
systemctl start multipathd
```

3. Each time you boot the host, the empty `/etc/multipath.conf` zero-byte file automatically loads the NetApp recommended host multipath parameters as the default settings. You shouldn't need to make changes to the `/etc/multipath.conf` file for your host because the host operating system is compiled with the multipath parameters that recognize and manage ONTAP LUNs correctly.

The following table shows the native Linux OS compiled multipath parameter settings for ONTAP LUNs.

Show parameter settings

Parameter	Setting
detect_prio	yes
dev_loss_tmo	"infinity"
failback	immediate
fast_io_fail_tmo	5
features	"3 queue_if_no_path pg_init_retries 50"
flush_on_last_del	"yes"
hardware_handler	"0"
no_path_retry	queue
path_checker	"tur"
path_grouping_policy	"group_by_prio"
path_selector	"service-time 0"
polling_interval	5
prio	"ontap"
product	LUN.*
retain_attached_hw_handler	yes
rr_weight	"uniform"
user_friendly_names	no
vendor	NETAPP

4. Verify the parameter settings and path status for your ONTAP LUNs:

```
multipath -ll
```

The default multipath parameters support ASA, AFF, and FAS configurations. In these configurations, a single ONTAP LUN shouldn't require more than four paths. If there are more than four paths, it might cause issues with the paths during a storage failure.

The following example outputs show the correct parameter settings and path status for ONTAP LUNs in an ASA, AFF, or FAS configuration.

ASA configuration

An ASA configuration optimizes all paths to a given LUN, keeping them active. This improves performance by serving I/O operations through all paths at the same time.

```
# multipath -ll
3600a09803831347657244e527766394e dm-5 NETAPP,LUN C-Mode
size=80G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
`-+- policy='service-time 0' prio=50 status=active
  |- 3:0:7:9    sdco 69:192  active ready running
  |- 3:0:8:9    sddi 71:0    active ready running
  |- 14:0:8:9   sdjq 65:320  active ready running
  `- 14:0:7:9   sdiw 8:256   active ready running
```

AFF or FAS configuration

An AFF or FAS configuration should have two groups of paths with higher and lower priorities. Higher priority Active/Optimized paths are served by the controller where the aggregate is located. Lower priority paths are active but non-optimized because they are served by a different controller. Non-optimized paths are only used when optimized paths aren't available.

The following example displays the output for an ONTAP LUN with two Active/Optimized paths and two Active/Non-Optimized paths:

```
# multipath -ll
3600a09803831347657244e527766394e dm-5 NETAPP,LUN C-Mode
size=80G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
|-+- policy='service-time 0' prio=50 status=active
| |- 3:0:3:0    sdd  8:48    active ready running
| |- 3:0:4:0    sdx  65:112  active ready running
`-+- policy='service-time 0' prio=10 status=enabled
  |- 14:0:2:0   sdfk 130:96  active ready running
  `- 14:0:5:0   sdgz 132:240 active ready running
```

Step 4: Optionally, exclude a device from multipathing

If required, you can exclude a device from multipathing by adding the WWID for the unwanted device to the "blacklist" stanza for the `multipath.conf` file.

Steps

1. Determine the WWID:

   ```
   /lib/udev/scsi_id -gud /dev/sda
   ```

   "sda" is the local SCSI disk that you want to add to the blacklist.

   An example WWID is `360030057024d0730239134810c0cb833`.

2. Add the WWID to the "blacklist" stanza:

   ```
   blacklist {
           wwid    360030057024d0730239134810c0cb833
           devnode "^(ram|raw|loop|fd|md|dm-|sr|scd|st)[0-9]*"
           devnode "^hd[a-z]"
           devnode "^cciss.*"
   }
   ```

Step 5: Customize multipath parameters for ONTAP LUNs

If your host is connected to LUNs from other vendors and any of the multipath parameter settings are overridden, you need to correct them by adding stanzas later in the `multipath.conf` file that apply specifically to ONTAP LUNs. If you don't do this, the ONTAP LUNs might not work as expected.

Check your `/etc/multipath.conf` file, especially in the defaults section, for settings that might be overriding the default settings for multipath parameters.

> ⚠️ You shouldn't override the recommended parameter settings for ONTAP LUNs. These settings are required for optimal performance of your host configuration. Contact NetApp support, your OS vendor, or both for more information.

The following example shows how to correct an overridden default. In this example, the `multipath.conf` file defines values for `path_checker` and `no_path_retry` that aren't compatible with ONTAP LUNs, and you can't remove these parameters because ONTAP storage arrays are still attached to the host. Instead, you correct the values for `path_checker` and `no_path_retry` by adding a device stanza to the `multipath.conf` file that applies specifically to the ONTAP LUNs.

Show example

```
defaults {
    path_checker        readsector0
    no_path_retry       fail
}

devices {
    device {
        vendor          "NETAPP"
        product         "LUN"
        no_path_retry   queue
        path_checker    tur
    }
}
```

Step 6: Review the known issues

There are no known issues.

What's next?

- Learn about using the Linux Host Utilities tool.
- Learn about ASM mirroring.

  Automatic Storage Management (ASM) mirroring might require changes to the Linux multipath settings to allow ASM to recognize a problem and switch over to an alternate failure group. Most ASM configurations on ONTAP use external redundancy, which means that data protection is provided by the external array and ASM doesn't mirror data. Some sites use ASM with normal redundancy to provide two-way mirroring, normally across different sites. See Oracle databases on ONTAP for further information.

Configure RHEL 7.2 for FCP and iSCSI with ONTAP storage

The Linux Host Utilities software provides management and diagnostic tools for Linux hosts that are connected to ONTAP storage. When you install the Linux Host Utilities on a Red Hat Enterprise Linux (RHEL) 7.2 host, you can use the Host Utilities to help you manage FCP and iSCSI protocol operations with ONTAP LUNs.

> ⓘ You don't need to manually configure Kernel-based Virtual Machine (KVM) settings because ONTAP LUNs are automatically mapped to the hypervisor.

Step 1: Optionally, enable SAN booting

You can configure your host to use SAN booting to simplify deployment and improve scalability.

Before you begin

Use the Interoperability Matrix Tool to verify that your Linux OS, host bus adapter (HBA), HBA firmware, HBA

boot BIOS, and ONTAP version support SAN booting.

Steps

1. [Create a SAN boot LUN and map it to the host](#).

2. Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is mapped.

   For information on how to enable the HBA BIOS, see your vendor-specific documentation.

3. Verify that the configuration was successful by rebooting the host and verifying that the OS is up and running.

Step 2: Install the Linux Host Utilities

NetApp strongly recommends installing the Linux Host Utilities to support ONTAP LUN management and assist technical support with gathering configuration data.

[Install Linux Host Utilities 7.1](#).

> (i)   Installing the Linux Host Utilities doesn't change any host timeout settings on your Linux host.

Step 3: Confirm the multipath configuration for your host

You can use multipathing with RHEL 7.2 to manage ONTAP LUNs.

To ensure that multipathing is configured correctly for your host, verify that the `/etc/multipath.conf` file is defined and that you have the NetApp recommended settings configured for your ONTAP LUNs.

Steps

1. Verify that the `/etc/multipath.conf` file exists:

   ```
   ls /etc/multipath.conf
   ```

   If the file doesn't exist, create an empty, zero-byte file:

   ```
   touch /etc/multipath.conf
   ```

2. The first time the `multipath.conf` file is created, you might need to enable and start the multipath services to load the recommended settings:

   ```
   systemctl enable multipathd
   ```

   ```
   systemctl start multipathd
   ```

3. Each time you boot the host, the empty `/etc/multipath.conf` zero-byte file automatically loads the NetApp recommended host multipath parameters as the default settings. You shouldn't need to make changes to the `/etc/multipath.conf` file for your host because the host operating system is compiled

with the multipath parameters that recognize and manage ONTAP LUNs correctly.

The following table shows the native Linux OS compiled multipath parameter settings for ONTAP LUNs.

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flush_on_last_del	"yes"
hardware_handler	"0"
no_path_retry	queue
path_checker	"tur"
path_grouping_policy	"group_by_prio"
path_selector	"service-time 0"
polling_interval	5
prio	"ontap"
product	LUN.*
retain_attached_hw_handler	yes
rr_weight	"uniform"
user_friendly_names	no
vendor	NETAPP

4. Verify the parameter settings and path status for your ONTAP LUNs:

```
multipath -ll
```

The default multipath parameters support ASA, AFF, and FAS configurations. In these configurations, a single ONTAP LUN shouldn't require more than four paths. If there are more than four paths, it might cause issues with the paths during a storage failure.

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hwhandler='1 alua' wp=rw
`-+- policy='service-time 0' prio=50 status=active
  |- 3:0:7:9    sdco 69:192  active ready running
  |- 3:0:8:9    sddi 71:0    active ready running
  |- 14:0:8:9   sdjq 65:320  active ready running
  `- 14:0:7:9   sdiw 8:256   active ready running
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AFF or FAS configuration

An AFF or FAS configuration should have two groups of paths with higher and lower priorities. Higher priority Active/Optimized paths are served by the controller where the aggregate is located. Lower priority paths are active but non-optimized because they are served by a different controller. Non-optimized paths are only used when optimized paths aren't available.

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hwhandler='1 alua' wp=rw
|-+- policy='service-time 0' prio=50 status=active
| |- 3:0:3:0    sdd  8:48    active ready running
| |- 3:0:4:0    sdx  65:112  active ready running
`-+- policy='service-time 0' prio=10 status=enabled
  |- 14:0:2:0   sdfk 130:96  active ready running
  `- 14:0:5:0   sdgz 132:240 active ready running
```

Step 4: Optionally, exclude a device from multipathing

If required, you can exclude a device from multipathing by adding the WWID for the unwanted device to the "blacklist" stanza for the `multipath.conf` file.

Steps

1. Determine the WWID:

```
/lib/udev/scsi_id -gud /dev/sda
```

"sda" is the local SCSI disk that you want to add to the blacklist.

An example WWID is `360030057024d0730239134810c0cb833`.

2. Add the WWID to the "blacklist" stanza:

```
blacklist {
        wwid    360030057024d0730239134810c0cb833
        devnode "^(ram|raw|loop|fd|md|dm-|sr|scd|st)[0-9]*"
        devnode "^hd[a-z]"
        devnode "^cciss.*"
}
```

Step 5: Customize multipath parameters for ONTAP LUNs

If your host is connected to LUNs from other vendors and any of the multipath parameter settings are overridden, you need to correct them by adding stanzas later in the `multipath.conf` file that apply specifically to ONTAP LUNs. If you don't do this, the ONTAP LUNs might not work as expected.

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The following example shows how to correct an overridden default. In this example, the `multipath.conf` file defines values for `path_checker` and `no_path_retry` that aren't compatible with ONTAP LUNs, and you can't remove these parameters because ONTAP storage arrays are still attached to the host. Instead, you correct the values for `path_checker` and `no_path_retry` by adding a device stanza to the `multipath.conf` file that applies specifically to the ONTAP LUNs.

Show example

```
defaults {
    path_checker        readsector0
    no_path_retry       fail
}

devices {
    device {
        vendor          "NETAPP"
        product         "LUN"
        no_path_retry   queue
        path_checker    tur
    }
}
```

Step 6: Review the known issues

There are no known issues.

What's next?

- Learn about using the Linux Host Utilities tool.

- Learn about ASM mirroring.

  Automatic Storage Management (ASM) mirroring might require changes to the Linux multipath settings to allow ASM to recognize a problem and switch over to an alternate failure group. Most ASM configurations on ONTAP use external redundancy, which means that data protection is provided by the external array and ASM doesn't mirror data. Some sites use ASM with normal redundancy to provide two-way mirroring, normally across different sites. See Oracle databases on ONTAP for further information.

Configure RHEL 7.1 for FCP and iSCSI with ONTAP storage

The Linux Host Utilities software provides management and diagnostic tools for Linux hosts that are connected to ONTAP storage. When you install the Linux Host Utilities on a Red Hat Enterprise Linux (RHEL) 7.1 host, you can use the Host Utilities to help you manage FCP and iSCSI protocol operations with ONTAP LUNs.

> ⓘ You don't need to manually configure Kernel-based Virtual Machine (KVM) settings because ONTAP LUNs are automatically mapped to the hypervisor.

Step 1: Optionally, enable SAN booting

You can configure your host to use SAN booting to simplify deployment and improve scalability.

Before you begin

Use the Interoperability Matrix Tool to verify that your Linux OS, host bus adapter (HBA), HBA firmware, HBA

boot BIOS, and ONTAP version support SAN booting.

Steps

1. [Create a SAN boot LUN and map it to the host](#).

2. Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is mapped.

   For information on how to enable the HBA BIOS, see your vendor-specific documentation.

3. Verify that the configuration was successful by rebooting the host and verifying that the OS is up and running.

Step 2: Install the Linux Host Utilities

NetApp strongly recommends installing the Linux Host Utilities to support ONTAP LUN management and assist technical support with gathering configuration data.

[Install Linux Host Utilities 7.1](#).

ⓘ | Installing the Linux Host Utilities doesn't change any host timeout settings on your Linux host.

Step 3: Confirm the multipath configuration for your host

You can use multipathing with RHEL 7.1 to manage ONTAP LUNs.

To ensure that multipathing is configured correctly for your host, verify that the `/etc/multipath.conf` file is defined and that you have the NetApp recommended settings configured for your ONTAP LUNs.

Steps

1. Verify that the `/etc/multipath.conf` file exists:

   ```
   ls /etc/multipath.conf
   ```

   If the file doesn't exist, create an empty, zero-byte file:

   ```
   touch /etc/multipath.conf
   ```

2. The first time the `multipath.conf` file is created, you might need to enable and start the multipath services to load the recommended settings:

   ```
   systemctl enable multipathd
   ```

   ```
   systemctl start multipathd
   ```

3. Each time you boot the host, the empty `/etc/multipath.conf` zero-byte file automatically loads the NetApp recommended host multipath parameters as the default settings. You shouldn't need to make changes to the `/etc/multipath.conf` file for your host because the host operating system is compiled

with the multipath parameters that recognize and manage ONTAP LUNs correctly.

The following table shows the native Linux OS compiled multipath parameter settings for ONTAP LUNs.

Show parameter settings

Parameter	Setting
detect_prio	yes
dev_loss_tmo	"infinity"
failback	immediate
fast_io_fail_tmo	5
features	"3 queue_if_no_path pg_init_retries 50"
flush_on_last_del	"yes"
hardware_handler	"0"
no_path_retry	queue
path_checker	"tur"
path_grouping_policy	"group_by_prio"
path_selector	"service-time 0"
polling_interval	5
prio	"ontap"
product	LUN.*
retain_attached_hw_handler	yes
rr_weight	"uniform"
user_friendly_names	no
vendor	NETAPP

4. Verify the parameter settings and path status for your ONTAP LUNs:

```
multipath -ll
```

The default multipath parameters support ASA, AFF, and FAS configurations. In these configurations, a single ONTAP LUN shouldn't require more than four paths. If there are more than four paths, it might cause issues with the paths during a storage failure.

The following example outputs show the correct parameter settings and path status for ONTAP LUNs in an ASA, AFF, or FAS configuration.

ASA configuration

An ASA configuration optimizes all paths to a given LUN, keeping them active. This improves performance by serving I/O operations through all paths at the same time.

```
# multipath -ll
3600a09803831347657244e527766394e dm-5 NETAPP,LUN C-Mode
size=80G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
`-+- policy='service-time 0' prio=50 status=active
  |- 3:0:7:9    sdco 69:192  active ready running
  |- 3:0:8:9    sddi 71:0    active ready running
  |- 14:0:8:9   sdjq 65:320  active ready running
  `- 14:0:7:9   sdiw 8:256   active ready running
```

AFF or FAS configuration

An AFF or FAS configuration should have two groups of paths with higher and lower priorities. Higher priority Active/Optimized paths are served by the controller where the aggregate is located. Lower priority paths are active but non-optimized because they are served by a different controller. Non-optimized paths are only used when optimized paths aren't available.

The following example displays the output for an ONTAP LUN with two Active/Optimized paths and two Active/Non-Optimized paths:

```
# multipath -ll
3600a09803831347657244e527766394e dm-5 NETAPP,LUN C-Mode
size=80G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
|-+- policy='service-time 0' prio=50 status=active
| |- 3:0:3:0    sdd  8:48    active ready running
| |- 3:0:4:0    sdx  65:112  active ready running
`-+- policy='service-time 0' prio=10 status=enabled
  |- 14:0:2:0   sdfk 130:96  active ready running
  `- 14:0:5:0   sdgz 132:240 active ready running
```

Step 4: Optionally, exclude a device from multipathing

If required, you can exclude a device from multipathing by adding the WWID for the unwanted device to the "blacklist" stanza for the `multipath.conf` file.

Steps

1. Determine the WWID:

```
/lib/udev/scsi_id -gud /dev/sda
```

"sda" is the local SCSI disk that you want to add to the blacklist.

An example WWID is `360030057024d0730239134810c0cb833`.

2. Add the WWID to the "blacklist" stanza:

```
blacklist {
        wwid    360030057024d0730239134810c0cb833
        devnode "^(ram|raw|loop|fd|md|dm-|sr|scd|st)[0-9]*"
        devnode "^hd[a-z]"
        devnode "^cciss.*"
}
```

Step 5: Customize multipath parameters for ONTAP LUNs

If your host is connected to LUNs from other vendors and any of the multipath parameter settings are overridden, you need to correct them by adding stanzas later in the `multipath.conf` file that apply specifically to ONTAP LUNs. If you don't do this, the ONTAP LUNs might not work as expected.

Check your `/etc/multipath.conf` file, especially in the defaults section, for settings that might be overriding the default settings for multipath parameters.

> ⚠️ You shouldn't override the recommended parameter settings for ONTAP LUNs. These settings
> are required for optimal performance of your host configuration. Contact NetApp support, your
> OS vendor, or both for more information.

The following example shows how to correct an overridden default. In this example, the `multipath.conf` file defines values for `path_checker` and `no_path_retry` that aren't compatible with ONTAP LUNs, and you can't remove these parameters because ONTAP storage arrays are still attached to the host. Instead, you correct the values for `path_checker` and `no_path_retry` by adding a device stanza to the `multipath.conf` file that applies specifically to the ONTAP LUNs.

Show example

```
defaults {
    path_checker        readsector0
    no_path_retry       fail
}

devices {
    device {
        vendor          "NETAPP"
        product         "LUN"
        no_path_retry   queue
        path_checker    tur
    }
}
```

Step 6: Review the known issues

The RHEL 7.1 with ONTAP storage release has the following known issues:

NetApp Bug ID	Title	Description
799323	Emulex FCoE (OCe10102-FX-D) host hang or path failures observed during I/O with storage failover operations	You might observe a host hang or path failures on Emulex 10G FCoE host (OCe10102-FX-D) during I/O with storage failover operations. In such scenarios, you might see the following message: "driver's buffer pool is empty, IO busied and SCSI Layer I/O Abort Request Status"
836875	IP addresses are not always assigned during the boot of a RHEL 7.0 OS installed on an iSCSI multipath'd LUN	When you install the root(/) on a iSCSI multipath'd LUN, the IP address for the Ethernet interfaces are specified in the kernel command line so that the IP addresses are assigned before the iSCSI service starts. However, dracut cannot assign IP addresses to all the Ethernet ports during the boot, before the iSCSI service starts. This causes the iSCSI login to fail on interfaces without IP addresses. You will see the iSCSI service attempt to login numerous times, which will cause a delay in the OS boot time.

What's next?

- Learn about using the Linux Host Utilities tool.

- Learn about ASM mirroring.

  Automatic Storage Management (ASM) mirroring might require changes to the Linux multipath settings to allow ASM to recognize a problem and switch over to an alternate failure group. Most ASM configurations on ONTAP use external redundancy, which means that data protection is provided by the external array and ASM doesn't mirror data. Some sites use ASM with normal redundancy to provide two-way mirroring, normally across different sites. See Oracle databases on ONTAP for further information.

Configure RHEL 7.0 for FCP and iSCSI with ONTAP storage

The Linux Host Utilities software provides management and diagnostic tools for Linux hosts that are connected to ONTAP storage. When you install the Linux Host Utilities on a Red Hat Enterprise Linux (RHEL) 7.0 host, you can use the Host Utilities to help you manage FCP and iSCSI protocol operations with ONTAP LUNs.

> ⓘ You don't need to manually configure Kernel-based Virtual Machine (KVM) settings because ONTAP LUNs are automatically mapped to the hypervisor.

Step 1: Optionally, enable SAN booting

You can configure your host to use SAN booting to simplify deployment and improve scalability.

Before you begin

Use the Interoperability Matrix Tool to verify that your Linux OS, host bus adapter (HBA), HBA firmware, HBA boot BIOS, and ONTAP version support SAN booting.

Steps

1. Create a SAN boot LUN and map it to the host.

2. Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is mapped.

   For information on how to enable the HBA BIOS, see your vendor-specific documentation.

3. Verify that the configuration was successful by rebooting the host and verifying that the OS is up and running.

Step 2: Install the Linux Host Utilities

NetApp strongly recommends installing the Linux Host Utilities to support ONTAP LUN management and assist technical support with gathering configuration data.

Install Linux Host Utilities 7.1.

> ⓘ Installing the Linux Host Utilities doesn't change any host timeout settings on your Linux host.

Step 3: Confirm the multipath configuration for your host

You can use multipathing with RHEL 7.0 to manage ONTAP LUNs.

To ensure that multipathing is configured correctly for your host, verify that the `/etc/multipath.conf` file is defined and that you have the NetApp recommended settings configured for your ONTAP LUNs.

Steps

1. Verify that the `/etc/multipath.conf` file exists:

   ```
   ls /etc/multipath.conf
   ```

   If the file doesn't exist, create an empty, zero-byte file:

   ```
   touch /etc/multipath.conf
   ```

2. The first time the `multipath.conf` file is created, you might need to enable and start the multipath services to load the recommended settings:

   ```
   systemctl enable multipathd
   ```

   ```
   systemctl start multipathd
   ```

3. Each time you boot the host, the empty `/etc/multipath.conf` zero-byte file automatically loads the NetApp recommended host multipath parameters as the default settings. You shouldn't need to make changes to the `/etc/multipath.conf` file for your host because the host operating system is compiled with the multipath parameters that recognize and manage ONTAP LUNs correctly.

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detect_prio	yes
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flush_on_last_del	"yes"
hardware_handler	"0"
no_path_retry	queue
path_checker	"tur"
path_grouping_policy	"group_by_prio"
path_selector	"service-time 0"
polling_interval	5
prio	"ontap"
product	LUN.*
retain_attached_hw_handler	yes
rr_weight	"uniform"
user_friendly_names	no
vendor	NETAPP

4. Verify the parameter settings and path status for your ONTAP LUNs:

```
multipath -ll
```

The default multipath parameters support ASA, AFF, and FAS configurations. In these configurations, a single ONTAP LUN shouldn't require more than four paths. If there are more than four paths, it might cause issues with the paths during a storage failure.

The following example outputs show the correct parameter settings and path status for ONTAP LUNs in an ASA, AFF, or FAS configuration.

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An ASA configuration optimizes all paths to a given LUN, keeping them active. This improves performance by serving I/O operations through all paths at the same time.

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size=80G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
|-+- policy='service-time 0' prio=50 status=active
| |- 3:0:3:0    sdd  8:48    active ready running
| |- 3:0:4:0    sdx  65:112  active ready running
`-+- policy='service-time 0' prio=10 status=enabled
  |- 14:0:2:0   sdfk 130:96  active ready running
  `- 14:0:5:0   sdgz 132:240 active ready running
```

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If required, you can exclude a device from multipathing by adding the WWID for the unwanted device to the "blacklist" stanza for the `multipath.conf` file.

Steps

1. Determine the WWID:

```
/lib/udev/scsi_id -gud /dev/sda
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"sda" is the local SCSI disk that you want to add to the blacklist.

An example WWID is `360030057024d0730239134810c0cb833`.

2. Add the WWID to the "blacklist" stanza:

```
blacklist {
        wwid    360030057024d0730239134810c0cb833
        devnode "^(ram|raw|loop|fd|md|dm-|sr|scd|st)[0-9]*"
        devnode "^hd[a-z]"
        devnode "^cciss.*"
}
```

Step 5: Customize multipath parameters for ONTAP LUNs

If your host is connected to LUNs from other vendors and any of the multipath parameter settings are overridden, you need to correct them by adding stanzas later in the `multipath.conf` file that apply specifically to ONTAP LUNs. If you don't do this, the ONTAP LUNs might not work as expected.

Check your `/etc/multipath.conf` file, especially in the defaults section, for settings that might be overriding the default settings for multipath parameters.

> ⚠️ You shouldn't override the recommended parameter settings for ONTAP LUNs. These settings are required for optimal performance of your host configuration. Contact NetApp support, your OS vendor, or both for more information.

The following example shows how to correct an overridden default. In this example, the `multipath.conf` file defines values for `path_checker` and `no_path_retry` that aren't compatible with ONTAP LUNs, and you can't remove these parameters because ONTAP storage arrays are still attached to the host. Instead, you correct the values for `path_checker` and `no_path_retry` by adding a device stanza to the `multipath.conf` file that applies specifically to the ONTAP LUNs.

Show example

```
defaults {
    path_checker        readsector0
    no_path_retry       fail
}

devices {
    device {
        vendor          "NETAPP"
        product         "LUN"
        no_path_retry   queue
        path_checker    tur
    }
}
```

Step 6: Review the known issues

The RHEL 7.0 with ONTAP storage release has the following known issues:

NetApp Bug ID	Title	Description
844417	Emulex 16G FC (LPe16002B-M6) host crashes during I/O with storage failover operations	You might observe a 16G FC Emulex (LPe16002B-M6) host crash during I/O with storage failover operations.
811587	Emulex 16G FC (LPe16002B-M6) host crashes during I/O with storage failover operations	You might observe a 16G FC Emulex (LPe16002B-M6) host crash during I/O with storage failover operations.
803071	Emulex 16G FC (LPe16002B-M6) host crashes during I/O with storage failover operations	You might observe a 16G FC Emulex (LPe16002B-M6) host crash during I/O with storage failover operations.
820163	QLogic host hang or path failures observed during I/O with storage failover operations	You might observe a host hang or path failures on QLogic host during I/O with storage failover operations. In such scenarios, you might see the following message: "Mailbox cmd timeout occurred, cmd=0x54, mb[0]=0x54 and Firmware dump saved to temp buffer" messages which leads to host hung/path failure.

NetApp Bug ID	Title	Description
799323	Emulex FCoE (OCe10102-FX-D) host hang or path failures observed during I/O with storage failover operations	You might observe a host hang or path failures on Emulex 10G FCoE host (OCe10102-FX-D) during I/O with storage failover operations. In such scenarios, you might see the following message: "driver's buffer pool is empty, IO busied and SCSI Layer I/O Abort Request Status" messages which leads to host hung/path failures.
849212	Emulex 16G FC (LPe16002B-M6) host hang or path failures are observed during I/O with storage failover operations	You might observe a host hang or path failures on Emulex 16G FC (LPe16002B-M6) host during I/O with storage failover operations. In such scenarios, you might see the following message: "RSCN timeout Data and iotag x1301 is out of range: max iotag" messages which leads to host hung/path failures.
836800	Anaconda displays an iSCSI login failure message although logins are successful during RHEL 7.0 OS installation	When you install the root(/) on a iSCSI multipath'd LUN, the IP address for the Ethernet interfaces are specified in the kernel command line so that the IP addresses are assigned before the iSCSI service starts. However, dracut cannot assign IP addresses to all the Ethernet ports during the boot, before the iSCSI service starts. This causes the iSCSI login to fail on interfaces without IP addresses. You will see the iSCSI service attempt to login numerous times, which will cause a delay in the OS boot time.
836875	IP addresses are not always assigned during the boot of a RHEL 7.0 OS installed on an iSCSI multipath'd LUN	When you are installing RHEL 7.0, the anaconda installation screen displays that iSCSI login to multiple target IPs have failed though the iSCSI logins are successful. Anaconda displays following error message: "Node Login Failed" You will observe this error only when you select multiple target IPs for iSCSI login. You can continue the OS installation by clicking the "ok" button. This bug does not hamper either the iSCSI or the RHEL 7.0 OS installation.

NetApp Bug ID	Title	Description
[836657](#)	Anaconda does not add bootdev argument in kernel cmd line to set IP address for RHEL 7.0 OS installed on iSCSI multipath'd LUN	Anaconda does not add a bootdev argument in the kernel command line where you set the IPv4 address during the RHEL 7.0 OS installation on an iSCSI multipath'd LUN. This prevents assigning of IP addresses to any of the Ethernet interfaces that were configured to establish iSCSI sessions with the storage subsystem during the RHEL 7.0 boot. Since iSCSI sessions are not established, the root LUN is not discovered when the OS boots and hence the OS boot fails.

What's next?

- Learn about using the Linux Host Utilities tool.

- Learn about ASM mirroring.

  Automatic Storage Management (ASM) mirroring might require changes to the Linux multipath settings to allow ASM to recognize a problem and switch over to an alternate failure group. Most ASM configurations on ONTAP use external redundancy, which means that data protection is provided by the external array and ASM doesn't mirror data. Some sites use ASM with normal redundancy to provide two-way mirroring, normally across different sites. See Oracle databases on ONTAP for further information.

RHEL 6

Use Red Hat Enterprise Linux 6.10 with ONTAP

You can use the ONTAP SAN host configuration settings to configure Red Hat Enterprise Linux 6.10 with ONTAP as the target.

Install the Linux Host Utilities

The NetApp Linux Host Utilities software package is available on the NetApp Support Site in a 32-bit and 64-bit .rpm file. If you don't know which file is right for your configuration, use the Interoperability Matrix Tool to verify which one you need.

NetApp strongly recommends installing the Linux Host Utilities, but it's not mandatory. The utilities don't change any settings on your Linux host. The utilities improve management and assist NetApp customer support in gathering information about your configuration.

If you have Linux Host Utilities currently installed, you should either upgrade it to the latest version, or remove it and follow these steps to install the latest version.

Steps

1. Download the 32-bit or 64-bit Linux Host Utilities software package from the NetApp Support Site to your host.

2. Install the software package:

```
rpm -ivh netapp_linux_unified_host_utilities-7-1.x86_64
```

> ℹ️ You can use the configuration settings provided in this procedure to configure cloud clients connected to [Cloud Volumes ONTAP](#) and [Amazon FSx for ONTAP](#).

SAN Toolkit

The toolkit is installed automatically when you install the NetApp Host Utilities package. This kit provides the `sanlun` utility, which helps you manage LUNs and HBAs. The `sanlun` command returns information about the LUNs mapped to your host, multipathing, and information necessary to create initiator groups.

Example

In the following example, the `sanlun lun show` command returns LUN information.

```
# sanlun lun show all
```

Example output:

```
controller(7mode/E-Series)/                   device      host                  lun
vserver(cDOT/FlashRay)    lun-pathname    filename    adapter   protocol   size
Product
--------------------------------------------------------------------------------
----------
data_vserver              /vol/vol1/lun1    /dev/sdb    host16    FCP
120.0g   cDOT
data_vserver              /vol/vol1/lun1    /dev/sdc    host15    FCP
120.0g   cDOT
data_vserver              /vol/vol2/lun2    /dev/sdd    host16    FCP
120.0g   cDOT
data_vserver              /vol/vol2/lun2    /dev/sde    host15    FCP
120.0g   cDOT
```

SAN Booting

Before you begin

If you decide to use SAN booting, it must be supported by your configuration. You can use the [Interoperability Matrix Tool](#) to verify that your OS, HBA, HBA firmware and the HBA boot BIOS, and ONTAP version are supported.

Steps

1. Map the SAN boot LUN to the host.

2. Verify that multiple paths are available.

   > ℹ️ Multiple paths become available after the host OS is up and running on the paths.

3. Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is mapped.

For information on how to enable the HBA BIOS, see your vendor-specific documentation.

4. Reboot the host to verify that the boot was successful.

Multipathing

For Red Hat Enterprise Linux (RHEL) 6.10 the /etc/multipath.conf file must exist, but you do not need to make specific changes to the file. RHEL 6.10 is compiled with all settings required to recognize and correctly manage ONTAP LUNs.
To Enable ALUA Handler, perform the following steps:

Steps

1. Create a backup of the initrd-image.

2. Append the following parameter value to the kernel for ALUA and non-ALUA to work:
   `rdloaddriver=scsi_dh_alua`

   Example

   ```
   kernel /vmlinuz-2.6.32-358.6.1.el6.x86_64 ro root=/dev/mapper/
   vg_ibmx355021082-lv_root rd_NO_LUKS rd_LVM_LV=vg_ibmx355021082/ lv_root
   LANG=en_US.UTF-8 rd_LVM_LV=vg_ibmx355021082/lv_swap rd_NO_MD
   SYSFONT=latarcyrheb-sun16 crashkernel=auto KEYBOARDTYPE=pc KEYTABLE=us
   rd_NO_DM rhgb quiet rdloaddriver=scsi_dh_alua
   ```

3. Use the `mkinitrd` command to recreate the initrd-image.
   RHEL 6x and later versions use either:
   The command: `mkinitrd -f /boot/ initrd-"uname -r".img uname -r`
   Or
   The command: `dracut -f`

4. Reboot the host.

5. Verify the output of the `cat /proc/cmdline` command to ensure that the setting is complete.

You can use the `multipath -ll` command to verify the settings for your ONTAP LUNs.

The following sections provide example multipath outputs for a LUN mapped to ASA and non-ASA personas.

All SAN Array configurations

All SAN Array (ASA) configurations optimize all paths to a given LUN, keeping them active. This improves performance by serving I/O operations through all paths at the same time.

Example
The following example displays the correct output for an ONTAP LUN.

```
# multipath -ll
3600a0980383034466b2b4a3775474859 dm-3 NETAPP,LUN C-Mode
size=20G features='4 queue_if_no_path pg_init_retries 50
retain_attached_hw_handle' hwhandler='1 alua' wp=rw
|-+- policy='round-robin 0' prio=50 status=active
|- 1:0:8:1  sdb 8:16 active ready running
|- 2:0:8:1  sdd 8:48 active ready running
|- 1:0:9:1  sdc 8:32 active ready running
|- 2:0:9:1  sde 8:64 active ready running
```

> ⓘ A single LUN shouldn't require more than four paths. Having more than four paths might cause
> path issues during storage failures.

Non-ASA configurations

For non-ASA configurations, there should be two groups of paths with different priorities. The paths with higher
priorities are Active/Optimized. This means they are serviced by the controller where the aggregate is located.
The paths with lower priorities are active but non-optimized because they are served from a different controller.
The non-optimized paths are only used when optimized paths are not available.

Example

The following example displays the correct output for an ONTAP LUN with two Active/Optimized paths and two
Active/Non-Optimized paths.

```
# multipath -ll
3600a0980383034466b2b4a3775474859 dm-3 NETAPP,LUN C-Mode
size=20G features='4 queue_if_no_path pg_init_retries 50
retain_attached_hw_handle' hwhandler='1 alua' wp=rw
|-+- policy='round-robin 0' prio=50 status=active
| |- 1:0:8:1  sdb 8:16 active ready running
| `- 2:0:8:1  sdd 8:48 active ready running
`-+- policy='round-robin 0' prio=10 status=enabled
  |- 1:0:9:1  sdc 8:32 active ready running
  `- 2:0:9:1  sde 8:64 active ready running
```

> ⓘ A single LUN shouldn't require more than four paths. Having more than four paths might cause
> path issues during storage failures.

Recommended Settings

The RHEL 6.10 OS is compiled to recognize ONTAP LUNs and automatically set all configuration parameters
correctly for both ASA and non-ASA configuration.

The `multipath.conf` file must exist for the multipath daemon to start. If this file doesn't exist, you can create
an empty, zero-byte file by using the `touch /etc/multipath.conf` command.

The first time you create the `multipath.conf` file, you might need to enable and start the multipath services by using the following commands:

```
chkconfig multipathd on
/etc/init.d/multipathd start
```

You don't need to add anything directly to the `multipath.conf` file unless you have devices that you don't want multipath to manage or you have existing settings that override defaults. To exclude unwanted devices, add the following syntax to the `multipath.conf` file, replacing <DevId> with the worldwide identifier (WWID) string of the device you want to exclude:

```
blacklist {
        wwid <DevId>
        devnode "^(ram|raw|loop|fd|md|dm-|sr|scd|st)[0-9]*"
        devnode "^hd[a-z]"
        devnode "^cciss.*"
}
```

The following example determines the WWID of a device and adds it to the `multipath.conf` file.

Steps

1. Determine the WWID:

   ```
   /lib/udev/scsi_id -gud /dev/sda
   ```

   ```
   3600a098038314c4a433f5774717a3046
   ```

   `sda` is the local SCSI disk that you want to add to the blacklist.

2. Add the `WWID` to the blacklist stanza in `/etc/multipath.conf`:

   ```
   blacklist {
           wwid    3600a098038314c4a433f5774717a3046
           devnode "^(ram|raw|loop|fd|md|dm-|sr|scd|st)[0-9]*"
           devnode "^hd[a-z]"
           devnode "^cciss.*"
   }
   ```

Always check your `/etc/multipath.conf` file, especially in the defaults section, for legacy settings that might be overriding default settings.

The following table demonstrates the critical `multipathd` parameters for ONTAP LUNs and the required

values. If a host is connected to LUNs from other vendors and any of these parameters are overridden, they must be corrected by later stanzas in the `multipath.conf` file that apply specifically to ONTAP LUNs. Without this correction, the ONTAP LUNs might not work as expected. You should only override these defaults in consultation with NetApp, the OS vendor, or both, and only when the impact is fully understood.

Parameter	Setting
detect_prio	yes
dev_loss_tmo	"infinity"
failback	immediate
fast_io_fail_tmo	5
features	"3 queue_if_no_path pg_init_retries 50"
flush_on_last_del	"yes"
hardware_handler	"0"
no_path_retry	queue
path_checker	"tur"
path_grouping_policy	"group_by_prio"
path_selector	"round-robin 0"
polling_interval	5
prio	"ontap"
product	LUN.*
retain_attached_hw_handler	yes
rr_weight	"uniform"
user_friendly_names	no
vendor	NETAPP

Example

The following example shows how to correct an overridden default. In this case, the `multipath.conf` file defines values for `path_checker` and `no_path_retry` that are not compatible with ONTAP LUNs. If they cannot be removed because of other SAN arrays still attached to the host, these parameters can be corrected specifically for ONTAP LUNs with a device stanza.

```
defaults {
    path_checker        readsector0
    no_path_retry        fail
}

devices {
    device {
        vendor          "NETAPP  "
        product          "LUN.*"
        no_path_retry      queue
        path_checker      tur
    }
}
```

Configure KVM settings

You don't need to configure settings for a Kernel-based Virtual Machine because the LUN is mapped to the hypervisor.

ASM mirroring

Automatic Storage Management (ASM) mirroring might require changes to the Linux multipath settings to allow ASM to recognize a problem and switch over to an alternate failure group. Most ASM configurations on ONTAP use external redundancy, which means that data protection is provided by the external array and ASM doesn't mirror data. Some sites use ASM with normal redundancy to provide two-way mirroring, normally across different sites. See Oracle databases on ONTAP for further information.

Known issues

There are no known issues for the RHEL 6.10 with ONTAP release.

Use Red Hat Enterprise Linux 6.9 with ONTAP

You can use the ONTAP SAN host configuration settings to configure Red Hat Enterprise Linux 6.9 with ONTAP as the target.

Install the Linux Host Utilities

The NetApp Linux Host Utilities software package is available on the NetApp Support Site in a 32-bit and 64-bit .rpm file. If you don't know which file is right for your configuration, use the Interoperability Matrix Tool to verify which one you need.

NetApp strongly recommends installing the Linux Host Utilities, but it's not mandatory. The utilities don't change any settings on your Linux host. The utilities improve management and assist NetApp customer support in gathering information about your configuration.

If you have Linux Host Utilities currently installed, you should either upgrade it to the latest version, or remove it and follow these steps to install the latest version.

Steps

1. Download the 32-bit or 64-bit Linux Host Utilities software package from the NetApp Support Site to your host.

2. Install the software package:

   ```
   rpm -ivh netapp_linux_unified_host_utilities-7-1.x86_64
   ```

> ⓘ You can use the configuration settings provided in this procedure to configure cloud clients connected to Cloud Volumes ONTAP and Amazon FSx for ONTAP.

SAN Toolkit

The toolkit is installed automatically when you install the NetApp Host Utilities package. This kit provides the `sanlun` utility, which helps you manage LUNs and HBAs. The `sanlun` command returns information about the LUNs mapped to your host, multipathing, and information necessary to create initiator groups.

Example

In the following example, the `sanlun lun show` command returns LUN information.

```
# sanlun lun show all
```

Example output:

```
controller(7mode/E-Series)/                 device    host                lun
vserver(cDOT/FlashRay)    lun-pathname   filename   adapter  protocol  size
Product
-------------------------------------------------------------------------
----------
data_vserver             /vol/vol1/lun1   /dev/sdb   host16   FCP
120.0g  cDOT
data_vserver             /vol/vol1/lun1   /dev/sdc   host15   FCP
120.0g  cDOT
data_vserver             /vol/vol2/lun2   /dev/sdd   host16   FCP
120.0g  cDOT
data_vserver             /vol/vol2/lun2   /dev/sde   host15   FCP
120.0g  cDOT
```

SAN Booting

Before you begin

If you decide to use SAN booting, it must be supported by your configuration. You can use the Interoperability Matrix Tool to verify that your OS, HBA, HBA firmware and the HBA boot BIOS, and ONTAP version are supported.

Steps

1. Map the SAN boot LUN to the host.

2. Verify that multiple paths are available.

| ⓘ | Multiple paths become available after the host OS is up and running on the paths. |

3. Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is mapped.

   For information on how to enable the HBA BIOS, see your vendor-specific documentation.

4. Reboot the host to verify that the boot was successful.

Multipathing

For Red Hat Enterprise Linux (RHEL) 6.9 the /etc/multipath.conf file must exist, but you do not need to make specific changes to the file. RHEL 6.9 is compiled with all settings required to recognize and correctly manage ONTAP LUNs.
To Enable ALUA Handler, perform the following steps:

Steps

1. Create a backup of the initrd-image.

2. Append the following parameter value to the kernel for ALUA and non-ALUA to work:
   `rdloaddriver=scsi_dh_alua`

   Example

   ```
   kernel /vmlinuz-2.6.32-358.6.1.el6.x86_64 ro root=/dev/mapper/
   vg_ibmx355021082-lv_root rd_NO_LUKS rd_LVM_LV=vg_ibmx355021082/ lv_root
   LANG=en_US.UTF-8 rd_LVM_LV=vg_ibmx355021082/lv_swap rd_NO_MD
   SYSFONT=latarcyrheb-sun16 crashkernel=auto KEYBOARDTYPE=pc KEYTABLE=us
   rd_NO_DM rhgb quiet rdloaddriver=scsi_dh_alua
   ```

3. Use the `mkinitrd` command to recreate the initrd-image.
   RHEL 6x and later versions use either:
   The command: `mkinitrd -f /boot/ initrd-"uname -r".img uname -r`
   Or
   The command: `dracut -f`

4. Reboot the host.

5. Verify the output of the `cat /proc/cmdline` command to ensure that the setting is complete.

You can use the `multipath -ll` command to verify the settings for your ONTAP LUNs.

The following sections provide example multipath outputs for a LUN mapped to ASA and non-ASA personas.

All SAN Array configurations

All SAN Array (ASA) configurations optimize all paths to a given LUN, keeping them active. This improves performance by serving I/O operations through all paths at the same time.

Example
The following example displays the correct output for an ONTAP LUN.

```
# multipath -ll
3600a0980383034466b2b4a3775474859 dm-3 NETAPP,LUN C-Mode
size=20G features='4 queue_if_no_path pg_init_retries 50
retain_attached_hw_handle' hwhandler='1 alua' wp=rw
|-+- policy='round-robin 0' prio=50 status=active
|- 1:0:8:1  sdb 8:16 active ready running
|- 2:0:8:1  sdd 8:48 active ready running
|- 1:0:9:1  sdc 8:32 active ready running
|- 2:0:9:1  sde 8:64 active ready running
```

> ⓘ A single LUN shouldn't require more than four paths. Having more than four paths might cause path issues during storage failures.

Non-ASA configurations

For non-ASA configurations, there should be two groups of paths with different priorities. The paths with higher priorities are Active/Optimized. This means they are serviced by the controller where the aggregate is located. The paths with lower priorities are active but non-optimized because they are served from a different controller. The non-optimized paths are only used when optimized paths are not available.

Example

The following example displays the correct output for an ONTAP LUN with two Active/Optimized paths and two Active/Non-Optimized paths.

```
# multipath -ll
3600a0980383034466b2b4a3775474859 dm-3 NETAPP,LUN C-Mode
size=20G features='4 queue_if_no_path pg_init_retries 50
retain_attached_hw_handle' hwhandler='1 alua' wp=rw
|-+- policy='round-robin 0' prio=50 status=active
| |- 1:0:8:1  sdb 8:16 active ready running
| `- 2:0:8:1  sdd 8:48 active ready running
`-+- policy='round-robin 0' prio=10 status=enabled
  |- 1:0:9:1  sdc 8:32 active ready running
  `- 2:0:9:1  sde 8:64 active ready running
```

> ⓘ A single LUN shouldn't require more than four paths. Having more than four paths might cause path issues during storage failures.

Recommended Settings

The RHEL 6.9 OS is compiled to recognize ONTAP LUNs and automatically set all configuration parameters correctly for both ASA and non-ASA configuration.

The `multipath.conf` file must exist for the multipath daemon to start. If this file doesn't exist, you can create an empty, zero-byte file by using the `touch /etc/multipath.conf` command.

The first time you create the `multipath.conf` file, you might need to enable and start the multipath services by using the following commands:

```
chkconfig multipathd on
/etc/init.d/multipathd start
```

You don't need to add anything directly to the `multipath.conf` file unless you have devices that you don't want multipath to manage or you have existing settings that override defaults. To exclude unwanted devices, add the following syntax to the `multipath.conf` file, replacing <DevId> with the worldwide identifier (WWID) string of the device you want to exclude:

```
blacklist {
        wwid <DevId>
        devnode "^(ram|raw|loop|fd|md|dm-|sr|scd|st)[0-9]*"
        devnode "^hd[a-z]"
        devnode "^cciss.*"
}
```

The following example determines the WWID of a device and adds it to the `multipath.conf` file.

Steps

1. Determine the WWID:

    ```
    /lib/udev/scsi_id -gud /dev/sda
    ```

    ```
    3600a098038314c4a433f5774717a3046
    ```

    `sda` is the local SCSI disk that you want to add to the blacklist.

2. Add the `WWID` to the blacklist stanza in `/etc/multipath.conf`:

    ```
    blacklist {
            wwid   3600a098038314c4a433f5774717a3046
            devnode "^(ram|raw|loop|fd|md|dm-|sr|scd|st)[0-9]*"
            devnode "^hd[a-z]"
            devnode "^cciss.*"
    }
    ```

Always check your `/etc/multipath.conf` file, especially in the defaults section, for legacy settings that might be overriding default settings.

The following table demonstrates the critical `multipathd` parameters for ONTAP LUNs and the required

values. If a host is connected to LUNs from other vendors and any of these parameters are overridden, they must be corrected by later stanzas in the `multipath.conf` file that apply specifically to ONTAP LUNs. Without this correction, the ONTAP LUNs might not work as expected. You should only override these defaults in consultation with NetApp, the OS vendor, or both, and only when the impact is fully understood.

Parameter	Setting
detect_prio	yes
dev_loss_tmo	"infinity"
failback	immediate
fast_io_fail_tmo	5
features	"3 queue_if_no_path pg_init_retries 50"
flush_on_last_del	"yes"
hardware_handler	"0"
no_path_retry	queue
path_checker	"tur"
path_grouping_policy	"group_by_prio"
path_selector	"round-robin 0"
polling_interval	5
prio	"ontap"
product	LUN.*
retain_attached_hw_handler	yes
rr_weight	"uniform"
user_friendly_names	no
vendor	NETAPP

Example

The following example shows how to correct an overridden default. In this case, the `multipath.conf` file defines values for `path_checker` and `no_path_retry` that are not compatible with ONTAP LUNs. If they cannot be removed because of other SAN arrays still attached to the host, these parameters can be corrected specifically for ONTAP LUNs with a device stanza.

```
defaults {
    path_checker        readsector0
    no_path_retry        fail
}

devices {
    device {
        vendor          "NETAPP  "
        product          "LUN.*"
        no_path_retry      queue
        path_checker      tur
    }
}
```

Configure KVM settings

You don't need to configure settings for a Kernel-based Virtual Machine because the LUN is mapped to the hypervisor.

ASM mirroring

Automatic Storage Management (ASM) mirroring might require changes to the Linux multipath settings to allow ASM to recognize a problem and switch over to an alternate failure group. Most ASM configurations on ONTAP use external redundancy, which means that data protection is provided by the external array and ASM doesn't mirror data. Some sites use ASM with normal redundancy to provide two-way mirroring, normally across different sites. See Oracle databases on ONTAP for further information.

Known issues

The RHEL 6.9 with ONTAP release has the following known issues:

NetApp Bug ID	Title	Description
1067272	Remote port status on EMULEX LPe32002 host might be in 'Blocked' state during storage failover operations	During storage failover operations, certain remote port status on RHEL 6.9 host with LPe32002 adapter might get into 'Blocked' state. Because the logical interfaces go down when a storage node is down, the remote port sets the storage node status to "Blocked" state. However, when the storage node comes back to optimal state, the logical interfaces also comes up and the remote port state is expected to be 'Online'. But, on certain occasion the remote port continues to be in 'Blocked' state. This state manifests as 'failed faulty' to LUNS at multipath layer.

NetApp Bug ID	Title	Description
1076584	Firmware dumps occur on Red Hat Enterprise Linux 6.9 QLogic QE8362 HBA during storage failover operations	Firmware dumps can occur during storage failover operations on Red Hat Enterprise Linux (RHEL) 6.9 hosts with QLogic QLE8362 host bus adapters (HBA), firmware dumps are observed occasionally. The firmware dumps might manifest as an I/O outage on the host that can last as long as 1200 seconds. After the adapter completes dumping the firmware cores, the I/O operation resumes normally. No further recovery procedure is required on the host. To indicate the firmware dump, the following message is displayed in /var/log/ message file: kernel: qla2xxx [0000:0c:00.3]-d001:3: Firmware dump saved to temp buffer (3/ffffc90018b01000), dump status flags (0x3f)

Use Red Hat Enterprise Linux 6.8 with ONTAP

You can use the ONTAP SAN host configuration settings to configure Red Hat Enterprise Linux 6.8 with ONTAP as the target.

Install the Linux Host Utilities

The NetApp Linux Host Utilities software package is available on the NetApp Support Site in a 32-bit and 64-bit .rpm file. If you don't know which file is right for your configuration, use the Interoperability Matrix Tool to verify which one you need.

NetApp strongly recommends installing the Linux Host Utilities, but it's not mandatory. The utilities don't change any settings on your Linux host. The utilities improve management and assist NetApp customer support in gathering information about your configuration.

If you have Linux Host Utilities currently installed, you should either upgrade it to the latest version, or remove it and follow these steps to install the latest version.

Steps

1. Download the 32-bit or 64-bit Linux Host Utilities software package from the NetApp Support Site to your host.

2. Install the software package:

   ```
   rpm -ivh netapp_linux_unified_host_utilities-7-1.x86_64
   ```

> ⓘ You can use the configuration settings provided in this procedure to configure cloud clients connected to Cloud Volumes ONTAP and Amazon FSx for ONTAP.

SAN Toolkit

The toolkit is installed automatically when you install the NetApp Host Utilities package. This kit provides the `sanlun` utility, which helps you manage LUNs and HBAs. The `sanlun` command returns information about the LUNs mapped to your host, multipathing, and information necessary to create initiator groups.

Example

In the following example, the `sanlun lun show` command returns LUN information.

```
# sanlun lun show all
```

Example output:

```
controller(7mode/E-Series)/                 device      host                    lun
vserver(cDOT/FlashRay)    lun-pathname    filename    adapter   protocol   size
Product
--------------------------------------------------------------------------
----------
data_vserver              /vol/vol1/lun1   /dev/sdb    host16     FCP
120.0g  cDOT
data_vserver              /vol/vol1/lun1   /dev/sdc    host15     FCP
120.0g  cDOT
data_vserver              /vol/vol2/lun2   /dev/sdd    host16     FCP
120.0g  cDOT
data_vserver              /vol/vol2/lun2   /dev/sde    host15     FCP
120.0g  cDOT
```

SAN Booting

Before you begin

If you decide to use SAN booting, it must be supported by your configuration. You can use the Interoperability Matrix Tool to verify that your OS, HBA, HBA firmware and the HBA boot BIOS, and ONTAP version are supported.

Steps

1. Map the SAN boot LUN to the host.

2. Verify that multiple paths are available.

   > ⓘ Multiple paths become available after the host OS is up and running on the paths.

3. Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is mapped.

   For information on how to enable the HBA BIOS, see your vendor-specific documentation.

4. Reboot the host to verify that the boot was successful.

Multipathing

For Red Hat Enterprise Linux (RHEL) 6.8 the /etc/multipath.conf file must exist, but you do not need to make specific changes to the file. RHEL 6.8 is compiled with all settings required to recognize and correctly manage ONTAP LUNs.
To Enable ALUA Handler, perform the following steps:

Steps

1. Create a backup of the initrd-image.

2. Append the following parameter value to the kernel for ALUA and non-ALUA to work:
   `rdloaddriver=scsi_dh_alua`

   Example

   ```
   kernel /vmlinuz-2.6.32-358.6.1.el6.x86_64 ro root=/dev/mapper/
   vg_ibmx355021082-lv_root rd_NO_LUKS rd_LVM_LV=vg_ibmx355021082/ lv_root
   LANG=en_US.UTF-8 rd_LVM_LV=vg_ibmx355021082/lv_swap rd_NO_MD
   SYSFONT=latarcyrheb-sun16 crashkernel=auto KEYBOARDTYPE=pc KEYTABLE=us
   rd_NO_DM rhgb quiet rdloaddriver=scsi_dh_alua
   ```

3. Use the `mkinitrd` command to recreate the initrd-image.
   RHEL 6x and later versions use either:
   The command: `mkinitrd -f /boot/ initrd-"uname -r".img uname -r`
   Or
   The command: `dracut -f`

4. Reboot the host.

5. Verify the output of the `cat /proc/cmdline` command to ensure that the setting is complete.

You can use the `multipath -ll` command to verify the settings for your ONTAP LUNs.

The following sections provide example multipath outputs for a LUN mapped to ASA and non-ASA personas.

All SAN Array configurations

All SAN Array (ASA) configurations optimize all paths to a given LUN, keeping them active. This improves performance by serving I/O operations through all paths at the same time.

Example

The following example displays the correct output for an ONTAP LUN.

```
# multipath -ll
3600a0980383034466b2b4a3775474859 dm-3 NETAPP,LUN C-Mode
size=20G features='4 queue_if_no_path pg_init_retries 50
retain_attached_hw_handle' hwhandler='1 alua' wp=rw
|-+- policy='round-robin 0' prio=50 status=active
|- 1:0:8:1  sdb 8:16 active ready running
|- 2:0:8:1  sdd 8:48 active ready running
|- 1:0:9:1  sdc 8:32 active ready running
|- 2:0:9:1  sde 8:64 active ready running
```

ⓘ A single LUN shouldn't require more than four paths. Having more than four paths might cause path issues during storage failures.

Non-ASA configurations

For non-ASA configurations, there should be two groups of paths with different priorities. The paths with higher priorities are Active/Optimized. This means they are serviced by the controller where the aggregate is located. The paths with lower priorities are active but non-optimized because they are served from a different controller. The non-optimized paths are only used when optimized paths are not available.

Example

The following example displays the correct output for an ONTAP LUN with two Active/Optimized paths and two Active/Non-Optimized paths.

```
# multipath -ll
3600a0980383034466b2b4a3775474859 dm-3 NETAPP,LUN C-Mode
size=20G features='4 queue_if_no_path pg_init_retries 50
retain_attached_hw_handle' hwhandler='1 alua' wp=rw
|-+- policy='round-robin 0' prio=50 status=active
| |- 1:0:8:1  sdb 8:16 active ready running
| `- 2:0:8:1  sdd 8:48 active ready running
`-+- policy='round-robin 0' prio=10 status=enabled
  |- 1:0:9:1  sdc 8:32 active ready running
  `- 2:0:9:1  sde 8:64 active ready running
```

ⓘ A single LUN shouldn't require more than four paths. Having more than four paths might cause path issues during storage failures.

Recommended Settings

The RHEL 6.8 OS is compiled to recognize ONTAP LUNs and automatically set all configuration parameters correctly for both ASA and non-ASA configuration.

The `multipath.conf` file must exist for the multipath daemon to start. If this file doesn't exist, you can create an empty, zero-byte file by using the `touch /etc/multipath.conf` command.

The first time you create the `multipath.conf` file, you might need to enable and start the multipath services by using the following commands:

```
chkconfig multipathd on
/etc/init.d/multipathd start
```

You don't need to add anything directly to the `multipath.conf` file unless you have devices that you don't want multipath to manage or you have existing settings that override defaults. To exclude unwanted devices, add the following syntax to the `multipath.conf` file, replacing <DevId> with the worldwide identifier (WWID) string of the device you want to exclude:

```
blacklist {
        wwid <DevId>
        devnode "^(ram|raw|loop|fd|md|dm-|sr|scd|st)[0-9]*"
        devnode "^hd[a-z]"
        devnode "^cciss.*"
}
```

The following example determines the WWID of a device and adds it to the `multipath.conf` file.

Steps

1. Determine the WWID:

```
/lib/udev/scsi_id -gud /dev/sda
```

```
3600a098038314c4a433f5774717a3046
```

`sda` is the local SCSI disk that you want to add to the blacklist.

2. Add the `WWID` to the blacklist stanza in `/etc/multipath.conf`:

```
blacklist {
        wwid    3600a098038314c4a433f5774717a3046
        devnode "^(ram|raw|loop|fd|md|dm-|sr|scd|st)[0-9]*"
        devnode "^hd[a-z]"
        devnode "^cciss.*"
}
```

Always check your `/etc/multipath.conf` file, especially in the defaults section, for legacy settings that might be overriding default settings.

The following table demonstrates the critical `multipathd` parameters for ONTAP LUNs and the required

values. If a host is connected to LUNs from other vendors and any of these parameters are overridden, they must be corrected by later stanzas in the `multipath.conf` file that apply specifically to ONTAP LUNs. Without this correction, the ONTAP LUNs might not work as expected. You should only override these defaults in consultation with NetApp, the OS vendor, or both, and only when the impact is fully understood.

Parameter	Setting
detect_prio	yes
dev_loss_tmo	"infinity"
failback	immediate
fast_io_fail_tmo	5
features	"3 queue_if_no_path pg_init_retries 50"
flush_on_last_del	"yes"
hardware_handler	"0"
no_path_retry	queue
path_checker	"tur"
path_grouping_policy	"group_by_prio"
path_selector	"round-robin 0"
polling_interval	5
prio	"ontap"
product	LUN.*
retain_attached_hw_handler	yes
rr_weight	"uniform"
user_friendly_names	no
vendor	NETAPP

Example

The following example shows how to correct an overridden default. In this case, the `multipath.conf` file defines values for `path_checker` and `no_path_retry` that are not compatible with ONTAP LUNs. If they cannot be removed because of other SAN arrays still attached to the host, these parameters can be corrected specifically for ONTAP LUNs with a device stanza.

```
defaults {
    path_checker        readsector0
    no_path_retry        fail
}

devices {
    device {
        vendor          "NETAPP  "
        product          "LUN.*"
        no_path_retry     queue
        path_checker      tur
    }
}
```

Configure KVM settings

You don't need to configure settings for a Kernel-based Virtual Machine because the LUN is mapped to the hypervisor.

ASM mirroring

Automatic Storage Management (ASM) mirroring might require changes to the Linux multipath settings to allow ASM to recognize a problem and switch over to an alternate failure group. Most ASM configurations on ONTAP use external redundancy, which means that data protection is provided by the external array and ASM doesn't mirror data. Some sites use ASM with normal redundancy to provide two-way mirroring, normally across different sites. See Oracle databases on ONTAP for further information.

Known issues

There are no known issues for the RHEL 6.8 with ONTAP release.

Use Red Hat Enterprise Linux 6.7 with ONTAP

You can use the ONTAP SAN host configuration settings to configure Red Hat Enterprise Linux 6.7 with ONTAP as the target.

Install the Linux Host Utilities

The NetApp Linux Host Utilities software package is available on the NetApp Support Site in a 32-bit and 64-bit .rpm file. If you don't know which file is right for your configuration, use the Interoperability Matrix Tool to verify which one you need.

NetApp strongly recommends installing the Linux Host Utilities, but it's not mandatory. The utilities don't change any settings on your Linux host. The utilities improve management and assist NetApp customer support in gathering information about your configuration.

If you have Linux Host Utilities currently installed, you should either upgrade it to the latest version, or remove it and follow these steps to install the latest version.

Steps

1. Download the 32-bit or 64-bit Linux Host Utilities software package from the NetApp Support Site to your host.

2. Install the software package:

```
rpm -ivh netapp_linux_unified_host_utilities-7-1.x86_64
```

> ⓘ You can use the configuration settings provided in this procedure to configure cloud clients connected to Cloud Volumes ONTAP and Amazon FSx for ONTAP.

SAN Toolkit

The toolkit is installed automatically when you install the NetApp Host Utilities package. This kit provides the `sanlun` utility, which helps you manage LUNs and HBAs. The `sanlun` command returns information about the LUNs mapped to your host, multipathing, and information necessary to create initiator groups.

Example

In the following example, the `sanlun lun show` command returns LUN information.

```
# sanlun lun show all
```

Example output:

```
controller(7mode/E-Series)/                 device     host                    lun
vserver(cDOT/FlashRay)    lun-pathname    filename   adapter  protocol  size
Product
--------------------------------------------------------------------------
----------
data_vserver             /vol/vol1/lun1   /dev/sdb   host16   FCP
120.0g  cDOT
data_vserver             /vol/vol1/lun1   /dev/sdc   host15   FCP
120.0g  cDOT
data_vserver             /vol/vol2/lun2   /dev/sdd   host16   FCP
120.0g  cDOT
data_vserver             /vol/vol2/lun2   /dev/sde   host15   FCP
120.0g  cDOT
```

SAN Booting

Before you begin

If you decide to use SAN booting, it must be supported by your configuration. You can use the Interoperability Matrix Tool to verify that your OS, HBA, HBA firmware and the HBA boot BIOS, and ONTAP version are supported.

Steps

1. Map the SAN boot LUN to the host.

2. Verify that multiple paths are available.

| | Multiple paths become available after the host OS is up and running on the paths. |

3. Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is mapped.

   For information on how to enable the HBA BIOS, see your vendor-specific documentation.

4. Reboot the host to verify that the boot was successful.

Multipathing

For Red Hat Enterprise Linux (RHEL) 6.7 the /etc/multipath.conf file must exist, but you do not need to make specific changes to the file. RHEL 6.7 is compiled with all settings required to recognize and correctly manage ONTAP LUNs.
To Enable ALUA Handler, perform the following steps:

Steps

1. Create a backup of the initrd-image.

2. Append the following parameter value to the kernel for ALUA and non-ALUA to work:
   `rdloaddriver=scsi_dh_alua`

   Example

   ```
   kernel /vmlinuz-2.6.32-358.6.1.el6.x86_64 ro root=/dev/mapper/
   vg_ibmx355021082-lv_root rd_NO_LUKS rd_LVM_LV=vg_ibmx355021082/ lv_root
   LANG=en_US.UTF-8 rd_LVM_LV=vg_ibmx355021082/lv_swap rd_NO_MD
   SYSFONT=latarcyrheb-sun16 crashkernel=auto KEYBOARDTYPE=pc KEYTABLE=us
   rd_NO_DM rhgb quiet rdloaddriver=scsi_dh_alua
   ```

3. Use the `mkinitrd` command to recreate the initrd-image.
   RHEL 6x and later versions use either:
   The command: `mkinitrd -f /boot/ initrd-"uname -r".img uname -r`
   Or
   The command: `dracut -f`

4. Reboot the host.

5. Verify the output of the `cat /proc/cmdline` command to ensure that the setting is complete.

You can use the `multipath -ll` command to verify the settings for your ONTAP LUNs.

The following sections provide example multipath outputs for a LUN mapped to ASA and non-ASA personas.

All SAN Array configurations

All SAN Array (ASA) configurations optimize all paths to a given LUN, keeping them active. This improves performance by serving I/O operations through all paths at the same time.

Example
The following example displays the correct output for an ONTAP LUN.

```
# multipath -ll
3600a0980383034466b2b4a3775474859 dm-3 NETAPP,LUN C-Mode
size=20G features='4 queue_if_no_path pg_init_retries 50
retain_attached_hw_handle' hwhandler='1 alua' wp=rw
|-+- policy='round-robin 0' prio=50 status=active
|- 1:0:8:1  sdb 8:16 active ready running
|- 2:0:8:1  sdd 8:48 active ready running
|- 1:0:9:1  sdc 8:32 active ready running
|- 2:0:9:1  sde 8:64 active ready running
```

> ⓘ A single LUN shouldn't require more than four paths. Having more than four paths might cause
>   path issues during storage failures.

Non-ASA configurations

For non-ASA configurations, there should be two groups of paths with different priorities. The paths with higher
priorities are Active/Optimized. This means they are serviced by the controller where the aggregate is located.
The paths with lower priorities are active but non-optimized because they are served from a different controller.
The non-optimized paths are only used when optimized paths are not available.

Example

The following example displays the correct output for an ONTAP LUN with two Active/Optimized paths and two
Active/Non-Optimized paths.

```
# multipath -ll
3600a0980383034466b2b4a3775474859 dm-3 NETAPP,LUN C-Mode
size=20G features='4 queue_if_no_path pg_init_retries 50
retain_attached_hw_handle' hwhandler='1 alua' wp=rw
|-+- policy='round-robin 0' prio=50 status=active
| |- 1:0:8:1  sdb 8:16 active ready running
| `- 2:0:8:1  sdd 8:48 active ready running
`-+- policy='round-robin 0' prio=10 status=enabled
  |- 1:0:9:1  sdc 8:32 active ready running
  `- 2:0:9:1  sde 8:64 active ready running
```

> ⓘ A single LUN shouldn't require more than four paths. Having more than four paths might cause
>   path issues during storage failures.

Recommended Settings

The RHEL 6.7 OS is compiled to recognize ONTAP LUNs and automatically set all configuration parameters
correctly for both ASA and non-ASA configuartion.

The `multipath.conf` file must exist for the multipath daemon to start. If this file doesn't exist, you can create
an empty, zero-byte file by using the `touch /etc/multipath.conf` command.

The first time you create the `multipath.conf` file, you might need to enable and start the multipath services by using the following commands:

```
chkconfig multipathd on
/etc/init.d/multipathd start
```

You don't need to add anything directly to the `multipath.conf` file unless you have devices that you don't want multipath to manage or you have existing settings that override defaults. To exclude unwanted devices, add the following syntax to the `multipath.conf` file, replacing <DevId> with the worldwide identifier (WWID) string of the device you want to exclude:

```
blacklist {
        wwid <DevId>
        devnode "^(ram|raw|loop|fd|md|dm-|sr|scd|st)[0-9]*"
        devnode "^hd[a-z]"
        devnode "^cciss.*"
}
```

The following example determines the WWID of a device and adds it to the `multipath.conf` file.

Steps

1. Determine the WWID:

   ```
   /lib/udev/scsi_id -gud /dev/sda
   ```

   ```
   3600a098038314c4a433f5774717a3046
   ```

   `sda` is the local SCSI disk that you want to add to the blacklist.

2. Add the `WWID` to the blacklist stanza in `/etc/multipath.conf`:

   ```
   blacklist {
           wwid    3600a098038314c4a433f5774717a3046
           devnode "^(ram|raw|loop|fd|md|dm-|sr|scd|st)[0-9]*"
           devnode "^hd[a-z]"
           devnode "^cciss.*"
   }
   ```

Always check your `/etc/multipath.conf` file, especially in the defaults section, for legacy settings that might be overriding default settings.

The following table demonstrates the critical `multipathd` parameters for ONTAP LUNs and the required

values. If a host is connected to LUNs from other vendors and any of these parameters are overridden, they must be corrected by later stanzas in the `multipath.conf` file that apply specifically to ONTAP LUNs. Without this correction, the ONTAP LUNs might not work as expected. You should only override these defaults in consultation with NetApp, the OS vendor, or both, and only when the impact is fully understood.

Parameter	Setting
detect_prio	yes
dev_loss_tmo	"infinity"
failback	immediate
fast_io_fail_tmo	5
features	"3 queue_if_no_path pg_init_retries 50"
flush_on_last_del	"yes"
hardware_handler	"0"
no_path_retry	queue
path_checker	"tur"
path_grouping_policy	"group_by_prio"
path_selector	"round-robin 0"
polling_interval	5
prio	"ontap"
product	LUN.*
retain_attached_hw_handler	yes
rr_weight	"uniform"
user_friendly_names	no
vendor	NETAPP

Example

The following example shows how to correct an overridden default. In this case, the `multipath.conf` file defines values for `path_checker` and `no_path_retry` that are not compatible with ONTAP LUNs. If they cannot be removed because of other SAN arrays still attached to the host, these parameters can be corrected specifically for ONTAP LUNs with a device stanza.

```
defaults {
    path_checker        readsector0
    no_path_retry        fail
}

devices {
    device {
        vendor          "NETAPP  "
        product          "LUN.*"
        no_path_retry     queue
        path_checker      tur
    }
}
```

Configure KVM settings

You don't need to configure settings for a Kernel-based Virtual Machine because the LUN is mapped to the hypervisor.

ASM mirroring

Automatic Storage Management (ASM) mirroring might require changes to the Linux multipath settings to allow ASM to recognize a problem and switch over to an alternate failure group. Most ASM configurations on ONTAP use external redundancy, which means that data protection is provided by the external array and ASM doesn't mirror data. Some sites use ASM with normal redundancy to provide two-way mirroring, normally across different sites. See Oracle databases on ONTAP for further information.

Known issues

There are no known issues for the RHEL 6.7 with ONTAP release.

Use Red Hat Enterprise Linux 6.6 with ONTAP

You can use the ONTAP SAN host configuration settings to configure Red Hat Enterprise Linux 6.6 with ONTAP as the target.

Install the Linux Host Utilities

The NetApp Linux Host Utilities software package is available on the NetApp Support Site in a 32-bit and 64-bit .rpm file. If you don't know which file is right for your configuration, use the Interoperability Matrix Tool to verify which one you need.

NetApp strongly recommends installing the Linux Host Utilities, but it's not mandatory. The utilities don't change any settings on your Linux host. The utilities improve management and assist NetApp customer support in gathering information about your configuration.

If you have Linux Host Utilities currently installed, you should either upgrade it to the latest version, or remove it and follow these steps to install the latest version.

Steps

1. Download the 32-bit or 64-bit Linux Host Utilities software package from the NetApp Support Site to your host.

2. Install the software package:

```
rpm -ivh netapp_linux_unified_host_utilities-7-1.x86_64
```

ⓘ You can use the configuration settings provided in this procedure to configure cloud clients connected to Cloud Volumes ONTAP and Amazon FSx for ONTAP.

SAN Toolkit

The toolkit is installed automatically when you install the NetApp Host Utilities package. This kit provides the `sanlun` utility, which helps you manage LUNs and HBAs. The `sanlun` command returns information about the LUNs mapped to your host, multipathing, and information necessary to create initiator groups.

Example

In the following example, the `sanlun lun show` command returns LUN information.

```
# sanlun lun show all
```

Example output:

```
controller(7mode/E-Series)/                 device    host              lun
vserver(cDOT/FlashRay)    lun-pathname    filename  adapter  protocol  size
Product
------------------------------------------------------------------------
----------
data_vserver             /vol/vol1/lun1  /dev/sdb   host16   FCP
120.0g  cDOT
data_vserver             /vol/vol1/lun1  /dev/sdc   host15   FCP
120.0g  cDOT
data_vserver             /vol/vol2/lun2  /dev/sdd   host16   FCP
120.0g  cDOT
data_vserver             /vol/vol2/lun2  /dev/sde   host15   FCP
120.0g  cDOT
```

SAN Booting

Before you begin

If you decide to use SAN booting, it must be supported by your configuration. You can use the Interoperability Matrix Tool to verify that your OS, HBA, HBA firmware and the HBA boot BIOS, and ONTAP version are supported.

Steps

1. Map the SAN boot LUN to the host.

2. Verify that multiple paths are available.

| ⓘ | Multiple paths become available after the host OS is up and running on the paths. |

3. Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is mapped.

   For information on how to enable the HBA BIOS, see your vendor-specific documentation.

4. Reboot the host to verify that the boot was successful.

Multipathing

For Red Hat Enterprise Linux (RHEL) 6.6 the /etc/multipath.conf file must exist, but you do not need to make specific changes to the file. RHEL 6.6 is compiled with all settings required to recognize and correctly manage ONTAP LUNs.
To Enable ALUA Handler, perform the following steps:

Steps

1. Create a backup of the initrd-image.

2. Append the following parameter value to the kernel for ALUA and non-ALUA to work:
   `rdloaddriver=scsi_dh_alua`

   Example

   ```
   kernel /vmlinuz-2.6.32-358.6.1.el6.x86_64 ro root=/dev/mapper/
   vg_ibmx355021082-lv_root rd_NO_LUKS rd_LVM_LV=vg_ibmx355021082/ lv_root
   LANG=en_US.UTF-8 rd_LVM_LV=vg_ibmx355021082/lv_swap rd_NO_MD
   SYSFONT=latarcyrheb-sun16 crashkernel=auto KEYBOARDTYPE=pc KEYTABLE=us
   rd_NO_DM rhgb quiet rdloaddriver=scsi_dh_alua
   ```

3. Use the `mkinitrd` command to recreate the initrd-image.
   RHEL 6x and later versions use either:
   The command: `mkinitrd -f /boot/ initrd-"uname -r".img uname -r`
   Or
   The command: `dracut -f`

4. Reboot the host.

5. Verify the output of the `cat /proc/cmdline` command to ensure that the setting is complete.

You can use the `multipath -ll` command to verify the settings for your ONTAP LUNs.

The following sections provide example multipath outputs for a LUN mapped to ASA and non-ASA personas.

All SAN Array configurations

All SAN Array (ASA) configurations optimize all paths to a given LUN, keeping them active. This improves performance by serving I/O operations through all paths at the same time.

Example
The following example displays the correct output for an ONTAP LUN.

```
# multipath -ll
3600a0980383034466b2b4a3775474859 dm-3 NETAPP,LUN C-Mode
size=20G features='4 queue_if_no_path pg_init_retries 50
retain_attached_hw_handle' hwhandler='1 alua' wp=rw
|-+- policy='round-robin 0' prio=50 status=active
|- 1:0:8:1  sdb 8:16 active ready running
|- 2:0:8:1  sdd 8:48 active ready running
|- 1:0:9:1  sdc 8:32 active ready running
|- 2:0:9:1  sde 8:64 active ready running
```

> (i) A single LUN shouldn't require more than four paths. Having more than four paths might cause path issues during storage failures.

Non-ASA configurations

For non-ASA configurations, there should be two groups of paths with different priorities. The paths with higher priorities are Active/Optimized. This means they are serviced by the controller where the aggregate is located. The paths with lower priorities are active but non-optimized because they are served from a different controller. The non-optimized paths are only used when optimized paths are not available.

Example

The following example displays the correct output for an ONTAP LUN with two Active/Optimized paths and two Active/Non-Optimized paths.

```
# multipath -ll
3600a0980383034466b2b4a3775474859 dm-3 NETAPP,LUN C-Mode
size=20G features='4 queue_if_no_path pg_init_retries 50
retain_attached_hw_handle' hwhandler='1 alua' wp=rw
|-+- policy='round-robin 0' prio=50 status=active
| |- 1:0:8:1  sdb 8:16 active ready running
| `- 2:0:8:1  sdd 8:48 active ready running
`-+- policy='round-robin 0' prio=10 status=enabled
  |- 1:0:9:1  sdc 8:32 active ready running
  `- 2:0:9:1  sde 8:64 active ready running
```

> (i) A single LUN shouldn't require more than four paths. Having more than four paths might cause path issues during storage failures.

Recommended Settings

The RHEL 6.6 OS is compiled to recognize ONTAP LUNs and automatically set all configuration parameters correctly for both ASA and non-ASA configuration.

The `multipath.conf` file must exist for the multipath daemon to start. If this file doesn't exist, you can create an empty, zero-byte file by using the `touch /etc/multipath.conf` command.

The first time you create the `multipath.conf` file, you might need to enable and start the multipath services by using the following commands:

```
chkconfig multipathd on
/etc/init.d/multipathd start
```

You don't need to add anything directly to the `multipath.conf` file unless you have devices that you don't want multipath to manage or you have existing settings that override defaults. To exclude unwanted devices, add the following syntax to the `multipath.conf` file, replacing <DevId> with the worldwide identifier (WWID) string of the device you want to exclude:

```
blacklist {
        wwid <DevId>
        devnode "^(ram|raw|loop|fd|md|dm-|sr|scd|st)[0-9]*"
        devnode "^hd[a-z]"
        devnode "^cciss.*"
}
```

The following example determines the WWID of a device and adds it to the `multipath.conf` file.

Steps

1. Determine the WWID:

   ```
   /lib/udev/scsi_id -gud /dev/sda
   ```

   ```
   3600a098038314c4a433f5774717a3046
   ```

   `sda` is the local SCSI disk that you want to add to the blacklist.

2. Add the `WWID` to the blacklist stanza in `/etc/multipath.conf`:

   ```
   blacklist {
           wwid    3600a098038314c4a433f5774717a3046
           devnode "^(ram|raw|loop|fd|md|dm-|sr|scd|st)[0-9]*"
           devnode "^hd[a-z]"
           devnode "^cciss.*"
   }
   ```

Always check your `/etc/multipath.conf` file, especially in the defaults section, for legacy settings that might be overriding default settings.

The following table demonstrates the critical `multipathd` parameters for ONTAP LUNs and the required

values. If a host is connected to LUNs from other vendors and any of these parameters are overridden, they must be corrected by later stanzas in the `multipath.conf` file that apply specifically to ONTAP LUNs. Without this correction, the ONTAP LUNs might not work as expected. You should only override these defaults in consultation with NetApp, the OS vendor, or both, and only when the impact is fully understood.

Parameter	Setting
detect_prio	yes
dev_loss_tmo	"infinity"
failback	immediate
fast_io_fail_tmo	5
features	"3 queue_if_no_path pg_init_retries 50"
flush_on_last_del	"yes"
hardware_handler	"0"
no_path_retry	queue
path_checker	"tur"
path_grouping_policy	"group_by_prio"
path_selector	"round-robin 0"
polling_interval	5
prio	"ontap"
product	LUN.*
retain_attached_hw_handler	yes
rr_weight	"uniform"
user_friendly_names	no
vendor	NETAPP

Example

The following example shows how to correct an overridden default. In this case, the `multipath.conf` file defines values for `path_checker` and `no_path_retry` that are not compatible with ONTAP LUNs. If they cannot be removed because of other SAN arrays still attached to the host, these parameters can be corrected specifically for ONTAP LUNs with a device stanza.

```
defaults {
    path_checker        readsector0
    no_path_retry        fail
}

devices {
    device {
        vendor          "NETAPP  "
        product          "LUN.*"
        no_path_retry     queue
        path_checker      tur
    }
}
```

Configure KVM settings

You don't need to configure settings for a Kernel-based Virtual Machine because the LUN is mapped to the hypervisor.

ASM mirroring

Automatic Storage Management (ASM) mirroring might require changes to the Linux multipath settings to allow ASM to recognize a problem and switch over to an alternate failure group. Most ASM configurations on ONTAP use external redundancy, which means that data protection is provided by the external array and ASM doesn't mirror data. Some sites use ASM with normal redundancy to provide two-way mirroring, normally across different sites. See Oracle databases on ONTAP for further information.

Known issues

The RHEL 6.6 with ONTAP release has the following known issues:

NetApp Bug ID	Title	Description
863878	Kernel crash occurs with RHEL 6U6 host during storage failures	You might observe kernel crash on RHEL 6U6 host during storage/fabric.
1076584	I/O stall up to 300 sec seen with QLogic 16G FC (QLE2672) host during storage failures in RHEL 6U4	You might observe an I/O stall up to 300 sec on QLogic 16G FC (QLE2672) host during storage/fabric failures.

NetApp Bug ID	Title	Description
795684	RHEL6 U5 multipathd incorrectly group multipath maps during MoD and storage failover fault operations	You might observe an incorrect path grouping on LUNs during LUN move on demand operation along with storage faults. During LUN move operation multipath path priorities will change and multipath is unable to reloads the device table due to device failure caused by storage fault. This leads to incorrect path grouping.

Use Red Hat Enterprise Linux 6.5 with ONTAP

You can use the ONTAP SAN host configuration settings to configure Red Hat Enterprise Linux 6.5 with ONTAP as the target.

Install the Linux Host Utilities

The NetApp Linux Host Utilities software package is available on the NetApp Support Site in a 32-bit and 64-bit .rpm file. If you don't know which file is right for your configuration, use the Interoperability Matrix Tool to verify which one you need.

NetApp strongly recommends installing the Linux Host Utilities, but it's not mandatory. The utilities don't change any settings on your Linux host. The utilities improve management and assist NetApp customer support in gathering information about your configuration.

If you have Linux Host Utilities currently installed, you should either upgrade it to the latest version, or remove it and follow these steps to install the latest version.

Steps

1. Download the 32-bit or 64-bit Linux Host Utilities software package from the NetApp Support Site to your host.

2. Install the software package:

   ```
   rpm -ivh netapp_linux_unified_host_utilities-7-1.x86_64
   ```

> ⓘ You can use the configuration settings provided in this procedure to configure cloud clients connected to Cloud Volumes ONTAP and Amazon FSx for ONTAP.

SAN Toolkit

The toolkit is installed automatically when you install the NetApp Host Utilities package. This kit provides the `sanlun` utility, which helps you manage LUNs and HBAs. The `sanlun` command returns information about the LUNs mapped to your host, multipathing, and information necessary to create initiator groups.

Example

In the following example, the `sanlun lun show` command returns LUN information.

```
# sanlun lun show all
```

Example output:

```
controller(7mode/E-Series)/                  device     host                    lun
vserver(cDOT/FlashRay)    lun-pathname   filename   adapter   protocol   size
Product
-------------------------------------------------------------------------
----------
data_vserver               /vol/vol1/lun1    /dev/sdb     host16     FCP
120.0g   cDOT
data_vserver               /vol/vol1/lun1    /dev/sdc     host15     FCP
120.0g   cDOT
data_vserver               /vol/vol2/lun2    /dev/sdd     host16     FCP
120.0g   cDOT
data_vserver               /vol/vol2/lun2    /dev/sde     host15     FCP
120.0g   cDOT
```

SAN Booting

Before you begin

If you decide to use SAN booting, it must be supported by your configuration. You can use the Interoperability Matrix Tool to verify that your OS, HBA, HBA firmware and the HBA boot BIOS, and ONTAP version are supported.

Steps

1. Map the SAN boot LUN to the host.

2. Verify that multiple paths are available.

   > ℹ️ Multiple paths become available after the host OS is up and running on the paths.

3. Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is mapped.

   For information on how to enable the HBA BIOS, see your vendor-specific documentation.

4. Reboot the host to verify that the boot was successful.

Multipathing

For Red Hat Enterprise Linux (RHEL) 6.5 the /etc/multipath.conf file must exist, but you do not need to make specific changes to the file. RHEL 6.5 is compiled with all settings required to recognize and correctly manage ONTAP LUNs.
To Enable ALUA Handler, perform the following steps:

Steps

1. Create a backup of the initrd-image.

2. Append the following parameter value to the kernel for ALUA and non-ALUA to work:

```
rdloaddriver=scsi_dh_alua
```

Example

```
kernel /vmlinuz-2.6.32-358.6.1.el6.x86_64 ro root=/dev/mapper/
vg_ibmx355021082-lv_root rd_NO_LUKS rd_LVM_LV=vg_ibmx355021082/ lv_root
LANG=en_US.UTF-8 rd_LVM_LV=vg_ibmx355021082/lv_swap rd_NO_MD
SYSFONT=latarcyrheb-sun16 crashkernel=auto KEYBOARDTYPE=pc KEYTABLE=us
rd_NO_DM rhgb quiet rdloaddriver=scsi_dh_alua
```

3. Use the `mkinitrd` command to recreate the initrd-image.
   RHEL 6x and later versions use either:
   The command: `mkinitrd -f /boot/ initrd-"uname -r".img uname -r`
   Or
   The command: `dracut -f`

4. Reboot the host.

5. Verify the output of the `cat /proc/cmdline` command to ensure that the setting is complete.

You can use the `multipath -ll` command to verify the settings for your ONTAP LUNs.

The following sections provide example multipath outputs for a LUN mapped to ASA and non-ASA personas.

All SAN Array configurations

All SAN Array (ASA) configurations optimize all paths to a given LUN, keeping them active. This improves performance by serving I/O operations through all paths at the same time.

Example

The following example displays the correct output for an ONTAP LUN.

```
# multipath -ll
3600a0980383034466b2b4a3775474859 dm-3 NETAPP,LUN C-Mode
size=20G features='4 queue_if_no_path pg_init_retries 50
retain_attached_hw_handle' hwhandler='1 alua' wp=rw
|-+- policy='round-robin 0' prio=50 status=active
|- 1:0:8:1  sdb 8:16 active ready running
|- 2:0:8:1  sdd 8:48 active ready running
|- 1:0:9:1  sdc 8:32 active ready running
|- 2:0:9:1  sde 8:64 active ready running
```

ⓘ A single LUN shouldn't require more than four paths. Having more than four paths might cause path issues during storage failures.

Non-ASA configurations

For non-ASA configurations, there should be two groups of paths with different priorities. The paths with higher priorities are Active/Optimized. This means they are serviced by the controller where the aggregate is located.

The paths with lower priorities are active but non-optimized because they are served from a different controller. The non-optimized paths are only used when optimized paths are not available.

Example

The following example displays the correct output for an ONTAP LUN with two Active/Optimized paths and two Active/Non-Optimized paths.

```
# multipath -ll
3600a0980383034466b2b4a3775474859 dm-3 NETAPP,LUN C-Mode
size=20G features='4 queue_if_no_path pg_init_retries 50
retain_attached_hw_handle' hwhandler='1 alua' wp=rw
|-+- policy='round-robin 0' prio=50 status=active
| |- 1:0:8:1  sdb 8:16 active ready running
| `- 2:0:8:1  sdd 8:48 active ready running
`-+- policy='round-robin 0' prio=10 status=enabled
  |- 1:0:9:1  sdc 8:32 active ready running
  `- 2:0:9:1  sde 8:64 active ready running
```

> (i) A single LUN shouldn't require more than four paths. Having more than four paths might cause path issues during storage failures.

Recommended Settings

The RHEL 6.5 OS is compiled to recognize ONTAP LUNs and automatically set all configuration parameters correctly for both ASA and non-ASA configuration.

The `multipath.conf` file must exist for the multipath daemon to start. If this file doesn't exist, you can create an empty, zero-byte file by using the `touch /etc/multipath.conf` command.

The first time you create the `multipath.conf` file, you might need to enable and start the multipath services by using the following commands:

```
chkconfig multipathd on
/etc/init.d/multipathd start
```

You don't need to add anything directly to the `multipath.conf` file unless you have devices that you don't want multipath to manage or you have existing settings that override defaults. To exclude unwanted devices, add the following syntax to the `multipath.conf` file, replacing <DevId> with the worldwide identifier (WWID) string of the device you want to exclude:

```
blacklist {
        wwid <DevId>
        devnode "^(ram|raw|loop|fd|md|dm-|sr|scd|st)[0-9]*"
        devnode "^hd[a-z]"
        devnode "^cciss.*"
}
```

The following example determines the WWID of a device and adds it to the `multipath.conf` file.

Steps

1. Determine the WWID:

   ```
   /lib/udev/scsi_id -gud /dev/sda
   ```

   ```
   3600a098038314c4a433f5774717a3046
   ```

   `sda` is the local SCSI disk that you want to add to the blacklist.

2. Add the `WWID` to the blacklist stanza in `/etc/multipath.conf`:

   ```
   blacklist {
          wwid   3600a098038314c4a433f5774717a3046
          devnode "^(ram|raw|loop|fd|md|dm-|sr|scd|st)[0-9]*"
          devnode "^hd[a-z]"
          devnode "^cciss.*"
   }
   ```

Always check your `/etc/multipath.conf` file, especially in the defaults section, for legacy settings that might be overriding default settings.

The following table demonstrates the critical `multipathd` parameters for ONTAP LUNs and the required values. If a host is connected to LUNs from other vendors and any of these parameters are overridden, they must be corrected by later stanzas in the `multipath.conf` file that apply specifically to ONTAP LUNs. Without this correction, the ONTAP LUNs might not work as expected. You should only override these defaults in consultation with NetApp, the OS vendor, or both, and only when the impact is fully understood.

Parameter	Setting
detect_prio	yes
dev_loss_tmo	"infinity"
failback	immediate
fast_io_fail_tmo	5
features	"3 queue_if_no_path pg_init_retries 50"
flush_on_last_del	"yes"
hardware_handler	"0"
no_path_retry	queue
path_checker	"tur"
path_grouping_policy	"group_by_prio"

Parameter	Setting
path_selector	"round-robin 0"
polling_interval	5
prio	"ontap"
product	LUN.*
retain_attached_hw_handler	yes
rr_weight	"uniform"
user_friendly_names	no
vendor	NETAPP

Example

The following example shows how to correct an overridden default. In this case, the `multipath.conf` file defines values for `path_checker` and `no_path_retry` that are not compatible with ONTAP LUNs. If they cannot be removed because of other SAN arrays still attached to the host, these parameters can be corrected specifically for ONTAP LUNs with a device stanza.

```
defaults {
    path_checker       readsector0
    no_path_retry       fail
}

devices {
    device {
        vendor          "NETAPP  "
        product         "LUN.*"
        no_path_retry     queue
        path_checker      tur
    }
}
```

Configure KVM settings

You don't need to configure settings for a Kernel-based Virtual Machine because the LUN is mapped to the hypervisor.

ASM mirroring

Automatic Storage Management (ASM) mirroring might require changes to the Linux multipath settings to allow ASM to recognize a problem and switch over to an alternate failure group. Most ASM configurations on ONTAP use external redundancy, which means that data protection is provided by the external array and ASM doesn't mirror data. Some sites use ASM with normal redundancy to provide two-way mirroring, normally across different sites. See Oracle databases on ONTAP for further information.

Known issues

The RHEL 6.5 with ONTAP release has the following known issues:

NetApp Bug ID	Title	Description
760515	Path failures or host hangs were observed in RHEL 6.5 8G Qlogic FC SAN host during storage failover operations	Path failures or host hangs were observed in RHEL 6.5 8G Qlogic FC SAN host during storage failover operations.
758271	bnx2 firmware fails to load when booting with custom initrd (dracut -f)	Broadcom NetXtreme II Gigabit controller ports will not ping due to bnx2 firmware fails to load during boot with custom initrd.
799394	RHEL 6U5: Emulex 16G FC (LPe16002B-M6) host crash is seen during I/O with storage failover operations	16G FC Emulex (LPe16002B-M6) host crash is seen during I/O with storage failover operations.
786571	QLogic FCoE host hangs/path failures observed in RHEL 6.5 during I/O with storage failover operations	QLogic FCoE (QLE8242) host hangs/path failures are observed in RHEL 6.5 during I/O with storage failover operations. In such scenarios, you might see the following message: "Mailbox cmd timeout occurred, cmd=0x54, mb[0]=0x54. Scheduling ISP abort" messages which leads to host hung/path failures.
801580	QLogic 16G FC host hangs or path failures observed in RHEL 6.5 during I/O with storage failover operations	The I/O delays of more than 600 seconds are observed with QLogic 16G FC host (QLE2672) during storage failover operations. In such scenarios, the following message is displayed: "Failed mbx[0]=54, mb[1]=0, mb[2]=76b9, mb[3]=5200, cmd=54"

Use Red Hat Enterprise Linux 6.4 with ONTAP

You can use the ONTAP SAN host configuration settings to configure Red Hat Enterprise Linux 6.4 with ONTAP as the target.

Install the Linux Host Utilities

The NetApp Linux Host Utilities software package is available on the NetApp Support Site in a 32-bit and 64-bit .rpm file. If you don't know which file is right for your configuration, use the Interoperability Matrix Tool to verify which one you need.

NetApp strongly recommends installing the Linux Host Utilities, but it's not mandatory. The utilities don't change any settings on your Linux host. The utilities improve management and assist NetApp customer support in gathering information about your configuration.

If you have Linux Host Utilities currently installed, you should either upgrade it to the latest version, or remove it and follow these steps to install the latest version.

Steps

1. Download the 32-bit or 64-bit Linux Host Utilities software package from the NetApp Support Site to your host.

2. Install the software package:

```
rpm -ivh netapp_linux_unified_host_utilities-7-1.x86_64
```

> (i) You can use the configuration settings provided in this procedure to configure cloud clients connected to Cloud Volumes ONTAP and Amazon FSx for ONTAP.

SAN Toolkit

The toolkit is installed automatically when you install the NetApp Host Utilities package. This kit provides the `sanlun` utility, which helps you manage LUNs and HBAs. The `sanlun` command returns information about the LUNs mapped to your host, multipathing, and information necessary to create initiator groups.

Example

In the following example, the `sanlun lun show` command returns LUN information.

```
# sanlun lun show all
```

Example output:

```
controller(7mode/E-Series)/                  device     host               lun
vserver(cDOT/FlashRay)    lun-pathname  filename   adapter  protocol  size
Product
-------------------------------------------------------------------------
----------
data_vserver             /vol/vol1/lun1   /dev/sdb   host16    FCP
120.0g  cDOT
data_vserver             /vol/vol1/lun1   /dev/sdc   host15    FCP
120.0g  cDOT
data_vserver             /vol/vol2/lun2   /dev/sdd   host16    FCP
120.0g  cDOT
data_vserver             /vol/vol2/lun2   /dev/sde   host15    FCP
120.0g  cDOT
```

SAN Booting

Before you begin

If you decide to use SAN booting, it must be supported by your configuration. You can use the Interoperability Matrix Tool to verify that your OS, HBA, HBA firmware and the HBA boot BIOS, and ONTAP version are supported.

Steps

1. Map the SAN boot LUN to the host.

2. Verify that multiple paths are available.

    > ℹ️ Multiple paths become available after the host OS is up and running on the paths.

3. Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is mapped.

    For information on how to enable the HBA BIOS, see your vendor-specific documentation.

4. Reboot the host to verify that the boot was successful.

Multipathing

For Red Hat Enterprise Linux (RHEL) 6.4 the /etc/multipath.conf file must exist, but you do not need to make specific changes to the file. RHEL 6.4 is compiled with all settings required to recognize and correctly manage ONTAP LUNs.
To Enable ALUA Handler, perform the following steps:

Steps

1. Create a backup of the initrd-image.

2. Append the following parameter value to the kernel for ALUA and non-ALUA to work:
   `rdloaddriver=scsi_dh_alua`

    Example

    ```
    kernel /vmlinuz-2.6.32-358.6.1.el6.x86_64 ro root=/dev/mapper/
    vg_ibmx355021082-lv_root rd_NO_LUKS rd_LVM_LV=vg_ibmx355021082/ lv_root
    LANG=en_US.UTF-8 rd_LVM_LV=vg_ibmx355021082/lv_swap rd_NO_MD
    SYSFONT=latarcyrheb-sun16 crashkernel=auto KEYBOARDTYPE=pc KEYTABLE=us
    rd_NO_DM rhgb quiet rdloaddriver=scsi_dh_alua
    ```

3. Use the `mkinitrd` command to recreate the initrd-image.
   RHEL 6x and later versions use either:
   The command: `mkinitrd -f /boot/ initrd-"uname -r".img uname -r`
   Or
   The command: `dracut -f`

4. Reboot the host.

5. Verify the output of the `cat /proc/cmdline` command to ensure that the setting is complete.

You can use the `multipath -ll` command to verify the settings for your ONTAP LUNs.

The following sections provide example multipath outputs for a LUN mapped to ASA and non-ASA personas.

All SAN Array configurations

All SAN Array (ASA) configurations optimize all paths to a given LUN, keeping them active. This improves performance by serving I/O operations through all paths at the same time.

Example

The following example displays the correct output for an ONTAP LUN.

```
# multipath -ll
3600a0980383034466b2b4a3775474859 dm-3 NETAPP,LUN C-Mode
size=20G features='4 queue_if_no_path pg_init_retries 50
retain_attached_hw_handle' hwhandler='1 alua' wp=rw
|-+- policy='round-robin 0' prio=50 status=active
|- 1:0:8:1  sdb 8:16 active ready running
|- 2:0:8:1  sdd 8:48 active ready running
|- 1:0:9:1  sdc 8:32 active ready running
|- 2:0:9:1  sde 8:64 active ready running
```

> (i) A single LUN shouldn't require more than four paths. Having more than four paths might cause path issues during storage failures.

Non-ASA configurations

For non-ASA configurations, there should be two groups of paths with different priorities. The paths with higher priorities are Active/Optimized. This means they are serviced by the controller where the aggregate is located. The paths with lower priorities are active but non-optimized because they are served from a different controller. The non-optimized paths are only used when optimized paths are not available.

Example

The following example displays the correct output for an ONTAP LUN with two Active/Optimized paths and two Active/Non-Optimized paths.

```
# multipath -ll
3600a0980383034466b2b4a3775474859 dm-3 NETAPP,LUN C-Mode
size=20G features='4 queue_if_no_path pg_init_retries 50
retain_attached_hw_handle' hwhandler='1 alua' wp=rw
|-+- policy='round-robin 0' prio=50 status=active
| |- 1:0:8:1  sdb 8:16 active ready running
| `- 2:0:8:1  sdd 8:48 active ready running
`-+- policy='round-robin 0' prio=10 status=enabled
  |- 1:0:9:1  sdc 8:32 active ready running
  `- 2:0:9:1  sde 8:64 active ready running
```

> (i) A single LUN shouldn't require more than four paths. Having more than four paths might cause path issues during storage failures.

Recommended Settings

The RHEL 6.4 OS is compiled to recognize ONTAP LUNs and automatically set all configuration parameters correctly for both ASA and non-ASA configuration.

The `multipath.conf` file must exist for the multipath daemon to start. If this file doesn't exist, you can create

an empty, zero-byte file by using the `touch /etc/multipath.conf` command.

The first time you create the `multipath.conf` file, you might need to enable and start the multipath services by using the following commands:

```
chkconfig multipathd on
/etc/init.d/multipathd start
```

You don't need to add anything directly to the `multipath.conf` file unless you have devices that you don't want multipath to manage or you have existing settings that override defaults. To exclude unwanted devices, add the following syntax to the `multipath.conf` file, replacing <DevId> with the worldwide identifier (WWID) string of the device you want to exclude:

```
blacklist {
        wwid <DevId>
        devnode "^(ram|raw|loop|fd|md|dm-|sr|scd|st)[0-9]*"
        devnode "^hd[a-z]"
        devnode "^cciss.*"
}
```

The following example determines the WWID of a device and adds it to the `multipath.conf` file.

Steps

1. Determine the WWID:

    ```
    /lib/udev/scsi_id -gud /dev/sda
    ```

    ```
    3600a098038314c4a433f5774717a3046
    ```

    `sda` is the local SCSI disk that you want to add to the blacklist.

2. Add the `WWID` to the blacklist stanza in `/etc/multipath.conf`:

    ```
    blacklist {
            wwid    3600a098038314c4a433f5774717a3046
            devnode "^(ram|raw|loop|fd|md|dm-|sr|scd|st)[0-9]*"
            devnode "^hd[a-z]"
            devnode "^cciss.*"
    }
    ```

Always check your `/etc/multipath.conf` file, especially in the defaults section, for legacy settings that might be overriding default settings.

The following table demonstrates the critical `multipathd` parameters for ONTAP LUNs and the required values. If a host is connected to LUNs from other vendors and any of these parameters are overridden, they must be corrected by later stanzas in the `multipath.conf` file that apply specifically to ONTAP LUNs. Without this correction, the ONTAP LUNs might not work as expected. You should only override these defaults in consultation with NetApp, the OS vendor, or both, and only when the impact is fully understood.

Parameter	Setting
detect_prio	yes
dev_loss_tmo	"infinity"
failback	immediate
fast_io_fail_tmo	5
features	"3 queue_if_no_path pg_init_retries 50"
flush_on_last_del	"yes"
hardware_handler	"0"
no_path_retry	queue
path_checker	"tur"
path_grouping_policy	"group_by_prio"
path_selector	"round-robin 0"
polling_interval	5
prio	"ontap"
product	LUN.*
retain_attached_hw_handler	yes
rr_weight	"uniform"
user_friendly_names	no
vendor	NETAPP

Example

The following example shows how to correct an overridden default. In this case, the `multipath.conf` file defines values for `path_checker` and `no_path_retry` that are not compatible with ONTAP LUNs. If they cannot be removed because of other SAN arrays still attached to the host, these parameters can be corrected specifically for ONTAP LUNs with a device stanza.

```
defaults {
    path_checker        readsector0
    no_path_retry        fail
}

devices {
    device {
        vendor          "NETAPP  "
        product          "LUN.*"
        no_path_retry      queue
        path_checker       tur
    }
}
```

Configure KVM settings

You don't need to configure settings for a Kernel-based Virtual Machine because the LUN is mapped to the hypervisor.

ASM mirroring

Automatic Storage Management (ASM) mirroring might require changes to the Linux multipath settings to allow ASM to recognize a problem and switch over to an alternate failure group. Most ASM configurations on ONTAP use external redundancy, which means that data protection is provided by the external array and ASM doesn't mirror data. Some sites use ASM with normal redundancy to provide two-way mirroring, normally across different sites. See Oracle databases on ONTAP for further information.

Known issues

The RHEL 6.4 with ONTAP release has the following known issues:

NetApp Bug ID	Title	Description
[673009](#)	Creating ext4 file system on LV striped across 15 or more discard-enabled, thinly provisioned multipath devices triggers "request botched" kernel errors	"Request blotched" kernel errors have been seen when users attempt to create an ext4 file system on discard-enabled, thinly provisioned multipath devices. As a result, creating the ext4 file system might take longer to complete and occasional disruption occurs. This issue has occurred only when users attempt to create the ext4 file system on a LV striped across 15 or more discard-enabled multipath devices on systems running Red Hat Enterprise Linux 6.x and Data ONTAP 8.1.3 and later operating in 7-Mode. The issue happens because the kernel erroneously attempts to merge discard requests, which is not supported on Red Hat Enterprise Linux 6.x at this time. When this issue occurs, multiple instances of the following message are written to syslog (/var/log/messages): kernel: blk: request botched. As a result, file system creation might take longer time to complete than expected.

Rocky Linux

Rocky Linux 10

Configure Rocky Linux 10 for FCP and iSCSI with ONTAP storage

The Linux Host Utilities software provides management and diagnostic tools for Linux hosts that are connected to ONTAP storage. When you install Linux Host Utilities on a Rocky Linux 10 host, you can use the Host Utilities to help you manage FCP and iSCSI protocol operations with ONTAP LUNs.

> ⓘ You don't need to manually configure Kernel-based Virtual Machine (KVM) settings because ONTAP LUNs are automatically mapped to the hypervisor.

Step 1: Optionally, enable SAN booting

You can configure your host to use SAN booting to simplify deployment and improve scalability.

Before you begin

Use the Interoperability Matrix Tool to verify that your Linux OS, host bus adapter (HBA), HBA firmware, HBA boot BIOS, and ONTAP version support SAN booting.

Steps

1. [Create a SAN boot LUN and map it to the host](#).

2. Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is mapped.

   For information on how to enable the HBA BIOS, see your vendor-specific documentation.

3. Verify that the configuration was successful by rebooting the host and verifying that the OS is up and running.

Step 2: Install the Linux Host Utilities

NetApp strongly recommends installing the Linux Host Utilities to support ONTAP LUN management and assist technical support with gathering configuration data.

[Install Linux Host Utilities 8.0](#).

> ⓘ   Installing the Linux Host Utilities doesn't change any host timeout settings on your Linux host.

Step 3: Confirm the multipath configuration for your host

You can use multipathing with Rocky Linux 10 to manage ONTAP LUNs.

To ensure that multipathing is configured correctly for your host, verify that the `/etc/multipath.conf` file is defined and that you have the NetApp recommended settings configured for your ONTAP LUNs.

Steps

1. Verify that the `/etc/multipath.conf` file exits. If the file doesn't exist, create an empty, zero-byte file:

   ```
   touch /etc/multipath.conf
   ```

2. The first time the `multipath.conf` file is created, you might need to enable and start the multipath services to load the recommended settings:

   ```
   systemctl enable multipathd
   ```

   ```
   systemctl start multipathd
   ```

3. Each time you boot the host, the empty `/etc/multipath.conf` zero-byte file automatically loads the NetApp recommended host multipath parameters as the default settings. You shouldn't need to make changes to the `/etc/multipath.conf` file for your host because the operating system is compiled with the multipath parameters that recognize and manage ONTAP LUNs correctly.

   The following table shows the Linux OS native compiled multipath parameter settings for ONTAP LUNs.

Show parameter settings

Parameter	Setting
detect_prio	yes
dev_loss_tmo	"infinity"
failback	immediate
fast_io_fail_tmo	5
features	"2 pg_init_retries 50"
flush_on_last_del	"yes"
hardware_handler	"0"
no_path_retry	queue
path_checker	"tur"
path_grouping_policy	"group_by_prio"
path_selector	"service-time 0"
polling_interval	5
prio	"ontap"
product	LUN
retain_attached_hw_handler	yes
rr_weight	"uniform"
user_friendly_names	no
vendor	NETAPP

4. Verify the parameter settings and path status for your ONTAP LUNs:

```
multipath -ll
```

The default multipath parameters support ASA, AFF, and FAS configurations. In these configurations, a single ONTAP LUN shouldn't require more than four paths. If there are more than four paths, it might cause issues with the paths during a storage failure.

The following example outputs show the correct parameter settings and path status for ONTAP LUNs in an ASA, AFF, or FAS configuration.

ASA configuration

An ASA configuration optimizes all paths to a given LUN, keeping them active. This improves performance by serving I/O operations through all paths at the same time.

```
# multipath -ll
3600a098038314e535a24584e4b496252 dm-32 NETAPP,LUN C-Mode
size=10G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
`-+- policy='service-time 0' prio=50 status=active
  |- 11:0:0:41 sdan 66:112  active ready running
  |- 11:0:1:41 sdcb 68:240  active ready running
  |- 14:0:2:41 sdfd 129:240 active ready running
  `- 14:0:0:41 sddp 71:112  active ready running
```

AFF or FAS configuration

An AFF or FAS configuration should have two groups of paths with higher and lower priorities. Higher priority Active/Optimized paths are served by the controller where the aggregate is located. Lower priority paths are active but non-optimized because they are served by a different controller. Non-optimized paths are only used when optimized paths aren't available.

The following example displays the output for an ONTAP LUN with two Active/Optimized paths and two Active/Non-Optimized paths:

```
# multipath -ll
3600a0980383149764b5d567257516273 dm-0 NETAPP,LUN C-Mode
size=150G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
|-+- policy='service-time 0' prio=50 status=active
| |- 16:0:3:0  sdcg 69:64  active ready running
| `- 10:0:0:0  sdb  8:16   active ready running
`-+- policy='service-time 0' prio=10 status=enabled
  |- 10:0:1:0  sdc  8:32   active ready running
  `- 16:0:2:0  sdcf 69:48  active ready running
```

Step 4: Optionally, exclude a device from multipathing

If required, you can exclude a device from multipathing by adding the WWID for the unwanted device to the "blacklist" stanza for the `multipath.conf` file.

Steps

1. Determine the WWID:

```
/lib/udev/scsi_id -gud /dev/sda
```

"sda" is the local SCSI disk that you want to add to the blacklist.

An example WWID is `360030057024d0730239134810c0cb833`.

2. Add the WWID to the "blacklist" stanza:

```
blacklist {
        wwid    360030057024d0730239134810c0cb833
        devnode "^(ram|raw|loop|fd|md|dm-|sr|scd|st)[0-9]*"
        devnode "^hd[a-z]"
        devnode "^cciss.*"
}
```

Step 5: Customize multipath parameters for ONTAP LUNs

If your host is connected to LUNs from other vendors and any of the multipath parameter settings are overridden, you need to correct them by adding stanzas later in the `multipath.conf` file that apply specifically to ONTAP LUNs. If you don't do this, the ONTAP LUNs might not work as expected.

Check your `/etc/multipath.conf` file, especially in the defaults section, for settings that might be overriding the default settings for multipath parameters.

> ⚠ You shouldn't override the recommended parameter settings for ONTAP LUNs. These settings are required for optimal performance of your host configuration. Contact NetApp support, your OS vendor, or both for more information.

The following example shows how to correct an overridden default. In this example, the `multipath.conf` file defines values for `path_checker` and `no_path_retry` that aren't compatible with ONTAP LUNs, and you can't remove these parameters because ONTAP storage arrays are still attached to the host. Instead, you correct the values for `path_checker` and `no_path_retry` by adding a device stanza to the `multipath.conf` file that applies specifically to the ONTAP LUNs.

Show example

```
defaults {
    path_checker       readsector0
    no_path_retry      fail
}

devices {
    device {
        vendor          "NETAPP"
        product         "LUN"
        no_path_retry   queue
        path_checker    tur
    }
}
```

Step 6: Review the known issues

There are no known issues.

What's next?

- Learn about using the Linux Host Utilities tool.

- Learn about ASM mirroring.

  Automatic Storage Management (ASM) mirroring might require changes to the Linux multipath settings to allow ASM to recognize a problem and switch over to an alternate failure group. Most ASM configurations on ONTAP use external redundancy, which means that data protection is provided by the external array and ASM doesn't mirror data. Some sites use ASM with normal redundancy to provide two-way mirroring, normally across different sites. See Oracle databases on ONTAP for further information.

Rocky Linux 9

Configure Rocky Linux 9.6 for FCP and iSCSI with ONTAP storage

The Linux Host Utilities software provides management and diagnostic tools for Linux hosts that are connected to ONTAP storage. When you install Linux Host Utilities on a Rocky Linux 9.6 host, you can use the Host Utilities to help you manage FCP and iSCSI protocol operations with ONTAP LUNs.

> ⓘ You don't need to manually configure Kernel-based Virtual Machine (KVM) settings because ONTAP LUNs are automatically mapped to the hypervisor.

Step 1: Optionally, enable SAN booting

You can configure your host to use SAN booting to simplify deployment and improve scalability.

Before you begin

Use the Interoperability Matrix Tool to verify that your Linux OS, host bus adapter (HBA), HBA firmware, HBA boot BIOS, and ONTAP version support SAN booting.

Steps

1. Create a SAN boot LUN and map it to the host.

2. Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is mapped.

   For information on how to enable the HBA BIOS, see your vendor-specific documentation.

3. Verify that the configuration was successful by rebooting the host and verifying that the OS is up and running.

Step 2: Install the Linux Host Utilities

NetApp strongly recommends installing the Linux Host Utilities to support ONTAP LUN management and assist technical support with gathering configuration data.

Install Linux Host Utilities 8.0.

> ⓘ Installing the Linux Host Utilities doesn't change any host timeout settings on your Linux host.

Step 3: Confirm the multipath configuration for your host

You can use multipathing with Rocky Linux 9.6 to manage ONTAP LUNs.

To ensure that multipathing is configured correctly for your host, verify that the `/etc/multipath.conf` file is defined and that you have the NetApp recommended settings configured for your ONTAP LUNs.

Steps

1. Verify that the `/etc/multipath.conf` file exits. If the file doesn't exist, create an empty, zero-byte file:

   ```
   touch /etc/multipath.conf
   ```

2. The first time the `multipath.conf` file is created, you might need to enable and start the multipath services to load the recommended settings:

   ```
   systemctl enable multipathd
   ```

   ```
   systemctl start multipathd
   ```

3. Each time you boot the host, the empty `/etc/multipath.conf` zero-byte file automatically loads the NetApp recommended host multipath parameters as the default settings. You shouldn't need to make changes to the `/etc/multipath.conf` file for your host because the operating system is compiled with the multipath parameters that recognize and manage ONTAP LUNs correctly.

   The following table shows the Linux OS native compiled multipath parameter settings for ONTAP LUNs.

Show parameter settings

Parameter	Setting
detect_prio	yes
dev_loss_tmo	"infinity"
failback	immediate
fast_io_fail_tmo	5
features	"2 pg_init_retries 50"
flush_on_last_del	"yes"
hardware_handler	"0"
no_path_retry	queue
path_checker	"tur"
path_grouping_policy	"group_by_prio"
path_selector	"service-time 0"
polling_interval	5
prio	"ontap"
product	LUN
retain_attached_hw_handler	yes
rr_weight	"uniform"
user_friendly_names	no
vendor	NETAPP

4. Verify the parameter settings and path status for your ONTAP LUNs:

```
multipath -ll
```

The default multipath parameters support ASA, AFF, and FAS configurations. In these configurations, a single ONTAP LUN shouldn't require more than four paths. If there are more than four paths, it might cause issues with the paths during a storage failure.

The following example outputs show the correct parameter settings and path status for ONTAP LUNs in an ASA, AFF, or FAS configuration.

ASA configuration

An ASA configuration optimizes all paths to a given LUN, keeping them active. This improves performance by serving I/O operations through all paths at the same time.

Show example

```
multipath -ll
3600a098038314c4a433f577471797958 dm-2 NETAPP,LUN C-Mode
size=180G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
`-+- policy='service-time 0' prio=50 status=active
  |- 14:0:0:0  sdc  8:32   active ready running
  |- 17:0:0:0  sdas 66:192 active ready running
  |- 14:0:3:0  sdar 66:176 active ready running
  `- 17:0:3:0  sdch 69:80  active ready running
```

AFF or FAS configuration

An AFF or FAS configuration should have two groups of paths with higher and lower priorities. Higher priority Active/Optimized paths are served by the controller where the aggregate is located. Lower priority paths are active but non-optimized because they are served by a different controller. Non-optimized paths are only used when optimized paths aren't available.

The following example displays the output for an ONTAP LUN with two Active/Optimized paths and two Active/Non-Optimized paths:

Show example

```
multipath -ll
3600a0980383149764b5d567257516273 dm-0 NETAPP,LUN C-Mode
size=150G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
|-+- policy='service-time 0' prio=50 status=active
| |- 16:0:3:0  sdcg 69:64  active ready running
| `- 10:0:0:0  sdb  8:16   active ready running
`-+- policy='service-time 0' prio=10 status=enabled
  |- 10:0:1:0  sdc  8:32   active ready running
  `- 16:0:2:0  sdcf 69:48  active ready running
```

Step 4: Optionally, exclude a device from multipathing

If required, you can exclude a device from multipathing by adding the WWID for the unwanted device to the "blacklist" stanza for the `multipath.conf` file.

Steps

1. Determine the WWID:

    ```
    /lib/udev/scsi_id -gud /dev/sda
    ```

    "sda" is the local SCSI disk that you want to add to the blacklist.

    An example WWID is `360030057024d0730239134810c0cb833`.

2. Add the WWID to the "blacklist" stanza:

    ```
    blacklist {
            wwid    360030057024d0730239134810c0cb833
            devnode "^(ram|raw|loop|fd|md|dm-|sr|scd|st)[0-9]*"
            devnode "^hd[a-z]"
            devnode "^cciss.*"
    }
    ```

Step 5: Customize multipath parameters for ONTAP LUNs

If your host is connected to LUNs from other vendors and any of the multipath parameter settings are overridden, you need to correct them by adding stanzas later in the `multipath.conf` file that apply specifically to ONTAP LUNs. If you don't do this, the ONTAP LUNs might not work as expected.

Check your `/etc/multipath.conf` file, especially in the defaults section, for settings that might be overriding the default settings for multipath parameters.

> ⚠️ You shouldn't override the recommended parameter settings for ONTAP LUNs. These settings are required for optimal performance of your host configuration. Contact NetApp support, your OS vendor, or both for more information.

The following example shows how to correct an overridden default. In this example, the `multipath.conf` file defines values for `path_checker` and `no_path_retry` that aren't compatible with ONTAP LUNs, and you can't remove these parameters because ONTAP storage arrays are still attached to the host. Instead, you correct the values for `path_checker` and `no_path_retry` by adding a device stanza to the `multipath.conf` file that applies specifically to the ONTAP LUNs.

Show example

```
defaults {
    path_checker        readsector0
    no_path_retry       fail
}

devices {
    device {
        vendor          "NETAPP"
        product         "LUN"
        no_path_retry   queue
        path_checker    tur
    }
}
```

Step 6: Review the known issues

There are no known issues.

What's next?

- Learn about using the Linux Host Utilities tool.

- Learn about ASM mirroring.

  Automatic Storage Management (ASM) mirroring might require changes to the Linux multipath settings to allow ASM to recognize a problem and switch over to an alternate failure group. Most ASM configurations on ONTAP use external redundancy, which means that data protection is provided by the external array and ASM doesn't mirror data. Some sites use ASM with normal redundancy to provide two-way mirroring, normally across different sites. See Oracle databases on ONTAP for further information.

Configure Rocky Linux 9.5 for FCP and iSCSI with ONTAP storage

The Linux Host Utilities software provides management and diagnostic tools for Linux hosts that are connected to ONTAP storage. When you install Linux Host Utilities on a Rocky Linux 9.5 host, you can use the Host Utilities to help you manage FCP and iSCSI protocol operations with ONTAP LUNs.

> (i) You don't need to configure Kernel-based Virtual Machine (KVM) settings because ONTAP LUNs are automatically mapped to the KVM hypervisor.

Step 1: Optionally, enable SAN booting

You can configure your host to use SAN booting to simplify deployment and improve scalability.

Before you begin

Use the Interoperability Matrix Tool to verify that your Linux OS, host bus adapter (HBA), HBA firmware, HBA

boot BIOS, and ONTAP version support SAN booting.

Steps

1. [Create a SAN boot LUN and map it to the host](#).

2. Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is mapped.

   For information on how to enable the HBA BIOS, see your vendor-specific documentation.

3. Verify that the configuration was successful by rebooting the host and verifying that the OS is up and running.

Step 2: Install the Linux Host Utilities

NetApp strongly recommends installing the Linux Host Utilities to support ONTAP LUN management and assist technical support with gathering configuration data.

[Install Linux Host Utilities 8.0](#).

> ⓘ   Installing the Linux Host Utilities doesn't change any host timeout settings on your Linux host.

Step 3: Confirm the multipath configuration for your host

You can use multipathing with Rocky Linux 9.5 to manage ONTAP LUNs.

To ensure that multipathing is configured correctly for your host, verify that the `/etc/multipath.conf` file is defined and that you have the NetApp recommended settings configured for your ONTAP LUNs.

Steps

1. Verify that the `/etc/multipath.conf` file exists:

   ```
   ls /etc/multipath.conf
   ```

   If the file doesn't exist, create an empty, zero-byte file:

   ```
   touch /etc/multipath.conf
   ```

2. The first time the `multipath.conf` file is created, you might need to enable and start the multipath services to load the recommended settings:

   ```
   systemctl enable multipathd
   ```

   ```
   systemctl start multipathd
   ```

3. Each time you boot the host, the empty `/etc/multipath.conf` zero-byte file automatically loads the NetApp recommended host multipath parameters as the default settings. You shouldn't need to make changes to the `/etc/multipath.conf` file for your host because the host operating system is compiled

with the multipath parameters that recognize and manage ONTAP LUNs correctly.

The following table shows the native Linux OS compiled multipath parameter settings for ONTAP LUNs.

Show parameter settings

Parameter	Setting
detect_prio	yes
dev_loss_tmo	"infinity"
failback	immediate
fast_io_fail_tmo	5
features	"2 pg_init_retries 50"
flush_on_last_del	"yes"
hardware_handler	"0"
no_path_retry	queue
path_checker	"tur"
path_grouping_policy	"group_by_prio"
path_selector	"service-time 0"
polling_interval	5
prio	"ontap"
product	LUN
retain_attached_hw_handler	yes
rr_weight	"uniform"
user_friendly_names	no
vendor	NETAPP

4. Verify the parameter settings and path status for your ONTAP LUNs:

```
multipath -ll
```

The default multipath parameters support ASA, AFF, and FAS configurations. In these configurations, a single ONTAP LUN shouldn't require more than four paths. If there are more than four paths, it might cause issues with the paths during a storage failure.

The following example outputs show the correct parameter settings and path status for ONTAP LUNs in an ASA, AFF, or FAS configuration.

ASA configuration

An ASA configuration optimizes all paths to a given LUN, keeping them active. This improves performance by serving I/O operations through all paths at the same time.

```
# multipath -ll
3600a098038314c4a433f577471797958 dm-2 NETAPP,LUN C-Mode
size=180G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
`-+- policy='service-time 0' prio=50 status=active
  |- 14:0:0:0  sdc  8:32   active ready running
  |- 17:0:0:0  sdas 66:192 active ready running
  |- 14:0:3:0  sdar 66:176 active ready running
  `- 17:0:3:0  sdch 69:80  active ready running
```

AFF or FAS configuration

An AFF or FAS configuration should have two groups of paths with higher and lower priorities. Higher priority Active/Optimized paths are served by the controller where the aggregate is located. Lower priority paths are active but non-optimized because they are served by a different controller. Non-optimized paths are only used when optimized paths aren't available.

The following example displays the output for an ONTAP LUN with two Active/Optimized paths and two Active/Non-Optimized paths:

```
# multipath -ll
3600a0980383149764b5d567257516273 dm-0 NETAPP,LUN C-Mode
size=150G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
|-+- policy='service-time 0' prio=50 status=active
| |- 16:0:3:0  sdcg 69:64  active ready running
| `- 10:0:0:0  sdb  8:16   active ready running
`-+- policy='service-time 0' prio=10 status=enabled
  |- 10:0:1:0  sdc  8:32   active ready running
  `- 16:0:2:0  sdcf 69:48  active ready running
```

Step 4: Optionally, exclude a device from multipathing

If required, you can exclude a device from multipathing by adding the WWID for the unwanted device to the "blacklist" stanza for the `multipath.conf` file.

Steps

1. Determine the WWID:

```
/lib/udev/scsi_id -gud /dev/sda
```

"sda" is the local SCSI disk that you want to add to the blacklist.

An example WWID is `360030057024d0730239134810c0cb833`.

2. Add the WWID to the "blacklist" stanza:

```
blacklist {
          wwid    360030057024d0730239134810c0cb833
          devnode "^(ram|raw|loop|fd|md|dm-|sr|scd|st)[0-9]*"
          devnode "^hd[a-z]"
          devnode "^cciss.*"
}
```

Step 5: Customize multipath parameters for ONTAP LUNs

If your host is connected to LUNs from other vendors and any of the multipath parameter settings are overridden, you need to correct them by adding stanzas later in the `multipath.conf` file that apply specifically to ONTAP LUNs. If you don't do this, the ONTAP LUNs might not work as expected.

Check your `/etc/multipath.conf` file, especially in the defaults section, for settings that might be overriding the default settings for multipath parameters.

> ⚠️ You shouldn't override the recommended parameter settings for ONTAP LUNs. These settings are required for optimal performance of your host configuration. Contact NetApp support, your OS vendor, or both for more information.

The following example shows how to correct an overridden default. In this example, the `multipath.conf` file defines values for `path_checker` and `no_path_retry` that aren't compatible with ONTAP LUNs, and you can't remove these parameters because ONTAP storage arrays are still attached to the host. Instead, you correct the values for `path_checker` and `no_path_retry` by adding a device stanza to the `multipath.conf` file that applies specifically to the ONTAP LUNs.

```
defaults {
    path_checker        readsector0
    no_path_retry       fail
}

devices {
    device {
        vendor          "NETAPP"
        product         "LUN"
        no_path_retry   queue
        path_checker    tur
    }
}
```

Step 6: Review the known issues

There are no known issues.

What's next?

- Learn about using the Linux Host Utilities tool.
- Learn about ASM mirroring.

  Automatic Storage Management (ASM) mirroring might require changes to the Linux multipath settings to allow ASM to recognize a problem and switch over to an alternate failure group. Most ASM configurations on ONTAP use external redundancy, which means that data protection is provided by the external array and ASM doesn't mirror data. Some sites use ASM with normal redundancy to provide two-way mirroring, normally across different sites. See Oracle databases on ONTAP for further information.

Configure Rocky Linux 9.4 for FCP and iSCSI with ONTAP storage

The Linux Host Utilities software provides management and diagnostic tools for Linux hosts that are connected to ONTAP storage. When you install Linux Host Utilities on a Rocky Linux 9.4 host, you can use the Host Utilities to help you manage FCP and iSCSI protocol operations with ONTAP LUNs.

> ⓘ You don't need to configure Kernel-based Virtual Machine (KVM) settings because ONTAP LUNs are automatically mapped to the KVM hypervisor.

Step 1: Optionally, enable SAN booting

You can configure your host to use SAN booting to simplify deployment and improve scalability.

Before you begin

Use the Interoperability Matrix Tool to verify that your Linux OS, host bus adapter (HBA), HBA firmware, HBA boot BIOS, and ONTAP version support SAN booting.

Steps

1. Create a SAN boot LUN and map it to the host.
2. Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is mapped.

   For information on how to enable the HBA BIOS, see your vendor-specific documentation.

3. Verify that the configuration was successful by rebooting the host and verifying that the OS is up and running.

Step 2: Install the Linux Host Utilities

NetApp strongly recommends installing the Linux Host Utilities to support ONTAP LUN management and assist technical support with gathering configuration data.

Install Linux Host Utilities 8.0.

> ⓘ Installing the Linux Host Utilities doesn't change any host timeout settings on your Linux host.

Step 3: Confirm the multipath configuration for your host

You can use multipathing with Rocky Linux 9.4 to manage ONTAP LUNs.

To ensure that multipathing is configured correctly for your host, verify that the `/etc/multipath.conf` file is defined and that you have the NetApp recommended settings configured for your ONTAP LUNs.

Steps

1. Verify that the `/etc/multipath.conf` file exists:

   ```
   ls /etc/multipath.conf
   ```

   If the file doesn't exist, create an empty, zero-byte file:

   ```
   touch /etc/multipath.conf
   ```

2. The first time the `multipath.conf` file is created, you might need to enable and start the multipath services to load the recommended settings:

   ```
   systemctl enable multipathd
   ```

   ```
   systemctl start multipathd
   ```

3. Each time you boot the host, the empty `/etc/multipath.conf` zero-byte file automatically loads the NetApp recommended host multipath parameters as the default settings. You shouldn't need to make changes to the `/etc/multipath.conf` file for your host because the host operating system is compiled with the multipath parameters that recognize and manage ONTAP LUNs correctly.

   The following table shows the native Linux OS compiled multipath parameter settings for ONTAP LUNs.

Show parameter settings

Parameter	Setting
detect_prio	yes
dev_loss_tmo	"infinity"
failback	immediate
fast_io_fail_tmo	5
features	"2 pg_init_retries 50"
flush_on_last_del	"yes"
hardware_handler	"0"
no_path_retry	queue
path_checker	"tur"
path_grouping_policy	"group_by_prio"
path_selector	"service-time 0"
polling_interval	5
prio	"ontap"
product	LUN
retain_attached_hw_handler	yes
rr_weight	"uniform"
user_friendly_names	no
vendor	NETAPP

4. Verify the parameter settings and path status for your ONTAP LUNs:

```
multipath -ll
```

The default multipath parameters support ASA, AFF, and FAS configurations. In these configurations, a single ONTAP LUN shouldn't require more than four paths. If there are more than four paths, it might cause issues with the paths during a storage failure.

The following example outputs show the correct parameter settings and path status for ONTAP LUNs in an ASA, AFF, or FAS configuration.

ASA configuration

An ASA configuration optimizes all paths to a given LUN, keeping them active. This improves performance by serving I/O operations through all paths at the same time.

```
# multipath -ll
3600a098038314c4a433f577471797958 dm-2 NETAPP,LUN C-Mode
size=180G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
`-+- policy='service-time 0' prio=50 status=active
  |- 14:0:0:0  sdc  8:32   active ready running
  |- 17:0:0:0  sdas 66:192 active ready running
  |- 14:0:3:0  sdar 66:176 active ready running
  `- 17:0:3:0  sdch 69:80  active ready running
```

AFF or FAS configuration

An AFF or FAS configuration should have two groups of paths with higher and lower priorities. Higher priority Active/Optimized paths are served by the controller where the aggregate is located. Lower priority paths are active but non-optimized because they are served by a different controller. Non-optimized paths are only used when optimized paths aren't available.

The following example displays the output for an ONTAP LUN with two Active/Optimized paths and two Active/Non-Optimized paths:

```
# multipath -ll
3600a0980383149764b5d567257516273 dm-0 NETAPP,LUN C-Mode
size=150G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
|-+- policy='service-time 0' prio=50 status=active
| |- 16:0:3:0  sdcg 69:64  active ready running
| `- 10:0:0:0  sdb  8:16   active ready running
`-+- policy='service-time 0' prio=10 status=enabled
  |- 10:0:1:0  sdc  8:32   active ready running
  `- 16:0:2:0  sdcf 69:48  active ready running
```

Step 4: Optionally, exclude a device from multipathing

If required, you can exclude a device from multipathing by adding the WWID for the unwanted device to the "blacklist" stanza for the `multipath.conf` file.

Steps

1. Determine the WWID:

```
/lib/udev/scsi_id -gud /dev/sda
```

"sda" is the local SCSI disk that you want to add to the blacklist.

An example WWID is `360030057024d0730239134810c0cb833`.

2. Add the WWID to the "blacklist" stanza:

```
blacklist {
        wwid    360030057024d0730239134810c0cb833
        devnode "^(ram|raw|loop|fd|md|dm-|sr|scd|st)[0-9]*"
        devnode "^hd[a-z]"
        devnode "^cciss.*"
}
```

Step 5: Customize multipath parameters for ONTAP LUNs

If your host is connected to LUNs from other vendors and any of the multipath parameter settings are overridden, you need to correct them by adding stanzas later in the `multipath.conf` file that apply specifically to ONTAP LUNs. If you don't do this, the ONTAP LUNs might not work as expected.

Check your `/etc/multipath.conf` file, especially in the defaults section, for settings that might be overriding the default settings for multipath parameters.

> ⚠️ You shouldn't override the recommended parameter settings for ONTAP LUNs. These settings are required for optimal performance of your host configuration. Contact NetApp support, your OS vendor, or both for more information.

The following example shows how to correct an overridden default. In this example, the `multipath.conf` file defines values for `path_checker` and `no_path_retry` that aren't compatible with ONTAP LUNs, and you can't remove these parameters because ONTAP storage arrays are still attached to the host. Instead, you correct the values for `path_checker` and `no_path_retry` by adding a device stanza to the `multipath.conf` file that applies specifically to the ONTAP LUNs.

```
defaults {
    path_checker        readsector0
    no_path_retry       fail
}

devices {
    device {
        vendor          "NETAPP"
        product         "LUN"
        no_path_retry   queue
        path_checker    tur
    }
}
```

Step 6: Review the known issues

There are no known issues.

What's next?

- Learn about using the Linux Host Utilities tool.
- Learn about ASM mirroring.

    Automatic Storage Management (ASM) mirroring might require changes to the Linux multipath settings to allow ASM to recognize a problem and switch over to an alternate failure group. Most ASM configurations on ONTAP use external redundancy, which means that data protection is provided by the external array and ASM doesn't mirror data. Some sites use ASM with normal redundancy to provide two-way mirroring, normally across different sites. See Oracle databases on ONTAP for further information.

Configure Rocky Linux 9.3 for FCP and iSCSI with ONTAP storage

The Linux Host Utilities software provides management and diagnostic tools for Linux hosts that are connected to ONTAP storage. When you install Linux Host Utilities on a Rocky Linux 9.3 host, you can use the Host Utilities to help you manage FCP and iSCSI protocol operations with ONTAP LUNs.

> ⓘ You don't need to configure Kernel-based Virtual Machine (KVM) settings because ONTAP LUNs are automatically mapped to the KVM hypervisor.

Step 1: Optionally, enable SAN booting

You can configure your host to use SAN booting to simplify deployment and improve scalability.

Before you begin

Use the Interoperability Matrix Tool to verify that your Linux OS, host bus adapter (HBA), HBA firmware, HBA boot BIOS, and ONTAP version support SAN booting.

Steps

1. Create a SAN boot LUN and map it to the host.
2. Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is mapped.

    For information on how to enable the HBA BIOS, see your vendor-specific documentation.

3. Verify that the configuration was successful by rebooting the host and verifying that the OS is up and running.

Step 2: Install the Linux Host Utilities

NetApp strongly recommends installing the Linux Host Utilities to support ONTAP LUN management and assist technical support with gathering configuration data.

Install Linux Host Utilities 8.0.

> ⓘ Installing the Linux Host Utilities doesn't change any host timeout settings on your Linux host.

Step 3: Confirm the multipath configuration for your host

You can use multipathing with Rocky Linux 9.3 to manage ONTAP LUNs.

To ensure that multipathing is configured correctly for your host, verify that the `/etc/multipath.conf` file is defined and that you have the NetApp recommended settings configured for your ONTAP LUNs.

Steps

1. Verify that the `/etc/multipath.conf` file exists:

   ```
   ls /etc/multipath.conf
   ```

   If the file doesn't exist, create an empty, zero-byte file:

   ```
   touch /etc/multipath.conf
   ```

2. The first time the `multipath.conf` file is created, you might need to enable and start the multipath services to load the recommended settings:

   ```
   systemctl enable multipathd
   ```

   ```
   systemctl start multipathd
   ```

3. Each time you boot the host, the empty `/etc/multipath.conf` zero-byte file automatically loads the NetApp recommended host multipath parameters as the default settings. You shouldn't need to make changes to the `/etc/multipath.conf` file for your host because the host operating system is compiled with the multipath parameters that recognize and manage ONTAP LUNs correctly.

   The following table shows the native Linux OS compiled multipath parameter settings for ONTAP LUNs.

Show parameter settings

Parameter	Setting
detect_prio	yes
dev_loss_tmo	"infinity"
failback	immediate
fast_io_fail_tmo	5
features	"2 pg_init_retries 50"
flush_on_last_del	"yes"
hardware_handler	"0"
no_path_retry	queue
path_checker	"tur"
path_grouping_policy	"group_by_prio"
path_selector	"service-time 0"
polling_interval	5
prio	"ontap"
product	LUN
retain_attached_hw_handler	yes
rr_weight	"uniform"
user_friendly_names	no
vendor	NETAPP

4. Verify the parameter settings and path status for your ONTAP LUNs:

```
multipath -ll
```

The default multipath parameters support ASA, AFF, and FAS configurations. In these configurations, a single ONTAP LUN shouldn't require more than four paths. If there are more than four paths, it might cause issues with the paths during a storage failure.

The following example outputs show the correct parameter settings and path status for ONTAP LUNs in an ASA, AFF, or FAS configuration.

ASA configuration

An ASA configuration optimizes all paths to a given LUN, keeping them active. This improves performance by serving I/O operations through all paths at the same time.

```
# multipath -ll
3600a098038314c4a433f577471797958 dm-2 NETAPP,LUN C-Mode
size=180G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
`-+- policy='service-time 0' prio=50 status=active
  |- 14:0:0:0  sdc  8:32   active ready running
  |- 17:0:0:0  sdas 66:192 active ready running
  |- 14:0:3:0  sdar 66:176 active ready running
  `- 17:0:3:0  sdch 69:80  active ready running
```

AFF or FAS configuration

An AFF or FAS configuration should have two groups of paths with higher and lower priorities. Higher priority Active/Optimized paths are served by the controller where the aggregate is located. Lower priority paths are active but non-optimized because they are served by a different controller. Non-optimized paths are only used when optimized paths aren't available.

The following example displays the output for an ONTAP LUN with two Active/Optimized paths and two Active/Non-Optimized paths:

```
# multipath -ll
3600a0980383149764b5d567257516273 dm-0 NETAPP,LUN C-Mode
size=150G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
|-+- policy='service-time 0' prio=50 status=active
| |- 16:0:3:0  sdcg 69:64  active ready running
| `- 10:0:0:0  sdb  8:16   active ready running
`-+- policy='service-time 0' prio=10 status=enabled
  |- 10:0:1:0  sdc  8:32   active ready running
  `- 16:0:2:0  sdcf 69:48  active ready running
```

Step 4: Optionally, exclude a device from multipathing

If required, you can exclude a device from multipathing by adding the WWID for the unwanted device to the "blacklist" stanza for the `multipath.conf` file.

Steps

1. Determine the WWID:

```
/lib/udev/scsi_id -gud /dev/sda
```

"sda" is the local SCSI disk that you want to add to the blacklist.

An example WWID is `360030057024d0730239134810c0cb833`.

2. Add the WWID to the "blacklist" stanza:

```
blacklist {
        wwid    360030057024d0730239134810c0cb833
        devnode "^(ram|raw|loop|fd|md|dm-|sr|scd|st)[0-9]*"
        devnode "^hd[a-z]"
        devnode "^cciss.*"
}
```

Step 5: Customize multipath parameters for ONTAP LUNs

If your host is connected to LUNs from other vendors and any of the multipath parameter settings are overridden, you need to correct them by adding stanzas later in the `multipath.conf` file that apply specifically to ONTAP LUNs. If you don't do this, the ONTAP LUNs might not work as expected.

Check your `/etc/multipath.conf` file, especially in the defaults section, for settings that might be overriding the default settings for multipath parameters.

> ⚠ You shouldn't override the recommended parameter settings for ONTAP LUNs. These settings
> are required for optimal performance of your host configuration. Contact NetApp support, your
> OS vendor, or both for more information.

The following example shows how to correct an overridden default. In this example, the `multipath.conf` file defines values for `path_checker` and `no_path_retry` that aren't compatible with ONTAP LUNs, and you can't remove these parameters because ONTAP storage arrays are still attached to the host. Instead, you correct the values for `path_checker` and `no_path_retry` by adding a device stanza to the `multipath.conf` file that applies specifically to the ONTAP LUNs.

```
defaults {
    path_checker        readsector0
    no_path_retry       fail
}

devices {
    device {
        vendor          "NETAPP"
        product         "LUN"
        no_path_retry   queue
        path_checker    tur
    }
}
```

Step 6: Review the known issues

The Rocky Linux 9.3 release for FCP and iSCSI with ONTAP storage has the following known issues:

NetApp Bug ID	Title	Description	JIRA ID
1508554	NetApp Linux Host Utilities CLI requires additional library package dependencies to support Emulex host bus adapter (HBA) adapter discovery	In RHEL 9.x, the NetApp Linux SAN Host Utilities CLI `sanlun fcp show adapter -v` fails because the library package dependencies to support Emulex host bus adapter (HBA) discovery cannot be found.	Not applicable
1593771	A Red Hat Enterprise Linux 9.3 QLogic SAN host encounters loss of partial multipaths during storage mobility operations	During the ONTAP storage controller takeover operation, half of the multipaths are expected to go down or switch to a failover mode and then recover to full path count during the giveback workflow. However, with a Red Hat Enterprise Linux (RHEL) 9.3 QLogic host, only partial multipaths are recovered after a storage failover giveback operation.	RHEL 17811

What's next?

- Learn about using the Linux Host Utilities tool.
- Learn about ASM mirroring.

  Automatic Storage Management (ASM) mirroring might require changes to the Linux multipath settings to allow ASM to recognize a problem and switch over to an alternate failure group. Most ASM configurations on ONTAP use external redundancy, which means that data protection is provided by the external array and ASM doesn't mirror data. Some sites use ASM with normal redundancy to provide two-way mirroring, normally across different sites. See Oracle databases on ONTAP for further information.

Configure Rocky Linux 9.2 for FCP and iSCSI with ONTAP storage

The Linux Host Utilities software provides management and diagnostic tools for Linux hosts that are connected to ONTAP storage. When you install Linux Host Utilities on a Rocky Linux 9.2 host, you can use the Host Utilities to help you manage FCP and iSCSI protocol operations with ONTAP LUNs.

> ⓘ You don't need to configure Kernel-based Virtual Machine (KVM) settings because ONTAP LUNs are automatically mapped to the KVM hypervisor.

Step 1: Optionally, enable SAN booting

You can configure your host to use SAN booting to simplify deployment and improve scalability.

Before you begin

Use the Interoperability Matrix Tool to verify that your Linux OS, host bus adapter (HBA), HBA firmware, HBA boot BIOS, and ONTAP version support SAN booting.

Steps

1. Create a SAN boot LUN and map it to the host.

2. Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is mapped.

   For information on how to enable the HBA BIOS, see your vendor-specific documentation.

3. Verify that the configuration was successful by rebooting the host and verifying that the OS is up and running.

Step 2: Install the Linux Host Utilities

NetApp strongly recommends installing the Linux Host Utilities to support ONTAP LUN management and assist technical support with gathering configuration data.

Install Linux Host Utilities 8.0.

> ⓘ Installing the Linux Host Utilities doesn't change any host timeout settings on your Linux host.

Step 3: Confirm the multipath configuration for your host

You can use multipathing with Rocky Linux 9.2 to manage ONTAP LUNs.

To ensure that multipathing is configured correctly for your host, verify that the `/etc/multipath.conf` file is defined and that you have the NetApp recommended settings configured for your ONTAP LUNs.

Steps

1. Verify that the `/etc/multipath.conf` file exists:

   ```
   ls /etc/multipath.conf
   ```

   If the file doesn't exist, create an empty, zero-byte file:

   ```
   touch /etc/multipath.conf
   ```

2. The first time the `multipath.conf` file is created, you might need to enable and start the multipath services to load the recommended settings:

   ```
   systemctl enable multipathd
   ```

   ```
   systemctl start multipathd
   ```

3. Each time you boot the host, the empty `/etc/multipath.conf` zero-byte file automatically loads the NetApp recommended host multipath parameters as the default settings. You shouldn't need to make changes to the `/etc/multipath.conf` file for your host because the host operating system is compiled with the multipath parameters that recognize and manage ONTAP LUNs correctly.

The following table shows the native Linux OS compiled multipath parameter settings for ONTAP LUNs.

Show parameter settings

Parameter	Setting
detect_prio	yes
dev_loss_tmo	"infinity"
failback	immediate
fast_io_fail_tmo	5
features	"2 pg_init_retries 50"
flush_on_last_del	"yes"
hardware_handler	"0"
no_path_retry	queue
path_checker	"tur"
path_grouping_policy	"group_by_prio"
path_selector	"service-time 0"
polling_interval	5
prio	"ontap"
product	LUN
retain_attached_hw_handler	yes
rr_weight	"uniform"
user_friendly_names	no
vendor	NETAPP

4. Verify the parameter settings and path status for your ONTAP LUNs:

```
multipath -ll
```

The default multipath parameters support ASA, AFF, and FAS configurations. In these configurations, a single ONTAP LUN shouldn't require more than four paths. If there are more than four paths, it might cause issues with the paths during a storage failure.

The following example outputs show the correct parameter settings and path status for ONTAP LUNs in an ASA, AFF, or FAS configuration.

ASA configuration

An ASA configuration optimizes all paths to a given LUN, keeping them active. This improves performance by serving I/O operations through all paths at the same time.

```
# multipath -ll
3600a098038314c4a433f577471797958 dm-2 NETAPP,LUN C-Mode
size=180G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
`-+- policy='service-time 0' prio=50 status=active
  |- 14:0:0:0  sdc  8:32   active ready running
  |- 17:0:0:0  sdas 66:192 active ready running
  |- 14:0:3:0  sdar 66:176 active ready running
  `- 17:0:3:0  sdch 69:80  active ready running
```

AFF or FAS configuration

An AFF or FAS configuration should have two groups of paths with higher and lower priorities. Higher priority Active/Optimized paths are served by the controller where the aggregate is located. Lower priority paths are active but non-optimized because they are served by a different controller. Non-optimized paths are only used when optimized paths aren't available.

The following example displays the output for an ONTAP LUN with two Active/Optimized paths and two Active/Non-Optimized paths:

```
# multipath -ll
3600a0980383149764b5d567257516273 dm-0 NETAPP,LUN C-Mode
size=150G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
|-+- policy='service-time 0' prio=50 status=active
| |- 16:0:3:0  sdcg 69:64  active ready running
| `- 10:0:0:0  sdb  8:16   active ready running
`-+- policy='service-time 0' prio=10 status=enabled
  |- 10:0:1:0  sdc  8:32   active ready running
  `- 16:0:2:0  sdcf 69:48  active ready running
```

Step 4: Optionally, exclude a device from multipathing

If required, you can exclude a device from multipathing by adding the WWID for the unwanted device to the "blacklist" stanza for the `multipath.conf` file.

Steps

1. Determine the WWID:

```
/lib/udev/scsi_id -gud /dev/sda
```

"sda" is the local SCSI disk that you want to add to the blacklist.

An example WWID is `360030057024d0730239134810c0cb833`.

2. Add the WWID to the "blacklist" stanza:

```
blacklist {
        wwid    360030057024d0730239134810c0cb833
        devnode "^(ram|raw|loop|fd|md|dm-|sr|scd|st)[0-9]*"
        devnode "^hd[a-z]"
        devnode "^cciss.*"
}
```

Step 5: Customize multipath parameters for ONTAP LUNs

If your host is connected to LUNs from other vendors and any of the multipath parameter settings are overridden, you need to correct them by adding stanzas later in the `multipath.conf` file that apply specifically to ONTAP LUNs. If you don't do this, the ONTAP LUNs might not work as expected.

Check your `/etc/multipath.conf` file, especially in the defaults section, for settings that might be overriding the default settings for multipath parameters.

> ⚠️ You shouldn't override the recommended parameter settings for ONTAP LUNs. These settings are required for optimal performance of your host configuration. Contact NetApp support, your OS vendor, or both for more information.

The following example shows how to correct an overridden default. In this example, the `multipath.conf` file defines values for `path_checker` and `no_path_retry` that aren't compatible with ONTAP LUNs, and you can't remove these parameters because ONTAP storage arrays are still attached to the host. Instead, you correct the values for `path_checker` and `no_path_retry` by adding a device stanza to the `multipath.conf` file that applies specifically to the ONTAP LUNs.

```
defaults {
    path_checker        readsector0
    no_path_retry       fail
}

devices {
    device {
        vendor          "NETAPP"
        product         "LUN"
        no_path_retry   queue
        path_checker    tur
    }
}
```

Step 6: Review the known issues

The Rocky Linux 9.2 release for FCP and iSCSI with ONTAP storage has the following known issues:

NetApp Bug ID	Title	Description
1508554	NetApp Linux Host Utilities CLI requires additional library package dependencies to support Emulex HBA adapter discovery	In RHEL 9.2, the NetApp Linux SAN Host Utilities CLI `sanlun fcp show adapter -v` fails because the library package dependencies to support HBA discovery cannot be found.
1537359	A Red Hat Linux 9.2 SAN booted host with Emulex HBA encounters stalled tasks leading to kernel disruption	During a storage failover giveback operation, a Red Hat Linux 9.2 SAN booted host with an Emulex host bus adapeter (HBA) encounters stalled tasks leading to kernel disruption. The kernel disruption causes the operating system to reboot and if `kdump` is configured, it generates the `vmcore` file under the `/var/crash/` directory. The issue is being triaged with the `lpfc` driver but it cannot be reproduced consistently.

What's next?

- Learn about using the Linux Host Utilities tool.
- Learn about ASM mirroring.

  Automatic Storage Management (ASM) mirroring might require changes to the Linux multipath settings to allow ASM to recognize a problem and switch over to an alternate failure group. Most ASM configurations on ONTAP use external redundancy, which means that data protection is provided by the external array and ASM doesn't mirror data. Some sites use ASM with normal redundancy to provide two-way mirroring, normally across different sites. See Oracle databases on ONTAP for further information.

Configure Rocky Linux 9.1 for FCP and iSCSI with ONTAP storage

The Linux Host Utilities software provides management and diagnostic tools for Linux hosts that are connected to ONTAP storage. When you install Linux Host Utilities on a Rocky Linux 9.1 host, you can use the Host Utilities to help you manage FCP and iSCSI protocol operations with ONTAP LUNs.

ⓘ You don't need to configure Kernel-based Virtual Machine (KVM) settings because ONTAP LUNs are automatically mapped to the KVM hypervisor.

Step 1: Optionally, enable SAN booting

You can configure your host to use SAN booting to simplify deployment and improve scalability.

Before you begin

Use the Interoperability Matrix Tool to verify that your Linux OS, host bus adapter (HBA), HBA firmware, HBA boot BIOS, and ONTAP version support SAN booting.

Steps

1. Create a SAN boot LUN and map it to the host.

2. Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is mapped.

   For information on how to enable the HBA BIOS, see your vendor-specific documentation.

3. Verify that the configuration was successful by rebooting the host and verifying that the OS is up and running.

Step 2: Install the Linux Host Utilities

NetApp strongly recommends installing the Linux Host Utilities to support ONTAP LUN management and assist technical support with gathering configuration data.

Install Linux Host Utilities 8.0.

> ⓘ   Installing the Linux Host Utilities doesn't change any host timeout settings on your Linux host.

Step 3: Confirm the multipath configuration for your host

You can use multipathing with Rocky Linux 9.1 to manage ONTAP LUNs.

To ensure that multipathing is configured correctly for your host, verify that the `/etc/multipath.conf` file is defined and that you have the NetApp recommended settings configured for your ONTAP LUNs.

Steps

1. Verify that the `/etc/multipath.conf` file exists:

   ```
   ls /etc/multipath.conf
   ```

   If the file doesn't exist, create an empty, zero-byte file:

   ```
   touch /etc/multipath.conf
   ```

2. The first time the `multipath.conf` file is created, you might need to enable and start the multipath services to load the recommended settings:

   ```
   systemctl enable multipathd
   ```

   ```
   systemctl start multipathd
   ```

3. Each time you boot the host, the empty `/etc/multipath.conf` zero-byte file automatically loads the NetApp recommended host multipath parameters as the default settings. You shouldn't need to make changes to the `/etc/multipath.conf` file for your host because the host operating system is compiled with the multipath parameters that recognize and manage ONTAP LUNs correctly.

The following table shows the native Linux OS compiled multipath parameter settings for ONTAP LUNs.

Show parameter settings

Parameter	Setting
detect_prio	yes
dev_loss_tmo	"infinity"
failback	immediate
fast_io_fail_tmo	5
features	"2 pg_init_retries 50"
flush_on_last_del	"yes"
hardware_handler	"0"
no_path_retry	queue
path_checker	"tur"
path_grouping_policy	"group_by_prio"
path_selector	"service-time 0"
polling_interval	5
prio	"ontap"
product	LUN
retain_attached_hw_handler	yes
rr_weight	"uniform"
user_friendly_names	no
vendor	NETAPP

4. Verify the parameter settings and path status for your ONTAP LUNs:

```
multipath -ll
```

The default multipath parameters support ASA, AFF, and FAS configurations. In these configurations, a single ONTAP LUN shouldn't require more than four paths. If there are more than four paths, it might cause issues with the paths during a storage failure.

The following example outputs show the correct parameter settings and path status for ONTAP LUNs in an ASA, AFF, or FAS configuration.

ASA configuration

An ASA configuration optimizes all paths to a given LUN, keeping them active. This improves performance by serving I/O operations through all paths at the same time.

```
# multipath -ll
3600a098038314c4a433f577471797958 dm-2 NETAPP,LUN C-Mode
size=180G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
`-+- policy='service-time 0' prio=50 status=active
  |- 14:0:0:0  sdc  8:32   active ready running
  |- 17:0:0:0  sdas 66:192 active ready running
  |- 14:0:3:0  sdar 66:176 active ready running
  `- 17:0:3:0  sdch 69:80  active ready running
```

AFF or FAS configuration

An AFF or FAS configuration should have two groups of paths with higher and lower priorities. Higher priority Active/Optimized paths are served by the controller where the aggregate is located. Lower priority paths are active but non-optimized because they are served by a different controller. Non-optimized paths are only used when optimized paths aren't available.

The following example displays the output for an ONTAP LUN with two Active/Optimized paths and two Active/Non-Optimized paths:

```
# multipath -ll
3600a0980383149764b5d567257516273 dm-0 NETAPP,LUN C-Mode
size=150G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
|-+- policy='service-time 0' prio=50 status=active
| |- 16:0:3:0  sdcg 69:64  active ready running
| `- 10:0:0:0  sdb  8:16   active ready running
`-+- policy='service-time 0' prio=10 status=enabled
  |- 10:0:1:0  sdc  8:32   active ready running
  `- 16:0:2:0  sdcf 69:48  active ready running
```

Step 4: Optionally, exclude a device from multipathing

If required, you can exclude a device from multipathing by adding the WWID for the unwanted device to the "blacklist" stanza for the `multipath.conf` file.

Steps

1. Determine the WWID:

```
/lib/udev/scsi_id -gud /dev/sda
```

"sda" is the local SCSI disk that you want to add to the blacklist.

An example WWID is `360030057024d0730239134810c0cb833`.

2. Add the WWID to the "blacklist" stanza:

```
blacklist {
           wwid    360030057024d0730239134810c0cb833
           devnode "^(ram|raw|loop|fd|md|dm-|sr|scd|st)[0-9]*"
           devnode "^hd[a-z]"
           devnode "^cciss.*"
}
```

Step 5: Customize multipath parameters for ONTAP LUNs

If your host is connected to LUNs from other vendors and any of the multipath parameter settings are overridden, you need to correct them by adding stanzas later in the `multipath.conf` file that apply specifically to ONTAP LUNs. If you don't do this, the ONTAP LUNs might not work as expected.

Check your `/etc/multipath.conf` file, especially in the defaults section, for settings that might be overriding the default settings for multipath parameters.

> ⚠️ You shouldn't override the recommended parameter settings for ONTAP LUNs. These settings are required for optimal performance of your host configuration. Contact NetApp support, your OS vendor, or both for more information.

The following example shows how to correct an overridden default. In this example, the `multipath.conf` file defines values for `path_checker` and `no_path_retry` that aren't compatible with ONTAP LUNs, and you can't remove these parameters because ONTAP storage arrays are still attached to the host. Instead, you correct the values for `path_checker` and `no_path_retry` by adding a device stanza to the `multipath.conf` file that applies specifically to the ONTAP LUNs.

```
defaults {
    path_checker        readsector0
    no_path_retry       fail
}

devices {
    device {
        vendor          "NETAPP"
        product         "LUN"
        no_path_retry   queue
        path_checker    tur
    }
}
```

Step 6: Review the known issues

The Rocky Linux 9.1 release for FCP and iSCSI with ONTAP storage has the following known issues:

NetApp Bug ID	Title	Description
1508554	NetApp Linux Host Utilities CLI requires additional library package dependencies to support Emulex HBA adapter discovery	In Rocky Linux 9.1, the NetApp Linux SAN Host Utilities CLI `sanlun fcp show adapter -v` fails because the library package dependencies to support HBA discovery cannot be found.

What's next?

- [Learn about using the Linux Host Utilities tool](#).
- Learn about ASM mirroring.

  Automatic Storage Management (ASM) mirroring might require changes to the Linux multipath settings to allow ASM to recognize a problem and switch over to an alternate failure group. Most ASM configurations on ONTAP use external redundancy, which means that data protection is provided by the external array and ASM doesn't mirror data. Some sites use ASM with normal redundancy to provide two-way mirroring, normally across different sites. See [Oracle databases on ONTAP](#) for further information.

Configure Rocky Linux 9.0 for FCP and iSCSI with ONTAP storage

The Linux Host Utilities software provides management and diagnostic tools for Linux hosts that are connected to ONTAP storage. When you install Linux Host Utilities on a Rocky Linux 9.0 host, you can use the Host Utilities to help you manage FCP and iSCSI protocol operations with ONTAP LUNs.

(i) | You don't need to configure Kernel-based Virtual Machine (KVM) settings because ONTAP LUNs are automatically mapped to the KVM hypervisor.

Step 1: Optionally, enable SAN booting

You can configure your host to use SAN booting to simplify deployment and improve scalability.

Before you begin

Use the [Interoperability Matrix Tool](#) to verify that your Linux OS, host bus adapter (HBA), HBA firmware, HBA boot BIOS, and ONTAP version support SAN booting.

Steps

1. [Create a SAN boot LUN and map it to the host](#).
2. Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is mapped.

   For information on how to enable the HBA BIOS, see your vendor-specific documentation.

3. Verify that the configuration was successful by rebooting the host and verifying that the OS is up and running.

Step 2: Install the Linux Host Utilities

NetApp strongly recommends installing the Linux Host Utilities to support ONTAP LUN management and assist technical support with gathering configuration data.

Install Linux Host Utilities 8.0.

> ⓘ   Installing the Linux Host Utilities doesn't change any host timeout settings on your Linux host.

Step 3: Confirm the multipath configuration for your host

You can use multipathing with Rocky Linux 9.0 to manage ONTAP LUNs.

To ensure that multipathing is configured correctly for your host, verify that the `/etc/multipath.conf` file is defined and that you have the NetApp recommended settings configured for your ONTAP LUNs.

Steps

1. Verify that the `/etc/multipath.conf` file exists:

   ```
   ls /etc/multipath.conf
   ```

   If the file doesn't exist, create an empty, zero-byte file:

   ```
   touch /etc/multipath.conf
   ```

2. The first time the `multipath.conf` file is created, you might need to enable and start the multipath services to load the recommended settings:

   ```
   systemctl enable multipathd
   ```

   ```
   systemctl start multipathd
   ```

3. Each time you boot the host, the empty `/etc/multipath.conf` zero-byte file automatically loads the NetApp recommended host multipath parameters as the default settings. You shouldn't need to make changes to the `/etc/multipath.conf` file for your host because the host operating system is compiled with the multipath parameters that recognize and manage ONTAP LUNs correctly.

   The following table shows the native Linux OS compiled multipath parameter settings for ONTAP LUNs.

Show parameter settings

Parameter	Setting
detect_prio	yes
dev_loss_tmo	"infinity"
failback	immediate
fast_io_fail_tmo	5
features	"2 pg_init_retries 50"
flush_on_last_del	"yes"
hardware_handler	"0"
no_path_retry	queue
path_checker	"tur"
path_grouping_policy	"group_by_prio"
path_selector	"service-time 0"
polling_interval	5
prio	"ontap"
product	LUN
retain_attached_hw_handler	yes
rr_weight	"uniform"
user_friendly_names	no
vendor	NETAPP

4. Verify the parameter settings and path status for your ONTAP LUNs:

```
multipath -ll
```

The default multipath parameters support ASA, AFF, and FAS configurations. In these configurations, a single ONTAP LUN shouldn't require more than four paths. If there are more than four paths, it might cause issues with the paths during a storage failure.

The following example outputs show the correct parameter settings and path status for ONTAP LUNs in an ASA, AFF, or FAS configuration.

ASA configuration

An ASA configuration optimizes all paths to a given LUN, keeping them active. This improves performance by serving I/O operations through all paths at the same time.

```
# multipath -ll
3600a098038314c4a433f577471797958 dm-2 NETAPP,LUN C-Mode
size=180G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
`-+- policy='service-time 0' prio=50 status=active
  |- 14:0:0:0  sdc  8:32   active ready running
  |- 17:0:0:0  sdas 66:192 active ready running
  |- 14:0:3:0  sdar 66:176 active ready running
  `- 17:0:3:0  sdch 69:80  active ready running
```

AFF or FAS configuration

An AFF or FAS configuration should have two groups of paths with higher and lower priorities. Higher priority Active/Optimized paths are served by the controller where the aggregate is located. Lower priority paths are active but non-optimized because they are served by a different controller. Non-optimized paths are only used when optimized paths aren't available.

The following example displays the output for an ONTAP LUN with two Active/Optimized paths and two Active/Non-Optimized paths:

```
# multipath -ll
3600a0980383149764b5d567257516273 dm-0 NETAPP,LUN C-Mode
size=150G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
|-+- policy='service-time 0' prio=50 status=active
| |- 16:0:3:0  sdcg 69:64  active ready running
| `- 10:0:0:0  sdb  8:16   active ready running
`-+- policy='service-time 0' prio=10 status=enabled
  |- 10:0:1:0  sdc  8:32   active ready running
  `- 16:0:2:0  sdcf 69:48  active ready running
```

Step 4: Optionally, exclude a device from multipathing

If required, you can exclude a device from multipathing by adding the WWID for the unwanted device to the "blacklist" stanza for the `multipath.conf` file.

Steps

1. Determine the WWID:

```
/lib/udev/scsi_id -gud /dev/sda
```

"sda" is the local SCSI disk that you want to add to the blacklist.

An example WWID is `360030057024d0730239134810c0cb833`.

2. Add the WWID to the "blacklist" stanza:

```
blacklist {
        wwid    360030057024d0730239134810c0cb833
        devnode "^(ram|raw|loop|fd|md|dm-|sr|scd|st)[0-9]*"
        devnode "^hd[a-z]"
        devnode "^cciss.*"
}
```

Step 5: Customize multipath parameters for ONTAP LUNs

If your host is connected to LUNs from other vendors and any of the multipath parameter settings are overridden, you need to correct them by adding stanzas later in the `multipath.conf` file that apply specifically to ONTAP LUNs. If you don't do this, the ONTAP LUNs might not work as expected.

Check your `/etc/multipath.conf` file, especially in the defaults section, for settings that might be overriding the default settings for multipath parameters.

> ⚠️ You shouldn't override the recommended parameter settings for ONTAP LUNs. These settings are required for optimal performance of your host configuration. Contact NetApp support, your OS vendor, or both for more information.

The following example shows how to correct an overridden default. In this example, the `multipath.conf` file defines values for `path_checker` and `no_path_retry` that aren't compatible with ONTAP LUNs, and you can't remove these parameters because ONTAP storage arrays are still attached to the host. Instead, you correct the values for `path_checker` and `no_path_retry` by adding a device stanza to the `multipath.conf` file that applies specifically to the ONTAP LUNs.

```
defaults {
    path_checker        readsector0
    no_path_retry       fail
}

devices {
    device {
        vendor          "NETAPP"
        product         "LUN"
        no_path_retry   queue
        path_checker    tur
    }
}
```

Step 6: Review the known issues

There are no known issues.

What's next?

- Learn about using the Linux Host Utilities tool.
- Learn about ASM mirroring.

  Automatic Storage Management (ASM) mirroring might require changes to the Linux multipath settings to allow ASM to recognize a problem and switch over to an alternate failure group. Most ASM configurations on ONTAP use external redundancy, which means that data protection is provided by the external array and ASM doesn't mirror data. Some sites use ASM with normal redundancy to provide two-way mirroring, normally across different sites. See Oracle databases on ONTAP for further information.

Rocky Linux 8

Configure Rocky Linux 8.10 for FCP and iSCSI with ONTAP storage

The Linux Host Utilities software provides management and diagnostic tools for Linux hosts that are connected to ONTAP storage. When you install Linux Host Utilities on a Rocky Linux 8.10 host, you can use the Host Utilities to help you manage FCP and iSCSI protocol operations with ONTAP LUNs.

> ⓘ You don't need to configure Kernel-based Virtual Machine (KVM) settings because ONTAP LUNs are automatically mapped to the KVM hypervisor.

Step 1: Optionally, enable SAN booting

You can configure your host to use SAN booting to simplify deployment and improve scalability.

Before you begin

Use the Interoperability Matrix Tool to verify that your Linux OS, host bus adapter (HBA), HBA firmware, HBA boot BIOS, and ONTAP version support SAN booting.

Steps

1. Create a SAN boot LUN and map it to the host.
2. Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is mapped.

   For information on how to enable the HBA BIOS, see your vendor-specific documentation.

3. Verify that the configuration was successful by rebooting the host and verifying that the OS is up and running.

Step 2: Install the Linux Host Utilities

NetApp strongly recommends installing the Linux Host Utilities to support ONTAP LUN management and assist technical support with gathering configuration data.

Install Linux Host Utilities 8.0.

| | Installing the Linux Host Utilities doesn't change any host timeout settings on your Linux host. |

Step 3: Confirm the multipath configuration for your host

You can use multipathing with Rocky Linux 8.10 to manage ONTAP LUNs.

To ensure that multipathing is configured correctly for your host, verify that the `/etc/multipath.conf` file is defined and that you have the NetApp recommended settings configured for your ONTAP LUNs.

Steps

1. Verify that the `/etc/multipath.conf` file exists:

   ```
   ls /etc/multipath.conf
   ```

   If the file doesn't exist, create an empty, zero-byte file:

   ```
   touch /etc/multipath.conf
   ```

2. The first time the `multipath.conf` file is created, you might need to enable and start the multipath services to load the recommended settings:

   ```
   systemctl enable multipathd
   ```

   ```
   systemctl start multipathd
   ```

3. Each time you boot the host, the empty `/etc/multipath.conf` zero-byte file automatically loads the NetApp recommended host multipath parameters as the default settings. You shouldn't need to make changes to the `/etc/multipath.conf` file for your host because the host operating system is compiled with the multipath parameters that recognize and manage ONTAP LUNs correctly.

   The following table shows the native Linux OS compiled multipath parameter settings for ONTAP LUNs.

Show parameter settings

Parameter	Setting
detect_prio	yes
dev_loss_tmo	"infinity"
failback	immediate
fast_io_fail_tmo	5
features	"2 pg_init_retries 50"
flush_on_last_del	"yes"
hardware_handler	"0"
no_path_retry	queue
path_checker	"tur"
path_grouping_policy	"group_by_prio"
path_selector	"service-time 0"
polling_interval	5
prio	"ontap"
product	LUN
retain_attached_hw_handler	yes
rr_weight	"uniform"
user_friendly_names	no
vendor	NETAPP

4. Verify the parameter settings and path status for your ONTAP LUNs:

```
multipath -ll
```

The default multipath parameters support ASA, AFF, and FAS configurations. In these configurations, a single ONTAP LUN shouldn't require more than four paths. If there are more than four paths, it might cause issues with the paths during a storage failure.

The following example outputs show the correct parameter settings and path status for ONTAP LUNs in an ASA, AFF, or FAS configuration.

ASA configuration

An ASA configuration optimizes all paths to a given LUN, keeping them active. This improves performance by serving I/O operations through all paths at the same time.

```
# multipath -ll
3600a098038314c4a433f577471797958 dm-2 NETAPP,LUN C-Mode
size=180G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
`-+- policy='service-time 0' prio=50 status=active
  |- 14:0:0:0  sdc  8:32   active ready running
  |- 17:0:0:0  sdas 66:192 active ready running
  |- 14:0:3:0  sdar 66:176 active ready running
  `- 17:0:3:0  sdch 69:80  active ready running
```

AFF or FAS configuration

An AFF or FAS configuration should have two groups of paths with higher and lower priorities. Higher priority Active/Optimized paths are served by the controller where the aggregate is located. Lower priority paths are active but non-optimized because they are served by a different controller. Non-optimized paths are only used when optimized paths aren't available.

The following example displays the output for an ONTAP LUN with two Active/Optimized paths and two Active/Non-Optimized paths:

```
# multipath -ll
3600a0980383149764b5d567257516273 dm-0 NETAPP,LUN C-Mode
size=150G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
|-+- policy='service-time 0' prio=50 status=active
| |- 16:0:3:0  sdcg 69:64  active ready running
| `- 10:0:0:0  sdb  8:16   active ready running
`-+- policy='service-time 0' prio=10 status=enabled
  |- 10:0:1:0  sdc  8:32   active ready running
  `- 16:0:2:0  sdcf 69:48  active ready running
```

Step 4: Optionally, exclude a device from multipathing

If required, you can exclude a device from multipathing by adding the WWID for the unwanted device to the "blacklist" stanza for the `multipath.conf` file.

Steps

1. Determine the WWID:

```
/lib/udev/scsi_id -gud /dev/sda
```

"sda" is the local SCSI disk that you want to add to the blacklist.

An example WWID is `360030057024d0730239134810c0cb833`.

2. Add the WWID to the "blacklist" stanza:

```
blacklist {
        wwid    360030057024d0730239134810c0cb833
        devnode "^(ram|raw|loop|fd|md|dm-|sr|scd|st)[0-9]*"
        devnode "^hd[a-z]"
        devnode "^cciss.*"
}
```

Step 5: Customize multipath parameters for ONTAP LUNs

If your host is connected to LUNs from other vendors and any of the multipath parameter settings are overridden, you need to correct them by adding stanzas later in the `multipath.conf` file that apply specifically to ONTAP LUNs. If you don't do this, the ONTAP LUNs might not work as expected.

Check your `/etc/multipath.conf` file, especially in the defaults section, for settings that might be overriding the default settings for multipath parameters.

> ⚠️ You shouldn't override the recommended parameter settings for ONTAP LUNs. These settings are required for optimal performance of your host configuration. Contact NetApp support, your OS vendor, or both for more information.

The following example shows how to correct an overridden default. In this example, the `multipath.conf` file defines values for `path_checker` and `no_path_retry` that aren't compatible with ONTAP LUNs, and you can't remove these parameters because ONTAP storage arrays are still attached to the host. Instead, you correct the values for `path_checker` and `no_path_retry` by adding a device stanza to the `multipath.conf` file that applies specifically to the ONTAP LUNs.

```
defaults {
    path_checker        readsector0
    no_path_retry       fail
}

devices {
    device {
        vendor          "NETAPP"
        product         "LUN"
        no_path_retry   queue
        path_checker    tur
    }
}
```

Step 6: Review the known issues

There are no known issues.

What's next?

- Learn about using the Linux Host Utilities tool.
- Learn about ASM mirroring.

  Automatic Storage Management (ASM) mirroring might require changes to the Linux multipath settings to allow ASM to recognize a problem and switch over to an alternate failure group. Most ASM configurations on ONTAP use external redundancy, which means that data protection is provided by the external array and ASM doesn't mirror data. Some sites use ASM with normal redundancy to provide two-way mirroring, normally across different sites. See Oracle databases on ONTAP for further information.

Configure Rocky Linux 8.9 for FCP and iSCSI with ONTAP storage

The Linux Host Utilities software provides management and diagnostic tools for Linux hosts that are connected to ONTAP storage. When you install Linux Host Utilities on a Rocky Linux 8.9 host, you can use the Host Utilities to help you manage FCP and iSCSI protocol operations with ONTAP LUNs.

> ⓘ You don't need to configure Kernel-based Virtual Machine (KVM) settings because ONTAP LUNs are automatically mapped to the KVM hypervisor.

Step 1: Optionally, enable SAN booting

You can configure your host to use SAN booting to simplify deployment and improve scalability.

Before you begin

Use the Interoperability Matrix Tool to verify that your Linux OS, host bus adapter (HBA), HBA firmware, HBA boot BIOS, and ONTAP version support SAN booting.

Steps

1. Create a SAN boot LUN and map it to the host.
2. Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is mapped.

   For information on how to enable the HBA BIOS, see your vendor-specific documentation.

3. Verify that the configuration was successful by rebooting the host and verifying that the OS is up and running.

Step 2: Install the Linux Host Utilities

NetApp strongly recommends installing the Linux Host Utilities to support ONTAP LUN management and assist technical support with gathering configuration data.

Install Linux Host Utilities 8.0.

> ⓘ Installing the Linux Host Utilities doesn't change any host timeout settings on your Linux host.

Step 3: Confirm the multipath configuration for your host

You can use multipathing with Rocky Linux 8.9 to manage ONTAP LUNs.

To ensure that multipathing is configured correctly for your host, verify that the `/etc/multipath.conf` file is defined and that you have the NetApp recommended settings configured for your ONTAP LUNs.

Steps

1. Verify that the `/etc/multipath.conf` file exists:

   ```
   ls /etc/multipath.conf
   ```

   If the file doesn't exist, create an empty, zero-byte file:

   ```
   touch /etc/multipath.conf
   ```

2. The first time the `multipath.conf` file is created, you might need to enable and start the multipath services to load the recommended settings:

   ```
   systemctl enable multipathd
   ```

   ```
   systemctl start multipathd
   ```

3. Each time you boot the host, the empty `/etc/multipath.conf` zero-byte file automatically loads the NetApp recommended host multipath parameters as the default settings. You shouldn't need to make changes to the `/etc/multipath.conf` file for your host because the host operating system is compiled with the multipath parameters that recognize and manage ONTAP LUNs correctly.

   The following table shows the native Linux OS compiled multipath parameter settings for ONTAP LUNs.

Show parameter settings

Parameter	Setting
detect_prio	yes
dev_loss_tmo	"infinity"
failback	immediate
fast_io_fail_tmo	5
features	"2 pg_init_retries 50"
flush_on_last_del	"yes"
hardware_handler	"0"
no_path_retry	queue
path_checker	"tur"
path_grouping_policy	"group_by_prio"
path_selector	"service-time 0"
polling_interval	5
prio	"ontap"
product	LUN
retain_attached_hw_handler	yes
rr_weight	"uniform"
user_friendly_names	no
vendor	NETAPP

4. Verify the parameter settings and path status for your ONTAP LUNs:

```
multipath -ll
```

The default multipath parameters support ASA, AFF, and FAS configurations. In these configurations, a single ONTAP LUN shouldn't require more than four paths. If there are more than four paths, it might cause issues with the paths during a storage failure.

The following example outputs show the correct parameter settings and path status for ONTAP LUNs in an ASA, AFF, or FAS configuration.

ASA configuration

An ASA configuration optimizes all paths to a given LUN, keeping them active. This improves performance by serving I/O operations through all paths at the same time.

```
# multipath -ll
3600a098038314c4a433f577471797958 dm-2 NETAPP,LUN C-Mode
size=180G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
`-+- policy='service-time 0' prio=50 status=active
  |- 14:0:0:0  sdc  8:32   active ready running
  |- 17:0:0:0  sdas 66:192 active ready running
  |- 14:0:3:0  sdar 66:176 active ready running
  `- 17:0:3:0  sdch 69:80  active ready running
```

AFF or FAS configuration

An AFF or FAS configuration should have two groups of paths with higher and lower priorities. Higher priority Active/Optimized paths are served by the controller where the aggregate is located. Lower priority paths are active but non-optimized because they are served by a different controller. Non-optimized paths are only used when optimized paths aren't available.

The following example displays the output for an ONTAP LUN with two Active/Optimized paths and two Active/Non-Optimized paths:

```
# multipath -ll
3600a0980383149764b5d567257516273 dm-0 NETAPP,LUN C-Mode
size=150G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
|-+- policy='service-time 0' prio=50 status=active
| |- 16:0:3:0  sdcg 69:64  active ready running
| `- 10:0:0:0  sdb  8:16   active ready running
`-+- policy='service-time 0' prio=10 status=enabled
  |- 10:0:1:0  sdc  8:32   active ready running
  `- 16:0:2:0  sdcf 69:48  active ready running
```

Step 4: Optionally, exclude a device from multipathing

If required, you can exclude a device from multipathing by adding the WWID for the unwanted device to the "blacklist" stanza for the `multipath.conf` file.

Steps

1. Determine the WWID:

```
/lib/udev/scsi_id -gud /dev/sda
```

"sda" is the local SCSI disk that you want to add to the blacklist.

An example WWID is `360030057024d0730239134810c0cb833`.

2. Add the WWID to the "blacklist" stanza:

```
blacklist {
        wwid    360030057024d0730239134810c0cb833
        devnode "^(ram|raw|loop|fd|md|dm-|sr|scd|st)[0-9]*"
        devnode "^hd[a-z]"
        devnode "^cciss.*"
}
```

Step 5: Customize multipath parameters for ONTAP LUNs

If your host is connected to LUNs from other vendors and any of the multipath parameter settings are overridden, you need to correct them by adding stanzas later in the `multipath.conf` file that apply specifically to ONTAP LUNs. If you don't do this, the ONTAP LUNs might not work as expected.

Check your `/etc/multipath.conf` file, especially in the defaults section, for settings that might be overriding the default settings for multipath parameters.

> ⚠️ You shouldn't override the recommended parameter settings for ONTAP LUNs. These settings are required for optimal performance of your host configuration. Contact NetApp support, your OS vendor, or both for more information.

The following example shows how to correct an overridden default. In this example, the `multipath.conf` file defines values for `path_checker` and `no_path_retry` that aren't compatible with ONTAP LUNs, and you can't remove these parameters because ONTAP storage arrays are still attached to the host. Instead, you correct the values for `path_checker` and `no_path_retry` by adding a device stanza to the `multipath.conf` file that applies specifically to the ONTAP LUNs.

```
defaults {
    path_checker        readsector0
    no_path_retry       fail
}

devices {
    device {
        vendor          "NETAPP"
        product         "LUN"
        no_path_retry   queue
        path_checker    tur
    }
}
```

Step 6: Review the known issues

There are no known issues.

What's next?

- Learn about using the Linux Host Utilities tool.
- Learn about ASM mirroring.

  Automatic Storage Management (ASM) mirroring might require changes to the Linux multipath settings to allow ASM to recognize a problem and switch over to an alternate failure group. Most ASM configurations on ONTAP use external redundancy, which means that data protection is provided by the external array and ASM doesn't mirror data. Some sites use ASM with normal redundancy to provide two-way mirroring, normally across different sites. See Oracle databases on ONTAP for further information.

Configure Rocky Linux 8.8 for FCP and iSCSI with ONTAP storage

The Linux Host Utilities software provides management and diagnostic tools for Linux hosts that are connected to ONTAP storage. When you install Linux Host Utilities on a Rocky Linux 8.8 host, you can use the Host Utilities to help you manage FCP and iSCSI protocol operations with ONTAP LUNs.

> ⓘ You don't need to configure Kernel-based Virtual Machine (KVM) settings because ONTAP LUNs are automatically mapped to the KVM hypervisor.

Step 1: Optionally, enable SAN booting

You can configure your host to use SAN booting to simplify deployment and improve scalability.

Before you begin

Use the Interoperability Matrix Tool to verify that your Linux OS, host bus adapter (HBA), HBA firmware, HBA boot BIOS, and ONTAP version support SAN booting.

Steps

1. Create a SAN boot LUN and map it to the host.
2. Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is mapped.

   For information on how to enable the HBA BIOS, see your vendor-specific documentation.

3. Verify that the configuration was successful by rebooting the host and verifying that the OS is up and running.

Step 2: Install the Linux Host Utilities

NetApp strongly recommends installing the Linux Host Utilities to support ONTAP LUN management and assist technical support with gathering configuration data.

Install Linux Host Utilities 8.0.

> ⓘ Installing the Linux Host Utilities doesn't change any host timeout settings on your Linux host.

Step 3: Confirm the multipath configuration for your host

You can use multipathing with Rocky Linux 8.8 to manage ONTAP LUNs.

To ensure that multipathing is configured correctly for your host, verify that the `/etc/multipath.conf` file is defined and that you have the NetApp recommended settings configured for your ONTAP LUNs.

Steps

1. Verify that the `/etc/multipath.conf` file exists:

```
ls /etc/multipath.conf
```

   If the file doesn't exist, create an empty, zero-byte file:

```
touch /etc/multipath.conf
```

2. The first time the `multipath.conf` file is created, you might need to enable and start the multipath services to load the recommended settings:

```
systemctl enable multipathd
```

```
systemctl start multipathd
```

3. Each time you boot the host, the empty `/etc/multipath.conf` zero-byte file automatically loads the NetApp recommended host multipath parameters as the default settings. You shouldn't need to make changes to the `/etc/multipath.conf` file for your host because the host operating system is compiled with the multipath parameters that recognize and manage ONTAP LUNs correctly.

   The following table shows the native Linux OS compiled multipath parameter settings for ONTAP LUNs.

Show parameter settings

Parameter	Setting
detect_prio	yes
dev_loss_tmo	"infinity"
failback	immediate
fast_io_fail_tmo	5
features	"2 pg_init_retries 50"
flush_on_last_del	"yes"
hardware_handler	"0"
no_path_retry	queue
path_checker	"tur"
path_grouping_policy	"group_by_prio"
path_selector	"service-time 0"
polling_interval	5
prio	"ontap"
product	LUN
retain_attached_hw_handler	yes
rr_weight	"uniform"
user_friendly_names	no
vendor	NETAPP

4. Verify the parameter settings and path status for your ONTAP LUNs:

```
multipath -ll
```

The default multipath parameters support ASA, AFF, and FAS configurations. In these configurations, a single ONTAP LUN shouldn't require more than four paths. If there are more than four paths, it might cause issues with the paths during a storage failure.

The following example outputs show the correct parameter settings and path status for ONTAP LUNs in an ASA, AFF, or FAS configuration.

ASA configuration

An ASA configuration optimizes all paths to a given LUN, keeping them active. This improves performance by serving I/O operations through all paths at the same time.

```
# multipath -ll
3600a098038314c4a433f577471797958 dm-2 NETAPP,LUN C-Mode
size=180G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
`-+- policy='service-time 0' prio=50 status=active
  |- 14:0:0:0  sdc  8:32   active ready running
  |- 17:0:0:0  sdas 66:192 active ready running
  |- 14:0:3:0  sdar 66:176 active ready running
  `- 17:0:3:0  sdch 69:80  active ready running
```

AFF or FAS configuration

An AFF or FAS configuration should have two groups of paths with higher and lower priorities. Higher priority Active/Optimized paths are served by the controller where the aggregate is located. Lower priority paths are active but non-optimized because they are served by a different controller. Non-optimized paths are only used when optimized paths aren't available.

The following example displays the output for an ONTAP LUN with two Active/Optimized paths and two Active/Non-Optimized paths:

```
# multipath -ll
3600a0980383149764b5d567257516273 dm-0 NETAPP,LUN C-Mode
size=150G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
|-+- policy='service-time 0' prio=50 status=active
| |- 16:0:3:0  sdcg 69:64  active ready running
| `- 10:0:0:0  sdb  8:16   active ready running
`-+- policy='service-time 0' prio=10 status=enabled
  |- 10:0:1:0  sdc  8:32   active ready running
  `- 16:0:2:0  sdcf 69:48  active ready running
```

Step 4: Optionally, exclude a device from multipathing

If required, you can exclude a device from multipathing by adding the WWID for the unwanted device to the "blacklist" stanza for the `multipath.conf` file.

Steps

1. Determine the WWID:

```
/lib/udev/scsi_id -gud /dev/sda
```

"sda" is the local SCSI disk that you want to add to the blacklist.

An example WWID is `360030057024d0730239134810c0cb833`.

2. Add the WWID to the "blacklist" stanza:

```
blacklist {
        wwid    360030057024d0730239134810c0cb833
        devnode "^(ram|raw|loop|fd|md|dm-|sr|scd|st)[0-9]*"
        devnode "^hd[a-z]"
        devnode "^cciss.*"
}
```

Step 5: Customize multipath parameters for ONTAP LUNs

If your host is connected to LUNs from other vendors and any of the multipath parameter settings are overridden, you need to correct them by adding stanzas later in the `multipath.conf` file that apply specifically to ONTAP LUNs. If you don't do this, the ONTAP LUNs might not work as expected.

Check your `/etc/multipath.conf` file, especially in the defaults section, for settings that might be overriding the default settings for multipath parameters.

> ⚠ You shouldn't override the recommended parameter settings for ONTAP LUNs. These settings are required for optimal performance of your host configuration. Contact NetApp support, your OS vendor, or both for more information.

The following example shows how to correct an overridden default. In this example, the `multipath.conf` file defines values for `path_checker` and `no_path_retry` that aren't compatible with ONTAP LUNs, and you can't remove these parameters because ONTAP storage arrays are still attached to the host. Instead, you correct the values for `path_checker` and `no_path_retry` by adding a device stanza to the `multipath.conf` file that applies specifically to the ONTAP LUNs.

```
defaults {
    path_checker        readsector0
    no_path_retry       fail
}

devices {
    device {
        vendor          "NETAPP"
        product         "LUN"
        no_path_retry   queue
        path_checker    tur
    }
}
```

Step 6: Review the known issues

There are no known issues.

What's next?

- Learn about using the Linux Host Utilities tool.
- Learn about ASM mirroring.

  Automatic Storage Management (ASM) mirroring might require changes to the Linux multipath settings to allow ASM to recognize a problem and switch over to an alternate failure group. Most ASM configurations on ONTAP use external redundancy, which means that data protection is provided by the external array and ASM doesn't mirror data. Some sites use ASM with normal redundancy to provide two-way mirroring, normally across different sites. See Oracle databases on ONTAP for further information.

Configure Rocky Linux 8.7 for FCP and iSCSI with ONTAP storage

The Linux Host Utilities software provides management and diagnostic tools for Linux hosts that are connected to ONTAP storage. When you install Linux Host Utilities on a Rocky Linux 8.7 host, you can use the Host Utilities to help you manage FCP and iSCSI protocol operations with ONTAP LUNs.

> ⓘ You don't need to configure Kernel-based Virtual Machine (KVM) settings because ONTAP LUNs are automatically mapped to the KVM hypervisor.

Step 1: Optionally, enable SAN booting

You can configure your host to use SAN booting to simplify deployment and improve scalability.

Before you begin

Use the Interoperability Matrix Tool to verify that your Linux OS, host bus adapter (HBA), HBA firmware, HBA boot BIOS, and ONTAP version support SAN booting.

Steps

1. Create a SAN boot LUN and map it to the host.
2. Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is mapped.

   For information on how to enable the HBA BIOS, see your vendor-specific documentation.

3. Verify that the configuration was successful by rebooting the host and verifying that the OS is up and running.

Step 2: Install the Linux Host Utilities

NetApp strongly recommends installing the Linux Host Utilities to support ONTAP LUN management and assist technical support with gathering configuration data.

Install Linux Host Utilities 8.0.

> ⓘ Installing the Linux Host Utilities doesn't change any host timeout settings on your Linux host.

Step 3: Confirm the multipath configuration for your host

You can use multipathing with Rocky Linux 8.7 to manage ONTAP LUNs.

To ensure that multipathing is configured correctly for your host, verify that the `/etc/multipath.conf` file is defined and that you have the NetApp recommended settings configured for your ONTAP LUNs.

Steps

1. Verify that the `/etc/multipath.conf` file exists:

   ```
   ls /etc/multipath.conf
   ```

   If the file doesn't exist, create an empty, zero-byte file:

   ```
   touch /etc/multipath.conf
   ```

2. The first time the `multipath.conf` file is created, you might need to enable and start the multipath services to load the recommended settings:

   ```
   systemctl enable multipathd
   ```

   ```
   systemctl start multipathd
   ```

3. Each time you boot the host, the empty `/etc/multipath.conf` zero-byte file automatically loads the NetApp recommended host multipath parameters as the default settings. You shouldn't need to make changes to the `/etc/multipath.conf` file for your host because the host operating system is compiled with the multipath parameters that recognize and manage ONTAP LUNs correctly.

   The following table shows the native Linux OS compiled multipath parameter settings for ONTAP LUNs.

Show parameter settings

Parameter	Setting
detect_prio	yes
dev_loss_tmo	"infinity"
failback	immediate
fast_io_fail_tmo	5
features	"2 pg_init_retries 50"
flush_on_last_del	"yes"
hardware_handler	"0"
no_path_retry	queue
path_checker	"tur"
path_grouping_policy	"group_by_prio"
path_selector	"service-time 0"
polling_interval	5
prio	"ontap"
product	LUN
retain_attached_hw_handler	yes
rr_weight	"uniform"
user_friendly_names	no
vendor	NETAPP

4. Verify the parameter settings and path status for your ONTAP LUNs:

```
multipath -ll
```

The default multipath parameters support ASA, AFF, and FAS configurations. In these configurations, a single ONTAP LUN shouldn't require more than four paths. If there are more than four paths, it might cause issues with the paths during a storage failure.

The following example outputs show the correct parameter settings and path status for ONTAP LUNs in an ASA, AFF, or FAS configuration.

ASA configuration

An ASA configuration optimizes all paths to a given LUN, keeping them active. This improves performance by serving I/O operations through all paths at the same time.

```
# multipath -ll
3600a098038314c4a433f577471797958 dm-2 NETAPP,LUN C-Mode
size=180G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
`-+- policy='service-time 0' prio=50 status=active
  |- 14:0:0:0  sdc  8:32   active ready running
  |- 17:0:0:0  sdas 66:192 active ready running
  |- 14:0:3:0  sdar 66:176 active ready running
  `- 17:0:3:0  sdch 69:80  active ready running
```

AFF or FAS configuration

An AFF or FAS configuration should have two groups of paths with higher and lower priorities. Higher priority Active/Optimized paths are served by the controller where the aggregate is located. Lower priority paths are active but non-optimized because they are served by a different controller. Non-optimized paths are only used when optimized paths aren't available.

The following example displays the output for an ONTAP LUN with two Active/Optimized paths and two Active/Non-Optimized paths:

```
# multipath -ll
3600a0980383149764b5d567257516273 dm-0 NETAPP,LUN C-Mode
size=150G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
|-+- policy='service-time 0' prio=50 status=active
| |- 16:0:3:0  sdcg 69:64  active ready running
| `- 10:0:0:0  sdb  8:16   active ready running
`-+- policy='service-time 0' prio=10 status=enabled
  |- 10:0:1:0  sdc  8:32   active ready running
  `- 16:0:2:0  sdcf 69:48  active ready running
```

Step 4: Optionally, exclude a device from multipathing

If required, you can exclude a device from multipathing by adding the WWID for the unwanted device to the "blacklist" stanza for the `multipath.conf` file.

Steps

1. Determine the WWID:

```
/lib/udev/scsi_id -gud /dev/sda
```

"sda" is the local SCSI disk that you want to add to the blacklist.

An example WWID is `360030057024d0730239134810c0cb833`.

2. Add the WWID to the "blacklist" stanza:

```
blacklist {
        wwid    360030057024d0730239134810c0cb833
        devnode "^(ram|raw|loop|fd|md|dm-|sr|scd|st)[0-9]*"
        devnode "^hd[a-z]"
        devnode "^cciss.*"
}
```

Step 5: Customize multipath parameters for ONTAP LUNs

If your host is connected to LUNs from other vendors and any of the multipath parameter settings are overridden, you need to correct them by adding stanzas later in the `multipath.conf` file that apply specifically to ONTAP LUNs. If you don't do this, the ONTAP LUNs might not work as expected.

Check your `/etc/multipath.conf` file, especially in the defaults section, for settings that might be overriding the default settings for multipath parameters.

> ⚠ You shouldn't override the recommended parameter settings for ONTAP LUNs. These settings are required for optimal performance of your host configuration. Contact NetApp support, your OS vendor, or both for more information.

The following example shows how to correct an overridden default. In this example, the `multipath.conf` file defines values for `path_checker` and `no_path_retry` that aren't compatible with ONTAP LUNs, and you can't remove these parameters because ONTAP storage arrays are still attached to the host. Instead, you correct the values for `path_checker` and `no_path_retry` by adding a device stanza to the `multipath.conf` file that applies specifically to the ONTAP LUNs.

```
defaults {
    path_checker        readsector0
    no_path_retry       fail
}

devices {
    device {
        vendor          "NETAPP"
        product         "LUN"
        no_path_retry   queue
        path_checker    tur
    }
}
```

Step 6: Review the known issues

There are no known issues.

What's next?

- Learn about using the Linux Host Utilities tool.
- Learn about ASM mirroring.

  Automatic Storage Management (ASM) mirroring might require changes to the Linux multipath settings to allow ASM to recognize a problem and switch over to an alternate failure group. Most ASM configurations on ONTAP use external redundancy, which means that data protection is provided by the external array and ASM doesn't mirror data. Some sites use ASM with normal redundancy to provide two-way mirroring, normally across different sites. See Oracle databases on ONTAP for further information.

Configure Rocky Linux 8.6 for FCP and iSCSI with ONTAP storage

The Linux Host Utilities software provides management and diagnostic tools for Linux hosts that are connected to ONTAP storage. When you install Linux Host Utilities on a Rocky Linux 8.6 host, you can use the Host Utilities to help you manage FCP and iSCSI protocol operations with ONTAP LUNs.

> ⓘ You don't need to configure Kernel-based Virtual Machine (KVM) settings because ONTAP LUNs are automatically mapped to the KVM hypervisor.

Step 1: Optionally, enable SAN booting

You can configure your host to use SAN booting to simplify deployment and improve scalability.

Before you begin

Use the Interoperability Matrix Tool to verify that your Linux OS, host bus adapter (HBA), HBA firmware, HBA boot BIOS, and ONTAP version support SAN booting.

Steps

1. Create a SAN boot LUN and map it to the host.
2. Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is mapped.

   For information on how to enable the HBA BIOS, see your vendor-specific documentation.

3. Verify that the configuration was successful by rebooting the host and verifying that the OS is up and running.

Step 2: Install the Linux Host Utilities

NetApp strongly recommends installing the Linux Host Utilities to support ONTAP LUN management and assist technical support with gathering configuration data.

Install Linux Host Utilities 8.0.

> ⓘ Installing the Linux Host Utilities doesn't change any host timeout settings on your Linux host.

Step 3: Confirm the multipath configuration for your host

You can use multipathing with Rocky Linux 8.6 to manage ONTAP LUNs.

To ensure that multipathing is configured correctly for your host, verify that the `/etc/multipath.conf` file is defined and that you have the NetApp recommended settings configured for your ONTAP LUNs.

Steps

1. Verify that the `/etc/multipath.conf` file exists:

   ```
   ls /etc/multipath.conf
   ```

   If the file doesn't exist, create an empty, zero-byte file:

   ```
   touch /etc/multipath.conf
   ```

2. The first time the `multipath.conf` file is created, you might need to enable and start the multipath services to load the recommended settings:

   ```
   systemctl enable multipathd
   ```

   ```
   systemctl start multipathd
   ```

3. Each time you boot the host, the empty `/etc/multipath.conf` zero-byte file automatically loads the NetApp recommended host multipath parameters as the default settings. You shouldn't need to make changes to the `/etc/multipath.conf` file for your host because the host operating system is compiled with the multipath parameters that recognize and manage ONTAP LUNs correctly.

   The following table shows the native Linux OS compiled multipath parameter settings for ONTAP LUNs.

Show parameter settings

Parameter	Setting
detect_prio	yes
dev_loss_tmo	"infinity"
failback	immediate
fast_io_fail_tmo	5
features	"2 pg_init_retries 50"
flush_on_last_del	"yes"
hardware_handler	"0"
no_path_retry	queue
path_checker	"tur"
path_grouping_policy	"group_by_prio"
path_selector	"service-time 0"
polling_interval	5
prio	"ontap"
product	LUN
retain_attached_hw_handler	yes
rr_weight	"uniform"
user_friendly_names	no
vendor	NETAPP

4. Verify the parameter settings and path status for your ONTAP LUNs:

```
multipath -ll
```

The default multipath parameters support ASA, AFF, and FAS configurations. In these configurations, a single ONTAP LUN shouldn't require more than four paths. If there are more than four paths, it might cause issues with the paths during a storage failure.

The following example outputs show the correct parameter settings and path status for ONTAP LUNs in an ASA, AFF, or FAS configuration.

ASA configuration

An ASA configuration optimizes all paths to a given LUN, keeping them active. This improves performance by serving I/O operations through all paths at the same time.

```
# multipath -ll
3600a098038314c4a433f577471797958 dm-2 NETAPP,LUN C-Mode
size=180G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
`-+- policy='service-time 0' prio=50 status=active
  |- 14:0:0:0  sdc  8:32   active ready running
  |- 17:0:0:0  sdas 66:192 active ready running
  |- 14:0:3:0  sdar 66:176 active ready running
  `- 17:0:3:0  sdch 69:80  active ready running
```

AFF or FAS configuration

An AFF or FAS configuration should have two groups of paths with higher and lower priorities. Higher priority Active/Optimized paths are served by the controller where the aggregate is located. Lower priority paths are active but non-optimized because they are served by a different controller. Non-optimized paths are only used when optimized paths aren't available.

The following example displays the output for an ONTAP LUN with two Active/Optimized paths and two Active/Non-Optimized paths:

```
# multipath -ll
3600a0980383149764b5d567257516273 dm-0 NETAPP,LUN C-Mode
size=150G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
|-+- policy='service-time 0' prio=50 status=active
| |- 16:0:3:0  sdcg 69:64  active ready running
| `- 10:0:0:0  sdb  8:16   active ready running
`-+- policy='service-time 0' prio=10 status=enabled
  |- 10:0:1:0  sdc  8:32   active ready running
  `- 16:0:2:0  sdcf 69:48  active ready running
```

Step 4: Optionally, exclude a device from multipathing

If required, you can exclude a device from multipathing by adding the WWID for the unwanted device to the "blacklist" stanza for the `multipath.conf` file.

Steps

1. Determine the WWID:

```
/lib/udev/scsi_id -gud /dev/sda
```

"sda" is the local SCSI disk that you want to add to the blacklist.

An example WWID is `360030057024d0730239134810c0cb833`.

2. Add the WWID to the "blacklist" stanza:

```
blacklist {
        wwid    360030057024d0730239134810c0cb833
        devnode "^(ram|raw|loop|fd|md|dm-|sr|scd|st)[0-9]*"
        devnode "^hd[a-z]"
        devnode "^cciss.*"
}
```

Step 5: Customize multipath parameters for ONTAP LUNs

If your host is connected to LUNs from other vendors and any of the multipath parameter settings are overridden, you need to correct them by adding stanzas later in the `multipath.conf` file that apply specifically to ONTAP LUNs. If you don't do this, the ONTAP LUNs might not work as expected.

Check your `/etc/multipath.conf` file, especially in the defaults section, for settings that might be overriding the default settings for multipath parameters.

> ⚠️ You shouldn't override the recommended parameter settings for ONTAP LUNs. These settings are required for optimal performance of your host configuration. Contact NetApp support, your OS vendor, or both for more information.

The following example shows how to correct an overridden default. In this example, the `multipath.conf` file defines values for `path_checker` and `no_path_retry` that aren't compatible with ONTAP LUNs, and you can't remove these parameters because ONTAP storage arrays are still attached to the host. Instead, you correct the values for `path_checker` and `no_path_retry` by adding a device stanza to the `multipath.conf` file that applies specifically to the ONTAP LUNs.

```
defaults {
    path_checker        readsector0
    no_path_retry       fail
}

devices {
    device {
        vendor          "NETAPP"
        product         "LUN"
        no_path_retry   queue
        path_checker    tur
    }
}
```

Step 6: Review the known issues

There are no known issues.

What's next?

- Learn about using the Linux Host Utilities tool.
- Learn about ASM mirroring.

  Automatic Storage Management (ASM) mirroring might require changes to the Linux multipath settings to allow ASM to recognize a problem and switch over to an alternate failure group. Most ASM configurations on ONTAP use external redundancy, which means that data protection is provided by the external array and ASM doesn't mirror data. Some sites use ASM with normal redundancy to provide two-way mirroring, normally across different sites. See Oracle databases on ONTAP for further information.

Configure Rocky Linux 8.5 for FCP and iSCSI with ONTAP storage

The Linux Host Utilities software provides management and diagnostic tools for Linux hosts that are connected to ONTAP storage. When you install Linux Host Utilities on a Rocky Linux 8.5 host, you can use the Host Utilities to help you manage FCP and iSCSI protocol operations with ONTAP LUNs.

> ⓘ You don't need to configure Kernel-based Virtual Machine (KVM) settings because ONTAP LUNs are automatically mapped to the KVM hypervisor.

Step 1: Optionally, enable SAN booting

You can configure your host to use SAN booting to simplify deployment and improve scalability.

Before you begin

Use the Interoperability Matrix Tool to verify that your Linux OS, host bus adapter (HBA), HBA firmware, HBA boot BIOS, and ONTAP version support SAN booting.

Steps

1. Create a SAN boot LUN and map it to the host.
2. Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is mapped.

   For information on how to enable the HBA BIOS, see your vendor-specific documentation.

3. Verify that the configuration was successful by rebooting the host and verifying that the OS is up and running.

Step 2: Install the Linux Host Utilities

NetApp strongly recommends installing the Linux Host Utilities to support ONTAP LUN management and assist technical support with gathering configuration data.

Install Linux Host Utilities 8.0.

> ⓘ Installing the Linux Host Utilities doesn't change any host timeout settings on your Linux host.

Step 3: Confirm the multipath configuration for your host

You can use multipathing with Rocky Linux 8.5 to manage ONTAP LUNs.

To ensure that multipathing is configured correctly for your host, verify that the `/etc/multipath.conf` file is defined and that you have the NetApp recommended settings configured for your ONTAP LUNs.

Steps

1. Verify that the `/etc/multipath.conf` file exists:

   ```
   ls /etc/multipath.conf
   ```

   If the file doesn't exist, create an empty, zero-byte file:

   ```
   touch /etc/multipath.conf
   ```

2. The first time the `multipath.conf` file is created, you might need to enable and start the multipath services to load the recommended settings:

   ```
   systemctl enable multipathd
   ```

   ```
   systemctl start multipathd
   ```

3. Each time you boot the host, the empty `/etc/multipath.conf` zero-byte file automatically loads the NetApp recommended host multipath parameters as the default settings. You shouldn't need to make changes to the `/etc/multipath.conf` file for your host because the host operating system is compiled with the multipath parameters that recognize and manage ONTAP LUNs correctly.

   The following table shows the native Linux OS compiled multipath parameter settings for ONTAP LUNs.

Show parameter settings

Parameter	Setting
detect_prio	yes
dev_loss_tmo	"infinity"
failback	immediate
fast_io_fail_tmo	5
features	"2 pg_init_retries 50"
flush_on_last_del	"yes"
hardware_handler	"0"
no_path_retry	queue
path_checker	"tur"
path_grouping_policy	"group_by_prio"
path_selector	"service-time 0"
polling_interval	5
prio	"ontap"
product	LUN
retain_attached_hw_handler	yes
rr_weight	"uniform"
user_friendly_names	no
vendor	NETAPP

4. Verify the parameter settings and path status for your ONTAP LUNs:

```
multipath -ll
```

The default multipath parameters support ASA, AFF, and FAS configurations. In these configurations, a single ONTAP LUN shouldn't require more than four paths. If there are more than four paths, it might cause issues with the paths during a storage failure.

The following example outputs show the correct parameter settings and path status for ONTAP LUNs in an ASA, AFF, or FAS configuration.

ASA configuration

An ASA configuration optimizes all paths to a given LUN, keeping them active. This improves performance by serving I/O operations through all paths at the same time.

```
# multipath -ll
3600a098038314c4a433f577471797958 dm-2 NETAPP,LUN C-Mode
size=180G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
`-+- policy='service-time 0' prio=50 status=active
  |- 14:0:0:0  sdc  8:32   active ready running
  |- 17:0:0:0  sdas 66:192 active ready running
  |- 14:0:3:0  sdar 66:176 active ready running
  `- 17:0:3:0  sdch 69:80  active ready running
```

AFF or FAS configuration

An AFF or FAS configuration should have two groups of paths with higher and lower priorities. Higher priority Active/Optimized paths are served by the controller where the aggregate is located. Lower priority paths are active but non-optimized because they are served by a different controller. Non-optimized paths are only used when optimized paths aren't available.

The following example displays the output for an ONTAP LUN with two Active/Optimized paths and two Active/Non-Optimized paths:

```
# multipath -ll
3600a0980383149764b5d567257516273 dm-0 NETAPP,LUN C-Mode
size=150G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
|-+- policy='service-time 0' prio=50 status=active
| |- 16:0:3:0  sdcg 69:64  active ready running
| `- 10:0:0:0  sdb  8:16   active ready running
`-+- policy='service-time 0' prio=10 status=enabled
  |- 10:0:1:0  sdc  8:32   active ready running
  `- 16:0:2:0  sdcf 69:48  active ready running
```

Step 4: Optionally, exclude a device from multipathing

If required, you can exclude a device from multipathing by adding the WWID for the unwanted device to the "blacklist" stanza for the `multipath.conf` file.

Steps

1. Determine the WWID:

```
/lib/udev/scsi_id -gud /dev/sda
```

"sda" is the local SCSI disk that you want to add to the blacklist.

An example WWID is `360030057024d0730239134810c0cb833`.

2. Add the WWID to the "blacklist" stanza:

```
blacklist {
        wwid    360030057024d0730239134810c0cb833
        devnode "^(ram|raw|loop|fd|md|dm-|sr|scd|st)[0-9]*"
        devnode "^hd[a-z]"
        devnode "^cciss.*"
}
```

Step 5: Customize multipath parameters for ONTAP LUNs

If your host is connected to LUNs from other vendors and any of the multipath parameter settings are overridden, you need to correct them by adding stanzas later in the `multipath.conf` file that apply specifically to ONTAP LUNs. If you don't do this, the ONTAP LUNs might not work as expected.

Check your `/etc/multipath.conf` file, especially in the defaults section, for settings that might be overriding the default settings for multipath parameters.

> ⚠️ You shouldn't override the recommended parameter settings for ONTAP LUNs. These settings are required for optimal performance of your host configuration. Contact NetApp support, your OS vendor, or both for more information.

The following example shows how to correct an overridden default. In this example, the `multipath.conf` file defines values for `path_checker` and `no_path_retry` that aren't compatible with ONTAP LUNs, and you can't remove these parameters because ONTAP storage arrays are still attached to the host. Instead, you correct the values for `path_checker` and `no_path_retry` by adding a device stanza to the `multipath.conf` file that applies specifically to the ONTAP LUNs.

```
defaults {
   path_checker        readsector0
   no_path_retry       fail
}

devices {
   device {
      vendor          "NETAPP"
      product         "LUN"
      no_path_retry   queue
      path_checker    tur
   }
}
```

Step 6: Review the known issues

There are no known issues.

What's next?

- Learn about using the Linux Host Utilities tool.
- Learn about ASM mirroring.

  Automatic Storage Management (ASM) mirroring might require changes to the Linux multipath settings to allow ASM to recognize a problem and switch over to an alternate failure group. Most ASM configurations on ONTAP use external redundancy, which means that data protection is provided by the external array and ASM doesn't mirror data. Some sites use ASM with normal redundancy to provide two-way mirroring, normally across different sites. See Oracle databases on ONTAP for further information.

Configure Rocky Linux 8.4 for FCP and iSCSI with ONTAP storage

The Linux Host Utilities software provides management and diagnostic tools for Linux hosts that are connected to ONTAP storage. When you install Linux Host Utilities on a Rocky Linux 8.4 host, you can use the Host Utilities to help you manage FCP and iSCSI protocol operations with ONTAP LUNs.

> ⓘ You don't need to configure Kernel-based Virtual Machine (KVM) settings because ONTAP LUNs are automatically mapped to the KVM hypervisor.

Step 1: Optionally, enable SAN booting

You can configure your host to use SAN booting to simplify deployment and improve scalability.

Before you begin

Use the Interoperability Matrix Tool to verify that your Linux OS, host bus adapter (HBA), HBA firmware, HBA boot BIOS, and ONTAP version support SAN booting.

Steps

1. Create a SAN boot LUN and map it to the host.
2. Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is mapped.

   For information on how to enable the HBA BIOS, see your vendor-specific documentation.

3. Verify that the configuration was successful by rebooting the host and verifying that the OS is up and running.

Step 2: Install the Linux Host Utilities

NetApp strongly recommends installing the Linux Host Utilities to support ONTAP LUN management and assist technical support with gathering configuration data.

Install Linux Host Utilities 8.0.

> ⓘ Installing the Linux Host Utilities doesn't change any host timeout settings on your Linux host.

Step 3: Confirm the multipath configuration for your host

You can use multipathing with Rocky Linux 8.4 to manage ONTAP LUNs.

To ensure that multipathing is configured correctly for your host, verify that the `/etc/multipath.conf` file is defined and that you have the NetApp recommended settings configured for your ONTAP LUNs.

Steps

1. Verify that the `/etc/multipath.conf` file exists:

   ```
   ls /etc/multipath.conf
   ```

   If the file doesn't exist, create an empty, zero-byte file:

   ```
   touch /etc/multipath.conf
   ```

2. The first time the `multipath.conf` file is created, you might need to enable and start the multipath services to load the recommended settings:

   ```
   systemctl enable multipathd
   ```

   ```
   systemctl start multipathd
   ```

3. Each time you boot the host, the empty `/etc/multipath.conf` zero-byte file automatically loads the NetApp recommended host multipath parameters as the default settings. You shouldn't need to make changes to the `/etc/multipath.conf` file for your host because the host operating system is compiled with the multipath parameters that recognize and manage ONTAP LUNs correctly.

   The following table shows the native Linux OS compiled multipath parameter settings for ONTAP LUNs.

Show parameter settings

Parameter	Setting
detect_prio	yes
dev_loss_tmo	"infinity"
failback	immediate
fast_io_fail_tmo	5
features	"2 pg_init_retries 50"
flush_on_last_del	"yes"
hardware_handler	"0"
no_path_retry	queue
path_checker	"tur"
path_grouping_policy	"group_by_prio"
path_selector	"service-time 0"
polling_interval	5
prio	"ontap"
product	LUN
retain_attached_hw_handler	yes
rr_weight	"uniform"
user_friendly_names	no
vendor	NETAPP

4. Verify the parameter settings and path status for your ONTAP LUNs:

```
multipath -ll
```

The default multipath parameters support ASA, AFF, and FAS configurations. In these configurations, a single ONTAP LUN shouldn't require more than four paths. If there are more than four paths, it might cause issues with the paths during a storage failure.

The following example outputs show the correct parameter settings and path status for ONTAP LUNs in an ASA, AFF, or FAS configuration.

ASA configuration

An ASA configuration optimizes all paths to a given LUN, keeping them active. This improves performance by serving I/O operations through all paths at the same time.

```
# multipath -ll
3600a098038314c4a433f577471797958 dm-2 NETAPP,LUN C-Mode
size=180G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
`-+- policy='service-time 0' prio=50 status=active
  |- 14:0:0:0  sdc  8:32   active ready running
  |- 17:0:0:0  sdas 66:192 active ready running
  |- 14:0:3:0  sdar 66:176 active ready running
  `- 17:0:3:0  sdch 69:80  active ready running
```

AFF or FAS configuration

An AFF or FAS configuration should have two groups of paths with higher and lower priorities. Higher priority Active/Optimized paths are served by the controller where the aggregate is located. Lower priority paths are active but non-optimized because they are served by a different controller. Non-optimized paths are only used when optimized paths aren't available.

The following example displays the output for an ONTAP LUN with two Active/Optimized paths and two Active/Non-Optimized paths:

```
# multipath -ll
3600a0980383149764b5d567257516273 dm-0 NETAPP,LUN C-Mode
size=150G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
|-+- policy='service-time 0' prio=50 status=active
| |- 16:0:3:0  sdcg 69:64  active ready running
| `- 10:0:0:0  sdb  8:16   active ready running
`-+- policy='service-time 0' prio=10 status=enabled
  |- 10:0:1:0  sdc  8:32   active ready running
  `- 16:0:2:0  sdcf 69:48  active ready running
```

Step 4: Optionally, exclude a device from multipathing

If required, you can exclude a device from multipathing by adding the WWID for the unwanted device to the "blacklist" stanza for the `multipath.conf` file.

Steps

1. Determine the WWID:

```
/lib/udev/scsi_id -gud /dev/sda
```

"sda" is the local SCSI disk that you want to add to the blacklist.

An example WWID is `360030057024d0730239134810c0cb833`.

2. Add the WWID to the "blacklist" stanza:

```
blacklist {
        wwid    360030057024d0730239134810c0cb833
        devnode "^(ram|raw|loop|fd|md|dm-|sr|scd|st)[0-9]*"
        devnode "^hd[a-z]"
        devnode "^cciss.*"
}
```

Step 5: Customize multipath parameters for ONTAP LUNs

If your host is connected to LUNs from other vendors and any of the multipath parameter settings are overridden, you need to correct them by adding stanzas later in the `multipath.conf` file that apply specifically to ONTAP LUNs. If you don't do this, the ONTAP LUNs might not work as expected.

Check your `/etc/multipath.conf` file, especially in the defaults section, for settings that might be overriding the default settings for multipath parameters.

> ⚠ You shouldn't override the recommended parameter settings for ONTAP LUNs. These settings are required for optimal performance of your host configuration. Contact NetApp support, your OS vendor, or both for more information.

The following example shows how to correct an overridden default. In this example, the `multipath.conf` file defines values for `path_checker` and `no_path_retry` that aren't compatible with ONTAP LUNs, and you can't remove these parameters because ONTAP storage arrays are still attached to the host. Instead, you correct the values for `path_checker` and `no_path_retry` by adding a device stanza to the `multipath.conf` file that applies specifically to the ONTAP LUNs.

```
defaults {
    path_checker        readsector0
    no_path_retry       fail
}

devices {
    device {
        vendor          "NETAPP"
        product         "LUN"
        no_path_retry   queue
        path_checker    tur
    }
}
```

Step 6: Review the known issues

There are no known issues.

What's next?

- [Learn about using the Linux Host Utilities tool](#).
- Learn about ASM mirroring.

Automatic Storage Management (ASM) mirroring might require changes to the Linux multipath settings to allow ASM to recognize a problem and switch over to an alternate failure group. Most ASM configurations on ONTAP use external redundancy, which means that data protection is provided by the external array and ASM doesn't mirror data. Some sites use ASM with normal redundancy to provide two-way mirroring, normally across different sites. See [Oracle databases on ONTAP](#) for further information.

Solaris

Configure Solaris 11.4 for FCP and iSCSI with ONTAP storage

The Solaris Host Utilities software provides management and diagnostic tools for Solaris hosts that are connected to ONTAP storage. When you install the Solaris Host Utilities on a Solaris 11.4 host, you can use the Host Utilities to help you manage FCP and iSCSI protocol operations with ONTAP LUNs.

Step 1: Optionally, enable SAN booting

You can configure your host to use SAN booting to simplify deployment and improve scalability. If your configuration doesn't support SAN booting, you can use a local boot.

SAN boot

SAN booting is the process of setting up a SAN-attached disk (a LUN) as a boot device for a Solaris host. You can set up a SAN boot LUN to work in a Solaris MPxIO environment that is using the FC protocol and running Solaris Host Utilities. The method you use to set up a SAN boot LUN depends on your volume manager and file system.

Steps

1. Use the [Interoperability Matrix Tool](#) to verify that your Solaris OS, protocol, and ONTAP version support SAN booting.

2. Follow the best practices for setting up a SAN boot in the Solaris vendor documentation.

Local boot

Perform a local boot by installing the Solaris OS on the local hard disk, for example, install on an SSD, SATA, or RAID.

Step 2: Install the Solaris Host Utilities

NetApp strongly recommends installing the Solaris Host Utilities to support ONTAP LUN management and assist technical support with gathering configuration data.

> ℹ️ Installing the Solaris Host Utilities changes some of the timeout settings on your Solaris host.

Step 3: Confirm the multipath configuration for your host

You can use multipathing with Solaris 11.4 to manage ONTAP LUNs.

Multipathing enables you to configure multiple network paths between the host and storage systems. If one path fails, traffic continues on the remaining paths. Oracle Solaris I/O Multipathing (MPxIO) is enabled by default for Solaris 11.4 and SPARC systems.

To ensure that multipathing and the recommended timeout parameters are configured correctly for your host, verify that you're using the NetApp recommended settings for your ONTAP LUNs.

Steps

1. If your host is configured for FC, verify that the default setting in `/kernel/drv/fp.conf` is set to `mpxio-disable="no"`.

2. The Solaris Host Utilities load the NetApp recommended parameter settings for SPARC and x86_64 processors.

   Show parameter settings

Parameter	Value
throttle_max	8
not_ready_retries	300
busy_retries	30
reset_retries	30
throttle_min	2
timeout_retries	10
physical_block_size	4096
disksort	false
cache-nonvolatile	true

   For additional information about Solaris 11.4 system settings, see Oracle Support DOC ID: 2595926.1.

3. If your storage configuration includes MetroCluster, Oracle Solaris virtualization, or SnapMirror active sync, change the default settings:

MetroCluster

By default, the Solaris OS fails to execute the I/O operations after **20s** if all paths to a LUN are lost. This is controlled by the `fcp_offline_delay` parameter. The default value for `fcp_offline_delay` is the appropriate for standard ONTAP clusters. However, in MetroCluster configurations, you must increase the value of `fcp_offline_delay` to **120s** to ensure that I/O doesn't prematurely time out during operations, including unplanned failovers.

For additional information and recommended changes to default settings for MetroCluster, see the Knowledge Base article Solaris host support considerations in a MetroCluster configuration.

Oracle Solaris virtualization

- Solaris virtualization options include Solaris Logical Domains (also called LDOMs or Oracle VM Server for SPARC), Solaris Dynamic Domains, Solaris Zones, and Solaris Containers. These technologies are also referred to as "Oracle Virtual Machines".

- You can use multiple options together, for example, a Solaris Container within a particular Solaris Logical Domain.

- NetApp supports the use of Solaris virtualization technologies where the overall configuration is supported by Oracle and any partition with direct access to LUNs is listed on the IMT in a supported configuration. This includes root containers, LDOM I/O domains, and LDOM using NPIV to access LUNs.

- Partitions or virtual machines that use only virtualized storage resources, such as a `vdsk`, don't need specific qualifications because they don't have direct access to ONTAP LUNs. You only need to verify that the partition or virtual machine that has direct access to the underlying LUN, such as an LDOM I/O domain, is listed on the IMT.

Steps

When LUNs are used as virtual disk devices within an LDOM, the source of the LUN is masked by virtualization and the LDOM doesn't correctly detect the block sizes. To prevent this issue:

a. Patch the LDOM OS for *Oracle Bug 15824910*

b. Create a `vdc.conf` file that sets the block size of the virtual disk to `4096`. See Oracle DOC: 2157669.1 for more information.

c. Verify the patch installation to ensure that the recommended settings have been configured correctly:

   i. Create a zpool:

   ```
   zpool create zpool_name disk_list
   ```

   ii. Run `zdb -C` against the zpool and verify that the value of **ashift** is `12`.

   If the value of **ashift** isn't `12`, re run `zdb -C11`, and verify that the correct patch was installed and recheck the contents of `vdc.conf`.

   Don't proceed until **ashift** shows a value of `12`.

   > ⓘ Patches are available for Oracle bug 15824910 on several Solaris versions. Contact Oracle if you need assistance in determining the best kernel patch.

SnapMirror active sync

Beginning with ONTAP 9.9.1, SnapMirror active sync setting configurations are supported in the Solaris host. To verify that the Solaris client applications are non-disruptive when an unplanned site failover switchover occurs in a SnapMirror active sync environment, you must configure the `scsi-vhci-failover-override` setting on the Solaris host. This setting overrides the failover module `f_tpgs` to prevent the execution of the code path that detects the contradiction.

Steps

a. Create the configuration file `/etc/driver/drv/scsi_vhci.conf` with an entry similar to the following example for the NetApp storage type connected to the host:

```
scsi-vhci-failover-override =
"NETAPP  LUN","f_tpgs"
```

b. Verify that the override parameter has been successfully applied:

```
devprop
```

```
mdb
```

Show examples

```
root@host-A:~# devprop -v -n /scsi_vhci scsi-vhci-failover-
override      scsi-vhci-failover-override=NETAPP  LUN + f_tpgs
root@host-A:~# echo "*scsi_vhci_dip::print -x struct dev_info
devi_child | ::list struct dev_info devi_sibling| ::print
struct dev_info devi_mdi_client| ::print mdi_client_t
ct_vprivate| ::print struct scsi_vhci_lun svl_lun_wwn
svl_fops_name"| mdb -k
```

```
svl_lun_wwn = 0xa002a1c8960 "600a098038313477543f524539787938"
svl_fops_name = 0xa00298d69e0 "conf f_tpgs"
```

> ⓘ After `scsi-vhci-failover-override` has been applied, `conf` is added to `svl_fops_name`. For additional information and recommended changes to default settings, refer to the NetApp Knowledge Base article Solaris Host support recommended settings in SnapMirror active sync configuration.

4. Verify that 4KB aligned I/O with zpools using ONTAP LUNs is supported:

a. Verify that you Solaris host is installed with the latest Support Repository Update (SRU):

```
pkg info entire`
```

b. Verify that the ONTAP LUN has `ostype` as "Solaris", independent of the LUN size:

```
lun show -vserver` <vsersver_name>
```

Show example

```
chat-a800-31-33-35-37::*> lun show -vserver solaris_fcp -path
/vol/sol_195_zpool_vol_9/lun -fields ostype
vserver      path                                 ostype
-----------  --------------------------  -------
solaris_fcp /vol/sol_195_zpool_vol_9/lun solaris
```

5. Verify the output for your ONTAP LUNs:

```
sanlun lun show
```

You should see an output similar to the following example for an ASA, AFF, or FAS configuration:

Show example

```
root@sparc-s7-55-148:~# sanlun lun show -pv

                    ONTAP Path: Solaris_148_siteA:/vol/Triage/lun
                          LUN: 0
                     LUN Size: 20g
                  Host Device:
/dev/rdsk/c0t600A098038314B32685D573064776172d0s2
                         Mode: C
             Multipath Provider: Sun Microsystems
               Multipath Policy: Native
```

6. Verify the path status for your ONTAP LUNs:

```
mpathadm show lu <LUN>`
```

The following example outputs show the correct path status for ONTAP LUNs in an ASA, AFF, or FAS configuration. The path priorities are displayed against "Access State" for each LUN in the output.

ASA configurations

An ASA configuration optimizes all paths to a given LUN, keeping them active. This improves performance by serving I/O operations through all paths at the same time.

```
root@sparc-s7-55-82:~# mpathadm show lu
/dev/rdsk/c0t600A098038313953495D58674777794Bd0s2
Logical Unit:  /dev/rdsk/c0t600A098038313953495D58674777794Bd0s2
        mpath-support:  libmpscsi_vhci.so
        Vendor:  NETAPP
        Product:  LUN C-Mode
        Revision:  9171
        Name Type:  unknown type
        Name:  600a098038313953495d58674777794b
        Asymmetric:  yes
        Current Load Balance:  round-robin
        Logical Unit Group ID:  NA
        Auto Failback:  on
        Auto Probing:  NA

        Paths:
                Initiator Port Name:  100000109bd30070
                Target Port Name:  20b9d039ea593393
                Logical Unit Number:  0
                Override Path:  NA
                Path State:  OK
                Disabled:  no

                Initiator Port Name:  100000109bd30070
                Target Port Name:  20b8d039ea593393
                Logical Unit Number:  0
                Override Path:  NA
                Path State:  OK
                Disabled:  no

                Initiator Port Name:  100000109bd3006f
                Target Port Name:  20b3d039ea593393
                Logical Unit Number:  0
                Override Path:  NA
                Path State:  OK
                Disabled:  no

                Initiator Port Name:  100000109bd3006f
                Target Port Name:  20b4d039ea593393
                Logical Unit Number:  0
                Override Path:  NA
                Path State:  OK
                Disabled:  no
```

```
        Target Port Groups:
                ID:  1003
                Explicit Failover:  no
                Access State:  active optimized
                Target Ports:
                        Name:  20b9d039ea593393
                        Relative ID:  8


                        Name:  20b4d039ea593393
                        Relative ID:  3


                ID:  1002
                Explicit Failover:  no
                Access State:  active optimized
                Target Ports:
                        Name:  20b8d039ea593393
                        Relative ID:  7


                        Name:  20b3d039ea593393
                        Relative ID:  2
```

AFF or FAS configuration

An AFF or FAS configuration should have two groups of paths with higher and lower priorities. Higher priority Active/Optimized paths are served by the controller where the aggregate is located. Lower priority paths are active but non-optimized because they are served by a different controller. Non-optimized paths are only used when optimized paths aren't available.

The following example displays the correct output for an ONTAP LUN with two Active/Optimized paths and two Active/Non-Optimized paths:

```
root@chatsol-54-195:~# mpathadm show lu
/dev/rdsk/c0t600A0980383044376C3F4E694E506E44d0s2
Logical Unit:  /dev/rdsk/c0t600A0980383044376C3F4E694E506E44d0s2
        mpath-support:  libmpscsi_vhci.so
        Vendor:  NETAPP
        Product:  LUN C-Mode
        Revision:  9171
        Name Type:  unknown type
        Name:  600a0980383044376c3f4e694e506e44
        Asymmetric:  yes
        Current Load Balance:  round-robin
        Logical Unit Group ID:  NA
        Auto Failback:  on
        Auto Probing:  NA

        Paths:

                Initiator Port Name:  100000109b56c5fb
                Target Port Name:  205200a098ba7afe
                Logical Unit Number:  1
                Override Path:  NA
                Path State:  OK
                Disabled:  no

                Initiator Port Name:  100000109b56c5fb
                Target Port Name:  205000a098ba7afe
                Logical Unit Number:  1
                Override Path:  NA
                Path State:  OK
                Demoted:  yes
                Disabled:  no

                Initiator Port Name:  100000109b56c5fa
                Target Port Name:  204f00a098ba7afe
                Logical Unit Number:  1
                Override Path:  NA
                Path State:  OK
                Demoted:  yes
                Disabled:  no

                Initiator Port Name:  100000109b56c5fa
                Target Port Name:  205100a098ba7afe
                Logical Unit Number:  1
                Override Path:  NA
```

```
                Path State:  OK
                Disabled:  no

        Target Port Groups:
                ID:  1001
                Explicit Failover:  no
                Access State:  active not optimized
                Target Ports:
                        Name:  205200a098ba7afe
                        Relative ID:  8

                        Name:  205100a098ba7afe
                        Relative ID:  7

                ID:  1000
                Explicit Failover:  no
                Access State:  active optimized
                Target Ports:
                        Name:  205000a098ba7afe
                        Relative ID:  6

                        Name:  204f00a098ba7afe
                        Relative ID:  5
```

Step 4: Review the known issues

The Solaris 11.4 release for FCP and iSCSI with ONTAP storage has the following known issues:

NetApp Bug ID	Title	Description	Oracle ID
1362435	HUK 6.2 and Solaris_11.4 FC driver binding changes	Refer to Solaris 11.4 and HUK recommendations. FC driver binding is changed from `ssd (4D)` to `sd (4D)`. Move the existing configuration from `ssd.conf` to `sd.conf` as mentioned in Oracle DOC: 2595926.1). The behavior varies across newly installed Solaris 11.4 systems and systems upgraded from Solaris 11.3 or earlier versions.	(Doc ID 2595926.1)

NetApp Bug ID	Title	Description	Oracle ID
1366780	Solaris LIF issue noticed during storage failover (SFO) giveback operation with Emulex 32G host bus adapter (HBA) on x86 Arch	Solaris LIF issue noticed with Emulex firmware version 12.6.x and later on the x86_64 platform.	SR 3-24746803021
1368957	Solaris 11.x `cfgadm -c configure` resulting in I/O error with end-to-end Emulex configuration	Running `cfgadm -c configure` on Emulex end-to-end configuration results in an I/O error. This is fixed in ONTAP 9.5P17, 9.6P14 , 9.7P13, and 9.8P2	Not Applicable
1345622	Abnormal path reporting on Solaris hosts with ASA/PPorts using OS native commands	Intermittent path reporting issues are noticed on Solaris 11.4 with All SAN Array (ASA).	Not Applicable

What's next?

Learn about using the Solaris Host Utilities tool.

Configure Solaris 11.3 for FCP and iSCSI with ONTAP storage

The Solaris Host Utilities software provides management and diagnostic tools for Solaris hosts that are connected to ONTAP storage. When you install the Solaris Host Utilities on a Solaris 11.3 host, you can use the Host Utilities to help you manage FCP and iSCSI protocol operations with ONTAP LUNs.

Step 1: Optionally, enable SAN booting

You can configure your host to use SAN booting to simplify deployment and improve scalability. If your configuration doesn't support SAN booting, you can use a local boot.

SAN boot

SAN booting is the process of setting up a SAN-attached disk (a LUN) as a boot device for a Solaris host. You can set up a SAN boot LUN to work in a Solaris MPxIO environment that is using the FC protocol and running Solaris Host Utilities. The method you use to set up a SAN boot LUN depends on your volume manager and file system.

Steps

1. Use the Interoperability Matrix Tool to verify that your Solaris OS, protocol, and ONTAP version support SAN booting.

2. Follow the best practices for setting up a SAN boot in the Solaris vendor documentation.

Local boot

Perform a local boot by installing the Solaris OS on the local hard disk, for example, install on an SSD, SATA, or RAID.

Step 2: Install the Solaris Host Utilities

NetApp strongly recommends installing the Solaris Host Utilities to support ONTAP LUN management and assist technical support with gathering configuration data.

> ⓘ Installing the Solaris Host Utilities changes some of the timeout settings on your Solaris host.

Install Solaris Host Utilities 6.2.

Step 3: Confirm the multipath configuration for your host

You can use multipathing with Solaris 11.3 to manage ONTAP LUNs.

Multipathing enables you to configure multiple network paths between the host and storage systems. If one path fails, traffic continues on the remaining paths.

To ensure that multipathing and the recommended timeout parameters are configured correctly for your host, verify that you're using the NetApp recommended settings for your ONTAP LUNs.

Steps

1. The Solaris Host Utilities load the NetApp recommended parameter settings for SPARC and x86_64 processors.

Show parameter settings

Parameter	Value
throttle_max	8
not_ready_retries	300
busy_retries	30
reset_retries	30
throttle_min	2
timeout_retries	10
physical_block_size	4096
disksort	false
cache-nonvolatile	true

2. If your storage configuration includes MetroCluster, Oracle Solaris virtualization, or SnapMirror active sync, change the default settings:

MetroCluster

By default, the Solaris OS fails to execute the I/O operations after **20s** if all paths to a LUN are lost. This is controlled by the `fcp_offline_delay` parameter. The default value for `fcp_offline_delay` is the appropriate for standard ONTAP clusters. However, in MetroCluster configurations, you must increase the value of `fcp_offline_delay` to **120s** to ensure that I/O doesn't prematurely time out during operations, including unplanned failovers.

For additional information and recommended changes to default settings for MetroCluster, see the Knowledge Base article Solaris host support considerations in a MetroCluster configuration.

Oracle Solaris virtualization

- Solaris virtualization options include Solaris Logical Domains (also called LDOMs or Oracle VM Server for SPARC), Solaris Dynamic Domains, Solaris Zones, and Solaris Containers. These technologies are also referred to as "Oracle Virtual Machines".

- You can use multiple options together, for example, a Solaris Container within a particular Solaris Logical Domain.

- NetApp supports the use of Solaris virtualization technologies where the overall configuration is supported by Oracle and any partition with direct access to LUNs is listed on the IMT in a supported configuration. This includes root containers, LDOM I/O domains, and LDOM using NPIV to access LUNs.

- Partitions or virtual machines that use only virtualized storage resources, such as a `vdsk`, don't need specific qualifications because they don't have direct access to ONTAP LUNs. You only need to verify that the partition or virtual machine that has direct access to the underlying LUN, such as an LDOM I/O domain, is listed on the IMT.

Steps

When LUNs are used as virtual disk devices within an LDOM, the source of the LUN is masked by virtualization and the LDOM doesn't correctly detect the block sizes. To prevent this issue:

a. Patch the LDOM OS for *Oracle Bug 15824910*

b. Create a `vdc.conf` file that sets the block size of the virtual disk to `4096`. See Oracle DOC: 2157669.1 for more information.

c. Verify the patch installation to ensure that the recommended settings have been configured correctly:

   i. Create a zpool:

   ```
   zpool create zpool_name disk_list
   ```

   ii. Run `zdb -C` against the zpool and verify that the value of **ashift** is `12`.

   If the value of **ashift** isn't `12`, re run `zdb -C11`, and verify that the correct patch was installed and recheck the contents of `vdc.conf`.

   Don't proceed until **ashift** shows a value of `12`.

   > ⓘ Patches are available for Oracle bug 15824910 on several Solaris versions. Contact Oracle if you need assistance in determining the best kernel patch.

SnapMirror active sync

Beginning with ONTAP 9.9.1, SnapMirror active sync setting configurations are supported in the Solaris host. To verify that the Solaris client applications are non-disruptive when an unplanned site failover switchover occurs in a SnapMirror active sync environment, you must configure the `scsi-vhci-failover-override` setting on the Solaris host. This setting overrides the failover module `f_tpgs` to prevent the execution of the code path that detects the contradiction.

Steps

a. Create the configuration file `/etc/driver/drv/scsi_vhci.conf` with an entry similar to the following example for the NetApp storage type connected to the host:

```
scsi-vhci-failover-override =
"NETAPP  LUN","f_tpgs"
```

b. Verify that the override parameter has been successfully applied:

```
devprop
```

```
mdb
```

Show examples

```
root@host-A:~# devprop -v -n /scsi_vhci scsi-vhci-failover-
override      scsi-vhci-failover-override=NETAPP  LUN + f_tpgs
root@host-A:~# echo "*scsi_vhci_dip::print -x struct dev_info
devi_child | ::list struct dev_info devi_sibling| ::print
struct dev_info devi_mdi_client| ::print mdi_client_t
ct_vprivate| ::print struct scsi_vhci_lun svl_lun_wwn
svl_fops_name"| mdb -k
```

```
svl_lun_wwn = 0xa002a1c8960 "600a098038313477543f524539787938"
svl_fops_name = 0xa00298d69e0 "conf f_tpgs"
```

> ⓘ After `scsi-vhci-failover-override` has been applied, `conf` is added to `svl_fops_name`. For additional information and recommended changes to default settings, refer to the NetApp Knowledge Base article Solaris Host support recommended settings in SnapMirror active sync configuration.

3. Verify that 4KB aligned I/O with zpools using ONTAP LUNs is supported:

a. Verify that you Solaris host is installed with the latest Support Repository Update (SRU):

```
pkg info entire`
```

b. Verify that the ONTAP LUN has `ostype` as "Solaris", independent of the LUN size:

```
lun show -vserver` <vsersver_name>
```

Show example

```
chat-a800-31-33-35-37::*> lun show -vserver solaris_fcp -path
/vol/sol_195_zpool_vol_9/lun -fields ostype
vserver     path                                ostype
----------- --------------------------- -------
solaris_fcp /vol/sol_195_zpool_vol_9/lun solaris
```

4. Verify the output for your ONTAP LUNs:

```
sanlun lun show
```

You should see an output similar to the following example for an ASA, AFF, or FAS configuration:

Show example

```
root@sparc-s7-55-148:~# sanlun lun show -pv

                    ONTAP Path: Solaris_148_siteA:/vol/Triage/lun
                          LUN: 0
                     LUN Size: 20g
                  Host Device:
/dev/rdsk/c0t600A098038314B32685D573064776172d0s2
                         Mode: C
           Multipath Provider: Sun Microsystems
             Multipath Policy: Native
```

5. Verify the path status for your ONTAP LUNs:

```
mpathadm show lu <LUN>`
```

The following example outputs show the correct path status for ONTAP LUNs in an ASA, AFF, or FAS configuration. The path priorities are displayed against "Access State" for each LUN in the output.

ASA configurations

An ASA configuration optimizes all paths to a given LUN, keeping them active. This improves performance by serving I/O operations through all paths at the same time.

```
root@sparc-s7-55-82:~# mpathadm show lu
/dev/rdsk/c0t600A098038313953495D58674777794Bd0s2
Logical Unit:  /dev/rdsk/c0t600A098038313953495D58674777794Bd0s2
        mpath-support:  libmpscsi_vhci.so
        Vendor:  NETAPP
        Product:  LUN C-Mode
        Revision:  9171
        Name Type:  unknown type
        Name:  600a098038313953495d58674777794b
        Asymmetric:  yes
        Current Load Balance:  round-robin
        Logical Unit Group ID:  NA
        Auto Failback:  on
        Auto Probing:  NA

        Paths:
                Initiator Port Name:  100000109bd30070
                Target Port Name:  20b9d039ea593393
                Logical Unit Number:  0
                Override Path:  NA
                Path State:  OK
                Disabled:  no

                Initiator Port Name:  100000109bd30070
                Target Port Name:  20b8d039ea593393
                Logical Unit Number:  0
                Override Path:  NA
                Path State:  OK
                Disabled:  no

                Initiator Port Name:  100000109bd3006f
                Target Port Name:  20b3d039ea593393
                Logical Unit Number:  0
                Override Path:  NA
                Path State:  OK
                Disabled:  no

                Initiator Port Name:  100000109bd3006f
                Target Port Name:  20b4d039ea593393
                Logical Unit Number:  0
                Override Path:  NA
                Path State:  OK
                Disabled:  no
```

```
        Target Port Groups:
                ID:  1003
                Explicit Failover:  no
                Access State:  active optimized
                Target Ports:
                        Name:  20b9d039ea593393
                        Relative ID:  8


                        Name:  20b4d039ea593393
                        Relative ID:  3


                ID:  1002
                Explicit Failover:  no
                Access State:  active optimized
                Target Ports:
                        Name:  20b8d039ea593393
                        Relative ID:  7


                        Name:  20b3d039ea593393
                        Relative ID:  2
```

AFF or FAS configuration

An AFF or FAS configuration should have two groups of paths with higher and lower priorities. Higher priority Active/Optimized paths are served by the controller where the aggregate is located. Lower priority paths are active but non-optimized because they are served by a different controller. Non-optimized paths are only used when optimized paths aren't available.

The following example displays the correct output for an ONTAP LUN with two Active/Optimized paths and two Active/Non-Optimized paths:

```
root@chatsol-54-195:~# mpathadm show lu
/dev/rdsk/c0t600A0980383044376C3F4E694E506E44d0s2
Logical Unit:  /dev/rdsk/c0t600A0980383044376C3F4E694E506E44d0s2
        mpath-support:  libmpscsi_vhci.so
        Vendor:  NETAPP
        Product:  LUN C-Mode
        Revision:  9171
        Name Type:  unknown type
        Name:  600a0980383044376c3f4e694e506e44
        Asymmetric:  yes
        Current Load Balance:  round-robin
        Logical Unit Group ID:  NA
        Auto Failback:  on
        Auto Probing:  NA

        Paths:

                Initiator Port Name:  100000109b56c5fb
                Target Port Name:  205200a098ba7afe
                Logical Unit Number:  1
                Override Path:  NA
                Path State:  OK
                Disabled:  no

                Initiator Port Name:  100000109b56c5fb
                Target Port Name:  205000a098ba7afe
                Logical Unit Number:  1
                Override Path:  NA
                Path State:  OK
                Demoted:  yes
                Disabled:  no

                Initiator Port Name:  100000109b56c5fa
                Target Port Name:  204f00a098ba7afe
                Logical Unit Number:  1
                Override Path:  NA
                Path State:  OK
                Demoted:  yes
                Disabled:  no

                Initiator Port Name:  100000109b56c5fa
                Target Port Name:  205100a098ba7afe
                Logical Unit Number:  1
                Override Path:  NA
```

```
                Path State:  OK
                Disabled:  no

        Target Port Groups:
                ID:  1001
                Explicit Failover:  no
                Access State:  active not optimized
                Target Ports:
                        Name:  205200a098ba7afe
                        Relative ID:  8

                        Name:  205100a098ba7afe
                        Relative ID:  7

                ID:  1000
                Explicit Failover:  no
                Access State:  active optimized
                Target Ports:
                        Name:  205000a098ba7afe
                        Relative ID:  6

                        Name:  204f00a098ba7afe
                        Relative ID:  5
```

Step 4: Review the known issues

The Solaris 11.3 release for FCP and iSCSI with ONTAP storage has the following known issues:

NetApp Bug ID	Title	Description	Oracle ID
1366780	Solaris LIF problem during GB with Emulex 32G HBA on x86 Arch	Seen with Emulex Firmware version 12.6.x and later on x86_64 Platform	SR 3-24746803021
1368957	Solaris 11.x 'cfgadm -c configure' resulting in I/O error with End-to-End Emulex configuration	Running `cfgadm -c configure` on Emulex end-to-end configurations results in I/O error. This is fixed in ONTAP 9.5P17, 9.6P14, 9.7P13 and 9.8P2	Not Applicable

What's next?

Learn about using the Solaris Host Utilities tool.

SUSE Linux Enterprise Server

SUSE Linux Enterprise Server 15

Configure SUSE Linux Enterprise Server 15 SP7 for FCP and iSCSI with ONTAP storage

The Linux Host Utilities software provides management and diagnostic tools for Linux hosts that are connected to ONTAP storage. When you install the Linux Host Utilities on a SUSE Linux Enterprise Server 15 SP7 host, you can use the Host Utilities to help you manage FCP and iSCSI protocol operations with ONTAP LUNs.

> ℹ️ You don't need to manually configure Kernel-based Virtual Machine (KVM) settings because ONTAP LUNs are automatically mapped to the hypervisor.

Step 1: Optionally, enable SAN booting

You can configure your host to use SAN booting to simplify deployment and improve scalability.

Before you begin

Use the Interoperability Matrix Tool to verify that your Linux OS, host bus adapter (HBA), HBA firmware, HBA boot BIOS, and ONTAP version support SAN booting.

Steps

1. Create a SAN boot LUN and map it to the host.
2. Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is mapped.

   For information on how to enable the HBA BIOS, see your vendor-specific documentation.

3. Verify that the configuration was successful by rebooting the host and verifying that the OS is up and running.

Step 2: Install the Linux Host Utilities

NetApp strongly recommends installing the Linux Host Utilities to support ONTAP LUN management and assist technical support with gathering configuration data.

Install Linux Host Utilities 8.0.

> ℹ️ Installing the Linux Host Utilities doesn't change any host timeout settings on your Linux host.

Step 3: Confirm the multipath configuration for your host

You can use multipathing with SUSE Linux Enterprise Server 15 SP7 to manage ONTAP LUNs.

To ensure that multipathing is configured correctly for your host, verify that the `/etc/multipath.conf` file is defined and that you have the NetApp recommended settings configured for your ONTAP LUNs.

Steps

1. Verify that the `/etc/multipath.conf` file exists:

```
ls /etc/multipath.conf
```

If the file doesn't exist, create an empty, zero-byte file:

```
touch /etc/multipath.conf
```

2. The first time the `multipath.conf` file is created, you might need to enable and start the multipath services to load the recommended settings:

```
systemctl enable multipathd
```

```
systemctl start multipathd
```

3. Each time you boot the host, the empty `/etc/multipath.conf` zero-byte file automatically loads the NetApp recommended host multipath parameters as the default settings. You shouldn't need to make changes to the `/etc/multipath.conf` file for your host because the host operating system is compiled with the multipath parameters that recognize and manage ONTAP LUNs correctly.

The following table shows the native Linux OS compiled multipath parameter settings for ONTAP LUNs.

Show parameter settings

Parameter	Setting
detect_prio	yes
dev_loss_tmo	"infinity"
failback	immediate
fast_io_fail_tmo	5
features	"2 pg_init_retries 50"
flush_on_last_del	"yes"
hardware_handler	"0"
no_path_retry	queue
path_checker	"tur"
path_grouping_policy	"group_by_prio"
path_selector	"service-time 0"
polling_interval	5
prio	"ontap"
product	LUN
retain_attached_hw_handler	yes
rr_weight	"uniform"
user_friendly_names	no
vendor	NETAPP

4. Verify the parameter settings and path status for your ONTAP LUNs:

```
multipath -ll
```

The default multipath parameters support ASA, AFF, and FAS configurations. In these configurations, a single ONTAP LUN shouldn't require more than four paths. If there are more than four paths, it might cause issues with the paths during a storage failure.

The following example outputs show the correct parameter settings and path status for ONTAP LUNs in an ASA, AFF, or FAS configuration.

ASA configuration

An ASA configuration optimizes all paths to a given LUN, keeping them active. This improves performance by serving I/O operations through all paths at the same time.

```
# multipath -ll
3600a09803831347657244e527766394e dm-5 NETAPP,LUN C-Mode
size=80G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
`-+- policy='service-time 0' prio=50 status=active
  |- 3:0:7:9    sdco 69:192  active ready running
  |- 3:0:8:9    sddi 71:0    active ready running
  |- 14:0:8:9   sdjq 65:320  active ready running
  `- 14:0:7:9   sdiw 8:256   active ready running
```

AFF or FAS configuration

An AFF or FAS configuration should have two groups of paths with higher and lower priorities. Higher priority Active/Optimized paths are served by the controller where the aggregate is located. Lower priority paths are active but non-optimized because they are served by a different controller. Non-optimized paths are only used when optimized paths aren't available.

The following example displays the output for an ONTAP LUN with two Active/Optimized paths and two Active/Non-Optimized paths:

```
# multipath -ll
3600a09803831347657244e527766394e dm-5 NETAPP,LUN C-Mode
size=80G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
|-+- policy='service-time 0' prio=50 status=active
| |- 3:0:3:0    sdd  8:48    active ready running
| |- 3:0:4:0    sdx  65:112  active ready running
`-+- policy='service-time 0' prio=10 status=enabled
  |- 14:0:2:0   sdfk 130:96  active ready running
  `- 14:0:5:0   sdgz 132:240 active ready running
```

Step 4: Optionally, exclude a device from multipathing

If required, you can exclude a device from multipathing by adding the WWID for the unwanted device to the "blacklist" stanza for the `multipath.conf` file.

Steps

1. Determine the WWID:

```
/lib/udev/scsi_id -gud /dev/sda
```

"sda" is the local SCSI disk that you want to add to the blacklist.

An example WWID is `360030057024d0730239134810c0cb833`.

2. Add the WWID to the "blacklist" stanza:

```
blacklist {
        wwid    360030057024d0730239134810c0cb833
        devnode "^(ram|raw|loop|fd|md|dm-|sr|scd|st)[0-9]*"
        devnode "^hd[a-z]"
        devnode "^cciss.*"
}
```

Step 5: Customize multipath parameters for ONTAP LUNs

If your host is connected to LUNs from other vendors and any of the multipath parameter settings are overridden, you need to correct them by adding stanzas later in the `multipath.conf` file that apply specifically to ONTAP LUNs. If you don't do this, the ONTAP LUNs might not work as expected.

Check your `/etc/multipath.conf` file, especially in the defaults section, for settings that might be overriding the default settings for multipath parameters.

> ⚠️ You shouldn't override the recommended parameter settings for ONTAP LUNs. These settings are required for optimal performance of your host configuration. Contact NetApp support, your OS vendor, or both for more information.

The following example shows how to correct an overridden default. In this example, the `multipath.conf` file defines values for `path_checker` and `no_path_retry` that aren't compatible with ONTAP LUNs, and you can't remove these parameters because ONTAP storage arrays are still attached to the host. Instead, you correct the values for `path_checker` and `no_path_retry` by adding a device stanza to the `multipath.conf` file that applies specifically to the ONTAP LUNs.

Show example

```
defaults {
    path_checker        readsector0
    no_path_retry       fail
}

devices {
    device {
        vendor          "NETAPP"
        product         "LUN"
        no_path_retry   queue
        path_checker    tur
    }
}
```

Step 6: Review the known issues

There are no known issues.

What's next?

- Learn about using the Linux Host Utilities tool.
- Learn about ASM mirroring.

  Automatic Storage Management (ASM) mirroring might require changes to the Linux multipath settings to allow ASM to recognize a problem and switch over to an alternate failure group. Most ASM configurations on ONTAP use external redundancy, which means that data protection is provided by the external array and ASM doesn't mirror data. Some sites use ASM with normal redundancy to provide two-way mirroring, normally across different sites. See Oracle databases on ONTAP for further information.

Configure SUSE Linux Enterprise Server 15 SP6 for FCP and iSCSI with ONTAP storage

The Linux Host Utilities software provides management and diagnostic tools for Linux hosts that are connected to ONTAP storage. When you install the Linux Host Utilities on a SUSE Linux Enterprise Server 15 SP6 host, you can use the Host Utilities to help you manage FCP and iSCSI protocol operations with ONTAP LUNs.

> ℹ️ You don't need to manually configure Kernel-based Virtual Machine (KVM) settings because ONTAP LUNs are automatically mapped to the hypervisor.

Step 1: Optionally, enable SAN booting

You can configure your host to use SAN booting to simplify deployment and improve scalability.

Before you begin

Use the Interoperability Matrix Tool to verify that your Linux OS, host bus adapter (HBA), HBA firmware, HBA

boot BIOS, and ONTAP version support SAN booting.

Steps

1. [Create a SAN boot LUN and map it to the host](#).

2. Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is mapped.

   For information on how to enable the HBA BIOS, see your vendor-specific documentation.

3. Verify that the configuration was successful by rebooting the host and verifying that the OS is up and running.

Step 2: Install the Linux Host Utilities

NetApp strongly recommends installing the Linux Host Utilities to support ONTAP LUN management and assist technical support with gathering configuration data.

[Install Linux Host Utilities 8.0](#).

> ⓘ   Installing the Linux Host Utilities doesn't change any host timeout settings on your Linux host.

Step 3: Confirm the multipath configuration for your host

You can use multipathing with SUSE Linux Enterprise Server 15 SP6 to manage ONTAP LUNs.

To ensure that multipathing is configured correctly for your host, verify that the `/etc/multipath.conf` file is defined and that you have the NetApp recommended settings configured for your ONTAP LUNs.

Steps

1. Verify that the `/etc/multipath.conf` file exists:

   ```
   ls /etc/multipath.conf
   ```

   If the file doesn't exist, create an empty, zero-byte file:

   ```
   touch /etc/multipath.conf
   ```

2. The first time the `multipath.conf` file is created, you might need to enable and start the multipath services to load the recommended settings:

   ```
   systemctl enable multipathd
   ```

   ```
   systemctl start multipathd
   ```

3. Each time you boot the host, the empty `/etc/multipath.conf` zero-byte file automatically loads the NetApp recommended host multipath parameters as the default settings. You shouldn't need to make changes to the `/etc/multipath.conf` file for your host because the host operating system is compiled

with the multipath parameters that recognize and manage ONTAP LUNs correctly.

The following table shows the native Linux OS compiled multipath parameter settings for ONTAP LUNs.

Show parameter settings

Parameter	Setting
detect_prio	yes
dev_loss_tmo	"infinity"
failback	immediate
fast_io_fail_tmo	5
features	"2 pg_init_retries 50"
flush_on_last_del	"yes"
hardware_handler	"0"
no_path_retry	queue
path_checker	"tur"
path_grouping_policy	"group_by_prio"
path_selector	"service-time 0"
polling_interval	5
prio	"ontap"
product	LUN
retain_attached_hw_handler	yes
rr_weight	"uniform"
user_friendly_names	no
vendor	NETAPP

4. Verify the parameter settings and path status for your ONTAP LUNs:

```
multipath -ll
```

The default multipath parameters support ASA, AFF, and FAS configurations. In these configurations, a single ONTAP LUN shouldn't require more than four paths. If there are more than four paths, it might cause issues with the paths during a storage failure.

The following example outputs show the correct parameter settings and path status for ONTAP LUNs in an ASA, AFF, or FAS configuration.

ASA configuration

An ASA configuration optimizes all paths to a given LUN, keeping them active. This improves performance by serving I/O operations through all paths at the same time.

```
# multipath -ll
3600a09803831347657244e527766394e dm-5 NETAPP,LUN C-Mode
size=80G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
`-+- policy='service-time 0' prio=50 status=active
  |- 3:0:7:9    sdco 69:192  active ready running
  |- 3:0:8:9    sddi 71:0    active ready running
  |- 14:0:8:9   sdjq 65:320  active ready running
  `- 14:0:7:9   sdiw 8:256   active ready running
```

AFF or FAS configuration

An AFF or FAS configuration should have two groups of paths with higher and lower priorities. Higher priority Active/Optimized paths are served by the controller where the aggregate is located. Lower priority paths are active but non-optimized because they are served by a different controller. Non-optimized paths are only used when optimized paths aren't available.

The following example displays the output for an ONTAP LUN with two Active/Optimized paths and two Active/Non-Optimized paths:

```
# multipath -ll
3600a09803831347657244e527766394e dm-5 NETAPP,LUN C-Mode
size=80G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
|-+- policy='service-time 0' prio=50 status=active
| |- 3:0:3:0    sdd  8:48    active ready running
| |- 3:0:4:0    sdx  65:112  active ready running
`-+- policy='service-time 0' prio=10 status=enabled
  |- 14:0:2:0   sdfk 130:96  active ready running
  `- 14:0:5:0   sdgz 132:240 active ready running
```

Step 4: Optionally, exclude a device from multipathing

If required, you can exclude a device from multipathing by adding the WWID for the unwanted device to the "blacklist" stanza for the `multipath.conf` file.

Steps

1. Determine the WWID:

```
/lib/udev/scsi_id -gud /dev/sda
```

"sda" is the local SCSI disk that you want to add to the blacklist.

An example WWID is `360030057024d0730239134810c0cb833`.

2. Add the WWID to the "blacklist" stanza:

```
blacklist {
        wwid    360030057024d0730239134810c0cb833
        devnode "^(ram|raw|loop|fd|md|dm-|sr|scd|st)[0-9]*"
        devnode "^hd[a-z]"
        devnode "^cciss.*"
}
```

Step 5: Customize multipath parameters for ONTAP LUNs

If your host is connected to LUNs from other vendors and any of the multipath parameter settings are overridden, you need to correct them by adding stanzas later in the `multipath.conf` file that apply specifically to ONTAP LUNs. If you don't do this, the ONTAP LUNs might not work as expected.

Check your `/etc/multipath.conf` file, especially in the defaults section, for settings that might be overriding the default settings for multipath parameters.

> ⚠️ You shouldn't override the recommended parameter settings for ONTAP LUNs. These settings are required for optimal performance of your host configuration. Contact NetApp support, your OS vendor, or both for more information.

The following example shows how to correct an overridden default. In this example, the `multipath.conf` file defines values for `path_checker` and `no_path_retry` that aren't compatible with ONTAP LUNs, and you can't remove these parameters because ONTAP storage arrays are still attached to the host. Instead, you correct the values for `path_checker` and `no_path_retry` by adding a device stanza to the `multipath.conf` file that applies specifically to the ONTAP LUNs.

Show example

```
defaults {
    path_checker       readsector0
    no_path_retry      fail
}

devices {
    device {
        vendor         "NETAPP"
        product        "LUN"
        no_path_retry  queue
        path_checker   tur
    }
}
```

Step 6: Review the known issues

There are no known issues.

What's next?

- Learn about using the Linux Host Utilities tool.
- Learn about ASM mirroring.

  Automatic Storage Management (ASM) mirroring might require changes to the Linux multipath settings to allow ASM to recognize a problem and switch over to an alternate failure group. Most ASM configurations on ONTAP use external redundancy, which means that data protection is provided by the external array and ASM doesn't mirror data. Some sites use ASM with normal redundancy to provide two-way mirroring, normally across different sites. See Oracle databases on ONTAP for further information.

Configure SUSE Linux Enterprise Server 15 SP5 for FCP and iSCSI with ONTAP storage

The Linux Host Utilities software provides management and diagnostic tools for Linux hosts that are connected to ONTAP storage. When you install the Linux Host Utilities on a SUSE Linux Enterprise Server 15 SP5 host, you can use the Host Utilities to help you manage FCP and iSCSI protocol operations with ONTAP LUNs.

> ⓘ You don't need to manually configure Kernel-based Virtual Machine (KVM) settings because ONTAP LUNs are automatically mapped to the hypervisor.

Step 1: Optionally, enable SAN booting

You can configure your host to use SAN booting to simplify deployment and improve scalability.

Before you begin

Use the Interoperability Matrix Tool to verify that your Linux OS, host bus adapter (HBA), HBA firmware, HBA

boot BIOS, and ONTAP version support SAN booting.

Steps

1. Create a SAN boot LUN and map it to the host.

2. Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is mapped.

   For information on how to enable the HBA BIOS, see your vendor-specific documentation.

3. Verify that the configuration was successful by rebooting the host and verifying that the OS is up and running.

Step 2: Install the Linux Host Utilities

NetApp strongly recommends installing the Linux Host Utilities to support ONTAP LUN management and assist technical support with gathering configuration data.

Install Linux Host Utilities 8.0.

> ⓘ   Installing the Linux Host Utilities doesn't change any host timeout settings on your Linux host.

Step 3: Confirm the multipath configuration for your host

You can use multipathing with SUSE Linux Enterprise Server 15 SP5 to manage ONTAP LUNs.

To ensure that multipathing is configured correctly for your host, verify that the `/etc/multipath.conf` file is defined and that you have the NetApp recommended settings configured for your ONTAP LUNs.

Steps

1. Verify that the `/etc/multipath.conf` file exists:

   ```
   ls /etc/multipath.conf
   ```

   If the file doesn't exist, create an empty, zero-byte file:

   ```
   touch /etc/multipath.conf
   ```

2. The first time the `multipath.conf` file is created, you might need to enable and start the multipath services to load the recommended settings:

   ```
   systemctl enable multipathd
   ```

   ```
   systemctl start multipathd
   ```

3. Each time you boot the host, the empty `/etc/multipath.conf` zero-byte file automatically loads the NetApp recommended host multipath parameters as the default settings. You shouldn't need to make changes to the `/etc/multipath.conf` file for your host because the host operating system is compiled

with the multipath parameters that recognize and manage ONTAP LUNs correctly.

The following table shows the native Linux OS compiled multipath parameter settings for ONTAP LUNs.

Show parameter settings

Parameter	Setting
detect_prio	yes
dev_loss_tmo	"infinity"
failback	immediate
fast_io_fail_tmo	5
features	"2 pg_init_retries 50"
flush_on_last_del	"yes"
hardware_handler	"0"
no_path_retry	queue
path_checker	"tur"
path_grouping_policy	"group_by_prio"
path_selector	"service-time 0"
polling_interval	5
prio	"ontap"
product	LUN
retain_attached_hw_handler	yes
rr_weight	"uniform"
user_friendly_names	no
vendor	NETAPP

4. Verify the parameter settings and path status for your ONTAP LUNs:

```
multipath -ll
```

The default multipath parameters support ASA, AFF, and FAS configurations. In these configurations, a single ONTAP LUN shouldn't require more than four paths. If there are more than four paths, it might cause issues with the paths during a storage failure.

The following example outputs show the correct parameter settings and path status for ONTAP LUNs in an ASA, AFF, or FAS configuration.

ASA configuration

An ASA configuration optimizes all paths to a given LUN, keeping them active. This improves performance by serving I/O operations through all paths at the same time.

```
# multipath -ll
3600a09803831347657244e527766394e dm-5 NETAPP,LUN C-Mode
size=80G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
`-+- policy='service-time 0' prio=50 status=active
  |- 3:0:7:9    sdco 69:192  active ready running
  |- 3:0:8:9    sddi 71:0    active ready running
  |- 14:0:8:9   sdjq 65:320  active ready running
  `- 14:0:7:9   sdiw 8:256   active ready running
```

AFF or FAS configuration

An AFF or FAS configuration should have two groups of paths with higher and lower priorities. Higher priority Active/Optimized paths are served by the controller where the aggregate is located. Lower priority paths are active but non-optimized because they are served by a different controller. Non-optimized paths are only used when optimized paths aren't available.

The following example displays the output for an ONTAP LUN with two Active/Optimized paths and two Active/Non-Optimized paths:

```
# multipath -ll
3600a09803831347657244e527766394e dm-5 NETAPP,LUN C-Mode
size=80G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
|-+- policy='service-time 0' prio=50 status=active
| |- 3:0:3:0    sdd  8:48    active ready running
| |- 3:0:4:0    sdx  65:112  active ready running
`-+- policy='service-time 0' prio=10 status=enabled
  |- 14:0:2:0   sdfk 130:96  active ready running
  `- 14:0:5:0   sdgz 132:240 active ready running
```

Step 4: Optionally, exclude a device from multipathing

If required, you can exclude a device from multipathing by adding the WWID for the unwanted device to the "blacklist" stanza for the `multipath.conf` file.

Steps

1. Determine the WWID:

```
/lib/udev/scsi_id -gud /dev/sda
```

"sda" is the local SCSI disk that you want to add to the blacklist.

An example WWID is `360030057024d0730239134810c0cb833`.

2. Add the WWID to the "blacklist" stanza:

```
blacklist {
        wwid    360030057024d0730239134810c0cb833
        devnode "^(ram|raw|loop|fd|md|dm-|sr|scd|st)[0-9]*"
        devnode "^hd[a-z]"
        devnode "^cciss.*"
}
```

Step 5: Customize multipath parameters for ONTAP LUNs

If your host is connected to LUNs from other vendors and any of the multipath parameter settings are overridden, you need to correct them by adding stanzas later in the `multipath.conf` file that apply specifically to ONTAP LUNs. If you don't do this, the ONTAP LUNs might not work as expected.

Check your `/etc/multipath.conf` file, especially in the defaults section, for settings that might be overriding the default settings for multipath parameters.

> ⚠ You shouldn't override the recommended parameter settings for ONTAP LUNs. These settings are required for optimal performance of your host configuration. Contact NetApp support, your OS vendor, or both for more information.

The following example shows how to correct an overridden default. In this example, the `multipath.conf` file defines values for `path_checker` and `no_path_retry` that aren't compatible with ONTAP LUNs, and you can't remove these parameters because ONTAP storage arrays are still attached to the host. Instead, you correct the values for `path_checker` and `no_path_retry` by adding a device stanza to the `multipath.conf` file that applies specifically to the ONTAP LUNs.

Show example

```
defaults {
    path_checker        readsector0
    no_path_retry       fail
}

devices {
    device {
        vendor          "NETAPP"
        product         "LUN"
        no_path_retry   queue
        path_checker    tur
    }
}
```

Step 6: Review the known issues

There are no known issues.

What's next?

- Learn about using the Linux Host Utilities tool.
- Learn about ASM mirroring.

  Automatic Storage Management (ASM) mirroring might require changes to the Linux multipath settings to allow ASM to recognize a problem and switch over to an alternate failure group. Most ASM configurations on ONTAP use external redundancy, which means that data protection is provided by the external array and ASM doesn't mirror data. Some sites use ASM with normal redundancy to provide two-way mirroring, normally across different sites. See Oracle databases on ONTAP for further information.

Configure SUSE Linux Enterprise Server 15 SP4 for FCP and iSCSI with ONTAP storage

The Linux Host Utilities software provides management and diagnostic tools for Linux hosts that are connected to ONTAP storage. When you install the Linux Host Utilities on a SUSE Linux Enterprise Server 15 SP4 host, you can use the Host Utilities to help you manage FCP and iSCSI protocol operations with ONTAP LUNs.

> ⓘ You don't need to manually configure Kernel-based Virtual Machine (KVM) settings because ONTAP LUNs are automatically mapped to the hypervisor.

Step 1: Optionally, enable SAN booting

You can configure your host to use SAN booting to simplify deployment and improve scalability.

Before you begin

Use the Interoperability Matrix Tool to verify that your Linux OS, host bus adapter (HBA), HBA firmware, HBA

boot BIOS, and ONTAP version support SAN booting.

Steps

1. Create a SAN boot LUN and map it to the host.

2. Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is mapped.

   For information on how to enable the HBA BIOS, see your vendor-specific documentation.

3. Verify that the configuration was successful by rebooting the host and verifying that the OS is up and running.

Step 2: Install the Linux Host Utilities

NetApp strongly recommends installing the Linux Host Utilities to support ONTAP LUN management and assist technical support with gathering configuration data.

Install Linux Host Utilities 8.0.

> ⓘ | Installing the Linux Host Utilities doesn't change any host timeout settings on your Linux host.

Step 3: Confirm the multipath configuration for your host

You can use multipathing with SUSE Linux Enterprise Server 15 SP4 to manage ONTAP LUNs.

To ensure that multipathing is configured correctly for your host, verify that the `/etc/multipath.conf` file is defined and that you have the NetApp recommended settings configured for your ONTAP LUNs.

Steps

1. Verify that the `/etc/multipath.conf` file exists:

   ```
   ls /etc/multipath.conf
   ```

   If the file doesn't exist, create an empty, zero-byte file:

   ```
   touch /etc/multipath.conf
   ```

2. The first time the `multipath.conf` file is created, you might need to enable and start the multipath services to load the recommended settings:

   ```
   systemctl enable multipathd
   ```

   ```
   systemctl start multipathd
   ```

3. Each time you boot the host, the empty `/etc/multipath.conf` zero-byte file automatically loads the NetApp recommended host multipath parameters as the default settings. You shouldn't need to make changes to the `/etc/multipath.conf` file for your host because the host operating system is compiled

with the multipath parameters that recognize and manage ONTAP LUNs correctly.

The following table shows the native Linux OS compiled multipath parameter settings for ONTAP LUNs.

Show parameter settings

Parameter	Setting
detect_prio	yes
dev_loss_tmo	"infinity"
failback	immediate
fast_io_fail_tmo	5
features	"2 pg_init_retries 50"
flush_on_last_del	"yes"
hardware_handler	"0"
no_path_retry	queue
path_checker	"tur"
path_grouping_policy	"group_by_prio"
path_selector	"service-time 0"
polling_interval	5
prio	"ontap"
product	LUN
retain_attached_hw_handler	yes
rr_weight	"uniform"
user_friendly_names	no
vendor	NETAPP

4. Verify the parameter settings and path status for your ONTAP LUNs:

```
multipath -ll
```

The default multipath parameters support ASA, AFF, and FAS configurations. In these configurations, a single ONTAP LUN shouldn't require more than four paths. If there are more than four paths, it might cause issues with the paths during a storage failure.

The following example outputs show the correct parameter settings and path status for ONTAP LUNs in an ASA, AFF, or FAS configuration.

ASA configuration

An ASA configuration optimizes all paths to a given LUN, keeping them active. This improves performance by serving I/O operations through all paths at the same time.

```
# multipath -ll
3600a09803831347657244e527766394e dm-5 NETAPP,LUN C-Mode
size=80G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
`-+- policy='service-time 0' prio=50 status=active
  |- 3:0:7:9    sdco 69:192  active ready running
  |- 3:0:8:9    sddi 71:0    active ready running
  |- 14:0:8:9   sdjq 65:320  active ready running
  `- 14:0:7:9   sdiw 8:256   active ready running
```

AFF or FAS configuration

An AFF or FAS configuration should have two groups of paths with higher and lower priorities. Higher priority Active/Optimized paths are served by the controller where the aggregate is located. Lower priority paths are active but non-optimized because they are served by a different controller. Non-optimized paths are only used when optimized paths aren't available.

The following example displays the output for an ONTAP LUN with two Active/Optimized paths and two Active/Non-Optimized paths:

```
# multipath -ll
3600a09803831347657244e527766394e dm-5 NETAPP,LUN C-Mode
size=80G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
|-+- policy='service-time 0' prio=50 status=active
| |- 3:0:3:0    sdd  8:48    active ready running
| |- 3:0:4:0    sdx  65:112  active ready running
`-+- policy='service-time 0' prio=10 status=enabled
  |- 14:0:2:0   sdfk 130:96  active ready running
  `- 14:0:5:0   sdgz 132:240 active ready running
```

Step 4: Optionally, exclude a device from multipathing

If required, you can exclude a device from multipathing by adding the WWID for the unwanted device to the "blacklist" stanza for the `multipath.conf` file.

Steps

1. Determine the WWID:

```
/lib/udev/scsi_id -gud /dev/sda
```

"sda" is the local SCSI disk that you want to add to the blacklist.

An example WWID is `360030057024d0730239134810c0cb833`.

2. Add the WWID to the "blacklist" stanza:

```
blacklist {
        wwid    360030057024d0730239134810c0cb833
        devnode "^(ram|raw|loop|fd|md|dm-|sr|scd|st)[0-9]*"
        devnode "^hd[a-z]"
        devnode "^cciss.*"
}
```

Step 5: Customize multipath parameters for ONTAP LUNs

If your host is connected to LUNs from other vendors and any of the multipath parameter settings are overridden, you need to correct them by adding stanzas later in the `multipath.conf` file that apply specifically to ONTAP LUNs. If you don't do this, the ONTAP LUNs might not work as expected.

Check your `/etc/multipath.conf` file, especially in the defaults section, for settings that might be overriding the default settings for multipath parameters.

> ⚠ You shouldn't override the recommended parameter settings for ONTAP LUNs. These settings are required for optimal performance of your host configuration. Contact NetApp support, your OS vendor, or both for more information.

The following example shows how to correct an overridden default. In this example, the `multipath.conf` file defines values for `path_checker` and `no_path_retry` that aren't compatible with ONTAP LUNs, and you can't remove these parameters because ONTAP storage arrays are still attached to the host. Instead, you correct the values for `path_checker` and `no_path_retry` by adding a device stanza to the `multipath.conf` file that applies specifically to the ONTAP LUNs.

Show example

```
defaults {
    path_checker        readsector0
    no_path_retry       fail
}

devices {
    device {
        vendor          "NETAPP"
        product         "LUN"
        no_path_retry   queue
        path_checker    tur
    }
}
```

Step 6: Review the known issues

There are no known issues.

What's next?

- Learn about using the Linux Host Utilities tool.
- Learn about ASM mirroring.

  Automatic Storage Management (ASM) mirroring might require changes to the Linux multipath settings to allow ASM to recognize a problem and switch over to an alternate failure group. Most ASM configurations on ONTAP use external redundancy, which means that data protection is provided by the external array and ASM doesn't mirror data. Some sites use ASM with normal redundancy to provide two-way mirroring, normally across different sites. See Oracle databases on ONTAP for further information.

Configure SUSE Linux Enterprise Server 15 SP3 for FCP and iSCSI with ONTAP storage

The Linux Host Utilities software provides management and diagnostic tools for Linux hosts that are connected to ONTAP storage. When you install the Linux Host Utilities on a SUSE Linux Enterprise Server 15 SP3 host, you can use the Host Utilities to help you manage FCP and iSCSI protocol operations with ONTAP LUNs.

> ⓘ You don't need to manually configure Kernel-based Virtual Machine (KVM) settings because ONTAP LUNs are automatically mapped to the hypervisor.

Step 1: Optionally, enable SAN booting

You can configure your host to use SAN booting to simplify deployment and improve scalability.

Before you begin

Use the Interoperability Matrix Tool to verify that your Linux OS, host bus adapter (HBA), HBA firmware, HBA

boot BIOS, and ONTAP version support SAN booting.

Steps

1. Create a SAN boot LUN and map it to the host.

2. Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is mapped.

   For information on how to enable the HBA BIOS, see your vendor-specific documentation.

3. Verify that the configuration was successful by rebooting the host and verifying that the OS is up and running.

Step 2: Install the Linux Host Utilities

NetApp strongly recommends installing the Linux Host Utilities to support ONTAP LUN management and assist technical support with gathering configuration data.

Install Linux Host Utilities 8.0.

> ⓘ   Installing the Linux Host Utilities doesn't change any host timeout settings on your Linux host.

Step 3: Confirm the multipath configuration for your host

You can use multipathing with SUSE Linux Enterprise Server 15 SP3 to manage ONTAP LUNs.

To ensure that multipathing is configured correctly for your host, verify that the `/etc/multipath.conf` file is defined and that you have the NetApp recommended settings configured for your ONTAP LUNs.

Steps

1. Verify that the `/etc/multipath.conf` file exists:

   ```
   ls /etc/multipath.conf
   ```

   If the file doesn't exist, create an empty, zero-byte file:

   ```
   touch /etc/multipath.conf
   ```

2. The first time the `multipath.conf` file is created, you might need to enable and start the multipath services to load the recommended settings:

   ```
   systemctl enable multipathd
   ```

   ```
   systemctl start multipathd
   ```

3. Each time you boot the host, the empty `/etc/multipath.conf` zero-byte file automatically loads the NetApp recommended host multipath parameters as the default settings. You shouldn't need to make changes to the `/etc/multipath.conf` file for your host because the host operating system is compiled

with the multipath parameters that recognize and manage ONTAP LUNs correctly.

The following table shows the native Linux OS compiled multipath parameter settings for ONTAP LUNs.

Show parameter settings

Parameter	Setting
detect_prio	yes
dev_loss_tmo	"infinity"
failback	immediate
fast_io_fail_tmo	5
features	"2 pg_init_retries 50"
flush_on_last_del	"yes"
hardware_handler	"0"
no_path_retry	queue
path_checker	"tur"
path_grouping_policy	"group_by_prio"
path_selector	"service-time 0"
polling_interval	5
prio	"ontap"
product	LUN
retain_attached_hw_handler	yes
rr_weight	"uniform"
user_friendly_names	no
vendor	NETAPP

4. Verify the parameter settings and path status for your ONTAP LUNs:

```
multipath -ll
```

The default multipath parameters support ASA, AFF, and FAS configurations. In these configurations, a single ONTAP LUN shouldn't require more than four paths. If there are more than four paths, it might cause issues with the paths during a storage failure.

The following example outputs show the correct parameter settings and path status for ONTAP LUNs in an ASA, AFF, or FAS configuration.

ASA configuration

An ASA configuration optimizes all paths to a given LUN, keeping them active. This improves performance by serving I/O operations through all paths at the same time.

```
# multipath -ll
3600a09803831347657244e527766394e dm-5 NETAPP,LUN C-Mode
size=80G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
`-+- policy='service-time 0' prio=50 status=active
  |- 3:0:7:9    sdco 69:192  active ready running
  |- 3:0:8:9    sddi 71:0    active ready running
  |- 14:0:8:9   sdjq 65:320  active ready running
  `- 14:0:7:9   sdiw 8:256   active ready running
```

AFF or FAS configuration

An AFF or FAS configuration should have two groups of paths with higher and lower priorities. Higher priority Active/Optimized paths are served by the controller where the aggregate is located. Lower priority paths are active but non-optimized because they are served by a different controller. Non-optimized paths are only used when optimized paths aren't available.

The following example displays the output for an ONTAP LUN with two Active/Optimized paths and two Active/Non-Optimized paths:

```
# multipath -ll
3600a09803831347657244e527766394e dm-5 NETAPP,LUN C-Mode
size=80G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
|-+- policy='service-time 0' prio=50 status=active
| |- 3:0:3:0    sdd  8:48    active ready running
| |- 3:0:4:0    sdx  65:112  active ready running
`-+- policy='service-time 0' prio=10 status=enabled
  |- 14:0:2:0   sdfk 130:96  active ready running
  `- 14:0:5:0   sdgz 132:240 active ready running
```

Step 4: Optionally, exclude a device from multipathing

If required, you can exclude a device from multipathing by adding the WWID for the unwanted device to the "blacklist" stanza for the `multipath.conf` file.

Steps

1. Determine the WWID:

```
/lib/udev/scsi_id -gud /dev/sda
```

"sda" is the local SCSI disk that you want to add to the blacklist.

An example WWID is `360030057024d0730239134810c0cb833`.

2. Add the WWID to the "blacklist" stanza:

```
blacklist {
        wwid    360030057024d0730239134810c0cb833
        devnode "^(ram|raw|loop|fd|md|dm-|sr|scd|st)[0-9]*"
        devnode "^hd[a-z]"
        devnode "^cciss.*"
}
```

Step 5: Customize multipath parameters for ONTAP LUNs

If your host is connected to LUNs from other vendors and any of the multipath parameter settings are overridden, you need to correct them by adding stanzas later in the `multipath.conf` file that apply specifically to ONTAP LUNs. If you don't do this, the ONTAP LUNs might not work as expected.

Check your `/etc/multipath.conf` file, especially in the defaults section, for settings that might be overriding the default settings for multipath parameters.

> ⚠️ You shouldn't override the recommended parameter settings for ONTAP LUNs. These settings are required for optimal performance of your host configuration. Contact NetApp support, your OS vendor, or both for more information.

The following example shows how to correct an overridden default. In this example, the `multipath.conf` file defines values for `path_checker` and `no_path_retry` that aren't compatible with ONTAP LUNs, and you can't remove these parameters because ONTAP storage arrays are still attached to the host. Instead, you correct the values for `path_checker` and `no_path_retry` by adding a device stanza to the `multipath.conf` file that applies specifically to the ONTAP LUNs.

Show example

```
defaults {
    path_checker        readsector0
    no_path_retry       fail
}

devices {
    device {
        vendor          "NETAPP"
        product         "LUN"
        no_path_retry   queue
        path_checker    tur
    }
}
```

Step 6: Review the known issues

There are no known issues.

What's next?

- Learn about using the Linux Host Utilities tool.
- Learn about ASM mirroring.

  Automatic Storage Management (ASM) mirroring might require changes to the Linux multipath settings to allow ASM to recognize a problem and switch over to an alternate failure group. Most ASM configurations on ONTAP use external redundancy, which means that data protection is provided by the external array and ASM doesn't mirror data. Some sites use ASM with normal redundancy to provide two-way mirroring, normally across different sites. See Oracle databases on ONTAP for further information.

Configure SUSE Linux Enterprise Server 15 SP2 for FCP and iSCSI with ONTAP storage

The Linux Host Utilities software provides management and diagnostic tools for Linux hosts that are connected to ONTAP storage. When you install the Linux Host Utilities on a SUSE Linux Enterprise Server 15 SP2 host, you can use the Host Utilities to help you manage FCP and iSCSI protocol operations with ONTAP LUNs.

ⓘ You don't need to manually configure Kernel-based Virtual Machine (KVM) settings because ONTAP LUNs are automatically mapped to the hypervisor.

Step 1: Optionally, enable SAN booting

You can configure your host to use SAN booting to simplify deployment and improve scalability.

Before you begin

Use the Interoperability Matrix Tool to verify that your Linux OS, host bus adapter (HBA), HBA firmware, HBA

boot BIOS, and ONTAP version support SAN booting.

Steps

1. [Create a SAN boot LUN and map it to the host](#).

2. Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is mapped.

   For information on how to enable the HBA BIOS, see your vendor-specific documentation.

3. Verify that the configuration was successful by rebooting the host and verifying that the OS is up and running.

Step 2: Install the Linux Host Utilities

NetApp strongly recommends installing the Linux Host Utilities to support ONTAP LUN management and assist technical support with gathering configuration data.

[Install Linux Host Utilities 8.0](#).

> ⓘ   Installing the Linux Host Utilities doesn't change any host timeout settings on your Linux host.

Step 3: Confirm the multipath configuration for your host

You can use multipathing with SUSE Linux Enterprise Server 15 SP2 to manage ONTAP LUNs.

To ensure that multipathing is configured correctly for your host, verify that the `/etc/multipath.conf` file is defined and that you have the NetApp recommended settings configured for your ONTAP LUNs.

Steps

1. Verify that the `/etc/multipath.conf` file exists:

   ```
   ls /etc/multipath.conf
   ```

   If the file doesn't exist, create an empty, zero-byte file:

   ```
   touch /etc/multipath.conf
   ```

2. The first time the `multipath.conf` file is created, you might need to enable and start the multipath services to load the recommended settings:

   ```
   systemctl enable multipathd
   ```

   ```
   systemctl start multipathd
   ```

3. Each time you boot the host, the empty `/etc/multipath.conf` zero-byte file automatically loads the NetApp recommended host multipath parameters as the default settings. You shouldn't need to make changes to the `/etc/multipath.conf` file for your host because the host operating system is compiled

with the multipath parameters that recognize and manage ONTAP LUNs correctly.

The following table shows the native Linux OS compiled multipath parameter settings for ONTAP LUNs.

Show parameter settings

Parameter	Setting
detect_prio	yes
dev_loss_tmo	"infinity"
failback	immediate
fast_io_fail_tmo	5
features	"2 pg_init_retries 50"
flush_on_last_del	"yes"
hardware_handler	"0"
no_path_retry	queue
path_checker	"tur"
path_grouping_policy	"group_by_prio"
path_selector	"service-time 0"
polling_interval	5
prio	"ontap"
product	LUN
retain_attached_hw_handler	yes
rr_weight	"uniform"
user_friendly_names	no
vendor	NETAPP

4. Verify the parameter settings and path status for your ONTAP LUNs:

```
multipath -ll
```

The default multipath parameters support ASA, AFF, and FAS configurations. In these configurations, a single ONTAP LUN shouldn't require more than four paths. If there are more than four paths, it might cause issues with the paths during a storage failure.

The following example outputs show the correct parameter settings and path status for ONTAP LUNs in an ASA, AFF, or FAS configuration.

ASA configuration

An ASA configuration optimizes all paths to a given LUN, keeping them active. This improves performance by serving I/O operations through all paths at the same time.

```
# multipath -ll
3600a09803831347657244e527766394e dm-5 NETAPP,LUN C-Mode
size=80G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
`-+- policy='service-time 0' prio=50 status=active
  |- 3:0:7:9    sdco 69:192  active ready running
  |- 3:0:8:9    sddi 71:0    active ready running
  |- 14:0:8:9   sdjq 65:320  active ready running
  `- 14:0:7:9   sdiw 8:256   active ready running
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AFF or FAS configuration

An AFF or FAS configuration should have two groups of paths with higher and lower priorities. Higher priority Active/Optimized paths are served by the controller where the aggregate is located. Lower priority paths are active but non-optimized because they are served by a different controller. Non-optimized paths are only used when optimized paths aren't available.

The following example displays the output for an ONTAP LUN with two Active/Optimized paths and two Active/Non-Optimized paths:

```
# multipath -ll
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size=80G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
|-+- policy='service-time 0' prio=50 status=active
| |- 3:0:3:0    sdd  8:48    active ready running
| |- 3:0:4:0    sdx  65:112  active ready running
`-+- policy='service-time 0' prio=10 status=enabled
  |- 14:0:2:0   sdfk 130:96  active ready running
  `- 14:0:5:0   sdgz 132:240 active ready running
```

Step 4: Optionally, exclude a device from multipathing

If required, you can exclude a device from multipathing by adding the WWID for the unwanted device to the "blacklist" stanza for the `multipath.conf` file.

Steps

1. Determine the WWID:

```
/lib/udev/scsi_id -gud /dev/sda
```

"sda" is the local SCSI disk that you want to add to the blacklist.

An example WWID is `360030057024d0730239134810c0cb833`.

2. Add the WWID to the "blacklist" stanza:

```
blacklist {
        wwid    360030057024d0730239134810c0cb833
        devnode "^(ram|raw|loop|fd|md|dm-|sr|scd|st)[0-9]*"
        devnode "^hd[a-z]"
        devnode "^cciss.*"
}
```

Step 5: Customize multipath parameters for ONTAP LUNs

If your host is connected to LUNs from other vendors and any of the multipath parameter settings are overridden, you need to correct them by adding stanzas later in the `multipath.conf` file that apply specifically to ONTAP LUNs. If you don't do this, the ONTAP LUNs might not work as expected.

Check your `/etc/multipath.conf` file, especially in the defaults section, for settings that might be overriding the default settings for multipath parameters.

> ⚠ You shouldn't override the recommended parameter settings for ONTAP LUNs. These settings are required for optimal performance of your host configuration. Contact NetApp support, your OS vendor, or both for more information.

The following example shows how to correct an overridden default. In this example, the `multipath.conf` file defines values for `path_checker` and `no_path_retry` that aren't compatible with ONTAP LUNs, and you can't remove these parameters because ONTAP storage arrays are still attached to the host. Instead, you correct the values for `path_checker` and `no_path_retry` by adding a device stanza to the `multipath.conf` file that applies specifically to the ONTAP LUNs.

Show example

```
defaults {
    path_checker        readsector0
    no_path_retry       fail
}

devices {
    device {
        vendor          "NETAPP"
        product         "LUN"
        no_path_retry   queue
        path_checker    tur
    }
}
```

Step 6: Review the known issues

The SUSE Linux Enterprise Server 15 SP2 with ONTAP storage release has the following known issues:

NetApp Bug ID	Title	Description

1308744	iSCSI boot from SAN fails to boot with a static IP configuration after completing an SUSE Linux Enterprise Server 15S P2 OS installation	iSCSI sanbooted LUN failed to boot up after completing an SUSE Linux Enterprise Server 15 SP2 OS installation with a static IP configuration. Bootup failure occurs every time with the static IP configuration. This leads to the server refusing to continue the boot up process with the following error message:
		
		 ```dracut-cmdline[241]: warning: Empty autoconf values default to dhcp```
		
		 ```dracut: FATAL: FATAL: For argument ip=eth4:static, setting client-ip does not make sense for dhcp```
		
		 ```dracut: Refusing to continue```
		
		 ```reboot: System halted```

What's next?

- Learn about using the Linux Host Utilities tool.
- Learn about ASM mirroring.

  Automatic Storage Management (ASM) mirroring might require changes to the Linux multipath settings to allow ASM to recognize a problem and switch over to an alternate failure group. Most ASM configurations on ONTAP use external redundancy, which means that data protection is provided by the external array and ASM doesn't mirror data. Some sites use ASM with normal redundancy to provide two-way mirroring, normally across different sites. See Oracle databases on ONTAP for further information.

Configure SUSE Linux Enterprise Server 15 SP1 for FCP and iSCSI with ONTAP storage

The Linux Host Utilities software provides management and diagnostic tools for Linux hosts that are connected to ONTAP storage. When you install the Linux Host Utilities on a SUSE Linux Enterprise Server 15 SP1 host, you can use the Host Utilities to help you manage FCP and iSCSI protocol operations with ONTAP LUNs.

> ⓘ You don't need to manually configure Kernel-based Virtual Machine (KVM) settings because ONTAP LUNs are automatically mapped to the hypervisor.

Step 1: Optionally, enable SAN booting

You can configure your host to use SAN booting to simplify deployment and improve scalability.

Before you begin

Use the Interoperability Matrix Tool to verify that your Linux OS, host bus adapter (HBA), HBA firmware, HBA boot BIOS, and ONTAP version support SAN booting.

Steps

1. Create a SAN boot LUN and map it to the host.
2. Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is mapped.

   For information on how to enable the HBA BIOS, see your vendor-specific documentation.

3. Verify that the configuration was successful by rebooting the host and verifying that the OS is up and running.

Step 2: Install the Linux Host Utilities

NetApp strongly recommends installing the Linux Host Utilities to support ONTAP LUN management and assist technical support with gathering configuration data.

Install Linux Host Utilities 8.0.

> ⓘ Installing the Linux Host Utilities doesn't change any host timeout settings on your Linux host.

Step 3: Confirm the multipath configuration for your host

You can use multipathing with SUSE Linux Enterprise Server 15 SP1 to manage ONTAP LUNs.

To ensure that multipathing is configured correctly for your host, verify that the `/etc/multipath.conf` file is defined and that you have the NetApp recommended settings configured for your ONTAP LUNs.

Steps

1. Verify that the `/etc/multipath.conf` file exists:

   ```
   ls /etc/multipath.conf
   ```

   If the file doesn't exist, create an empty, zero-byte file:

   ```
   touch /etc/multipath.conf
   ```

2. The first time the `multipath.conf` file is created, you might need to enable and start the multipath services to load the recommended settings:

   ```
   systemctl enable multipathd
   ```

   ```
   systemctl start multipathd
   ```

3. Each time you boot the host, the empty `/etc/multipath.conf` zero-byte file automatically loads the NetApp recommended host multipath parameters as the default settings. You shouldn't need to make changes to the `/etc/multipath.conf` file for your host because the host operating system is compiled with the multipath parameters that recognize and manage ONTAP LUNs correctly.

   The following table shows the native Linux OS compiled multipath parameter settings for ONTAP LUNs.

Show parameter settings

Parameter	Setting
detect_prio	yes
dev_loss_tmo	"infinity"
failback	immediate
fast_io_fail_tmo	5
features	"2 pg_init_retries 50"
flush_on_last_del	"yes"
hardware_handler	"0"
no_path_retry	queue
path_checker	"tur"
path_grouping_policy	"group_by_prio"
path_selector	"service-time 0"
polling_interval	5
prio	"ontap"
product	LUN
retain_attached_hw_handler	yes
rr_weight	"uniform"
user_friendly_names	no
vendor	NETAPP

4. Verify the parameter settings and path status for your ONTAP LUNs:

```
multipath -ll
```

The default multipath parameters support ASA, AFF, and FAS configurations. In these configurations, a single ONTAP LUN shouldn't require more than four paths. If there are more than four paths, it might cause issues with the paths during a storage failure.

The following example outputs show the correct parameter settings and path status for ONTAP LUNs in an ASA, AFF, or FAS configuration.

ASA configuration

An ASA configuration optimizes all paths to a given LUN, keeping them active. This improves performance by serving I/O operations through all paths at the same time.

```
# multipath -ll
3600a09803831347657244e527766394e dm-5 NETAPP,LUN C-Mode
size=80G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
`-+- policy='service-time 0' prio=50 status=active
  |- 3:0:7:9    sdco 69:192  active ready running
  |- 3:0:8:9    sddi 71:0    active ready running
  |- 14:0:8:9   sdjq 65:320  active ready running
  `- 14:0:7:9   sdiw 8:256   active ready running
```

AFF or FAS configuration

An AFF or FAS configuration should have two groups of paths with higher and lower priorities. Higher priority Active/Optimized paths are served by the controller where the aggregate is located. Lower priority paths are active but non-optimized because they are served by a different controller. Non-optimized paths are only used when optimized paths aren't available.

The following example displays the output for an ONTAP LUN with two Active/Optimized paths and two Active/Non-Optimized paths:

```
# multipath -ll
3600a09803831347657244e527766394e dm-5 NETAPP,LUN C-Mode
size=80G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
|-+- policy='service-time 0' prio=50 status=active
| |- 3:0:3:0    sdd  8:48    active ready running
| |- 3:0:4:0    sdx  65:112  active ready running
`-+- policy='service-time 0' prio=10 status=enabled
  |- 14:0:2:0   sdfk 130:96  active ready running
  `- 14:0:5:0   sdgz 132:240 active ready running
```

Step 4: Optionally, exclude a device from multipathing

If required, you can exclude a device from multipathing by adding the WWID for the unwanted device to the "blacklist" stanza for the `multipath.conf` file.

Steps

1. Determine the WWID:

```
/lib/udev/scsi_id -gud /dev/sda
```

"sda" is the local SCSI disk that you want to add to the blacklist.

An example WWID is `360030057024d0730239134810c0cb833`.

2. Add the WWID to the "blacklist" stanza:

```
blacklist {
        wwid    360030057024d0730239134810c0cb833
        devnode "^(ram|raw|loop|fd|md|dm-|sr|scd|st)[0-9]*"
        devnode "^hd[a-z]"
        devnode "^cciss.*"
}
```

Step 5: Customize multipath parameters for ONTAP LUNs

If your host is connected to LUNs from other vendors and any of the multipath parameter settings are overridden, you need to correct them by adding stanzas later in the `multipath.conf` file that apply specifically to ONTAP LUNs. If you don't do this, the ONTAP LUNs might not work as expected.

Check your `/etc/multipath.conf` file, especially in the defaults section, for settings that might be overriding the default settings for multipath parameters.

> ⚠️ You shouldn't override the recommended parameter settings for ONTAP LUNs. These settings are required for optimal performance of your host configuration. Contact NetApp support, your OS vendor, or both for more information.

The following example shows how to correct an overridden default. In this example, the `multipath.conf` file defines values for `path_checker` and `no_path_retry` that aren't compatible with ONTAP LUNs, and you can't remove these parameters because ONTAP storage arrays are still attached to the host. Instead, you correct the values for `path_checker` and `no_path_retry` by adding a device stanza to the `multipath.conf` file that applies specifically to the ONTAP LUNs.

Show example

```
defaults {
    path_checker        readsector0
    no_path_retry       fail
}

devices {
    device {
        vendor          "NETAPP"
        product         "LUN"
        no_path_retry   queue
        path_checker    tur
    }
}
```

Step 6: Review the known issues

The SUSE Linux Enterprise Server 15 SP1 with ONTAP storage release has the following known issues:

NetApp Bug ID	Title	Description
[1246622](#)	Remote ports transit to a blocked state on SLES15SP1 with Emulex LPe12002 8GB FC during storage failover operations.	Remote ports transit to a blocked state on SLES15SP1 with Emulex LPe12002 8GB Fibre Channel (FC) during storage failover operations. When the storage node returns to an optimal state, the LIFs also come up and the remote port state should read "online." Occasionally, the remote port state might continue to read as "blocked" or "not present." This state can lead to a "failed faulty" path to LUNs at the multipath layer as well as an I/O outage for those LUNs. You can check the remoteport's details against the following sample commands: ---- cat/sys/class/fc_host/host*/device/rport*/fc_remote_ports/rport*/port_name cat/sys/class/fc_host/host*/device/rport*/fc_remote_ports/rport*/port_state ----

What's next?

- [Learn about using the Linux Host Utilities tool](#).
- Learn about ASM mirroring.

  Automatic Storage Management (ASM) mirroring might require changes to the Linux multipath settings to allow ASM to recognize a problem and switch over to an alternate failure group. Most ASM configurations on ONTAP use external redundancy, which means that data protection is provided by the external array and ASM doesn't mirror data. Some sites use ASM with normal redundancy to provide two-way mirroring, normally across different sites. See [Oracle databases on ONTAP](#) for further information.

Configure SUSE Linux Enterprise Server 15 for FCP and iSCSI with ONTAP storage

The Linux Host Utilities software provides management and diagnostic tools for Linux hosts that are connected to ONTAP storage. When you install the Linux Host Utilities on a SUSE Linux Enterprise Server 15 host, you can use the Host Utilities to help you manage FCP and iSCSI protocol operations with ONTAP LUNs.

> ⓘ You don't need to manually configure Kernel-based Virtual Machine (KVM) settings because ONTAP LUNs are automatically mapped to the hypervisor.

Step 1: Optionally, enable SAN booting

You can configure your host to use SAN booting to simplify deployment and improve scalability.

Before you begin

Use the Interoperability Matrix Tool to verify that your Linux OS, host bus adapter (HBA), HBA firmware, HBA boot BIOS, and ONTAP version support SAN booting.

Steps

1. Create a SAN boot LUN and map it to the host.

2. Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is mapped.

   For information on how to enable the HBA BIOS, see your vendor-specific documentation.

3. Verify that the configuration was successful by rebooting the host and verifying that the OS is up and running.

Step 2: Install the Linux Host Utilities

NetApp strongly recommends installing the Linux Host Utilities to support ONTAP LUN management and assist technical support with gathering configuration data.

Install Linux Host Utilities 8.0.

> ⓘ Installing the Linux Host Utilities doesn't change any host timeout settings on your Linux host.

Step 3: Confirm the multipath configuration for your host

You can use multipathing with SUSE Linux Enterprise Server 15 to manage ONTAP LUNs.

To ensure that multipathing is configured correctly for your host, verify that the `/etc/multipath.conf` file is defined and that you have the NetApp recommended settings configured for your ONTAP LUNs.

Steps

1. Verify that the `/etc/multipath.conf` file exists:

   ```
   ls /etc/multipath.conf
   ```

   If the file doesn't exist, create an empty, zero-byte file:

   ```
   touch /etc/multipath.conf
   ```

2. The first time the `multipath.conf` file is created, you might need to enable and start the multipath services to load the recommended settings:

```
systemctl enable multipathd
```

```
systemctl start multipathd
```

3. Each time you boot the host, the empty `/etc/multipath.conf` zero-byte file automatically loads the NetApp recommended host multipath parameters as the default settings. You shouldn't need to make changes to the `/etc/multipath.conf` file for your host because the host operating system is compiled with the multipath parameters that recognize and manage ONTAP LUNs correctly.

The following table shows the native Linux OS compiled multipath parameter settings for ONTAP LUNs.

Show parameter settings

Parameter	Setting
detect_prio	yes
dev_loss_tmo	"infinity"
failback	immediate
fast_io_fail_tmo	5
features	"2 pg_init_retries 50"
flush_on_last_del	"yes"
hardware_handler	"0"
no_path_retry	queue
path_checker	"tur"
path_grouping_policy	"group_by_prio"
path_selector	"service-time 0"
polling_interval	5
prio	"ontap"
product	LUN
retain_attached_hw_handler	yes
rr_weight	"uniform"
user_friendly_names	no
vendor	NETAPP

4. Verify the parameter settings and path status for your ONTAP LUNs:

```
multipath -ll
```

The default multipath parameters support ASA, AFF, and FAS configurations. In these configurations, a single ONTAP LUN shouldn't require more than four paths. If there are more than four paths, it might cause issues with the paths during a storage failure.

The following example outputs show the correct parameter settings and path status for ONTAP LUNs in an ASA, AFF, or FAS configuration.

ASA configuration

An ASA configuration optimizes all paths to a given LUN, keeping them active. This improves performance by serving I/O operations through all paths at the same time.

```
# multipath -ll
3600a09803831347657244e527766394e dm-5 NETAPP,LUN C-Mode
size=80G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
`-+- policy='service-time 0' prio=50 status=active
  |- 3:0:7:9    sdco 69:192   active ready running
  |- 3:0:8:9    sddi 71:0     active ready running
  |- 14:0:8:9   sdjq 65:320   active ready running
  `- 14:0:7:9   sdiw 8:256    active ready running
```

AFF or FAS configuration

An AFF or FAS configuration should have two groups of paths with higher and lower priorities. Higher priority Active/Optimized paths are served by the controller where the aggregate is located. Lower priority paths are active but non-optimized because they are served by a different controller. Non-optimized paths are only used when optimized paths aren't available.

The following example displays the output for an ONTAP LUN with two Active/Optimized paths and two Active/Non-Optimized paths:

```
# multipath -ll
3600a09803831347657244e527766394e dm-5 NETAPP,LUN C-Mode
size=80G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
|-+- policy='service-time 0' prio=50 status=active
| |- 3:0:3:0    sdd  8:48     active ready running
| |- 3:0:4:0    sdx  65:112   active ready running
`-+- policy='service-time 0' prio=10 status=enabled
  |- 14:0:2:0   sdfk 130:96   active ready running
  `- 14:0:5:0   sdgz 132:240  active ready running
```

Step 4: Optionally, exclude a device from multipathing

If required, you can exclude a device from multipathing by adding the WWID for the unwanted device to the "blacklist" stanza for the `multipath.conf` file.

Steps

1. Determine the WWID:

   ```
   /lib/udev/scsi_id -gud /dev/sda
   ```

   "sda" is the local SCSI disk that you want to add to the blacklist.

   An example WWID is `360030057024d0730239134810c0cb833`.

2. Add the WWID to the "blacklist" stanza:

   ```
   blacklist {
           wwid    360030057024d0730239134810c0cb833
           devnode "^(ram|raw|loop|fd|md|dm-|sr|scd|st)[0-9]*"
           devnode "^hd[a-z]"
           devnode "^cciss.*"
   }
   ```

Step 5: Customize multipath parameters for ONTAP LUNs

If your host is connected to LUNs from other vendors and any of the multipath parameter settings are overridden, you need to correct them by adding stanzas later in the `multipath.conf` file that apply specifically to ONTAP LUNs. If you don't do this, the ONTAP LUNs might not work as expected.

Check your `/etc/multipath.conf` file, especially in the defaults section, for settings that might be overriding the default settings for multipath parameters.

> ⚠ You shouldn't override the recommended parameter settings for ONTAP LUNs. These settings are required for optimal performance of your host configuration. Contact NetApp support, your OS vendor, or both for more information.

The following example shows how to correct an overridden default. In this example, the `multipath.conf` file defines values for `path_checker` and `no_path_retry` that aren't compatible with ONTAP LUNs, and you can't remove these parameters because ONTAP storage arrays are still attached to the host. Instead, you correct the values for `path_checker` and `no_path_retry` by adding a device stanza to the `multipath.conf` file that applies specifically to the ONTAP LUNs.

Show example

```
defaults {
    path_checker        readsector0
    no_path_retry       fail
}

devices {
    device {
        vendor          "NETAPP"
        product         "LUN"
        no_path_retry   queue
        path_checker    tur
    }
}
```

Step 6: Review the known issues

The SUSE Linux Enterprise Server 15 with ONTAP storage release has the following known issue:

NetApp Bug ID	Title	Description
1154309	SLES 15 host with more than 20 mapped LUNs might go into maintenance mode after a reboot	SLES 15 host with more than 20 mapped LUNs might go into maintenance mode after a reboot. The maintenance mode becomes single user mode following the message: `Give root password for maintenance (or press Control-D to continue)`

What's next?

- Learn about using the Linux Host Utilities tool.
- Learn about ASM mirroring.

  Automatic Storage Management (ASM) mirroring might require changes to the Linux multipath settings to allow ASM to recognize a problem and switch over to an alternate failure group. Most ASM configurations on ONTAP use external redundancy, which means that data protection is provided by the external array and ASM doesn't mirror data. Some sites use ASM with normal redundancy to provide two-way mirroring, normally across different sites. See Oracle databases on ONTAP for further information.

SUSE Linux Enterprise Server 12

Configure SUSE Linux Enterprise Server 12 SP5 for FCP and iSCSI with ONTAP storage

The Linux Host Utilities software provides management and diagnostic tools for Linux

hosts that are connected to ONTAP storage. When you install the Linux Host Utilities on a SUSE Linux Enterprise Server 12 SP5 host, you can use the Host Utilities to help you manage FCP and iSCSI protocol operations with ONTAP LUNs.

> ℹ️ You don't need to manually configure Kernel-based Virtual Machine (KVM) settings because ONTAP LUNs are automatically mapped to the hypervisor.

Step 1: Optionally, enable SAN booting

You can configure your host to use SAN booting to simplify deployment and improve scalability.

Before you begin

Use the Interoperability Matrix Tool to verify that your Linux OS, host bus adapter (HBA), HBA firmware, HBA boot BIOS, and ONTAP version support SAN booting.

Steps

1. Create a SAN boot LUN and map it to the host.
2. Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is mapped.

   For information on how to enable the HBA BIOS, see your vendor-specific documentation.

3. Verify that the configuration was successful by rebooting the host and verifying that the OS is up and running.

Step 2: Install the Linux Host Utilities

NetApp strongly recommends installing the Linux Host Utilities to support ONTAP LUN management and assist technical support with gathering configuration data.

Install Linux Host Utilities 7.1.

> ℹ️ Installing the Linux Host Utilities doesn't change any host timeout settings on your Linux host.

Step 3: Confirm the multipath configuration for your host

You can use multipathing with SUSE Linux Enterprise Server 12 SP5 to manage ONTAP LUNs.

To ensure that multipathing is configured correctly for your host, verify that the `/etc/multipath.conf` file is defined and that you have the NetApp recommended settings configured for your ONTAP LUNs.

Steps

1. Verify that the `/etc/multipath.conf` file exists:

   ```
   ls /etc/multipath.conf
   ```

   If the file doesn't exist, create an empty, zero-byte file:

   ```
   touch /etc/multipath.conf
   ```

2. The first time the `multipath.conf` file is created, you might need to enable and start the multipath services to load the recommended settings:

```
systemctl enable multipathd
```

```
systemctl start multipathd
```

3. Each time you boot the host, the empty `/etc/multipath.conf` zero-byte file automatically loads the NetApp recommended host multipath parameters as the default settings. You shouldn't need to make changes to the `/etc/multipath.conf` file for your host because the host operating system is compiled with the multipath parameters that recognize and manage ONTAP LUNs correctly.

   The following table shows the native Linux OS compiled multipath parameter settings for ONTAP LUNs.

   Show parameter settings

Parameter	Setting
detect_prio	yes
dev_loss_tmo	"infinity"
failback	immediate
fast_io_fail_tmo	5
features	"2 pg_init_retries 50"
flush_on_last_del	"yes"
hardware_handler	"0"
no_path_retry	queue
path_checker	"tur"
path_grouping_policy	"group_by_prio"
path_selector	"service-time 0"
polling_interval	5
prio	"ontap"
product	LUN
retain_attached_hw_handler	yes
rr_weight	"uniform"
user_friendly_names	no
vendor	NETAPP

4. Verify the parameter settings and path status for your ONTAP LUNs:

```
multipath -ll
```

The default multipath parameters support ASA, AFF, and FAS configurations. In these configurations, a single ONTAP LUN shouldn't require more than four paths. If there are more than four paths, it might cause issues with the paths during a storage failure.

The following example outputs show the correct parameter settings and path status for ONTAP LUNs in an ASA, AFF, or FAS configuration.

ASA configuration

An ASA configuration optimizes all paths to a given LUN, keeping them active. This improves performance by serving I/O operations through all paths at the same time.

```
# multipath -ll
3600a09803831347657244e527766394e dm-5 NETAPP,LUN C-Mode
size=80G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
`-+- policy='service-time 0' prio=50 status=active
  |- 3:0:7:9    sdco 69:192  active ready running
  |- 3:0:8:9    sddi 71:0    active ready running
  |- 14:0:8:9   sdjq 65:320  active ready running
  `- 14:0:7:9   sdiw 8:256   active ready running
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AFF or FAS configuration

An AFF or FAS configuration should have two groups of paths with higher and lower priorities. Higher priority Active/Optimized paths are served by the controller where the aggregate is located. Lower priority paths are active but non-optimized because they are served by a different controller. Non-optimized paths are only used when optimized paths aren't available.

The following example displays the output for an ONTAP LUN with two Active/Optimized paths and two Active/Non-Optimized paths:

```
# multipath -ll
3600a09803831347657244e527766394e dm-5 NETAPP,LUN C-Mode
size=80G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
|-+- policy='service-time 0' prio=50 status=active
| |- 3:0:3:0    sdd  8:48    active ready running
| |- 3:0:4:0    sdx  65:112  active ready running
`-+- policy='service-time 0' prio=10 status=enabled
  |- 14:0:2:0   sdfk 130:96  active ready running
  `- 14:0:5:0   sdgz 132:240 active ready running
```

Step 4: Optionally, exclude a device from multipathing

If required, you can exclude a device from multipathing by adding the WWID for the unwanted device to the "blacklist" stanza for the `multipath.conf` file.

Steps

1. Determine the WWID:

   ```
   /lib/udev/scsi_id -gud /dev/sda
   ```

   "sda" is the local SCSI disk that you want to add to the blacklist.

   An example WWID is `360030057024d0730239134810c0cb833`.

2. Add the WWID to the "blacklist" stanza:

   ```
   blacklist {
           wwid    360030057024d0730239134810c0cb833
           devnode "^(ram|raw|loop|fd|md|dm-|sr|scd|st)[0-9]*"
           devnode "^hd[a-z]"
           devnode "^cciss.*"
   }
   ```

Step 5: Customize multipath parameters for ONTAP LUNs

If your host is connected to LUNs from other vendors and any of the multipath parameter settings are overridden, you need to correct them by adding stanzas later in the `multipath.conf` file that apply specifically to ONTAP LUNs. If you don't do this, the ONTAP LUNs might not work as expected.

Check your `/etc/multipath.conf` file, especially in the defaults section, for settings that might be overriding the default settings for multipath parameters.

> ⚠ You shouldn't override the recommended parameter settings for ONTAP LUNs. These settings are required for optimal performance of your host configuration. Contact NetApp support, your OS vendor, or both for more information.

The following example shows how to correct an overridden default. In this example, the `multipath.conf` file defines values for `path_checker` and `no_path_retry` that aren't compatible with ONTAP LUNs, and you can't remove these parameters because ONTAP storage arrays are still attached to the host. Instead, you correct the values for `path_checker` and `no_path_retry` by adding a device stanza to the `multipath.conf` file that applies specifically to the ONTAP LUNs.

Show example

```
defaults {
    path_checker       readsector0
    no_path_retry      fail
}

devices {
    device {
        vendor          "NETAPP"
        product         "LUN"
        no_path_retry   queue
        path_checker    tur
    }
}
```

Step 6: Review the known issues

The SUSE Linux Enterprise Server 12 SP5 with ONTAP storage release has the following known issues:

NetApp Bug ID	Title	Description
1284293	Kernel disruption occurs on SLES12 SP5 with QLogic QLE2562 8GB FC HBA during storage failover operations	Kernel disruption occurs during storage failover operations on the SLES12 SP5 kernel with a QLogic QLE2562 Fibre Channel (FC) host bus adapter (HBA). The kernel disruption causes SLES12 SP5 to reboot, leading to application disruption. If the kdump mechanism is enabled, the kernel disruption generates a vmcore file located in the /var/crash/ directory. Check the vmcore file to determine the cause of the disruption. A storage failover with a QLogic QLE2562 HBA event affects the "THREAD_INFO: ffff8aedf723c2c0" module. Locate this event in the vmcore file by finding the following string: "[THREAD_INFO: ffff8aedf723c2c0]". After the kernel disruption, reboot the host OS to enable it to recover. Then restart the applications.

What's next?

- Learn about using the Linux Host Utilities tool.

- Learn about ASM mirroring.

  Automatic Storage Management (ASM) mirroring might require changes to the Linux multipath settings to allow ASM to recognize a problem and switch over to an alternate failure group. Most ASM configurations on ONTAP use external redundancy, which means that data protection is provided by the external array and ASM doesn't mirror data. Some sites use ASM with normal redundancy to provide two-way mirroring, normally across different sites. See Oracle databases on ONTAP for further information.

Configure SUSE Linux Enterprise Server 12 SP4 for FCP and iSCSI with ONTAP storage

The Linux Host Utilities software provides management and diagnostic tools for Linux hosts that are connected to ONTAP storage. When you install the Linux Host Utilities on a SUSE Linux Enterprise Server 12 SP4 host, you can use the Host Utilities to help you manage FCP and iSCSI protocol operations with ONTAP LUNs.

> ⓘ You don't need to manually configure Kernel-based Virtual Machine (KVM) settings because ONTAP LUNs are automatically mapped to the hypervisor.

Step 1: Optionally, enable SAN booting

You can configure your host to use SAN booting to simplify deployment and improve scalability.

Before you begin

Use the Interoperability Matrix Tool to verify that your Linux OS, host bus adapter (HBA), HBA firmware, HBA boot BIOS, and ONTAP version support SAN booting.

Steps

1. Create a SAN boot LUN and map it to the host.
2. Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is mapped.

   For information on how to enable the HBA BIOS, see your vendor-specific documentation.

3. Verify that the configuration was successful by rebooting the host and verifying that the OS is up and running.

Step 2: Install the Linux Host Utilities

NetApp strongly recommends installing the Linux Host Utilities to support ONTAP LUN management and assist technical support with gathering configuration data.

Install Linux Host Utilities 7.1.

> ⓘ Installing the Linux Host Utilities doesn't change any host timeout settings on your Linux host.

Step 3: Confirm the multipath configuration for your host

You can use multipathing with SUSE Linux Enterprise Server 12 SP4 to manage ONTAP LUNs.

To ensure that multipathing is configured correctly for your host, verify that the `/etc/multipath.conf` file is defined and that you have the NetApp recommended settings configured for your ONTAP LUNs.

Steps

1. Verify that the `/etc/multipath.conf` file exists:

```
ls /etc/multipath.conf
```

If the file doesn't exist, create an empty, zero-byte file:

```
touch /etc/multipath.conf
```

2. The first time the `multipath.conf` file is created, you might need to enable and start the multipath services to load the recommended settings:

```
systemctl enable multipathd
```

```
systemctl start multipathd
```

3. Each time you boot the host, the empty `/etc/multipath.conf` zero-byte file automatically loads the NetApp recommended host multipath parameters as the default settings. You shouldn't need to make changes to the `/etc/multipath.conf` file for your host because the host operating system is compiled with the multipath parameters that recognize and manage ONTAP LUNs correctly.

The following table shows the native Linux OS compiled multipath parameter settings for ONTAP LUNs.

Show parameter settings

Parameter	Setting
detect_prio	yes
dev_loss_tmo	"infinity"
failback	immediate
fast_io_fail_tmo	5
features	"2 pg_init_retries 50"
flush_on_last_del	"yes"
hardware_handler	"0"
no_path_retry	queue
path_checker	"tur"
path_grouping_policy	"group_by_prio"
path_selector	"service-time 0"
polling_interval	5
prio	"ontap"
product	LUN
retain_attached_hw_handler	yes
rr_weight	"uniform"
user_friendly_names	no
vendor	NETAPP

4. Verify the parameter settings and path status for your ONTAP LUNs:

```
multipath -ll
```

The default multipath parameters support ASA, AFF, and FAS configurations. In these configurations, a single ONTAP LUN shouldn't require more than four paths. If there are more than four paths, it might cause issues with the paths during a storage failure.

The following example outputs show the correct parameter settings and path status for ONTAP LUNs in an ASA, AFF, or FAS configuration.

ASA configuration

An ASA configuration optimizes all paths to a given LUN, keeping them active. This improves performance by serving I/O operations through all paths at the same time.

```
# multipath -ll
3600a09803831347657244e527766394e dm-5 NETAPP,LUN C-Mode
size=80G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
`-+- policy='service-time 0' prio=50 status=active
  |- 3:0:7:9    sdco 69:192  active ready running
  |- 3:0:8:9    sddi 71:0    active ready running
  |- 14:0:8:9   sdjq 65:320  active ready running
  `- 14:0:7:9   sdiw 8:256   active ready running
```

AFF or FAS configuration

An AFF or FAS configuration should have two groups of paths with higher and lower priorities. Higher priority Active/Optimized paths are served by the controller where the aggregate is located. Lower priority paths are active but non-optimized because they are served by a different controller. Non-optimized paths are only used when optimized paths aren't available.

The following example displays the output for an ONTAP LUN with two Active/Optimized paths and two Active/Non-Optimized paths:

```
# multipath -ll
3600a09803831347657244e527766394e dm-5 NETAPP,LUN C-Mode
size=80G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
|-+- policy='service-time 0' prio=50 status=active
| |- 3:0:3:0    sdd  8:48    active ready running
| |- 3:0:4:0    sdx  65:112  active ready running
`-+- policy='service-time 0' prio=10 status=enabled
  |- 14:0:2:0   sdfk 130:96  active ready running
  `- 14:0:5:0   sdgz 132:240 active ready running
```

Step 4: Optionally, exclude a device from multipathing

If required, you can exclude a device from multipathing by adding the WWID for the unwanted device to the "blacklist" stanza for the `multipath.conf` file.

Steps

1. Determine the WWID:

```
/lib/udev/scsi_id -gud /dev/sda
```

"sda" is the local SCSI disk that you want to add to the blacklist.

An example WWID is `360030057024d0730239134810c0cb833`.

2. Add the WWID to the "blacklist" stanza:

```
blacklist {
        wwid    360030057024d0730239134810c0cb833
        devnode "^(ram|raw|loop|fd|md|dm-|sr|scd|st)[0-9]*"
        devnode "^hd[a-z]"
        devnode "^cciss.*"
}
```

Step 5: Customize multipath parameters for ONTAP LUNs

If your host is connected to LUNs from other vendors and any of the multipath parameter settings are overridden, you need to correct them by adding stanzas later in the `multipath.conf` file that apply specifically to ONTAP LUNs. If you don't do this, the ONTAP LUNs might not work as expected.

Check your `/etc/multipath.conf` file, especially in the defaults section, for settings that might be overriding the default settings for multipath parameters.

> ⚠️ You shouldn't override the recommended parameter settings for ONTAP LUNs. These settings are required for optimal performance of your host configuration. Contact NetApp support, your OS vendor, or both for more information.

The following example shows how to correct an overridden default. In this example, the `multipath.conf` file defines values for `path_checker` and `no_path_retry` that aren't compatible with ONTAP LUNs, and you can't remove these parameters because ONTAP storage arrays are still attached to the host. Instead, you correct the values for `path_checker` and `no_path_retry` by adding a device stanza to the `multipath.conf` file that applies specifically to the ONTAP LUNs.

```
defaults {
    path_checker        readsector0
    no_path_retry       fail
}

devices {
    device {
        vendor          "NETAPP"
        product         "LUN"
        no_path_retry   queue
        path_checker    tur
    }
}
```

Step 6: Review the known issues

There are no known issues.

What's next?

- [Learn about using the Linux Host Utilities tool](#).
- Learn about ASM mirroring.

  Automatic Storage Management (ASM) mirroring might require changes to the Linux multipath settings to allow ASM to recognize a problem and switch over to an alternate failure group. Most ASM configurations on ONTAP use external redundancy, which means that data protection is provided by the external array and ASM doesn't mirror data. Some sites use ASM with normal redundancy to provide two-way mirroring, normally across different sites. See [Oracle databases on ONTAP](#) for further information.

Configure SUSE Linux Enterprise Server 12 SP3 for FCP and iSCSI with ONTAP storage

The Linux Host Utilities software provides management and diagnostic tools for Linux hosts that are connected to ONTAP storage. When you install the Linux Host Utilities on a SUSE Linux Enterprise Server 12 SP3 host, you can use the Host Utilities to help you manage FCP and iSCSI protocol operations with ONTAP LUNs.

> (i) You don't need to manually configure Kernel-based Virtual Machine (KVM) settings because ONTAP LUNs are automatically mapped to the hypervisor.

Step 1: Optionally, enable SAN booting

You can configure your host to use SAN booting to simplify deployment and improve scalability.

Before you begin

Use the [Interoperability Matrix Tool](#) to verify that your Linux OS, host bus adapter (HBA), HBA firmware, HBA

boot BIOS, and ONTAP version support SAN booting.

Steps

1. [Create a SAN boot LUN and map it to the host](#).

2. Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is mapped.

   For information on how to enable the HBA BIOS, see your vendor-specific documentation.

3. Verify that the configuration was successful by rebooting the host and verifying that the OS is up and running.

Step 2: Install the Linux Host Utilities

NetApp strongly recommends installing the Linux Host Utilities to support ONTAP LUN management and assist technical support with gathering configuration data.

[Install Linux Host Utilities 7.1](#).

ⓘ | Installing the Linux Host Utilities doesn't change any host timeout settings on your Linux host.

Step 3: Confirm the multipath configuration for your host

You can use multipathing with SUSE Linux Enterprise Server 12 SP3 to manage ONTAP LUNs.

To ensure that multipathing is configured correctly for your host, verify that the `/etc/multipath.conf` file is defined and that you have the NetApp recommended settings configured for your ONTAP LUNs.

Steps

1. Verify that the `/etc/multipath.conf` file exists:

   ```
   ls /etc/multipath.conf
   ```

   If the file doesn't exist, create an empty, zero-byte file:

   ```
   touch /etc/multipath.conf
   ```

2. The first time the `multipath.conf` file is created, you might need to enable and start the multipath services to load the recommended settings:

   ```
   systemctl enable multipathd
   ```

   ```
   systemctl start multipathd
   ```

3. Each time you boot the host, the empty `/etc/multipath.conf` zero-byte file automatically loads the NetApp recommended host multipath parameters as the default settings. You shouldn't need to make changes to the `/etc/multipath.conf` file for your host because the host operating system is compiled

with the multipath parameters that recognize and manage ONTAP LUNs correctly.

The following table shows the native Linux OS compiled multipath parameter settings for ONTAP LUNs.

Show parameter settings

Parameter	Setting
detect_prio	yes
dev_loss_tmo	"infinity"
failback	immediate
fast_io_fail_tmo	5
features	"2 pg_init_retries 50"
flush_on_last_del	"yes"
hardware_handler	"0"
no_path_retry	queue
path_checker	"tur"
path_grouping_policy	"group_by_prio"
path_selector	"service-time 0"
polling_interval	5
prio	"ontap"
product	LUN
retain_attached_hw_handler	yes
rr_weight	"uniform"
user_friendly_names	no
vendor	NETAPP

4. Verify the parameter settings and path status for your ONTAP LUNs:

```
multipath -ll
```

The default multipath parameters support ASA, AFF, and FAS configurations. In these configurations, a single ONTAP LUN shouldn't require more than four paths. If there are more than four paths, it might cause issues with the paths during a storage failure.

The following example outputs show the correct parameter settings and path status for ONTAP LUNs in an ASA, AFF, or FAS configuration.

ASA configuration

An ASA configuration optimizes all paths to a given LUN, keeping them active. This improves performance by serving I/O operations through all paths at the same time.

```
# multipath -ll
3600a09803831347657244e527766394e dm-5 NETAPP,LUN C-Mode
size=80G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
`-+- policy='service-time 0' prio=50 status=active
  |- 3:0:7:9    sdco 69:192  active ready running
  |- 3:0:8:9    sddi 71:0    active ready running
  |- 14:0:8:9   sdjq 65:320  active ready running
  `- 14:0:7:9   sdiw 8:256   active ready running
```

AFF or FAS configuration

An AFF or FAS configuration should have two groups of paths with higher and lower priorities. Higher priority Active/Optimized paths are served by the controller where the aggregate is located. Lower priority paths are active but non-optimized because they are served by a different controller. Non-optimized paths are only used when optimized paths aren't available.

The following example displays the output for an ONTAP LUN with two Active/Optimized paths and two Active/Non-Optimized paths:

```
# multipath -ll
3600a09803831347657244e527766394e dm-5 NETAPP,LUN C-Mode
size=80G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
|-+- policy='service-time 0' prio=50 status=active
| |- 3:0:3:0    sdd  8:48    active ready running
| |- 3:0:4:0    sdx  65:112  active ready running
`-+- policy='service-time 0' prio=10 status=enabled
  |- 14:0:2:0   sdfk 130:96  active ready running
  `- 14:0:5:0   sdgz 132:240 active ready running
```

Step 4: Optionally, exclude a device from multipathing

If required, you can exclude a device from multipathing by adding the WWID for the unwanted device to the "blacklist" stanza for the `multipath.conf` file.

Steps

1. Determine the WWID:

```
/lib/udev/scsi_id -gud /dev/sda
```

"sda" is the local SCSI disk that you want to add to the blacklist.

An example WWID is `360030057024d0730239134810c0cb833`.

2. Add the WWID to the "blacklist" stanza:

```
blacklist {
        wwid    360030057024d0730239134810c0cb833
        devnode "^(ram|raw|loop|fd|md|dm-|sr|scd|st)[0-9]*"
        devnode "^hd[a-z]"
        devnode "^cciss.*"
}
```

Step 5: Customize multipath parameters for ONTAP LUNs

If your host is connected to LUNs from other vendors and any of the multipath parameter settings are overridden, you need to correct them by adding stanzas later in the `multipath.conf` file that apply specifically to ONTAP LUNs. If you don't do this, the ONTAP LUNs might not work as expected.

Check your `/etc/multipath.conf` file, especially in the defaults section, for settings that might be overriding the default settings for multipath parameters.

> ⚠️ You shouldn't override the recommended parameter settings for ONTAP LUNs. These settings are required for optimal performance of your host configuration. Contact NetApp support, your OS vendor, or both for more information.

The following example shows how to correct an overridden default. In this example, the `multipath.conf` file defines values for `path_checker` and `no_path_retry` that aren't compatible with ONTAP LUNs, and you can't remove these parameters because ONTAP storage arrays are still attached to the host. Instead, you correct the values for `path_checker` and `no_path_retry` by adding a device stanza to the `multipath.conf` file that applies specifically to the ONTAP LUNs.

Show example

```
defaults {
    path_checker      readsector0
    no_path_retry     fail
}

devices {
    device {
        vendor          "NETAPP"
        product         "LUN"
        no_path_retry   queue
        path_checker    tur
    }
}
```

Step 6: Review the known issues

The SUSE Linux Enterprise Server 12 SP3 with ONTAP storage release has the following known issues:

NetApp Bug ID	Title	Description
1089555	Kernel disruption observed on kernel version SLES12 SP3 with Emulex LPe16002 16GB FC during storage failover operation	A kernel disruption might occur during storage failover operations on kernel version SLES12 SP3 with Emulex LPe16002 HBA. The kernel disruption prompts a reboot of the operating system, which in turn causes an application disruption. If the kdump is configured, the kernel disruption generates a vmcore file under /var/crash/directory. You can investigate the cause of the failure in the vmcore file. Example: In the observed case, the kernel disruption was observed in the module "lpfc_sli_ringtxcmpl_put+51" and is logged in the vmcore file – exception RIP: lpfc_sli_ringtxcmpl_put+51. Recover the operating system after the kernel disruption by rebooting the host operating system and restarting the application.

NetApp Bug ID	Title	Description
1089561	Kernel disruption observed on kernel version SLES12 SP3 with Emulex LPe32002 32GB FC during storage failover operations	A kernel disruption might occur during storage failover operations on kernel version SLES12 SP3 with Emulex LPe32002 HBA. The kernel disruption prompts a reboot of the operating system, which in turn causes an application disruption. If the kdump is configured, the kernel disruption generates a vmcore file under /var/crash/directory. You can investigate the cause of the failure in the vmcore file. Example: In the observed case, the kernel disruption was observed in the module "lpfc_sli_free_hbq+76" and is logged in the vmcore file – exception RIP: lpfc_sli_free_hbq+76. Recover the operating system after the kernel disruption by rebooting the host operating system and restarting the application.

NetApp Bug ID	Title	Description
1117248	Kernel disruption observed on SLES12SP3 with QLogic QLE2562 8GB FC during storage failover operations	During storage failover operations on the Sles12sp3 kernel (kernel-default-4.4.82-6.3.1) with QLogic QLE2562 HBA, the kernel disruption was observed due to a panic in the kernel. The kernel panic leads to a reboot of the operating system, causing an application disruption. The kernel panic generates the vmcore file under the /var/crash/ directory if kdump is configured. Upon the kernel panic, the vmcore file can be used to understand the cause of the failure. Example: In this case, the panic was observed in the "blk_finish_request+289" module. It is logged in the vmcore file with the following string: "exception RIP: blk_finish_request+289" After the kernel disruption, you can recover the operating system by rebooting the Host OS. You can restart the application as required.

NetApp Bug ID	Title	Description
1117261	Kernel disruption observed on SLES12SP3 with Qlogic QLE2662 16GB FC during storage failover operations	During storage failover operations on Sles12sp3 kernel (kernel-default-4.4.82-6.3.1) with Qlogic QLE2662 HBA, you might observe kernel disruption. This prompts a reboot of the operating system causing application disruption. The kernel disruption generates a vmcore file under /var/crash/ directory if kdump is configured. The vmcore file can be used to understand the cause of the failure. Example: In this case the Kernel disruption was observed in the module "unknown or invalid address" and is logged in vmcore file with the following string - exception RIP: unknown or invalid address. After kernel disruption, the operating system can be recovered by rebooting the host operating system and restarting the application as required.
1117274	Kernel disruption observed on SLES12SP3 with Emulex LPe16002 16GB FC during storage failover operations	During storage failover operations on Sles12sp3 kernel (kernel-default-4.4.87-3.1) with Emulex LPe16002 HBA, you might observe kernel disruption. This prompts a reboot of the operating system causing application disruption. The kernel disruption generates a vmcore file under the /var/crash/ directory if kdump is configured. The vmcore file can be used to understand the cause of the failure. Example: In this case kernel disruption was observed in the module "raw_spin_lock_irqsave+30" and is logged in the vmcore file with the following string: – exception RIP: _raw_spin_lock_irqsave+30. After kernel disruption, the operating system can be recovered by rebooting the host operating system and restarting the application as required.

What's next?

- Learn about using the Linux Host Utilities tool.

- Learn about ASM mirroring.

  Automatic Storage Management (ASM) mirroring might require changes to the Linux multipath settings to allow ASM to recognize a problem and switch over to an alternate failure group. Most ASM configurations on ONTAP use external redundancy, which means that data protection is provided by the external array and ASM doesn't mirror data. Some sites use ASM with normal redundancy to provide two-way mirroring, normally across different sites. See Oracle databases on ONTAP for further information.

Configure SUSE Linux Enterprise Server 12 SP2 for FCP and iSCSI with ONTAP storage

The Linux Host Utilities software provides management and diagnostic tools for Linux hosts that are connected to ONTAP storage. When you install the Linux Host Utilities on a SUSE Linux Enterprise Server 12 SP2 host, you can use the Host Utilities to help you manage FCP and iSCSI protocol operations with ONTAP LUNs.

> ⓘ You don't need to manually configure Kernel-based Virtual Machine (KVM) settings because ONTAP LUNs are automatically mapped to the hypervisor.

Step 1: Optionally, enable SAN booting

You can configure your host to use SAN booting to simplify deployment and improve scalability.

Before you begin

Use the Interoperability Matrix Tool to verify that your Linux OS, host bus adapter (HBA), HBA firmware, HBA boot BIOS, and ONTAP version support SAN booting.

Steps

1. Create a SAN boot LUN and map it to the host.

2. Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is mapped.

   For information on how to enable the HBA BIOS, see your vendor-specific documentation.

3. Verify that the configuration was successful by rebooting the host and verifying that the OS is up and running.

Step 2: Install the Linux Host Utilities

NetApp strongly recommends installing the Linux Host Utilities to support ONTAP LUN management and assist technical support with gathering configuration data.

Install Linux Host Utilities 7.1.

> ⓘ Installing the Linux Host Utilities doesn't change any host timeout settings on your Linux host.

Step 3: Confirm the multipath configuration for your host

You can use multipathing with SUSE Linux Enterprise Server 12 SP2 to manage ONTAP LUNs.

To ensure that multipathing is configured correctly for your host, verify that the `/etc/multipath.conf` file is defined and that you have the NetApp recommended settings configured for your ONTAP LUNs.

Steps

1. Verify that the `/etc/multipath.conf` file exists:

   ```
   ls /etc/multipath.conf
   ```

   If the file doesn't exist, create an empty, zero-byte file:

   ```
   touch /etc/multipath.conf
   ```

2. The first time the `multipath.conf` file is created, you might need to enable and start the multipath services to load the recommended settings:

   ```
   systemctl enable multipathd
   ```

   ```
   systemctl start multipathd
   ```

3. Each time you boot the host, the empty `/etc/multipath.conf` zero-byte file automatically loads the NetApp recommended host multipath parameters as the default settings. You shouldn't need to make changes to the `/etc/multipath.conf` file for your host because the host operating system is compiled with the multipath parameters that recognize and manage ONTAP LUNs correctly.

   The following table shows the native Linux OS compiled multipath parameter settings for ONTAP LUNs.

Show parameter settings

Parameter	Setting
detect_prio	yes
dev_loss_tmo	"infinity"
failback	immediate
fast_io_fail_tmo	5
features	"2 pg_init_retries 50"
flush_on_last_del	"yes"
hardware_handler	"0"
no_path_retry	queue
path_checker	"tur"
path_grouping_policy	"group_by_prio"
path_selector	"service-time 0"
polling_interval	5
prio	"ontap"
product	LUN
retain_attached_hw_handler	yes
rr_weight	"uniform"
user_friendly_names	no
vendor	NETAPP

4. Verify the parameter settings and path status for your ONTAP LUNs:

```
multipath -ll
```

The default multipath parameters support ASA, AFF, and FAS configurations. In these configurations, a single ONTAP LUN shouldn't require more than four paths. If there are more than four paths, it might cause issues with the paths during a storage failure.

The following example outputs show the correct parameter settings and path status for ONTAP LUNs in an ASA, AFF, or FAS configuration.

ASA configuration

An ASA configuration optimizes all paths to a given LUN, keeping them active. This improves performance by serving I/O operations through all paths at the same time.

```
# multipath -ll
3600a09803831347657244e527766394e dm-5 NETAPP,LUN C-Mode
size=80G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
`-+- policy='service-time 0' prio=50 status=active
  |- 3:0:7:9   sdco 69:192  active ready running
  |- 3:0:8:9   sddi 71:0    active ready running
  |- 14:0:8:9  sdjq 65:320  active ready running
  `- 14:0:7:9  sdiw 8:256   active ready running
```

AFF or FAS configuration

An AFF or FAS configuration should have two groups of paths with higher and lower priorities. Higher priority Active/Optimized paths are served by the controller where the aggregate is located. Lower priority paths are active but non-optimized because they are served by a different controller. Non-optimized paths are only used when optimized paths aren't available.

The following example displays the output for an ONTAP LUN with two Active/Optimized paths and two Active/Non-Optimized paths:

```
# multipath -ll
3600a09803831347657244e527766394e dm-5 NETAPP,LUN C-Mode
size=80G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
|-+- policy='service-time 0' prio=50 status=active
| |- 3:0:3:0   sdd  8:48    active ready running
| |- 3:0:4:0   sdx  65:112  active ready running
`-+- policy='service-time 0' prio=10 status=enabled
  |- 14:0:2:0  sdfk 130:96  active ready running
  `- 14:0:5:0  sdgz 132:240 active ready running
```

Step 4: Optionally, exclude a device from multipathing

If required, you can exclude a device from multipathing by adding the WWID for the unwanted device to the "blacklist" stanza for the `multipath.conf` file.

Steps

1. Determine the WWID:

```
/lib/udev/scsi_id -gud /dev/sda
```

"sda" is the local SCSI disk that you want to add to the blacklist.

An example WWID is `360030057024d0730239134810c0cb833`.

2. Add the WWID to the "blacklist" stanza:

```
blacklist {
         wwid    360030057024d0730239134810c0cb833
         devnode "^(ram|raw|loop|fd|md|dm-|sr|scd|st)[0-9]*"
         devnode "^hd[a-z]"
         devnode "^cciss.*"
}
```

Step 5: Customize multipath parameters for ONTAP LUNs

If your host is connected to LUNs from other vendors and any of the multipath parameter settings are overridden, you need to correct them by adding stanzas later in the `multipath.conf` file that apply specifically to ONTAP LUNs. If you don't do this, the ONTAP LUNs might not work as expected.

Check your `/etc/multipath.conf` file, especially in the defaults section, for settings that might be overriding the default settings for multipath parameters.

> ⚠ You shouldn't override the recommended parameter settings for ONTAP LUNs. These settings are required for optimal performance of your host configuration. Contact NetApp support, your OS vendor, or both for more information.

The following example shows how to correct an overridden default. In this example, the `multipath.conf` file defines values for `path_checker` and `no_path_retry` that aren't compatible with ONTAP LUNs, and you can't remove these parameters because ONTAP storage arrays are still attached to the host. Instead, you correct the values for `path_checker` and `no_path_retry` by adding a device stanza to the `multipath.conf` file that applies specifically to the ONTAP LUNs.

Show example

```
defaults {
    path_checker        readsector0
    no_path_retry       fail
}

devices {
    device {
        vendor          "NETAPP"
        product         "LUN"
        no_path_retry   queue
        path_checker    tur
    }
}
```

Step 6: Review the known issues

There are no known issues.

What's next?

- Learn about using the Linux Host Utilities tool.
- Learn about ASM mirroring.

  Automatic Storage Management (ASM) mirroring might require changes to the Linux multipath settings to allow ASM to recognize a problem and switch over to an alternate failure group. Most ASM configurations on ONTAP use external redundancy, which means that data protection is provided by the external array and ASM doesn't mirror data. Some sites use ASM with normal redundancy to provide two-way mirroring, normally across different sites. See Oracle databases on ONTAP for further information.

Configure SUSE Linux Enterprise Server 12 SP1 for FCP and iSCSI with ONTAP storage

The Linux Host Utilities software provides management and diagnostic tools for Linux hosts that are connected to ONTAP storage. When you install the Linux Host Utilities on a SUSE Linux Enterprise Server 12 SP1 host, you can use the Host Utilities to help you manage FCP and iSCSI protocol operations with ONTAP LUNs.

ⓘ You don't need to manually configure Kernel-based Virtual Machine (KVM) settings because ONTAP LUNs are automatically mapped to the hypervisor.

Step 1: Optionally, enable SAN booting

You can configure your host to use SAN booting to simplify deployment and improve scalability.

Before you begin

Use the Interoperability Matrix Tool to verify that your Linux OS, host bus adapter (HBA), HBA firmware, HBA

boot BIOS, and ONTAP version support SAN booting.

Steps

1. [Create a SAN boot LUN and map it to the host](#).

2. Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is mapped.

   For information on how to enable the HBA BIOS, see your vendor-specific documentation.

3. Verify that the configuration was successful by rebooting the host and verifying that the OS is up and running.

Step 2: Install the Linux Host Utilities

NetApp strongly recommends installing the Linux Host Utilities to support ONTAP LUN management and assist technical support with gathering configuration data.

[Install Linux Host Utilities 7.1](#).

> ℹ️ Installing the Linux Host Utilities doesn't change any host timeout settings on your Linux host.

Step 3: Confirm the multipath configuration for your host

You can use multipathing with SUSE Linux Enterprise Server 12 SP1 to manage ONTAP LUNs.

To ensure that multipathing is configured correctly for your host, verify that the `/etc/multipath.conf` file is defined and that you have the NetApp recommended settings configured for your ONTAP LUNs.

Steps

1. Verify that the `/etc/multipath.conf` file exists:

   ```
   ls /etc/multipath.conf
   ```

   If the file doesn't exist, create an empty, zero-byte file:

   ```
   touch /etc/multipath.conf
   ```

2. The first time the `multipath.conf` file is created, you might need to enable and start the multipath services to load the recommended settings:

   ```
   systemctl enable multipathd
   ```

   ```
   systemctl start multipathd
   ```

3. Each time you boot the host, the empty `/etc/multipath.conf` zero-byte file automatically loads the NetApp recommended host multipath parameters as the default settings. You shouldn't need to make changes to the `/etc/multipath.conf` file for your host because the host operating system is compiled

with the multipath parameters that recognize and manage ONTAP LUNs correctly.

The following table shows the native Linux OS compiled multipath parameter settings for ONTAP LUNs.

Show parameter settings

Parameter	Setting
detect_prio	yes
dev_loss_tmo	"infinity"
failback	immediate
fast_io_fail_tmo	5
features	"2 pg_init_retries 50"
flush_on_last_del	"yes"
hardware_handler	"0"
no_path_retry	queue
path_checker	"tur"
path_grouping_policy	"group_by_prio"
path_selector	"service-time 0"
polling_interval	5
prio	"ontap"
product	LUN
retain_attached_hw_handler	yes
rr_weight	"uniform"
user_friendly_names	no
vendor	NETAPP

4. Verify the parameter settings and path status for your ONTAP LUNs:

```
multipath -ll
```

The default multipath parameters support ASA, AFF, and FAS configurations. In these configurations, a single ONTAP LUN shouldn't require more than four paths. If there are more than four paths, it might cause issues with the paths during a storage failure.

The following example outputs show the correct parameter settings and path status for ONTAP LUNs in an ASA, AFF, or FAS configuration.

ASA configuration

An ASA configuration optimizes all paths to a given LUN, keeping them active. This improves performance by serving I/O operations through all paths at the same time.

```
# multipath -ll
3600a09803831347657244e527766394e dm-5 NETAPP,LUN C-Mode
size=80G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
`-+- policy='service-time 0' prio=50 status=active
  |- 3:0:7:9    sdco 69:192  active ready running
  |- 3:0:8:9    sddi 71:0    active ready running
  |- 14:0:8:9   sdjq 65:320  active ready running
  `- 14:0:7:9   sdiw 8:256   active ready running
```

AFF or FAS configuration

An AFF or FAS configuration should have two groups of paths with higher and lower priorities. Higher priority Active/Optimized paths are served by the controller where the aggregate is located. Lower priority paths are active but non-optimized because they are served by a different controller. Non-optimized paths are only used when optimized paths aren't available.

The following example displays the output for an ONTAP LUN with two Active/Optimized paths and two Active/Non-Optimized paths:

```
# multipath -ll
3600a09803831347657244e527766394e dm-5 NETAPP,LUN C-Mode
size=80G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
|-+- policy='service-time 0' prio=50 status=active
| |- 3:0:3:0    sdd  8:48    active ready running
| |- 3:0:4:0    sdx  65:112  active ready running
`-+- policy='service-time 0' prio=10 status=enabled
  |- 14:0:2:0   sdfk 130:96  active ready running
  `- 14:0:5:0   sdgz 132:240 active ready running
```

Step 4: Optionally, exclude a device from multipathing

If required, you can exclude a device from multipathing by adding the WWID for the unwanted device to the "blacklist" stanza for the `multipath.conf` file.

Steps

1. Determine the WWID:

```
/lib/udev/scsi_id -gud /dev/sda
```

"sda" is the local SCSI disk that you want to add to the blacklist.

An example WWID is `360030057024d0730239134810c0cb833`.

2. Add the WWID to the "blacklist" stanza:

```
blacklist {
        wwid    360030057024d0730239134810c0cb833
        devnode "^(ram|raw|loop|fd|md|dm-|sr|scd|st)[0-9]*"
        devnode "^hd[a-z]"
        devnode "^cciss.*"
}
```

Step 5: Customize multipath parameters for ONTAP LUNs

If your host is connected to LUNs from other vendors and any of the multipath parameter settings are overridden, you need to correct them by adding stanzas later in the `multipath.conf` file that apply specifically to ONTAP LUNs. If you don't do this, the ONTAP LUNs might not work as expected.

Check your `/etc/multipath.conf` file, especially in the defaults section, for settings that might be overriding the default settings for multipath parameters.

> ⚠️ You shouldn't override the recommended parameter settings for ONTAP LUNs. These settings are required for optimal performance of your host configuration. Contact NetApp support, your OS vendor, or both for more information.

The following example shows how to correct an overridden default. In this example, the `multipath.conf` file defines values for `path_checker` and `no_path_retry` that aren't compatible with ONTAP LUNs, and you can't remove these parameters because ONTAP storage arrays are still attached to the host. Instead, you correct the values for `path_checker` and `no_path_retry` by adding a device stanza to the `multipath.conf` file that applies specifically to the ONTAP LUNs.

```
defaults {
    path_checker        readsector0
    no_path_retry       fail
}

devices {
    device {
        vendor          "NETAPP"
        product         "LUN"
        no_path_retry   queue
        path_checker    tur
    }
}
```

Step 6: Review the known issues

There are no known issues.

What's next?

- Learn about using the Linux Host Utilities tool.

- Learn about ASM mirroring.

  Automatic Storage Management (ASM) mirroring might require changes to the Linux multipath settings to allow ASM to recognize a problem and switch over to an alternate failure group. Most ASM configurations on ONTAP use external redundancy, which means that data protection is provided by the external array and ASM doesn't mirror data. Some sites use ASM with normal redundancy to provide two-way mirroring, normally across different sites. See Oracle databases on ONTAP for further information.

Configure SUSE Linux Enterprise Server 12 for FCP and iSCSI with ONTAP storage

The Linux Host Utilities software provides management and diagnostic tools for Linux hosts that are connected to ONTAP storage. When you install the Linux Host Utilities on a SUSE Linux Enterprise Server 12 host, you can use the Host Utilities to help you manage FCP and iSCSI protocol operations with ONTAP LUNs.

> ⓘ   You don't need to manually configure Kernel-based Virtual Machine (KVM) settings because ONTAP LUNs are automatically mapped to the hypervisor.

Step 1: Optionally, enable SAN booting

You can configure your host to use SAN booting to simplify deployment and improve scalability.

Before you begin

Use the Interoperability Matrix Tool to verify that your Linux OS, host bus adapter (HBA), HBA firmware, HBA

boot BIOS, and ONTAP version support SAN booting.

Steps

1. [Create a SAN boot LUN and map it to the host](#).

2. Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is mapped.

   For information on how to enable the HBA BIOS, see your vendor-specific documentation.

3. Verify that the configuration was successful by rebooting the host and verifying that the OS is up and running.

Step 2: Install the Linux Host Utilities

NetApp strongly recommends installing the Linux Host Utilities to support ONTAP LUN management and assist technical support with gathering configuration data.

[Install Linux Host Utilities 7.1](#).

> ⓘ   Installing the Linux Host Utilities doesn't change any host timeout settings on your Linux host.

Step 3: Confirm the multipath configuration for your host

You can use multipathing with SUSE Linux Enterprise Server 12 to manage ONTAP LUNs.

To ensure that multipathing is configured correctly for your host, verify that the `/etc/multipath.conf` file is defined and that you have the NetApp recommended settings configured for your ONTAP LUNs.

Steps

1. Verify that the `/etc/multipath.conf` file exists:

   ```
   ls /etc/multipath.conf
   ```

   If the file doesn't exist, create an empty, zero-byte file:

   ```
   touch /etc/multipath.conf
   ```

2. The first time the `multipath.conf` file is created, you might need to enable and start the multipath services to load the recommended settings:

   ```
   systemctl enable multipathd
   ```

   ```
   systemctl start multipathd
   ```

3. Each time you boot the host, the empty `/etc/multipath.conf` zero-byte file automatically loads the NetApp recommended host multipath parameters as the default settings. You shouldn't need to make changes to the `/etc/multipath.conf` file for your host because the host operating system is compiled

with the multipath parameters that recognize and manage ONTAP LUNs correctly.

The following table shows the native Linux OS compiled multipath parameter settings for ONTAP LUNs.

Show parameter settings

Parameter	Setting
detect_prio	yes
dev_loss_tmo	"infinity"
failback	immediate
fast_io_fail_tmo	5
features	"2 pg_init_retries 50"
flush_on_last_del	"yes"
hardware_handler	"0"
no_path_retry	queue
path_checker	"tur"
path_grouping_policy	"group_by_prio"
path_selector	"service-time 0"
polling_interval	5
prio	"ontap"
product	LUN
retain_attached_hw_handler	yes
rr_weight	"uniform"
user_friendly_names	no
vendor	NETAPP

4. Verify the parameter settings and path status for your ONTAP LUNs:

```
multipath -ll
```

The default multipath parameters support ASA, AFF, and FAS configurations. In these configurations, a single ONTAP LUN shouldn't require more than four paths. If there are more than four paths, it might cause issues with the paths during a storage failure.

The following example outputs show the correct parameter settings and path status for ONTAP LUNs in an ASA, AFF, or FAS configuration.

ASA configuration

An ASA configuration optimizes all paths to a given LUN, keeping them active. This improves performance by serving I/O operations through all paths at the same time.

```
# multipath -ll
3600a09803831347657244e527766394e dm-5 NETAPP,LUN C-Mode
size=80G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
`-+- policy='service-time 0' prio=50 status=active
  |- 3:0:7:9    sdco 69:192  active ready running
  |- 3:0:8:9    sddi 71:0    active ready running
  |- 14:0:8:9   sdjq 65:320  active ready running
  `- 14:0:7:9   sdiw 8:256   active ready running
```

AFF or FAS configuration

An AFF or FAS configuration should have two groups of paths with higher and lower priorities. Higher priority Active/Optimized paths are served by the controller where the aggregate is located. Lower priority paths are active but non-optimized because they are served by a different controller. Non-optimized paths are only used when optimized paths aren't available.

The following example displays the output for an ONTAP LUN with two Active/Optimized paths and two Active/Non-Optimized paths:

```
# multipath -ll
3600a09803831347657244e527766394e dm-5 NETAPP,LUN C-Mode
size=80G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
|-+- policy='service-time 0' prio=50 status=active
| |- 3:0:3:0    sdd  8:48    active ready running
| |- 3:0:4:0    sdx  65:112  active ready running
`-+- policy='service-time 0' prio=10 status=enabled
  |- 14:0:2:0   sdfk 130:96  active ready running
  `- 14:0:5:0   sdgz 132:240 active ready running
```

Step 4: Optionally, exclude a device from multipathing

If required, you can exclude a device from multipathing by adding the WWID for the unwanted device to the "blacklist" stanza for the `multipath.conf` file.

Steps

1. Determine the WWID:

```
/lib/udev/scsi_id -gud /dev/sda
```

"sda" is the local SCSI disk that you want to add to the blacklist.

An example WWID is `360030057024d0730239134810c0cb833`.

2. Add the WWID to the "blacklist" stanza:

```
blacklist {
         wwid    360030057024d0730239134810c0cb833
         devnode "^(ram|raw|loop|fd|md|dm-|sr|scd|st)[0-9]*"
         devnode "^hd[a-z]"
         devnode "^cciss.*"
}
```

Step 5: Customize multipath parameters for ONTAP LUNs

If your host is connected to LUNs from other vendors and any of the multipath parameter settings are overridden, you need to correct them by adding stanzas later in the `multipath.conf` file that apply specifically to ONTAP LUNs. If you don't do this, the ONTAP LUNs might not work as expected.

Check your `/etc/multipath.conf` file, especially in the defaults section, for settings that might be overriding the default settings for multipath parameters.

> ⚠ You shouldn't override the recommended parameter settings for ONTAP LUNs. These settings are required for optimal performance of your host configuration. Contact NetApp support, your OS vendor, or both for more information.

The following example shows how to correct an overridden default. In this example, the `multipath.conf` file defines values for `path_checker` and `no_path_retry` that aren't compatible with ONTAP LUNs, and you can't remove these parameters because ONTAP storage arrays are still attached to the host. Instead, you correct the values for `path_checker` and `no_path_retry` by adding a device stanza to the `multipath.conf` file that applies specifically to the ONTAP LUNs.

Show example

```
defaults {
    path_checker      readsector0
    no_path_retry     fail
}

devices {
    device {
        vendor          "NETAPP"
        product         "LUN"
        no_path_retry   queue
        path_checker    tur
    }
}
```

Step 6: Review the known issues

The SUSE Linux Enterprise Server 12 with ONTAP storage release has the following known issues:

NetApp Bug ID	Title	Description
873555	scsi_dh_alua module is not loaded during multipathd startup on local boot	scsi_dh_alua is a Linux ALUA device handler module. This is is not loaded during multipathd startup on local boot. Due to this device handler will not be loaded though ALUA is enabled on target side.
863584	The message "conflicting device node '/dev/mapper/360xx' found" appears on the screen when you create a DM device on SLES12	You might observe a failure in creating a link to DM devices under /dev/mapper dir in SLES 12 and see the messages "conflicting device node '/dev/mapper/360xx' found".
847490	Multipath daemon shows path failures on SLES 12	You might observe path failures on the SLES12 multipath daemon during I/O with storage or fabric faults.

What's next?

- Learn about using the Linux Host Utilities tool.
- Learn about ASM mirroring.

  Automatic Storage Management (ASM) mirroring might require changes to the Linux multipath settings to allow ASM to recognize a problem and switch over to an alternate failure group. Most ASM configurations on ONTAP use external redundancy, which means that data protection is provided by the external array

and ASM doesn't mirror data. Some sites use ASM with normal redundancy to provide two-way mirroring, normally across different sites. See Oracle databases on ONTAP for further information.

Ubuntu

Configure Ubuntu 24.04 for FCP and iSCSI with ONTAP storage

The Linux Host Utilities software provides management and diagnostic tools for Linux hosts that are connected to ONTAP storage. When you install the Linux Host Utilities on an Ubuntu 24.04 host, you can use the Host Utilities to help you manage FCP and iSCSI protocol operations with ONTAP LUNs.

> ⓘ You don't need to manually configure Kernel-based Virtual Machine (KVM) settings because ONTAP LUNs are automatically mapped to the hypervisor.

Step 1: Optionally, enable SAN booting

You can configure your host to use SAN booting to simplify deployment and improve scalability.

Before you begin

Use the Interoperability Matrix Tool to verify that your Linux OS, host bus adapter (HBA), HBA firmware, HBA boot BIOS, and ONTAP version support SAN booting.

Steps

1. Create a SAN boot LUN and map it to the host.

2. Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is mapped.

   For information on how to enable the HBA BIOS, see your vendor-specific documentation.

3. Verify that the configuration was successful by rebooting the host and verifying that the OS is up and running.

Step 2: Install the Linux Host Utilities

NetApp strongly recommends installing the Linux Host Utilities to support ONTAP LUN management and assist technical support with gathering configuration data.

Install Linux Host Utilities 8.0.

> ⓘ Installing the Linux Host Utilities doesn't change any host timeout settings on your Linux host.

Step 3: Confirm the multipath configuration for your host

You can use multipathing with Ubuntu 24.04 to manage ONTAP LUNs.

To ensure that multipathing is configured correctly for your host, verify that the `/etc/multipath.conf` file is defined and that you have the NetApp recommended settings configured for your ONTAP LUNs.

Steps

1. Verify that the `/etc/multipath.conf` file exits. If the file doesn't exist, create an empty, zero-byte file:

```
touch /etc/multipath.conf
```

2. The first time the `multipath.conf` file is created, you might need to enable and start the multipath services to load the recommended settings:

```
systemctl enable multipathd
```

```
systemctl start multipathd
```

3. Each time you boot the host, the empty `/etc/multipath.conf` zero-byte file automatically loads the NetApp recommended host multipath parameters as the default settings. You shouldn't need to make changes to the `/etc/multipath.conf` file for your host because the operating system is compiled with the multipath parameters that recognize and manage ONTAP LUNs correctly.

The following table shows the Linux OS native compiled multipath parameter settings for ONTAP LUNs.

Show parameter settings

Parameter	Setting
detect_prio	yes
dev_loss_tmo	"infinity"
failback	immediate
fast_io_fail_tmo	5
features	"2 pg_init_retries 50"
flush_on_last_del	"yes"
hardware_handler	"0"
no_path_retry	queue
path_checker	"tur"
path_grouping_policy	"group_by_prio"
path_selector	"service-time 0"
polling_interval	5
prio	"ontap"
product	LUN
retain_attached_hw_handler	yes
rr_weight	"uniform"
user_friendly_names	no
vendor	NETAPP

4. Verify the parameter settings and path status for your ONTAP LUNs:

```
multipath -ll
```

The default multipath parameters support ASA, AFF, and FAS configurations. In these configurations, a single ONTAP LUN shouldn't require more than four paths. If there are more than four paths, it might cause issues with the paths during a storage failure.

The following example outputs show the correct parameter settings and path status for ONTAP LUNs in an ASA, AFF, or FAS configuration.

ASA configuration

An ASA configuration optimizes all paths to a given LUN, keeping them active. This improves performance by serving I/O operations through all paths at the same time.

Show example

```
# multipath -ll
3600a098038314559533f524d6c652f62 dm-24 NETAPP,LUN C-Mode
size=10G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
`-+- policy='service-time 0' prio=50 status=active
  |- 11:0:1:13 sdm  8:192  active ready running
  |- 11:0:3:13 sdah 66:16  active ready running
  |- 12:0:1:13 sdbc 67:96  active ready running
  `- 12:0:3:13 sdbx 68:176 active ready running
```

AFF or FAS configuration

An AFF or FAS configuration should have two groups of paths with higher and lower priorities. Higher priority Active/Optimized paths are served by the controller where the aggregate is located. Lower priority paths are active but non-optimized because they are served by a different controller. Non-optimized paths are only used when optimized paths aren't available.

The following example displays the output for an ONTAP LUN with two Active/Optimized paths and two Active/Non-Optimized paths:

Show example

```
# multipath -ll
3600a098038314837352453694b542f4a dm-0 NETAPP,LUN C-Mode
size=160G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
|-+- policy='service-time 0' prio=50 status=active
| |- 14:0:3:0 sdbk 67:224 active ready running
| `- 15:0:2:0 sdbl 67:240 active ready running
`-+- policy='service-time 0' prio=10 status=enabled
  |- 14:0:0:0 sda  8:0    active ready running
  `- 15:0:1:0 sdv  65:80  active ready running
```

Step 4: Optionally, exclude a device from multipathing

If required, you can exclude a device from multipathing by adding the WWID for the unwanted device to the "blacklist" stanza for the `multipath.conf` file.

Steps

1. Determine the WWID:

   ```
   /lib/udev/scsi_id -gud /dev/sda
   ```

   "sda" is the local SCSI disk that you want to add to the blacklist.

   An example WWID is `360030057024d0730239134810c0cb833`.

2. Add the WWID to the "blacklist" stanza:

   ```
   blacklist {
           wwid   360030057024d0730239134810c0cb833
           devnode "^(ram|raw|loop|fd|md|dm-|sr|scd|st)[0-9]*"
           devnode "^hd[a-z]"
           devnode "^cciss.*"
   }
   ```

Step 5: Customize multipath parameters for ONTAP LUNs

If your host is connected to LUNs from other vendors and any of the multipath parameter settings are overridden, you need to correct them by adding stanzas later in the `multipath.conf` file that apply specifically to ONTAP LUNs. If you don't do this, the ONTAP LUNs might not work as expected.

Check your `/etc/multipath.conf` file, especially in the defaults section, for settings that might be overriding the default settings for multipath parameters.

> ⚠️ You shouldn't override the recommended parameter settings for ONTAP LUNs. These settings are required for optimal performance of your host configuration. Contact NetApp support, your OS vendor, or both for more information.

The following example shows how to correct an overridden default. In this example, the `multipath.conf` file defines values for `path_checker` and `no_path_retry` that aren't compatible with ONTAP LUNs, and you can't remove these parameters because ONTAP storage arrays are still attached to the host. Instead, you correct the values for `path_checker` and `no_path_retry` by adding a device stanza to the `multipath.conf` file that applies specifically to the ONTAP LUNs.

Show example

```
defaults {
    path_checker        readsector0
    no_path_retry       fail
}

devices {
    device {
        vendor          "NETAPP"
        product         "LUN"
        no_path_retry   queue
        path_checker    tur
    }
}
```

Step 6: Review the known issues

There are no known issues.

What's next?

- Learn about using the Linux Host Utilities tool.

- Learn about ASM mirroring.

  Automatic Storage Management (ASM) mirroring might require changes to the Linux multipath settings to allow ASM to recognize a problem and switch over to an alternate failure group. Most ASM configurations on ONTAP use external redundancy, which means that data protection is provided by the external array and ASM doesn't mirror data. Some sites use ASM with normal redundancy to provide two-way mirroring, normally across different sites. See Oracle databases on ONTAP for further information.

Configure Ubuntu 22.04 for FCP and iSCSI with ONTAP storage

The Linux Host Utilities software provides management and diagnostic tools for Linux hosts that are connected to ONTAP storage. When you install the Linux Host Utilities on an Ubuntu 22.04 host, you can use the Host Utilities to help you manage FCP and iSCSI protocol operations with ONTAP LUNs.

ⓘ You don't need to manually configure Kernel-based Virtual Machine (KVM) settings because ONTAP LUNs are automatically mapped to the hypervisor.

Step 1: Optionally, enable SAN booting

You can configure your host to use SAN booting to simplify deployment and improve scalability.

Before you begin

Use the Interoperability Matrix Tool to verify that your Linux OS, host bus adapter (HBA), HBA firmware, HBA boot BIOS, and ONTAP version support SAN booting.

Steps

1. Create a SAN boot LUN and map it to the host.

2. Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is mapped.

   For information on how to enable the HBA BIOS, see your vendor-specific documentation.

3. Verify that the configuration was successful by rebooting the host and verifying that the OS is up and running.

Step 2: Install the Linux Host Utilities

NetApp strongly recommends installing the Linux Host Utilities to support ONTAP LUN management and assist technical support with gathering configuration data.

Install Linux Host Utilities 8.0.

> (i) | Installing the Linux Host Utilities doesn't change any host timeout settings on your Linux host.

Step 3: Confirm the multipath configuration for your host

You can use multipathing with Ubuntu 22.04 to manage ONTAP LUNs.

To ensure that multipathing is configured correctly for your host, verify that the `/etc/multipath.conf` file is defined and that you have the NetApp recommended settings configured for your ONTAP LUNs.

Steps

1. Verify that the `/etc/multipath.conf` file exits. If the file doesn't exist, create an empty, zero-byte file:

   ```
   touch /etc/multipath.conf
   ```

2. The first time the `multipath.conf` file is created, you might need to enable and start the multipath services to load the recommended settings:

   ```
   systemctl enable multipathd
   ```

   ```
   systemctl start multipathd
   ```

3. Each time you boot the host, the empty `/etc/multipath.conf` zero-byte file automatically loads the NetApp recommended host multipath parameters as the default settings. You shouldn't need to make changes to the `/etc/multipath.conf` file for your host because the operating system is compiled with the multipath parameters that recognize and manage ONTAP LUNs correctly.

   The following table shows the Linux OS native compiled multipath parameter settings for ONTAP LUNs.

Show parameter settings

Parameter	Setting
detect_prio	yes
dev_loss_tmo	"infinity"
failback	immediate
fast_io_fail_tmo	5
features	"2 pg_init_retries 50"
flush_on_last_del	"yes"
hardware_handler	"0"
no_path_retry	queue
path_checker	"tur"
path_grouping_policy	"group_by_prio"
path_selector	"service-time 0"
polling_interval	5
prio	"ontap"
product	LUN
retain_attached_hw_handler	yes
rr_weight	"uniform"
user_friendly_names	no
vendor	NETAPP

4. Verify the parameter settings and path status for your ONTAP LUNs:

```
multipath -ll
```

The default multipath parameters support ASA, AFF, and FAS configurations. In these configurations, a single ONTAP LUN shouldn't require more than four paths. If there are more than four paths, it might cause issues with the paths during a storage failure.

The following example outputs show the correct parameter settings and path status for ONTAP LUNs in an ASA, AFF, or FAS configuration.

ASA configuration

An ASA configuration optimizes all paths to a given LUN, keeping them active. This improves performance by serving I/O operations through all paths at the same time.

Show example

```
# multipath -ll
3600a098038314559533f524d6c652f62 dm-24 NETAPP,LUN C-Mode
size=10G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
`-+- policy='service-time 0' prio=50 status=active
  |- 11:0:1:13 sdm  8:192  active ready running
  |- 11:0:3:13 sdah 66:16  active ready running
  |- 12:0:1:13 sdbc 67:96  active ready running
  `- 12:0:3:13 sdbx 68:176 active ready running
```

AFF or FAS configuration

An AFF or FAS configuration should have two groups of paths with higher and lower priorities. Higher priority Active/Optimized paths are served by the controller where the aggregate is located. Lower priority paths are active but non-optimized because they are served by a different controller. Non-optimized paths are only used when optimized paths aren't available.

The following example displays the output for an ONTAP LUN with two Active/Optimized paths and two Active/Non-Optimized paths:

Show example

```
# multipath -ll
3600a098038314837352453694b542f4a dm-0 NETAPP,LUN C-Mode
size=160G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
|-+- policy='service-time 0' prio=50 status=active
| |- 14:0:3:0 sdbk 67:224 active ready running
| `- 15:0:2:0 sdbl 67:240 active ready running
`-+- policy='service-time 0' prio=10 status=enabled
  |- 14:0:0:0 sda  8:0    active ready running
  `- 15:0:1:0 sdv  65:80  active ready running
```

Step 4: Optionally, exclude a device from multipathing

If required, you can exclude a device from multipathing by adding the WWID for the unwanted device to the "blacklist" stanza for the `multipath.conf` file.

Steps

1. Determine the WWID:

   ```
   /lib/udev/scsi_id -gud /dev/sda
   ```

   "sda" is the local SCSI disk that you want to add to the blacklist.

   An example WWID is `360030057024d0730239134810c0cb833`.

2. Add the WWID to the "blacklist" stanza:

   ```
   blacklist {
           wwid   360030057024d0730239134810c0cb833
           devnode "^(ram|raw|loop|fd|md|dm-|sr|scd|st)[0-9]*"
           devnode "^hd[a-z]"
           devnode "^cciss.*"
   }
   ```

Step 5: Customize multipath parameters for ONTAP LUNs

If your host is connected to LUNs from other vendors and any of the multipath parameter settings are overridden, you need to correct them by adding stanzas later in the `multipath.conf` file that apply specifically to ONTAP LUNs. If you don't do this, the ONTAP LUNs might not work as expected.

Check your `/etc/multipath.conf` file, especially in the defaults section, for settings that might be overriding the default settings for multipath parameters.

> ⚠️ You shouldn't override the recommended parameter settings for ONTAP LUNs. These settings are required for optimal performance of your host configuration. Contact NetApp support, your OS vendor, or both for more information.

The following example shows how to correct an overridden default. In this example, the `multipath.conf` file defines values for `path_checker` and `no_path_retry` that aren't compatible with ONTAP LUNs, and you can't remove these parameters because ONTAP storage arrays are still attached to the host. Instead, you correct the values for `path_checker` and `no_path_retry` by adding a device stanza to the `multipath.conf` file that applies specifically to the ONTAP LUNs.

```
defaults {
    path_checker      readsector0
    no_path_retry     fail
}

devices {
    device {
        vendor          "NETAPP"
        product         "LUN"
        no_path_retry   queue
        path_checker    tur
    }
}
```

Step 6: Review the known issues

There are no known issues.

What's next?

- [Learn about using the Linux Host Utilities tool](#).
- Learn about ASM mirroring.

  Automatic Storage Management (ASM) mirroring might require changes to the Linux multipath settings to allow ASM to recognize a problem and switch over to an alternate failure group. Most ASM configurations on ONTAP use external redundancy, which means that data protection is provided by the external array and ASM doesn't mirror data. Some sites use ASM with normal redundancy to provide two-way mirroring, normally across different sites. See [Oracle databases on ONTAP](#) for further information.

Configure Ubuntu 20.04 for FCP and iSCSI with ONTAP storage

Configure Ubuntu 20.04 for multipathing and with specific parameters and settings for FCP and iSCSI protocol operations with ONTAP storage.

> ⓘ The Linux Host Utilities software package doesn't support Ubuntu operating systems.
>
> You don't need to manually configure Kernel-based Virtual Machine (KVM) settings because ONTAP LUNs are automatically mapped to the hypervisor.

Step 1: Optionally, enable SAN booting

You can configure your host to use SAN booting to simplify deployment and improve scalability.

Before you begin

Use the [Interoperability Matrix Tool](#) to verify that your Linux OS, host bus adapter (HBA), HBA firmware, HBA

boot BIOS, and ONTAP version support SAN booting.

Steps

1. [Create a SAN boot LUN and map it to the host](#).

2. Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is mapped.

   For information on how to enable the HBA BIOS, see your vendor-specific documentation.

3. Verify that the configuration was successful by rebooting the host and verifying that the OS is up and running.

Step 2: Confirm the multipath configuration for your host

You can use multipathing with Ubuntu 20.04 to manage ONTAP LUNs.

To ensure that multipathing is configured correctly for your host, verify that the `/etc/multipath.conf` file is defined and that you have the NetApp recommended settings configured for your ONTAP LUNs.

Steps

1. Verify that the `/etc/multipath.conf` file exits. If the file doesn't exist, create an empty, zero-byte file:

   ```
   touch /etc/multipath.conf
   ```

2. The first time the `multipath.conf` file is created, you might need to enable and start the multipath services to load the recommended settings:

   ```
   systemctl enable multipathd
   ```

   ```
   systemctl start multipathd
   ```

3. Each time you boot the host, the empty `/etc/multipath.conf` zero-byte file automatically loads the NetApp recommended host multipath parameters as the default settings. You shouldn't need to make changes to the `/etc/multipath.conf` file for your host because the operating system is compiled with the multipath parameters that recognize and manage ONTAP LUNs correctly.

   The following table shows the Linux OS native compiled multipath parameter settings for ONTAP LUNs.

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Parameter	Setting
detect_prio	yes
dev_loss_tmo	"infinity"
failback	immediate
fast_io_fail_tmo	5
features	"2 pg_init_retries 50"
flush_on_last_del	"yes"
hardware_handler	"0"
no_path_retry	queue
path_checker	"tur"
path_grouping_policy	"group_by_prio"
path_selector	"service-time 0"
polling_interval	5
prio	"ontap"
product	LUN
retain_attached_hw_handler	yes
rr_weight	"uniform"
user_friendly_names	no
vendor	NETAPP

4. Verify the parameter settings and path status for your ONTAP LUNs:

```
multipath -ll
```

The default multipath parameters support ASA, AFF, and FAS configurations. In these configurations, a single ONTAP LUN shouldn't require more than four paths. If there are more than four paths, it might cause issues with the paths during a storage failure.

The following example outputs show the correct parameter settings and path status for ONTAP LUNs in an ASA, AFF, or FAS configuration.

ASA configuration

An ASA configuration optimizes all paths to a given LUN, keeping them active. This improves performance by serving I/O operations through all paths at the same time.

Show example

```
# multipath -ll
3600a098038314559533f524d6c652f62 dm-24 NETAPP,LUN C-Mode
size=10G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
`-+- policy='service-time 0' prio=50 status=active
  |- 11:0:1:13 sdm  8:192  active ready running
  |- 11:0:3:13 sdah 66:16  active ready running
  |- 12:0:1:13 sdbc 67:96  active ready running
  `- 12:0:3:13 sdbx 68:176 active ready running
```

AFF or FAS configuration

An AFF or FAS configuration should have two groups of paths with higher and lower priorities. Higher priority Active/Optimized paths are served by the controller where the aggregate is located. Lower priority paths are active but non-optimized because they are served by a different controller. Non-optimized paths are only used when optimized paths aren't available.

The following example displays the output for an ONTAP LUN with two Active/Optimized paths and two Active/Non-Optimized paths:

Show example

```
# multipath -ll
3600a098038314837352453694b542f4a dm-0 NETAPP,LUN C-Mode
size=160G features='3 queue_if_no_path pg_init_retries 50'
hwhandler='1 alua' wp=rw
|-+- policy='service-time 0' prio=50 status=active
| |- 14:0:3:0 sdbk 67:224 active ready running
| `- 15:0:2:0 sdbl 67:240 active ready running
`-+- policy='service-time 0' prio=10 status=enabled
  |- 14:0:0:0 sda  8:0    active ready running
  `- 15:0:1:0 sdv  65:80  active ready running
```

Step 3: Optionally, exclude a device from multipathing

If required, you can exclude a device from multipathing by adding the WWID for the unwanted device to the "blacklist" stanza for the `multipath.conf` file.

Steps

1. Determine the WWID:

   ```
   /lib/udev/scsi_id -gud /dev/sda
   ```

   "sda" is the local SCSI disk that you want to add to the blacklist.

   An example WWID is `360030057024d0730239134810c0cb833`.

2. Add the WWID to the "blacklist" stanza:

   ```
   blacklist {
           wwid    360030057024d0730239134810c0cb833
           devnode "^(ram|raw|loop|fd|md|dm-|sr|scd|st)[0-9]*"
           devnode "^hd[a-z]"
           devnode "^cciss.*"
   }
   ```

Step 4: Customize multipath parameters for ONTAP LUNs

If your host is connected to LUNs from other vendors and any of the multipath parameter settings are overridden, you need to correct them by adding stanzas later in the `multipath.conf` file that apply specifically to ONTAP LUNs. If you don't do this, the ONTAP LUNs might not work as expected.

Check your `/etc/multipath.conf` file, especially in the defaults section, for settings that might be overriding the default settings for multipath parameters.

> ⚠️ You shouldn't override the recommended parameter settings for ONTAP LUNs. These settings are required for optimal performance of your host configuration. Contact NetApp support, your OS vendor, or both for more information.

The following example shows how to correct an overridden default. In this example, the `multipath.conf` file defines values for `path_checker` and `no_path_retry` that aren't compatible with ONTAP LUNs, and you can't remove these parameters because ONTAP storage arrays are still attached to the host. Instead, you correct the values for `path_checker` and `no_path_retry` by adding a device stanza to the `multipath.conf` file that applies specifically to the ONTAP LUNs.

Show example

```
defaults {
    path_checker        readsector0
    no_path_retry       fail
}

devices {
    device {
        vendor          "NETAPP"
        product         "LUN"
        no_path_retry   queue
        path_checker    tur
    }
}
```

Step 5: Review the known issues

There are no known issues.

Veritas

Use Veritas Infoscale 8 for Linux with ONTAP

You can use ONTAP SAN host configuration settings for the Veritas Infoscale storage foundation 8 series release for Red Hat Enterprise Linux and Oracle Linux (Red Hat Compatible Kernel based) platforms with FC, FCoE, and iSCSI protocols.

Install the Linux Host Utilities

You can download the NetApp Linux Host Utilities software package as a 64-bit.rpm file from the NetApp Support Site.

NetApp strongly recommends installing the Linux Host Utilities, but it is not mandatory. The utilities do not change any settings on your Linux host. The utilities improve management and assist NetApp customer support in gathering information about your configuration.

Steps

1. Download the 64-bit Linux Host Utilities software package from the NetApp Support Site to your host.

2. Install the software package:

   ```
   rpm -ivh netapp_linux_unified_host_utilities-7-1.x86_64
   ```

SAN Toolkit

Installing the NetApp Host Utilities package automatically installs the toolkit. This kit provides the `sanlun`

utility, which helps you manage LUNs and host bus adapters (HBAs). The `sanlun` command returns information about the LUNs mapped to your host, multipathing, and information necessary to create initiator groups.

Example

In the following illustration, the `sanlun show` command returns LUN information.

```
# sanlun show -p -v SFRAC:/vol/fen1/lun1

             ONTAP Path: SFRAC:/vol/fen1/lun1
                    LUN: 0
               LUN Size: 10g
                Product: cDOT
               DMP NODE: sfrac0_47
      Multipath Provider: Veritas
----------  ------  ---------  ------
--------------------------------------
Veritas      host    vserver     host:
path         path    path      /dev/    chan:     vserver            major:
state        state   type      node     id:lun    LIF                    minor
----------  ------  ---------  ------
--------------------------------------
enabled      up      active/non-optimized sdea   14:0:1:0   lif_10
128:32
enabled (a)  up      active/optimized     sdcj   14:0:0:0   lif_2
69:112
enabled (a)  up      active/optimized     sdb    13:0:0:0   lif_1
8:16
enabled      up      active/non-optimized sdas   13:0:1:0   lif_9
66:192
```

SAN Booting

Before you begin

If you decide to use SAN booting, it must be supported by your configuration. You can use the Interoperability Matrix Tool to verify that your OS, HBA, HBA firmware and the HBA boot BIOS, and ONTAP version are supported.

Refer to Veritas Support Portal (Product Matrix, Platform Lookup, HCL Matrix) to verify SAN Boot configuration supportability and known caveats.

Steps

1. Map the SAN boot LUN to the host.

2. Verify that multiple paths are available.

> ⓘ Multiple paths become available after the host OS is up and running on the paths.

3. Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is mapped.

    For information on how to enable the HBA BIOS, see your vendor-specific documentation.

4. Reboot the host to verify that the boot was successful.

Multipathing

You must verify that your configuration meets the system requirements. For more information, see the Interoperability Matrix Tool and the Veritas HCL Matrix.

Example

In the following example, the `vxdmpadm` command is used to verify that the VxDMP Multipath has the ONTAP target array attached.

```
# vxdmpadm listenclosure
ENCLR_NAME    ENCLR_TYPE   ENCLR_SNO        STATUS        ARRAY_TYPE    LUN_COUNT
FIRMWARE
======================================================================================
===========
sfrac0        SFRAC        804Xw$PqE52h  CONNECTED    ALUA              43
9800
# vxdmpadm getdmpnode
NAME          STATE      ENCLR-TYPE   PATHS   ENBL   DSBL ENCLR-NAME
=================================================================================
sfrac0_47   ENABLED   SFRAC         4       4      0     sfrac0
```

With Veritas Dynamic Multipathing (VxDMP), you must perform configuration tasks to claim NetApp LUNs as Veritas Multipath Devices. You must have the Array Support Library (ASL) and the Array Policy Module (APM) packages installed that Veritas provides for NetApp storage systems. While the Veritas Software Installation loads the default ASL APM packages along with the product, it is recommended to use the latest supported packages listed on Veritas support portal.

Example

The following example displays the Veritas Support Library (ASL) and the Array Policy Module (APM) configuration.

```
# vxdmpadm list dmpnode dmpnodename=sfrac0_47 | grep asl
asl         = libvxnetapp.so
# vxddladm listversion |grep libvxnetapp.so
libvxnetapp.so                      vm-8.0.0-rev-1    8.0

# rpm -qa |grep VRTSaslapm
VRTSaslapm-x.x.x.0000-RHEL8.X86_64
vxddladm listsupport libname=libvxnetapp.so
ATTR_NAME    ATTR_VALUE
=========================================
LIBNAME      libvxnetapp.so
VID          NETAPP
PID          All
ARRAY_TYPE   ALUA, A/A
```

All SAN Array Configuration

In All SAN Array (ASA) configurations, all paths to a given Logical Unit (LUN) are active and optimized. This means I/O can be served through all paths at the same time, thereby enabling better performance.

Example

The following example displays the correct output for an ONTAP LUN:

```
# vxdmpadm getsubpaths dmpnodename-sfrac0_47
NAME   STATE[A]    PATH-TYPE[M]    CTLR-NAME    ENCLR-TYPE   ENCLR-NAME   ATTRS
PRIORITY
===================================================================================
=========
sdas   ENABLED (A)    Active/Optimized c13   SFRAC        sfrac0     -
-
sdb    ENABLED(A) Active/Optimized    c14   SFRAC        sfrac0     -
-
sdcj   ENABLED(A)  Active/Optimized    c14   SFRAC         sfrac0     -
-
sdea   ENABLED (A)    Active/Optimized c14   SFRAC        sfrac0     -
```

> ⓘ Do not use an excessive number of paths to a single LUN. No more than 4 paths should be required. More than 8 paths might cause path issues during storage failures.

Non-ASA Configuration

For non-ASA configuration there should be two groups of paths with different priorities. The paths with higher priorities are Active/Optimized. This means they are serviced by the controller where the aggregate is located. The paths with lower priorities are active but non-optimized because they are served from a different controller. The non-optimized paths are only used when optimized paths are not available.

Example

The following example displays the correct output for an ONTAP LUN with two Active/Optimized paths and two Active/Non-Optimized paths:

```
# vxdmpadm getsubpaths dmpnodename-sfrac0_47
NAME   STATE[A]    PATH-TYPE[M]    CTLR-NAME   ENCLR-TYPE   ENCLR-NAME   ATTRS
PRIORITY
========================================================================
=========
sdas   ENABLED     Active/Non-Optimized c13   SFRAC        sfrac0       -
-
sdb    ENABLED(A)  Active/Optimized    c14   SFRAC        sfrac0       -
-
sdcj   ENABLED(A)  Active/Optimized    c14   SFRAC        sfrac0       -
-
sdea   ENABLED     Active/Non-Optimized c14   SFRAC        sfrac0       -
-
```

> ℹ️ Do not use an excessive number of paths to a single LUN. No more than 4 paths should be required. More than 8 paths might cause path issues during storage failures.

Recommended Settings

Settings for Veritas Multipath

NetApp recommends the following Veritas VxDMP tunables for optimum system configuration in storage failover operations.

Parameter	Setting
dmp_lun_retry_timeout	60
dmp_path_age	120
dmp_restore_interval	60

DMP tunables are set online by using the `vxdmpadm` command as follows:

`# vxdmpadm settune dmp_tunable=value`

The values of these tunable can be verified dynamically by using `#vxdmpadm gettune`.

Example

The following example shows the effective VxDMP tunables on the SAN host.

```
# vxdmpadm gettune

Tunable                        Current Value    Default Value
dmp_cache_open                         on                on
dmp_daemon_count                       10                10
dmp_delayq_interval                    15                15
dmp_display_alua_states                on                on
dmp_fast_recovery                      on                on
dmp_health_time                        60                60
dmp_iostats_state                  enabled           enabled
dmp_log_level                           1                 1
dmp_low_impact_probe                   on                on
dmp_lun_retry_timeout                  60                30
dmp_path_age                          120               300
dmp_pathswitch_blks_shift               9                 9
dmp_probe_idle_lun                     on                on
dmp_probe_threshold                     5                 5
dmp_restore_cycles                     10                10
dmp_restore_interval                   60               300
dmp_restore_policy         check_disabled    check_disabled
dmp_restore_state                  enabled           enabled
dmp_retry_count                         5                 5
dmp_scsi_timeout                       20                20
dmp_sfg_threshold                       1                 1
dmp_stat_interval                       1                 1
dmp_monitor_ownership                  on                on
dmp_monitor_fabric                     on                on
dmp_native_support                    off               off
```

Settings by protocol

- For FC/FCoE only: Use the default timeout values.

- For iSCSI only: Set the `replacement_timeout` parameter value to 120.

  The iSCSI `replacement_timeout` parameter controls how long the iSCSI layer should wait for a timed-out path or session to reestablish itself before failing any commands on it. Setting the value of `replacement_timeout` to 120 in the iSCSI configuration file is recommended.

Example

```
# grep replacement_timeout /etc/iscsi/iscsid.conf
node.session.timeo.replacement_timeout = 120
```

Settings by OS platforms

For Red Hat Enterprise Linux 7 and 8 series, you must configure `udev rport` values to support the Veritas Infoscale environment in storage failover scenarios. Create the file `/etc/udev/rules.d/40-rport.rules` with the following file content:

```
# cat /etc/udev/rules.d/40-rport.rules
KERNEL=="rport-*", SUBSYSTEM=="fc_remote_ports", ACTION=="add",
RUN+=/bin/sh -c 'echo 20 >
/sys/class/fc_remote_ports/%k/fast_io_fail_tmo;echo 864000
>/sys/class/fc_remote_ports/%k/dev_loss_tmo'"
```

> ⓘ For all other settings specific to Veritas, refer to the standard Veritas Infoscale product documentation.

Multipath Coexistence

If you have a heterogenous multipath environment including Veritas Infoscale, Linux Native Device Mapper, and LVM volume manager, refer to the Veritas Product Administration documentation for configuration settings.

Known issues

There are no known issues for the Veritas Infoscale 8 for Linux with ONTAP release.

Use Veritas Infoscale 7 for Linux with ONTAP

You can use ONTAP SAN host configuration settings for the Veritas Infoscale storage foundation 7 series release for Red Hat Enterprise Linux and Oracle Linux (Red Hat Compatible Kernel based) platforms with FC, FCoE and iSCSI protocols.

Install the Linux Host Utilities

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NetApp strongly recommends installing the Linux Host Utilities, but it is not mandatory. The utilities do not change any settings on your Linux host. The utilities improve management and assist NetApp customer support in gathering information about your configuration.

Steps

1. Download the 64-bit Linux Host Utilities software package from the NetApp Support Site to your host.

2. Install the software package:

   ```
   rpm -ivh netapp_linux_unified_host_utilities-7-1.x86_64
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Installing the NetApp Host Utilities package automatically installs the toolkit. This kit provides the `sanlun` utility, which helps you manage LUNs and host bus adapters (HBAs). The `sanlun` command returns

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Example

In the following illustration, the `sanlun show` command returns LUN information.

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              ONTAP Path: SFRAC:/vol/fen1/lun1
                     LUN: 0
                LUN Size: 10g
                 Product: cDOT
                DMP NODE: sfrac0_47
      Multipath Provider: Veritas
----------  ------  ---------  ------
--------------------------------------
Veritas      host    vserver     host:
path         path    path     /dev/   chan:     vserver            major:
state        state   type      node   id:lun    LIF                    minor
----------  ------  ---------  ------
--------------------------------------
enabled      up      active/non-optimized sdea   14:0:1:0   lif_10
128:32
enabled (a)  up      active/optimized     sdcj   14:0:0:0   lif_2
69:112
enabled (a)  up      active/optimized     sdb    13:0:0:0   lif_1
8:16
enabled      up      active/non-optimized sdas   13:0:1:0   lif_9
66:192
```

SAN Booting

Before you begin

If you decide to use SAN booting, it must be supported by your configuration. You can use the Interoperability Matrix Tool to verify that your OS, HBA, HBA firmware and the HBA boot BIOS, and ONTAP version are supported.

Refer to Veritas Support Portal (Product Matrix, Platform Lookup, HCL Matrix) to verify SAN Boot configuration supportability and known caveats.

Steps

1. Map the SAN boot LUN to the host.

2. Verify that multiple paths are available.

> ⓘ Multiple paths become available after the host OS is up and running on the paths.

3. Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is mapped.

For information on how to enable the HBA BIOS, see your vendor-specific documentation.

4. Reboot the host to verify that the boot was successful.

Multipathing

You must verify that your configuration meets the system requirements. For more information, see the Interoperability Matrix Tool and the Veritas HCL Matrix.

Example

In this example, the `vxdmpadm` command is used to verify that the VxDMP Multipath has the ONTAP target array attached.

```
# vxdmpadm listenclosure
ENCLR_NAME    ENCLR_TYPE   ENCLR_SNO       STATUS       ARRAY_TYPE     LUN_COUNT
FIRMWARE
============================================================================
===========
sfrac0        SFRAC        804Xw$PqE52h  CONNECTED    ALUA           43
9800
# vxdmpadm getdmpnode
NAME          STATE      ENCLR-TYPE   PATHS   ENBL   DSBL ENCLR-NAME
===============================================================
sfrac0_47   ENABLED   SFRAC          4       4      0     sfrac0
```

With Veritas Dynamic Multipathing (VxDMP), you must perform configuration tasks to claim NetApp LUNs as Veritas Multipath Devices. You must have the Array Support Library (ASL) and the Array Policy Module (APM) packages installed that Veritas provides for NetApp storage systems. While the Veritas Software Installation loads the default ASL APM packages along with the product, it is recommended to use the latest supported packages listed on Veritas support portal.

Example

The following example displays the Veritas Support Library (ASL) and the Array Policy Module (APM) configuration.

```
# vxdmpadm list dmpnode dmpnodename=sfrac0_47 | grep asl
asl          = libvxnetapp.so
# vxddladm listversion |grep libvxnetapp.so
libvxnetapp.so                  vm-7.4-rev-1    6.1

# rpm -qa |grep VRTSaslapm
VRTSaslapm-x.x.x.0000-RHEL8.X86_64
vxddladm listsupport libname=libvxnetapp.so
ATTR_NAME    ATTR_VALUE
==========================================
LIBNAME      libvxnetapp.so
VID          NETAPP
PID          All
ARRAY_TYPE   ALUA, A/A
```

All SAN Array Configuration

In All SAN Array (ASA) configurations, all paths to a given Logical Unit (LUN) are active and optimized. This means I/O can be served through all paths at the same time, thereby enabling better performance.

Example

The following example displays the correct output for an ONTAP LUN:

```
# vxdmpadm getsubpaths dmpnodename-sfrac0_47
NAME   STATE[A]    PATH-TYPE[M]    CTLR-NAME    ENCLR-TYPE   ENCLR-NAME   ATTRS
PRIORITY
========================================================================
=========
sdas   ENABLED (A)    Active/Optimized c13   SFRAC        sfrac0      -
-
sdb    ENABLED(A)  Active/Optimized    c14    SFRAC        sfrac0      -
-
sdcj   ENABLED(A)   Active/Optimized    c14    SFRAC         sfrac0     -
-
sdea   ENABLED (A)    Active/Optimized c14   SFRAC        sfrac0      -
```

> (i) Do not use an excessive number of paths to a single LUN. No more than 4 paths should be
>   required. More than 8 paths might cause path issues during storage failures.

Non-ASA configurations

For non-ASA configurations, there should be two groups of paths with different priorities. The paths with higher priorities are Active/Optimized. This means they are serviced by the controller where the aggregate is located. The paths with lower priorities are active but non-optimized because they are served from a different controller. The non-optimized paths are only used when optimized paths are not available.

Example

The following example displays the correct output for an ONTAP LUN with two Active/Optimized paths and two Active/Non-Optimized paths.

```
# vxdmpadm getsubpaths dmpnodename-sfrac0_47
NAME   STATE[A]   PATH-TYPE[M]    CTLR-NAME   ENCLR-TYPE   ENCLR-NAME   ATTRS
PRIORITY
========================================================================
=========
sdas   ENABLED    Active/Non-Optimized c13   SFRAC        sfrac0       -
-
sdb    ENABLED(A) Active/Optimized     c14   SFRAC        sfrac0       -
-
sdcj   ENABLED(A) Active/Optimized     c14   SFRAC        sfrac0       -
-
sdea   ENABLED    Active/Non-Optimized c14   SFRAC        sfrac0       -
-
```

> ⓘ A single LUN shouldn't require more than four paths. Having more than four paths might cause path issues during storage failures.

Recommended Settings

Settings for Veritas Multipath

NetApp recommends the following Veritas VxDMP tunables for optimum system configuration in storage failover operations.

Parameter	Setting
dmp_lun_retry_timeout	60
dmp_path_age	120
dmp_restore_interval	60

DMP tunables are set online by using the `vxdmpadm` command as follows:

`# vxdmpadm settune dmp_tunable=value`

The values of these tunable can be verified dynamically by using `#vxdmpadm gettune`.

Example

The following example shows the effective VxDMP tunables on the SAN host.

```
# vxdmpadm gettune

Tunable                         Current Value     Default Value
dmp_cache_open                            on                on
dmp_daemon_count                          10                10
dmp_delayq_interval                       15                15
dmp_display_alua_states                   on                on
dmp_fast_recovery                         on                on
dmp_health_time                           60                60
dmp_iostats_state                    enabled           enabled
dmp_log_level                              1                 1
dmp_low_impact_probe                      on                on
dmp_lun_retry_timeout                     60                30
dmp_path_age                             120               300
dmp_pathswitch_blks_shift                  9                 9
dmp_probe_idle_lun                        on                on
dmp_probe_threshold                        5                 5
dmp_restore_cycles                        10                10
dmp_restore_interval                      60               300
dmp_restore_policy          check_disabled    check_disabled
dmp_restore_state                    enabled           enabled
dmp_retry_count                            5                 5
dmp_scsi_timeout                          20                20
dmp_sfg_threshold                          1                 1
dmp_stat_interval                          1                 1
dmp_monitor_ownership                     on                on
dmp_monitor_fabric                        on                on
dmp_native_support                       off               off
```

Settings by protocol

- For FC/FCoE only: Use the default timeout values.

- For iSCSI only: Set the `replacement_timeout` parameter value to 120.

  The iSCSI `replacement_timeout` parameter controls how long the iSCSI layer should wait for a timed-out path or session to reestablish itself before failing any commands on it. Setting the value of `replacement_timeout` to 120 in the iSCSI configuration file is recommended.

Example

```
# grep replacement_timeout /etc/iscsi/iscsid.conf
node.session.timeo.replacement_timeout = 120
```

Settings by OS platforms

For Red Hat Enterprise Linux 7 and 8 series, you must configure `udev rport` values to support the Veritas Infoscale environment in storage failover scenarios. Create the file `/etc/udev/rules.d/40-rport.rules` with the following file content:

```
# cat /etc/udev/rules.d/40-rport.rules
KERNEL=="rport-*", SUBSYSTEM=="fc_remote_ports", ACTION=="add",
RUN+=/bin/sh -c 'echo 20 >
/sys/class/fc_remote_ports/%k/fast_io_fail_tmo;echo 864000
>/sys/class/fc_remote_ports/%k/dev_loss_tmo'"
```

> ⓘ   For all other settings specific to Veritas, refer to the standard Veritas Infoscale product documentation.

Multipath Coexistence

If you have a heterogenous multipath environment including Veritas Infoscale, Linux Native Device Mapper, and LVM volume manager, refer to the Veritas Product Administration documentation for configuration settings.

Known issues

There are no known issues for the Veritas Infoscale 7 for Linux with ONTAP release.

Use Veritas Storage Foundation 6 for Linux with ONTAP

You can use ONTAP SAN host configuration settings for the Veritas Storage Foundation 6 series release for Red Hat Enterprise Linux and Oracle Linux (Red Hat Compatible Kernel based) platforms with FC, FCoE and iSCSI protocols.

Install the Linux Host Utilities

You can download the NetApp Linux Host Utilities software package as a 64-bit.rpm file from the NetApp Support Site.

NetApp strongly recommends installing the Linux Host Utilities, but it is not mandatory. The utilities do not change any settings on your Linux host. The utilities improve management and assist NetApp customer support in gathering information about your configuration.

Steps

1. Download the 64-bit Linux Host Utilities software package from the NetApp Support Site to your host.

2. Install the software package:

   ```
   rpm -ivh netapp_linux_unified_host_utilities-7-1.x86_64
   ```

SAN Toolkit

Installing the NetApp Host Utilities package automatically installs the toolkit. This kit provides the `sanlun` utility, which helps you manage LUNs and host bus adapters (HBAs). The `sanlun` command returns

information about the LUNs mapped to your host, multipathing, and information necessary to create initiator groups.

Example

In the following illustration, the `sanlun show` command returns LUN information.

```
# sanlun show -p -v SFRAC:/vol/fen1/lun1

              ONTAP Path: SFRAC:/vol/fen1/lun1
                     LUN: 0
                LUN Size: 10g
                 Product: cDOT
                DMP NODE: sfrac0_47
      Multipath Provider: Veritas
---------- ------ --------- ------
--------------------------------------
Veritas      host    vserver    host:
path         path    path     /dev/   chan:    vserver          major:
state        state   type      node   id:lun   LIF                 minor
---------- ------ --------- ------
--------------------------------------
enabled      up      active/non-optimized sdea   14:0:1:0   lif_10
128:32
enabled (a)  up      active/optimized     sdcj   14:0:0:0   lif_2
69:112
enabled (a)  up      active/optimized     sdb    13:0:0:0   lif_1
8:16
enabled      up      active/non-optimized sdas   13:0:1:0   lif_9
66:192
```

SAN Booting

Before you begin

If you decide to use SAN booting, it must be supported by your configuration. You can use the Interoperability Matrix Tool to verify that your OS, HBA, HBA firmware and the HBA boot BIOS, and ONTAP version are supported.

Refer to Veritas Support Portal (Product Matrix, Platform Lookup, HCL Matrix) to verify SAN Boot configuration supportability and known caveats.

Steps

1. Map the SAN boot LUN to the host.

2. Verify that multiple paths are available.

   ⓘ Multiple paths become available after the host OS is up and running on the paths.

3. Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is mapped.

For information on how to enable the HBA BIOS, see your vendor-specific documentation.

4. Reboot the host to verify that the boot was successful.

Multipathing

You must verify that your configuration meets the system requirements. For more information, see the Interoperability Matrix Tool and the Veritas HCL Matrix.

Example

In the following example, the `vxdmpadm` command is used to verify that the VxDMP Multipath has the ONTAP target array attached.

```
# vxdmpadm listenclosure
ENCLR_NAME    ENCLR_TYPE   ENCLR_SNO       STATUS       ARRAY_TYPE     LUN_COUNT
FIRMWARE
=============================================================================
===========
sfrac0        SFRAC        804Xw$PqE52h  CONNECTED    ALUA           43
9800
```

```
# vxdmpadm getdmpnode
NAME         STATE     ENCLR-TYPE   PATHS   ENBL   DSBL ENCLR-NAME
===============================================================
sfrac0_47   ENABLED   SFRAC        4       4      0     sfrac0
```

With Veritas Dynamic Multipathing (VxDMP), you must perform configuration tasks to claim NetApp LUNs as Veritas Multipath Devices. You must have the Array Support Library (ASL) and the Array Policy Module (APM) packages installed that Veritas provides for NetApp storage systems. While the Veritas Software Installation loads the default ASL APM packages along with the product, it is recommended to use the latest supported packages listed on Veritas support portal.

Example

The following example displays the Veritas Support Library (ASL) and the Array Policy Module (APM) configuration.

```
# vxdmpadm list dmpnode dmpnodename=sfrac0_47 | grep asl
asl         = libvxnetapp.so
```

```
# vxddladm listversion |grep libvxnetapp.so
libvxnetapp.so              vm-7.4-rev-1    6.1

# rpm -qa |grep VRTSaslapm
VRTSaslapm-x.x.x.0000-RHEL8.X86_64
```

```
vxddladm listsupport libname=libvxnetapp.so
ATTR_NAME    ATTR_VALUE
=======================================
LIBNAME      libvxnetapp.so
VID          NETAPP
PID          All
ARRAY_TYPE   ALUA, A/A
```

Non-ASA configurations

For non-ASA configurations, there should be two groups of paths with different priorities. The paths with higher priorities are Active/Optimized. This means they are serviced by the controller where the aggregate is located. The paths with lower priorities are active but non-optimized because they are served from a different controller. The non-optimized paths are only used when optimized paths are not available.

Example

The following example displays the correct output for an ONTAP LUN with two Active/Optimized paths and two Active/Non-Optimized paths.

```
# vxdmpadm getsubpaths dmpnodename-sfrac0_47
NAME   STATE[A]    PATH-TYPE[M]    CTLR-NAME   ENCLR-TYPE   ENCLR-NAME   ATTRS
PRIORITY
===========================================================================
=========
sdas   ENABLED     Active/Non-Optimized c13   SFRAC        sfrac0       -
-
sdb    ENABLED(A)  Active/Optimized     c14   SFRAC        sfrac0       -
-
sdcj   ENABLED(A)  Active/Optimized     c14   SFRAC        sfrac0       -
-
sdea   ENABLED     Active/Non-Optimized c14   SFRAC        sfrac0       -
-
```

> ⓘ   A single LUN shouldn't require more than four paths. Having more than four paths might cause path issues during storage failures.

Recommended Settings

Settings for Veritas Multipath

NetApp recommends the following Veritas VxDMP tunables for optimum system configuration in storage failover operations.

Parameter	Setting
dmp_lun_retry_timeout	60

Parameter	Setting
dmp_path_age	120
dmp_restore_interval	60

DMP tunables are set online by using the `vxdmpadm` command as follows:

```
# vxdmpadm settune dmp_tunable=value
```

The values of these tunable can be verified dynamically by using `#vxdmpadm gettune`.

Example

The following example shows the effective VxDMP tunables on the SAN host.

```
# vxdmpadm gettune

Tunable                       Current Value    Default Value
dmp_cache_open                          on               on
dmp_daemon_count                        10               10
dmp_delayq_interval                     15               15
dmp_display_alua_states                 on               on
dmp_fast_recovery                       on               on
dmp_health_time                         60               60
dmp_iostats_state                  enabled          enabled
dmp_log_level                            1                1
dmp_low_impact_probe                    on               on
dmp_lun_retry_timeout                   60               30
dmp_path_age                           120              300
dmp_pathswitch_blks_shift                9                9
dmp_probe_idle_lun                      on               on
dmp_probe_threshold                      5                5
dmp_restore_cycles                      10               10
dmp_restore_interval                    60              300
dmp_restore_policy         check_disabled    check_disabled
dmp_restore_state                  enabled          enabled
dmp_retry_count                          5                5
dmp_scsi_timeout                        20               20
dmp_sfg_threshold                        1                1
dmp_stat_interval                        1                1
dmp_monitor_ownership                   on               on
dmp_monitor_fabric                      on               on
dmp_native_support                     off              off
```

Settings by protocol

- For FC/FCoE only: Use the default timeout values.

- For iSCSI only: Set the `replacement_timeout` parameter value to 120.

  The iSCSI `replacement_timeout` parameter controls how long the iSCSI layer should wait for a timed-out path or session to reestablish itself before failing any commands on it. Setting the value of `replacement_timeout` to 120 in the iSCSI configuration file is recommended.

Example

```
# grep replacement_timeout /etc/iscsi/iscsid.conf
node.session.timeo.replacement_timeout = 120
```

Settings by OS platforms

For Red Hat Enterprise Linux 7 and 8 series, you must configure `udev rport` values to support the Veritas Infoscale environment in storage failover scenarios. Create the file `/etc/udev/rules.d/40-rport.rules` with the following file content:

```
# cat /etc/udev/rules.d/40-rport.rules
KERNEL=="rport-*", SUBSYSTEM=="fc_remote_ports", ACTION=="add",
RUN+=/bin/sh -c 'echo 20 >
/sys/class/fc_remote_ports/%k/fast_io_fail_tmo;echo 864000
>/sys/class/fc_remote_ports/%k/dev_loss_tmo'"
```

> ⓘ   For all other settings specific to Veritas, refer to the standard Veritas Infoscale product documentation.

Multipath Coexistence

If you have a heterogenous multipath environment including Veritas Infoscale, Linux Native Device Mapper, and LVM volume manager, refer to the Veritas Product Administration documentation for configuration settings.

Known issues

There are no known issues for the Veritas Storage Foundation 6 for Linux with ONTAP release.

Windows

Configure Windows Server 2025 for ONTAP storage

You can use the ONTAP SAN host configuration settings to configure Windows Server 2025 for operation with ONTAP storage.

Boot the Windows OS

You can boot the Windows OS using a local boot or a SAN boot. NetApp recommends using a SAN boot if it is supported by your configuration.

Local boot

Perform a local boot by installing the Windows OS on the local hard disk (SSD, SATA, RAID, and so on).

SAN boot

If you choose to use SAN booting, it must be supported by your configuration.

Before you begin

Use the Interoperability Matrix Tool to verify that your Windows OS, host bus adapter (HBA), HBA firmware, HBA boot BIOS, and ONTAP version support SAN booting.

Steps

1. Map the SAN boot LUN to the host.

   See SAN storage management.

2. Verify that multiple paths are available.

   > ⓘ   Multiple paths only become available after the host OS is up and running on the paths.

3. Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is mapped.

   For information on how to enable the HBA BIOS, see your vendor-specific documentation.

4. Reboot the host to verify the boot was successful

Install Windows hotfixes

NetApp recommends installing the **latest cumulative update** available from the Microsoft Update Catalog on the host server.

Steps

1. Download the hotfixes from the Microsoft Update Catalog 2025.

   > ⓘ   You need to contact Microsoft support for the hotfixes that aren't available for download from the Microsoft Update Catalog.

2. Follow the instructions provided by Microsoft to install the hotfixes.

   > 💡   Many hotfixes require a reboot of your Windows host. You can choose to wait to reboot the host until *after* you install or upgrade the Host Utilities.

Install the Windows Host Utilities

The Windows Host Utilities are a set of software programs with documentation that enables you to connect host computers to virtual disks (LUNs) on a NetApp SAN. NetApp recommends downloading and installing the latest utility kit. For Windows Host Utilities configuration information and instructions, see the Windows Host Utilities documentation and select the installation procedure for your Windows Host Utilities version.

Multipathing

You need to install the Microsoft Multipath I/O (MPIO) software and enable multipathing if your Windows host has more than one path to the storage system.

The MPIO software presents a single disk to the Windows OS for all paths, and a device-specific module (DSM) manages path failover. On a Windows system, the two main components in any MPIO solution are the DSM and the Windows MPIO.

> ⚠️ If you don't install the MPIO software, the Windows OS might see each path as a separate disk. This can lead to data corruption.

> ℹ️
> - For Windows Host Utilities 8.0, the MPIO feature is enabled automatically when you select MPIO support.
> - Windows XP or Windows Vista running in a Hyper-V virtual machine don't support MPIO.

SAN configuration

Depending on your SAN configuration, the host uses All SAN Array (ASA) or non-ASA configurations to access ONTAP LUNs. In both ASA and non-ASA configurations, you shouldn't require more than four paths to access a single ONTAP LUN. If you have more than four paths, it might cause issues with the paths during a storage failure.

All SAN array configuration

An ASA configuration should have one group of Active/Optimized paths with single priorities. This means the paths are serviced by the controller and the I/O is sent on all the active paths.
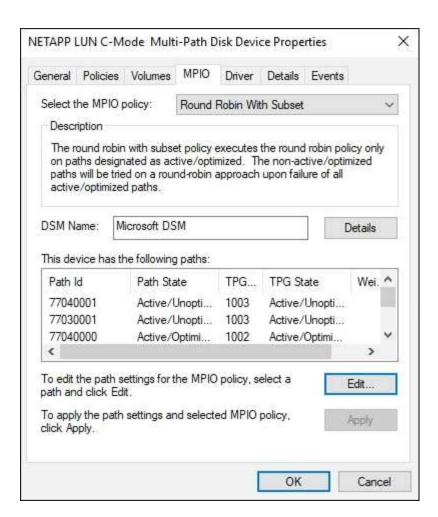
The following example displays the correct output for an ONTAP LUN with Active/Optimized paths.

Non-ASA configuration

A non-ASA configuration should have two groups of paths with different priorities. The paths with higher priorities are Active/Optimized. This means the Active/Optimized paths are serviced by the controller where the aggregate is located. The paths with lower priorities are active but non-optimized because they are served from a different controller. The non-optimized paths are only used when optimized paths aren't available.

The following example displays the correct output for an ONTAP LUN with two Active/Optimized paths and two Active/Non-Optimized paths.

Recommended settings

When you select MPIO on systems using FC, the Host Utilities installer sets the required timeout values for Emulex and QLogic FC HBAs.

Emulex FC
The timeout values for Emulex FC HBAs:

Property type	Property value
LinkTimeOut	1
NodeTimeOut	10

QLogic FC
The timeout values for QLogic FC HBAs:

Property type	Property value
LinkDownTimeOut	1
PortDownRetryCount	10

| | For more information on the recommended settings, see Configure registry settings for Windows Host Utilities. |

Known issues

There are no known issues for the Windows Server 2025 with ONTAP release.

Use Windows Server 2022 with ONTAP

You can use the ONTAP SAN host configuration settings to configure Windows Server 2022 for operation with ONTAP storage.

Boot the Windows OS

You can boot the Windows OS using a local boot or a SAN boot. NetApp recommends using a SAN boot if it is supported by your configuration.

Local boot

Perform a local boot by installing the Windows OS on the local hard disk (SSD, SATA, RAID, and so on).

SAN boot

If you choose to use SAN booting, it must be supported by your configuration.

Before you begin

Use the Interoperability Matrix Tool to verify that your Windows OS, host bus adapter (HBA), HBA firmware, HBA boot BIOS, and ONTAP version support SAN booting.

Steps

1. Map the SAN boot LUN to the host.

   See SAN storage management.

2. Verify that multiple paths are available.

   | | Multiple paths only become available after the host OS is up and running on the paths. |

3. Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is mapped.

   For information on how to enable the HBA BIOS, see your vendor-specific documentation.

4. Reboot the host to verify the boot was successful

Install Windows hotfixes

NetApp recommends installing the **latest cumulative update** available from the Microsoft Update Catalog on the host server.

Steps

1. Download the hotfixes from the Microsoft Update Catalog 2022.

> ℹ️ You need to contact Microsoft support for the hotfixes that aren't available for download from the Microsoft Update Catalog.

2. Follow the instructions provided by Microsoft to install the hotfixes.

> 💡 Many hotfixes require a reboot of your Windows host. You can choose to wait to reboot the host until *after* you install or upgrade the Host Utilities.

Install the Windows Host Utilities

The Windows Host Utilities are a set of software programs with documentation that enables you to connect host computers to virtual disks (LUNs) on a NetApp SAN. NetApp recommends downloading and installing the latest utility kit. For Windows Host Utilities configuration information and instructions, see the Windows Host Utilities documentation and select the installation procedure for your Windows Host Utilities version.

Multipathing

You need to install the Microsoft Multipath I/O (MPIO) software and enable multipathing if your Windows host has more than one path to the storage system. When you select MPIO support, the Windows Host Utilities enables the MPIO feature included in Windows Server 2022. If you're not using the Windows Host Utilities, you need to enable multipathing manually.

The MPIO software presents a single disk to the Windows OS for all paths, and a device-specific module (DSM) manages path failover. On a Windows system, the two main components in any MPIO solution are the DSM and the Windows MPIO.

> ⚠️ If you don't install the MPIO software, the Windows OS might see each path as a separate disk. This can lead to data corruption.

> ℹ️ • For Windows Host Utilities 8.0, the MPIO feature is enabled automatically when you select MPIO support.
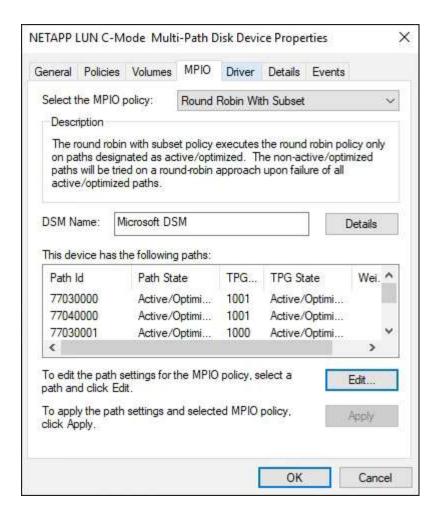> • Windows XP or Windows Vista running in a Hyper-V virtual machine don't support MPIO.

SAN configuration

Depending on your SAN configuration, the host uses All SAN Array (ASA) or non-ASA configurations to access ONTAP LUNs. In both ASA and non-ASA configurations, you shouldn't require more than four paths to access a single ONTAP LUN. If you have more than four paths, it might cause issues with the paths during a storage failure.

All SAN array configuration

An ASA configuration should have one group of Active/Optimized paths with single priorities. This means the paths are serviced by the controller and the I/O is sent on all the active paths.
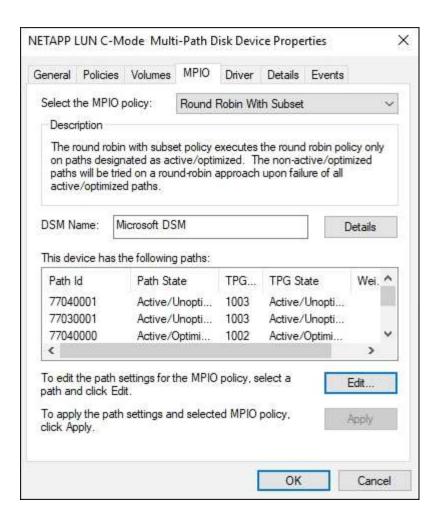
The following example displays the correct output for an ONTAP LUN with Active/Optimized paths.

Non-ASA configuration

A non-ASA configuration should have two groups of paths with different priorities. The paths with higher priorities are Active/Optimized. This means the Active/Optimized paths are serviced by the controller where the aggregate is located. The paths with lower priorities are active but non-optimized because they are served from a different controller. The non-optimized paths are only used when optimized paths aren't available.

The following example displays the correct output for an ONTAP LUN with two Active/Optimized paths and two Active/Non-Optimized paths.

Recommended settings

When you select MPIO on systems using FC, the Host Utilities installer sets the required timeout values for Emulex and QLogic FC HBAs.

Emulex FC

The timeout values for Emulex FC HBAs:

Property type	Property value
LinkTimeOut	1
NodeTimeOut	10

QLogic FC

The timeout values for QLogic FC HBAs:

Property type	Property value
LinkDownTimeOut	1
PortDownRetryCount	10

> ⓘ For more information on the recommended settings, see Configure registry settings for Windows Host Utilities.

Known issues

There are no known issues for the Windows Server 2022 with ONTAP release.

Use Windows Server 2019 with ONTAP

You can use the ONTAP SAN host configuration settings to configure Windows server 2019 with ONTAP for operation with ONTAP storage.

Boot the Windows OS

You can boot the Windows OS using a local boot or a SAN boot. NetApp recommends using a SAN boot if it is supported by your configuration.

Local boot

Perform a local boot by installing the Windows OS on the local hard disk (SSD, SATA, RAID, and so on).

SAN boot

If you choose to use SAN booting, it must be supported by your configuration.

> ⓘ You can use the configuration settings provided in this procedure to configure cloud clients connected to Cloud Volumes ONTAP and Amazon FSx for ONTAP.

Before you begin

Use the Interoperability Matrix Tool to verify that your Windows OS, host bus adapter (HBA), HBA firmware, HBA boot BIOS, and ONTAP version support SAN booting.

Steps

1. Map the SAN boot LUN to the host.

   See SAN storage management.

2. Verify that multiple paths are available.

   > ⓘ Multiple paths only become available after the host OS is up and running on the paths.

3. Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is mapped.

   For information on how to enable the HBA BIOS, see your vendor-specific documentation.

4. Reboot the host to verify the boot was successful

Install Windows hotfixes

NetApp recommends installing the **latest cumulative update** available from the Microsoft Update Catalog on the host server.

Steps

1. Download the hotfixes from the Microsoft Update Catalog 2019.

> ⓘ You need to contact Microsoft support for the hotfixes that aren't available for download from the Microsoft Update Catalog.

2. Follow the instructions provided by Microsoft to install the hotfixes.

> 💡 Many hotfixes require a reboot of your Windows host. You can choose to wait to reboot the host until *after* you install or upgrade the Host Utilities.

Install the Windows Host Utilities

The Windows Host Utilities are a set of software programs with documentation that enables you to connect host computers to virtual disks (LUNs) on a NetApp SAN. NetApp recommends downloading and installing the latest utility kit. For Windows Host Utilities configuration information and instructions, see the Windows Host Utilities documentation and select the installation procedure for your Windows Host Utilities version.

Multipathing

You need to install the Microsoft Multipath I/O (MPIO) software and enable multipathing if your Windows host has more than one path to the storage system. When you select MPIO support, the Windows Host Utilities enables the MPIO feature included in Windows Server 2019. If you're not using the Windows Host Utilities, you need to enable multipathing manually.

The MPIO software presents a single disk to the Windows OS for all paths, and a device-specific module (DSM) manages path failover. On a Windows system, the two main components in any MPIO solution are the DSM and the Windows MPIO.

> ⚠️ If you don't install the MPIO software, the Windows OS might see each path as a separate disk. This can lead to data corruption.

> ⓘ • For Windows Host Utilities 8.0, the MPIO feature is enabled automatically when you select MPIO support.
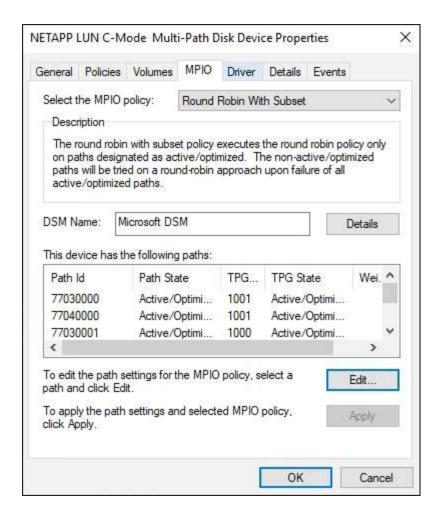> • Windows XP or Windows Vista running in a Hyper-V virtual machine don't support MPIO.

SAN configuration

Depending on your SAN configuration, the host uses All SAN Array (ASA) or non-ASA configurations to access ONTAP LUNs. In both ASA and non-ASA configurations, you shouldn't require more than four paths to access a single ONTAP LUN. If you have more than four paths, it might cause issues with the paths during a storage failure.

All SAN array configuration

An ASA configuration should have one group of Active/Optimized paths with single priorities. This means the paths are serviced by the controller and the I/O is sent on all the active paths.
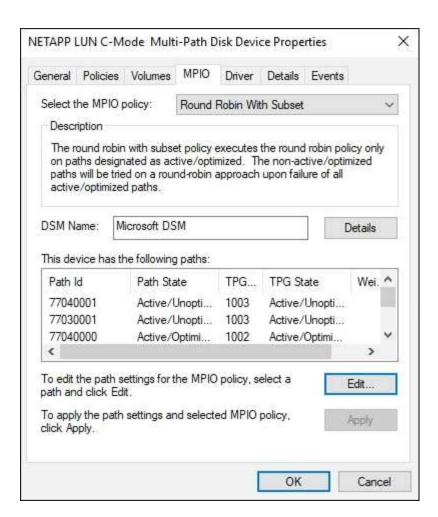
The following example displays the correct output for an ONTAP LUN with Active/Optimized paths.

Non-ASA configuration

A non-ASA configuration should have two groups of paths with different priorities. The paths with higher priorities are Active/Optimized. This means the Active/Optimized paths are serviced by the controller where the aggregate is located. The paths with lower priorities are active but non-optimized because they are served from a different controller. The non-optimized paths are only used when optimized paths aren't available.

The following example displays the correct output for an ONTAP LUN with two Active/Optimized paths and two Active/Non-Optimized paths.

Recommended settings

When you select MPIO on systems using FC, the Host Utilities installer sets the required timeout values for Emulex and QLogic FC HBAs.

Emulex FC
The timeout values for Emulex FC HBAs:

Property type	Property value
LinkTimeOut	1
NodeTimeOut	10

QLogic FC
The timeout values for QLogic FC HBAs:

Property type	Property value
LinkDownTimeOut	1
PortDownRetryCount	10

For more information on the recommended settings, see Configure registry settings for Windows Host Utilities.

Known issues

There are no known issues for the Windows Server 2019 with ONTAP release.

Use Windows Server 2016 with ONTAP

You can use the ONTAP SAN host configuration settings to configure Windows Server 2016 for operation with ONTAP storage.

Boot the Windows OS

You can boot the Windows OS using a local boot or a SAN boot. NetApp recommends using a SAN boot if it is supported by your configuration.

Local boot

Perform a local boot by installing the Windows OS on the local hard disk (SSD, SATA, RAID, and so on).

SAN boot

If you choose to use SAN booting, it must be supported by your configuration.

> You can use the configuration settings provided in this procedure to configure cloud clients connected to Cloud Volumes ONTAP and Amazon FSx for ONTAP.

Before you begin

Use the Interoperability Matrix Tool to verify that your Windows OS, host bus adapter (HBA), HBA firmware, HBA boot BIOS, and ONTAP version support SAN booting.

Steps

1. Map the SAN boot LUN to the host.

   See SAN storage management.

2. Verify that multiple paths are available.

   > Multiple paths only become available after the host OS is up and running on the paths.

3. Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is mapped.

   For information on how to enable the HBA BIOS, see your vendor-specific documentation.

4. Reboot the host to verify the boot was successful

Install Windows hotfixes

NetApp recommends installing the **latest cumulative update** available from the Microsoft Update Catalog on the host server.

Steps

1. Download the hotfixes from the Microsoft Update Catalog 2016.

> ⓘ You need to contact Microsoft support for the hotfixes that aren't available for download from the Microsoft Update Catalog.

2. Follow the instructions provided by Microsoft to install the hotfixes.

> 💡 Many hotfixes require a reboot of your Windows host. You can choose to wait to reboot the host until *after* you install or upgrade the Host Utilities.

Install the Windows Host Utilities

The Windows Host Utilities are a set of software programs with documentation that enables you to connect host computers to virtual disks (LUNs) on a NetApp SAN. NetApp recommends downloading and installing the latest utility kit. For Windows Host Utilities configuration information and instructions, see the Windows Host Utilities documentation and select the installation procedure for your Windows Host Utilities version.

Multipathing

You need to install the Microsoft Multipath I/O (MPIO) software and enable multipathing if your Windows host has more than one path to the storage system. When you select MPIO support, the Windows Host Utilities enables the MPIO feature included in Windows Server 2016. If you're not using the Windows Host Utilities, you need to enable multipathing manually.

The MPIO software presents a single disk to the Windows OS for all paths, and a device-specific module (DSM) manages path failover. On a Windows system, the two main components in any MPIO solution are the DSM and the Windows MPIO.

> ⚠ If you don't install the MPIO software, the Windows OS might see each path as a separate disk. This can lead to data corruption.

> ⓘ • For Windows Host Utilities 8.0, the MPIO feature is enabled automatically when you select MPIO support.
> • Windows XP or Windows Vista running in a Hyper-V virtual machine don't support MPIO.

SAN configuration

Depending on your SAN configuration, the host uses All SAN Array (ASA) or non-ASA configurations to access ONTAP LUNs. In both ASA and non-ASA configurations, you shouldn't require more than four paths to access a single ONTAP LUN. If you have more than four paths, it might cause issues with the paths during a storage failure.

All SAN array configuration

An ASA configuration should have one group of Active/Optimized paths with single priorities. This means the paths are serviced by the controller and the I/O is sent on all the active paths.

The following example displays the correct output for an ONTAP LUN with Active/Optimized paths.

Non-ASA configuration

A non-ASA configuration should have two groups of paths with different priorities. The paths with higher priorities are Active/Optimized. This means the Active/Optimized paths are serviced by the controller where the aggregate is located. The paths with lower priorities are active but non-optimized because they are served from a different controller. The non-optimized paths are only used when optimized paths aren't available.

The following example displays the correct output for an ONTAP LUN with two Active/Optimized paths and two Active/Non-Optimized paths.

Recommended settings

When you select MPIO on systems using FC, the Host Utilities installer sets the required timeout values for Emulex and QLogic FC HBAs.

Emulex FC

The timeout values for Emulex FC HBAs:

Property type	Property value
LinkTimeOut	1
NodeTimeOut	10

QLogic FC

The timeout values for QLogic FC HBAs:

Property type	Property value
LinkDownTimeOut	1
PortDownRetryCount	10

> **ⓘ** For more information on the recommended settings, see Configure registry settings for Windows Host Utilities.

Known issues

There are no known issues for the Windows Server 2016 with ONTAP release.

Use Windows Server 2012 R2 with ONTAP

You can use the ONTAP SAN host configuration settings to configure Windows server 2012 R2 for operation with ONTAP storage.

Boot the Windows OS

You can boot the Windows OS using a local boot or a SAN boot. NetApp recommends using a SAN boot if it is supported by your configuration.

Local boot

Perform a local boot by installing the Windows OS on the local hard disk (SSD, SATA, RAID, and so on).

SAN boot

If you choose to use SAN booting, it must be supported by your configuration.

> **ⓘ** You can use the configuration settings provided in this procedure to configure cloud clients connected to Cloud Volumes ONTAP and Amazon FSx for ONTAP.

Before you begin

Use the Interoperability Matrix Tool to verify that your Windows OS, host bus adapter (HBA), HBA firmware, HBA boot BIOS, and ONTAP version support SAN booting.

Steps

1. Map the SAN boot LUN to the host.

   See SAN storage management.

2. Verify that multiple paths are available.

   > **ⓘ** Multiple paths only become available after the host OS is up and running on the paths.

3. Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is mapped.

   For information on how to enable the HBA BIOS, see your vendor-specific documentation.

4. Reboot the host to verify the boot was successful

Install Windows hotfixes

NetApp recommends installing the **latest cumulative update** available from the Microsoft Update Catalog on the host server.

Steps

1. Download the hotfixes from the Microsoft Update Catalog 2012 R2.

    ℹ️ You need to contact Microsoft support for the hotfixes that aren't available for download from the Microsoft Update Catalog.

2. Follow the instructions provided by Microsoft to install the hotfixes.

    💡 Many hotfixes require a reboot of your Windows host. You can choose to wait to reboot the host until *after* you install or upgrade the Host Utilities.

Install the Windows Host Utilities

The Windows Host Utilities are a set of software programs with documentation that enables you to connect host computers to virtual disks (LUNs) on a NetApp SAN. NetApp recommends downloading and installing the latest utility kit. For Windows Host Utilities configuration information and instructions, see the Windows Host Utilities documentation and select the installation procedure for your Windows Host Utilities version.

Multipathing

You need to install the Microsoft Multipath I/O (MPIO) software and enable multipathing if your Windows host has more than one path to the storage system. When you select MPIO support, the Windows Host Utilities enables the MPIO feature included in Windows Server 2012 R2. If you're not using the Windows Host Utilities, you need to enable multipathing manually.

The MPIO software presents a single disk to the Windows OS for all paths, and a device-specific module (DSM) manages path failover. On a Windows system, the two main components in any MPIO solution are the DSM and the Windows MPIO.

⚠️ If you don't install the MPIO software, the Windows OS might see each path as a separate disk. This can lead to data corruption.

ℹ️
- For Windows Host Utilities 8.0, the MPIO feature is enabled automatically when you select MPIO support.
- Windows XP or Windows Vista running in a Hyper-V virtual machine don't support MPIO.

SAN configuration

Depending on your SAN configuration, the host uses All SAN Array (ASA) or non-ASA configurations to access ONTAP LUNs. In both ASA and non-ASA configurations, you shouldn't require more than four paths to access a single ONTAP LUN. If you have more than four paths, it might cause issues with the paths during a storage failure.

All SAN array configuration

An ASA configuration should have one group of Active/Optimized paths with single priorities. This means the paths are serviced by the controller and the I/O is sent on all the active paths.

The following example displays the correct output for an ONTAP LUN with Active/Optimized paths.

Non-ASA configuration

A non-ASA configuration should have two groups of paths with different priorities. The paths with higher priorities are Active/Optimized. This means the Active/Optimized paths are serviced by the controller where the aggregate is located. The paths with lower priorities are active but non-optimized because they are served from a different controller. The non-optimized paths are only used when optimized paths aren't available.

The following example displays the correct output for an ONTAP LUN with two Active/Optimized paths and two Active/Non-Optimized paths.

Hyper-V VHD requires alignment for best performance

If the data block boundaries of a disk partition don't align with the block boundaries of the underlying LUN, the storage system often has to complete two block reads or writes for every operating system block read or write. The additional block reads and writes caused by the misalignment might create serious performance problems.

The location of the starting sector for each partition defined by the master boot record causes misalignment.

> (i)   Partitions created by Windows Server 2016 should be aligned by default.

Use the `Get-NaVirtualDiskAlignment` cmdlet in the ONTAP PowerShell Toolkit to check whether partitions are aligned with underlying LUNs. If the partitions are incorrectly aligned, use the `Repair-NaVirtualDiskAlignment` cmdlet to create a new VHD file with the correct alignment. This cmdlet copies all of the partitions to the new file. The original VHD file is not modified or deleted. The virtual machine must be shut down while the data is copied.

You can download the ONTAP PowerShell Toolkit at NetApp Communities. You must unzip the `DataONTAP.zip` file into the location specified by the environment variable `%PSModulePath%` (or use the `Install.ps1` script to do it for you). After you have completed the installation, use the `Show-NaHelp` cmdlet to get help for the cmdlets.

The PowerShell Toolkit supports only fixed-size VHD files with MBR-type partitions. VHDs using Windows dynamic disks or GPT partitions aren't supported. In addition, the PowerShell Toolkit requires a minimum partition size of 4GB. Smaller partitions cannot be correctly aligned.

> ⓘ For Linux virtual machines using the GRUB boot loader on a VHD, you need to update the boot configuration after running the PowerShell Toolkit.

Reinstall GRUB for Linux guests after correcting MBR alignment with PowerShell Toolkit

After running `mbralign` on disks for correcting MBR alignment with PowerShell Toolkit on Linux guest operating systems using the GRUB boot loader, you must reinstall GRUB to ensure that the guest operating system boots correctly.

About this task

The PowerShell Toolkit cmdlet has completed on the VHD file for the virtual machine. This procedure applies only to Linux guest operating systems using the GRUB boot loader and `SystemRescueCd`.

Steps

1. Mount the ISO image of Disk 1 of the installation CDs for the correct version of Linux for the virtual machine.

2. Open the console for the virtual machine in Hyper-V Manager.

3. If the VM is running and frozen at the GRUB screen, click in the display area to make sure it is active, then select the **Ctrl-Alt-Delete** toolbar icon to reboot the VM. If the VM is not running, start it, and then immediately click in the display area to make sure it is active.

4. As soon as you see the VMware BIOS splash screen, press the **Esc** key once. The boot menu displays.

5. At the boot menu, select **CD-ROM**.

6. At the Linux boot screen, enter: `linux rescue`

7. Take the defaults for Anaconda (the blue/red configuration screens). Networking is optional.

8. Launch GRUB by entering: `grub`

9. If there is only one virtual disk in this VM, or if there are multiple disks and the first is the boot disk, run the following GRUB commands:

```
root (hd0,0)
setup (hd0)
quit
```

If you have multiple virtual disks in the VM, and the boot disk isn't the first disk, or you are fixing GRUB by booting from the misaligned backup VHD, enter the following command to identify the boot disk:

```
find /boot/grub/stage1
```

Then run the following commands:

```
root (boot_disk,0)
setup (boot_disk)
quit
```

> (i) In `setup (boot_disk)`, `boot_disk` is a placeholder for the actual disk identifier of the boot disk.

10. Press **Ctrl-D** to log out.

   Linux rescue shuts down and then reboots.

Recommended settings

When you select MPIO on systems using FC, the Host Utilities installer sets the required timeout values for Emulex and QLogic FC HBAs.

Emulex FC

The timeout values for Emulex FC HBAs:

Property type	Property value
LinkTimeOut	1
NodeTimeOut	10

QLogic FC

The timeout values for QLogic FC HBAs:

Property type	Property value
LinkDownTimeOut	1
PortDownRetryCount	10

> (i) For more information on the recommended settings, see Configure registry settings for Windows Host Utilities.

Known issues

There are no known issues for the Windows Server 2012 R2 with ONTAP release.