



Configure hosts with FCP and iSCSI

SAN hosts and cloud clients

NetApp
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Configure hosts with FCP and iSCSI

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, and then you verify the multipath settings for the NetApp ONTAP LUNs.

AIX and PowerVM/VIOS

Use IBM AIX 7.2 and/or PowerVM (VIOS 3.1) with ONTAP

You can use the ONTAP SAN host configuration settings to configure IBM AIX 7.2 and/or PowerVM (VIOS 3.1) with ONTAP as the target.

Install the AIX/VIOS host utilities

You must install the AIX Host Utilities Kit while using AIX MPIO with NetApp ONTAP storage.

You can download the compressed file containing the Host Utilities software packages from the [NetApp Support Site](#). After you have the file, you must decompress it to get the two software packages you need to install the host utilities.

NetApp AIX Host Utilities 6.1 is the latest release. This release addresses the memory leak issue that was reported in the previous releases. Refer to release notes section for additional information.

Steps

1. Login to your host.
 - On an AIX host, log in as **root**.
 - On a PowerVM host, log in as **padmin**, and then enter the `oem_setup_env` command to become root.
2. Download a copy of the compressed file containing the Host Utilities from NetApp Support Site to a directory on your host.
3. Go to the directory containing the download.
4. Uncompress the file and extract the SAN Toolkit software package.

```
tar -xvf ntap_aix_host_utilities_6.1.tar.gz
```

The following directory is created when you decompress the file: `ntap_aix_host_utilities_6.1`. This directory will have one of the following subdirectories: `MPIO`, `NON_MPIO`, or `SAN_Tool_Kit`.

5. Install the AIX MPIO:

```
installp -aXYd /var/tmp/ntap_aix_host_utilities_6.1/MPIO  
NetApp.MPIO_Host_Uilities_Kit
```

6. Install the SAN Toolkit:

```
installp -aXYd /var/tmp/ntap_aix_host_utilities_6.1/SAN_Tool_Kit  
NetApp.SAN_toolkit
```

7. Reboot the host.

SAN toolkit

The tool kit 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

controller(7mode) /          device      host      lun
vserver(Cmode)   lun-pathname filename  adapter  protocol  size
mode
-----
-----
data_vserver     /vol/vol1/lun1   hdisk0    fcs0     FCP       60g
C
data_vserver     /vol/vol2/lun2   hdisk0    fcs0     FCP       20g
C
data_vserver     /vol/vol3/lun3   hdisk11   fcs0     FCP       20g
C
data_vserver     /vol/vol4/lun4   hdisk14   fcs0     FCP       20g
C
```

SAN booting

What you'll need

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

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

Multipathing

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

For AIX, Path Control Module (PCM) is responsible for controlling multiple paths. PCM is a storage vendor supplied code that handles path management. This gets installed and enabled as part of the Host Utilities installation.

Non-ASA configurations

For non-ASA configurations, there should be two groups of paths with different priorities. The paths with the higher priorities are Active/Optimized, meaning they are serviced by the controller where the aggregate is located. The paths with the lower priorities are active but are non-optimized because they are served from a different controller. The non-optimized paths are only used when no optimized paths are available.

Example

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

```
# 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	host	vserver	AIX MPIO
path	path	MPIO	path	path	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

All SAN Array configurations

In All SAN Array (ASA) configurations, all paths to a given LUN are active and optimized. 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:



All SAN Arrays (ASA) configurations are supported beginning in ONTAP 9.8 for AIX Hosts.

```
# 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    vservers  AIX      host    vservers  AIX MPIO
path    path      MPIO     path    path      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
```

Recommended Settings

Following are some recommended parameter settings for ONTAP LUNs. The critical parameters for ONTAP LUNs are set automatically after installing the NetApp Host Utilities Kit.

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
rw_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

Parameter	Environment	Value for AIX	Note
num_cmd_elems	MPIO / non-MPIO	1024 for AIX	FC EN0G

Recommended settings for MetroCluster

By default, the AIX operating system enforces a shorter I/O timeout when no paths to a LUN are available. This might occur in configurations including single-switch SAN fabric and MetroCluster configurations that experience unplanned failovers. For additional information and recommended changes to default settings, refer to [NetApp KB1001318](#)

AIX support with SM-BC

Beginning with ONTAP 9.11.1, AIX is supported with SM-BC. With an AIX configuration, the primary cluster is the "active" cluster.

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

To configure AIX for SM-BC, refer to the Knowledge Base article [How to configure an AIX host for SnapMirror Business Continuity \(SM-BC\)](#).

Known issues

The IBM AIX 7.2 and/or PowerVM (VIOS 3.1) with ONTAP 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 <code>rw_timeout</code> 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 <code>rw_timeout</code> value using the <code>chdev</code> command.	NA

NetApp Bug ID	Title	Description	Partner ID
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 <code>rw_timeout</code> 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	Seeing I/O issues on VIOS 3.1.1.10 during SFO faults and straight I/O	On VIOS 3.1.1 IO failures may be seen on NPIV client disk which are backed by 16/32Gb FC adapters. Also, a <code>vfchost</code> driver may get into a state where it stops processing I/O requests from the client. Applying IBM APAR IJ22290 IBM APAR IJ23222 will fix the issue.	NA

Use IBM AIX 7.1 with ONTAP

You can use the ONTAP SAN host configuration settings to configure IBM AIX 7.1 with ONTAP as the target.

Install the AIX Host Utilities

You must install the AIX Host Utilities Kit while using AIX MPIO with NetApp ONTAP storage.

You can download the compressed file containing the Host Utilities software packages from the [NetApp Support Site](#). After you have the file, you must extract it to get the two software packages you need to install the Host Utilities.

Steps

1. Login to your host.
 - On an AIX host, log in as **root**.
2. Download a copy of the compressed file containing the Host Utilities from NetApp Support Site to a directory on your host.
3. Go to the directory containing the download.
4. Decompress the file and extract the SAN Toolkit software package.


```
tar -xvf ntap_aix_host_utilities_6.1.tar.tgz
```

The following directory is created when you decompress the file: `ntap_aix_host_utilities_6.1`. This directory will have one of the following subdirectories: `MPIO`, `NON_MPIO`, or `SAN_Tool_Kit`.

5. Install the AIX MPIO:

```
installp -aXYd /var/tmp/ntap_aix_host_utilities_6.1/MPIO  
NetApp.MPIO_Host_Utility_Kit
```

6. Install the SAN Toolkit:

```
installp -aXYd /var/tmp/ntap_aix_host_utilities_6.1/SAN_Tool_Kit  
NetApp.SAN_toolkit
```

7. Reboot the host.

SAN Toolkit

The tool kit 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
```

controller(7mode) / vserver(Cmode) mode	lun-pathname	device filename	host adapter	lun protocol	size
data_vserver C	/vol/vol1/lun1	hdisk0	fcs0	FCP	60g
data_vserver C	/vol/vol2/lun2	hdisk0	fcs0	FCP	20g
data_vserver C	/vol/vol3/lun3	hdisk11	fcs0	FCP	20g
data_vserver C	/vol/vol4/lun4	hdisk14	fcs0	FCP	20g

SAN Booting

What you'll need

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

SAN booting is the process of setting up a SAN-attached disk (a LUN) as a boot device for an AIX host. You can set up a SAN boot LUN to work in an AIX MPIO environment that is running the AIX Host Utilities with

either the FC or FCoE protocol. The method you use for creating a SAN boot LUN and installing a new OS image on it in an AIX MPIO environment can vary, depending on which protocol you are using.

Multipathing

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

For AIX, Path Control Module (PCM) is responsible for controlling multiple paths. PCM is a storage vendor-supplied code that handles path management. This gets installed and enabled as part of the Host Utilities installation.

Non-ASA configurations

For non-ASA configurations, there should be two groups of paths with different priorities. The paths with the higher priorities are Active/Optimized, meaning they are serviced by the controller where the aggregate is located. The paths with the lower priorities are active but are non-optimized because they are served from a different controller. The non-optimized paths are only used when no optimized paths are available.

Example

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

```
# 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	host	vserver	AIX MPIO
path	path	MPIO	path	path	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

All SAN Array configurations

In All SAN Array (ASA) configurations, all paths to a given LUN are active and optimized. 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:



All SAN Arrays (ASA) configurations are supported beginning in ONTAP 9.8 for AIX Hosts.

```
# 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	host	vserver	AIX MPIO
path	path	MPIO	path	path	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

Recommended Settings

Following are some recommended parameter settings for ONTAP LUNs. The critical parameters for ONTAP LUNs are set automatically after installing the NetApp Host Utilities Kit.

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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

Parameter	Environment	Value for AIX	Note
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

Recommended Settings for MetroCluster

By default, the AIX operating system enforces a shorter I/O timeout when no paths to a LUN are available. This might occur in configurations including single-switch SAN fabric and MetroCluster configurations that experience unplanned failovers. For additional information and recommended changes to default settings, refer to [NetApp KB1001318](#)

AIX support with SM-BC

Beginning with ONTAP 9.11.1, AIX is supported with SM-BC. With an AIX configuration, the primary cluster is the "active" cluster.

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

To configure AIX for SM-BC, refer to the Knowledge Base article [How to configure an AIX host for SnapMirror Business Continuity \(SM-BC\)](#).

Known issues

There are no known issues.

CentOS

Release notes

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 does not 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 8

Use CentOS 8.5 with ONTAP

You can use the ONTAP SAN host configuration settings to configure CentOS 8.5 with ONTAP as the target.

Install the Linux Unified Host Utilities

The NetApp Linux Unified Host Utilities software package is available on the [NetApp Support Site](#) in a 64-bit .rpm file.

NetApp strongly recommends installing the Linux Unified 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.

What you'll need

If you have a version of Linux Unified Host Utilities currently installed, you should upgrade or remove it, and then use the following steps to install the latest version.

Steps

1. Download the 64-bit Linux Unified 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 document 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) / vserver(cDOT/FlashRay) Product	lun-pathname	device filename	host adapter	lun protocol	size
data_vserver 120.0g cDOT	/vol/vol1/lun1	/dev/sdb	host16	FCP	
data_vserver 120.0g cDOT	/vol/vol1/lun1	/dev/sdc	host15	FCP	
data_vserver 120.0g cDOT	/vol/vol2/lun2	/dev/sdd	host16	FCP	
data_vserver 120.0g cDOT	/vol/vol2/lun2	/dev/sde	host15	FCP	

SAN Booting

What you'll need

If you decide to use SAN booting, it must be supported by your configuration. You can use the [NetApp 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 is successful.

Multipathing

For CentOS 8.5 the `/etc/multipath.conf` file must exist, but you do not need to make specific changes to the file. CentOS 8.5 is compiled with all settings required to recognize and correctly manage ONTAP LUNs.

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

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

All SAN Array configurations

In All SAN Array (ASA) configurations, all paths to a given LUN are active and optimized. 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
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
```



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight 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 the higher priorities are Active/Optimized, meaning they are serviced by the controller where the aggregate is located. The paths with the lower priorities are active but are non-optimized because they are served from a different controller. The non-optimized paths are only used when no optimized paths are 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
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
```



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight paths might cause path issues during storage failures.

Recommended Settings

CentOS 8.5 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, but you can create an empty, zero-byte file by using the following command:

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

The first time you create this file, you might need to enable and start the multipath services:

```
# systemctl enable multipathd
# systemctl start multipathd
```

- There is no requirement to add anything directly to the `multipath.conf` file, unless you have devices that you do not want to be managed by multipath or you have existing settings that override defaults.
- To exclude unwanted devices, add the following syntax to the `multipath.conf` file .

```

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

```

Replace the <DevId> with the WWID string of the device you want to exclude.

Example

In this example, we are going to determine the WWID of a device and add to the `multipath.conf` file.

Steps

1. Run the following command to determine the WWID:

```

# /lib/udev/scsi_id -gud /dev/sda
360030057024d0730239134810c0cb833

```

`sda` is the local SCSI disk that we need to add it to the blacklist.

2. Add the 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 for legacy settings, especially in the defaults section, that might be overriding the 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 will need to be corrected by later stanzas in the `multipath.conf` file that apply specifically to ONTAP LUNs. If this is not done, the ONTAP LUNs might not work as expected. These defaults should only be overridden in consultation with NetApp and/or an OS vendor and only when the impact is fully understood.

Parameter	Setting
<code>detect_prio</code>	<code>yes</code>
<code>dev_loss_tmo</code>	<code>"infinity"</code>
<code>failback</code>	<code>immediate</code>
<code>fast_io_fail_tmo</code>	<code>5</code>

Parameter	Setting
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

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
    }
}
```

KVM settings

You can use the recommended settings to configure Kernel-based Virtual Machine (KVM) as well. There are no changes required to configure KVM as the LUN is mapped to the hypervisor.

Known issues

There are no known issues for the CentOS 8.5 with ONTAP release.

Use CentOS 8.4 with ONTAP

You can use the ONTAP SAN host configuration settings to configure CentOS 8.4 with ONTAP as the target.

Install the Linux Unified Host Utilities

The NetApp Linux Unified Host Utilities software package is available on the [NetApp Support Site](#) in a 64-bit .rpm file.

NetApp strongly recommends installing the Linux Unified 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.

What you'll need

If you have a version of Linux Unified Host Utilities currently installed, you should upgrade or remove it, and then use the following steps to install the latest version.

Steps

1. Download the 64-bit Linux Unified 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 document 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) / vserver (cDOT/FlashRay) Product	lun-pathname	device filename	host adapter	protocol	lun size
data_vserver 120.0g cDOT	/vol/vol1/lun1	/dev/sdb	host16	FCP	
data_vserver 120.0g cDOT	/vol/vol1/lun1	/dev/sdc	host15	FCP	
data_vserver 120.0g cDOT	/vol/vol2/lun2	/dev/sdd	host16	FCP	
data_vserver 120.0g cDOT	/vol/vol2/lun2	/dev/sde	host15	FCP	

SAN Booting

What you'll need

If you decide to use SAN booting, it must be supported by your configuration. You can use the [NetApp 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 is successful.

Multipathing

For CentOS 8.4 the `/etc/multipath.conf` file must exist, but you do not need to make specific changes to the file. CentOS 8.4 is compiled with all settings required to recognize and correctly manage ONTAP LUNs.

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

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

All SAN Array configurations

In All SAN Array (ASA) configurations, all paths to a given LUN are active and optimized. 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
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
```



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight 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 the higher priorities are Active/Optimized, meaning they are serviced by the controller where the aggregate is located. The paths with the lower priorities are active but are non-optimized because they are served from a different controller. The non-optimized paths are only used when no optimized paths are 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
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
```



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight paths might cause path issues during storage failures.

Recommended Settings

CentOS 8.4 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, but you can create an empty, zero-byte file by using the following command:

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

The first time you create this file, you might need to enable and start the multipath services:

```
# systemctl enable multipathd
# systemctl start multipathd
```

- There is no requirement to add anything directly to the `multipath.conf` file, unless you have devices that you do not want to be managed by multipath or you have existing settings that override defaults.
- To exclude unwanted devices, add the following syntax to the `multipath.conf` file .

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

Replace the `<DevId>` with the WWID string of the device you want to exclude.

Example

In this example, we are going to determine the WWID of a device and add to the `multipath.conf` file.

Steps

1. Run the following command to determine the WWID:

```
# /lib/udev/scsi_id -gud /dev/sda
360030057024d0730239134810c0cb833
```

`sda` is the local SCSI disk that we need to add it to the blacklist.

2. Add the 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 for legacy settings, especially in the defaults section, that might be overriding the 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 will need to be corrected by later stanzas in the `multipath.conf` file that apply specifically to ONTAP LUNs. If this is not done, the ONTAP LUNs might not work as expected. These defaults should only be overridden in consultation with NetApp and/or an OS vendor and only when the impact is fully understood.

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

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
    }
}

```

KVM settings

You can use the recommended settings to configure Kernel-based Virtual Machine (KVM) as well. There are no changes required to configure KVM as the LUN is mapped to the hypervisor.

Known issues

There are no known issues for the CentOS 8.4 with ONTAP release.

Use CentOS 8.3 with ONTAP

You can use the ONTAP SAN host configuration settings to configure CentOS 8.3 with ONTAP as the target.

Install the Linux Unified Host Utilities

The NetApp Linux Unified Host Utilities software package is available on the [NetApp Support Site](#) in a 64-bit .rpm file.

NetApp strongly recommends installing the Linux Unified 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.

What you'll need

If you have a version of Linux Unified Host Utilities currently installed, you should upgrade or remove it, and then use the following steps to install the latest version.

Steps

1. Download the 64-bit Linux Unified 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 document 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

What you'll need

If you decide to use SAN booting, it must be supported by your configuration. You can use the [NetApp 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 is successful.

Multipathing

For CentOS 8.3 the `/etc/multipath.conf` file must exist, but you do not need to make specific changes to the file. CentOS 8.3 is compiled with all settings required to recognize and correctly manage ONTAP LUNs.

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

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

All SAN Array configurations

In All SAN Array (ASA) configurations, all paths to a given LUN are active and optimized. 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
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
```



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight 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 the higher priorities are Active/Optimized, meaning they are serviced by the controller where the aggregate is located. The paths with the lower priorities are active but are non-optimized because they are served from a different controller. The non-optimized paths are only used when no optimized paths are 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
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
```



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight paths might cause path issues during storage failures.

Recommended Settings

The CentOS 8.3 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, but you can create an empty, zero-byte file by using the following command:

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

The first time you create this file, you might need to enable and start the multipath services:

```
# systemctl enable multipathd
# systemctl start multipathd
```

- There is no requirement to add anything directly to the `multipath.conf` file, unless you have devices that you do not want to be managed by multipath or you have existing settings that override defaults.
- To exclude unwanted devices, add the following syntax to the `multipath.conf` file .

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

Replace the `<DevId>` with the WWID string of the device you want to exclude.

Example

In this example, we are going to determine the WWID of a device and add to the `multipath.conf` file.

Steps

1. Run the following command to determine the WWID:

```
# /lib/udev/scsi_id -gud /dev/sda
360030057024d0730239134810c0cb833
```

sda is the local SCSI disk that we need to add it to the blacklist.

2. Add the 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 for legacy settings, especially in the defaults section, that might be overriding the 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 will need to be corrected by later stanzas in the `multipath.conf` file that apply specifically to ONTAP LUNs. If this is not done, the ONTAP LUNs might not work as expected. These defaults should only be overridden in consultation with NetApp and/or an OS vendor 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	"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.*

Parameter	Setting
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
    }
}
```

KVM settings

You can use the recommended settings to configure Kernel-based Virtual Machine (KVM) as well. There are no changes required to configure KVM as the LUN is mapped to the hypervisor.

Known issues

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

Use CentOS 8.2 with ONTAP

You can use the ONTAP SAN host configuration settings to configure CentOS 8.2 with ONTAP as the target.

Install the Linux Unified Host Utilities

The NetApp Linux Unified Host Utilities software package is available on the [NetApp Support Site](#) in a 64-bit .rpm file.

NetApp strongly recommends installing the Linux Unified 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.

What you'll need

If you have a version of Linux Unified Host Utilities currently installed, you should upgrade or remove it, and then use the following steps to install the latest version.

Steps

1. Download the 64-bit Linux Unified 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 document 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

What you'll need

If you decide to use SAN booting, it must be supported by your configuration. You can use the [NetApp](#)

[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 is successful.

Multipathing

For CentOS 8.2 the `/etc/multipath.conf` file must exist, but you do not need to make specific changes to the file. CentOS 8.2 is compiled with all settings required to recognize and correctly manage ONTAP LUNs.

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 the higher priorities are Active/Optimized, which means they are serviced by the controller where the aggregate is located. The paths with the lower priorities are active but are non-optimized because they are served from a different controller. The non-optimized paths are only used when no optimized paths are 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
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
```



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight paths might cause path issues during storage failures.

Recommended Settings

The CentOS 8.2 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, but you can create an empty, zero-byte file by using the following command:

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

The first time you create this file, you might need to enable and start the multipath services:

```
# systemctl enable multipathd
# systemctl start multipathd
```

- There is no requirement to add anything directly to the `multipath.conf` file, unless you have devices that you do not want to be managed by multipath or you have existing settings that override defaults.
- To exclude unwanted devices, add the following syntax to the `multipath.conf` file .

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

Replace the `<DevId>` with the WWID string of the device you want to exclude.

Example

In this example, we are going to determine the WWID of a device and add to the `multipath.conf` file.

Steps

1. Run the following command to determine the WWID:

```
# /lib/udev/scsi_id -gud /dev/sda
360030057024d0730239134810c0cb833
```

`sda` is the local SCSI disk that we need to add it to the blacklist.

2. Add the 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 for legacy settings, especially in the defaults section, that might be overriding the 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 will need to be corrected by later stanzas in the `multipath.conf` file that apply specifically to ONTAP LUNs. If this is not done, the ONTAP LUNs might not work as expected. These defaults should only be overridden in consultation with NetApp and/or an OS vendor and only when the impact is fully understood.

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

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
    }
}

```

KVM settings

You can use the recommended settings to configure Kernel-based Virtual Machine (KVM) as well. There are no changes required to configure KVM as the LUN is mapped to the hypervisor.

Known issues

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

Use CentOS 8.1 with ONTAP

You can use the ONTAP SAN host configuration settings to configure CentOS 8.1 with ONTAP as the target.

Install the Linux Unified Host Utilities

The NetApp Linux Unified Host Utilities software package is available on the [NetApp Support Site](#) in a 64-bit .rpm file.

NetApp strongly recommends installing the Linux Unified 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.

What you'll need

If you have a version of Linux Unified Host Utilities currently installed, you should upgrade or remove it, and then use the following steps to install the latest version.

Steps

1. Download the 64-bit Linux Unified 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 document 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

What you'll need

If you decide to use SAN booting, it must be supported by your configuration. You can use the [NetApp 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 is successful.

Multipathing

For CentOS 8.1 the `/etc/multipath.conf` file must exist, but you do not need to make specific changes to the file. CentOS 8.1 is compiled with all settings required to recognize and correctly manage ONTAP LUNs.

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

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

All SAN Array configurations

In All SAN Array (ASA) configurations, all paths to a given LUN are active and optimized. 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
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
```



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight 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 the higher priorities are Active/Optimized, meaning they are serviced by the controller where the aggregate is located. The paths with the lower priorities are active but are non-optimized because they are served from a different controller. The non-optimized paths are only used when no optimized paths are 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
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
| |- 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
```



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight paths might cause path issues during storage failures.

Recommended Settings

The CentOS 8.1 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, but you can create an empty, zero-byte file by using the following command:

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

The first time you create this file, you might need to enable and start the multipath services:

```
# systemctl enable multipathd
# systemctl start multipathd
```

- There is no requirement to add anything directly to the `multipath.conf` file, unless you have devices that you do not want to be managed by multipath or you have existing settings that override defaults.
- To exclude unwanted devices, add the following syntax to the `multipath.conf` file .

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

Replace the `<DevId>` with the WWID string of the device you want to exclude.

Example

In this example, we are going to determine the WWID of a device and add to the `multipath.conf` file.

Steps

1. Run the following command to determine the WWID:

```
# /lib/udev/scsi_id -gud /dev/sda
360030057024d0730239134810c0cb833
```

sda is the local SCSI disk that we need to add it to the blacklist.

2. Add the 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 for legacy settings, especially in the defaults section, that might be overriding the 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 will need to be corrected by later stanzas in the `multipath.conf` file that apply specifically to ONTAP LUNs. If this is not done, the ONTAP LUNs might not work as expected. These defaults should only be overridden in consultation with NetApp and/or an OS vendor 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	"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.*

Parameter	Setting
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
    }
}
```

KVM settings

You can use the recommended settings to configure Kernel-based Virtual Machine (KVM) as well. There are no changes required to configure KVM as the LUN is mapped to the hypervisor.

Known issues

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

Use CentOS 8.0 with ONTAP

You can use the ONTAP SAN host configuration settings to configure CentOS 8.0 with ONTAP as the target.

Install the Linux Unified Host Utilities

The NetApp Linux Unified Host Utilities software package is available on the [NetApp Support Site](#) in a 64-bit .rpm file.

NetApp strongly recommends installing the Linux Unified 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.

What you'll need

If you have a version of Linux Unified Host Utilities currently installed, you should upgrade or remove it, and then use the following steps to install the latest version.

Steps

1. Download the 64-bit Linux Unified 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 document 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

What you'll need

If you decide to use SAN booting, it must be supported by your configuration. You can use the [NetApp](#)

[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 is successful.

Multipathing

For CentOS 8.0 the `/etc/multipath.conf` file must exist, but you do not need to make specific changes to the file. CentOS 8.0 is compiled with all settings required to recognize and correctly manage ONTAP LUNs.

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

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

All SAN Array configurations

In All SAN Array (ASA) configurations, all paths to a given LUN are active and optimized. 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
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
```



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight 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 the higher priorities are Active/Optimized, meaning they are serviced by the controller where the aggregate is located. The paths with the lower priorities are active but are non-optimized because they are served from a different controller. The non-optimized paths are only used when no optimized paths are 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
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
```



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight paths might cause path issues during storage failures.

Recommended Settings

The CentOS 8.0 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, but you can create an empty, zero-byte file by using the following command:

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

The first time you create this file, you might need to enable and start the multipath services:

```
# systemctl enable multipathd
# systemctl start multipathd
```

- There is no requirement to add anything directly to the `multipath.conf` file, unless you have devices that you do not want to be managed by multipath or you have existing settings that override defaults.
- To exclude unwanted devices, add the following syntax to the `multipath.conf` file .

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

Replace the `<DevId>` with the WWID string of the device you want to exclude.

Example

In this example, we are going to determine the WWID of a device and add to the `multipath.conf` file.

Steps

1. Run the following command to determine the WWID:

```
# /lib/udev/scsi_id -gud /dev/sda
360030057024d0730239134810c0cb833
```

`sda` is the local SCSI disk that we need to add it to the blacklist.

2. Add the 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 for legacy settings, especially in the defaults section, that might be overriding the 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 will need to be corrected by later stanzas in the `multipath.conf` file that apply specifically to ONTAP LUNs. If this is not done, the ONTAP LUNs might not work as expected. These defaults should only be overridden in consultation with NetApp and/or an OS vendor and only when the impact is fully understood.

Parameter	Setting
<code>detect_prio</code>	<code>yes</code>
<code>dev_loss_tmo</code>	<code>"infinity"</code>
<code>failback</code>	<code>immediate</code>
<code>fast_io_fail_tmo</code>	<code>5</code>
<code>features</code>	<code>"2 pg_init_retries 50"</code>
<code>flush_on_last_del</code>	<code>"yes"</code>
<code>hardware_handler</code>	<code>"0"</code>
<code>no_path_retry</code>	<code>queue</code>
<code>path_checker</code>	<code>"tur"</code>
<code>path_grouping_policy</code>	<code>"group_by_prio"</code>
<code>path_selector</code>	<code>"service-time 0"</code>
<code>polling_interval</code>	<code>5</code>

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 `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
    }
}
```

KVM settings

You can use the recommended settings to configure Kernel-based Virtual Machine (KVM) as well. There are no changes required to configure KVM as the LUN is mapped to the hypervisor.

Known issues

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

CentOS 7

Use CentOS 7.9 with ONTAP

You can use the ONTAP SAN host configuration settings to configure CentOS 7.9 with ONTAP as the target.

Install the Linux Unified Host Utilities

The NetApp Linux Unified Host Utilities software package is available on the [NetApp Support Site](#) in a 32-bit and 64-bit .rpm file. If you do not know which file is right for your configuration, use the [NetApp Interoperability Matrix Tool](#) to verify which one you need.

NetApp strongly recommends installing the Linux Unified 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.

What you'll need

If you have a version of Linux Unified Host Utilities currently installed you should upgrade it or, you should remove it and use the following steps to install the latest version.

1. Download the 32-bit or 64-bit Linux Unified Host Utilities software package from the [NetApp Support Site](#) to your host.
2. Use the following command to install the software package:

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



You can use the configuration settings provided in this document 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) / vserver (cDOT/FlashRay) Product	lun-pathname	device filename	host adapter	protocol	lun size
data_vserver 120.0g cDOT	/vol/vol1/lun1	/dev/sdb	host16	FCP	
data_vserver 120.0g cDOT	/vol/vol1/lun1	/dev/sdc	host15	FCP	
data_vserver 120.0g cDOT	/vol/vol2/lun2	/dev/sdd	host16	FCP	
data_vserver 120.0g cDOT	/vol/vol2/lun2	/dev/sde	host15	FCP	

SAN Booting

What you'll need

If you decide to use SAN booting, it must be supported by your configuration. You can use the [NetApp 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 is successful.

Multipathing

For CentOS 7.9 the `/etc/multipath.conf` file must exist, but you do not need to make specific changes to the file. CentOS 7.9 is compiled with all settings required to recognize and correctly manage ONTAP LUNs.

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

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

All SAN Array configurations

In All SAN Array (ASA) configurations, all paths to a given LUN are active and optimized. 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
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='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
```



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight 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 the higher priorities are Active/Optimized, meaning they are serviced by the controller where the aggregate is located. The paths with the lower priorities are active but are non-optimized because they are served from a different controller. The non-optimized paths are only used when no optimized paths are 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='service-time 0' prio=50 status=active
| |- 11:0:1:0 sdj 8:144 active ready running
| |- 11:0:2:0 sdr 65:16 active ready running
`-+- policy='service-time 0' prio=10 status=enabled
|- 11:0:0:0 sdb 8:i6 active ready running
|- 12:0:0:0 sdz 65:144 active ready running
```



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight paths might cause path issues during storage failures.

Recommended Settings

The CentOS 7.9 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, but you can create an empty, zero-byte file by using the following command:

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

The first time you create this file, you might need to enable and start the multipath services:

```
# systemctl enable multipathd
# systemctl start multipathd
```

- There is no requirement to add anything directly to the `multipath.conf` file, unless you have devices that you do not want to be managed by multipath or you have existing settings that override defaults.
- To exclude unwanted devices, add the following syntax to the `multipath.conf` file .

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

Replace the `<DevId>` with the WWID string of the device you want to exclude.

Example

In this example, we are going to determine the WWID of a device and add to the `multipath.conf` file.

Steps

1. Run the following command to determine the WWID:

```
# /lib/udev/scsi_id -gud /dev/sda
360030057024d0730239134810c0cb833
```

`sda` is the local SCSI disk that we need to add it to the blacklist.

2. Add the 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 for legacy settings, especially in the defaults section, that might be overriding the 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

will need to be corrected by later stanzas in the `multipath.conf` file that apply specifically to ONTAP LUNs. If this is not done, the ONTAP LUNs might not work as expected. These defaults should only be overridden in consultation with NetApp and/or an OS vendor 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	"service-time 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
    }
}

```

KVM settings

You can use the recommended settings to configure Kernel-based Virtual Machine (KVM) as well. There are no changes required to configure KVM as the LUN is mapped to the hypervisor.

Known issues

The CentOS 7.9 with ONTAP release has the following known issues:

NetApp Bug ID	Title	Description	Bugzilla ID
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.	N/A

Use CentOS 7.8 with ONTAP

You can use the ONTAP SAN host configuration settings to configure CentOS 7.8 with ONTAP as the target.

Install the Linux Unified Host Utilities

The NetApp Linux Unified Host Utilities software package is available on the [NetApp Support Site](#) in a 32-bit and 64-bit .rpm file. If you do not know which file is right for your configuration, use the [NetApp Interoperability Matrix Tool](#) to verify which one you need.

NetApp strongly recommends installing the Linux Unified 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.

What you'll need

If you have a version of Linux Unified Host Utilities currently installed you should upgrade it or, you should remove it and use the following steps to install the latest version.

1. Download the 32-bit or 64-bit Linux Unified Host Utilities software package from the [NetApp Support Site](#) to your host.
2. Use the following command to install the software package:

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



You can use the configuration settings provided in this document 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) / vserver (cDOT/FlashRay) Product	lun-pathname	device filename	host adapter	protocol	lun size
data_vserver 120.0g cDOT	/vol/vol1/lun1	/dev/sdb	host16	FCP	
data_vserver 120.0g cDOT	/vol/vol1/lun1	/dev/sdc	host15	FCP	
data_vserver 120.0g cDOT	/vol/vol2/lun2	/dev/sdd	host16	FCP	
data_vserver 120.0g cDOT	/vol/vol2/lun2	/dev/sde	host15	FCP	

SAN Booting

What you'll need

If you decide to use SAN booting, it must be supported by your configuration. You can use the [NetApp 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 is successful.

Multipathing

For CentOS 7.8 the `/etc/multipath.conf` file must exist, but you do not need to make specific changes to the file. CentOS 7.8 is compiled with all settings required to recognize and correctly manage ONTAP LUNs.

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

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

All SAN Array configurations

In All SAN Array (ASA) configurations, all paths to a given LUN are active and optimized. 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
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='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
```



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight 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 the higher priorities are Active/Optimized, meaning they are serviced by the controller where the aggregate is located. The paths with the lower priorities are active but are non-optimized because they are served from a different controller. The non-optimized paths are only used when no optimized paths are 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='service-time 0' prio=50 status=active
| |- 11:0:1:0 sdj 8:144 active ready running
| |- 11:0:2:0 sdr 65:16 active ready running
`-+- policy='service-time 0' prio=10 status=enabled
|- 11:0:0:0 sdb 8:i6 active ready running
|- 12:0:0:0 sdz 65:144 active ready running
```



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight paths might cause path issues during storage failures.

Recommended Settings

The CentOS 7.8 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, but you can create an empty, zero-byte file by using the following command:

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

The first time you create this file, you might need to enable and start the multipath services:

```
# systemctl enable multipathd
# systemctl start multipathd
```

- There is no requirement to add anything directly to the `multipath.conf` file, unless you have devices that you do not want to be managed by multipath or you have existing settings that override defaults.
- To exclude unwanted devices, add the following syntax to the `multipath.conf` file .

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

Replace the `<DevId>` with the WWID string of the device you want to exclude.

Example

In this example, we are going to determine the WWID of a device and add to the `multipath.conf` file.

Steps

1. Run the following command to determine the WWID:

```
# /lib/udev/scsi_id -gud /dev/sda
360030057024d0730239134810c0cb833
```

`sda` is the local SCSI disk that we need to add it to the blacklist.

2. Add the 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 for legacy settings, especially in the defaults section, that might be overriding the 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

will need to be corrected by later stanzas in the `multipath.conf` file that apply specifically to ONTAP LUNs. If this is not done, the ONTAP LUNs might not work as expected. These defaults should only be overridden in consultation with NetApp and/or an OS vendor and only when the impact is fully understood.

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

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
    }
}

```

KVM settings

You can use the recommended settings to configure Kernel-based Virtual Machine (KVM) as well. There are no changes required to configure KVM as the LUN is mapped to the hypervisor.

Known issues

The CentOS 7.8 with ONTAP release has the following known issues:

NetApp Bug ID	Title	Description	Bugzilla ID
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.	N/A

Use CentOS 7.7 with ONTAP

You can use the ONTAP SAN host configuration settings to configure CentOS 7.7 with ONTAP as the target.

Install the Linux Unified Host Utilities

The NetApp Linux Unified Host Utilities software package is available on the [NetApp Support Site](#) in a 32-bit and 64-bit .rpm file. If you do not know which file is right for your configuration, use the [NetApp Interoperability Matrix Tool](#) to verify which one you need.

NetApp strongly recommends installing the Linux Unified 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.

What you'll need

If you have a version of Linux Unified Host Utilities currently installed you should upgrade it or, you should remove it and use the following steps to install the latest version.

1. Download the 32-bit or 64-bit Linux Unified Host Utilities software package from the [NetApp Support Site](#) to your host.
2. Use the following command to install the software package:

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



You can use the configuration settings provided in this document 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) / vserver (cDOT/FlashRay) Product	lun-pathname	device filename	host adapter	protocol	lun size
data_vserver 120.0g cDOT	/vol/vol1/lun1	/dev/sdb	host16	FCP	
data_vserver 120.0g cDOT	/vol/vol1/lun1	/dev/sdc	host15	FCP	
data_vserver 120.0g cDOT	/vol/vol2/lun2	/dev/sdd	host16	FCP	
data_vserver 120.0g cDOT	/vol/vol2/lun2	/dev/sde	host15	FCP	

SAN Booting

What you'll need

If you decide to use SAN booting, it must be supported by your configuration. You can use the [NetApp 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 is successful.

Multipathing

For CentOS 7.7 the `/etc/multipath.conf` file must exist, but you do not need to make specific changes to the file. CentOS 7.7 is compiled with all settings required to recognize and correctly manage ONTAP LUNs.

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

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

All SAN Array configurations

In All SAN Array (ASA) configurations, all paths to a given LUN are active and optimized. 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
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='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
```



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight 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 the higher priorities are Active/Optimized, meaning they are serviced by the controller where the aggregate is located. The paths with the lower priorities are active but are non-optimized because they are served from a different controller. The non-optimized paths are only used when no optimized paths are 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='service-time 0' prio=50 status=active
| |- 11:0:1:0 sdj    8:144   active ready running
| |- 11:0:2:0 sdr    65:16   active ready running
`-+- policy='service-time 0' prio=10 status=enabled
  |- 11:0:0:0 sdb    8:i6    active ready running
  |- 12:0:0:0 sdz    65:144  active ready running
```



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight paths might cause path issues during storage failures.

Recommended Settings

The CentOS 7.7 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, but you can create an empty, zero-byte file by using the following command:

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

The first time you create this file, you might need to enable and start the multipath services:

```
# systemctl enable multipathd
# systemctl start multipathd
```

- There is no requirement to add anything directly to the `multipath.conf` file, unless you have devices that you do not want to be managed by multipath or you have existing settings that override defaults.
- To exclude unwanted devices, add the following syntax to the `multipath.conf` file .

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

Replace the `<DevId>` with the WWID string of the device you want to exclude.

Example

In this example, we are going to determine the WWID of a device and add to the `multipath.conf` file.

Steps

1. Run the following command to determine the WWID:

```
# /lib/udev/scsi_id -gud /dev/sda
360030057024d0730239134810c0cb833
```

`sda` is the local SCSI disk that we need to add it to the blacklist.

2. Add the 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 for legacy settings, especially in the defaults section, that might be overriding the 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

will need to be corrected by later stanzas in the `multipath.conf` file that apply specifically to ONTAP LUNs. If this is not done, the ONTAP LUNs might not work as expected. These defaults should only be overridden in consultation with NetApp and/or an OS vendor 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	"service-time 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
    }
}

```

KVM settings

You can use the recommended settings to configure Kernel-based Virtual Machine (KVM) as well. There are no changes required to configure KVM as the LUN is mapped to the hypervisor.

Known issues

The CentOS 7.7 with ONTAP release has the following known issues:

NetApp Bug ID	Title	Description	Bugzilla ID
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.	N/A

Use CentOS 7.6 with ONTAP

You can use the ONTAP SAN host configuration settings to configure CentOS 7.6 with ONTAP as the target.

Install the Linux Unified Host Utilities

The NetApp Linux Unified Host Utilities software package is available on the [NetApp Support Site](#) in a 32-bit and 64-bit .rpm file. If you do not know which file is right for your configuration, use the [NetApp Interoperability Matrix Tool](#) to verify which one you need.

NetApp strongly recommends installing the Linux Unified 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.

What you'll need

If you have a version of Linux Unified Host Utilities currently installed you should upgrade it or, you should remove it and use the following steps to install the latest version.

1. Download the 32-bit or 64-bit Linux Unified Host Utilities software package from the [NetApp Support Site](#) to your host.
2. Use the following command to install the software package:

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



You can use the configuration settings provided in this document 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) / vserver(cDOT/FlashRay) lun-pathname filename device host adapter protocol lun 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

What you'll need

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

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

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

All SAN Array configurations

In All SAN Array (ASA) configurations, all paths to a given LUN are active and optimized. 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
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='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
```



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight 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 the higher priorities are Active/Optimized, meaning they are serviced by the controller where the aggregate is located. The paths with the lower priorities are active but are non-optimized because they are served from a different controller. The non-optimized paths are only used when no optimized paths are 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='service-time 0' prio=50 status=active
| |- 11:0:1:0 sdj 8:144 active ready running
| |- 11:0:2:0 sdr 65:16 active ready running
`-+- policy='service-time 0' prio=10 status=enabled
   |- 11:0:0:0 sdb 8:i6 active ready running
   |- 12:0:0:0 sdz 65:144 active ready running
```



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight paths might cause path issues during storage failures.

Recommended Settings

The CentOS 7.6 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, but you can create an empty, zero-byte file by using the following command:

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

The first time you create this file, you might need to enable and start the multipath services:

```
# systemctl enable multipathd
# systemctl start multipathd
```

- There is no requirement to add anything directly to the `multipath.conf` file, unless you have devices that you do not want to be managed by multipath or you have existing settings that override defaults.
- To exclude unwanted devices, add the following syntax to the `multipath.conf` file .


```

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

```

Replace the <DevId> with the WWID string of the device you want to exclude.

Example

In this example, we are going to determine the WWID of a device and add to the `multipath.conf` file.

Steps

1. Run the following command to determine the WWID:

```

# /lib/udev/scsi_id -gud /dev/sda
360030057024d0730239134810c0cb833

```

`sda` is the local SCSI disk that we need to add it to the blacklist.

2. Add the 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 for legacy settings, especially in the defaults section, that might be overriding the 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 will need to be corrected by later stanzas in the `multipath.conf` file that apply specifically to ONTAP LUNs. If this is not done, the ONTAP LUNs might not work as expected. These defaults should only be overridden in consultation with NetApp and/or an OS vendor and only when the impact is fully understood.

Parameter	Setting
<code>detect_prio</code>	<code>yes</code>
<code>dev_loss_tmo</code>	<code>"infinity"</code>
<code>failback</code>	<code>immediate</code>
<code>fast_io_fail_tmo</code>	<code>5</code>

Parameter	Setting
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

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
    }
}
```

KVM settings

You can use the recommended settings to configure Kernel-based Virtual Machine (KVM) as well. There are no changes required to configure KVM as the LUN is mapped to the hypervisor.

Known issues

The CentOS 7.6 with ONTAP release has the following known issues:

NetApp Bug ID	Title	Description	Bugzilla ID
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 .	N/A

Use CentOS 7.5 with ONTAP

You can use the ONTAP SAN host configuration settings to configure CentOS 7.5 with ONTAP as the target.

Install the Linux Unified Host Utilities

The NetApp Linux Unified Host Utilities software package is available on the [NetApp Support Site](#) in a 32-bit and 64-bit .rpm file. If you do not know which file is right for your configuration, use the [NetApp Interoperability Matrix Tool](#) to verify which one you need.

NetApp strongly recommends installing the Linux Unified 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.

What you'll need

If you have a version of Linux Unified Host Utilities currently installed you should upgrade it or, you should remove it and use the following steps to install the latest version.

1. Download the 32-bit or 64-bit Linux Unified Host Utilities software package from the [NetApp Support Site](#) to your host.
2. Use the following command to install the software package:

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



You can use the configuration settings provided in this document 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
vservers(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

What you'll need

If you decide to use SAN booting, it must be supported by your configuration. You can use the [NetApp 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 is successful.

Multipathing

For CentOS 7.5 the `/etc/multipath.conf` file must exist, but you do not need to make specific changes to the file. CentOS 7.5 is compiled with all settings required to recognize and correctly manage ONTAP LUNs.

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

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

All SAN Array configurations

In All SAN Array (ASA) configurations, all paths to a given LUN are active and optimized. 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
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='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
```



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight 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 the higher priorities are Active/Optimized, meaning they are serviced by the controller where the aggregate is located. The paths with the lower priorities are active but are non-optimized because they are served from a different controller. The non-optimized paths are only used when no optimized paths are 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='service-time 0' prio=50 status=active
|  |- 11:0:1:0 sdj 8:144 active ready running
|  |- 11:0:2:0 sdr 65:16 active ready running
`-+- policy='service-time 0' prio=10 status=enabled
    |- 11:0:0:0 sdb 8:i6 active ready running
    |- 12:0:0:0 sdz 65:144 active ready running
```



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight paths might cause path issues during storage failures.

Recommended Settings

The CentOS 7.5 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, but you can create an empty, zero-byte file by using the following command:

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

The first time you create this file, you might need to enable and start the multipath services:

```
# systemctl enable multipathd
# systemctl start multipathd
```

- There is no requirement to add anything directly to the `multipath.conf` file, unless you have devices that you do not want to be managed by multipath or you have existing settings that override defaults.
- To exclude unwanted devices, add the following syntax to the `multipath.conf` file .

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

Replace the `<DevId>` with the WWID string of the device you want to exclude.

Example

In this example, we are going to determine the WWID of a device and add to the `multipath.conf` file.

Steps

1. Run the following command to determine the WWID:

```
# /lib/udev/scsi_id -gud /dev/sda
360030057024d0730239134810c0cb833
```

sda is the local SCSI disk that we need to add it to the blacklist.

2. Add the 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 for legacy settings, especially in the defaults section, that might be overriding the 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 will need to be corrected by later stanzas in the multipath.conf file that apply specifically to ONTAP LUNs. If this is not done, the ONTAP LUNs might not work as expected. These defaults should only be overridden in consultation with NetApp and/or an OS vendor 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	"service-time 0"
polling_interval	5
prio	"ontap"
product	LUN.*

Parameter	Setting
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
    }
}
```

KVM settings

You can use the recommended settings to configure Kernel-based Virtual Machine (KVM) as well. There are no changes required to configure KVM as the LUN is mapped to the hypervisor.

Known issues

The CentOS 7.5 with ONTAP release has the following known issues:

NetApp Bug ID	Title	Description	Bugzilla ID
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 .	N/A

Use CentOS 7.4 with ONTAP

You can use the ONTAP SAN host configuration settings to configure CentOS 7.4 with ONTAP as the target.

Install the Linux Unified Host Utilities

The NetApp Linux Unified Host Utilities software package is available on the [NetApp Support Site](#) in a 32-bit and 64-bit .rpm file. If you do not know which file is right for your configuration, use the [NetApp Interoperability Matrix Tool](#) to verify which one you need.

NetApp strongly recommends installing the Linux Unified 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.

What you'll need

If you have a version of Linux Unified Host Utilities currently installed you should upgrade it or, you should remove it and use the following steps to install the latest version.

1. Download the 32-bit or 64-bit Linux Unified Host Utilities software package from the [NetApp Support Site](#) to your host.
2. Use the following command to install the software package:

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



You can use the configuration settings provided in this document 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
vservers(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

What you'll need

If you decide to use SAN booting, it must be supported by your configuration. You can use the [NetApp 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 is successful.

Multipathing

For CentOS 7.4 the `/etc/multipath.conf` file must exist, but you do not need to make specific changes to the file. CentOS 7.4 is compiled with all settings required to recognize and correctly manage ONTAP LUNs.

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

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

All SAN Array configurations

In All SAN Array (ASA) configurations, all paths to a given LUN are active and optimized. 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
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='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
```



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight 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 the higher priorities are Active/Optimized, meaning they are serviced by the controller where the aggregate is located. The paths with the lower priorities are active but are non-optimized because they are served from a different controller. The non-optimized paths are only used when no optimized paths are 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='service-time 0' prio=50 status=active
| |- 11:0:1:0 sdj    8:144   active ready running
| |- 11:0:2:0 sdr   65:16   active ready running
`-+- policy='service-time 0' prio=10 status=enabled
  |- 11:0:0:0 sdb    8:i6    active ready running
  |- 12:0:0:0 sdz   65:144   active ready running
```



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight paths might cause path issues during storage failures.

Recommended Settings

The CentOS 7.4 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, but you can create an empty, zero-byte file by using the following command:

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

The first time you create this file, you might need to enable and start the multipath services:

```
# systemctl enable multipathd
# systemctl start multipathd
```

- There is no requirement to add anything directly to the `multipath.conf` file, unless you have devices that you do not want to be managed by multipath or you have existing settings that override defaults.
- To exclude unwanted devices, add the following syntax to the `multipath.conf` file .

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

Replace the `<DevId>` with the WWID string of the device you want to exclude.

Example

In this example, we are going to determine the WWID of a device and add to the `multipath.conf` file.

Steps

1. Run the following command to determine the WWID:

```
# /lib/udev/scsi_id -gud /dev/sda
360030057024d0730239134810c0cb833
```

`sda` is the local SCSI disk that we need to add it to the blacklist.

2. Add the 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 for legacy settings, especially in the defaults section, that might be overriding the 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 will need to be corrected by later stanzas in the `multipath.conf` file that apply specifically to ONTAP LUNs. If this is not done, the ONTAP LUNs might not work as expected. These defaults should only be overridden in consultation with NetApp and/or an OS vendor and only when the impact is fully understood.

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

KVM settings

You can use the recommended settings to configure Kernel-based Virtual Machine (KVM) as well. There are no changes required to configure KVM as the LUN is mapped to the hypervisor.

Known issues

The CentOS 7.4 with ONTAP release has the following known issues:

NetApp Bug ID	Title	Description	Bugzilla ID
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.	N/A

Use CentOS 7.3 with ONTAP

You can use the ONTAP SAN host configuration settings to configure CentOS 7.3 with ONTAP as the target.

Install the Linux Unified Host Utilities

The NetApp Linux Unified Host Utilities software package is available on the [NetApp Support Site](#) in a 32-bit and 64-bit .rpm file. If you do not know which file is right for your configuration, use the [NetApp Interoperability Matrix Tool](#) to verify which one you need.

NetApp strongly recommends installing the Linux Unified 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.

What you'll need

If you have a version of Linux Unified Host Utilities currently installed you should upgrade it or, you should remove it and use the following steps to install the latest version.

1. Download the 32-bit or 64-bit Linux Unified Host Utilities software package from the [NetApp Support Site](#) to your host.
2. Use the following command to install the software package:

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



You can use the configuration settings provided in this document 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) / vserver (cDOT/FlashRay) Product	lun-pathname	device filename	host adapter	protocol	lun size
data_vserver 120.0g cDOT	/vol/vol1/lun1	/dev/sdb	host16	FCP	
data_vserver 120.0g cDOT	/vol/vol1/lun1	/dev/sdc	host15	FCP	
data_vserver 120.0g cDOT	/vol/vol2/lun2	/dev/sdd	host16	FCP	
data_vserver 120.0g cDOT	/vol/vol2/lun2	/dev/sde	host15	FCP	

SAN Booting

What you'll need

If you decide to use SAN booting, it must be supported by your configuration. You can use the [NetApp 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 is successful.

Multipathing

For CentOS 7.3 the `/etc/multipath.conf` file must exist, but you do not need to make specific changes to the file. CentOS 7.3 is compiled with all settings required to recognize and correctly manage ONTAP LUNs.

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

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

All SAN Array configurations

In All SAN Array (ASA) configurations, all paths to a given LUN are active and optimized. 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
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='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
```



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight 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 the higher priorities are Active/Optimized, meaning they are serviced by the controller where the aggregate is located. The paths with the lower priorities are active but are non-optimized because they are served from a different controller. The non-optimized paths are only used when no optimized paths are 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='service-time 0' prio=50 status=active
| |- 11:0:1:0 sdj    8:144   active ready running
| |- 11:0:2:0 sdr    65:16   active ready running
`-+- policy='service-time 0' prio=10 status=enabled
  |- 11:0:0:0 sdb    8:i6    active ready running
  |- 12:0:0:0 sdz    65:144  active ready running
```



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight paths might cause path issues during storage failures.

Recommended Settings

The CentOS 7.3 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, but you can create an empty, zero-byte file by using the following command:

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

The first time you create this file, you might need to enable and start the multipath services:

```
# systemctl enable multipathd
# systemctl start multipathd
```

- There is no requirement to add anything directly to the `multipath.conf` file, unless you have devices that you do not want to be managed by multipath or you have existing settings that override defaults.
- To exclude unwanted devices, add the following syntax to the `multipath.conf` file .

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

Replace the `<DevId>` with the WWID string of the device you want to exclude.

Example

In this example, we are going to determine the WWID of a device and add to the `multipath.conf` file.

Steps

1. Run the following command to determine the WWID:

```
# /lib/udev/scsi_id -gud /dev/sda
360030057024d0730239134810c0cb833
```

`sda` is the local SCSI disk that we need to add it to the blacklist.

2. Add the 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 for legacy settings, especially in the defaults section, that might be overriding the 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

will need to be corrected by later stanzas in the `multipath.conf` file that apply specifically to ONTAP LUNs. If this is not done, the ONTAP LUNs might not work as expected. These defaults should only be overridden in consultation with NetApp and/or an OS vendor and only when the impact is fully understood.

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

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
    }
}

```

KVM settings

You can use the recommended settings to configure Kernel-based Virtual Machine (KVM) as well. There are no changes required to configure KVM as the LUN is mapped to the hypervisor.

Known issues

There are no known issues for the CentOS 7.3 with ONTAP release.

Use CentOS 7.2 with ONTAP

You can use the ONTAP SAN host configuration settings to configure CentOS 7.2 with ONTAP as the target.

Install the Linux Unified Host Utilities

The NetApp Linux Unified Host Utilities software package is available on the [NetApp Support Site](#) in a 32-bit and 64-bit .rpm file. If you do not know which file is right for your configuration, use the [NetApp Interoperability Matrix Tool](#) to verify which one you need.

NetApp strongly recommends installing the Linux Unified 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.

What you'll need

If you have a version of Linux Unified Host Utilities currently installed you should upgrade it or, you should remove it and use the following steps to install the latest version.

1. Download the 32-bit or 64-bit Linux Unified Host Utilities software package from the [NetApp Support Site](#) to your host.
2. Use the following command to install the software package:

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



You can use the configuration settings provided in this document 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

What you'll need

If you decide to use SAN booting, it must be supported by your configuration. You can use the [NetApp 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 is successful.

Multipathing

For CentOS 7.2 the `/etc/multipath.conf` file must exist, but you do not need to make specific changes to the file. CentOS 7.2 is compiled with all settings required to recognize and correctly manage ONTAP LUNs.

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

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

All SAN Array configurations

In All SAN Array (ASA) configurations, all paths to a given LUN are active and optimized. 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
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='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
```



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight 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 the higher priorities are Active/Optimized, meaning they are serviced by the controller where the aggregate is located. The paths with the lower priorities are active but are non-optimized because they are served from a different controller. The non-optimized paths are only used when no optimized paths are 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='service-time 0' prio=50 status=active
|  |- 11:0:1:0 sdj 8:144 active ready running
|  |- 11:0:2:0 sdr 65:16 active ready running
`-+- policy='service-time 0' prio=10 status=enabled
    |- 11:0:0:0 sdb 8:i6 active ready running
    |- 12:0:0:0 sdz 65:144 active ready running
```



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight paths might cause path issues during storage failures.

Recommended Settings

The CentOS 7.2 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, but you can create an empty, zero-byte file by using the following command:

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

The first time you create this file, you might need to enable and start the multipath services:

```
# systemctl enable multipathd
# systemctl start multipathd
```

- There is no requirement to add anything directly to the `multipath.conf` file, unless you have devices that you do not want to be managed by multipath or you have existing settings that override defaults.
- To exclude unwanted devices, add the following syntax to the `multipath.conf` file .

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

Replace the `<DevId>` with the WWID string of the device you want to exclude.

Example

In this example, we are going to determine the WWID of a device and add to the `multipath.conf` file.

Steps

1. Run the following command to determine the WWID:

```
# /lib/udev/scsi_id -gud /dev/sda
360030057024d0730239134810c0cb833
```

sda is the local SCSI disk that we need to add it to the blacklist.

2. Add the 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 for legacy settings, especially in the defaults section, that might be overriding the 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 will need to be corrected by later stanzas in the multipath.conf file that apply specifically to ONTAP LUNs. If this is not done, the ONTAP LUNs might not work as expected. These defaults should only be overridden in consultation with NetApp and/or an OS vendor 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	"service-time 0"
polling_interval	5
prio	"ontap"
product	LUN.*

Parameter	Setting
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
    }
}
```

KVM settings

You can use the recommended settings to configure Kernel-based Virtual Machine (KVM) as well. There are no changes required to configure KVM as the LUN is mapped to the hypervisor.

Known issues

There are no known issues for the CentOS 7.2 with ONTAP release.

Use CentOS 7.1 with ONTAP

You can use the ONTAP SAN host configuration settings to configure CentOS 7.1 with ONTAP as the target.

Install the Linux Unified Host Utilities

The NetApp Linux Unified Host Utilities software package is available on the [NetApp Support Site](#) in a 32-bit and 64-bit .rpm file. If you do not know which file is right for your configuration, use the [NetApp Interoperability Matrix Tool](#) to verify which one you need.

NetApp strongly recommends installing the Linux Unified 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.

What you'll need

If you have a version of Linux Unified Host Utilities currently installed you should upgrade it or, you should remove it and use the following steps to install the latest version.

1. Download the 32-bit or 64-bit Linux Unified Host Utilities software package from the [NetApp Support Site](#) to your host.
2. Use the following command to install the software package:

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



You can use the configuration settings provided in this document 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

What you'll need

If you decide to use SAN booting, it must be supported by your configuration. You can use the [NetApp 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 is successful.

Multipathing

For CentOS 7.1 the `/etc/multipath.conf` file must exist, but you do not need to make specific changes to the file. CentOS 7.1 is compiled with all settings required to recognize and correctly manage ONTAP LUNs.

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

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

All SAN Array configurations

In All SAN Array (ASA) configurations, all paths to a given LUN are active and optimized. 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
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='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
```



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight 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 the higher priorities are Active/Optimized, meaning they are serviced by the controller where the aggregate is located. The paths with the lower priorities are active but are non-optimized because they are served from a different controller. The non-optimized paths are only used when no optimized paths are 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='service-time 0' prio=50 status=active
| |- 11:0:1:0 sdj 8:144 active ready running
| |- 11:0:2:0 sdr 65:16 active ready running
`+- policy='service-time 0' prio=10 status=enabled
  |- 11:0:0:0 sdb 8:i6 active ready running
  |- 12:0:0:0 sdz 65:144 active ready running
```



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight paths might cause path issues during storage failures.

Recommended Settings

The CentOS 7.1 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, but you can create an empty, zero-byte file by using the following command:

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

The first time you create this file, you might need to enable and start the multipath services:

```
# systemctl enable multipathd
# systemctl start multipathd
```

- There is no requirement to add anything directly to the `multipath.conf` file, unless you have devices that you do not want to be managed by multipath or you have existing settings that override defaults.
- To exclude unwanted devices, add the following syntax to the `multipath.conf` file .

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

Replace the `<DevId>` with the WWID string of the device you want to exclude.

Example

In this example, we are going to determine the WWID of a device and add to the `multipath.conf` file.

Steps

1. Run the following command to determine the WWID:

```
# /lib/udev/scsi_id -gud /dev/sda
360030057024d0730239134810c0cb833
```

`sda` is the local SCSI disk that we need to add it to the blacklist.

2. Add the 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 for legacy settings, especially in the defaults section, that might be overriding the 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 will need to be corrected by later stanzas in the `multipath.conf` file that apply specifically to ONTAP LUNs. If this is not done, the ONTAP LUNs might not work as expected. These defaults should only be overridden in consultation with NetApp and/or an OS vendor and only when the impact is fully understood.

Parameter	Setting
<code>detect_prio</code>	<code>yes</code>
<code>dev_loss_tmo</code>	<code>"infinity"</code>
<code>failback</code>	<code>immediate</code>
<code>fast_io_fail_tmo</code>	<code>5</code>
<code>features</code>	<code>"3 queue_if_no_path pg_init_retries 50"</code>
<code>flush_on_last_del</code>	<code>"yes"</code>
<code>hardware_handler</code>	<code>"0"</code>
<code>no_path_retry</code>	<code>queue</code>
<code>path_checker</code>	<code>"tur"</code>
<code>path_grouping_policy</code>	<code>"group_by_prio"</code>
<code>path_selector</code>	<code>"service-time 0"</code>

Parameter	Setting
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
    }
}
```

KVM settings

You can use the recommended settings to configure Kernel-based Virtual Machine (KVM) as well. There are no changes required to configure KVM as the LUN is mapped to the hypervisor.

Known issues

There are no known issues for the CentOS 7.1 with ONTAP release.

Use CentOS 7.0 with ONTAP

You can use the ONTAP SAN host configuration settings to configure CentOS 7.0 with ONTAP as the target.

Install the Linux Unified Host Utilities

The NetApp Linux Unified Host Utilities software package is available on the [NetApp Support Site](#) in a 32-bit and 64-bit .rpm file. If you do not know which file is right for your configuration, use the [NetApp Interoperability Matrix Tool](#) to verify which one you need.

NetApp strongly recommends installing the Linux Unified 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.

What you'll need

If you have a version of Linux Unified Host Utilities currently installed you should upgrade it or, you should remove it and use the following steps to install the latest version.

1. Download the 32-bit or 64-bit Linux Unified Host Utilities software package from the [NetApp Support Site](#) to your host.
2. Use the following command to install the software package:

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



You can use the configuration settings provided in this document 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) / vserver (cDOT/FlashRay) Product	lun-pathname	device filename	host adapter	protocol	lun size
data_vserver 120.0g cDOT	/vol/vol1/lun1	/dev/sdb	host16	FCP	
data_vserver 120.0g cDOT	/vol/vol1/lun1	/dev/sdc	host15	FCP	
data_vserver 120.0g cDOT	/vol/vol2/lun2	/dev/sdd	host16	FCP	
data_vserver 120.0g cDOT	/vol/vol2/lun2	/dev/sde	host15	FCP	

SAN Booting

What you'll need

If you decide to use SAN booting, it must be supported by your configuration. You can use the [NetApp 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 is successful.

Multipathing

For CentOS 7.0 the `/etc/multipath.conf` file must exist, but you do not need to make specific changes to the file. CentOS 7.0 is compiled with all settings required to recognize and correctly manage ONTAP LUNs.

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

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

All SAN Array configurations

In All SAN Array (ASA) configurations, all paths to a given LUN are active and optimized. 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
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='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
```



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight 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 the higher priorities are Active/Optimized, meaning they are serviced by the controller where the aggregate is located. The paths with the lower priorities are active but are non-optimized because they are served from a different controller. The non-optimized paths are only used when no optimized paths are 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='service-time 0' prio=50 status=active
| |- 11:0:1:0 sdj    8:144   active ready running
| |- 11:0:2:0 sdr    65:16   active ready running
`-+- policy='service-time 0' prio=10 status=enabled
  |- 11:0:0:0 sdb    8:i6    active ready running
  |- 12:0:0:0 sdz    65:144  active ready running
```



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight paths might cause path issues during storage failures.

Recommended Settings

The CentOS 7.0 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, but you can create an empty, zero-byte file by using the following command:

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

The first time you create this file, you might need to enable and start the multipath services:

```
# systemctl enable multipathd
# systemctl start multipathd
```

- There is no requirement to add anything directly to the `multipath.conf` file, unless you have devices that you do not want to be managed by multipath or you have existing settings that override defaults.
- To exclude unwanted devices, add the following syntax to the `multipath.conf` file .

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

Replace the `<DevId>` with the WWID string of the device you want to exclude.

Example

In this example, we are going to determine the WWID of a device and add to the `multipath.conf` file.

Steps

1. Run the following command to determine the WWID:

```
# /lib/udev/scsi_id -gud /dev/sda
360030057024d0730239134810c0cb833
```

`sda` is the local SCSI disk that we need to add it to the blacklist.

2. Add the 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 for legacy settings, especially in the defaults section, that might be overriding the 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

will need to be corrected by later stanzas in the `multipath.conf` file that apply specifically to ONTAP LUNs. If this is not done, the ONTAP LUNs might not work as expected. These defaults should only be overridden in consultation with NetApp and/or an OS vendor and only when the impact is fully understood.

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

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
    }
}

```

KVM settings

You can use the recommended settings to configure Kernel-based Virtual Machine (KVM) as well. There are no changes required to configure KVM as the LUN is mapped to the hypervisor.

Known issues

There are no known issues for the CentOS 7.0 with ONTAP release.

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 Unified Host Utilities

The NetApp Linux Unified Host Utilities software package is available on the [NetApp Support Site](#) in a 32-bit and 64-bit .rpm file. If you do not know which file is right for your configuration, use the [NetApp Interoperability Matrix Tool](#) to verify which one you need.

NetApp strongly recommends installing the Linux Unified 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.

What you'll need

If you have a version of Linux Unified Host Utilities currently installed you should upgrade it or, you should remove it and use the following steps to install the latest version.

1. Download the 32-bit or 64-bit Linux Unified Host Utilities software package from the [NetApp Support Site](#) to your host.
2. Use the following command to install the software package:

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



You can use the configuration settings provided in this document 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

What you'll need

If you decide to use SAN booting, it must be supported by your configuration. You can use the [NetApp 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 is 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 sample multipath output for a LUN mapped to ASA and non-ASA personas.

All SAN Array configurations

In All SAN Array (ASA) configurations, all paths to a given LUN are active and optimized. 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
```



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight 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 the higher priorities are Active/Optimized, meaning they are serviced by the controller where the aggregate is located. The paths with the lower priorities are active but are non-optimized because they are served from a different controller. The non-optimized paths are only used when no optimized paths are 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
```



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight 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, but you can create an empty, zero-byte file by using the following command:

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

The first time you create this file, you might need to enable and start the multipath services:

```
# systemctl enable multipathd
# systemctl start multipathd
```

- There is no requirement to add anything directly to the `multipath.conf` file, unless you have devices that you do not want to be managed by multipath or you have existing settings that override defaults.
- To exclude unwanted devices, add the following syntax to the `multipath.conf` file .

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

Replace the `<DevId>` with the WWID string of the device you want to exclude.

Example

In this example, we are going to determine the WWID of a device and add to the `multipath.conf` file.

Steps

1. Run the following command to determine the WWID:

```
# /lib/udev/scsi_id -gud /dev/sda
360030057024d0730239134810c0cb833
```

`sda` is the local SCSI disk that we need to add it to the blacklist.

2. Add the 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 for legacy settings, especially in the defaults section, that might be overriding the 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 will need to be corrected by later stanzas in the `multipath.conf` file that apply specifically to ONTAP LUNs. If this is not done, the ONTAP LUNs might not work as expected. These defaults should only be overridden in consultation with NetApp and/or an OS vendor and only when the impact is fully understood.

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

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
    }
}

```

KVM settings

You can use the recommended settings to configure Kernel-based Virtual Machine (KVM) as well. There are no changes required to configure KVM as the LUN is mapped to the hypervisor.

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 Unified Host Utilities

The NetApp Linux Unified Host Utilities software package is available on the [NetApp Support Site](#) in a 32-bit and 64-bit .rpm file. If you do not know which file is right for your configuration, use the [NetApp Interoperability Matrix Tool](#) to verify which one you need.

NetApp strongly recommends installing the Linux Unified 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.

What you'll need

If you have a version of Linux Unified Host Utilities currently installed you should upgrade it or, you should remove it and use the following steps to install the latest version.

1. Download the 32-bit or 64-bit Linux Unified Host Utilities software package from the [NetApp Support Site](#) to your host.
2. Use the following command to install the software package:

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



You can use the configuration settings provided in this document 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

What you'll need

If you decide to use SAN booting, it must be supported by your configuration. You can use the [NetApp 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 is 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 sample multipath output for a LUN mapped to ASA and non-ASA personas.

All SAN Array configurations

In All SAN Array (ASA) configurations, all paths to a given LUN are active and optimized. 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
```



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight 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 the higher priorities are Active/Optimized, meaning they are serviced by the controller where the aggregate is located. The paths with the lower priorities are active but are non-optimized because they are served from a different controller. The non-optimized paths are only used when no optimized paths are 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
```



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight 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, but you can create an empty, zero-byte file by using the following command:

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

The first time you create this file, you might need to enable and start the multipath services:

```
# systemctl enable multipathd
# systemctl start multipathd
```

- There is no requirement to add anything directly to the `multipath.conf` file, unless you have devices that you do not want to be managed by multipath or you have existing settings that override defaults.
- To exclude unwanted devices, add the following syntax to the `multipath.conf` file .

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

Replace the `<DevId>` with the WWID string of the device you want to exclude.

Example

In this example, we are going to determine the WWID of a device and add to the `multipath.conf` file.

Steps

1. Run the following command to determine the WWID:

```
# /lib/udev/scsi_id -gud /dev/sda
360030057024d0730239134810c0cb833
```

`sda` is the local SCSI disk that we need to add it to the blacklist.

2. Add the 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 for legacy settings, especially in the defaults section, that might be overriding the 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 will need to be corrected by later stanzas in the `multipath.conf` file that apply specifically to ONTAP LUNs. If this is not done, the ONTAP LUNs might not work as expected. These defaults should only be overridden in consultation with NetApp and/or an OS vendor and only when the impact is fully understood.

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

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
    }
}

```

KVM settings

You can use the recommended settings to configure Kernel-based Virtual Machine (KVM) as well. There are no changes required to configure KVM as the LUN is mapped to the hypervisor.

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 Unified Host Utilities

The NetApp Linux Unified Host Utilities software package is available on the [NetApp Support Site](#) in a 32-bit and 64-bit .rpm file. If you do not know which file is right for your configuration, use the [NetApp Interoperability Matrix Tool](#) to verify which one you need.

NetApp strongly recommends installing the Linux Unified 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.

What you'll need

If you have a version of Linux Unified Host Utilities currently installed you should upgrade it or, you should remove it and use the following steps to install the latest version.

1. Download the 32-bit or 64-bit Linux Unified Host Utilities software package from the [NetApp Support Site](#) to your host.
2. Use the following command to install the software package:

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




You can use the configuration settings provided in this document 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

What you'll need

If you decide to use SAN booting, it must be supported by your configuration. You can use the [NetApp 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 is 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 sample multipath output for a LUN mapped to ASA and non-ASA personas.

All SAN Array configurations

In All SAN Array (ASA) configurations, all paths to a given LUN are active and optimized. 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
```



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight 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 the higher priorities are Active/Optimized, meaning they are serviced by the controller where the aggregate is located. The paths with the lower priorities are active but are non-optimized because they are served from a different controller. The non-optimized paths are only used when no optimized paths are 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
```



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight 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, but you can create an empty, zero-byte file by using the following command:

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

The first time you create this file, you might need to enable and start the multipath services:

```
# systemctl enable multipathd
# systemctl start multipathd
```

- There is no requirement to add anything directly to the `multipath.conf` file, unless you have devices that you do not want to be managed by multipath or you have existing settings that override defaults.
- To exclude unwanted devices, add the following syntax to the `multipath.conf` file .

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

Replace the `<DevId>` with the WWID string of the device you want to exclude.

Example

In this example, we are going to determine the WWID of a device and add to the `multipath.conf` file.

Steps

1. Run the following command to determine the WWID:

```
# /lib/udev/scsi_id -gud /dev/sda
360030057024d0730239134810c0cb833
```

`sda` is the local SCSI disk that we need to add it to the blacklist.

2. Add the 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 for legacy settings, especially in the defaults section, that might be overriding the 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 will need to be corrected by later stanzas in the `multipath.conf` file that apply specifically to ONTAP LUNs. If this is not done, the ONTAP LUNs might not work as expected. These defaults should only be overridden in consultation with NetApp and/or an OS vendor and only when the impact is fully understood.

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

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
    }
}

```

KVM settings

You can use the recommended settings to configure Kernel-based Virtual Machine (KVM) as well. There are no changes required to configure KVM as the LUN is mapped to the hypervisor.

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 Unified Host Utilities

The NetApp Linux Unified Host Utilities software package is available on the [NetApp Support Site](#) in a 32-bit and 64-bit .rpm file. If you do not know which file is right for your configuration, use the [NetApp Interoperability Matrix Tool](#) to verify which one you need.

NetApp strongly recommends installing the Linux Unified 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.

What you'll need

If you have a version of Linux Unified Host Utilities currently installed you should upgrade it or, you should remove it and use the following steps to install the latest version.

1. Download the 32-bit or 64-bit Linux Unified Host Utilities software package from the [NetApp Support Site](#) to your host.
2. Use the following command to install the software package:

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



You can use the configuration settings provided in this document 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

What you'll need

If you decide to use SAN booting, it must be supported by your configuration. You can use the [NetApp 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 is 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 sample multipath output for a LUN mapped to ASA and non-ASA personas.

All SAN Array configurations

In All SAN Array (ASA) configurations, all paths to a given LUN are active and optimized. 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
```




Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight 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 the higher priorities are Active/Optimized, meaning they are serviced by the controller where the aggregate is located. The paths with the lower priorities are active but are non-optimized because they are served from a different controller. The non-optimized paths are only used when no optimized paths are 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
```



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight 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, but you can create an empty, zero-byte file by using the following command:

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

The first time you create this file, you might need to enable and start the multipath services:

```
# systemctl enable multipathd
# systemctl start multipathd
```

- There is no requirement to add anything directly to the `multipath.conf` file, unless you have devices that you do not want to be managed by multipath or you have existing settings that override defaults.
- To exclude unwanted devices, add the following syntax to the `multipath.conf` file .

```

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

```

Replace the <DevId> with the WWID string of the device you want to exclude.

Example

In this example, we are going to determine the WWID of a device and add to the `multipath.conf` file.

Steps

1. Run the following command to determine the WWID:

```

# /lib/udev/scsi_id -gud /dev/sda
360030057024d0730239134810c0cb833

```

`sda` is the local SCSI disk that we need to add it to the blacklist.

2. Add the 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 for legacy settings, especially in the defaults section, that might be overriding the 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 will need to be corrected by later stanzas in the `multipath.conf` file that apply specifically to ONTAP LUNs. If this is not done, the ONTAP LUNs might not work as expected. These defaults should only be overridden in consultation with NetApp and/or an OS vendor and only when the impact is fully understood.

Parameter	Setting
<code>detect_prio</code>	yes
<code>dev_loss_tmo</code>	"infinity"
<code>failback</code>	immediate
<code>fast_io_fail_tmo</code>	5

Parameter	Setting
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
    }
}
```

KVM settings

You can use the recommended settings to configure Kernel-based Virtual Machine (KVM) as well. There are no changes required to configure KVM as the LUN is mapped to the hypervisor.

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 Unified Host Utilities

The NetApp Linux Unified Host Utilities software package is available on the [NetApp Support Site](#) in a 32-bit and 64-bit .rpm file. If you do not know which file is right for your configuration, use the [NetApp Interoperability Matrix Tool](#) to verify which one you need.

NetApp strongly recommends installing the Linux Unified 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.

What you'll need

If you have a version of Linux Unified Host Utilities currently installed you should upgrade it or, you should remove it and use the following steps to install the latest version.

1. Download the 32-bit or 64-bit Linux Unified Host Utilities software package from the [NetApp Support Site](#) to your host.
2. Use the following command to install the software package:

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



You can use the configuration settings provided in this document 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) / vserver (cDOT/FlashRay) Product	lun-pathname	device filename	host adapter	protocol	lun size
data_vserver 120.0g cDOT	/vol/vol1/lun1	/dev/sdb	host16	FCP	
data_vserver 120.0g cDOT	/vol/vol1/lun1	/dev/sdc	host15	FCP	
data_vserver 120.0g cDOT	/vol/vol2/lun2	/dev/sdd	host16	FCP	
data_vserver 120.0g cDOT	/vol/vol2/lun2	/dev/sde	host15	FCP	

SAN Booting

What you'll need

If you decide to use SAN booting, it must be supported by your configuration. You can use the [NetApp 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 is 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=latacyrheb-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 sample multipath output for a LUN mapped to ASA and non-ASA personas.

All SAN Array configurations

In All SAN Array (ASA) configurations, all paths to a given LUN are active and optimized. 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
```



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight 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 the higher priorities are Active/Optimized, meaning they are serviced by the controller where the aggregate is located. The paths with the lower priorities are active but are non-optimized because they are served from a different controller. The non-optimized paths are only used when no optimized paths are 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
```



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight 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, but you can create an empty, zero-byte file by using the following command:

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

The first time you create this file, you might need to enable and start the multipath services:

```
# systemctl enable multipathd
# systemctl start multipathd
```

- There is no requirement to add anything directly to the `multipath.conf` file, unless you have devices that you do not want to be managed by multipath or you have existing settings that override defaults.
- To exclude unwanted devices, add the following syntax to the `multipath.conf` file .

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

Replace the `<DevId>` with the WWID string of the device you want to exclude.

Example

In this example, we are going to determine the WWID of a device and add to the `multipath.conf` file.

Steps

1. Run the following command to determine the WWID:

```
# /lib/udev/scsi_id -gud /dev/sda
360030057024d0730239134810c0cb833
```

`sda` is the local SCSI disk that we need to add it to the blacklist.

2. Add the 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 for legacy settings, especially in the defaults section, that might be overriding the 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 will need to be corrected by later stanzas in the `multipath.conf` file that apply specifically to ONTAP LUNs. If this is not done, the ONTAP LUNs might not work as expected. These defaults should only be overridden in consultation with NetApp and/or an OS vendor and only when the impact is fully understood.

Parameter	Setting
<code>detect_prio</code>	<code>yes</code>
<code>dev_loss_tmo</code>	<code>"infinity"</code>
<code>failback</code>	<code>immediate</code>
<code>fast_io_fail_tmo</code>	<code>5</code>
<code>features</code>	<code>"3 queue_if_no_path pg_init_retries 50"</code>
<code>flush_on_last_del</code>	<code>"yes"</code>
<code>hardware_handler</code>	<code>"0"</code>
<code>no_path_retry</code>	<code>queue</code>
<code>path_checker</code>	<code>"tur"</code>
<code>path_grouping_policy</code>	<code>"group_by_prio"</code>
<code>path_selector</code>	<code>"round-robin 0"</code>

Parameter	Setting
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
    }
}
```

KVM settings

You can use the recommended settings to configure Kernel-based Virtual Machine (KVM) as well. There are no changes required to configure KVM as the LUN is mapped to the hypervisor.

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 Unified Host Utilities

The NetApp Linux Unified Host Utilities software package is available on the [NetApp Support Site](#) in a 32-bit and 64-bit .rpm file. If you do not know which file is right for your configuration, use the [NetApp Interoperability Matrix Tool](#) to verify which one you need.

NetApp strongly recommends installing the Linux Unified 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.

What you'll need

If you have a version of Linux Unified Host Utilities currently installed you should upgrade it or, you should remove it and use the following steps to install the latest version.

1. Download the 32-bit or 64-bit Linux Unified Host Utilities software package from the [NetApp Support Site](#) to your host.
2. Use the following command to install the software package:

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



You can use the configuration settings provided in this document 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) / vserver (cDOT/FlashRay) Product	lun-pathname	device filename	host adapter	protocol	lun size
data_vserver 120.0g cDOT	/vol/vol1/lun1	/dev/sdb	host16	FCP	
data_vserver 120.0g cDOT	/vol/vol1/lun1	/dev/sdc	host15	FCP	
data_vserver 120.0g cDOT	/vol/vol2/lun2	/dev/sdd	host16	FCP	
data_vserver 120.0g cDOT	/vol/vol2/lun2	/dev/sde	host15	FCP	

SAN Booting

What you'll need

If you decide to use SAN booting, it must be supported by your configuration. You can use the [NetApp 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 is 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=latacyrheb-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 sample multipath output for a LUN mapped to ASA and non-ASA personas.

All SAN Array configurations

In All SAN Array (ASA) configurations, all paths to a given LUN are active and optimized. 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
```



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight 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 the higher priorities are Active/Optimized, meaning they are serviced by the controller where the aggregate is located. The paths with the lower priorities are active but are non-optimized because they are served from a different controller. The non-optimized paths are only used when no optimized paths are 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
```



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight 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, but you can create an empty, zero-byte file by using the following command:

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

The first time you create this file, you might need to enable and start the multipath services:

```
# systemctl enable multipathd
# systemctl start multipathd
```

- There is no requirement to add anything directly to the `multipath.conf` file, unless you have devices that you do not want to be managed by multipath or you have existing settings that override defaults.
- To exclude unwanted devices, add the following syntax to the `multipath.conf` file .

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

Replace the `<DevId>` with the WWID string of the device you want to exclude.

Example

In this example, we are going to determine the WWID of a device and add to the `multipath.conf` file.

Steps

1. Run the following command to determine the WWID:

```
# /lib/udev/scsi_id -gud /dev/sda
360030057024d0730239134810c0cb833
```

`sda` is the local SCSI disk that we need to add it to the blacklist.

2. Add the 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 for legacy settings, especially in the defaults section, that might be overriding the 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 will need to be corrected by later stanzas in the `multipath.conf` file that apply specifically to ONTAP LUNs. If this is not done, the ONTAP LUNs might not work as expected. These defaults should only be overridden in consultation with NetApp and/or an OS vendor and only when the impact is fully understood.

Parameter	Setting
<code>detect_prio</code>	<code>yes</code>
<code>dev_loss_tmo</code>	<code>"infinity"</code>
<code>failback</code>	<code>immediate</code>
<code>fast_io_fail_tmo</code>	<code>5</code>
<code>features</code>	<code>"3 queue_if_no_path pg_init_retries 50"</code>
<code>flush_on_last_del</code>	<code>"yes"</code>
<code>hardware_handler</code>	<code>"0"</code>
<code>no_path_retry</code>	<code>queue</code>
<code>path_checker</code>	<code>"tur"</code>
<code>path_grouping_policy</code>	<code>"group_by_prio"</code>
<code>path_selector</code>	<code>"round-robin 0"</code>

Parameter	Setting
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
    }
}
```

KVM settings

You can use the recommended settings to configure Kernel-based Virtual Machine (KVM) as well. There are no changes required to configure KVM as the LUN is mapped to the hypervisor.

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 Unified Host Utilities

The NetApp Linux Unified Host Utilities software package is available on the [NetApp Support Site](#) in a 32-bit and 64-bit .rpm file. If you do not know which file is right for your configuration, use the [NetApp Interoperability Matrix Tool](#) to verify which one you need.

NetApp strongly recommends installing the Linux Unified 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.

What you'll need

If you have a version of Linux Unified Host Utilities currently installed you should upgrade it or, you should remove it and use the following steps to install the latest version.

1. Download the 32-bit or 64-bit Linux Unified Host Utilities software package from the [NetApp Support Site](#) to your host.
2. Use the following command to install the software package:

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



You can use the configuration settings provided in this document 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) / vserver (cDOT/FlashRay) Product	lun-pathname	device filename	host adapter	protocol	lun size
data_vserver 120.0g cDOT	/vol/vol1/lun1	/dev/sdb	host16	FCP	
data_vserver 120.0g cDOT	/vol/vol1/lun1	/dev/sdc	host15	FCP	
data_vserver 120.0g cDOT	/vol/vol2/lun2	/dev/sdd	host16	FCP	
data_vserver 120.0g cDOT	/vol/vol2/lun2	/dev/sde	host15	FCP	

SAN Booting

What you'll need

If you decide to use SAN booting, it must be supported by your configuration. You can use the [NetApp 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 is 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=latacyrheb-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 sample multipath output for a LUN mapped to ASA and non-ASA personas.

All SAN Array configurations

In All SAN Array (ASA) configurations, all paths to a given LUN are active and optimized. 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
```



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight 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 the higher priorities are Active/Optimized, meaning they are serviced by the controller where the aggregate is located. The paths with the lower priorities are active but are non-optimized because they are served from a different controller. The non-optimized paths are only used when no optimized paths are 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
```



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight 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, but you can create an empty, zero-byte file by using the following command:

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

The first time you create this file, you might need to enable and start the multipath services:

```
# systemctl enable multipathd
# systemctl start multipathd
```

- There is no requirement to add anything directly to the `multipath.conf` file, unless you have devices that you do not want to be managed by multipath or you have existing settings that override defaults.
- To exclude unwanted devices, add the following syntax to the `multipath.conf` file .

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

Replace the `<DevId>` with the WWID string of the device you want to exclude.

Example

In this example, we are going to determine the WWID of a device and add to the `multipath.conf` file.

Steps

1. Run the following command to determine the WWID:

```
# /lib/udev/scsi_id -gud /dev/sda
360030057024d0730239134810c0cb833
```

`sda` is the local SCSI disk that we need to add it to the blacklist.

2. Add the 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 for legacy settings, especially in the defaults section, that might be overriding the 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 will need to be corrected by later stanzas in the `multipath.conf` file that apply specifically to ONTAP LUNs. If this is not done, the ONTAP LUNs might not work as expected. These defaults should only be overridden in consultation with NetApp and/or an OS vendor and only when the impact is fully understood.

Parameter	Setting
<code>detect_prio</code>	<code>yes</code>
<code>dev_loss_tmo</code>	<code>"infinity"</code>
<code>failback</code>	<code>immediate</code>
<code>fast_io_fail_tmo</code>	<code>5</code>
<code>features</code>	<code>"3 queue_if_no_path pg_init_retries 50"</code>
<code>flush_on_last_del</code>	<code>"yes"</code>
<code>hardware_handler</code>	<code>"0"</code>
<code>no_path_retry</code>	<code>queue</code>
<code>path_checker</code>	<code>"tur"</code>
<code>path_grouping_policy</code>	<code>"group_by_prio"</code>
<code>path_selector</code>	<code>"round-robin 0"</code>

Parameter	Setting
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
    }
}
```

KVM settings

You can use the recommended settings to configure Kernel-based Virtual Machine (KVM) as well. There are no changes required to configure KVM as the LUN is mapped to the hypervisor.

Known issues

For CentOS (Red Hat compatible kernel) known issues, see the [known issues](#) for Red Hat Enterprise Linux (RHEL) 6.4.

Citrix

Use Citrix Hypervisor with ONTAP

You can configure ONTAP SAN host configuration settings for Citrix Hypervisor 8 series

OS releases with FC, FCoE and iSCSI protocols.

SAN Booting

What you'll need

If you decide to use SAN booting, it must be supported by your configuration. You can use the [NetApp 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 is successful.

Multipathing

For Citrix Hypervisor (CH) 8.x the `/etc/multipath.conf` file must exist, but you do not need to make specific changes to the file. CH 8.x is compiled with all settings required to recognize and correctly manage ONTAP LUNs.

You can use the `/sbin/mpathutil status` command to verify the settings for your ONTAP LUNs. The following sections provide sample multipath output for a LUN mapped to ASA personas.

All SAN Array (ASA) Configuration

For All SAN Array (ASA) configuration there should be one group of paths with single priorities. All the paths are Active/Optimized, which means they are serviced by the controller and I/O is sent on all the active paths.

Example

The following example displays the correct output for an ONTAP LUN with four Active/Optimized paths:

```
# mpathutil status
3600a09803830344674244a357579386a dm-13 NETAPP ,LUN C-Mode
size=30G 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
|- 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
```



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 the higher priorities are Active/Optimized, meaning they are serviced by the controller where the aggregate is located. The paths with the lower priorities are active but are non-optimized because they are served from a different controller. The non-optimized paths are only used when no optimized paths are available.

Example

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

```
# mpathutil status
3600a09803830344674244a357579386a dm-13 NETAPP ,LUN C-Mode
size=30G 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
|- 1:0:0:11 sde 8:64 active ready running
`- 12:0:8:11 sdva 66:544 active ready running
`-+- policy='service-time 0' prio=10 status=enabled
|- 1:0:9:11 sddo 71:96 active ready running
`- 12:0:26:11 sdyt 129:720 active ready running
```



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight paths might cause path issues during storage failures.

Recommended Settings

The Citrix Hypervisor 8.x OS is compiled with all settings required to recognize and correctly manage ONTAP LUNs. For Citrix Hypervisor 8.x, an empty zerobyte `/etc/multipath.conf` file must exist, but you do not need to make specific changes to the file.

Enable the host multipath service from the **Xencenter Management Portal** and verify that the multipath service is enabled and running.

```
# systemctl status multipathd
multipathd.service - Device-Mapper Multipath Device Controller
   Loaded:   load (/usr/lib/systemd/system/multipathd.service; enabled;
vendor preset: enabled)
   Drop-In:  /etc/systemd/system/multipathd.service.d
             slice.config
   Active:   active (running) since Fri YYYY-MM-DD 00:00:26 IST; 1 month 9
days ago
 Main PID:   3789 (multipathd)
   CGroup:   /control.slice/multipathd.service
             3789 /sbin/multipathd
```

There is no requirement to append content to the `/etc/multipath.conf` file, unless you have devices that

you do not want to be managed by multipath or you have existing settings that override defaults. You can add the following syntax to the `multipath.conf` file to exclude the unwanted devices.

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



Replace the **<DevId>** with the WWID string of the device you want to exclude.

Example

In this example for Citrix Hypervisor 8.x, `sda` is the local SCSI disk that we need to add to the blacklist.

1. Run the following command to determine the WWID:

```
# lib/udev/scsi_id -gud /dev/sda
3600a098038303458772450714535317a
```

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

```
#cat /etc/multipath.conf
blacklist {
    wwid      3600a098038303458772450714535317a
    devnode   "(ram|raw|loop|fd|md|dm-|sr|scd|st) [0-9]*"
    devnode   "^hd[a-z]"
    devnode   "^cciss.*"
}
```

Refer to the multipath parameter runtime configuration by using the `$multipathd show config` command. You should always check your running configuration for legacy settings that might be overriding default settings, especially in the defaults section.

The following table shows 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 need to be corrected by later stanzas in **multipath.conf** that apply specifically to ONTAP LUNs. If this is not done, the ONTAP LUNs might not work as expected. The following defaults should only be overridden in consultation with NetApp and/or the OS vendor and only when the impact is fully understood.

Parameter	Setting
<code>detect_prio</code>	yes
<code>dev_loss_tmo</code>	"infinity"

Parameter	Setting
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"
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

Example

The following example illustrates 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 attached to the host, these parameters can be corrected specifically for ONTAP LUNs with a device stanza.

```
# cat /etc/multipath.conf
defaults {
    path_checker readsector0
    detect_prio no
}
devices{
    device{
        vendor "NETAPP "
        product "LUN.*"
        path_checker tur
        detect_prio yes
    }
}
```



Citrix Hypervisor recommends use of Citrix VM tools for all Linux and Windows based guest VMs for a supported configuration.

Known issues

The Citrix Hypervisor with ONTAP release has the following known issues:

NetApp Bug ID	Title	Description	Citrix Tracker ID
1242343	Kernel disruption on Citrix Hypervisor 8.0 with QLogic QLE2742 32GB FC during storage failover operations	Kernel disruption might occur during storage failover operations on Citrix Hypervisor 8.0 kernel (4.19.0+1) with QLogic QLE2742 32GB HBA. This issue prompts a reboot of the operating system and causes application disruption. If kdump is configured, the kernel disruption generates a vmcore file under the /var/crash/ directory. You can use the vmcore file to understand the cause of the failure. After the kernel disruption, you can recover the operating system by rebooting the host operating system and restarting the application.	NETAPP-98

Use Citrix XenServer with ONTAP

You can configure ONTAP SAN host configuration settings for Citrix XenServer 7 series OS releases with FC, FCoE, and iSCSi protocols.

SAN Booting

What you'll need

If you decide to use SAN booting, it must be supported by your configuration. You can use the [NetApp 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 is successful.

Multipathing

Multipath support in Citrix XenServer is based on the Device Mapper Multipathd components. Device mapper nodes are not automatically created for all LUNs presented to the XenServer and are only provisioned when LUNs are actively used by the Storage Management Layer (API). Citrix XenServer Storage Manager API plugin handles activating and deactivating multipath nodes automatically.

Due to incompatibilities with the Integrated Multipath Management architecture, Citrix recommends that you use the Citrix XenCenter application for managing the storage configuration. If it is necessary to query the status of Device Mapper tables manually, or list active device mapper multipath nodes on the system, you can use the `/sbin/mpathutil status` command to verify the settings for your ONTAP LUNs. For more information refer to the standard vendor documentation for Citrix XenServer.

Non-ASA configurations

For non-ASA configurations, there should be two groups of paths with different priorities. The paths with the higher priorities are Active/Optimized, meaning they are serviced by the controller where the aggregate is located. The paths with the lower priorities are active but are non-optimized because they are served from a different controller. The non-optimized paths are only used when no optimized paths are available.

Example

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

```
# mpathutil status
show topology
3600a098038303458772450714535317a dm-0 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='service-time 0' prio=50 status=active
| |- 2:0:2:0 sdc 8:32 active ready running
| |- 12:0:5:0 sdn 8:208 active ready running
| |- 2:0:6:0 sdg 8:96 active ready running
| `-- 12:0:0:0 sdi 8:128 active ready running
|+- policy='service-time 0' prio=10 status=enabled
| |- 2:0:0:0 sda 8:0 active ready running
| |- 2:0:1:0 sdb 8:16 active ready running
| |- 12:0:3:0 sd1 8:176 active ready running
| `-- 12:0:6:0 sdo 8:224 active ready running
[root@sanhost ~]#
```



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight paths might cause path issues during storage failures.

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 with all four Active/Optimized paths:

```
# mpathutil status
show topology
3600a098038303458772450714535317a dm-0 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='service-time 0' prio=50 status=active
| |- 2:0:2:0 sdc 8:32 active ready running
| |- 12:0:5:0 sdn 8:208 active ready running
| |- 2:0:6:0 sdg 8:96 active ready running
| `-- 12:0:0:0 sdi 8:128 active ready running
[root@sanhost ~]#
```



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight paths might cause path issues during storage failures.

Recommended Settings

The Citrix XenServer 7.x OS is compiled with all settings required to recognize and correctly manage ONTAP LUNs. For Citrix XenServer 7.x, an empty zero-byte `/etc/multipath.conf` file must exist, but you do not need to make specific changes to the file.

Enable the host multipath service from the **Xencenter Management Portal** and verify that the multipath service is enabled and running.

```
# systemctl status multipathd
multipathd.service - Device-Mapper Multipath Device Controller
   Loaded:   load (/usr/lib/systemd/system/multipathd.service; enabled;
vendor preset: enabled)
   Drop-In:  /etc/systemd/system/multipathd.service.d
             slice.config
   Active:   active (running) since Fri YYYY-MM-DD 00:00:26 IST; 1 month 9
days ago
   Main PID: 3789 (multipathd)
   CGroup:   /control.slice/multipathd.service
             3789 /sbin/multipathd
```

There is no requirement to append content to the `/etc/multipath.conf` file, unless you have devices that you do not want to be managed by multipath or you have existing settings that override defaults. You can add the following syntax to the `multipath.conf` file to exclude the unwanted devices.

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



Replace the **<DevId>** with the WWID string of the device you want to exclude.

Example

In this example for Citrix XenServer 7.x, `sda` is the local SCSI disk that we need to add to the blacklist.

1. Run the following command to determine the WWID:

```
# lib/udev/scsi_id -gud /dev/sda
3600a098038303458772450714535317a
```

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

```
#cat /etc/multipath.conf
blacklist {
    wwid      3600a098038303458772450714535317a
    devnode   "(ram|raw|loop|fd|md|dm-|sr|scd|st) [0-9]*"
    devnode   "^hd[a-z]"
    devnode   "^cciss.*"
}
```

Refer to the multipath parameter runtime configuration by using the `$multipathd show config` command. You should always check your running configuration for legacy settings that might be overriding default settings, especially in the defaults section.

The following table shows 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 need to be corrected by later stanzas in **multipath.conf** that apply specifically to ONTAP LUNs. If this is not done, the ONTAP LUNs might not work as expected. The following defaults should only be overridden in consultation with NetApp and/or the OS vendor and only when the impact is fully understood.

Parameter	Setting
<code>detect_prio</code>	yes
<code>dev_loss_tmo</code>	"infinity"
<code>failback</code>	immediate

Parameter	Setting
fast_io_fail_tmo	5
features	"3 queue_if_no_path pg_init_retries 50"
flush_on_last_del	"yes"
hardware_handler	"0"
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

Example

The following example illustrates 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 attached to the host, these parameters can be corrected specifically for ONTAP LUNs with a device stanza.

```
# cat /etc/multipath.conf
defaults {
    path_checker readsector0
    detect_prio no
}
devices{
    device{
        vendor "NETAPP "
        product "LUN.*"
        path_checker tur
        detect_prio yes
    }
}
```



Citrix XenServer recommends use of Citrix VM tools for all Linux and Windows based guest VMs for a supported configuration.

Known issues

There are no known issues for the Citrix XenServer with ONTAP release.

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

What you'll need

If you decide to use SAN booting, it must be supported by your configuration. You can use the [NetApp 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 is 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 NetApp ONTAP storage, VMW_SATP_ALUA plugin is used by default with VMW_PSP_RR as a path selection policy (PSP). You can confirm by using the following command:

```
`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 the higher priorities are Active/Optimized, meaning they are serviced by the controller where the aggregate is located. The paths with the lower priorities are active but are non-optimized because they are served from a different controller. The non-optimized paths are only used when no optimized paths are 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.600a0980383148693724545244395855
```

Example output:


```

naa.600a0980383148693724545244395855
  Device Display Name: NETAPP Fibre Channel Disk
(naa.600a0980383148693724545244395855)
  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.600a0980383148693724545244395855
```

Example output:

```

fc.20000024ff7f4a51:21000024ff7f4a51-fc.2009d039ea3ab21f:2003d039ea3ab21f-
naa.600a0980383148693724545244395855
  Runtime Name: vmhba4:C0:T0:L11
  Device: naa.600a0980383148693724545244395855
  Device Display Name: NETAPP Fibre Channel Disk
(naa.600a0980383148693724545244395855)
  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.600a0980383148693724545244395855
  Runtime Name: vmhba3:C0:T0:L11
  Device: naa.600a0980383148693724545244395855
  Device Display Name: NETAPP Fibre Channel Disk
(naa.600a0980383148693724545244395855)
  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.600a0980383148693724545244395855
```

```
Runtime Name: vmhba4:C0:T3:L11
```

```
Device: naa.600a0980383148693724545244395855
```

```
Device Display Name: NETAPP Fibre Channel Disk  
(naa.600a0980383148693724545244395855)
```

```
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.600a0980383148693724545244395855
```

```
Runtime Name: vmhba3:C0:T3:L11
```

```
Device: naa.600a0980383148693724545244395855
```

```
Device Display Name: NETAPP Fibre Channel Disk  
(naa.600a0980383148693724545244395855)
```

```
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

In All SAN Array (ASA) configurations, all paths to a given LUN are active and optimized. 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 user interface, 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 [NetApp 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 ONTAP tools for VMware vSphere documentation, [TR-4597](#), and [TR-4400](#).

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/QueueFullSampleSize	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

- [TR-4597-VMware vSphere with ONTAP](#)
- [VMware vSphere 5.x, 6.x and 7.x support with NetApp MetroCluster \(2031038\)](#)
- [NetApp ONTAP with NetApp SnapMirror Business Continuity \(SM-BC\) 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

What you'll need

If you decide to use SAN booting, it must be supported by your configuration. You can use the [NetApp 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 is 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 NetApp ONTAP storage, VMW_SATP_ALUA plugin is used by default with VMW_PSP_RR as a path

selection policy (PSP). This can be confirmed by using the below command.

```
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 the higher priorities are Active/Optimized, meaning they are serviced by the controller where the aggregate is located. The paths with the lower priorities are active but are non-optimized because they are served from a different controller. The non-optimized paths are only used when no optimized paths are 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

In All SAN Array (ASA) configurations, all paths to a given LUN are active and optimized. 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 user interface, 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 [NetApp 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, please refer to ONTAP tools for VMware vSphere documentation as well as [TR-4597-VMware vSphere with ONTAP](#) and [TR-4400](#).

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.
```

Validating 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

- [TR-4597-VMware vSphere with ONTAP](#)
- [VMware vSphere 5.x, 6.x and 7.x support with NetApp MetroCluster \(2031038\)](#)
- [NetApp ONTAP with NetApp SnapMirror Business Continuity \(SM-BC\) 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

What you'll need

If you decide to use SAN booting, it must be supported by your configuration. You can use the [NetApp 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 is 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 NetApp ONTAP storage, VMW_SATP_ALUA plugin is used by default with VMW_PSP_RR as a path selection policy (PSP). This can be confirmed by using the below command:

```
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

In All SAN Array (ASA) configurations, all paths to a given LUN are active and optimized. 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 the higher priorities are Active/Optimized, meaning they are serviced by the controller where the aggregate is located. The paths with the lower priorities are active but are non-optimized because they are served from a different controller. The non-optimized paths are only used when no optimized paths are 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 user interface, 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 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 does not recommend changing any vVols settings from default at this time.

Refer to the [NetApp 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, please refer to ONTAP tools for VMware vSphere documentation as well as [TR-4597](#) and [TR-4400](#).

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 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.
```

Validating 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

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-mode cluster controllers.
ESXi 6.5.x and ESXi 6.7.x	1256473	PLOGI issue seen during testing on Emulex adapters	

Related information

- [TR-4597-VMware vSphere with ONTAP](#)
- [VMware vSphere 5.x, 6.x and 7.x support with NetApp MetroCluster \(2031038\)](#)
- [NetApp ONTAP with NetApp SnapMirror Business Continuity \(SM-BC\) with VMware vSphere Metro Storage Cluster \(vMSC\)](#)

HP-UX

Use HP-UX 11i v3 with ONTAP

You can use the ONTAP SAN host configuration settings to configure HP-UX 11i v3 with ONTAP as the target.

Install the HP-UX Host Utilities

You can download the compressed file containing the Host Utilities software packages from the [NetApp Support Site](#). After you have the file, you must uncompress it to get the software packages you need to install the Host Utilities.

Steps

1. Download a copy of the compressed file containing the Host Utilities from the [NetApp Support Site](#) to a directory on your host.
2. Go to the directory containing the download.
3. Uncompress the file.

```
gunzip netapp_hpx_host_utilities_6.0_ia_pa.depot.gz
```

4. Enter the following command to install the software:

```
swinstall -s /netapp_hpx_host_utilities_6.0_ia_pa.depot NetApp_santoolkit
```

5. Reboot the host.

SAN Toolkit

The tool kit 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

controller(7mode) /                               device
host      lun
vserver(Cmode)   lun-pathname                     filename
adapter protocol size  mode
-----
-----
sanboot_unix      /vol/hpux_215_boot_en_0/goot_hpux_215_lun
/dev/rdisk/c11t0d0 fcd0   FCP      150g   C
sanboot_unix      /vol/hpux_215_boot_en_0/goot_hpux_215_lun
/dev/rdisk/c24t0d0 fcd1   FCP      150g   C
sanboot_unix      /vol/hpux_215_boot_en_0/goot_hpux_215_lun
/dev/rdisk/c21t0d0 fcd1   FCP      150g   C
sanboot_unix      /vol/hpux_215_boot_en_0/goot_hpux_215_lun
/dev/rdisk/c12t0d0 fcd0   FCP      150g   C
```


SAN Booting

What you'll need

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

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.

Multipathing

Multipathing allows you to configure multiple network paths between the host and storage system. If one path fails, traffic continues on the remaining paths. For a host to have multiple paths to a LUN, multipathing must be enabled. The HP-UX Host Utilities support different multipathing solutions based on your configuration. The following is for the Native Multipathing solution.

Non-ASA configurations

For non-ASA configurations, there should be two groups of paths with different priorities. The paths with the higher priorities are Active/Optimized, meaning they are serviced by the controller where the aggregate is located. The paths with the lower priorities are active but are non-optimized because they are served from a different controller. The non-optimized paths are only used when no optimized paths are available.

Example

The following example displays the correct 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	host	vserver	HP A/A
path	path	filename	path	path	path failover
state	type	or hardware	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

All SAN Array configurations

In All SAN Array (ASA) configurations, all paths to a given LUN are active and optimized. 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:



All SAN Array (ASA) configurations are supported beginning in ONTAP 9.8 for HP-UX 11iv3

```
# 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      vservers /dev/dsk
path      path      filename      host      vservers
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
```

Recommended Settings

Following are some recommended parameter settings for HP-UX 11i v3 and NetApp ONTAP LUNs. NetApp uses the default settings for HP-UX.

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

Known issues

The HP-UX 11i v3 with ONTAP release has the following known issues:

NetApp Bug ID	Title	Description	Partner ID
1447287	AUFO event on the isolated master cluster in SM-BC 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 Business Continuity (SM-BC) 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 1 MB 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 1 MB. Refer HP-UX vendor documentation for details.	NA

Oracle Linux

Release notes

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 does not 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.

OL 9

Use Oracle Linux 9.2 with ONTAP

You can use the ONTAP SAN host configuration settings to configure Oracle Linux 9.2 with ONTAP as the target.

Install the Linux Unified Host Utilities

The NetApp Linux Unified Host Utilities software package is available on the [NetApp Support Site](#) in a 64-bit .rpm file.

NetApp strongly recommends installing the Linux Unified 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.

What you'll need

If you have a version of Linux Unified Host Utilities currently installed, you should upgrade or remove it, and then use the following steps to install the latest version.

Steps

1. Download the 64-bit Linux Unified 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 tool kit is installed automatically when you install the NetApp Host Utilities package. 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.

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

```
# sanlun lun show all
```

Example output:

controller (7mode/E-Series) / vserver (cDOT/FlashRay) Product	lun-pathname	device filename	host adapter	protocol	lun size
data_vserver cDOT	/vol/vol1/lun1	/dev/sdb	host16	FCP	80.0g
data_vserver cDOT	/vol/vol1/lun1	/dev/sdc	host15	FCP	80.0g
data_vserver cDOT	/vol/vol2/lun2	/dev/sdd	host16	FCP	80.0g
data_vserver cDOT	/vol/vol2/lun2	/dev/sde	host15	FCP	80.0g

SAN booting

What you'll need

If you decide to use SAN booting, it must be supported by your configuration. You can use the [NetApp 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 is successful.

Multipathing

For OL 9.2 the `/etc/multipath.conf` file must exist, but you do not need to make specific changes to the file. OL 9.2 is compiled with all the settings required to recognize and correctly manage ONTAP LUNs.

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

The following sections provide sample multipath output for a LUN mapped to ASA and non-ASA configurations.

All SAN Array configurations

In All SAN Array (ASA) configurations, all paths to a given LUN are active and optimized. 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
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
```



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight 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 the higher priorities are Active/Optimized, meaning they are serviced by the controller where the aggregate is located. The paths with the lower priorities are active but are non-optimized because they are served from a different controller. The non-optimized paths are only used when no optimized paths are 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
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
```



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight paths might cause path issues during storage failures.

Recommended settings

The Oracle Linux 9.2 OS is compiled to recognize ONTAP LUNs and automatically set all configuration parameters correctly for both ASA and non-ASA configurations. You can further optimize performance for your host configuration with the following recommended settings.

The `multipath.conf` file must exist for the multipath daemon to start, but you can create an empty, zero-byte file by using the following command:

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

The first time you create this file, you might need to enable and start the multipath services:

```
# systemctl enable multipathd
# systemctl start multipathd
```

- There is no requirement to add anything directly to the `multipath.conf` file, unless you have devices that you do not want to be managed by multipath or you have existing settings that override defaults.
- To exclude unwanted devices, add the following syntax to the `multipath.conf` file .

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

Replace the `<DevId>` with the WWID string of the device you want to exclude.

Example

In this example, we are going to determine the WWID of a device and add to the `multipath.conf` file.

Steps

1. Run the following command to determine the WWID:

```
# /lib/udev/scsi_id -gud /dev/sda
360030057024d0730239134810c0cb833
```

`sda` is the local SCSI disk that we need to add it to the blacklist.

2. Add the 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 for legacy settings, especially in the defaults section, that might be overriding the 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 will need to be corrected by later stanzas in the `multipath.conf` file that apply specifically to ONTAP LUNs. If this is not done, the ONTAP LUNs might not work as expected. These defaults should only be overridden in consultation with NetApp and/or an OS vendor and only when the impact is fully understood.

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

Example

The following example demonstrates 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 other SAN arrays are 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
  }
}

```



To configure Oracle Linux 9.2 RedHat Enterprise Kernel (RHCK), use the [recommended settings](#) for Red Hat Enterprise Linux (RHEL) 9.2.

KVM settings

You can also use the recommended settings to configure Kernel-based Virtual Machine (KVM). There are no changes required to configure KVM as the LUN is mapped to the hypervisor.

Known issues

The Oracle Linux 9.2 with ONTAP release has the following known issues:

NetApp Bug ID	Title	Description	Bugzilla ID
1508554	SAN LUN utility with Emulex HBA needs symbolic links from library packages	<p>When you execute the Linux Unified 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:</p> <pre> [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 </pre>	Not Applicable

Use Oracle Linux 9.1 with ONTAP

You can use the ONTAP SAN host configuration settings to configure Oracle Linux 9.1 with ONTAP as the target.

Install the Linux Unified Host Utilities

The NetApp Linux Unified Host Utilities software package is available on the [NetApp Support Site](#) in a 64-bit .rpm file.

NetApp strongly recommends installing the Linux Unified 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.

What you'll need

If you have a version of Linux Unified Host Utilities currently installed, you should upgrade or remove it, and then use the following steps to install the latest version.

Steps

1. Download the 64-bit Linux Unified 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 tool kit is installed automatically when you install the NetApp Host Utilities package. 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.

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

```
# sanlun lun show all
```

Example output:

controller (7mode/E-Series) / vserver (cDOT/FlashRay) Product	lun-pathname	device filename	host adapter	protocol	lun size
data_vserver cDOT	/vol/vol1/lun1	/dev/sdb	host16	FCP	80.0g
data_vserver cDOT	/vol/vol1/lun1	/dev/sdc	host15	FCP	80.0g
data_vserver cDOT	/vol/vol2/lun2	/dev/sdd	host16	FCP	80.0g
data_vserver cDOT	/vol/vol2/lun2	/dev/sde	host15	FCP	80.0g

SAN booting

What you'll need

If you decide to use SAN booting, it must be supported by your configuration. You can use the [NetApp 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 is successful.

Multipathing

For OL 9.1 the `/etc/multipath.conf` file must exist, but you do not need to make specific changes to the file. OL 9.1 is compiled with all the settings required to recognize and correctly manage ONTAP LUNs.

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

The following sections provide sample multipath output for a LUN mapped to ASA and non-ASA configurations.

All SAN Array configurations

In All SAN Array (ASA) configurations, all paths to a given LUN are active and optimized. 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
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
|  |- 11:0:7:6   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
```



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight 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 the higher priorities are Active/Optimized, meaning they are serviced by the controller where the aggregate is located. The paths with the lower priorities are active but are non-optimized because they are served from a different controller. The non-optimized paths are only used when no optimized paths are 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
3600a0980383036347ffb4d59646c4436 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
```



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight paths might cause path issues during storage failures.

Recommended settings

The Oracle Linux 9.1 OS is compiled to recognize ONTAP LUNs and automatically set all configuration parameters correctly for both ASA and non-ASA configurations. You can further optimize performance for your host configuration with the following recommended settings.

The `multipath.conf` file must exist for the multipath daemon to start, but you can create an empty, zero-byte file by using the following command:

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

The first time you create this file, you might need to enable and start the multipath services:

```
# systemctl enable multipathd
# systemctl start multipathd
```

- There is no requirement to add anything directly to the `multipath.conf` file, unless you have devices that you do not want to be managed by multipath or you have existing settings that override defaults.
- To exclude unwanted devices, add the following syntax to the `multipath.conf` file .

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

Replace the `<DevId>` with the WWID string of the device you want to exclude.

Example

In this example, we are going to determine the WWID of a device and add to the `multipath.conf` file.

Steps

1. Run the following command to determine the WWID:

```
# /lib/udev/scsi_id -gud /dev/sda
360030057024d0730239134810c0cb833
```

`sda` is the local SCSI disk that we need to add it to the blacklist.

2. Add the 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 for legacy settings, especially in the defaults section, that might be overriding the 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 will need to be corrected by later stanzas in the `multipath.conf` file that apply specifically to ONTAP LUNs. If this is not done, the ONTAP LUNs might not work as expected. These defaults should only be overridden in consultation with NetApp and/or an OS vendor and only when the impact is fully understood.

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

Example

The following example demonstrates 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 other SAN arrays are 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
  }
}

```



To configure Oracle Linux 9.1 RedHat Enterprise Kernel (RHCK), use the [recommended settings](#) for Red Hat Enterprise Linux (RHEL) 9.1.

KVM settings

You can also use the recommended settings to configure Kernel-based Virtual Machine (KVM). There are no changes required to configure KVM as the LUN is mapped to the hypervisor.

Known issues

The Oracle Linux 9.1 with NetApp ONTAP release has the following known issues:

NetApp Bug ID	Title	Description	Bugzilla ID
1508554	SAN LUN utility with Emulex HBA needs symbolic links from library packages	<p>When you execute the Linux Unified 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:</p> <pre> [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 </pre>	Not Applicable

Use Oracle Linux 9.0 with ONTAP

You can use the ONTAP SAN host configuration settings to configure Oracle Linux 9.0 with ONTAP as the target.

Install the Linux Unified Host Utilities

The NetApp Linux Unified Host Utilities software package is available on the [NetApp Support Site](#) in a 64-bit .rpm file.

NetApp strongly recommends installing the Linux Unified 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.

What you'll need

If you have a version of Linux Unified Host Utilities currently installed, you should upgrade or remove it, and then use the following steps to install the latest version.

Steps

1. Download the 64-bit Linux Unified 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.

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

```
# sanlun lun show all
```

Example output:

controller (7mode/E-Series) / vserver (cDOT/FlashRay) Product	lun-pathname	device filename	host adapter	protocol	lun size
data_vserver cDOT	/vol/vol1/lun1	/dev/sdb	host16	FCP	80.0g
data_vserver cDOT	/vol/vol1/lun1	/dev/sdc	host15	FCP	80.0g
data_vserver cDOT	/vol/vol2/lun2	/dev/sdd	host16	FCP	80.0g
data_vserver cDOT	/vol/vol2/lun2	/dev/sde	host15	FCP	80.0g

SAN booting

What you'll need

If you decide to use SAN booting, it must be supported by your configuration. You can use the [NetApp 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 is successful.

Multipathing

For Oracle Linux (OL) 9.0 the `/etc/multipath.conf` file must exist, but you do not need to make specific changes to the file. OL 9.0 is compiled with all settings required to recognize and correctly manage ONTAP LUNs.

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

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

All SAN Array configurations

In All SAN Array (ASA) configurations, all paths to a given LUN are active and optimized. 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
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
|  |- 11:0:7:6   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
```



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 the higher priorities are Active/Optimized, meaning they are serviced by the controller where the aggregate is located. The paths with the lower priorities are active but are non-optimized because they are served from a different controller. The non-optimized paths are only used when no optimized paths are 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
3600a0980383036347ffb4d59646c4436 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
```



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight paths might cause path issues during storage failures.

Recommended settings

The Oracle Linux 9.0 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, but you can create an empty, zero-byte file by using the following command:

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

The first time you create this file, you might need to enable and start the multipath services:

```
# systemctl enable multipathd
# systemctl start multipathd
```

- There is no requirement to add anything directly to the `multipath.conf` file, unless you have devices that you do not want to be managed by multipath or you have existing settings that override defaults.
- To exclude unwanted devices, add the following syntax to the `multipath.conf` file .

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

Replace the `<DevId>` with the WWID string of the device you want to exclude.

Example

In this example, we are going to determine the WWID of a device and add to the `multipath.conf` file.

Steps

1. Run the following command to determine the WWID:

```
# /lib/udev/scsi_id -gud /dev/sda
360030057024d0730239134810c0cb833
```

`sda` is the local SCSI disk that we need to add it to the blacklist.

2. Add the 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 for legacy settings, especially in the defaults section, that might be overriding the 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 will need to be corrected by later stanzas in the `multipath.conf` file that apply specifically to ONTAP LUNs. If this is not done, the ONTAP LUNs might not work as expected. These defaults should only be overridden in consultation with NetApp and/or an OS vendor and only when the impact is fully understood.

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

```



To configure Oracle Linux 9.0 RedHat Enterprise Kernel (RHCK), use the [recommended settings](#) for Red Hat Enterprise Linux (RHEL) 9.0.

KVM settings

You can also use the recommended settings to configure Kernel-based Virtual Machine (KVM). There are no changes required to configure KVM as the LUN is mapped to the hypervisor.

Known issues

The Oracle Linux 9.0 with NetApp ONTAP release has the following known issues:

NetApp Bug ID	Title	Description	Bugzilla ID
1508554	SAN LUN utility with Emulex HBA needs symbolic links from library packages	<p>When you execute the Linux Unified 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:</p> <pre> [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 </pre>	Not Applicable

OL 8

Use Oracle Linux 8.8 with ONTAP

You can use the ONTAP SAN host configuration settings to configure Oracle Linux 8.8 with ONTAP as the target.

Install the Linux Unified Host Utilities

The NetApp Linux Unified Host Utilities software package is available on the [NetApp Support Site](#) in a 64-bit .rpm file.

NetApp strongly recommends installing the Linux Unified 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.

What you'll need

If you have a version of Linux Unified Host Utilities currently installed, you should upgrade or remove it, and then use the following steps to install the latest version.

Steps

1. Download the 64-bit Linux Unified 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 tool kit is installed automatically when you install the NetApp Host Utilities package. 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.

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

```
# sanlun lun show all
```

Example output:

controller (7mode/E-Series) / vserver (cDOT/FlashRay) Product	lun-pathname	device filename	host adapter	protocol	lun size
data_vserver cDOT	/vol/vol1/lun1	/dev/sdb	host16	FCP	80.0g
data_vserver cDOT	/vol/vol1/lun1	/dev/sdc	host15	FCP	80.0g
data_vserver cDOT	/vol/vol2/lun2	/dev/sdd	host16	FCP	80.0g
data_vserver cDOT	/vol/vol2/lun2	/dev/sde	host15	FCP	80.0g

SAN booting

What you'll need

If you decide to use SAN booting, it must be supported by your configuration. You can use the [NetApp 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 is successful.

Multipathing

For Oracle Linux (OL) 8.8 the `/etc/multipath.conf` file must exist, but you do not need to make specific changes to the file. OL 8.8 is compiled with all the settings required to recognize and correctly manage ONTAP LUNs.

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

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

All SAN Array configurations

In All SAN Array (ASA) configurations, all paths to a given LUN are active and optimized. 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
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
```



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight 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 the higher priorities are Active/Optimized, meaning they are serviced by the controller where the aggregate is located. The paths with the lower priorities are active but are non-optimized because they are served from a different controller. The non-optimized paths are only used when no optimized paths are 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
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
```



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight paths might cause path issues during storage failures.

Recommended settings

The OL 8.8 OS is compiled to recognize ONTAP LUNs and automatically set all configuration parameters correctly for both ASA and non-ASA configurations. You can further optimize performance for your host configuration with the following recommended settings.

The `multipath.conf` file must exist for the multipath daemon to start, but you can create an empty, zero-

byte file by using the following command:

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

The first time you create this file, you might need to enable and start the multipath services:

```
# systemctl enable multipathd
# systemctl start multipathd
```

- There is no requirement to add anything directly to the `multipath.conf` file, unless you have devices that you do not want to be managed by multipath or you have existing settings that override defaults.
- To exclude unwanted devices, add the following syntax to the `multipath.conf` file .

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

Replace the `<DevId>` with the WWID string of the device you want to exclude.

Example

In this example, we are going to determine the WWID of a device and add to the `multipath.conf` file.

Steps

1. Run the following command to determine the WWID:

```
# /lib/udev/scsi_id -gud /dev/sda
360030057024d0730239134810c0cb833
```

`sda` is the local SCSI disk that we need to add it to the blacklist.

2. Add the 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 for legacy settings, especially in the defaults

section, that might be overriding the 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 will need to be corrected by later stanzas in the `multipath.conf` file that apply specifically to ONTAP LUNs. If this is not done, the ONTAP LUNs might not work as expected. These defaults should only be overridden in consultation with NetApp and/or an OS vendor and only when the impact is fully understood.

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

Example

The following example demonstrates 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 other SAN arrays are 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
  }
}
```



To configure Oracle Linux 8.8 RedHat Enterprise Kernel, use the [recommended settings](#) for Red Hat Enterprise Linux (RHEL) 8.8.

KVM settings

You can also use the recommended settings to configure a Kernel-based Virtual Machine (KVM). There are no changes required to configure a KVM as the LUN is mapped to the hypervisor.

Known issues

There are no known issues for the Oracle Linux 8.8 with ONTAP release.

Use Oracle Linux 8.7 with ONTAP

You can use the ONTAP SAN host configuration settings to configure Oracle Linux 8.7 with ONTAP as the target.

Install the Linux Unified Host Utilities

The NetApp Linux Unified Host Utilities software package is available on the [NetApp Support Site](#) in a 64-bit .rpm file.

NetApp strongly recommends installing the Linux Unified 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.

What you'll need

If you have a version of Linux Unified Host Utilities currently installed, you should upgrade or remove it, and then use the following steps to install the latest version.

Steps

1. Download the 64-bit Linux Unified 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 host bus adapters (HBAs). The `sanlun` command returns information about the LUNs mapped to your host, multipathing, and information necessary to create initiator groups.

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

```
# sanlun lun show all
```

Example output:

controller(7mode/E-Series) / vserver(cDOT/FlashRay) Product	lun-pathname	device filename	host adapter	protocol	lun size
data_vserver cDOT	/vol/vol1/lun1	/dev/sdb	host16	FCP	80.0g
data_vserver cDOT	/vol/vol1/lun1	/dev/sdc	host15	FCP	80.0g
data_vserver cDOT	/vol/vol2/lun2	/dev/sdd	host16	FCP	80.0g
data_vserver cDOT	/vol/vol2/lun2	/dev/sde	host15	FCP	80.0g

SAN booting

What you'll need

If you decide to use SAN booting, it must be supported by your configuration. You can use the [NetApp 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 is successful.

Multipathing

For Oracle Linux (OL) 8.7, the `/etc/multipath.conf` file must exist. You do not need to make specific

changes to the file because OL 8.7 is compiled with all the settings required to recognize and correctly manage ONTAP LUNs.

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

The following sections provide sample multipath output for a LUN mapped to All SAN Array (ASA) and non-ASA configurations.

All SAN Array configurations

In All SAN Array (ASA) configurations, all paths to a given LUN are active and optimized. 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
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
|- 11:0:7:6 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
```



Do not use an excessive number of paths to a single LUN. You should require no more than four paths. More than eight 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 the higher priorities are Active/Optimized, meaning they are serviced by the controller where the aggregate is located. The paths with the lower priorities are active but are non-optimized because they are served from a different controller. The non-optimized paths are only used when no optimized paths are 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
3600a0980383036347ffb4d59646c4436 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
```



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight paths might cause path issues during storage failures.

Recommended settings

The Oracle Linux 8.7 OS is compiled to recognize ONTAP LUNs and automatically set all configuration parameters correctly for both ASA and non-ASA configurations.

The `multipath.conf` file must exist for the multipath daemon to start, but you can create an empty, zero-byte file by using the following command:

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

The first time you create this file, you might need to enable and start the multipath services:

```
# systemctl enable multipathd
# systemctl start multipathd
```

- There is no requirement to add anything directly to the `multipath.conf` file, unless you have devices that you do not want to be managed by multipath or you have existing settings that override defaults.
- To exclude unwanted devices, add the following syntax to the `multipath.conf` file .

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

Replace the `<DevId>` with the WWID string of the device you want to exclude.

Example

In this example, we are going to determine the WWID of a device and add to the `multipath.conf` file.

Steps

1. Run the following command to determine the WWID:

```
# /lib/udev/scsi_id -gud /dev/sda
360030057024d0730239134810c0cb833
```

sda is the local SCSI disk that we need to add it to the blacklist.

2. Add the 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 for legacy settings, especially in the defaults section, that might be overriding the 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 will need to be corrected by later stanzas in the `multipath.conf` file that apply specifically to ONTAP LUNs. If this is not done, the ONTAP LUNs might not work as expected. These defaults should only be overridden in consultation with NetApp and/or an OS vendor 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	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

Parameter	Setting
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
    }
}
```



To configure Oracle Linux 8.7 RedHat Enterprise Kernel (RHCK), use the [recommended settings](#) for Red Hat Enterprise Linux (RHEL) 8.7.

KVM settings

You can also use the recommended settings to configure the Kernel-based Virtual Machine (KVM). There are no changes required to configure the KVM as the LUN is mapped to the hypervisor.

Known issues

There are no known issues for the Oracle Linux 8.7 with ONTAP release.

Use Oracle Linux 8.6 with ONTAP

You can use the ONTAP SAN host configuration settings to configure Oracle Linux 8.6 with ONTAP as the target.

Install the Linux Unified Host Utilities

The NetApp Linux Unified Host Utilities software package is available on the [NetApp Support Site](#) in a 64-bit

.rpm file.

NetApp strongly recommends installing the Linux Unified 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.

What you'll need

If you have a version of Linux Unified Host Utilities currently installed, you should upgrade or remove it, and then use the following steps to install the latest version.

Steps

1. Download the 64-bit Linux Unified 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 document 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

What you'll need

If you decide to use SAN booting, it must be supported by your configuration. You can use the [NetApp 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 is successful.

Multipathing

For Oracle Linux (OL) 8.6 the `/etc/multipath.conf` file must exist, but you do not need to make specific changes to the file. OL 8.6 is compiled with all settings required to recognize and correctly manage ONTAP LUNs.

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

The following sections provide sample multipath output for a LUN mapped non-ASA personas.

Non-ASA configurations

For non-ASA configurations, there should be two groups of paths with different priorities. The paths with the higher priorities are Active/Optimized, meaning they are serviced by the controller where the aggregate is located. The paths with the lower priorities are active but are non-optimized because they are served from a different controller. The non-optimized paths are only used when no optimized paths are 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
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
```



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight paths might cause path issues during storage failures.

All SAN Array configurations

In All SAN Array (ASA) configurations, all paths to a given LUN are active and optimized. 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
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
  |- 11:0:7:6   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
```



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

The Oracle Linux 8.6 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, but you can create an empty, zero-byte file by using the following command:

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

The first time you create this file, you might need to enable and start the multipath services:

```
# systemctl enable multipathd
# systemctl start multipathd
```

- There is no requirement to add anything directly to the `multipath.conf` file, unless you have devices that you do not want to be managed by multipath or you have existing settings that override defaults.
- To exclude unwanted devices, add the following syntax to the `multipath.conf` file .

```

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

```

Replace the <DevId> with the WWID string of the device you want to exclude.

Example

In this example, we are going to determine the WWID of a device and add to the `multipath.conf` file.

Steps

1. Run the following command to determine the WWID:

```

# /lib/udev/scsi_id -gud /dev/sda
360030057024d0730239134810c0cb833

```

`sda` is the local SCSI disk that we need to add it to the blacklist.

2. Add the 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 for legacy settings, especially in the defaults section, that might be overriding the 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 will need to be corrected by later stanzas in the `multipath.conf` file that apply specifically to ONTAP LUNs. If this is not done, the ONTAP LUNs might not work as expected. These defaults should only be overridden in consultation with NetApp and/or an OS vendor and only when the impact is fully understood.

Parameter	Setting
<code>detect_prio</code>	yes
<code>dev_loss_tmo</code>	infinity
<code>failback</code>	immediate
<code>fast_io_fail_tmo</code>	5

Parameter	Setting
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

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
  }
}
```



To configure Oracle Linux 8.6 RedHat Enterprise Kernel (RHCK), use the [recommended settings](#) for Red Hat Enterprise Linux (RHEL) 8.6.

KVM Settings

You can use the recommended settings to configure Kernel-based Virtual Machine (KVM) as well. There are

no changes required to configure KVM as the LUN is mapped to the hypervisor.

Known issues

There are no known issues for the Oracle Linux 8.6 with ONTAP release.



For Oracle Linux (Red Hat compatible kernel) known issues, see the [known issues](#) section in the corresponding Red Hat Enterprise Linux release documentation.

Use Oracle Linux 8.5 with ONTAP

You can use the ONTAP SAN host configuration settings to configure Oracle Linux 8.5 with ONTAP as the target.

Install the Linux Unified Host Utilities

The NetApp Linux Unified Host Utilities software package is available on the [NetApp Support Site](#) in a 64-bit .rpm file.

NetApp strongly recommends installing the Linux Unified 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.

What you'll need

If you have a version of Linux Unified Host Utilities currently installed, you should upgrade or remove it, and then use the following steps to install the latest version.

Steps

1. Download the 64-bit Linux Unified 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 document 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) / vserver (cDOT/FlashRay) Product	lun-pathname	device filename	host adapter	protocol	lun size
data_vserver 120.0g cDOT	/vol/vol1/lun1	/dev/sdb	host16	FCP	
data_vserver 120.0g cDOT	/vol/vol1/lun1	/dev/sdc	host15	FCP	
data_vserver 120.0g cDOT	/vol/vol2/lun2	/dev/sdd	host16	FCP	
data_vserver 120.0g cDOT	/vol/vol2/lun2	/dev/sde	host15	FCP	

SAN Booting

What you'll need

If you decide to use SAN booting, it must be supported by your configuration. You can use the [NetApp 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 is successful.

Multipathing

For Oracle Linux (OL) 8.5 the `/etc/multipath.conf` file must exist, but you do not need to make specific changes to the file. OL 8.5 is compiled with all settings required to recognize and correctly manage ONTAP LUNs.

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

The following sections provide sample multipath output for a LUN mapped non-ASA personas.

Non-ASA configurations

For non-ASA configurations, there should be two groups of paths with different priorities. The paths with the higher priorities are Active/Optimized, meaning they are serviced by the controller where the aggregate is located. The paths with the lower priorities are active but are non-optimized because they are served from a different controller. The non-optimized paths are only used when no optimized paths are 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
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
```



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight paths might cause path issues during storage failures.

All SAN Array configurations

In All SAN Array (ASA) configurations, all paths to a given LUN are active and optimized. 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
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
|  |- 11:0:7:6   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
```



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

The Oracle Linux 8.5 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, but you can create an empty, zero-byte file by using the following command:

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


The first time you create this file, you might need to enable and start the multipath services:

```
# systemctl enable multipathd
# systemctl start multipathd
```

- There is no requirement to add anything directly to the `multipath.conf` file, unless you have devices that you do not want to be managed by multipath or you have existing settings that override defaults.
- To exclude unwanted devices, add the following syntax to the `multipath.conf` file .

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

Replace the `<DevId>` with the WWID string of the device you want to exclude.

Example

In this example, we are going to determine the WWID of a device and add to the `multipath.conf` file.

Steps

1. Run the following command to determine the WWID:

```
# /lib/udev/scsi_id -gud /dev/sda
360030057024d0730239134810c0cb833
```

`sda` is the local SCSI disk that we need to add it to the blacklist.

2. Add the 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 for legacy settings, especially in the defaults section, that might be overriding the 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

will need to be corrected by later stanzas in the `multipath.conf` file that apply specifically to ONTAP LUNs. If this is not done, the ONTAP LUNs might not work as expected. These defaults should only be overridden in consultation with NetApp and/or an OS vendor and only when the impact is fully understood.

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

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
  }
}
```



To configure Oracle Linux 8.5 RedHat Enterprise Kernel (RHCK), use the [recommended settings](#) for Red Hat Enterprise Linux (RHEL) 8.5.

KVM Settings

You can use the recommended settings to configure Kernel-based Virtual Machine (KVM) as well. There are no changes required to configure KVM as the LUN is mapped to the hypervisor.

Known issues

There are no known issues for the Oracle Linux 8.5 with ONTAP release.



For Oracle Linux (Red Hat compatible kernel) known issues, see the [known issues](#) section in the corresponding Red Hat Enterprise Linux release documentation.

Use Oracle Linux 8.4 with ONTAP

You can use the ONTAP SAN host configuration settings to configure Oracle Linux 8.4 with ONTAP as the target.

Install the Linux Unified Host Utilities

The NetApp Linux Unified Host Utilities software package is available on the [NetApp Support Site](#) in a 64-bit .rpm file.

NetApp strongly recommends installing the Linux Unified 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.

What you'll need

If you have a version of Linux Unified Host Utilities currently installed, you should upgrade or remove it, and then use the following steps to install the latest version.

Steps

1. Download the 64-bit Linux Unified 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 document 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) / vserver(cDOT/FlashRay) Product	lun-pathname	device filename	host adapter	protocol	lun size
data_vserver 120.0g cDOT	/vol/vol1/lun1	/dev/sdb	host16	FCP	
data_vserver 120.0g cDOT	/vol/vol1/lun1	/dev/sdc	host15	FCP	
data_vserver 120.0g cDOT	/vol/vol2/lun2	/dev/sdd	host16	FCP	
data_vserver 120.0g cDOT	/vol/vol2/lun2	/dev/sde	host15	FCP	

SAN Booting

What you'll need

If you decide to use SAN booting, it must be supported by your configuration. You can use the [NetApp 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 is successful.

Multipathing

For Oracle Linux (OL) 8.4 the `/etc/multipath.conf` file must exist, but you do not need to make specific changes to the file. OL 8.4 is compiled with all settings required to recognize and correctly manage ONTAP LUNs.

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

The following sections provide sample multipath output for a LUN mapped non-ASA personas.

Non-ASA configurations

For non-ASA configurations, there should be two groups of paths with different priorities. The paths with the higher priorities are Active/Optimized, meaning they are serviced by the controller where the aggregate is located. The paths with the lower priorities are active but are non-optimized because they are served from a different controller. The non-optimized paths are only used when no optimized paths are 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
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 sda j 66:48 active ready running
|- 15:0:1:35 sdb x 68:176 active ready running
```



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight paths might cause path issues during storage failures.

All SAN Array configurations

In All SAN Array (ASA) configurations, all paths to a given LUN are active and optimized. 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
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
|- 11:0:7:6 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
```



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

The Oracle Linux 8.4 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, but you can create an empty, zero-byte file by using the following command:

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

The first time you create this file, you might need to enable and start the multipath services:

```
# systemctl enable multipathd
# systemctl start multipathd
```

- There is no requirement to add anything directly to the `multipath.conf` file, unless you have devices that you do not want to be managed by multipath or you have existing settings that override defaults.
- To exclude unwanted devices, add the following syntax to the `multipath.conf` file .

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

Replace the `<DevId>` with the WWID string of the device you want to exclude.

Example

In this example, we are going to determine the WWID of a device and add to the `multipath.conf` file.

Steps

1. Run the following command to determine the WWID:

```
# /lib/udev/scsi_id -gud /dev/sda
360030057024d0730239134810c0cb833
```

sda is the local SCSI disk that we need to add it to the blacklist.

2. Add the 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 for legacy settings, especially in the defaults section, that might be overriding the 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 will need to be corrected by later stanzas in the `multipath.conf` file that apply specifically to ONTAP LUNs. If this is not done, the ONTAP LUNs might not work as expected. These defaults should only be overridden in consultation with NetApp and/or an OS vendor 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	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.*

Parameter	Setting
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
    }
}
```



To configure Oracle Linux 8.4 RedHat Enterprise Kernel (RHCK), use the [recommended settings](#) for Red Hat Enterprise Linux (RHEL) 8.4.

KVM Settings

You can use the recommended settings to configure Kernel-based Virtual Machine (KVM) as well. There are no changes required to configure KVM as the LUN is mapped to the hypervisor.

Known issues

There are no known issues for the Oracle Linux 8.4 with ONTAP release.



For Oracle Linux (Red Hat compatible kernel) known issues, see the [known issues](#) section in the corresponding Red Hat Enterprise Linux release documentation.

Use Oracle Linux 8.3 with ONTAP

You can use the ONTAP SAN host configuration settings to configure Oracle Linux 8.3 with ONTAP as the target.

Install the Linux Unified Host Utilities

The NetApp Linux Unified Host Utilities software package is available on the [NetApp Support Site](#) in a 64-bit .rpm file.

NetApp strongly recommends installing the Linux Unified 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.

What you'll need

If you have a version of Linux Unified Host Utilities currently installed, you should upgrade or remove it, and then use the following steps to install the latest version.

Steps

1. Download the 64-bit Linux Unified 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 document 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) / vserver (cDOT/FlashRay) Product	lun-pathname	device filename	host adapter	protocol	lun size
data_vserver 120.0g cDOT	/vol/vol1/lun1	/dev/sdb	host16	FCP	
data_vserver 120.0g cDOT	/vol/vol1/lun1	/dev/sdc	host15	FCP	
data_vserver 120.0g cDOT	/vol/vol2/lun2	/dev/sdd	host16	FCP	
data_vserver 120.0g cDOT	/vol/vol2/lun2	/dev/sde	host15	FCP	

SAN Booting

What you'll need

If you decide to use SAN booting, it must be supported by your configuration. You can use the [NetApp 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 is successful.

Multipathing

For Oracle Linux (OL) 8.3 the `/etc/multipath.conf` file must exist, but you do not need to make specific changes to the file. OL 8.3 is compiled with all settings required to recognize and correctly manage ONTAP LUNs.

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

The following sections provide sample multipath output for a LUN mapped non-ASA personas.

Non-ASA configurations

For non-ASA configurations, there should be two groups of paths with different priorities. The paths with the higher priorities are Active/Optimized, meaning they are serviced by the controller where the aggregate is located. The paths with the lower priorities are active but are non-optimized because they are served from a different controller. The non-optimized paths are only used when no optimized paths are 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
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
```



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight paths might cause path issues during storage failures.

All SAN Array configurations

In All SAN Array (ASA) configurations, all paths to a given LUN are active and optimized. 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
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
| |- 11:0:7:6 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
```



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

The Oracle Linux 8.3 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, but you can create an empty, zero-byte file by using the following command:

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

The first time you create this file, you might need to enable and start the multipath services:

```
# systemctl enable multipathd
# systemctl start multipathd
```

- There is no requirement to add anything directly to the `multipath.conf` file, unless you have devices that you do not want to be managed by multipath or you have existing settings that override defaults.
- To exclude unwanted devices, add the following syntax to the `multipath.conf` file .

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

Replace the `<DevId>` with the WWID string of the device you want to exclude.

Example

In this example, we are going to determine the WWID of a device and add to the `multipath.conf` file.

Steps

1. Run the following command to determine the WWID:

```
# /lib/udev/scsi_id -gud /dev/sda
360030057024d0730239134810c0cb833
```

`sda` is the local SCSI disk that we need to add it to the blacklist.

2. Add the 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 for legacy settings, especially in the defaults section, that might be overriding the 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

will need to be corrected by later stanzas in the `multipath.conf` file that apply specifically to ONTAP LUNs. If this is not done, the ONTAP LUNs might not work as expected. These defaults should only be overridden in consultation with NetApp and/or an OS vendor and only when the impact is fully understood.

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

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
  }
}
```



To configure Oracle Linux 8.3 Red Hat Enterprise Kernel (RHCK), use the [recommended settings](#) for Red Hat Enterprise Linux (RHEL) 8.3.

Known issues

There are no known issues for the Oracle Linux 8.3 with ONTAP release.



For Oracle Linux (Red Hat compatible kernel) known issues, see the [known issues](#) section in the corresponding Red Hat Enterprise Linux release documentation.

Use Oracle Linux 8.2 with ONTAP

You can use the ONTAP SAN host configuration settings to configure Oracle Linux 8.2 with ONTAP as the target.

Install the Linux Unified Host Utilities

The NetApp Linux Unified Host Utilities software package is available on the [NetApp Support Site](#) in a 64-bit .rpm file.

NetApp strongly recommends installing the Linux Unified 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.

What you'll need

If you have a version of Linux Unified Host Utilities currently installed, you should upgrade or remove it, and then use the following steps to install the latest version.

Steps

1. Download the 64-bit Linux Unified 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 document 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

What you'll need

If you decide to use SAN booting, it must be supported by your configuration. You can use the [NetApp 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 is successful.

Multipathing

For Oracle Linux (OL) 8.2 the `/etc/multipath.conf` file must exist, but you do not need to make specific changes to the file. OL 8.2 is compiled with all settings required to recognize and correctly manage ONTAP LUNs.

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

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

All SAN Array configurations

In All SAN Array (ASA) configurations, all paths to a given LUN are active and optimized. 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
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
```



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight 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 the higher priorities are Active/Optimized, meaning they are serviced by the controller where the aggregate is located. The paths with the lower priorities are active but are non-optimized because they are served from a different controller. The non-optimized paths are only used when no optimized paths are 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
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
```



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight paths might cause path issues during storage failures.

Recommended settings

The Oracle Linux 8.2 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, but you can create an empty, zero-byte file by using the following command:

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

The first time you create this file, you might need to enable and start the multipath services:

```
# systemctl enable multipathd
# systemctl start multipathd
```

- There is no requirement to add anything directly to the `multipath.conf` file, unless you have devices that you do not want to be managed by multipath or you have existing settings that override defaults.
- To exclude unwanted devices, add the following syntax to the `multipath.conf` file .

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

Replace the `<DevId>` with the WWID string of the device you want to exclude.

Example

In this example, we are going to determine the WWID of a device and add to the `multipath.conf` file.

Steps

1. Run the following command to determine the WWID:

```
# /lib/udev/scsi_id -gud /dev/sda
360030057024d0730239134810c0cb833
```

sda is the local SCSI disk that we need to add it to the blacklist.

2. Add the 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 for legacy settings, especially in the defaults section, that might be overriding the 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 will need to be corrected by later stanzas in the `multipath.conf` file that apply specifically to ONTAP LUNs. If this is not done, the ONTAP LUNs might not work as expected. These defaults should only be overridden in consultation with NetApp and/or an OS vendor 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	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

Parameter	Setting
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
    }
}
```



To configure Oracle Linux 8.2 RedHat Enterprise Kernel (RHCK), use the [recommended settings](#) for Red Hat Enterprise Linux (RHEL) 8.2.

Known issues

There are no known issues for the Oracle Linux 8.2 with ONTAP release.



For Oracle Linux (Red Hat compatible kernel) known issues, see the [known issues](#) for Red Hat Enterprise Linux (RHEL) 8.2.

Use Oracle Linux 8.1 with ONTAP

You can use the ONTAP SAN host configuration settings to configure Oracle Linux 8.1 with ONTAP as the target.

Install the Linux Unified Host Utilities

The NetApp Linux Unified Host Utilities software package is available on the [NetApp Support Site](#) in a 64-bit .rpm file.

NetApp strongly recommends installing the Linux Unified 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.

What you'll need

If you have a version of Linux Unified Host Utilities currently installed, you should upgrade or remove it, and then use the following steps to install the latest version.

Steps

- 1. Download the 64-bit Linux Unified 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 document 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) / vserver(cDOT/FlashRay) lun-pathname		device filename	host adapter	protocol	lun 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

What you'll need

If you decide to use SAN booting, it must be supported by your configuration. You can use the [NetApp 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 is successful.

Multipathing

For Oracle Linux 8.1 the `/etc/multipath.conf` file must exist, but you do not need to make specific changes to the file. Oracle Linux 8.1 is compiled with all settings required to recognize and correctly manage ONTAP LUNs.

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 the higher priorities are Active/Optimized, which means they are serviced by the controller where the aggregate is located. The paths with the lower priorities are active but are non-optimized because they are served from a different controller. The non-optimized paths are only used when no optimized paths are 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
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
| |- 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 sda j 66:48 active ready running
|- 15:0:1:35 sdb x 68:176 active ready running
```



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight paths might cause path issues during storage failures.

Recommended Settings

The Oracle Linux 8.1 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, but you can create an empty, zero-byte file by using the following command:

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

The first time you create this file, you might need to enable and start the multipath services:

```
# systemctl enable multipathd
# systemctl start multipathd
```

- There is no requirement to add anything directly to the `multipath.conf` file, unless you have devices that you do not want to be managed by multipath or you have existing settings that override defaults.
- To exclude unwanted devices, add the following syntax to the `multipath.conf` file .

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

Replace the `<DevId>` with the WWID string of the device you want to exclude.

Example

In this example, we are going to determine the WWID of a device and add to the `multipath.conf` file.

Steps

1. Run the following command to determine the WWID:

```
# /lib/udev/scsi_id -gud /dev/sda
360030057024d0730239134810c0cb833
```

`sda` is the local SCSI disk that we need to add it to the blacklist.

2. Add the 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 for legacy settings, especially in the defaults section, that might be overriding the 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 will need to be corrected by later stanzas in the `multipath.conf` file that apply specifically to ONTAP LUNs. If this is not done, the ONTAP LUNs might not work as expected. These defaults should only be overridden in consultation with NetApp and/or an OS vendor and only when the impact is fully understood.

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



To configure Oracle Linux 8.1 RedHat Enterprise Kernel (RHCK), use the [recommended settings](#) for Red Hat Enterprise Linux (RHEL) 8.1.

Known issues

There are no known issues for the Oracle Linux 8.1 with ONTAP release.



For Oracle Linux (Red Hat compatible kernel) known issues, see the [known issues](#) for Red Hat Enterprise Linux (RHEL) 8.1.

Use Oracle Linux 8.0 with ONTAP

You can use the ONTAP SAN host configuration settings to configure Oracle Linux 8.0 with ONTAP as the target.

Install the Linux Unified Host Utilities

The NetApp Linux Unified Host Utilities software package is available on the [NetApp Support Site](#) in a 64-bit .rpm file.

NetApp strongly recommends installing the Linux Unified 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.

What you'll need

If you have a version of Linux Unified Host Utilities currently installed, you should upgrade or remove it, and then use the following steps to install the latest version.

Steps

1. Download the 64-bit Linux Unified 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 document 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

What you'll need

If you decide to use SAN booting, it must be supported by your configuration. You can use the [NetApp 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 is successful.

Multipathing

For Oracle Linux 8.0 the `/etc/multipath.conf` file must exist, but you do not need to make specific changes to the file. Oracle Linux 8.0 is compiled with all settings required to recognize and correctly manage ONTAP LUNs.

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 the higher priorities are Active/Optimized, which means they are serviced by the controller where the aggregate is located. The paths with the lower priorities are active but are non-optimized because they are served from a different controller. The non-optimized paths are only used when no optimized paths are 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
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
|  |- 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 sda_ 66:48 active ready running
|  |- 15:0:1:35 sdbx 68:176 active ready running
```



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight paths might cause path issues during storage failures.

Recommended Settings

The Oracle Linux 8.0 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, but you can create an empty, zero-byte file by using the following command:

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

The first time you create this file, you might need to enable and start the multipath services:

```
# systemctl enable multipathd
# systemctl start multipathd
```

- There is no requirement to add anything directly to the `multipath.conf` file, unless you have devices that you do not want to be managed by multipath or you have existing settings that override defaults.
- To exclude unwanted devices, add the following syntax to the `multipath.conf` file .

```

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

```

Replace the <DevId> with the WWID string of the device you want to exclude.

Example

In this example, we are going to determine the WWID of a device and add to the `multipath.conf` file.

Steps

1. Run the following command to determine the WWID:

```

# /lib/udev/scsi_id -gud /dev/sda
360030057024d0730239134810c0cb833

```

`sda` is the local SCSI disk that we need to add it to the blacklist.

2. Add the 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 for legacy settings, especially in the defaults section, that might be overriding the 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 will need to be corrected by later stanzas in the `multipath.conf` file that apply specifically to ONTAP LUNs. If this is not done, the ONTAP LUNs might not work as expected. These defaults should only be overridden in consultation with NetApp and/or an OS vendor and only when the impact is fully understood.

Parameter	Setting
<code>detect_prio</code>	yes
<code>dev_loss_tmo</code>	"infinity"
<code>failback</code>	immediate
<code>fast_io_fail_tmo</code>	5

Parameter	Setting
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

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
    }
}
```



To configure Oracle Linux 8.0 RedHat Enterprise Kernel (RHCK), use the [recommended settings](#) for Red Hat Enterprise Linux (RHEL) 8.0.

Known issues

There are no known issues for the Oracle Linux 8.0 with ONTAP release.



For Oracle Linux (Red Hat compatible kernel) known issues, see the [known issues](#) for Red Hat Enterprise Linux (RHEL) 8.0.

OL 7

Use Oracle Linux 7.9 with ONTAP

You can use the ONTAP SAN host configuration settings to configure Oracle Linux 7.9 with ONTAP as the target.

Install the Linux Unified Host Utilities

The NetApp Linux Unified Host Utilities software package is available on the [NetApp Support Site](#) in a 32-bit and 64-bit .rpm file. If you do not know which file is right for your configuration, use the [NetApp Interoperability Matrix Tool](#) to verify which one you need.

NetApp strongly recommends installing the Linux Unified 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.

What you'll need

If you have a version of Linux Unified Host Utilities currently installed you should upgrade it or, you should remove it and use the following steps to install the latest version.

1. Download the 32-bit or 64-bit Linux Unified Host Utilities software package from the [NetApp Support Site](#) to your host.
2. Use the following command to install the software package:

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



You can use the configuration settings provided in this document 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) / vserver (cDOT/FlashRay) Product	lun-pathname	device filename	host adapter	protocol	lun size
data_vserver 120.0g cDOT	/vol/vol1/lun1	/dev/sdb	host16	FCP	
data_vserver 120.0g cDOT	/vol/vol1/lun1	/dev/sdc	host15	FCP	
data_vserver 120.0g cDOT	/vol/vol2/lun2	/dev/sdd	host16	FCP	
data_vserver 120.0g cDOT	/vol/vol2/lun2	/dev/sde	host15	FCP	

SAN Booting

What you'll need

If you decide to use SAN booting, it must be supported by your configuration. You can use the [NetApp 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 is successful.

Multipathing

For Oracle Linux (OL) 7.9 the `/etc/multipath.conf` file must exist, but you do not need to make specific changes to the file. OL 7.9 is compiled with all settings required to recognize and correctly manage ONTAP LUNs.

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

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

All SAN Array configurations

In All SAN Array (ASA) configurations, all paths to a given LUN are active and optimized. 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
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
```



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight 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 the higher priorities are Active/Optimized, meaning they are serviced by the controller where the aggregate is located. The paths with the lower priorities are active but are non-optimized because they are served from a different controller. The non-optimized paths are only used when no optimized paths are 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
3600a098038303458772450714535415a dm-15 NETAPP ,LUN C-Mode
size=40G 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
| | - 11:0:5:7      sdbg    67:160    active ready running
| | - 12:0:13:7     sdlg    67:480    active ready running
|-+- policy='service-time 0' prio=10 status=enabled
| - 11:0:8:7       sdck    69:128    active ready running
| - 11:0:12:7      sddy    128:0     active ready running
```



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight paths might cause path issues during storage failures.

Recommended settings

The Oracle Linux 7.9 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, but you can create an empty, zero-byte file by using the following command:

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

The first time you create this file, you might need to enable and start the multipath services:

```
# systemctl enable multipathd
# systemctl start multipathd
```

- There is no requirement to add anything directly to the `multipath.conf` file, unless you have devices that you do not want to be managed by multipath or you have existing settings that override defaults.
- To exclude unwanted devices, add the following syntax to the `multipath.conf` file .

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

Replace the `<DevId>` with the WWID string of the device you want to exclude.

Example

In this example, we are going to determine the WWID of a device and add to the `multipath.conf` file.

Steps

1. Run the following command to determine the WWID:

```
# /lib/udev/scsi_id -gud /dev/sda
360030057024d0730239134810c0cb833
```

`sda` is the local SCSI disk that we need to add it to the blacklist.

2. Add the 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 for legacy settings, especially in the defaults section, that might be overriding the 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

will need to be corrected by later stanzas in the `multipath.conf` file that apply specifically to ONTAP LUNs. If this is not done, the ONTAP LUNs might not work as expected. These defaults should only be overridden in consultation with NetApp and/or an OS vendor and only when the impact is fully understood.

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

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 7.9 RedHat Enterprise Kernel (RHCK), use the [recommended settings](#) for Red Hat Enterprise Linux (RHEL) 7.9.

Known issues

The Oracle Linux 7.9 with ONTAP release has the following known issues:

NetApp Bug ID	Title	Description	Bugzilla ID
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 <code>disable_changed_wwids</code> 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.	Not applicable

Use Oracle Linux 7.8 with ONTAP

You can use the ONTAP SAN host configuration settings to configure Oracle Linux 7.8 with ONTAP as the target.

Install the Linux Unified Host Utilities

The NetApp Linux Unified Host Utilities software package is available on the [NetApp Support Site](#) in a 32-bit and 64-bit .rpm file. If you do not know which file is right for your configuration, use the [NetApp Interoperability](#)

[Matrix Tool](#) to verify which one you need.

NetApp strongly recommends installing the Linux Unified 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.

What you'll need

If you have a version of Linux Unified Host Utilities currently installed you should upgrade it or, you should remove it and use the following steps to install the latest version.

1. Download the 32-bit or 64-bit Linux Unified Host Utilities software package from the [NetApp Support Site](#) to your host.
2. Use the following command to install the software package:

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



You can use the configuration settings provided in this document 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

What you'll need

If you decide to use SAN booting, it must be supported by your configuration. You can use the [NetApp 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 is successful.

Multipathing

For Oracle Linux (OL) 7.8 the `/etc/multipath.conf` file must exist, but you do not need to make specific changes to the file. OL 7.8 is compiled with all settings required to recognize and correctly manage ONTAP LUNs.

You can use the `multipath -ll` command to verify the settings for your ONTAP LUNs. The following sections provide sample multipath output for a LUN mapped non-ASA personas.

Non-ASA configurations

For non-ASA configurations, there should be two groups of paths with different priorities. The paths with the higher priorities are Active/Optimized, meaning they are serviced by the controller where the aggregate is located. The paths with the lower priorities are active but are non-optimized because they are served from a different controller. The non-optimized paths are only used when no optimized paths are 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
3600a098038303634722b4d59646c4436 dm-28 NETAPP,LUN C-Mode
size=80G features='4 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
```



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight paths might cause path issues during storage failures.

Recommended Settings

The Oracle Linux 7.8 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, but you can create an empty, zero-byte file by using the following command:

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

The first time you create this file, you might need to enable and start the multipath services:

```
# systemctl enable multipathd
# systemctl start multipathd
```

- There is no requirement to add anything directly to the `multipath.conf` file, unless you have devices that you do not want to be managed by multipath or you have existing settings that override defaults.
- To exclude unwanted devices, add the following syntax to the `multipath.conf` file .

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

Replace the `<DevId>` with the WWID string of the device you want to exclude.

Example

In this example, we are going to determine the WWID of a device and add to the `multipath.conf` file.

Steps

1. Run the following command to determine the WWID:

```
# /lib/udev/scsi_id -gud /dev/sda
360030057024d0730239134810c0cb833
```

`sda` is the local SCSI disk that we need to add it to the blacklist.

2. Add the 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 for legacy settings, especially in the defaults section, that might be overriding the 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 will need to be corrected by later stanzas in the `multipath.conf` file that apply specifically to ONTAP LUNs. If this is not done, the ONTAP LUNs might not work as expected. These defaults should only be overridden in consultation with NetApp and/or an OS vendor and only when the impact is fully understood.

Parameter	Setting
<code>detect_prio</code>	yes
<code>dev_loss_tmo</code>	"infinity"
<code>failback</code>	immediate
<code>fast_io_fail_tmo</code>	5
<code>features</code>	"3 queue_if_no_path pg_init_retries 50"
<code>flush_on_last_del</code>	"yes"
<code>hardware_handler</code>	"0"
<code>path_checker</code>	"tur"
<code>path_grouping_policy</code>	"group_by_prio"
<code>path_selector</code>	"service-time 0"
<code>polling_interval</code>	5
<code>prio</code>	"ontap"
<code>product</code>	LUN.*
<code>retain_attached_hw_handler</code>	yes
<code>rr_weight</code>	"uniform"
<code>user_friendly_names</code>	no
<code>vendor</code>	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 7.8 RedHat Enterprise Kernel (RHCK), use the [recommended settings](#) for Red Hat Enterprise Linux (RHEL) 7.8.

Known issues

The Oracle Linux 7.8 with ONTAP release has the following known issues:

NetApp Bug ID	Title	Description	Bugzilla ID
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.	N/A

NetApp Bug ID	Title	Description	Bugzilla ID
1311575	IO 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.	17171
1311576	IO 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.	17172

NetApp Bug ID	Title	Description	Bugzilla ID
1246134	IO 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.	16852

NetApp Bug ID	Title	Description	Bugzilla ID
1246327	IO delays observed and Rports are moving to blocked, NOT PRESENT state during storage failover with Qlogic QLE2672(16G) and QLE2742(32G)	<p>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. IO 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:</p> <pre># cat /sys/class/fc_remote_ports/rport-*/port_status</pre> <p>You should see the following output:</p> <pre>Blocked Blocked Blocked Blocked Online Online</pre>	16853

Use Oracle Linux 7.7 with ONTAP

You can use the ONTAP SAN host configuration settings to configure Oracle Linux 7.7 with ONTAP as the target.

Install the Linux Unified Host Utilities

The NetApp Linux Unified Host Utilities software package is available on the [NetApp Support Site](#) in a 32-bit and 64-bit .rpm file. If you do not know which file is right for your configuration, use the [NetApp Interoperability Matrix Tool](#) to verify which one you need.

NetApp strongly recommends installing the Linux Unified 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.

What you'll need

If you have a version of Linux Unified Host Utilities currently installed you should upgrade it or, you should remove it and use the following steps to install the latest version.

1. Download the 32-bit or 64-bit Linux Unified Host Utilities software package from the [NetApp Support Site](#) to your host.
2. Use the following command to install the software package:

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



You can use the configuration settings provided in this document 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) / vserver (cDOT/FlashRay) Product	lun-pathname	device filename	host adapter	protocol	lun size
data_vserver 120.0g cDOT	/vol/vol1/lun1	/dev/sdb	host16	FCP	
data_vserver 120.0g cDOT	/vol/vol1/lun1	/dev/sdc	host15	FCP	
data_vserver 120.0g cDOT	/vol/vol2/lun2	/dev/sdd	host16	FCP	
data_vserver 120.0g cDOT	/vol/vol2/lun2	/dev/sde	host15	FCP	

SAN Booting

What you'll need

If you decide to use SAN booting, it must be supported by your configuration. You can use the [NetApp 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 is successful.

Multipathing

For Oracle Linux 7.7 the `/etc/multipath.conf` file must exist, but you do not need to make specific changes to the file. Oracle Linux 7.7 is compiled with all settings required to recognize and correctly manage ONTAP LUNs.

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 the higher priorities are Active/Optimized, which means they are serviced by the controller where the aggregate is located. The paths with the lower priorities are active but are non-optimized because they are served from a different controller. The non-optimized paths are only used when no optimized paths are 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='service-time 0' prio=50 status=active
|  |- 11:0:1:0 sdj 8:144 active ready running
|  |- 11:0:2:0 sdr 65:16 active ready running
|-+- policy='service-time 0' prio=10 status=enabled
|  |- 11:0:0:0 sdb 8:i6 active ready running
|  |- 12:0:0:0 sdz 65:144 active ready running
```



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight paths might cause path issues during storage failures.

Recommended Settings

The Oracle Linux 7.7 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, but you can create an empty, zero-byte file by using the following command:

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

The first time you create this file, you might need to enable and start the multipath services:

```
# systemctl enable multipathd
# systemctl start multipathd
```

- There is no requirement to add anything directly to the `multipath.conf` file, unless you have devices that you do not want to be managed by multipath or you have existing settings that override defaults.
- To exclude unwanted devices, add the following syntax to the `multipath.conf` file .

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

Replace the `<DevId>` with the WWID string of the device you want to exclude.

Example

In this example, we are going to determine the WWID of a device and add to the `multipath.conf` file.

Steps

1. Run the following command to determine the WWID:

```
# /lib/udev/scsi_id -gud /dev/sda
360030057024d0730239134810c0cb833
```

sda is the local SCSI disk that we need to add it to the blacklist.

2. Add the 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 for legacy settings, especially in the defaults section, that might be overriding the 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 will need to be corrected by later stanzas in the `multipath.conf` file that apply specifically to ONTAP LUNs. If this is not done, the ONTAP LUNs might not work as expected. These defaults should only be overridden in consultation with NetApp and/or an OS vendor 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"
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

Parameter	Setting
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 7.7 RedHat Enterprise Kernel (RHCK), use the [recommended settings](#) for Red Hat Enterprise Linux (RHEL) 7.7.

Known issues

The Oracle Linux 7.7 with ONTAP release has the following known issues:

NetApp Bug ID	Title	Description	Bugzilla ID
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.	N/A
1311575	IO 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.	17171

NetApp Bug ID	Title	Description	Bugzilla ID
1311576	IO 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.	17172
1246134	IO 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.	16852

NetApp Bug ID	Title	Description	Bugzilla ID
1246327	IO delays observed and Rports are moving to blocked, NOT PRESENT state during storage failover with Qlogic QLE2672(16G) and QLE2742(32G)	<p>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. IO 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:</p> <pre># cat /sys/class/fc_remote_ports/rport-*/port_status</pre> <p>You should see the following output:</p> <pre>Blocked Blocked Blocked Blocked Online Online</pre>	16853

Use Oracle Linux 7.6 with ONTAP

You can use the ONTAP SAN host configuration settings to configure Oracle Linux 7.6 with ONTAP as the target.

Install the Linux Unified Host Utilities

The NetApp Linux Unified Host Utilities software package is available on the [NetApp Support Site](#) in a 32-bit and 64-bit .rpm file. If you do not know which file is right for your configuration, use the [NetApp Interoperability Matrix Tool](#) to verify which one you need.

NetApp strongly recommends installing the Linux Unified 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.

What you'll need

If you have a version of Linux Unified Host Utilities currently installed you should upgrade it or, you should remove it and use the following steps to install the latest version.

1. Download the 32-bit or 64-bit Linux Unified Host Utilities software package from the [NetApp Support Site](#) to your host.
2. Use the following command to install the software package:

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



You can use the configuration settings provided in this document 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) / vserver (cDOT/FlashRay) Product	lun-pathname	device filename	host adapter	protocol	lun size
data_vserver 120.0g cDOT	/vol/vol1/lun1	/dev/sdb	host16	FCP	
data_vserver 120.0g cDOT	/vol/vol1/lun1	/dev/sdc	host15	FCP	
data_vserver 120.0g cDOT	/vol/vol2/lun2	/dev/sdd	host16	FCP	
data_vserver 120.0g cDOT	/vol/vol2/lun2	/dev/sde	host15	FCP	

SAN Booting

What you'll need

If you decide to use SAN booting, it must be supported by your configuration. You can use the [NetApp 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 is successful.

Multipathing

For Oracle Linux 7.6 the `/etc/multipath.conf` file must exist, but you do not need to make specific changes to the file. Oracle Linux 7.6 is compiled with all settings required to recognize and correctly manage ONTAP LUNs.

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 the higher priorities are Active/Optimized, which means they are serviced by the controller where the aggregate is located. The paths with the lower priorities are active but are non-optimized because they are served from a different controller. The non-optimized paths are only used when no optimized paths are 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='service-time 0' prio=50 status=active
|  |- 11:0:1:0 sdj 8:144 active ready running
|  |- 11:0:2:0 sdr 65:16 active ready running
|-+- policy='service-time 0' prio=10 status=enabled
|  |- 11:0:0:0 sdb 8:i6 active ready running
|  |- 12:0:0:0 sdz 65:144 active ready running
```



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight paths might cause path issues during storage failures.

Recommended Settings

The Oracle Linux 7.6 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, but you can create an empty, zero-byte file by using the following command:

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

The first time you create this file, you might need to enable and start the multipath services:

```
# systemctl enable multipathd
# systemctl start multipathd
```

- There is no requirement to add anything directly to the `multipath.conf` file, unless you have devices that you do not want to be managed by multipath or you have existing settings that override defaults.
- To exclude unwanted devices, add the following syntax to the `multipath.conf` file .

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

Replace the `<DevId>` with the WWID string of the device you want to exclude.

Example

In this example, we are going to determine the WWID of a device and add to the `multipath.conf` file.

Steps

1. Run the following command to determine the WWID:

```
# /lib/udev/scsi_id -gud /dev/sda
360030057024d0730239134810c0cb833
```

sda is the local SCSI disk that we need to add it to the blacklist.

2. Add the 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 for legacy settings, especially in the defaults section, that might be overriding the 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 will need to be corrected by later stanzas in the `multipath.conf` file that apply specifically to ONTAP LUNs. If this is not done, the ONTAP LUNs might not work as expected. These defaults should only be overridden in consultation with NetApp and/or an OS vendor 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"
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

Parameter	Setting
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 7.6 RedHat Enterprise Kernel (RHCK), use the [recommended settings](#) for Red Hat Enterprise Linux (RHEL) 7.6.

Known issues

The Oracle Linux 7.6 with ONTAP release has the following known issues:

NetApp Bug ID	Title	Description	Bugzilla ID
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 .	N/A
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	16613

NetApp Bug ID	Title	Description	Bugzilla ID
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.	16606
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.	16605

NetApp Bug ID	Title	Description	Bugzilla ID
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.	16607
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.	16852

NetApp Bug ID	Title	Description	Bugzilla ID
1246327	Remote port status on QLogic QLE2672 16G host blocked during storage failover operations	<p>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. IO 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:</p> <pre># cat /sys/class/fc_remote_ports/rport-*/port_status You should see the following output: Blocked Blocked Blocked Blocked Online Online</pre>	16853

Use Oracle Linux 7.5 with ONTAP

You can use the ONTAP SAN host configuration settings to configure Oracle Linux 7.5 with ONTAP as the target.

Install the Linux Unified Host Utilities

The NetApp Linux Unified Host Utilities software package is available on the [NetApp Support Site](#) in a 32-bit and 64-bit .rpm file. If you do not know which file is right for your configuration, use the [NetApp Interoperability Matrix Tool](#) to verify which one you need.

NetApp strongly recommends installing the Linux Unified 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.

What you'll need

If you have a version of Linux Unified Host Utilities currently installed you should upgrade it or, you should remove it and use the following steps to install the latest version.

1. Download the 32-bit or 64-bit Linux Unified Host Utilities software package from the [NetApp Support Site](#) to your host.
2. Use the following command to install the software package:

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



You can use the configuration settings provided in this document 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) / vserver (cDOT/FlashRay) Product	lun-pathname	device filename	host adapter	protocol	lun size
data_vserver 120.0g cDOT	/vol/vol1/lun1	/dev/sdb	host16	FCP	
data_vserver 120.0g cDOT	/vol/vol1/lun1	/dev/sdc	host15	FCP	
data_vserver 120.0g cDOT	/vol/vol2/lun2	/dev/sdd	host16	FCP	
data_vserver 120.0g cDOT	/vol/vol2/lun2	/dev/sde	host15	FCP	

SAN Booting

What you'll need

If you decide to use SAN booting, it must be supported by your configuration. You can use the [NetApp 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 is successful.

Multipathing

For Oracle Linux 7.5 the `/etc/multipath.conf` file must exist, but you do not need to make specific changes to the file. Oracle Linux 7.5 is compiled with all settings required to recognize and correctly manage ONTAP LUNs.

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 the higher priorities are Active/Optimized, which means they are serviced by the controller where the aggregate is located. The paths with the lower priorities are active but are non-optimized because they are served from a different controller. The non-optimized paths are only used when no optimized paths are 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='service-time 0' prio=50 status=active
| |- 11:0:1:0 sdj 8:144 active ready running
| |- 11:0:2:0 sdr 65:16 active ready running
|+- policy='service-time 0' prio=10 status=enabled
|- 11:0:0:0 sdb 8:i6 active ready running
|- 12:0:0:0 sdz 65:144 active ready running
```



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight paths might cause path issues during storage failures.

Recommended Settings

The Oracle Linux 7.5 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, but you can create an empty, zero-byte file by using the following command:

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

The first time you create this file, you might need to enable and start the multipath services:

```
# systemctl enable multipathd
# systemctl start multipathd
```

- There is no requirement to add anything directly to the `multipath.conf` file, unless you have devices that you do not want to be managed by multipath or you have existing settings that override defaults.
- To exclude unwanted devices, add the following syntax to the `multipath.conf` file .

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

Replace the `<DevId>` with the WWID string of the device you want to exclude.

Example

In this example, we are going to determine the WWID of a device and add to the `multipath.conf` file.

Steps

1. Run the following command to determine the WWID:

```
# /lib/udev/scsi_id -gud /dev/sda
360030057024d0730239134810c0cb833
```

`sda` is the local SCSI disk that we need to add it to the blacklist.

2. Add the 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 for legacy settings, especially in the defaults section, that might be overriding the 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 will need to be corrected by later stanzas in the `multipath.conf` file that apply specifically to ONTAP LUNs. If this is not done, the ONTAP LUNs might not work as expected. These defaults should only be overridden in consultation with NetApp and/or an OS vendor and only when the impact is fully understood.

Parameter	Setting
<code>detect_prio</code>	<code>yes</code>
<code>dev_loss_tmo</code>	<code>"infinity"</code>
<code>failback</code>	<code>immediate</code>
<code>fast_io_fail_tmo</code>	<code>5</code>
<code>features</code>	<code>"3 queue_if_no_path pg_init_retries 50"</code>
<code>flush_on_last_del</code>	<code>"yes"</code>
<code>hardware_handler</code>	<code>"0"</code>
<code>path_checker</code>	<code>"tur"</code>
<code>path_grouping_policy</code>	<code>"group_by_prio"</code>
<code>path_selector</code>	<code>"service-time 0"</code>
<code>polling_interval</code>	<code>5</code>
<code>prio</code>	<code>"ontap"</code>
<code>product</code>	<code>LUN.*</code>
<code>retain_attached_hw_handler</code>	<code>yes</code>

Parameter	Setting
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 7.5 RedHat Enterprise Kernel (RHCK), use the [recommended settings](#) for Red Hat Enterprise Linux (RHEL) 7.5.

Known issues

The Oracle Linux 7.5 with ONTAP release has the following known issues:

NetApp Bug ID	Title	Description	Bugzilla ID
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.	N/A
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.	

Use Oracle Linux 7.4 with ONTAP

You can use the ONTAP SAN host configuration settings to configure Oracle Linux 7.4 with ONTAP as the target.

Install the Linux Unified Host Utilities

The NetApp Linux Unified Host Utilities software package is available on the [NetApp Support Site](#) in a 32-bit and 64-bit .rpm file. If you do not know which file is right for your configuration, use the [NetApp Interoperability Matrix Tool](#) to verify which one you need.

NetApp strongly recommends installing the Linux Unified 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.

What you'll need

If you have a version of Linux Unified Host Utilities currently installed you should upgrade it or, you should remove it and use the following steps to install the latest version.

1. Download the 32-bit or 64-bit Linux Unified Host Utilities software package from the [NetApp Support Site](#) to your host.
2. Use the following command to install the software package:

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



You can use the configuration settings provided in this document 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) / vserver (cDOT/FlashRay) Product	lun-pathname	device filename	host adapter	protocol	lun size
data_vserver 120.0g cDOT	/vol/vol1/lun1	/dev/sdb	host16	FCP	
data_vserver 120.0g cDOT	/vol/vol1/lun1	/dev/sdc	host15	FCP	
data_vserver 120.0g cDOT	/vol/vol2/lun2	/dev/sdd	host16	FCP	
data_vserver 120.0g cDOT	/vol/vol2/lun2	/dev/sde	host15	FCP	

SAN Booting

What you'll need

If you decide to use SAN booting, it must be supported by your configuration. You can use the [NetApp 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 is successful.

Multipathing

For Oracle Linux 7.4 the `/etc/multipath.conf` file must exist, but you do not need to make specific changes to the file. Oracle Linux 7.4 is compiled with all settings required to recognize and correctly manage ONTAP LUNs.

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 the higher priorities are Active/Optimized, which means they are serviced by the controller where the aggregate is located. The paths with the lower priorities are active but are non-optimized because they are served from a different controller. The non-optimized paths are only used when no optimized paths are 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='service-time 0' prio=50 status=active
|  |- 11:0:1:0 sdj 8:144 active ready running
|  |- 11:0:2:0 sdr 65:16 active ready running
|-+- policy='service-time 0' prio=10 status=enabled
|  |- 11:0:0:0 sdb 8:i6 active ready running
|  |- 12:0:0:0 sdz 65:144 active ready running
```



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight paths might cause path issues during storage failures.

Recommended Settings

The Oracle Linux 7.4 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, but you can create an empty, zero-byte file by using the following command:

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

The first time you create this file, you might need to enable and start the multipath services:

```
# systemctl enable multipathd
# systemctl start multipathd
```

- There is no requirement to add anything directly to the `multipath.conf` file, unless you have devices that you do not want to be managed by multipath or you have existing settings that override defaults.
- To exclude unwanted devices, add the following syntax to the `multipath.conf` file .

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

Replace the `<DevId>` with the WWID string of the device you want to exclude.

Example

In this example, we are going to determine the WWID of a device and add to the `multipath.conf` file.

Steps

1. Run the following command to determine the WWID:

```
# /lib/udev/scsi_id -gud /dev/sda
360030057024d0730239134810c0cb833
```

sda is the local SCSI disk that we need to add it to the blacklist.

2. Add the 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 for legacy settings, especially in the defaults section, that might be overriding the 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 will need to be corrected by later stanzas in the `multipath.conf` file that apply specifically to ONTAP LUNs. If this is not done, the ONTAP LUNs might not work as expected. These defaults should only be overridden in consultation with NetApp and/or an OS vendor 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"
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

Parameter	Setting
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 7.4 RedHat Enterprise Kernel (RHCK), use the [recommended settings](#) for Red Hat Enterprise Linux (RHEL) 7.4.

Known issues

The Oracle Linux 7.4 with ONTAP release has the following known issues:

NetApp Bug ID	Title	Description	Bugzilla ID
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.	N/A
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: qia2xxx [0000:0c:00.3]-d001:8: Firmware dump saved to temp buffer (8/ffffc90008901000), dump status flags (0x3f)	16039

Use Oracle Linux 7.3 with ONTAP

You can use the ONTAP SAN host configuration settings to configure Oracle Linux 7.3 with ONTAP as the target.

Install the Linux Unified Host Utilities

The NetApp Linux Unified Host Utilities software package is available on the [NetApp Support Site](#) in a 32-bit

and 64-bit .rpm file. If you do not know which file is right for your configuration, use the [NetApp Interoperability Matrix Tool](#) to verify which one you need.

NetApp strongly recommends installing the Linux Unified 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.

What you'll need

If you have a version of Linux Unified Host Utilities currently installed you should upgrade it or, you should remove it and use the following steps to install the latest version.

1. Download the 32-bit or 64-bit Linux Unified Host Utilities software package from the [NetApp Support Site](#) to your host.
2. Use the following command to install the software package:

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



You can use the configuration settings provided in this document 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) / vserver(cDOT/FlashRay) Product	lun-pathname	device filename	host adapter	protocol	lun size
data_vserver 120.0g cDOT	/vol/vol1/lun1	/dev/sdb	host16	FCP	
data_vserver 120.0g cDOT	/vol/vol1/lun1	/dev/sdc	host15	FCP	
data_vserver 120.0g cDOT	/vol/vol2/lun2	/dev/sdd	host16	FCP	
data_vserver 120.0g cDOT	/vol/vol2/lun2	/dev/sde	host15	FCP	

SAN Booting

What you'll need

If you decide to use SAN booting, it must be supported by your configuration. You can use the [NetApp 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 is successful.

Multipathing

For Oracle Linux 7.3 the `/etc/multipath.conf` file must exist, but you do not need to make specific changes to the file. Oracle Linux 7.3 is compiled with all settings required to recognize and correctly manage ONTAP LUNs.

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 the higher priorities are Active/Optimized, which means they are serviced by the controller where the aggregate is located. The paths with the lower priorities are active but are non-optimized because they are served from a different controller. The non-optimized paths are only used when no optimized paths are 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='service-time 0' prio=50 status=active
| |- 11:0:1:0 sdj 8:144 active ready running
| |- 11:0:2:0 sdr 65:16 active ready running
|+- policy='service-time 0' prio=10 status=enabled
|- 11:0:0:0 sdb 8:i6 active ready running
|- 12:0:0:0 sdz 65:144 active ready running
```



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight paths might cause path issues during storage failures.

Recommended Settings

The Oracle Linux 7.3 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, but you can create an empty, zero-byte file by using the following command:

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

The first time you create this file, you might need to enable and start the multipath services:

```
# systemctl enable multipathd
# systemctl start multipathd
```

- There is no requirement to add anything directly to the `multipath.conf` file, unless you have devices that you do not want to be managed by multipath or you have existing settings that override defaults.
- To exclude unwanted devices, add the following syntax to the `multipath.conf` file .

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

Replace the `<DevId>` with the WWID string of the device you want to exclude.

Example

In this example, we are going to determine the WWID of a device and add to the `multipath.conf` file.

Steps

1. Run the following command to determine the WWID:

```
# /lib/udev/scsi_id -gud /dev/sda
360030057024d0730239134810c0cb833
```

`sda` is the local SCSI disk that we need to add it to the blacklist.

2. Add the 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 for legacy settings, especially in the defaults section, that might be overriding the 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 will need to be corrected by later stanzas in the `multipath.conf` file that apply specifically to ONTAP LUNs. If this is not done, the ONTAP LUNs might not work as expected. These defaults should only be overridden in consultation with NetApp and/or an OS vendor and only when the impact is fully understood.

Parameter	Setting
<code>detect_prio</code>	yes
<code>dev_loss_tmo</code>	"infinity"
<code>failback</code>	immediate
<code>fast_io_fail_tmo</code>	5
<code>features</code>	"3 queue_if_no_path pg_init_retries 50"
<code>flush_on_last_del</code>	"yes"
<code>hardware_handler</code>	"0"
<code>path_checker</code>	"tur"
<code>path_grouping_policy</code>	"group_by_prio"
<code>path_selector</code>	"service-time 0"
<code>polling_interval</code>	5
<code>prio</code>	"ontap"
<code>product</code>	LUN.*
<code>retain_attached_hw_handler</code>	yes
<code>rr_weight</code>	"uniform"
<code>user_friendly_names</code>	no
<code>vendor</code>	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 7.3 RedHat Enterprise Kernel (RHCK), use the [recommended settings](#) for Red Hat Enterprise Linux (RHEL) 7.3.

Known issues

There are no known issues for the Oracle Linux 7.3 with ONTAP release.

Use Oracle Linux 7.2 with ONTAP

You can use the ONTAP SAN host configuration settings to configure Oracle Linux 7.2 with ONTAP as the target.

Install the Linux Unified Host Utilities

The NetApp Linux Unified Host Utilities software package is available on the [NetApp Support Site](#) in a 32-bit and 64-bit .rpm file. If you do not know which file is right for your configuration, use the [NetApp Interoperability Matrix Tool](#) to verify which one you need.

NetApp strongly recommends installing the Linux Unified 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.

What you'll need

If you have a version of Linux Unified Host Utilities currently installed you should upgrade it or, you should remove it and use the following steps to install the latest version.

1. Download the 32-bit or 64-bit Linux Unified Host Utilities software package from the [NetApp Support Site](#) to your host.
2. Use the following command to install the software package:

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



You can use the configuration settings provided in this document 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

What you'll need

If you decide to use SAN booting, it must be supported by your configuration. You can use the [NetApp 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 is successful.

Multipathing

Oracle Linux 7.2 supports Unbreakable Enterprise Kernel (UEK) R3 and UEK R4. The OS boots with UEK R3 kernel by default.

Oracle Linux 7.2 UEK R3 Configuration

For Oracle Linux 7.2 UEK R3, create an empty multipath.conf file. The settings for Oracle Linux 7.2 UEK with and without ALUA update automatically by default. To Enable ALUA Handler, perform the following 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_MDYSYFONT=latacyrheb-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 `dracut -f` command to recreate the initrd-image.
4. Reboot the host.
5. Verify the output of the `cat /proc/cmdline` command to ensure that the setting is complete.

Oracle Linux 7.2 UEK R4 Configuration

For Oracle Linux 7.2 UEK R4 the `/etc/multipath.conf` file must exist, but you do not need to make specific changes to the file. Oracle Linux 7.2 is compiled with all settings required to recognize and correctly manage ONTAP LUNs.

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 the higher priorities are Active/Optimized, which means they are serviced by the controller where the aggregate is located. The paths with the lower priorities are active but are non-optimized because they are served from a different controller. The non-optimized paths are only used when no optimized paths are 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='service-time 0' prio=50 status=active
|  |- 11:0:1:0 sdj 8:144 active ready running
|  |- 11:0:2:0 sdr 65:16 active ready running
|-+- policy='service-time 0' prio=10 status=enabled
|  |- 11:0:0:0 sdb 8:i6 active ready running
|  |- 12:0:0:0 sdz 65:144 active ready running
```



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight paths might cause path issues during storage failures.

Recommended Settings

The Oracle Linux 7.2 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, but you can create an empty, zero-byte file by using the following command:

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

The first time you create this file, you might need to enable and start the multipath services:

```
# systemctl enable multipathd
# systemctl start multipathd
```

- There is no requirement to add anything directly to the `multipath.conf` file, unless you have devices that you do not want to be managed by multipath or you have existing settings that override defaults.
- To exclude unwanted devices, add the following syntax to the `multipath.conf` file .

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

Replace the `<DevId>` with the WWID string of the device you want to exclude.

Example

In this example, we are going to determine the WWID of a device and add to the `multipath.conf` file.

Steps

1. Run the following command to determine the WWID:

```
# /lib/udev/scsi_id -gud /dev/sda
360030057024d0730239134810c0cb833
```

sda is the local SCSI disk that we need to add it to the blacklist.

2. Add the 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 for legacy settings, especially in the defaults section, that might be overriding the 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 will need to be corrected by later stanzas in the `multipath.conf` file that apply specifically to ONTAP LUNs. If this is not done, the ONTAP LUNs might not work as expected. These defaults should only be overridden in consultation with NetApp and/or an OS vendor 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"
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

Parameter	Setting
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 7.2 RedHat Enterprise Kernel (RHCK), use the [recommended settings](#) for Red Hat Enterprise Linux (RHEL) 7.2.

Known issues

There are no known issues for the Oracle Linux 7.2 with ONTAP release.

Use Oracle Linux 7.1 with ONTAP

You can use the ONTAP SAN host configuration settings to configure Oracle Linux 7.1 with ONTAP as the target.

Install the Linux Unified Host Utilities

The NetApp Linux Unified Host Utilities software package is available on the [NetApp Support Site](#) in a 32-bit and 64-bit .rpm file. If you do not know which file is right for your configuration, use the [NetApp Interoperability Matrix Tool](#) to verify which one you need.

NetApp strongly recommends installing the Linux Unified 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.

What you'll need

If you have a version of Linux Unified Host Utilities currently installed you should upgrade it or, you should remove it and use the following steps to install the latest version.

1. Download the 32-bit or 64-bit Linux Unified Host Utilities software package from the [NetApp Support Site](#) to your host.
2. Use the following command to install the software package:

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



You can use the configuration settings provided in this document 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) / vserver(cDOT/FlashRay) lun-pathname		device filename	host adapter	lun protocol size	
Product					

data_vserver 120.0g cDOT	/vol/vol1/lun1	/dev/sdb	host16	FCP	
data_vserver 120.0g cDOT	/vol/vol1/lun1	/dev/sdc	host15	FCP	
data_vserver 120.0g cDOT	/vol/vol2/lun2	/dev/sdd	host16	FCP	
data_vserver 120.0g cDOT	/vol/vol2/lun2	/dev/sde	host15	FCP	

SAN Booting

What you'll need

If you decide to use SAN booting, it must be supported by your configuration. You can use the [NetApp 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 is successful.

Multipathing

Oracle Linux 7.1 supports Unbreakable Enterprise Kernel (UEK) R3 and UEK R4. The OS boots with UEK R3 kernel by default.

Oracle Linux 7.1 UEK R3 Configuration

For Oracle Linux 7.1 UEK R3, create an empty `multipath.conf` file. The settings for Oracle Linux 7.1 UEK with and without ALUA update automatically by default. To Enable ALUA Handler, perform the following 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=latacyrheb-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 `dracut -f` command to recreate the `initrd-image`.
4. Reboot the host.
5. Verify the output of the `cat /proc/cmdline` command to ensure that the setting is complete.

Oracle Linux 7.1 UEK R4 Configuration

For Oracle Linux 7.1 UEK R4 the `/etc/multipath.conf` file must exist, but you do not need to make specific changes to the file. Oracle Linux 7.1 is compiled with all settings required to recognize and correctly manage ONTAP LUNs.

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 the higher priorities are Active/Optimized, which means they are serviced by the controller where the aggregate is located. The paths with the lower priorities are active but are non-optimized because they are served from a different controller. The non-optimized paths are only used when no optimized paths are 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='service-time 0' prio=50 status=active
|  |- 11:0:1:0 sdj 8:144 active ready running
|  |- 11:0:2:0 sdr 65:16 active ready running
|+- policy='service-time 0' prio=10 status=enabled
|  |- 11:0:0:0 sdb 8:i6 active ready running
|  |- 12:0:0:0 sdz 65:144 active ready running
```



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight paths might cause path issues during storage failures.

Recommended Settings

The Oracle Linux 7.1 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, but you can create an empty, zero-byte file by using the following command:

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

The first time you create this file, you might need to enable and start the multipath services:

```
# systemctl enable multipathd
# systemctl start multipathd
```

- There is no requirement to add anything directly to the `multipath.conf` file, unless you have devices that you do not want to be managed by multipath or you have existing settings that override defaults.
- To exclude unwanted devices, add the following syntax to the `multipath.conf` file .

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

Replace the `<DevId>` with the WWID string of the device you want to exclude.

Example

In this example, we are going to determine the WWID of a device and add to the `multipath.conf` file.

Steps

1. Run the following command to determine the WWID:

```
# /lib/udev/scsi_id -gud /dev/sda
360030057024d0730239134810c0cb833
```

sda is the local SCSI disk that we need to add it to the blacklist.

2. Add the 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 for legacy settings, especially in the defaults section, that might be overriding the 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 will need to be corrected by later stanzas in the `multipath.conf` file that apply specifically to ONTAP LUNs. If this is not done, the ONTAP LUNs might not work as expected. These defaults should only be overridden in consultation with NetApp and/or an OS vendor 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"
path_checker	"tur"
path_grouping_policy	"group_by_prio"
path_selector	"service-time 0"
polling_interval	5
prio	"ontap"
product	LUN.*

Parameter	Setting
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 7.1 RedHat Enterprise Kernel (RHCK), use the [recommended settings](#) for Red Hat Enterprise Linux (RHEL) 7.1.

Known issues

There are no known issues for the Oracle Linux 7.1 with ONTAP release.

Use Oracle Linux 7.0 with ONTAP

You can use the ONTAP SAN host configuration settings to configure Oracle Linux 7.0 with ONTAP as the target.

Install the Linux Unified Host Utilities

The NetApp Linux Unified Host Utilities software package is available on the [NetApp Support Site](#) in a 32-bit and 64-bit .rpm file. If you do not know which file is right for your configuration, use the [NetApp Interoperability Matrix Tool](#) to verify which one you need.

NetApp strongly recommends installing the Linux Unified 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.

What you'll need

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2. Use the following command to install the software package:

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



You can use the configuration settings provided in this document 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) / vserver(cDOT/FlashRay) Product	lun-pathname	device filename	host adapter	protocol	lun size
data_vserver 120.0g cDOT	/vol/vol1/lun1	/dev/sdb	host16	FCP	
data_vserver 120.0g cDOT	/vol/vol1/lun1	/dev/sdc	host15	FCP	
data_vserver 120.0g cDOT	/vol/vol2/lun2	/dev/sdd	host16	FCP	
data_vserver 120.0g cDOT	/vol/vol2/lun2	/dev/sde	host15	FCP	

SAN Booting

What you'll need

If you decide to use SAN booting, it must be supported by your configuration. You can use the [NetApp 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 is successful.

Multipathing

For Oracle Linux 7.0 the `/etc/multipath.conf` file must exist, but you do not need to make specific changes to the file. Oracle Linux 7.0 is compiled with all settings required to recognize and correctly manage ONTAP LUNs. To Enable ALUA Handler, perform the following 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=latacyrheb-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` with the `dracut -f` command.
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 the higher priorities are Active/Optimized, which means they are serviced by the controller where the aggregate is located. The paths with the lower priorities are active but are non-optimized because they are served from a different controller. The non-optimized paths are only used when no optimized paths are 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='service-time 0' prio=50 status=active
|  |- 11:0:1:0 sdj 8:144 active ready running
|  |- 11:0:2:0 sdr 65:16 active ready running
|-+- policy='service-time 0' prio=10 status=enabled
|  |- 11:0:0:0 sdb 8:i6 active ready running
|  |- 12:0:0:0 sdz 65:144 active ready running
```



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight paths might cause path issues during storage failures.

Recommended Settings

The Oracle Linux 7.0 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, but you can create an empty, zero-byte file by using the following command:

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

The first time you create this file, you might need to enable and start the multipath services:

```
# systemctl enable multipathd
# systemctl start multipathd
```

- There is no requirement to add anything directly to the `multipath.conf` file, unless you have devices that you do not want to be managed by multipath or you have existing settings that override defaults.
- To exclude unwanted devices, add the following syntax to the `multipath.conf` file .

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

Replace the `<DevId>` with the WWID string of the device you want to exclude.

Example

In this example, we are going to determine the WWID of a device and add to the `multipath.conf` file.

Steps

1. Run the following command to determine the WWID:

```
# /lib/udev/scsi_id -gud /dev/sda
360030057024d0730239134810c0cb833
```

sda is the local SCSI disk that we need to add it to the blacklist.

2. Add the 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 for legacy settings, especially in the defaults section, that might be overriding the 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 will need to be corrected by later stanzas in the `multipath.conf` file that apply specifically to ONTAP LUNs. If this is not done, the ONTAP LUNs might not work as expected. These defaults should only be overridden in consultation with NetApp and/or an OS vendor 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"
path_checker	"tur"
path_grouping_policy	"group_by_prio"
path_selector	"service-time 0"
polling_interval	5
prio	"ontap"
product	LUN.*

Parameter	Setting
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 7.0 RedHat Enterprise Kernel (RHCK), use the [recommended settings](#) for Red Hat Enterprise Linux (RHEL) 7.0.

Known issues

The Oracle Linux 7.0 with ONTAP release has the following known issues:

NetApp Bug ID	Title	Description	Bugzilla ID
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.	14898
901557	OL 7.0: High IO outage observed on QLogic 8G FC (QLE2562) SAN host during storage failover operations with IO	You might observe high IO outage on QLogic 8G FC (QLE2562) host during storage failover operations with IO. Aborts and Device resets manifests as IO outage on the host. Probability of hitting this IO outage is high.	14894
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.	14860

NetApp Bug ID	Title	Description	Bugzilla ID
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.	14870
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.	14871
916501	Qlogic 10G FCoE (QLE8152) host kernel crash observed during storage failover operations with IO	You may observe a kernel crash in Qlogic driver module on 10G FCoE Qlogic (QLE8152) host. The crash occurs during storage failover operations with IO. Probability of hitting this crash is high which leads to longer IO outage on the host.	15019

OL 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 Unified Host Utilities

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NetApp strongly recommends installing the Linux Unified 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.

What you'll need

If you have a version of Linux Unified Host Utilities currently installed you should upgrade it or, you should remove it and use the following steps to install the latest version.

1. Download the 32-bit or 64-bit Linux Unified Host Utilities software package from the [NetApp Support Site](#) to your host.
2. Use the following command to install the software package:

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



You can use the configuration settings provided in this document 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) / vserver (cDOT/FlashRay) Product	lun-pathname	device filename	host adapter	protocol	lun size
data_vserver 120.0g cDOT	/vol/vol1/lun1	/dev/sdb	host16	FCP	
data_vserver 120.0g cDOT	/vol/vol1/lun1	/dev/sdc	host15	FCP	
data_vserver 120.0g cDOT	/vol/vol2/lun2	/dev/sdd	host16	FCP	
data_vserver 120.0g cDOT	/vol/vol2/lun2	/dev/sde	host15	FCP	

SAN Booting

What you'll need

If you decide to use SAN booting, it must be supported by your configuration. You can use the [NetApp 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 is 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_MDYSYFONT=lataarcyrb-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 the higher priorities are Active/Optimized, which means they are serviced by the controller where the aggregate is located. The paths with the lower priorities are active but are non-optimized because they are served from a different controller. The non-optimized paths are only used when no optimized paths are 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
```



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight 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, but you can create an empty, zero-byte file by using the following command:


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

The first time you create this file, you might need to enable and start the multipath services.

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

- There is no requirement to add anything 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.
- You can add the following syntax to the `multipath.conf` file to exclude the unwanted devices:
 - Replace the `<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 this example, `sda` is the local SCSI disk that we need 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 for legacy settings, especially in the defaults section, 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. If this is not done, the ONTAP LUNs might not work as expected. You should only override these defaults in consultation with NetApp and/or the OS vendor and only when the impact is fully understood.

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

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 RedHat Enterprise 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 (Red Hat compatible kernel) known issues, see the [known issues](#) for Red Hat Enterprise Linux (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 Unified Host Utilities

The NetApp Linux Unified Host Utilities software package is available on the [NetApp Support Site](#) in a 32-bit and 64-bit .rpm file. If you do not know which file is right for your configuration, use the [NetApp Interoperability Matrix Tool](#) to verify which one you need.

NetApp strongly recommends installing the Linux Unified 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.

What you'll need

If you have a version of Linux Unified Host Utilities currently installed you should upgrade it or, you should remove it and use the following steps to install the latest version.

1. Download the 32-bit or 64-bit Linux Unified Host Utilities software package from the [NetApp Support Site](#) to your host.
2. Use the following command to install the software package:

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



You can use the configuration settings provided in this document 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

What you'll need

If you decide to use SAN booting, it must be supported by your configuration. You can use the [NetApp 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 is 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:

```
rdloadddriver=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=lataarcyrb-heb-sun16 crashkernel=256M KEYBOARDTYPE=pc
KEYTABLE=us rd_LVM_LV=vg_ibmx3550m421096/lv_swap rd_NO_DM rhgb quiet
rdloadddriver=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 the higher priorities are Active/Optimized, which means they are serviced by the controller where the aggregate is located. The paths with the lower priorities are active but are non-optimized because they are served from a different controller. The non-optimized paths are only used when no optimized paths are 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
```



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight 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, but you can create an empty, zero-byte file by using the following command:

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

The first time you create this file, you might need to enable and start the multipath services.

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

- There is no requirement to add anything 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.
- You can add the following syntax to the `multipath.conf` file to exclude the unwanted devices:
 - Replace the `<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 this example, `sda` is the local SCSI disk that we need 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 for legacy settings, especially in the defaults section, 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. If this is not done, the ONTAP LUNs might not work as expected. You should only override these defaults in consultation with NetApp and/or the OS vendor and only when the impact is fully understood.

Parameter	Setting
<code>detect_prio</code>	yes
<code>dev_loss_tmo</code>	"infinity"
<code>failback</code>	immediate
<code>fast_io_fail_tmo</code>	5
<code>features</code>	"3 queue_if_no_path pg_init_retries 50"
<code>flush_on_last_del</code>	"yes"
<code>hardware_handler</code>	"0"
<code>no_path_retry</code>	queue
<code>path_checker</code>	"tur"
<code>path_grouping_policy</code>	"group_by_prio"
<code>path_selector</code>	"round-robin 0"
<code>polling_interval</code>	5
<code>prio</code>	"ontap"
<code>product</code>	LUN.*
<code>retain_attached_hw_handler</code>	yes
<code>rr_weight</code>	"uniform"
<code>user_friendly_names</code>	no
<code>vendor</code>	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 6.9 RedHat Enterprise Kernel (RHCK), use the [recommended settings](#) for Red Hat Enterprise Linux (RHEL) 6.9.

Known issues

The Oracle Linux 6.9 with ONTAP release has the following known issues:

NetApp Bug ID	Title	Description	Bugzilla ID
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).	16039



For Oracle Linux (Red Hat compatible kernel) known issues, see the [known issues](#) for Red Hat Enterprise Linux (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 Unified Host Utilities

The NetApp Linux Unified Host Utilities software package is available on the [NetApp Support Site](#) in a 32-bit and 64-bit .rpm file. If you do not know which file is right for your configuration, use the [NetApp Interoperability Matrix Tool](#) to verify which one you need.

NetApp strongly recommends installing the Linux Unified 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.

What you'll need

If you have a version of Linux Unified Host Utilities currently installed you should upgrade it or, you should remove it and use the following steps to install the latest version.

1. Download the 32-bit or 64-bit Linux Unified Host Utilities software package from the [NetApp Support Site](#) to your host.
2. Use the following command to install the software package:

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



You can use the configuration settings provided in this document 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) / vserver (cDOT/FlashRay) Product	lun-pathname	device filename	host adapter	protocol	lun size
data_vserver 120.0g cDOT	/vol/vol1/lun1	/dev/sdb	host16	FCP	
data_vserver 120.0g cDOT	/vol/vol1/lun1	/dev/sdc	host15	FCP	
data_vserver 120.0g cDOT	/vol/vol2/lun2	/dev/sdd	host16	FCP	
data_vserver 120.0g cDOT	/vol/vol2/lun2	/dev/sde	host15	FCP	

SAN Booting

What you'll need

If you decide to use SAN booting, it must be supported by your configuration. You can use the [NetApp 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 is 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=latacyrheb-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 the higher priorities are Active/Optimized, which means they are serviced by the controller where the aggregate is located. The paths with the lower priorities are active but are non-optimized because they are served from a different controller. The non-optimized paths are only used when no optimized paths are 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
```



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight 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, but you can create an empty, zero-byte file by using the following command:

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

The first time you create this file, you might need to enable and start the multipath services.

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

- There is no requirement to add anything 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.
- You can add the following syntax to the `multipath.conf` file to exclude the unwanted devices:
 - Replace the `<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 this example, `sda` is the local SCSI disk that we need 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 for legacy settings, especially in the defaults section, 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. If this is not done, the ONTAP LUNs might not work as expected. You should only override these defaults in consultation with NetApp and/or the OS vendor and only when the impact is fully understood.

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

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 6.8 RedHat Enterprise Kernel (RHCK), use the [recommended settings](#) for Red Hat Enterprise Linux (RHEL) 6.8.

Known issues

There are no known issues for the Oracle Linux 6.8 with ONTAP release.



For Oracle Linux (Red Hat compatible kernel) known issues, see the [known issues](#) for Red Hat Enterprise Linux (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 Unified Host Utilities

The NetApp Linux Unified Host Utilities software package is available on the [NetApp Support Site](#) in a 32-bit and 64-bit .rpm file. If you do not know which file is right for your configuration, use the [NetApp Interoperability Matrix Tool](#) to verify which one you need.

NetApp strongly recommends installing the Linux Unified 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.

What you'll need

If you have a version of Linux Unified Host Utilities currently installed you should upgrade it or, you should remove it and use the following steps to install the latest version.

1. Download the 32-bit or 64-bit Linux Unified Host Utilities software package from the [NetApp Support Site](#) to your host.
2. Use the following command to install the software package:

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



You can use the configuration settings provided in this document 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

What you'll need

If you decide to use SAN booting, it must be supported by your configuration. You can use the [NetApp 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 is 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:

```
rdloadaddriver=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=lataarcyrb-heb-sun16 crashkernel=256M KEYBOARDTYPE=pc
KEYTABLE=us rd_LVM_LV=vg_ibmx3550m421096/lv_swap rd_NO_DM rhgb quiet
rdloadaddriver=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 the higher priorities are Active/Optimized, which means they are serviced by the controller where the aggregate is located. The paths with the lower priorities are active but are non-optimized because they are served from a different controller. The non-optimized paths are only used when no optimized paths are 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
```




Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight 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, but you can create an empty, zero-byte file by using the following command:

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

The first time you create this file, you might need to enable and start the multipath services.

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

- There is no requirement to add anything 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.
- You can add the following syntax to the `multipath.conf` file to exclude the unwanted devices:
 - Replace the `<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 this example, `sda` is the local SCSI disk that we need 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 for legacy settings, especially in the defaults section, 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. If this is not done, the ONTAP LUNs might not work as expected. You should only override these defaults in consultation with NetApp and/or the OS vendor and only when the impact is fully understood.

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

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 RedHat Enterprise Kernel (RHCK), use the [recommended settings](#) for Red Hat Enterprise Linux (RHEL) 6.7.

Known issues

There are no known issues for the Oracle Linux 6.7 with ONTAP release.



For Oracle Linux (Red Hat compatible kernel) known issues, see the [known issues](#) for Red Hat Enterprise Linux (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 Unified Host Utilities

The NetApp Linux Unified Host Utilities software package is available on the [NetApp Support Site](#) in a 32-bit and 64-bit .rpm file. If you do not know which file is right for your configuration, use the [NetApp Interoperability Matrix Tool](#) to verify which one you need.

NetApp strongly recommends installing the Linux Unified 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.

What you'll need

If you have a version of Linux Unified Host Utilities currently installed you should upgrade it or, you should remove it and use the following steps to install the latest version.

1. Download the 32-bit or 64-bit Linux Unified Host Utilities software package from the [NetApp Support Site](#) to your host.
2. Use the following command to install the software package:

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



You can use the configuration settings provided in this document 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

What you'll need

If you decide to use SAN booting, it must be supported by your configuration. You can use the [NetApp 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 is 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:

```
rdloadaddriver=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=lataarcyrb-heb-sun16 crashkernel=256M KEYBOARDTYPE=pc
KEYTABLE=us rd_LVM_LV=vg_ibmx3550m421096/lv_swap rd_NO_DM rhgb quiet
rdloadaddriver=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 the higher priorities are Active/Optimized, which means they are serviced by the controller where the aggregate is located. The paths with the lower priorities are active but are non-optimized because they are served from a different controller. The non-optimized paths are only used when no optimized paths are 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
```



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight 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, but you can create an empty, zero-byte file by using the following command:

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

The first time you create this file, you might need to enable and start the multipath services.

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

- There is no requirement to add anything 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.
- You can add the following syntax to the `multipath.conf` file to exclude the unwanted devices:
 - Replace the `<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 this example, `sda` is the local SCSI disk that we need 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 for legacy settings, especially in the defaults section, 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. If this is not done, the ONTAP LUNs might not work as expected. You should only override these defaults in consultation with NetApp and/or the OS vendor and only when the impact is fully understood.

Parameter	Setting
<code>detect_prio</code>	yes
<code>dev_loss_tmo</code>	"infinity"
<code>failback</code>	immediate
<code>fast_io_fail_tmo</code>	5
<code>features</code>	"3 queue_if_no_path pg_init_retries 50"
<code>flush_on_last_del</code>	"yes"
<code>hardware_handler</code>	"0"
<code>no_path_retry</code>	queue
<code>path_checker</code>	"tur"
<code>path_grouping_policy</code>	"group_by_prio"
<code>path_selector</code>	"round-robin 0"
<code>polling_interval</code>	5
<code>prio</code>	"ontap"
<code>product</code>	LUN.*
<code>retain_attached_hw_handler</code>	yes
<code>rr_weight</code>	"uniform"
<code>user_friendly_names</code>	no
<code>vendor</code>	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 RedHat Enterprise Kernel (RHCK), use the [recommended settings](#) for Red Hat Enterprise Linux (RHEL) 6.6.

Known issues

There are no known issues for the Oracle Linux 6.6 with ONTAP release.



For Oracle Linux (Red Hat compatible kernel) known issues, see the [known issues](#) for Red Hat Enterprise Linux (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 Unified Host Utilities

The NetApp Linux Unified Host Utilities software package is available on the [NetApp Support Site](#) in a 32-bit and 64-bit .rpm file. If you do not know which file is right for your configuration, use the [NetApp Interoperability Matrix Tool](#) to verify which one you need.

NetApp strongly recommends installing the Linux Unified 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.

What you'll need

If you have a version of Linux Unified Host Utilities currently installed you should upgrade it or, you should remove it and use the following steps to install the latest version.

1. Download the 32-bit or 64-bit Linux Unified Host Utilities software package from the [NetApp Support Site](#) to your host.
2. Use the following command to install the software package:

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




You can use the configuration settings provided in this document 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

What you'll need

If you decide to use SAN booting, it must be supported by your configuration. You can use the [NetApp 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 is 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=latacyrheb-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 the higher priorities are Active/Optimized, which means they are serviced by the controller where the aggregate is located. The paths with the lower priorities are active but are non-optimized because they are served from a different controller. The non-optimized paths are only used when no optimized paths are 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
```



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight 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, but you can create an empty, zero-byte file by using the following command:

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

The first time you create this file, you might need to enable and start the multipath services.

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

- There is no requirement to add anything 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.
- You can add the following syntax to the `multipath.conf` file to exclude the unwanted devices:
 - Replace the `<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 this example, `sda` is the local SCSI disk that we need 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 for legacy settings, especially in the defaults section, 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. If this is not done, the ONTAP LUNs might not work as expected. You should only override these defaults in consultation with NetApp and/or the OS vendor and only when the impact is fully understood.

Parameter	Setting
<code>detect_prio</code>	yes
<code>dev_loss_tmo</code>	"infinity"
<code>failback</code>	immediate
<code>fast_io_fail_tmo</code>	5
<code>features</code>	"3 queue_if_no_path pg_init_retries 50"
<code>flush_on_last_del</code>	"yes"
<code>hardware_handler</code>	"0"
<code>no_path_retry</code>	queue
<code>path_checker</code>	"tur"
<code>path_grouping_policy</code>	"group_by_prio"
<code>path_selector</code>	"round-robin 0"
<code>polling_interval</code>	5
<code>prio</code>	"ontap"
<code>product</code>	LUN.*
<code>retain_attached_hw_handler</code>	yes
<code>rr_weight</code>	"uniform"
<code>user_friendly_names</code>	no
<code>vendor</code>	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 6.5 RedHat Enterprise Kernel (RHCK), use the [recommended settings](#) for Red Hat Enterprise Linux (RHEL) 6.5.

Known issues

There are no known issues for the Oracle Linux 6.5 with ONTAP release.



For Oracle Linux (Red Hat compatible kernel) known issues, see the [known issues](#) for Red Hat Enterprise Linux (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 Unified Host Utilities

The NetApp Linux Unified Host Utilities software package is available on the [NetApp Support Site](#) in a 32-bit and 64-bit .rpm file. If you do not know which file is right for your configuration, use the [NetApp Interoperability Matrix Tool](#) to verify which one you need.

NetApp strongly recommends installing the Linux Unified 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.

What you'll need

If you have a version of Linux Unified Host Utilities currently installed you should upgrade it or, you should remove it and use the following steps to install the latest version.

1. Download the 32-bit or 64-bit Linux Unified Host Utilities software package from the [NetApp Support Site](#) to your host.
2. Use the following command to install the software package:

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



You can use the configuration settings provided in this document 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

What you'll need

If you decide to use SAN booting, it must be supported by your configuration. You can use the [NetApp 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 is 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=lataarcyrb-heb-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 the higher priorities are Active/Optimized, which means they are serviced by the controller where the aggregate is located. The paths with the lower priorities are active but are non-optimized because they are served from a different controller. The non-optimized paths are only used when no optimized paths are 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
```



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight 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, but you can create an empty, zero-byte file by using the following command:

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

The first time you create this file, you might need to enable and start the multipath services.

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

- There is no requirement to add anything 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.
- You can add the following syntax to the `multipath.conf` file to exclude the unwanted devices:
 - Replace the `<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 this example, `sda` is the local SCSI disk that we need 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 for legacy settings, especially in the defaults section, 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. If this is not done, the ONTAP LUNs might not work as expected. You should only override these defaults in consultation with NetApp and/or the OS vendor and only when the impact is fully understood.

Parameter	Setting
<code>detect_prio</code>	yes
<code>dev_loss_tmo</code>	"infinity"
<code>failback</code>	immediate
<code>fast_io_fail_tmo</code>	5
<code>features</code>	"3 queue_if_no_path pg_init_retries 50"
<code>flush_on_last_del</code>	"yes"
<code>hardware_handler</code>	"0"
<code>no_path_retry</code>	queue
<code>path_checker</code>	"tur"
<code>path_grouping_policy</code>	"group_by_prio"
<code>path_selector</code>	"round-robin 0"
<code>polling_interval</code>	5
<code>prio</code>	"ontap"
<code>product</code>	LUN.*
<code>retain_attached_hw_handler</code>	yes
<code>rr_weight</code>	"uniform"
<code>user_friendly_names</code>	no
<code>vendor</code>	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 6.4 RedHat Enterprise Kernel (RHCK), use the [recommended settings](#) for Red Hat Enterprise Linux (RHEL) 6.4.

Known issues

The Oracle Linux 6.4 with ONTAP release has the following known issues:

NetApp Bug ID	Title	Description	Bugzilla ID
713555	QLogic adapter resets are seen on OL6.4 and OL5.9 with UEK2 on controller faults such as takeover/giveback, and reboot	<p>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.</p> <p>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.</p> <p>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</p>	13999

NetApp Bug ID	Title	Description	Bugzilla ID
715217	Delay in path recovery on OL6.4 or OL5.9 hosts with UEK2 may result in delayed I/O resumption on controller or fabric faults	<p>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).</p> <p>Sometimes, during the paths recovering to active state, the following lpfc driver errors are also seen:</p> <pre>kernel: sd 0:0:8:3: [sdl] Result: hostbyte=DID_ERROR driverbyte=DRIVER_OK</pre> <p>Due to this delay in path recovery during fault events, the I/O resumption also delays.</p> <p>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</p> <p>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</p>	14001

NetApp Bug ID	Title	Description	Bugzilla ID
709911	DM Multipath on OL6.4 & OL5.9 iSCSI with UEK2 kernel takes long time to update LUN path status after storage faults	<p>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).</p> <p>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."</p> <p>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</p> <p>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</p>	13984

NetApp Bug ID	Title	Description	Bugzilla ID
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	<p>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:</p> <pre># sg_inq -v /dev/mapper/3600a09804 1764937303f436c753243 70 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/3600a09804 1764937303f436c753243 70 #</pre> <p>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:</p> <p>OL6.4 versions:</p>	14082
348			



For Oracle Linux (Red Hat compatible kernel) known issues, see the [known issues](#) for Red Hat Enterprise Linux (RHEL) 6.4.

RHEL

Release notes

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 does not 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

Use Red Hat Enterprise Linux 9.3 with ONTAP

You can use the ONTAP SAN host configuration settings to configure Red Hat Enterprise Linux 9.3 with ONTAP as the target.

Install the Linux Unified Host Utilities

The NetApp Linux Unified Host Utilities software package is available on the [NetApp Support Site](#) in a 64-bit .rpm file.

NetApp strongly recommends installing the Linux Unified 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.

What you'll need

If you have a version of Linux Unified Host Utilities currently installed, you should upgrade or remove it, and then use the following steps to install the latest version.

Steps

1. Download the 64-bit Linux Unified 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 Tool Kit

The tool kit 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.

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
-----
-----
vs_147_32glpe           /vol/vol1/lun  /dev/sdb   Host11   FCP       10g
cDOT
vs_147_32glpe           /vol/vol1/lun  /dev/sdx   Host11   FCP       10g
cDOT
vs_147_32glpe           /vol/vol2/lun  /dev/sdbt  host12   FCP       10g
cDOT
vs_147_32glpe           /vol/vol2/lun  /dev/sdax  host12   FCP       10g
cDOT
```

SAN booting

What you'll need

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

Multipathing

For Red Hat Enterprise Linux (RHEL) 9.3, the `/etc/multipath.conf` file must exist, but you do not need to make specific changes to the file. RHEL 9.3 is compiled with all the settings that are required to recognize and correctly manage ONTAP LUNs.

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

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

All SAN Array configurations

In All SAN Array (ASA) configurations, all paths to a given LUN are active and optimized. 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
3600a098038314359725d516c69733471 dm-22 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
| - 11:0:3:0 sdau 66:224 active ready running
| - 12:0:4:0 sdco 69:192 active ready running
| - 12:0:0:0 sdav 66:240 active ready running
`- 11:0:2:0 sdat 66:208 active ready running
```



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight 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 the higher priorities are Active/Optimized, meaning they are serviced by the controller where the aggregate is located. The paths with the lower priorities are active but are non-optimized because they are served from a different controller. The non-optimized paths are only used when no optimized paths are 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
3600a0980383149783224544d334a644d dm-10 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
| | - 12:0:0:18 sdbj 67:208 active ready running
| ` - 11:0:1:18 sdan 66:112 active ready running
`-+- policy='service-time 0' prio=10 status=enabled
| - 11:0:0:18 sdt 65:48 active ready running
`- 12:0:3:18 sdcf 69:48 active ready running
```



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight paths might cause path issues during storage failures.

Recommended settings

The RHEL 9.3 OS is compiled to recognize ONTAP LUNs and automatically set all configuration parameters correctly for both ASA and non-ASA configurations. You can further optimize performance for your host configuration with the following recommended settings.

The `multipath.conf` file must exist for the multipath daemon to start, but you can create an empty, zero-byte file by using the following command:

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

The first time you create this file, you might need to enable and start the multipath services:

```
# systemctl enable multipathd
# systemctl start multipathd
```

- There is no requirement to add anything directly to the `multipath.conf` file, unless you have devices that you do not want to be managed by multipath or you have existing settings that override defaults.
- To exclude unwanted devices, add the following syntax to the `multipath.conf` file .

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

Replace the `<DevId>` with the WWID string of the device you want to exclude.

Example

In this example, we are going to determine the WWID of a device and add to the `multipath.conf` file.

Steps

1. Run the following command to determine the WWID:

```
# /lib/udev/scsi_id -gud /dev/sda
360030057024d0730239134810c0cb833
```

`sda` is the local SCSI disk that we need to add it to the blacklist.

2. Add the 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 for legacy settings, especially in the defaults section, that might be overriding the 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 will need to be corrected by later stanzas in the `multipath.conf` file that apply specifically to ONTAP LUNs. If this is not done, the ONTAP LUNs might not work as expected. These defaults should only be overridden in consultation with NetApp and/or an OS vendor and only when the impact is fully understood.

Parameter	Setting
<code>detect_prio</code>	yes
<code>dev_loss_tmo</code>	"infinity"
<code>failback</code>	immediate
<code>fast_io_fail_tmo</code>	5
<code>features</code>	"2 pg_init_retries 50"
<code>flush_on_last_del</code>	"yes"
<code>hardware_handler</code>	"0"
<code>no_path_retry</code>	queue
<code>path_checker</code>	"tur"
<code>path_grouping_policy</code>	"group_by_prio"
<code>path_selector</code>	"service-time 0"
<code>polling_interval</code>	5
<code>prio</code>	"ontap"
<code>product</code>	LUN.*
<code>retain_attached_hw_handler</code>	yes
<code>rr_weight</code>	"uniform"
<code>user_friendly_names</code>	no
<code>vendor</code>	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 other SAN arrays are 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
  }
}
```

KVM settings

You can use the recommended settings to configure Kernel-based Virtual Machine (KVM) as well. There are no changes required to configure KVM as the LUN is mapped to the hypervisor.

Known issues

The RHEL 9.3 with ONTAP 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 <code>sanlun fcp show adapter -v</code> 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

Use Red Hat Enterprise Linux 9.2 with ONTAP

You can use the ONTAP SAN host configuration settings to configure Red Hat Enterprise Linux 9.2 with ONTAP as the target.

Install the Linux Unified Host Utilities

The NetApp Linux Unified Host Utilities software package is available on the [NetApp Support Site](#) in a 64-bit .rpm file.

NetApp strongly recommends installing the Linux Unified 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.

What you'll need

If you have a version of Linux Unified Host Utilities currently installed, you should upgrade or remove it, and then use the following steps to install the latest version.

Steps

- 1. Download the 64-bit Linux Unified 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 Tool Kit

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) / vserver(cDOT/FlashRay) lun-pathname		device filename	host adapter	protocol	lun 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

What you'll need

If you decide to use SAN booting, it must be supported by your configuration. You can use the [NetApp 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 is successful.

Multipathing

For Red Hat Enterprise Linux (RHEL) 9.2, the `/etc/multipath.conf` file must exist, but you do not need to make specific changes to the file. RHEL 9.2 is compiled with all settings required to recognize and correctly manage ONTAP LUNs.

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

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

All SAN Array configurations

In All SAN Array (ASA) configurations, all paths to a given LUN are active and optimized. 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
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='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
```



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight 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 the higher priorities are Active/Optimized, meaning they are serviced by the controller where the aggregate is located. The paths with the lower priorities are active but are non-optimized because they are served from a different controller. The non-optimized paths are only used when no optimized paths are 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='service-time 0' prio=50 status=active
|  |- 11:0:1:0 sdj 8:144 active ready running
|  |- 11:0:2:0 sdr 65:16 active ready running
`--+- policy='service-time 0' prio=10 status=enabled
|  |- 11:0:0:0 sdb 8:i6 active ready running
|  |- 12:0:0:0 sdz 65:144 active ready running
```



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight paths might cause path issues during storage failures.

Recommended settings

The RHEL 9.2 OS is compiled to recognize ONTAP LUNs and automatically set all configuration parameters correctly for both ASA and non-ASA configurations. You can further optimize performance for your host configuration with the following recommended settings.

The `multipath.conf` file must exist for the multipath daemon to start, but you can create an empty, zero-byte file by using the following command:

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

The first time you create this file, you might need to enable and start the multipath services:

```
# systemctl enable multipathd
# systemctl start multipathd
```

- There is no requirement to add anything directly to the `multipath.conf` file, unless you have devices that you do not want to be managed by multipath or you have existing settings that override defaults.
- To exclude unwanted devices, add the following syntax to the `multipath.conf` file .

```

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

```

Replace the <DevId> with the WWID string of the device you want to exclude.

Example

In this example, we are going to determine the WWID of a device and add to the `multipath.conf` file.

Steps

1. Run the following command to determine the WWID:

```

# /lib/udev/scsi_id -gud /dev/sda
360030057024d0730239134810c0cb833

```

`sda` is the local SCSI disk that we need to add it to the blacklist.

2. Add the 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 for legacy settings, especially in the defaults section, that might be overriding the 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 will need to be corrected by later stanzas in the `multipath.conf` file that apply specifically to ONTAP LUNs. If this is not done, the ONTAP LUNs might not work as expected. These defaults should only be overridden in consultation with NetApp and/or an OS vendor and only when the impact is fully understood.

Parameter	Setting
<code>detect_prio</code>	yes
<code>dev_loss_tmo</code>	"infinity"
<code>failback</code>	immediate
<code>fast_io_fail_tmo</code>	5

Parameter	Setting
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

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 other SAN arrays are 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
    }
}
```

KVM settings

You can use the recommended settings to configure Kernel-based Virtual Machine (KVM) as well. There are no changes required to configure KVM as the LUN is mapped to the hypervisor.

Known issues

The RHEL 9.2 with ONTAP release has the following known issues:

NetApp Bug ID	Title	Description	Bugzilla ID
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 <code>sanlun fcp show adapter -v</code> fails because the library package dependencies to support HBA discovery cannot be found.	Not Applicable
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 <code>kdump</code> is configured, it generates the <code>vmcore</code> file under the <code>/var/crash/</code> directory. The issue is being triaged with the <code>lpfc</code> driver but it cannot be reproduced consistently.	2173947

Use Red Hat Enterprise Linux 9.1 with ONTAP

You can use the ONTAP SAN host configuration settings to configure Red Hat Enterprise Linux 9.1 with ONTAP as the target.

Install the Linux Unified Host Utilities

The NetApp Linux Unified Host Utilities software package is available on the [NetApp Support Site](#) in a 64-bit .rpm file.

Install the Linux Unified Host Utilities is strongly recommended by NetApp, but 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.

What you'll need

If you have a version of Linux Unified Host Utilities currently installed, you should upgrade or remove it and use the following steps to install the latest version.

Steps

1. Download the 64-bit Linux Unified 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 document 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
vservers(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

What you'll need

If you decide to use SAN booting, it must be supported by your configuration. You can use the [NetApp 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 is successful.

Multipathing

For Red Hat Enterprise Linux (RHEL) 9.1 the `/etc/multipath.conf` file must exist, but you do not need to make specific changes to the file. RHEL 9.1 is compiled with all settings required to recognize and correctly manage ONTAP LUNs.

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

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

All SAN Array configurations

In All SAN Array (ASA) configurations, all paths to a given LUN are active and optimized. 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
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='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
```



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight 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 the higher priorities are Active/Optimized, meaning they are serviced by the controller where the aggregate is located. The paths with the lower priorities are active but are non-optimized because they are served from a different controller. The non-optimized paths are only used when no optimized paths are 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='service-time 0' prio=50 status=active
| |- 11:0:1:0 sdj 8:144 active ready running
| |- 11:0:2:0 sdr 65:16 active ready running
`+- policy='service-time 0' prio=10 status=enabled
|- 11:0:0:0 sdb 8:i6 active ready running
|- 12:0:0:0 sdz 65:144 active ready running
```



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight paths might cause path issues during storage failures.

Recommended settings

The RHEL 9.1 OS is compiled to recognize ONTAP LUNs and automatically set all configuration parameters correctly for both ASA and non-ASA configurations.

The `multipath.conf` file must exist for the multipath daemon to start, but you can create an empty, zero-byte file by using the following command:

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

The first time you create this file, you might need to enable and start the multipath services:

```
# systemctl enable multipathd
# systemctl start multipathd
```

- There is no requirement to add anything directly to the `multipath.conf` file, unless you have devices that you do not want to be managed by multipath or you have existing settings that override defaults.
- To exclude unwanted devices, add the following syntax to the `multipath.conf` file .

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

Replace the `<DevId>` with the WWID string of the device you want to exclude.

Example

In this example, we are going to determine the WWID of a device and add to the `multipath.conf` file.

Steps

1. Run the following command to determine the WWID:

```
# /lib/udev/scsi_id -gud /dev/sda
360030057024d0730239134810c0cb833
```

sda is the local SCSI disk that we need to add it to the blacklist.

2. Add the 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 for legacy settings, especially in the defaults section, that might be overriding the 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 will need to be corrected by later stanzas in the `multipath.conf` file that apply specifically to ONTAP LUNs. If this is not done, the ONTAP LUNs might not work as expected. These defaults should only be overridden in consultation with NetApp and/or an OS vendor 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	"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"

Parameter	Setting
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 other SAN arrays are 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
    }
}
```

KVM settings

You can use the recommended settings to configure Kernel-based Virtual Machine (KVM) as well. There are no changes required to configure KVM as the LUN is mapped to the hypervisor.

Known issues

The RHEL 9.1 with ONTAP release has the following known issues:

NetApp Bug ID	Title	Description	Bugzilla ID
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 <code>sanlun fcp show adapter -v</code> fails because the library package dependencies to support HBA discovery cannot be found.	N/A

Use Red Hat Enterprise Linux 9.0 with ONTAP

You can use the ONTAP SAN host configuration settings to configure Red Hat Enterprise Linux 9.0 with ONTAP as the target.

Install the Linux Unified Host Utilities

The NetApp Linux Unified Host Utilities software package is available on the [NetApp Support Site](#) in a 64-bit .rpm file.

NetApp strongly recommends installing the Linux Unified 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.

What you'll need

If you have a version of Linux Unified Host Utilities currently installed, you should upgrade or remove it, and then use the following steps to install the latest version.

Steps

1. Download the 64-bit Linux Unified 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 document 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) / vserver (cDOT/FlashRay) Product	lun-pathname	device filename	host adapter	protocol	lun size
data_vserver 120.0g cDOT	/vol/vol1/lun1	/dev/sdb	host16	FCP	
data_vserver 120.0g cDOT	/vol/vol1/lun1	/dev/sdc	host15	FCP	
data_vserver 120.0g cDOT	/vol/vol2/lun2	/dev/sdd	host16	FCP	
data_vserver 120.0g cDOT	/vol/vol2/lun2	/dev/sde	host15	FCP	

SAN Booting

What you'll need

If you decide to use SAN booting, it must be supported by your configuration. You can use the [NetApp 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 is successful.

Multipathing

For Red Hat Enterprise Linux (RHEL) 9.0 the `/etc/multipath.conf` file must exist, but you do not need to make specific changes to the file. RHEL 9.0 is compiled with all settings required to recognize and correctly manage ONTAP LUNs.

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

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

All SAN Array configurations

In All SAN Array (ASA) configurations, all paths to a given LUN are active and optimized. 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
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
```



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight 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 the higher priorities are Active/Optimized, meaning they are serviced by the controller where the aggregate is located. The paths with the lower priorities are active but are non-optimized because they are served from a different controller. The non-optimized paths are only used when no optimized paths are 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
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
```



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight paths might cause path issues during storage failures.

Recommended Settings

The RHEL 9.0 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, but you can create an empty, zero-byte file by using the following command:

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

The first time you create this file, you might need to enable and start the multipath services:

```
# systemctl enable multipathd
# systemctl start multipathd
```

- There is no requirement to add anything directly to the `multipath.conf` file, unless you have devices that you do not want to be managed by multipath or you have existing settings that override defaults.
- To exclude unwanted devices, add the following syntax to the `multipath.conf` file .

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

Replace the `<DevId>` with the WWID string of the device you want to exclude.

Example

In this example, we are going to determine the WWID of a device and add to the `multipath.conf` file.

Steps

1. Run the following command to determine the WWID:

```
# /lib/udev/scsi_id -gud /dev/sda
360030057024d0730239134810c0cb833
```

`sda` is the local SCSI disk that we need to add it to the blacklist.

2. Add the 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 for legacy settings, especially in the defaults section, that might be overriding the 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 will need to be corrected by later stanzas in the `multipath.conf` file that apply specifically to ONTAP LUNs. If this is not done, the ONTAP LUNs might not work as expected. These defaults should only be overridden in consultation with NetApp and/or an OS vendor and only when the impact is fully understood.

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

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
    }
}

```

KVM settings

You can use the recommended settings to configure Kernel-based Virtual Machine (KVM) as well. There are no changes required to configure KVM as the LUN is mapped to the hypervisor.

Known issues

There are no known issues for the RHEL 9.0 with ONTAP release.

RHEL 8

Use Red Hat Enterprise Linux 8.9 with ONTAP

You can use the ONTAP SAN host configuration settings to configure Red Hat Enterprise Linux (RHEL) 8.9 with ONTAP as the target.

Install the Linux Unified Host Utilities

The NetApp Linux Unified Host Utilities software package is available on the [NetApp Support Site](#) in a 64-bit .rpm file.

NetApp strongly recommends installing the Linux Unified 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.

What you'll need

If you have a version of Linux Unified Host Utilities currently installed, you should upgrade or remove it, and then use the following steps to install the latest version.

Steps

1. Download the 64-bit Linux Unified 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 Tool Kit

The tool kit is installed automatically when you install the NetApp Host Utilities package. 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 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
-----
vs_161_32gLpe          /vol/vol19/lun  /dev/sdcd  host15    FCP
10g      cDOT
vs_161_32gLpe          /vol/vol20/lun  /dev/sdce  host15    FCP
10g      cDOT
vs_161_32gLpe          /vol/vol18/lun  /dev/sdcc  host15    FCP
10g      cDOT
vs_161_32gLpe          /vol/vol17/lun  /dev/sdcb  host15    FCP
10g      cDOT
```

SAN booting

What you'll need

If you decide to use SAN booting, it must be supported by your configuration. You can use the [NetApp 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 is successful.

Multipathing

For RHEL 8.9, the `/etc/multipath.conf` file must exist, but you do not need to make specific changes to the file. RHEL 8.9 is compiled with all the settings required to recognize and correctly manage ONTAP LUNs.

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

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

All SAN Array configurations

In All SAN Array (ASA) configurations, all paths to a given LUN are active and optimized. 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
3600a098038314778375d53694b536e53 dm-16 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
   |- 14:0:0:0    sda  8:0    active ready running
   |- 15:0:8:0    sdcf 69:48  active ready running
   |- 15:0:0:0    sdaq 66:160 active ready running
   `-- 14:0:9:0    sdv   65:80  active ready running
```



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight 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 the higher priorities are Active/Optimized, meaning they are serviced by the controller where the aggregate is located. The paths with the lower priorities are active but are non-optimized because they are served from a different controller. The non-optimized paths are only used when no optimized paths are 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
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
```



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight paths might cause path issues during storage failures.

Recommended settings

The RHEL 8.9 OS recognizes ONTAP LUNs and automatically sets all configuration parameters correctly for both ASA and non-ASA configurations. You can further optimize performance for your host configuration with the following recommended settings.

The `multipath.conf` file must exist for the multipath daemon to start, but you can create an empty, zero-byte file by using the following command:

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

The first time you create this file, you might need to enable and start the multipath services:

```
# systemctl enable multipathd
# systemctl start multipathd
```

- There is no requirement to add anything directly to the `multipath.conf` file, unless you have devices that you do not want to be managed by multipath or you have existing settings that override defaults.
- To exclude unwanted devices, add the following syntax to the `multipath.conf` file .

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

Replace the `<DevId>` with the WWID string of the device you want to exclude.

Example

In this example, we are going to determine the WWID of a device and add to the `multipath.conf` file.

Steps

1. Run the following command to determine the WWID:

```
# /lib/udev/scsi_id -gud /dev/sda
360030057024d0730239134810c0cb833
```

sda is the local SCSI disk that we need to add it to the blacklist.

2. Add the 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 for legacy settings, especially in the defaults section, that might be overriding the 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 will need to be corrected by later stanzas in the `multipath.conf` file that apply specifically to ONTAP LUNs. If this is not done, the ONTAP LUNs might not work as expected. These defaults should only be overridden in consultation with NetApp and/or an OS vendor 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	"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"

Parameter	Setting
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 other SAN arrays are 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
    }
}
```

KVM settings

You can use the recommended settings to configure Kernel-based Virtual Machine (KVM) as well. There are no changes required to configure KVM as the LUN is mapped to the hypervisor.

Known issues

There are no known issues for RHEL 8.9.

Use Red Hat Enterprise Linux 8.8 with ONTAP

You can use the ONTAP SAN host configuration settings to configure Red Hat Enterprise Linux 8.8 with ONTAP as the target.

Install the Linux Unified Host Utilities

The NetApp Linux Unified Host Utilities software package is available on the [NetApp Support Site](#) in a 64-bit .rpm file.

NetApp strongly recommends installing the Linux Unified 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.

What you'll need

If you have a version of Linux Unified Host Utilities currently installed, you should upgrade or remove it, and then use the following steps to install the latest version.

Steps

- 1. Download the 64-bit Linux Unified 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 Tool Kit

The tool kit is installed automatically when you install the NetApp Host Utilities package. 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 example, the `sanlun lun show` command returns LUN information.

```
# sanlun lun show all
```

Example output:

controller(7mode/E-Series) / vserver(cDOT/FlashRay) Product	lun-pathname	device filename	host adapter	lun protocol	size
vs_163_32gQ1c 10.0g cDOT	/vol/vol1/lun1	/dev/sdb	host14	FCP	
vs_163_32gQ1c 10.0g cDOT	/vol/vol1/lun1	/dev/sdc	host15	FCP	
vs_163_32gQ1c 10.0g cDOT	/vol/vol2/lun2	/dev/sdd	host14	FCP	
vs_163_32gQ1c 10.0g cDOT	/vol/vol2/lun2	/dev/sde	host15	FCP	

SAN booting

What you'll need

If you decide to use SAN booting, it must be supported by your configuration. You can use the [NetApp 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 is successful.

Multipathing

For Red Hat Enterprise Linux (RHEL) 8.8, the `/etc/multipath.conf` file must exist, but you do not need to make specific changes to the file. RHEL 8.8 is compiled with all the settings required to recognize and correctly manage ONTAP LUNs.

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

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

All SAN Array configurations

In All SAN Array (ASA) configurations, all paths to a given LUN are active and optimized. 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
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='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
```



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight 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 the higher priorities are Active/Optimized, meaning they are serviced by the controller where the aggregate is located. The paths with the lower priorities are active but are non-optimized because they are served from a different controller. The non-optimized paths are only used when no optimized paths are 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
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
```



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight paths might cause path issues during storage failures.

Recommended settings

The RHEL 8.8 OS is compiled to recognize ONTAP LUNs and automatically set all configuration parameters correctly for both ASA and non-ASA configurations. You can further optimize performance for your host configuration with the following recommended settings.

The `multipath.conf` file must exist for the multipath daemon to start, but you can create an empty, zero-byte file by using the following command:

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

The first time you create this file, you might need to enable and start the multipath services:

```
# systemctl enable multipathd
# systemctl start multipathd
```

- There is no requirement to add anything directly to the `multipath.conf` file, unless you have devices that you do not want to be managed by multipath or you have existing settings that override defaults.
- To exclude unwanted devices, add the following syntax to the `multipath.conf` file .

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

Replace the <DevId> with the WWID string of the device you want to exclude.

Example

In this example, we are going to determine the WWID of a device and add to the `multipath.conf` file.

Steps

1. Run the following command to determine the WWID:

```
# /lib/udev/scsi_id -gud /dev/sda
360030057024d0730239134810c0cb833
```

`sda` is the local SCSI disk that we need to add it to the blacklist.

2. Add the 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 for legacy settings, especially in the defaults section, that might be overriding the 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 will need to be corrected by later stanzas in the `multipath.conf` file that apply specifically to ONTAP LUNs. If this is not done, the ONTAP LUNs might not work as expected. These defaults should only be overridden in consultation with NetApp and/or an OS vendor and only when the impact is fully understood.

Parameter	Setting
<code>detect_prio</code>	<code>yes</code>
<code>dev_loss_tmo</code>	<code>"infinity"</code>
<code>failback</code>	<code>immediate</code>
<code>fast_io_fail_tmo</code>	<code>5</code>
<code>features</code>	<code>"2 pg_init_retries 50"</code>
<code>flush_on_last_del</code>	<code>"yes"</code>
<code>hardware_handler</code>	<code>"0"</code>
<code>no_path_retry</code>	<code>queue</code>
<code>path_checker</code>	<code>"tur"</code>
<code>path_grouping_policy</code>	<code>"group_by_prio"</code>

Parameter	Setting
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

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 other SAN arrays are 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
    }
}
```

KVM settings

You can use the recommended settings to configure Kernel-based Virtual Machine (KVM) as well. There are no changes required to configure KVM as the LUN is mapped to the hypervisor.

Known issues

There are no known issues for the RHEL 8.8 with ONTAP release.

Use Red Hat Enterprise Linux 8.7 with ONTAP

You can use the ONTAP SAN host configuration settings to configure Red Hat Enterprise Linux 8.7 with ONTAP as the target.

Install the Linux Unified Host Utilities

The NetApp Linux Unified Host Utilities software package is available on the [NetApp Support Site](#) in a 64-bit .rpm file.

NetApp strongly recommends installing the Linux Unified 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.

What you'll need

If you have a version of Linux Unified Host Utilities currently installed, you should upgrade or remove it, and then use the following steps to install the latest version.

Steps

1. Download the 64-bit Linux Unified 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 document 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) / vserver (cDOT/FlashRay) Product	lun-pathname	device filename	host adapter	protocol	lun size
data_vserver 120.0g cDOT	/vol/vol1/lun1	/dev/sdb	host16	FCP	
data_vserver 120.0g cDOT	/vol/vol1/lun1	/dev/sdc	host15	FCP	
data_vserver 120.0g cDOT	/vol/vol2/lun2	/dev/sdd	host16	FCP	
data_vserver 120.0g cDOT	/vol/vol2/lun2	/dev/sde	host15	FCP	

SAN Booting

What you'll need

If you decide to use SAN booting, it must be supported by your configuration. You can use the [NetApp 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 is successful.

Multipathing

For Red Hat Enterprise Linux (RHEL) 8.7 the `/etc/multipath.conf` file must exist, but you do not need to make specific changes to the file. RHEL 8.7 is compiled with all settings required to recognize and correctly manage ONTAP LUNs.

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

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

All SAN Array configurations

In All SAN Array (ASA) configurations, all paths to a given LUN are active and optimized. 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
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
```



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight 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 the higher priorities are Active/Optimized, meaning they are serviced by the controller where the aggregate is located. The paths with the lower priorities are active but are non-optimized because they are served from a different controller. The non-optimized paths are only used when no optimized paths are 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
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
```



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight paths might cause path issues during storage failures.

Recommended Settings

The RHEL 8.7 OS is compiled to recognize ONTAP LUNs and automatically set all configuration parameters correctly for both ASA and non-ASA configurations. You can further optimize performance for your host configuration with the following recommended settings.

The `multipath.conf` file must exist for the multipath daemon to start, but you can create an empty, zero-byte file by using the following command:

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

The first time you create this file, you might need to enable and start the multipath services:

```
# systemctl enable multipathd
# systemctl start multipathd
```

- There is no requirement to add anything directly to the `multipath.conf` file, unless you have devices that you do not want to be managed by multipath or you have existing settings that override defaults.
- To exclude unwanted devices, add the following syntax to the `multipath.conf` file .

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

Replace the `<DevId>` with the WWID string of the device you want to exclude.

Example

In this example, we are going to determine the WWID of a device and add to the `multipath.conf` file.

Steps

1. Run the following command to determine the WWID:

```
# /lib/udev/scsi_id -gud /dev/sda
360030057024d0730239134810c0cb833
```

`sda` is the local SCSI disk that we need to add it to the blacklist.

2. Add the 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 for legacy settings, especially in the defaults section, that might be overriding the 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 will need to be corrected by later stanzas in the `multipath.conf` file that apply specifically to ONTAP LUNs. If this is not done, the ONTAP LUNs might not work as expected. These defaults should only be overridden in consultation with NetApp and/or an OS vendor and only when the impact is fully understood.

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

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
    }
}

```

KVM settings

You can use the recommended settings to configure Kernel-based Virtual Machine (KVM) as well. There are no changes required to configure KVM as the LUN is mapped to the hypervisor.

Known issues

There are no known issues for the RHEL 8.7 with ONTAP release.

Use Red Hat Enterprise Linux 8.6 with ONTAP

You can use the ONTAP SAN host configuration settings to configure Red Hat Enterprise Linux 8.6 with ONTAP as the target.

Install the Linux Unified Host Utilities

The NetApp Linux Unified Host Utilities software package is available on the [NetApp Support Site](#) in a 64-bit .rpm file.

NetApp strongly recommends installing the Linux Unified 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.

What you'll need

If you have a version of Linux Unified Host Utilities currently installed, you should upgrade or remove it, and then use the following steps to install the latest version.

Steps

1. Download the 64-bit Linux Unified 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 document 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

What you'll need

If you decide to use SAN booting, it must be supported by your configuration. You can use the [NetApp 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 is successful.

Multipathing

For Red Hat Enterprise Linux (RHEL) 8.6 the `/etc/multipath.conf` file must exist, but you do not need to make specific changes to the file. RHEL 8.6 is compiled with all settings required to recognize and correctly manage ONTAP LUNs.

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

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

All SAN Array configurations

In All SAN Array (ASA) configurations, all paths to a given LUN are active and optimized. 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
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
```



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight 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 the higher priorities are Active/Optimized, meaning they are serviced by the controller where the aggregate is located. The paths with the lower priorities are active but are non-optimized because they are served from a different controller. The non-optimized paths are only used when no optimized paths are 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
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
```



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight paths might cause path issues during storage failures.

Recommended Settings

The RHEL 8.6 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, but you can create an empty, zero-byte file by using the following command:

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

The first time you create this file, you might need to enable and start the multipath services:

```
# systemctl enable multipathd
# systemctl start multipathd
```

- There is no requirement to add anything directly to the `multipath.conf` file, unless you have devices that you do not want to be managed by multipath or you have existing settings that override defaults.
- To exclude unwanted devices, add the following syntax to the `multipath.conf` file .

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

Replace the `<DevId>` with the WWID string of the device you want to exclude.

Example

In this example, we are going to determine the WWID of a device and add to the `multipath.conf` file.

Steps

1. Run the following command to determine the WWID:

```
# /lib/udev/scsi_id -gud /dev/sda
360030057024d0730239134810c0cb833
```

sda is the local SCSI disk that we need to add it to the blacklist.

2. Add the 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 for legacy settings, especially in the defaults section, that might be overriding the 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 will need to be corrected by later stanzas in the `multipath.conf` file that apply specifically to ONTAP LUNs. If this is not done, the ONTAP LUNs might not work as expected. These defaults should only be overridden in consultation with NetApp and/or an OS vendor 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	"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"

Parameter	Setting
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
    }
}
```

KVM settings

You can use the recommended settings to configure Kernel-based Virtual Machine (KVM) as well. There are no changes required to configure KVM as the LUN is mapped to the hypervisor.

Known issues

There are no known issues for the RHEL 8.6 with ONTAP release.

Use Red Hat Enterprise Linux 8.5 with ONTAP

You can use the ONTAP SAN host configuration settings to configure Red Hat Enterprise Linux 8.5 with ONTAP as the target.

Install the Linux Unified Host Utilities

The NetApp Linux Unified Host Utilities software package is available on the [NetApp Support Site](#) in a 64-bit .rpm file.

NetApp strongly recommends installing the Linux Unified 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.

What you'll need

If you have a version of Linux Unified Host Utilities currently installed, you should upgrade or remove it, and then use the following steps to install the latest version.

Steps

- 1. Download the 64-bit Linux Unified 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 document 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) / vserver(cDOT/FlashRay) lun-pathname		device filename	host adapter	protocol	lun size
Product					

data_vserver 120.0g cDOT	/vol/vol1/lun1	/dev/sdb	host16	FCP	
data_vserver 120.0g cDOT	/vol/vol1/lun1	/dev/sdc	host15	FCP	
data_vserver 120.0g cDOT	/vol/vol2/lun2	/dev/sdd	host16	FCP	
data_vserver 120.0g cDOT	/vol/vol2/lun2	/dev/sde	host15	FCP	

SAN Booting

What you'll need

If you decide to use SAN booting, it must be supported by your configuration. You can use the [NetApp 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 is successful.

Multipathing

For Red Hat Enterprise Linux (RHEL) 8.5 the `/etc/multipath.conf` file must exist, but you do not need to make specific changes to the file. RHEL 8.5 is compiled with all settings required to recognize and correctly manage ONTAP LUNs.

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

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

All SAN Array configurations

In All SAN Array (ASA) configurations, all paths to a given LUN are active and optimized. 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
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
```



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight 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 the higher priorities are Active/Optimized, meaning they are serviced by the controller where the aggregate is located. The paths with the lower priorities are active but are non-optimized because they are served from a different controller. The non-optimized paths are only used when no optimized paths are 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
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
```



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight paths might cause path issues during storage failures.

Recommended Settings

The RHEL 8.5 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, but you can create an empty, zero-byte file by using the following command:

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

The first time you create this file, you might need to enable and start the multipath services:

```
# systemctl enable multipathd
# systemctl start multipathd
```

- There is no requirement to add anything directly to the `multipath.conf` file, unless you have devices that you do not want to be managed by multipath or you have existing settings that override defaults.
- To exclude unwanted devices, add the following syntax to the `multipath.conf` file .

```

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

```

Replace the <DevId> with the WWID string of the device you want to exclude.

Example

In this example, we are going to determine the WWID of a device and add to the `multipath.conf` file.

Steps

1. Run the following command to determine the WWID:

```

# /lib/udev/scsi_id -gud /dev/sda
360030057024d0730239134810c0cb833

```

`sda` is the local SCSI disk that we need to add it to the blacklist.

2. Add the 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 for legacy settings, especially in the defaults section, that might be overriding the 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 will need to be corrected by later stanzas in the `multipath.conf` file that apply specifically to ONTAP LUNs. If this is not done, the ONTAP LUNs might not work as expected. These defaults should only be overridden in consultation with NetApp and/or an OS vendor and only when the impact is fully understood.

Parameter	Setting
<code>detect_prio</code>	yes
<code>dev_loss_tmo</code>	"infinity"
<code>failback</code>	immediate
<code>fast_io_fail_tmo</code>	5

Parameter	Setting
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

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
    }
}
```

KVM settings

You can use the recommended settings to configure Kernel-based Virtual Machine (KVM) as well. There are no changes required to configure KVM as the LUN is mapped to the hypervisor.

Known issues

There are no known issues for the RHEL 8.5 with ONTAP release.

Use Red Hat Enterprise Linux 8.4 with ONTAP

You can use the ONTAP SAN host configuration settings to configure Red Hat Enterprise Linux 8.4 with ONTAP as the target.

Install the Linux Unified Host Utilities

The NetApp Linux Unified Host Utilities software package is available on the [NetApp Support Site](#) in a 64-bit .rpm file.

NetApp strongly recommends installing the Linux Unified 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.

What you'll need

If you have a version of Linux Unified Host Utilities currently installed, you should upgrade or remove it, and then use the following steps to install the latest version.

Steps

1. Download the 64-bit Linux Unified 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 document 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) / vserver (cDOT/FlashRay) Product	lun-pathname	device filename	host adapter	protocol	lun size
data_vserver 120.0g cDOT	/vol/vol1/lun1	/dev/sdb	host16	FCP	
data_vserver 120.0g cDOT	/vol/vol1/lun1	/dev/sdc	host15	FCP	
data_vserver 120.0g cDOT	/vol/vol2/lun2	/dev/sdd	host16	FCP	
data_vserver 120.0g cDOT	/vol/vol2/lun2	/dev/sde	host15	FCP	

SAN Booting

What you'll need

If you decide to use SAN booting, it must be supported by your configuration. You can use the [NetApp 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 is successful.

Multipathing

For Red Hat Enterprise Linux (RHEL) 8.4 the `/etc/multipath.conf` file must exist, but you do not need to make specific changes to the file. RHEL 8.4 is compiled with all settings required to recognize and correctly manage ONTAP LUNs.

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

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

All SAN Array configurations

In All SAN Array (ASA) configurations, all paths to a given LUN are active and optimized. 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
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
```



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight 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 the higher priorities are Active/Optimized, meaning they are serviced by the controller where the aggregate is located. The paths with the lower priorities are active but are non-optimized because they are served from a different controller. The non-optimized paths are only used when no optimized paths are 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
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
```



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight paths might cause path issues during storage failures.

Recommended Settings

The RHEL 8.4 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, but you can create an empty, zero-byte file by using the following command:

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

The first time you create this file, you might need to enable and start the multipath services:

```
# systemctl enable multipathd
# systemctl start multipathd
```

- There is no requirement to add anything directly to the `multipath.conf` file, unless you have devices that you do not want to be managed by multipath or you have existing settings that override defaults.
- To exclude unwanted devices, add the following syntax to the `multipath.conf` file .

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

Replace the `<DevId>` with the WWID string of the device you want to exclude.

Example

In this example, we are going to determine the WWID of a device and add to the `multipath.conf` file.

Steps

1. Run the following command to determine the WWID:

```
# /lib/udev/scsi_id -gud /dev/sda
360030057024d0730239134810c0cb833
```

`sda` is the local SCSI disk that we need to add it to the blacklist.

2. Add the 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 for legacy settings, especially in the defaults section, that might be overriding the 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 will need to be corrected by later stanzas in the `multipath.conf` file that apply specifically to ONTAP LUNs. If this is not done, the ONTAP LUNs might not work as expected. These defaults should only be overridden in consultation with NetApp and/or an OS vendor and only when the impact is fully understood.

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

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
    }
}

```

KVM settings

You can use the recommended settings to configure Kernel-based Virtual Machine (KVM) as well. There are no changes required to configure KVM as the LUN is mapped to the hypervisor.

Known issues

There are no known issues for the RHEL 8.4 with ONTAP release.

Use Red Hat Enterprise Linux 8.3 with ONTAP

You can use the ONTAP SAN host configuration settings to configure Red Hat Enterprise Linux 8.3 with ONTAP as the target.

Install the Linux Unified Host Utilities

The NetApp Linux Unified Host Utilities software package is available on the [NetApp Support Site](#) in a 64-bit .rpm file.

NetApp strongly recommends installing the Linux Unified 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.

What you'll need

If you have a version of Linux Unified Host Utilities currently installed, you should upgrade or remove it, and then use the following steps to install the latest version.

Steps

1. Download the 64-bit Linux Unified 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 document 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

What you'll need

If you decide to use SAN booting, it must be supported by your configuration. You can use the [NetApp 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 is successful.

Multipathing

For Red Hat Enterprise Linux (RHEL) 8.3 the `/etc/multipath.conf` file must exist, but you do not need to make specific changes to the file. RHEL 8.3 is compiled with all settings required to recognize and correctly manage ONTAP LUNs.

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

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

All SAN Array configurations

In All SAN Array (ASA) configurations, all paths to a given LUN are active and optimized. 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
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
```



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight 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 the higher priorities are Active/Optimized, meaning they are serviced by the controller where the aggregate is located. The paths with the lower priorities are active but are non-optimized because they are served from a different controller. The non-optimized paths are only used when no optimized paths are 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
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
```



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight paths might cause path issues during storage failures.

Recommended Settings

The RHEL 8.3 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, but you can create an empty, zero-byte file by using the following command:

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

The first time you create this file, you might need to enable and start the multipath services:

```
# systemctl enable multipathd
# systemctl start multipathd
```

- There is no requirement to add anything directly to the `multipath.conf` file, unless you have devices that you do not want to be managed by multipath or you have existing settings that override defaults.
- To exclude unwanted devices, add the following syntax to the `multipath.conf` file .

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

Replace the `<DevId>` with the WWID string of the device you want to exclude.

Example

In this example, we are going to determine the WWID of a device and add to the `multipath.conf` file.

Steps

1. Run the following command to determine the WWID:

```
# /lib/udev/scsi_id -gud /dev/sda
360030057024d0730239134810c0cb833
```

sda is the local SCSI disk that we need to add it to the blacklist.

2. Add the 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 for legacy settings, especially in the defaults section, that might be overriding the 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 will need to be corrected by later stanzas in the `multipath.conf` file that apply specifically to ONTAP LUNs. If this is not done, the ONTAP LUNs might not work as expected. These defaults should only be overridden in consultation with NetApp and/or an OS vendor 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	"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"

Parameter	Setting
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
    }
}
```

KVM settings

You can use the recommended settings to configure Kernel-based Virtual Machine (KVM) as well. There are no changes required to configure KVM as the LUN is mapped to the hypervisor.

Known issues

There are no known issues for the RHEL 8.3 with ONTAP release.

Use Red Hat Enterprise Linux 8.2 with ONTAP

You can use the ONTAP SAN host configuration settings to configure Red Hat Enterprise Linux 8.2 with ONTAP as the target.

Install the Linux Unified Host Utilities

The NetApp Linux Unified Host Utilities software package is available on the [NetApp Support Site](#) in a 64-bit .rpm file.

NetApp strongly recommends installing the Linux Unified 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.

What you'll need

If you have a version of Linux Unified Host Utilities currently installed, you should upgrade or remove it, and then use the following steps to install the latest version.

Steps

- 1. Download the 64-bit Linux Unified 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) / vserver(cDOT/FlashRay) lun-pathname		device filename	host adapter	protocol	lun size
Product					

data_vserver 120.0g cDOT	/vol/vol1/lun1	/dev/sdb	host16	FCP	
data_vserver 120.0g cDOT	/vol/vol1/lun1	/dev/sdc	host15	FCP	
data_vserver 120.0g cDOT	/vol/vol2/lun2	/dev/sdd	host16	FCP	
data_vserver 120.0g cDOT	/vol/vol2/lun2	/dev/sde	host15	FCP	

SAN Booting

What you'll need

If you decide to use SAN booting, it must be supported by your configuration. You can use the [NetApp 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 is successful.

Multipathing

For Red Hat Enterprise Linux (RHEL) 8.2 the `/etc/multipath.conf` file must exist, but you do not need to make specific changes to the file. RHEL 8.2 is compiled with all the settings required to recognize and correctly manage ONTAP LUNs.

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

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

All SAN Array configurations

In All SAN Array (ASA) configurations, all paths to a given LUN are active and optimized. 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
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
```



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight 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 the higher priorities are Active/Optimized, meaning they are serviced by the controller where the aggregate is located. The paths with the lower priorities are active but are non-optimized because they are served from a different controller. The non-optimized paths are only used when no optimized paths are 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
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
```



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight paths might cause path issues during storage failures.

Recommended settings

The RHEL 8.2 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, but you can create an empty, zero-byte file by using the following command:

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

The first time you create this file, you might need to enable and start the multipath services:

```
# systemctl enable multipathd
# systemctl start multipathd
```

- There is no requirement to add anything directly to the `multipath.conf` file, unless you have devices that you do not want to be managed by multipath or you have existing settings that override defaults.
- To exclude unwanted devices, add the following syntax to the `multipath.conf` file .

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

Replace the `<DevId>` with the WWID string of the device you want to exclude.

Example

In this example, we are going to determine the WWID of a device and add to the `multipath.conf` file.

Steps

1. Run the following command to determine the WWID:

```
# /lib/udev/scsi_id -gud /dev/sda
360030057024d0730239134810c0cb833
```

`sda` is the local SCSI disk that we need to add it to the blacklist.

2. Add the 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 for legacy settings, especially in the defaults section, that might be overriding the 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 will need to be corrected by later stanzas in the `multipath.conf` file that apply specifically to ONTAP LUNs. If this is not done, the ONTAP LUNs might not work as expected. These defaults should only be overridden in consultation with NetApp and/or an OS vendor and only when the impact is fully understood.

Parameter	Setting
<code>detect_prio</code>	<code>yes</code>
<code>dev_loss_tmo</code>	<code>"infinity"</code>
<code>failback</code>	<code>immediate</code>
<code>fast_io_fail_tmo</code>	<code>5</code>
<code>features</code>	<code>"2 pg_init_retries 50"</code>
<code>flush_on_last_del</code>	<code>"yes"</code>
<code>hardware_handler</code>	<code>"0"</code>
<code>no_path_retry</code>	<code>queue</code>
<code>path_checker</code>	<code>"tur"</code>
<code>path_grouping_policy</code>	<code>"group_by_prio"</code>
<code>path_selector</code>	<code>"service-time 0"</code>

Parameter	Setting
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
    }
}
```

KVM settings

You can use the recommended settings to configure Kernel-based Virtual Machine (KVM) as well. There are no changes required to configure KVM as the LUN is mapped to the hypervisor.

Known issues

There are no known issues for the RHEL 8.2 with ONTAP release.

Use Red Hat Enterprise Linux 8.1 with ONTAP

You can use the ONTAP SAN host configuration settings to configure Red Hat Enterprise Linux 8.1 with ONTAP as the target.

Install the Linux Unified Host Utilities

The NetApp Linux Unified Host Utilities software package is available on the [NetApp Support Site](#) in a 64-bit .rpm file.

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What you'll need

If you have a version of Linux Unified Host Utilities currently installed, you should upgrade or remove it, and then use the following steps to install the latest version.

Steps

1. Download the 64-bit Linux Unified 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 document to configure cloud clients connected to [Cloud Volumes ONTAP](#) and [Amazon FSx for ONTAP](#).

SAN Toolkit

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Example

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

```
# sanlun lun show all
```

Example output:

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

SAN Booting

What you'll need

If you decide to use SAN booting, it must be supported by your configuration. You can use the [NetApp 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 is successful.

Multipathing

For Red Hat Enterprise Linux (RHEL) 8.1 the `/etc/multipath.conf` file must exist, but you do not need to make specific changes to the file. RHEL 8.1 is compiled with all settings required to recognize and correctly manage ONTAP LUNs.

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

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

All SAN Array configurations

In All SAN Array (ASA) configurations, all paths to a given LUN are active and optimized. 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
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
```



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight 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 the higher priorities are Active/Optimized, meaning they are serviced by the controller where the aggregate is located. The paths with the lower priorities are active but are non-optimized because they are served from a different controller. The non-optimized paths are only used when no optimized paths are 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
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
| |- 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
```



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight paths might cause path issues during storage failures.

Recommended Settings

The RHEL 8.1 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, but you can create an empty, zero-byte file by using the following command:

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

The first time you create this file, you might need to enable and start the multipath services:

```
# systemctl enable multipathd
# systemctl start multipathd
```

- There is no requirement to add anything directly to the `multipath.conf` file, unless you have devices that you do not want to be managed by multipath or you have existing settings that override defaults.
- To exclude unwanted devices, add the following syntax to the `multipath.conf` file .

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

Replace the `<DevId>` with the WWID string of the device you want to exclude.

Example

In this example, we are going to determine the WWID of a device and add to the `multipath.conf` file.

Steps

1. Run the following command to determine the WWID:

```
# /lib/udev/scsi_id -gud /dev/sda
360030057024d0730239134810c0cb833
```

`sda` is the local SCSI disk that we need to add it to the blacklist.

2. Add the 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 for legacy settings, especially in the defaults section, that might be overriding the 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 will need to be corrected by later stanzas in the `multipath.conf` file that apply specifically to ONTAP LUNs. If this is not done, the ONTAP LUNs might not work as expected. These defaults should only be overridden in consultation with NetApp and/or an OS vendor and only when the impact is fully understood.

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

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
    }
}
```

KVM settings

You can use the recommended settings to configure Kernel-based Virtual Machine (KVM) as well. There are no changes required to configure KVM as the LUN is mapped to the hypervisor.

Known issues

The RHEL 8.1 with ONTAP release has the following known issues:

NetApp Bug ID	Title	Description	Bugzilla ID
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	1760819

NetApp Bug ID	Title	Description	Bugzilla ID
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.	1744082
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.	1758504

Use Red Hat Enterprise Linux 8.0 with ONTAP

You can use the ONTAP SAN host configuration settings to configure Red Hat Enterprise Linux 8.0 with ONTAP as the target.

Install the Linux Unified Host Utilities

The NetApp Linux Unified Host Utilities software package is available on the [NetApp Support Site](#) in a 64-bit .rpm file.

NetApp strongly recommends installing the Linux Unified 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.

What you'll need

If you have a version of Linux Unified Host Utilities currently installed, you should upgrade or remove it, and then use the following steps to install the latest version.

Steps

1. Download the 64-bit Linux Unified 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 document 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) / vserver (cDOT/FlashRay) Product	lun-pathname	device filename	host adapter	protocol	lun size
data_vserver 120.0g cDOT	/vol/vol1/lun1	/dev/sdb	host16	FCP	
data_vserver 120.0g cDOT	/vol/vol1/lun1	/dev/sdc	host15	FCP	
data_vserver 120.0g cDOT	/vol/vol2/lun2	/dev/sdd	host16	FCP	
data_vserver 120.0g cDOT	/vol/vol2/lun2	/dev/sde	host15	FCP	

SAN Booting

What you'll need

If you decide to use SAN booting, it must be supported by your configuration. You can use the [NetApp 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 is successful.

Multipathing

For Red Hat Enterprise Linux (RHEL) 8.0 the `/etc/multipath.conf` file must exist, but you do not need to make specific changes to the file. RHEL 8.0 is compiled with all settings required to recognize and correctly manage ONTAP LUNs.

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

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

All SAN Array configurations

In All SAN Array (ASA) configurations, all paths to a given LUN are active and optimized. 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
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
```



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight 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 the higher priorities are Active/Optimized, meaning they are serviced by the controller where the aggregate is located. The paths with the lower priorities are active but are non-optimized because they are served from a different controller. The non-optimized paths are only used when no optimized paths are 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
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
```



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight paths might cause path issues during storage failures.

Recommended Settings

The RHEL 8.0 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, but you can create an empty, zero-byte file by using the following command:

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

The first time you create this file, you might need to enable and start the multipath services:

```
# systemctl enable multipathd
# systemctl start multipathd
```

- There is no requirement to add anything directly to the `multipath.conf` file, unless you have devices that you do not want to be managed by multipath or you have existing settings that override defaults.
- To exclude unwanted devices, add the following syntax to the `multipath.conf` file .

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

Replace the `<DevId>` with the WWID string of the device you want to exclude.

Example

In this example, we are going to determine the WWID of a device and add to the `multipath.conf` file.

Steps

1. Run the following command to determine the WWID:

```
# /lib/udev/scsi_id -gud /dev/sda
360030057024d0730239134810c0cb833
```

`sda` is the local SCSI disk that we need to add it to the blacklist.

2. Add the 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 for legacy settings, especially in the defaults section, that might be overriding the 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

will need to be corrected by later stanzas in the `multipath.conf` file that apply specifically to ONTAP LUNs. If this is not done, the ONTAP LUNs might not work as expected. These defaults should only be overridden in consultation with NetApp and/or an OS vendor and only when the impact is fully understood.

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

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
    }
}
```

KVM settings

You can use the recommended settings to configure Kernel-based Virtual Machine (KVM) as well. There are no changes required to configure KVM as the LUN is mapped to the hypervisor.

Known issues

The RHEL 8.0 with ONTAP release has the following known issues:

NetApp Bug ID	Title	Description	Bugzilla ID
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.	1710009
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 system reboot 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.	1690356
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.	1709995

NetApp Bug ID	Title	Description	Bugzilla ID
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.	1709995
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	1702005
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 32GB 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.	1705573

RHEL 7

Use Red Hat Enterprise Linux 7.9 with ONTAP

You can use the ONTAP SAN host configuration settings to configure Red Hat Enterprise Linux 7.9 with ONTAP as the target.

Install the Linux Unified Host Utilities

The NetApp Linux Unified Host Utilities software package is available on the [NetApp Support Site](#) in a 32-bit and 64-bit .rpm file. If you do not know which file is right for your configuration, use the [NetApp Interoperability Matrix Tool](#) to verify which one you need.

NetApp strongly recommends installing the Linux Unified 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.

What you'll need

If you have a version of Linux Unified Host Utilities currently installed you should upgrade it or, you should remove it and use the following steps to install the latest version.

1. Download the 32-bit or 64-bit Linux Unified Host Utilities software package from the [NetApp Support Site](#) to your host.
2. Use the following command to install the software package:

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



You can use the configuration settings provided in this document 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) / vserver (cDOT/FlashRay) Product	lun-pathname	device filename	host adapter	protocol	lun size
data_vserver 120.0g cDOT	/vol/vol1/lun1	/dev/sdb	host16	FCP	
data_vserver 120.0g cDOT	/vol/vol1/lun1	/dev/sdc	host15	FCP	
data_vserver 120.0g cDOT	/vol/vol2/lun2	/dev/sdd	host16	FCP	
data_vserver 120.0g cDOT	/vol/vol2/lun2	/dev/sde	host15	FCP	

SAN Booting

What you'll need

If you decide to use SAN booting, it must be supported by your configuration. You can use the [NetApp 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 is successful.

Multipathing

For Red Hat Enterprise Linux (RHEL) 7.9 the `/etc/multipath.conf` file must exist, but you do not need to make specific changes to the file. RHEL 7.9 is compiled with all settings required to recognize and correctly manage ONTAP LUNs.

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

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

All SAN Array configurations

In All SAN Array (ASA) configurations, all paths to a given LUN are active and optimized. 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
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='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
```



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight 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 the higher priorities are Active/Optimized, meaning they are serviced by the controller where the aggregate is located. The paths with the lower priorities are active but are non-optimized because they are served from a different controller. The non-optimized paths are only used when no optimized paths are 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='service-time 0' prio=50 status=active
| |- 11:0:1:0 sdj 8:144 active ready running
| |- 11:0:2:0 sdr 65:16 active ready running
`-+- policy='service-time 0' prio=10 status=enabled
|- 11:0:0:0 sdb 8:i6 active ready running
|- 12:0:0:0 sdz 65:144 active ready running
```



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight paths might cause path issues during storage failures.

Recommended Settings

The RHEL 7.9 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, but you can create an empty, zero-byte file by using the following command:

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

The first time you create this file, you might need to enable and start the multipath services:

```
# systemctl enable multipathd
# systemctl start multipathd
```

- There is no requirement to add anything directly to the `multipath.conf` file, unless you have devices that you do not want to be managed by multipath or you have existing settings that override defaults.
- To exclude unwanted devices, add the following syntax to the `multipath.conf` file .

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

Replace the `<DevId>` with the WWID string of the device you want to exclude.

Example

In this example, we are going to determine the WWID of a device and add to the `multipath.conf` file.

Steps

1. Run the following command to determine the WWID:

```
# /lib/udev/scsi_id -gud /dev/sda
360030057024d0730239134810c0cb833
```

`sda` is the local SCSI disk that we need to add it to the blacklist.

2. Add the 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 for legacy settings, especially in the defaults section, that might be overriding the 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 will need to be corrected by later stanzas in the `multipath.conf` file that apply specifically to ONTAP LUNs. If this is not done, the ONTAP LUNs might not work as expected. These defaults should only be overridden in consultation with NetApp and/or an OS vendor and only when the impact is fully understood.

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

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
    }
}

```

KVM settings

You can use the recommended settings to configure Kernel-based Virtual Machine (KVM) as well. There are no changes required to configure KVM as the LUN is mapped to the hypervisor.

Known issues

The RHEL 7.9 with ONTAP release has the following known issues:

NetApp Bug ID	Title	Description	Bugzilla ID
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.	N/A

Use Red Hat Enterprise Linux 7.8 with ONTAP

You can use the ONTAP SAN host configuration settings to configure Red Hat Enterprise Linux 7.8 with ONTAP as the target.

Install the Linux Unified Host Utilities

The NetApp Linux Unified Host Utilities software package is available on the [NetApp Support Site](#) in a 32-bit and 64-bit .rpm file. If you do not know which file is right for your configuration, use the [NetApp Interoperability Matrix Tool](#) to verify which one you need.

NetApp strongly recommends installing the Linux Unified 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.

What you'll need

If you have a version of Linux Unified Host Utilities currently installed you should upgrade it or, you should remove it and use the following steps to install the latest version.

1. Download the 32-bit or 64-bit Linux Unified Host Utilities software package from the [NetApp Support Site](#) to your host.
2. Use the following command to install the software package:

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



You can use the configuration settings provided in this document 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) / vserver (cDOT/FlashRay) Product	lun-pathname	device filename	host adapter	protocol	lun size
data_vserver 120.0g cDOT	/vol/vol1/lun1	/dev/sdb	host16	FCP	
data_vserver 120.0g cDOT	/vol/vol1/lun1	/dev/sdc	host15	FCP	
data_vserver 120.0g cDOT	/vol/vol2/lun2	/dev/sdd	host16	FCP	
data_vserver 120.0g cDOT	/vol/vol2/lun2	/dev/sde	host15	FCP	

SAN Booting

What you'll need

If you decide to use SAN booting, it must be supported by your configuration. You can use the [NetApp 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 is successful.

Multipathing

For Red Hat Enterprise Linux (RHEL) 7.8 the `/etc/multipath.conf` file must exist, but you do not need to make specific changes to the file. RHEL 7.8 is compiled with all settings required to recognize and correctly manage ONTAP LUNs.

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

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

All SAN Array configurations

In All SAN Array (ASA) configurations, all paths to a given LUN are active and optimized. 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
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='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
```



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight 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 the higher priorities are Active/Optimized, meaning they are serviced by the controller where the aggregate is located. The paths with the lower priorities are active but are non-optimized because they are served from a different controller. The non-optimized paths are only used when no optimized paths are 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='service-time 0' prio=50 status=active
| |- 11:0:1:0 sdj 8:144 active ready running
| |- 11:0:2:0 sdr 65:16 active ready running
`-+- policy='service-time 0' prio=10 status=enabled
|- 11:0:0:0 sdb 8:i6 active ready running
|- 12:0:0:0 sdz 65:144 active ready running
```



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight paths might cause path issues during storage failures.

Recommended Settings

The RHEL 7.8 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, but you can create an empty, zero-byte file by using the following command:


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

The first time you create this file, you might need to enable and start the multipath services:

```
# systemctl enable multipathd
# systemctl start multipathd
```

- There is no requirement to add anything directly to the `multipath.conf` file, unless you have devices that you do not want to be managed by multipath or you have existing settings that override defaults.
- To exclude unwanted devices, add the following syntax to the `multipath.conf` file .

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

Replace the `<DevId>` with the WWID string of the device you want to exclude.

Example

In this example, we are going to determine the WWID of a device and add to the `multipath.conf` file.

Steps

1. Run the following command to determine the WWID:

```
# /lib/udev/scsi_id -gud /dev/sda
360030057024d0730239134810c0cb833
```

`sda` is the local SCSI disk that we need to add it to the blacklist.

2. Add the 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 for legacy settings, especially in the defaults section, that might be overriding the 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 will need to be corrected by later stanzas in the `multipath.conf` file that apply specifically to ONTAP LUNs. If this is not done, the ONTAP LUNs might not work as expected. These defaults should only be overridden in consultation with NetApp and/or an OS vendor and only when the impact is fully understood.

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

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
    }
}

```

KVM settings

You can use the recommended settings to configure Kernel-based Virtual Machine (KVM) as well. There are no changes required to configure KVM as the LUN is mapped to the hypervisor.

Known issues

The RHEL 7.8 with ONTAP release has the following known issues:

NetApp Bug ID	Title	Description	Bugzilla ID
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.	N/A

Use Red Hat Enterprise Linux 7.7 with ONTAP

You can use the ONTAP SAN host configuration settings to configure Red Hat Enterprise Linux 7.7 with ONTAP as the target.

Install the Linux Unified Host Utilities

The NetApp Linux Unified Host Utilities software package is available on the [NetApp Support Site](#) in a 32-bit and 64-bit .rpm file. If you do not know which file is right for your configuration, use the [NetApp Interoperability Matrix Tool](#) to verify which one you need.

NetApp strongly recommends installing the Linux Unified 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.

What you'll need

If you have a version of Linux Unified Host Utilities currently installed you should upgrade it or, you should remove it and use the following steps to install the latest version.

1. Download the 32-bit or 64-bit Linux Unified Host Utilities software package from the [NetApp Support Site](#) to your host.
2. Use the following command to install the software package:

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



You can use the configuration settings provided in this document 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) / vserver (cDOT/FlashRay) Product	lun-pathname	device filename	host adapter	protocol	lun size
data_vserver 120.0g cDOT	/vol/vol1/lun1	/dev/sdb	host16	FCP	
data_vserver 120.0g cDOT	/vol/vol1/lun1	/dev/sdc	host15	FCP	
data_vserver 120.0g cDOT	/vol/vol2/lun2	/dev/sdd	host16	FCP	
data_vserver 120.0g cDOT	/vol/vol2/lun2	/dev/sde	host15	FCP	

SAN Booting

What you'll need

If you decide to use SAN booting, it must be supported by your configuration. You can use the [NetApp 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 is successful.

Multipathing

For Red Hat Enterprise Linux (RHEL) 7.7 the `/etc/multipath.conf` file must exist, but you do not need to make specific changes to the file. RHEL 7.7 is compiled with all settings required to recognize and correctly manage ONTAP LUNs.

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

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

All SAN Array configurations

In All SAN Array (ASA) configurations, all paths to a given LUN are active and optimized. 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
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='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
```



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight 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 the higher priorities are Active/Optimized, meaning they are serviced by the controller where the aggregate is located. The paths with the lower priorities are active but are non-optimized because they are served from a different controller. The non-optimized paths are only used when no optimized paths are 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='service-time 0' prio=50 status=active
| |- 11:0:1:0 sdj    8:144   active ready running
| |- 11:0:2:0 sdr    65:16   active ready running
`-+- policy='service-time 0' prio=10 status=enabled
  |- 11:0:0:0 sdb    8:i6    active ready running
  |- 12:0:0:0 sdz    65:144  active ready running
```



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight paths might cause path issues during storage failures.

Recommended Settings

The RHEL 7.7 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, but you can create an empty, zero-byte file by using the following command:

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

The first time you create this file, you might need to enable and start the multipath services:

```
# systemctl enable multipathd
# systemctl start multipathd
```

- There is no requirement to add anything directly to the `multipath.conf` file, unless you have devices that you do not want to be managed by multipath or you have existing settings that override defaults.
- To exclude unwanted devices, add the following syntax to the `multipath.conf` file .

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

Replace the `<DevId>` with the WWID string of the device you want to exclude.

Example

In this example, we are going to determine the WWID of a device and add to the `multipath.conf` file.

Steps

1. Run the following command to determine the WWID:

```
# /lib/udev/scsi_id -gud /dev/sda
360030057024d0730239134810c0cb833
```

`sda` is the local SCSI disk that we need to add it to the blacklist.

2. Add the 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 for legacy settings, especially in the defaults section, that might be overriding the 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 will need to be corrected by later stanzas in the `multipath.conf` file that apply specifically to ONTAP LUNs. If this is not done, the ONTAP LUNs might not work as expected. These defaults should only be overridden in consultation with NetApp and/or an OS vendor and only when the impact is fully understood.

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

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
    }
}

```

KVM settings

You can use the recommended settings to configure Kernel-based Virtual Machine (KVM) as well. There are no changes required to configure KVM as the LUN is mapped to the hypervisor.

Known issues

The RHEL 7.7 with ONTAP release has the following known issues:

NetApp Bug ID	Title	Description	Bugzilla ID
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.	N/A

NetApp Bug ID	Title	Description	Bugzilla ID
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.	1743667
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.	1745995

Use Red Hat Enterprise Linux 7.6 with ONTAP

You can use the ONTAP SAN host configuration settings to configure Red Hat Enterprise Linux 7.6 with ONTAP as the target.

Install the Linux Unified Host Utilities

The NetApp Linux Unified Host Utilities software package is available on the [NetApp Support Site](#) in a 32-bit and 64-bit .rpm file. If you do not know which file is right for your configuration, use the [NetApp Interoperability Matrix Tool](#) to verify which one you need.

NetApp strongly recommends installing the Linux Unified 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.

What you'll need

If you have a version of Linux Unified Host Utilities currently installed you should upgrade it or, you should remove it and use the following steps to install the latest version.

1. Download the 32-bit or 64-bit Linux Unified Host Utilities software package from the [NetApp Support Site](#) to your host.
2. Use the following command to install the software package:

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



You can use the configuration settings provided in this document 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

What you'll need

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

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

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

All SAN Array configurations

In All SAN Array (ASA) configurations, all paths to a given LUN are active and optimized. 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
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='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
```



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight 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 the higher priorities are Active/Optimized, meaning they are serviced by the controller where the aggregate is located. The paths with the lower priorities are active but are non-optimized because they are served from a different controller. The non-optimized paths are only used when no optimized paths are 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='service-time 0' prio=50 status=active
| |- 11:0:1:0 sdj    8:144   active ready running
| |- 11:0:2:0 sdr    65:16   active ready running
`-+- policy='service-time 0' prio=10 status=enabled
  |- 11:0:0:0 sdb    8:i6    active ready running
  |- 12:0:0:0 sdz    65:144  active ready running
```



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight paths might cause path issues during storage failures.

Recommended Settings

The RHEL 7.6 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, but you can create an empty, zero-byte file by using the following command:

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

The first time you create this file, you might need to enable and start the multipath services:

```
# systemctl enable multipathd
# systemctl start multipathd
```

- There is no requirement to add anything directly to the `multipath.conf` file, unless you have devices that you do not want to be managed by multipath or you have existing settings that override defaults.
- To exclude unwanted devices, add the following syntax to the `multipath.conf` file .

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

Replace the `<DevId>` with the WWID string of the device you want to exclude.

Example

In this example, we are going to determine the WWID of a device and add to the `multipath.conf` file.

Steps

1. Run the following command to determine the WWID:

```
# /lib/udev/scsi_id -gud /dev/sda
360030057024d0730239134810c0cb833
```

`sda` is the local SCSI disk that we need to add it to the blacklist.

2. Add the 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 for legacy settings, especially in the defaults section, that might be overriding the 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 will need to be corrected by later stanzas in the `multipath.conf` file that apply specifically to ONTAP LUNs. If this is not done, the ONTAP LUNs might not work as expected. These defaults should only be overridden in consultation with NetApp and/or an OS vendor and only when the impact is fully understood.

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

KVM settings

You can use the recommended settings to configure Kernel-based Virtual Machine (KVM) as well. There are no changes required to configure KVM as the LUN is mapped to the hypervisor.

Known issues

The RHEL 7.6 with ONTAP release has the following known issues:

NetApp Bug ID	Title	Description	Bugzilla ID
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.	N/A

NetApp Bug ID	Title	Description	Bugzilla ID
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	1628039
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 ports might 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	1643459

Use Red Hat Enterprise Linux 7.5 with ONTAP

You can use the ONTAP SAN host configuration settings to configure Red Hat Enterprise Linux 7.5 with ONTAP as the target.

Install the Linux Unified Host Utilities

The NetApp Linux Unified Host Utilities software package is available on the [NetApp Support Site](#) in a 32-bit and 64-bit .rpm file. If you do not know which file is right for your configuration, use the [NetApp Interoperability Matrix Tool](#) to verify which one you need.

NetApp strongly recommends installing the Linux Unified 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.

What you'll need

If you have a version of Linux Unified Host Utilities currently installed you should upgrade it or, you should remove it and use the following steps to install the latest version.

1. Download the 32-bit or 64-bit Linux Unified Host Utilities software package from the [NetApp Support Site](#) to your host.
2. Use the following command to install the software package:

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



You can use the configuration settings provided in this document 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) / vserver (cDOT/FlashRay) Product	lun-pathname	device filename	host adapter	protocol	lun size
data_vserver 120.0g cDOT	/vol/vol1/lun1	/dev/sdb	host16	FCP	
data_vserver 120.0g cDOT	/vol/vol1/lun1	/dev/sdc	host15	FCP	
data_vserver 120.0g cDOT	/vol/vol2/lun2	/dev/sdd	host16	FCP	
data_vserver 120.0g cDOT	/vol/vol2/lun2	/dev/sde	host15	FCP	

SAN Booting

What you'll need

If you decide to use SAN booting, it must be supported by your configuration. You can use the [NetApp 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 is successful.

Multipathing

For Red Hat Enterprise Linux (RHEL) 7.5 the `/etc/multipath.conf` file must exist, but you do not need to make specific changes to the file. RHEL 7.5 is compiled with all settings required to recognize and correctly manage ONTAP LUNs.

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

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

All SAN Array configurations

In All SAN Array (ASA) configurations, all paths to a given LUN are active and optimized. 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
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='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
```



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight 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 the higher priorities are Active/Optimized, meaning they are serviced by the controller where the aggregate is located. The paths with the lower priorities are active but are non-optimized because they are served from a different controller. The non-optimized paths are only used when no optimized paths are 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='service-time 0' prio=50 status=active
| |- 11:0:1:0 sdj 8:144 active ready running
| |- 11:0:2:0 sdr 65:16 active ready running
`-+- policy='service-time 0' prio=10 status=enabled
  |- 11:0:0:0 sdb 8:i6 active ready running
  |- 12:0:0:0 sdz 65:144 active ready running
```



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight paths might cause path issues during storage failures.

Recommended Settings

The RHEL 7.5 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, but you can create an empty, zero-byte file by using the following command:

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

The first time you create this file, you might need to enable and start the multipath services:

```
# systemctl enable multipathd
# systemctl start multipathd
```

- There is no requirement to add anything directly to the `multipath.conf` file, unless you have devices that you do not want to be managed by multipath or you have existing settings that override defaults.
- To exclude unwanted devices, add the following syntax to the `multipath.conf` file .

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

Replace the `<DevId>` with the WWID string of the device you want to exclude.

Example

In this example, we are going to determine the WWID of a device and add to the `multipath.conf` file.

Steps

1. Run the following command to determine the WWID:

```
# /lib/udev/scsi_id -gud /dev/sda
360030057024d0730239134810c0cb833
```

`sda` is the local SCSI disk that we need to add it to the blacklist.

2. Add the 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 for legacy settings, especially in the defaults section, that might be overriding the 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 will need to be corrected by later stanzas in the `multipath.conf` file that apply specifically to ONTAP LUNs. If this is not done, the ONTAP LUNs might not work as expected. These defaults should only be overridden in consultation with NetApp and/or an OS vendor and only when the impact is fully understood.

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

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
    }
}

```

KVM settings

You can use the recommended settings to configure Kernel-based Virtual Machine (KVM) as well. There are no changes required to configure KVM as the LUN is mapped to the hypervisor.

Known issues

The RHEL 7.5 with ONTAP release has the following known issues:

NetApp Bug ID	Title	Description	Bugzilla ID
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.	N/A

NetApp Bug ID	Title	Description	Bugzilla ID
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.	1542564

NetApp Bug ID	Title	Description	Bugzilla ID
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.	1541972

NetApp Bug ID	Title	Description	Bugzilla ID
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.	1559050

NetApp Bug ID	Title	Description	Bugzilla ID
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.	1554777

Use Red Hat Enterprise Linux 7.4 with ONTAP

You can use the ONTAP SAN host configuration settings to configure Red Hat Enterprise Linux 7.4 with ONTAP as the target.

Install the Linux Unified Host Utilities

The NetApp Linux Unified Host Utilities software package is available on the [NetApp Support Site](#) in a 32-bit and 64-bit .rpm file. If you do not know which file is right for your configuration, use the [NetApp Interoperability Matrix Tool](#) to verify which one you need.

NetApp strongly recommends installing the Linux Unified 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.

What you'll need

If you have a version of Linux Unified Host Utilities currently installed you should upgrade it or, you should remove it and use the following steps to install the latest version.

1. Download the 32-bit or 64-bit Linux Unified Host Utilities software package from the [NetApp Support Site](#) to your host.
2. Use the following command to install the software package:

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



You can use the configuration settings provided in this document 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

What you'll need

If you decide to use SAN booting, it must be supported by your configuration. You can use the [NetApp 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 is successful.

Multipathing

For Red Hat Enterprise Linux (RHEL) 7.4 the `/etc/multipath.conf` file must exist, but you do not need to make specific changes to the file. RHEL 7.4 is compiled with all settings required to recognize and correctly manage ONTAP LUNs.

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

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

All SAN Array configurations

In All SAN Array (ASA) configurations, all paths to a given LUN are active and optimized. 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
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='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
```



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight 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 the higher priorities are Active/Optimized, meaning they are serviced by the controller where the aggregate is located. The paths with the lower priorities are active but are non-optimized because they are served from a different controller. The non-optimized paths are only used when no optimized paths are 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='service-time 0' prio=50 status=active
| |- 11:0:1:0 sdj 8:144 active ready running
| |- 11:0:2:0 sdr 65:16 active ready running
`+- policy='service-time 0' prio=10 status=enabled
  |- 11:0:0:0 sdb 8:i6 active ready running
  |- 12:0:0:0 sdz 65:144 active ready running
```



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight paths might cause path issues during storage failures.

Recommended Settings

The RHEL 7.4 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, but you can create an empty, zero-byte file by using the following command:

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

The first time you create this file, you might need to enable and start the multipath services:

```
# systemctl enable multipathd
# systemctl start multipathd
```

- There is no requirement to add anything directly to the `multipath.conf` file, unless you have devices that you do not want to be managed by multipath or you have existing settings that override defaults.
- To exclude unwanted devices, add the following syntax to the `multipath.conf` file .

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

Replace the `<DevId>` with the WWID string of the device you want to exclude.

Example

In this example, we are going to determine the WWID of a device and add to the `multipath.conf` file.

Steps

1. Run the following command to determine the WWID:

```
# /lib/udev/scsi_id -gud /dev/sda
360030057024d0730239134810c0cb833
```

sda is the local SCSI disk that we need to add it to the blacklist.

2. Add the 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 for legacy settings, especially in the defaults section, that might be overriding the 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 will need to be corrected by later stanzas in the `multipath.conf` file that apply specifically to ONTAP LUNs. If this is not done, the ONTAP LUNs might not work as expected. These defaults should only be overridden in consultation with NetApp and/or an OS vendor 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	"service-time 0"
polling_interval	5
prio	"ontap"

Parameter	Setting
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
    }
}
```

KVM settings

You can use the recommended settings to configure Kernel-based Virtual Machine (KVM) as well. There are no changes required to configure KVM as the LUN is mapped to the hypervisor.

Known issues

The RHEL 7.4 with ONTAP release has the following known issues:

NetApp Bug ID	Title	Description	Bugzilla ID
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 .	N/A

Use Red Hat Enterprise Linux 7.3 with ONTAP

You can use the ONTAP SAN host configuration settings to configure Red Hat Enterprise Linux 7.3 with ONTAP as the target.

Install the Linux Unified Host Utilities

The NetApp Linux Unified Host Utilities software package is available on the [NetApp Support Site](#) in a 32-bit and 64-bit .rpm file. If you do not know which file is right for your configuration, use the [NetApp Interoperability Matrix Tool](#) to verify which one you need.

NetApp strongly recommends installing the Linux Unified 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.

What you'll need

If you have a version of Linux Unified Host Utilities currently installed you should upgrade it or, you should remove it and use the following steps to install the latest version.

1. Download the 32-bit or 64-bit Linux Unified Host Utilities software package from the [NetApp Support Site](#) to your host.
2. Use the following command to install the software package:

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



You can use the configuration settings provided in this document 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

What you'll need

If you decide to use SAN booting, it must be supported by your configuration. You can use the [NetApp 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 is successful.

Multipathing

For Red Hat Enterprise Linux (RHEL) 7.3 the `/etc/multipath.conf` file must exist, but you do not need to make specific changes to the file. RHEL 7.3 is compiled with all settings required to recognize and correctly manage ONTAP LUNs.

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

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

All SAN Array configurations

In All SAN Array (ASA) configurations, all paths to a given LUN are active and optimized. 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
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='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
```



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight 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 the higher priorities are Active/Optimized, meaning they are serviced by the controller where the aggregate is located. The paths with the lower priorities are active but are non-optimized because they are served from a different controller. The non-optimized paths are only used when no optimized paths are 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='service-time 0' prio=50 status=active
| |- 11:0:1:0 sdj   8:144   active ready running
| |- 11:0:2:0 sdr   65:16   active ready running
`-+- policy='service-time 0' prio=10 status=enabled
  |- 11:0:0:0 sdb   8:i6    active ready running
  |- 12:0:0:0 sdz   65:144  active ready running
```



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight paths might cause path issues during storage failures.

Recommended Settings

The RHEL 7.3 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, but you can create an empty, zero-byte file by using the following command:

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

The first time you create this file, you might need to enable and start the multipath services:

```
# systemctl enable multipathd
# systemctl start multipathd
```

- There is no requirement to add anything directly to the `multipath.conf` file, unless you have devices that you do not want to be managed by multipath or you have existing settings that override defaults.
- To exclude unwanted devices, add the following syntax to the `multipath.conf` file .

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

Replace the `<DevId>` with the WWID string of the device you want to exclude.

Example

In this example, we are going to determine the WWID of a device and add to the `multipath.conf` file.

Steps

1. Run the following command to determine the WWID:

```
# /lib/udev/scsi_id -gud /dev/sda
360030057024d0730239134810c0cb833
```

`sda` is the local SCSI disk that we need to add it to the blacklist.

2. Add the 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 for legacy settings, especially in the defaults section, that might be overriding the 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 will need to be corrected by later stanzas in the `multipath.conf` file that apply specifically to ONTAP LUNs. If this is not done, the ONTAP LUNs might not work as expected. These defaults should only be overridden in consultation with NetApp and/or an OS vendor and only when the impact is fully understood.

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

KVM settings

You can use the recommended settings to configure Kernel-based Virtual Machine (KVM) as well. There are no changes required to configure KVM as the LUN is mapped to the hypervisor.

Known issues

There are no known issues for the RHEL 7.3 with ONTAP release.

Use Red Hat Enterprise Linux 7.2 with ONTAP

You can use the ONTAP SAN host configuration settings to configure Red Hat Enterprise Linux 7.2 with ONTAP as the target.

Install the Linux Unified Host Utilities

The NetApp Linux Unified Host Utilities software package is available on the [NetApp Support Site](#) in a 32-bit and 64-bit .rpm file. If you do not know which file is right for your configuration, use the [NetApp Interoperability Matrix Tool](#) to verify which one you need.

NetApp strongly recommends installing the Linux Unified 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.

What you'll need

If you have a version of Linux Unified Host Utilities currently installed you should upgrade it or, you should remove it and use the following steps to install the latest version.

1. Download the 32-bit or 64-bit Linux Unified Host Utilities software package from the [NetApp Support Site](#) to your host.
2. Use the following command to install the software package:

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



You can use the configuration settings provided in this document 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

What you'll need

If you decide to use SAN booting, it must be supported by your configuration. You can use the [NetApp 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 is successful.

Multipathing

For Red Hat Enterprise Linux (RHEL) 7.2 the `/etc/multipath.conf` file must exist, but you do not need to make specific changes to the file. RHEL 7.2 is compiled with all settings required to recognize and correctly manage ONTAP LUNs.

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

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

All SAN Array configurations

In All SAN Array (ASA) configurations, all paths to a given LUN are active and optimized. 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
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='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
```



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight 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 the higher priorities are Active/Optimized, meaning they are serviced by the controller where the aggregate is located. The paths with the lower priorities are active but are non-optimized because they are served from a different controller. The non-optimized paths are only used when no optimized paths are 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='service-time 0' prio=50 status=active
| |- 11:0:1:0 sdj 8:144 active ready running
| |- 11:0:2:0 sdr 65:16 active ready running
`+- policy='service-time 0' prio=10 status=enabled
  |- 11:0:0:0 sdb 8:i6 active ready running
  |- 12:0:0:0 sdz 65:144 active ready running
```



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight paths might cause path issues during storage failures.

Recommended Settings

The RHEL 7.2 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, but you can create an empty, zero-byte file by using the following command:

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

The first time you create this file, you might need to enable and start the multipath services:

```
# systemctl enable multipathd
# systemctl start multipathd
```

- There is no requirement to add anything directly to the `multipath.conf` file, unless you have devices that you do not want to be managed by multipath or you have existing settings that override defaults.
- To exclude unwanted devices, add the following syntax to the `multipath.conf` file .

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

Replace the `<DevId>` with the WWID string of the device you want to exclude.

Example

In this example, we are going to determine the WWID of a device and add to the `multipath.conf` file.

Steps

1. Run the following command to determine the WWID:

```
# /lib/udev/scsi_id -gud /dev/sda
360030057024d0730239134810c0cb833
```

sda is the local SCSI disk that we need to add it to the blacklist.

2. Add the 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 for legacy settings, especially in the defaults section, that might be overriding the 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 will need to be corrected by later stanzas in the `multipath.conf` file that apply specifically to ONTAP LUNs. If this is not done, the ONTAP LUNs might not work as expected. These defaults should only be overridden in consultation with NetApp and/or an OS vendor 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	"service-time 0"
polling_interval	5
prio	"ontap"

Parameter	Setting
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
    }
}
```

KVM settings

You can use the recommended settings to configure Kernel-based Virtual Machine (KVM) as well. There are no changes required to configure KVM as the LUN is mapped to the hypervisor.

Known issues

There are no known issues for the RHEL 7.2 with ONTAP release.

Use Red Hat Enterprise Linux 7.1 with ONTAP

You can use the ONTAP SAN host configuration settings to configure Red Hat Enterprise Linux 7.1 with ONTAP as the target.

Install the Linux Unified Host Utilities

The NetApp Linux Unified Host Utilities software package is available on the [NetApp Support Site](#) in a 32-bit and 64-bit .rpm file. If you do not know which file is right for your configuration, use the [NetApp Interoperability Matrix Tool](#) to verify which one you need.

NetApp strongly recommends installing the Linux Unified 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.

What you'll need

If you have a version of Linux Unified Host Utilities currently installed you should upgrade it or, you should remove it and use the following steps to install the latest version.

1. Download the 32-bit or 64-bit Linux Unified Host Utilities software package from the [NetApp Support Site](#) to your host.
2. Use the following command to install the software package:

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



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

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

SAN Booting

What you'll need

If you decide to use SAN booting, it must be supported by your configuration. You can use the [NetApp](#)

[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 is successful.

Multipathing

For Red Hat Enterprise Linux (RHEL) 7.1 the `/etc/multipath.conf` file must exist, but you do not need to make specific changes to the file. RHEL 7.1 is compiled with all settings required to recognize and correctly manage ONTAP LUNs.

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

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

All SAN Array configurations

In All SAN Array (ASA) configurations, all paths to a given LUN are active and optimized. 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
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='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
```



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight 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 the higher priorities are Active/Optimized, meaning they are serviced by the controller where the aggregate is located. The paths with the lower priorities are active but are non-optimized because they are served from a

different controller. The non-optimized paths are only used when no optimized paths are 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='service-time 0' prio=50 status=active
| |- 11:0:1:0 sdj 8:144 active ready running
| |- 11:0:2:0 sdr 65:16 active ready running
`-+- policy='service-time 0' prio=10 status=enabled
    |- 11:0:0:0 sdb 8:i6 active ready running
    |- 12:0:0:0 sdz 65:144 active ready running
```



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight paths might cause path issues during storage failures.

Recommended Settings

The RHEL 7.1 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, but you can create an empty, zero-byte file by using the following command:

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

The first time you create this file, you might need to enable and start the multipath services:

```
# systemctl enable multipathd
# systemctl start multipathd
```

- There is no requirement to add anything directly to the `multipath.conf` file, unless you have devices that you do not want to be managed by multipath or you have existing settings that override defaults.
- To exclude unwanted devices, add the following syntax to the `multipath.conf` file .

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

Replace the <DevId> with the WWID string of the device you want to exclude.

Example

In this example, we are going to determine the WWID of a device and add to the `multipath.conf` file.

Steps

1. Run the following command to determine the WWID:

```
# /lib/udev/scsi_id -gud /dev/sda
360030057024d0730239134810c0cb833
```

`sda` is the local SCSI disk that we need to add it to the blacklist.

2. Add the 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 for legacy settings, especially in the defaults section, that might be overriding the 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 will need to be corrected by later stanzas in the `multipath.conf` file that apply specifically to ONTAP LUNs. If this is not done, the ONTAP LUNs might not work as expected. These defaults should only be overridden in consultation with NetApp and/or an OS vendor and only when the impact is fully understood.

Parameter	Setting
<code>detect_prio</code>	<code>yes</code>
<code>dev_loss_tmo</code>	<code>"infinity"</code>
<code>failback</code>	<code>immediate</code>
<code>fast_io_fail_tmo</code>	<code>5</code>
<code>features</code>	<code>"3 queue_if_no_path pg_init_retries 50"</code>
<code>flush_on_last_del</code>	<code>"yes"</code>
<code>hardware_handler</code>	<code>"0"</code>
<code>no_path_retry</code>	<code>queue</code>
<code>path_checker</code>	<code>"tur"</code>
<code>path_grouping_policy</code>	<code>"group_by_prio"</code>

Parameter	Setting
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

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
    }
}
```

KVM settings

You can use the recommended settings to configure Kernel-based Virtual Machine (KVM) as well. There are no changes required to configure KVM as the LUN is mapped to the hypervisor.

Known issues

The RHEL 7.1 with ONTAP release has the following known issues:

NetApp Bug ID	Title	Description	Bugzilla ID
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"	1061755
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.	1114966

Use Red Hat Enterprise Linux 7.0 with ONTAP

You can use the ONTAP SAN host configuration settings to configure Red Hat Enterprise Linux 7.0 with ONTAP as the target.

Install the Linux Unified Host Utilities

The NetApp Linux Unified Host Utilities software package is available on the [NetApp Support Site](#) in a 32-bit and 64-bit .rpm file. If you do not know which file is right for your configuration, use the [NetApp Interoperability Matrix Tool](#) to verify which one you need.

NetApp strongly recommends installing the Linux Unified 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.

What you'll need

If you have a version of Linux Unified Host Utilities currently installed you should upgrade it or, you should

remove it and use the following steps to install the latest version.

1. Download the 32-bit or 64-bit Linux Unified Host Utilities software package from the [NetApp Support Site](#) to your host.
2. Use the following command to install the software package:

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



You can use the configuration settings provided in this document 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) / vserver(cDOT/FlashRay) Product	lun-pathname	device filename	host adapter	lun protocol	size
data_vserver 120.0g cDOT	/vol/vol1/lun1	/dev/sdb	host16	FCP	
data_vserver 120.0g cDOT	/vol/vol1/lun1	/dev/sdc	host15	FCP	
data_vserver 120.0g cDOT	/vol/vol2/lun2	/dev/sdd	host16	FCP	
data_vserver 120.0g cDOT	/vol/vol2/lun2	/dev/sde	host15	FCP	

SAN Booting

What you'll need

If you decide to use SAN booting, it must be supported by your configuration. You can use the [NetApp 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 is successful.

Multipathing

For Red Hat Enterprise Linux (RHEL) 7.0 the `/etc/multipath.conf` file must exist, but you do not need to make specific changes to the file. RHEL 7.0 is compiled with all settings required to recognize and correctly manage ONTAP LUNs.

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

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

All SAN Array configurations

In All SAN Array (ASA) configurations, all paths to a given LUN are active and optimized. 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
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='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
```



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight 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 the higher priorities are Active/Optimized, meaning they are serviced by the controller where the aggregate is located. The paths with the lower priorities are active but are non-optimized because they are served from a different controller. The non-optimized paths are only used when no optimized paths are 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='service-time 0' prio=50 status=active
| |- 11:0:1:0 sdj 8:144 active ready running
| |- 11:0:2:0 sdr 65:16 active ready running
`+- policy='service-time 0' prio=10 status=enabled
  |- 11:0:0:0 sdb 8:i6 active ready running
  |- 12:0:0:0 sdz 65:144 active ready running
```



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight paths might cause path issues during storage failures.

Recommended Settings

The RHEL 7.0 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, but you can create an empty, zero-byte file by using the following command:

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

The first time you create this file, you might need to enable and start the multipath services:

```
# systemctl enable multipathd
# systemctl start multipathd
```

- There is no requirement to add anything directly to the `multipath.conf` file, unless you have devices that you do not want to be managed by multipath or you have existing settings that override defaults.
- To exclude unwanted devices, add the following syntax to the `multipath.conf` file .

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

Replace the `<DevId>` with the WWID string of the device you want to exclude.

Example

In this example, we are going to determine the WWID of a device and add to the `multipath.conf` file.

Steps

1. Run the following command to determine the WWID:

```
# /lib/udev/scsi_id -gud /dev/sda
360030057024d0730239134810c0cb833
```

sda is the local SCSI disk that we need to add it to the blacklist.

2. Add the 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 for legacy settings, especially in the defaults section, that might be overriding the 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 will need to be corrected by later stanzas in the `multipath.conf` file that apply specifically to ONTAP LUNs. If this is not done, the ONTAP LUNs might not work as expected. These defaults should only be overridden in consultation with NetApp and/or an OS vendor 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	"service-time 0"
polling_interval	5
prio	"ontap"

Parameter	Setting
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
    }
}
```

KVM settings

You can use the recommended settings to configure Kernel-based Virtual Machine (KVM) as well. There are no changes required to configure KVM as the LUN is mapped to the hypervisor.

Known issues

The RHEL 7.0 with ONTAP release has the following known issues:

NetApp Bug ID	Title	Description	Bugzilla ID
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.	1131393

NetApp Bug ID	Title	Description	Bugzilla ID
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.	1079735
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.	1067895
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.	1090378
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.	1061755

NetApp Bug ID	Title	Description	Bugzilla ID
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.	1109274
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.	1114966

NetApp Bug ID	Title	Description	Bugzilla ID
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.	1114820
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.	1114464

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 Unified Host Utilities

The NetApp Linux Unified Host Utilities software package is available on the [NetApp Support Site](#) in a 32-bit and 64-bit .rpm file. If you do not know which file is right for your configuration, use the [NetApp Interoperability](#)

[Matrix Tool](#) to verify which one you need.

NetApp strongly recommends installing the Linux Unified 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.

What you'll need

If you have a version of Linux Unified Host Utilities currently installed you should upgrade it or, you should remove it and use the following steps to install the latest version.

1. Download the 32-bit or 64-bit Linux Unified Host Utilities software package from the [NetApp Support Site](#) to your host.
2. Use the following command to install the software package:

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



You can use the configuration settings provided in this document 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

What you'll need

If you decide to use SAN booting, it must be supported by your configuration. You can use the [NetApp 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 is 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 sample multipath output for a LUN mapped to ASA and non-ASA personas.

All SAN Array configurations

In All SAN Array (ASA) configurations, all paths to a given LUN are active and optimized. 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
```



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight 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 the higher priorities are Active/Optimized, meaning they are serviced by the controller where the aggregate is located. The paths with the lower priorities are active but are non-optimized because they are served from a different controller. The non-optimized paths are only used when no optimized paths are 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
```



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight 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, but you can create an empty, zero-byte file by using the following command:

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

The first time you create this file, you might need to enable and start the multipath services:

```
# systemctl enable multipathd
# systemctl start multipathd
```

- There is no requirement to add anything directly to the `multipath.conf` file, unless you have devices that you do not want to be managed by multipath or you have existing settings that override defaults.
- To exclude unwanted devices, add the following syntax to the `multipath.conf` file .

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

Replace the `<DevId>` with the WWID string of the device you want to exclude.

Example

In this example, we are going to determine the WWID of a device and add to the `multipath.conf` file.

Steps

1. Run the following command to determine the WWID:

```
# /lib/udev/scsi_id -gud /dev/sda
360030057024d0730239134810c0cb833
```

`sda` is the local SCSI disk that we need to add it to the blacklist.

2. Add the 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 for legacy settings, especially in the defaults section, that might be overriding the 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 will need to be corrected by later stanzas in the `multipath.conf` file that apply specifically to ONTAP LUNs. If this is not done, the ONTAP LUNs might not work as expected. These defaults should only be overridden in consultation with NetApp and/or an OS vendor and only when the impact is fully understood.

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

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
    }
}
```

KVM settings

You can use the recommended settings to configure Kernel-based Virtual Machine (KVM) as well. There are no changes required to configure KVM as the LUN is mapped to the hypervisor.

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 Unified Host Utilities

The NetApp Linux Unified Host Utilities software package is available on the [NetApp Support Site](#) in a 32-bit and 64-bit .rpm file. If you do not know which file is right for your configuration, use the [NetApp Interoperability Matrix Tool](#) to verify which one you need.

NetApp strongly recommends installing the Linux Unified 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.

What you'll need

If you have a version of Linux Unified Host Utilities currently installed you should upgrade it or, you should remove it and use the following steps to install the latest version.

1. Download the 32-bit or 64-bit Linux Unified Host Utilities software package from the [NetApp Support Site](#) to your host.
2. Use the following command to install the software package:

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



You can use the configuration settings provided in this document 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

What you'll need

If you decide to use SAN booting, it must be supported by your configuration. You can use the [NetApp 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 is 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 sample multipath output for a LUN mapped to ASA and non-ASA personas.

All SAN Array configurations

In All SAN Array (ASA) configurations, all paths to a given LUN are active and optimized. 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
```



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight 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 the higher priorities are Active/Optimized, meaning they are serviced by the controller where the aggregate is located. The paths with the lower priorities are active but are non-optimized because they are served from a different controller. The non-optimized paths are only used when no optimized paths are 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
```



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight 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, but you can create an empty, zero-byte file by using the following command:

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

The first time you create this file, you might need to enable and start the multipath services:

```
# systemctl enable multipathd
# systemctl start multipathd
```

- There is no requirement to add anything directly to the `multipath.conf` file, unless you have devices that you do not want to be managed by multipath or you have existing settings that override defaults.
- To exclude unwanted devices, add the following syntax to the `multipath.conf` file .

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

Replace the `<DevId>` with the WWID string of the device you want to exclude.

Example

In this example, we are going to determine the WWID of a device and add to the `multipath.conf` file.

Steps

1. Run the following command to determine the WWID:

```
# /lib/udev/scsi_id -gud /dev/sda
360030057024d0730239134810c0cb833
```

`sda` is the local SCSI disk that we need to add it to the blacklist.

2. Add the 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 for legacy settings, especially in the defaults section, that might be overriding the 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 will need to be corrected by later stanzas in the `multipath.conf` file that apply specifically to ONTAP LUNs. If this is not done, the ONTAP LUNs might not work as expected. These defaults should only be overridden in consultation with NetApp and/or an OS vendor and only when the impact is fully understood.

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

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
    }
}

```

KVM settings

You can use the recommended settings to configure Kernel-based Virtual Machine (KVM) as well. There are no changes required to configure KVM as the LUN is mapped to the hypervisor.

Known issues

The RHEL 6.9 with ONTAP release has the following known issues:

NetApp Bug ID	Title	Description	Bugzilla ID
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.	427496

NetApp Bug ID	Title	Description	Bugzilla ID
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)	1438711

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 Unified Host Utilities

The NetApp Linux Unified Host Utilities software package is available on the [NetApp Support Site](#) in a 32-bit and 64-bit .rpm file. If you do not know which file is right for your configuration, use the [NetApp Interoperability Matrix Tool](#) to verify which one you need.

NetApp strongly recommends installing the Linux Unified 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.

What you'll need

If you have a version of Linux Unified Host Utilities currently installed you should upgrade it or, you should remove it and use the following steps to install the latest version.

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

2. Use the following command to install the software package:

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



You can use the configuration settings provided in this document 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

What you'll need

If you decide to use SAN booting, it must be supported by your configuration. You can use the [NetApp 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 is 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 sample multipath output for a LUN mapped to ASA and non-ASA personas.

All SAN Array configurations

In All SAN Array (ASA) configurations, all paths to a given LUN are active and optimized. 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
```



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight 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 the higher priorities are Active/Optimized, meaning they are serviced by the controller where the aggregate is located. The paths with the lower priorities are active but are non-optimized because they are served from a different controller. The non-optimized paths are only used when no optimized paths are 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
```



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight 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, but you can create an empty, zero-byte file by using the following command:


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

The first time you create this file, you might need to enable and start the multipath services:

```
# systemctl enable multipathd
# systemctl start multipathd
```

- There is no requirement to add anything directly to the `multipath.conf` file, unless you have devices that you do not want to be managed by multipath or you have existing settings that override defaults.
- To exclude unwanted devices, add the following syntax to the `multipath.conf` file .

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

Replace the `<DevId>` with the WWID string of the device you want to exclude.

Example

In this example, we are going to determine the WWID of a device and add to the `multipath.conf` file.

Steps

1. Run the following command to determine the WWID:

```
# /lib/udev/scsi_id -gud /dev/sda
360030057024d0730239134810c0cb833
```

`sda` is the local SCSI disk that we need to add it to the blacklist.

2. Add the 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 for legacy settings, especially in the defaults section, that might be overriding the 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 will need to be corrected by later stanzas in the `multipath.conf` file that apply specifically to ONTAP LUNs. If this is not done, the ONTAP LUNs might not work as expected. These defaults should only be overridden in consultation with NetApp and/or an OS vendor and only when the impact is fully understood.

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

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
    }
}

```

KVM settings

You can use the recommended settings to configure Kernel-based Virtual Machine (KVM) as well. There are no changes required to configure KVM as the LUN is mapped to the hypervisor.

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 Unified Host Utilities

The NetApp Linux Unified Host Utilities software package is available on the [NetApp Support Site](#) in a 32-bit and 64-bit .rpm file. If you do not know which file is right for your configuration, use the [NetApp Interoperability Matrix Tool](#) to verify which one you need.

NetApp strongly recommends installing the Linux Unified 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.

What you'll need

If you have a version of Linux Unified Host Utilities currently installed you should upgrade it or, you should remove it and use the following steps to install the latest version.

1. Download the 32-bit or 64-bit Linux Unified Host Utilities software package from the [NetApp Support Site](#) to your host.
2. Use the following command to install the software package:

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



You can use the configuration settings provided in this document 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

What you'll need

If you decide to use SAN booting, it must be supported by your configuration. You can use the [NetApp 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 is 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 sample multipath output for a LUN mapped to ASA and non-ASA personas.

All SAN Array configurations

In All SAN Array (ASA) configurations, all paths to a given LUN are active and optimized. 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
```



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight 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 the higher priorities are Active/Optimized, meaning they are serviced by the controller where the aggregate is located. The paths with the lower priorities are active but are non-optimized because they are served from a different controller. The non-optimized paths are only used when no optimized paths are 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
```



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight 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 configuration.

The `multipath.conf` file must exist for the multipath daemon to start, but you can create an empty, zero-byte file by using the following command:

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

The first time you create this file, you might need to enable and start the multipath services:

```
# systemctl enable multipathd
# systemctl start multipathd
```

- There is no requirement to add anything directly to the `multipath.conf` file, unless you have devices that you do not want to be managed by multipath or you have existing settings that override defaults.
- To exclude unwanted devices, add the following syntax to the `multipath.conf` file .

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

Replace the `<DevId>` with the WWID string of the device you want to exclude.

Example

In this example, we are going to determine the WWID of a device and add to the `multipath.conf` file.

Steps

1. Run the following command to determine the WWID:

```
# /lib/udev/scsi_id -gud /dev/sda
360030057024d0730239134810c0cb833
```

`sda` is the local SCSI disk that we need to add it to the blacklist.

2. Add the 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 for legacy settings, especially in the defaults section, that might be overriding the 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 will need to be corrected by later stanzas in the `multipath.conf` file that apply specifically to ONTAP LUNs. If this is not done, the ONTAP LUNs might not work as expected. These defaults should only be overridden in consultation with NetApp and/or an OS vendor and only when the impact is fully understood.

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

```

KVM settings

You can use the recommended settings to configure Kernel-based Virtual Machine (KVM) as well. There are no changes required to configure KVM as the LUN is mapped to the hypervisor.

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 Unified Host Utilities

The NetApp Linux Unified Host Utilities software package is available on the [NetApp Support Site](#) in a 32-bit and 64-bit .rpm file. If you do not know which file is right for your configuration, use the [NetApp Interoperability Matrix Tool](#) to verify which one you need.

NetApp strongly recommends installing the Linux Unified 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.

What you'll need

If you have a version of Linux Unified Host Utilities currently installed you should upgrade it or, you should remove it and use the following steps to install the latest version.

1. Download the 32-bit or 64-bit Linux Unified Host Utilities software package from the [NetApp Support Site](#) to your host.
2. Use the following command to install the software package:

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



You can use the configuration settings provided in this document 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

What you'll need

If you decide to use SAN booting, it must be supported by your configuration. You can use the [NetApp 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 is 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 sample multipath output for a LUN mapped to ASA and non-ASA personas.

All SAN Array configurations

In All SAN Array (ASA) configurations, all paths to a given LUN are active and optimized. 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
```



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight 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 the higher priorities are Active/Optimized, meaning they are serviced by the controller where the aggregate is located. The paths with the lower priorities are active but are non-optimized because they are served from a different controller. The non-optimized paths are only used when no optimized paths are 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
```



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight 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, but you can create an empty, zero-byte file by using the following command:

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

The first time you create this file, you might need to enable and start the multipath services:

```
# systemctl enable multipathd
# systemctl start multipathd
```

- There is no requirement to add anything directly to the `multipath.conf` file, unless you have devices that you do not want to be managed by multipath or you have existing settings that override defaults.
- To exclude unwanted devices, add the following syntax to the `multipath.conf` file .

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

Replace the `<DevId>` with the WWID string of the device you want to exclude.

Example

In this example, we are going to determine the WWID of a device and add to the `multipath.conf` file.

Steps

1. Run the following command to determine the WWID:

```
# /lib/udev/scsi_id -gud /dev/sda
360030057024d0730239134810c0cb833
```

`sda` is the local SCSI disk that we need to add it to the blacklist.

2. Add the 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 for legacy settings, especially in the defaults section, that might be overriding the 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 will need to be corrected by later stanzas in the `multipath.conf` file that apply specifically to ONTAP LUNs. If this is not done, the ONTAP LUNs might not work as expected. These defaults should only be overridden in consultation with NetApp and/or an OS vendor and only when the impact is fully understood.

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

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
    }
}

```

KVM settings

You can use the recommended settings to configure Kernel-based Virtual Machine (KVM) as well. There are no changes required to configure KVM as the LUN is mapped to the hypervisor.

Known issues

The RHEL 6.6 with ONTAP release has the following known issues:

NetApp Bug ID	Title	Description	Bugzilla ID
863878	Kernel crash occurs with RHEL 6U6 host during storage failures	You might observe kernel crash on RHEL 6U6 host during storage/fabric.	1158363
1076584	IO stall up to 300 sec seen with QLogic 16G FC (QLE2672) host during storage failures in RHEL 6U4	You might observe an IO stall up to 300 sec on QLogic 16G FC (QLE2672) host during storage/fabric failures.	1135962
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.	1151020

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 Unified Host Utilities

The NetApp Linux Unified Host Utilities software package is available on the [NetApp Support Site](#) in a 32-bit and 64-bit .rpm file. If you do not know which file is right for your configuration, use the [NetApp Interoperability Matrix Tool](#) to verify which one you need.

NetApp strongly recommends installing the Linux Unified 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.

What you'll need

If you have a version of Linux Unified Host Utilities currently installed you should upgrade it or, you should remove it and use the following steps to install the latest version.

1. Download the 32-bit or 64-bit Linux Unified Host Utilities software package from the [NetApp Support Site](#) to your host.
2. Use the following command to install the software package:

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



You can use the configuration settings provided in this document 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) / vserver (cDOT/FlashRay) Product	lun-pathname	device filename	host adapter	protocol	lun size
data_vserver 120.0g cDOT	/vol/vol1/lun1	/dev/sdb	host16	FCP	
data_vserver 120.0g cDOT	/vol/vol1/lun1	/dev/sdc	host15	FCP	
data_vserver 120.0g cDOT	/vol/vol2/lun2	/dev/sdd	host16	FCP	
data_vserver 120.0g cDOT	/vol/vol2/lun2	/dev/sde	host15	FCP	

SAN Booting

What you'll need

If you decide to use SAN booting, it must be supported by your configuration. You can use the [NetApp 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 is 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 sample multipath output for a LUN mapped to ASA and non-ASA personas.

All SAN Array configurations

In All SAN Array (ASA) configurations, all paths to a given LUN are active and optimized. 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
```



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight 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 the higher priorities are Active/Optimized, meaning they are serviced by the controller where the aggregate is located. The paths with the lower priorities are active but are non-optimized because they are served from a different controller. The non-optimized paths are only used when no optimized paths are 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
```



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight 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, but you can create an empty, zero-byte file by using the following command:

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

The first time you create this file, you might need to enable and start the multipath services:

```
# systemctl enable multipathd
# systemctl start multipathd
```

- There is no requirement to add anything directly to the `multipath.conf` file, unless you have devices that you do not want to be managed by multipath or you have existing settings that override defaults.
- To exclude unwanted devices, add the following syntax to the `multipath.conf` file .

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

Replace the `<DevId>` with the WWID string of the device you want to exclude.

Example

In this example, we are going to determine the WWID of a device and add to the `multipath.conf` file.

Steps

1. Run the following command to determine the WWID:

```
# /lib/udev/scsi_id -gud /dev/sda
360030057024d0730239134810c0cb833
```

`sda` is the local SCSI disk that we need to add it to the blacklist.

2. Add the 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 for legacy settings, especially in the defaults section, that might be overriding the 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 will need to be corrected by later stanzas in the `multipath.conf` file that apply specifically to ONTAP LUNs. If this is not done, the ONTAP LUNs might not work as expected. These defaults should only be overridden in consultation with NetApp and/or an OS vendor and only when the impact is fully understood.

Parameter	Setting
<code>detect_prio</code>	<code>yes</code>
<code>dev_loss_tmo</code>	<code>"infinity"</code>
<code>failback</code>	<code>immediate</code>
<code>fast_io_fail_tmo</code>	<code>5</code>
<code>features</code>	<code>"3 queue_if_no_path pg_init_retries 50"</code>
<code>flush_on_last_del</code>	<code>"yes"</code>
<code>hardware_handler</code>	<code>"0"</code>
<code>no_path_retry</code>	<code>queue</code>
<code>path_checker</code>	<code>"tur"</code>
<code>path_grouping_policy</code>	<code>"group_by_prio"</code>
<code>path_selector</code>	<code>"round-robin 0"</code>

Parameter	Setting
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
    }
}
```

KVM settings

You can use the recommended settings to configure Kernel-based Virtual Machine (KVM) as well. There are no changes required to configure KVM as the LUN is mapped to the hypervisor.

Known issues

The RHEL 6.5 with ONTAP release has the following known issues:

NetApp Bug ID	Title	Description	Bugzilla ID
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.	1033136

NetApp Bug ID	Title	Description	Bugzilla ID
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.	1007463
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.	1063699
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.	1068619
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"	1068622

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 Unified Host Utilities

The NetApp Linux Unified Host Utilities software package is available on the [NetApp Support Site](#) in a 32-bit and 64-bit .rpm file. If you do not know which file is right for your configuration, use the [NetApp Interoperability Matrix Tool](#) to verify which one you need.

NetApp strongly recommends installing the Linux Unified 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.

What you'll need

If you have a version of Linux Unified Host Utilities currently installed you should upgrade it or, you should remove it and use the following steps to install the latest version.

1. Download the 32-bit or 64-bit Linux Unified Host Utilities software package from the [NetApp Support Site](#) to your host.
2. Use the following command to install the software package:

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



You can use the configuration settings provided in this document 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

What you'll need

If you decide to use SAN booting, it must be supported by your configuration. You can use the [NetApp 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 is 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 sample multipath output for a LUN mapped to ASA and non-ASA personas.

All SAN Array configurations

In All SAN Array (ASA) configurations, all paths to a given LUN are active and optimized. 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
```



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight 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 the higher priorities are Active/Optimized, meaning they are serviced by the controller where the aggregate is located. The paths with the lower priorities are active but are non-optimized because they are served from a different controller. The non-optimized paths are only used when no optimized paths are 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
```



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight 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, but you can create an empty, zero-byte file by using the following command:

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

The first time you create this file, you might need to enable and start the multipath services:

```
# systemctl enable multipathd
# systemctl start multipathd
```

- There is no requirement to add anything directly to the `multipath.conf` file, unless you have devices that you do not want to be managed by multipath or you have existing settings that override defaults.
- To exclude unwanted devices, add the following syntax to the `multipath.conf` file .

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

Replace the `<DevId>` with the WWID string of the device you want to exclude.

Example

In this example, we are going to determine the WWID of a device and add to the `multipath.conf` file.

Steps

1. Run the following command to determine the WWID:

```
# /lib/udev/scsi_id -gud /dev/sda
360030057024d0730239134810c0cb833
```

`sda` is the local SCSI disk that we need to add it to the blacklist.

2. Add the 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 for legacy settings, especially in the defaults section, that might be overriding the 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 will need to be corrected by later stanzas in the `multipath.conf` file that apply specifically to ONTAP LUNs. If this is not done, the ONTAP LUNs might not work as expected. These defaults should only be overridden in consultation with NetApp and/or an OS vendor and only when the impact is fully understood.

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

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
    }
}
```

KVM settings

You can use the recommended settings to configure Kernel-based Virtual Machine (KVM) as well. There are no changes required to configure KVM as the LUN is mapped to the hypervisor.

Known issues

The RHEL 6.4 with ONTAP release has the following known issues:

NetApp Bug ID	Title	Description	Bugzilla ID
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.	907844

Solaris

Use Solaris 11.4 with ONTAP

You can use the ONTAP SAN host configuration settings to configure Solaris 11.4 with ONTAP as the target.

Install the Solaris Host Utilities

You can download the compressed file containing the Host Utilities software packages from the [NetApp Support Site](#). After you download the file, you must extract the zip file to get the software packages you need to

install the Host Utilities.

Steps

1. Download a copy of the compressed file containing the Host Utilities from the [NetApp Support Site](#) to a directory on your host.
2. Go to the directory containing the download.
3. Decompress the file.

The following example decompresses files for a SPARC system. For x86-64 platforms, use the x86/x64 package.

```
gunzip netapp_solaris_host_utilities_6_2N20170913_0304_sparc.tar.gz
```

4. Use the `tar xvf` command to extract the file.

```
tar xvf netapp_solaris_host_utilities_6_2N20170913_0304_sparc.tar
```

5. Add the packages that you extracted from the .tar file to your host.

```
pkgadd -d NTAPSANTool.pkg
```

The packages are added to the `/opt/NTAP/SANToolkit/bin` directory.

To complete the installation, you must configure the host parameters for your environment (Oracle Solaris I/O Multipathing or MPxIO in this case) by using the `host_config` command.

The `host_config` command has the following format:

```
/opt/NTAP/SANToolkit/bin/host_config <setup> <protocol fcp|iscsi|mixed>  
<multipath mpxio|dmp| non> [-noalua] [-mcc 60|90|120]
```

The `host_config` command does the following:

- Changes the FC and SCSI driver settings for x86 and SPARC systems
- Provides SCSI timeout settings for both MPxIO configurations
- Sets the VID/PID information
- Enables or disables ALUA
- Configures the ALUA settings used by MPxIO and the SCSI drivers for both x86 and SPARC systems

6. Reboot the host.

SAN toolkit

The tool kit 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

controller(7mode) /                               device
host                lun
vservers(Cmode)     lun-pathname  filename
adapter protocol   size   mode
-----
data_vserver        /vol/vol1/lun1
/dev/rdisk/c0t600A098038314362692451465A2F4F39d0s2  qlc1  FCP      60g  C
data_vserver        /vol/vol2/lun2
/dev/rdisk/c0t600A098038314362705D51465A626475d0s2  qlc1  FCP      20g  C
```

SAN booting

What you'll need

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

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 using the FC protocol and running Solaris Host Utilities. The method you use to set up a SAN boot LUN can vary depending on your volume manager and file system. See [Install Solaris Host Utilities](#) for details on a SAN boot LUNs in a Solaris MPIO (Multipath I/O) environment.

Multipathing

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 or MPxIO is enabled by default for Solaris 11.4. The default setting in `/kernel/drv/fp.conf` changes to `mpxio-disable="no"`.

Non-ASA configurations

For non-ASA configurations, there should be two groups of paths with different priorities. The paths with the higher priorities are Active/Optimized, meaning they are serviced by the controller where the aggregate is located. The paths with the lower priorities are active but are non-optimized because they are served from a different controller. The non-optimized paths are only used when no optimized paths are available.

Example

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

The path priorities are displayed against the **Access State** section for each LUN in the OS native `mpathadm show lu <LUN>` command.

All SAN Array configurations

In All SAN Array (ASA) configurations, all paths to a given LUN are active and optimized. 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:

The output for the `sanlun` command is the same for ASA and non-ASA configurations.

The path priorities are displayed against the **Access State** section for each LUN in the OS native `mpathadm show lu <LUN>` command.

```
#sanlun lun show -pv sparc-s7-16-49:/vol/solaris_vol_1_0/solaris_lun

          ONTAP Path: sparc-s7-16-
49:/vol/solaris_vol_1_0/solaris_lun
          LUN: 0
          LUN Size: 30g
          Host Device:
/dev/rdisk/c0t600A098038314362692451465A2F4F39d0s2
          Mode: C
          Multipath Provider: Sun Microsystems
          Multipath Policy: Native
```



All SAN Arrays (ASA) configurations are supported beginning ONTAP 9.8 for Solaris hosts.

Recommended settings

NetApp recommends using the following parameter settings for Solaris 11.4 SPARC and x86_64 with NetApp ONTAP LUNs. These parameter values are set by Host Utilities. For additional Solaris 11.4 system settings, see Oracle DOC ID: 2595926.1.

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

All Solaris OS versions (including Solaris 10.x and Solaris 11.x) support Solaris HUK 6.2.

- For Solaris 11.4, the FC driver binding is changed from `ssd` to `sd`. The following configuration files get partially updated during the HUK 6.2 installation process:
 - `/kernel/drv/sd.conf`

- `/etc/driver/drv/scsi_vhci.conf`
- For Solaris 11.3, the FC driver binding uses `ssd`. The following configuration files get partially updated during the HUK 6.2 installation process:
 - `/kernel/drv/ssd.conf`
 - `/etc/driver/drv/scsi_vhci.conf`
- For Solaris 10.x, the following configuration files get fully updated during the HUK 6.2 installation process:
 - `/kernel/drv/sd.conf`
 - `/kernel/drv/ssd.conf`
 - `/kernel/drv/scsi_vhci.conf`

To resolve any configuration issues, see the Knowledge Base article [What are the Solaris host recommendations for supporting HUK 6.2](#).

NetApp recommends the following for a successful 4KB aligned I/O with zpools using NetApp LUNs:

- Verify that you are running a recent enough Solaris OS to ensure that all Solaris features supporting 4KB I/O size alignment are available.
- Verify that the Solaris 10 update 11 is installed with latest kernel patches and Solaris 11.4 with the latest Support Repository Update (SRU).
- The NetApp logical unit must have `lun/host-type` as `Solaris` regardless of the LUN size.

Recommended settings for MetroCluster

By default, the Solaris OS will fail to execute the I/O operations after **20s** if all paths to a LUN are lost. This is controlled by the `fcplib_offline_delay` parameter. The default value for `fcplib_offline_delay` is appropriate for standard ONTAP clusters. However, in MetroCluster configurations the value of `fcplib_offline_delay` must be increased to **120s** to ensure that I/O does not prematurely time out during operations including unplanned fail overs. For additional information and recommended changes to default settings, 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 have been re-branded generally as "Oracle Virtual Machines" despite the fact that they are based on different architectures.
- In some cases, multiple options can be used together such as a Solaris Container within a particular Solaris Logical Domain.
- NetApp generally supports the use of these virtualization technologies where the overall configuration is supported by Oracle and any partition with direct access to LUNs is listed on the [NetApp Interoperability Matrix](#) 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`, do not need specific qualifications as they do not have direct access to NetApp LUNs. Only the partition or virtual machine that has direct access to the underlying LUN, such as an LDOM I/O domain, must be found in the [NetApp Interoperability Matrix Tool](#).

Recommended settings for virtualization

When LUNs are used as virtual disk devices within an LDOM, the source of the LUN is masked by virtualization and the LDOM will not properly detect the block sizes. To prevent this issue, the LDOM OS must be patched for *Oracle Bug 15824910* and a `vdc.conf` file must be created that sets the block size of the virtual disk to 4096. See Oracle DOC: 2157669.1 for more information.

To verify the patch do the following:

Steps

1. Create a zpool.
2. Run `zdb -C` against the zpool and verify that the value of **ashift** is 12.

If the value of **ashift** is not 12, verify that the correct patch was installed and recheck the contents of `vdc.conf`.

Do not proceed until **ashift** shows a value of 12.



Patches are available for Oracle bug 15824910 on various versions of Solaris. Contact Oracle if assistance is required in determining the best kernel patch.

Recommended settings for SnapMirror Business Continuity

In order to verify that the Solaris client applications are non-disruptive when an unplanned site failover switchover occurs in a SnapMirror Business Continuity (SM-BC) environment, you must configure the following setting on the Solaris 11.4 host. This setting overrides the failover module `f_tpgs` to prevent the execution of the code path that detects the contradiction.



Beginning with ONTAP 9.9.1, SM-BC setting configurations are supported in the Solaris 11.4 host.

Follow the instructions to configure the override parameter:

Steps

1. Create the configuration file `/etc/driver/drv/scsi_vhci.conf` with an entry similar to the following for the NetApp storage type connected to the host:

```
scsi-vhci-failover-override =  
"NETAPP LUN", "f_tpgs"
```

2. Use the `devprop` and `mdb` commands to verify that the override parameter has been successfully applied:

```
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_wnn  
svl_fops_name"| mdb -k
```

```
svl_lun_wnn = 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 Business Continuity \(SM-BC\) configuration](#).

Known issues

The Solaris 11.4 with ONTAP release 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 <code>ssd (4D)</code> to <code>sd (4D)</code> . Move the existing configuration from <code>ssd.conf</code> to <code>sd.conf</code> 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)
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 <code>cfgadm -c configure</code> resulting in I/O error with end-to-end Emulex configuration	Running <code>cfgadm -c configure</code> 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

Use Solaris 11.3 with ONTAP

You can use the ONTAP SAN host configuration settings to configure Solaris 11.3 with ONTAP as the target.

Install the Solaris Host Utilities

You can download the compressed file containing the Host Utilities software packages from the [NetApp Support Site](#). After you have the file, you must extract it to get the software packages you need to install the Host Utilities.

Steps

1. Download a copy of the compressed file containing the Host Utilities from the [NetApp Support Site](#) to a directory on your host.
2. Go to the directory containing the download.
3. Extract the file.

The following example decompresses files for a SPARC system. For x86-64 platforms, use the x86/x64 package.

```
gunzip netapp_solaris_host_utilities_6_2N20170913_0304_sparc.tar.gz
```

4. Use the `tar xvf` command to unzip the file.

```
tar xvf netapp_solaris_host_utilities_6_2N20170913_0304_sparc.tar
```

5. Add the packages that you extracted from the tar file to your host.

```
pkgadd -d NTAPSANTool.pkg
```

The packages are added to the `/opt/NTAP/SANToolkit/bin` directory.

To complete the installation, you must configure the host parameters for your environment (MPxIO in this case) by using the `host_config` command.

The `host_config` command has the following format:

```
/opt/NTAP/SANToolkit/bin/host_config <-setup> <-protocol fcp|iscsi|mixed> <-multipath mpxio|dmp| non> [-noalua] [-mcc 60|90|120]
```

The `host_config` command does the following:

- Changes the Fibre Channel and SCSI driver settings for the X86 and SPARC systems
- Provides SCSI timeout settings for both the MPxIO configurations
- Sets the VID/PID information
- Enables or disables ALUA
- Configures the ALUA settings used by MPxIO and the SCSI drivers for both X86 and SPARC systems.

6. Reboot the host.

SAN toolkit

The tool kit 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

controller(7mode)/                               device
host              lun
vservers(Cmode)   lun-pathname  filename
adapter protocol  size  mode
-----
data_vserver      /vol/vol1/lun1
/dev/rdisk/c0t600A098038314362692451465A2F4F39d0s2  qlc1  FCP      60g  C
data_vserver      /vol/vol2/lun2
/dev/rdisk/c0t600A098038314362705D51465A626475d0s2  qlc1  FCP      20g  C
```

SAN booting

What you'll need

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

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 using the FC protocol and running the Solaris Host Utilities. The method you use to set up a SAN boot LUN can vary depending on your volume manager and file system. See [Install Solaris Host Utilities](#) for details on SAN Booting LUNs in a Solaris MPIO environment.

Multipathing

Multipathing allows you to configure multiple network paths between the host and storage system. If one path fails, traffic continues on the remaining paths.

Non-ASA configurations

For non-ASA configurations, there should be two groups of paths with different priorities. The paths with the higher priorities are Active/Optimized, meaning they are serviced by the controller where the aggregate is located. The paths with the lower priorities are active but are non-optimized because they are served from a different controller. The non-optimized paths are only used when no optimized paths are available.

Example

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

Active/Non-Optimized paths:

The path priorities are displayed against the **Access State** section for each LUN in the OS native `mpathadm show lu <LUN>` command.

All SAN Array configurations

In All SAN Array (ASA) configurations, all paths to a given LUN are active and optimized. 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:

The output for the `sanlun` command is the same for ASA and non-ASA configurations.

The path priorities are displayed against the **Access State** section for each LUN in the OS native `mpathadm show lu <LUN>` command.

```
#sanlun lun show -pv sparc-s7-16-49:/vol/solaris_vol_1_0/solaris_lun

                ONTAP Path: sparc-s7-16-
49:/vol/solaris_vol_1_0/solaris_lun
                LUN: 0
                LUN Size: 30g
                Host Device:
/dev/rdisk/c0t600A098038314362692451465A2F4F39d0s2
                Mode: C
                Multipath Provider: Sun Microsystems
                Multipath Policy: Native
```



All SAN Arrays (ASA) configurations are supported beginning in ONTAP 9.8 for Solaris Hosts.

Recommended settings

Following are some parameter settings that are recommended for Solaris 11.3 SPARC and x86_64 with NetApp ONTAP LUNs. These parameter values are set by Host Utilities.

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

Recommended settings for MetroCluster

By default, the Solaris operating system will fail I/Os after 20 seconds if all paths to a LUN are lost. This is controlled by the `fcg_offline_delay` parameter. The default value for `fcg_offline_delay` is appropriate for standard ONTAP clusters. However, in MetroCluster configurations, the value of `fcg_offline_delay` must be increased to **120s** to ensure that I/O does not prematurely time out during operations including unplanned failovers. For additional information and recommended changes to default settings, 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 have been rebranded generally as "Oracle Virtual Machines" despite the fact that they are based on very different architectures.
- In some cases, multiple options can be used together such as a Solaris Container within a particular Solaris Logical Domain.
- NetApp generally supports the use of these virtualization technologies where the overall configuration is supported by Oracle and any partition with direct access to LUNs is listed on the [NetApp Interoperability Matrix](#) in a supported configuration. This includes root containers, LDOM IO domains, and LDOM's using NPIV to access LUNs.
- Partitions and/or virtual machines which use only virtualized storage resources, such as a `vdsk`, do not need specific qualification as they do not have direct access to NetApp LUNs. Only the partition/VM that has direct access to the underlying LUN, such as an LDOM IO domain, must be found in the [NetApp Interoperability Matrix](#).

Recommended settings for virtualization

When LUNs are used as virtual disk devices within an LDOM, the source of the LUN is masked by virtualization and the LDOM will not properly detect the block sizes. To prevent this issue, the LDOM operating system must be patched for Oracle Bug 15824910 and a `vdc.conf` file must be created that sets the block size of the virtual disk to 4096. See Oracle Doc 2157669.1 for more information.

To verify the patch, do the following:

Steps

1. Create a zpool.
2. Run `zdb -C` against the zpool and verify that the value of **ashift** is 12.

If the value of **ashift** is not 12, verify that the correct patch was installed and recheck the contents of `vdc.conf`.

Do not proceed until **ashift** shows a value of 12.



Patches are available for Oracle bug 15824910 on various versions of Solaris. Contact Oracle if assistance is required in determining the best kernel patch.

Recommended settings for SnapMirror Business Continuity

In order to verify that the Solaris client applications are non-disruptive when an unplanned site failover switchover occurs in a SnapMirror Business Continuity (SM-BC) environment, you must configure the following setting on the Solaris 11.3 host. This setting overrides the failover module `f_tpgs` to prevent the execution of

the code path that detects the contradiction.



Beginning with ONTAP 9.9.1, SM-BC setting configurations are supported in the Solaris 11.3 host.

Follow the instructions to configure the override parameter:

Steps

- 1. Create the configuration file `/etc/driver/drv/scsi_vhci.conf` with an entry similar to the following for the NetApp storage type connected to the host:

```
scsi-vhci-failover-override =  
"NETAPP LUN", "f_tpgs"
```

- 2. Use the `devprop` and `mdb` commands to verify that the override parameter has been successfully applied:

```
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_wnn  
svl_fops_name"| mdb -k
```

```
svl_lun_wnn = 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 KB article [Solaris Host support recommended settings in SnapMirror Business Continuity \(SM-BC\) configuration](#).

Known issues

The Solaris 11.3 with ONTAP release 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

NetApp Bug ID	Title	Description	Oracle ID
1368957	Solaris 11.x 'cfgadm -c configure' resulting in I/O error with End-to-End Emulex configuration	Running <code>cfgadm -c configure</code> 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

SLES

Release notes

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 does not 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.

SLES 15

Use SUSE Linux Enterprise Server 15 SP5 with ONTAP

You can use the ONTAP SAN host configuration settings to configure SUSE Linux Enterprise Server 15 SP5 with ONTAP as the target.

Install the Linux Unified Host Utilities

The NetApp Linux Unified Host Utilities software package is available on the [NetApp Support Site](#) in a 32-bit and 64-bit .rpm file. If you do not know which file is right for your configuration, use the [NetApp Interoperability Matrix Tool](#) to verify which one you need.

NetApp strongly recommends installing the Linux Unified 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.

What you'll need

If you have a version of Linux Unified Host Utilities currently installed you should upgrade it or, you should remove it and use the following steps to install the latest version.

1. Download the 32-bit or 64-bit Linux Unified Host Utilities software package from the [NetApp Support Site](#) to your host.
2. Use the following command to install the software package:

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



You can use the configuration settings provided in this document 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

What you'll need

If you decide to use SAN booting, it must be supported by your configuration. You can use the [NetApp 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 is successful.

Multipathing

For SUSE Linux Enterprise Server 15 SP5, the `/etc/multipath.conf` file must exist, but you do not need to make specific changes to the file. The SUSE Linux Enterprise Server 15 SP5 is compiled with all the settings required to recognize and correctly manage ONTAP LUNs.

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

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

All SAN Array configurations

In All SAN Array (ASA) configurations, all paths to a given LUN are active and optimized. 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
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
```



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight 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 the higher priorities are Active/Optimized, meaning they are serviced by the controller where the aggregate is located. The paths with the lower priorities are active but are non-optimized because they are served from a different controller. The non-optimized paths are only used when no optimized paths are 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='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
```



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight paths might cause path issues during storage failures.

Recommended settings

SUSE Linux Enterprise Server 15 SP5 OS is compiled to recognize ONTAP LUNs and automatically set all configuration parameters correctly for both ASA and non-ASA configurations. You can further optimize performance for your host configuration with the following recommended settings.

The `multipath.conf` file must exist for the multipath daemon to start, but you can create an empty, zero-byte file by using the following command:

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

The first time you create this file, you might need to enable and start the multipath services:

```
# systemctl enable multipathd
# systemctl start multipathd
```

- There is no requirement to add anything directly to the `multipath.conf` file, unless you have devices that you do not want to be managed by multipath or you have existing settings that override defaults.
- To exclude unwanted devices, add the following syntax to the `multipath.conf` file .

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

Replace the `<DevId>` with the WWID string of the device you want to exclude.

Example

In this example, we are going to determine the WWID of a device and add to the `multipath.conf` file.

Steps

1. Run the following command to determine the WWID:

```
# /lib/udev/scsi_id -gud /dev/sda
360030057024d0730239134810c0cb833
```

sda is the local SCSI disk that we need to add it to the blacklist.

2. Add the 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 for legacy settings, especially in the defaults section, that might be overriding the 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 will need to be corrected by later stanzas in the `multipath.conf` file that apply specifically to ONTAP LUNs. If this is not done, the ONTAP LUNs might not work as expected. These defaults should only be overridden in consultation with NetApp and/or an OS vendor 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	"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"

Parameter	Setting
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
    }
}
```

Known issues

There are no known issues for the SUSE Linux Enterprise Server 15 SP5 with ONTAP release.

Use SUSE Linux Enterprise Server 15 SP4 with ONTAP

You can use the ONTAP SAN host configuration settings to configure SUSE Linux Enterprise Server 15 SP4 with ONTAP as the target.

Install the Linux Unified Host Utilities

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NetApp strongly recommends installing the Linux Unified 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.

What you'll need

If you have a version of Linux Unified Host Utilities currently installed you should upgrade it or, you should remove it and use the following steps to install the latest version.

- 1. Download the 32-bit or 64-bit Linux Unified Host Utilities software package from the [NetApp Support Site](#) to your host.
- 2. Use the following command to install the software package:

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



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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) / vserver (cDOT/FlashRay) lun-pathname		device filename	host adapter	lun 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

What you'll need

If you decide to use SAN booting, it must be supported by your configuration. You can use the [NetApp 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 is successful.

Multipathing

For SUSE Linux Enterprise Server 15 SP4 the `/etc/multipath.conf` file must exist, but you do not need to make specific changes to the file. SUSE Linux Enterprise Server 15 SP4 is compiled with all settings required to recognize and correctly manage ONTAP LUNs.

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

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

All SAN Array configurations

In All SAN Array (ASA) configurations, all paths to a given LUN are active and optimized. 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
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
```



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight 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 the higher priorities are Active/Optimized, meaning they are serviced by the controller where the aggregate is located. The paths with the lower priorities are active but are non-optimized because they are served from a different controller. The non-optimized paths are only used when no optimized paths are 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='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
```



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight paths might cause path issues during storage failures.

Recommended settings

SUSE Linux Enterprise Server 15 SP4 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, but you can create an empty, zero-byte file by using the command:

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

The first time you create this file, you might need to enable and start the multipath services.

There is no requirement to add anything directly to the `multipath.conf` file, unless you have devices that you do not want to be managed by multipath or you have existing settings that override defaults.

You can add the following syntax to the `multipath.conf` file to exclude the unwanted devices.

Replace `<DevId>` with the `WWID` string of the device you want to exclude. Use the following command to determine the `WWID`:

Example

In this example, `sda` is the local SCSI disk that we need to add to the blacklist.

Steps

1. Run the following command to determine the `WWID`:

```
# /usr/lib/udev/scsi_id -gud /dev/sda
360030057024d0730239134810c0cb833
```

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

```

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 for legacy settings, especially in the defaults section, that might be overriding default settings.

The table below shows 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 will need to be corrected by later stanzas in `multipath.conf` that apply specifically to ONTAP LUNs. If this is not done, the ONTAP LUNs might not work as expected. These defaults should only be overridden in consultation with NetApp and/or OS vendor and only when the impact is fully understood.

Parameter	Setting
<code>detect_prio</code>	yes
<code>dev_loss_tmo</code>	"infinity"
<code>failback</code>	immediate
<code>fast_io_fail_tmo</code>	5
<code>features</code>	"2 pg_init_retries 50"
<code>flush_on_last_del</code>	"yes"
<code>hardware_handler</code>	"0"
<code>no_path_retry</code>	queue
<code>path_checker</code>	"tur"
<code>path_grouping_policy</code>	"group_by_prio"
<code>path_selector</code>	"service-time 0"
<code>polling_interval</code>	5
<code>prio</code>	"ontap"
<code>product</code>	LUN.*
<code>retain_attached_hw_handler</code>	yes
<code>rr_weight</code>	"uniform"
<code>user_friendly_names</code>	no
<code>vendor</code>	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 these parameters cannot be removed because other SAN arrays are still attached to the host, they can instead 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
    }
}

```

Known issues

There are no known issues for the SUSE Linux Enterprise Server 15 SP4 with ONTAP release.

Use SUSE Linux Enterprise Server 15 SP3 with ONTAP

You can use the ONTAP SAN host configuration settings to configure SUSE Linux Enterprise Server 15 SP3 with ONTAP as the target.

Install the Linux Unified Host Utilities

The NetApp Linux Unified Host Utilities software package is available on the [NetApp Support Site](#) in a 32-bit and 64-bit .rpm file. If you do not know which file is right for your configuration, use the [NetApp Interoperability Matrix Tool](#) to verify which one you need.

NetApp strongly recommends installing the Linux Unified 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.

What you'll need

If you have a version of Linux Unified Host Utilities currently installed you should upgrade it or, you should remove it and use the following steps to install the latest version.

1. Download the 32-bit or 64-bit Linux Unified Host Utilities software package from the [NetApp Support Site](#) to your host.
2. Use the following command to install the software package:

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



You can use the configuration settings provided in this document 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) / vserver(cDOT/FlashRay) Product	lun-pathname	device filename	host adapter	protocol	lun size

data_vserver 120.0g cDOT	/vol/vol1/lun1	/dev/sdb	host16	FCP	
data_vserver 120.0g cDOT	/vol/vol1/lun1	/dev/sdc	host15	FCP	
data_vserver 120.0g cDOT	/vol/vol2/lun2	/dev/sdd	host16	FCP	
data_vserver 120.0g cDOT	/vol/vol2/lun2	/dev/sde	host15	FCP	

SAN Booting

What you'll need

If you decide to use SAN booting, it must be supported by your configuration. You can use the [NetApp 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 is successful.

Multipathing

For SUSE Linux Enterprise Server 15 SP3 the `/etc/multipath.conf` file must exist, but you do not need to make specific changes to the file. SUSE Linux Enterprise Server 15 SP3 is compiled with all settings required to recognize and correctly manage ONTAP LUNs.

You can use the `multipath -ll` command to verify the settings for your ONTAP LUNs. The following sections provide sample multipath output for a LUN mapped to ASA and non-ASA personas.

All SAN Array configurations

In All SAN Array (ASA) configurations, all paths to a given LUN are active and optimized. 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
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
```



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight 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 the higher priorities are Active/Optimized, meaning they are serviced by the controller where the aggregate is located. The paths with the lower priorities are active but are non-optimized because they are served from a different controller. The non-optimized paths are only used when no optimized paths are 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='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
```



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight paths might cause path issues during storage failures.

Recommended Settings

SUSE Linux Enterprise Server 15 SP3 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, but you can create an empty, zero-byte file by using the following command:

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

The first time you create this file, you might need to enable and start the multipath services:

```
# systemctl enable multipathd
# systemctl start multipathd
```

- There is no requirement to add anything directly to the `multipath.conf` file, unless you have devices that you do not want to be managed by multipath or you have existing settings that override defaults.
- To exclude unwanted devices, add the following syntax to the `multipath.conf` file .

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

Replace the `<DevId>` with the WWID string of the device you want to exclude.

Example

In this example, we are going to determine the WWID of a device and add to the `multipath.conf` file.

Steps

1. Run the following command to determine the WWID:

```
# /lib/udev/scsi_id -gud /dev/sda
360030057024d0730239134810c0cb833
```

`sda` is the local SCSI disk that we need to add it to the blacklist.

2. Add the 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 for legacy settings, especially in the defaults section, that might be overriding the 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 will need to be corrected by later stanzas in the `multipath.conf` file that apply specifically to ONTAP LUNs. If this is not done, the ONTAP LUNs might not work as expected. These defaults should only be overridden in consultation with NetApp and/or an OS vendor and only when the impact is fully understood.

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

Known issues

There are no known issues for the SUSE Linux Enterprise Server 15 SP3 with ONTAP release.

Use SUSE Linux Enterprise Server 15 SP2 with ONTAP

You can use the ONTAP SAN host configuration settings to configure SUSE Linux Enterprise Server 15 SP2 with ONTAP as the target.

Install the Linux Unified Host Utilities

The NetApp Linux Unified Host Utilities software package is available on the [NetApp Support Site](#) in a 32-bit and 64-bit .rpm file. If you do not know which file is right for your configuration, use the [NetApp Interoperability Matrix Tool](#) to verify which one you need.

NetApp strongly recommends installing the Linux Unified 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.

What you'll need

If you have a version of Linux Unified Host Utilities currently installed you should upgrade it or, you should remove it and use the following steps to install the latest version.

1. Download the 32-bit or 64-bit Linux Unified Host Utilities software package from the [NetApp Support Site](#) to your host.
2. Use the following command to install the software package:

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



You can use the configuration settings provided in this document 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

What you'll need

If you decide to use SAN booting, it must be supported by your configuration. You can use the [NetApp 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 is successful.

Multipathing

For SUSE Linux Enterprise Server 15 SP2 the `/etc/multipath.conf` file must exist, but you do not need to make specific changes to the file. SUSE Linux Enterprise Server 15 SP2 is compiled with all settings required to recognize and correctly manage ONTAP LUNs. Use the `multipath -ll` command verify the settings for your ONTAP LUNs.

There should be two groups of paths with different priorities. The paths with the higher priorities are Active/Optimized, meaning they are serviced by the controller where the aggregate is located. The paths with the lower priorities are active but are non-optimized because they are served from a different controller. The non-optimized paths are only used when no optimized paths are 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='3 queue_if_no_path pg_init_retries 50' hwhandler='1
alua' wp=rw
|+- policy='service-time 0' prio=50 status=enabled
| |- 11:0:1:0 sdj 8:144 active ready running
| |- 11:0:2:0 sdr 65:16 active ready running
`+- policy='service-time 0' prio=10 status=enabled
|- 11:0:0:0 sdb 8:i6 active ready running
|- 12:0:0:0 sdz 65:144 active ready running
```

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

SUSE Linux Enterprise Server 15 SP2 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, but you can create an empty, zero-byte file by using the following command:

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

The first time you create this file, you might need to enable and start the multipath services:

```
# systemctl enable multipathd
# systemctl start multipathd
```

- There is no requirement to add anything directly to the `multipath.conf` file, unless you have devices that you do not want to be managed by multipath or you have existing settings that override defaults.
- To exclude unwanted devices, add the following syntax to the `multipath.conf` file .

```

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

```

Replace the <DevId> with the WWID string of the device you want to exclude.

Example

In this example, we are going to determine the WWID of a device and add to the `multipath.conf` file.

Steps

1. Run the following command to determine the WWID:

```

# /lib/udev/scsi_id -gud /dev/sda
360030057024d0730239134810c0cb833

```

`sda` is the local SCSI disk that we need to add it to the blacklist.

2. Add the 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 for legacy settings, especially in the defaults section, that might be overriding the 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 will need to be corrected by later stanzas in the `multipath.conf` file that apply specifically to ONTAP LUNs. If this is not done, the ONTAP LUNs might not work as expected. These defaults should only be overridden in consultation with NetApp and/or an OS vendor and only when the impact is fully understood.

Parameter	Setting
<code>detect_prio</code>	yes
<code>dev_loss_tmo</code>	"infinity"
<code>failback</code>	immediate
<code>fast_io_fail_tmo</code>	5

Parameter	Setting
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

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
    }
}
```

Known issues

The SLES 15 SP2 with ONTAP release has the following known issues:

NetApp Bug ID	Title	Description	Bugzilla ID
1308744	iSCSI boot from SAN fails to boot with a static IP configuration after completing an SLES15SP2 OS installation	<p>iSCSI sanbooted LUN failed to boot up after completing an SLES 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:</p> <pre> 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 </pre>	1167494

Use SUSE Linux Enterprise Server 15 SP1 with ONTAP

You can use the ONTAP SAN host configuration settings to configure SUSE Linux Enterprise Server 15 SP1 with ONTAP as the target.

Install the Linux Unified Host Utilities

The NetApp Linux Unified Host Utilities software package is available on the [NetApp Support Site](#) in a 32-bit and 64-bit .rpm file. If you do not know which file is right for your configuration, use the [NetApp Interoperability Matrix Tool](#) to verify which one you need.

NetApp strongly recommends installing the Linux Unified 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.

What you'll need

If you have a version of Linux Unified Host Utilities currently installed you should upgrade it or, you should remove it and use the following steps to install the latest version.

1. Download the 32-bit or 64-bit Linux Unified Host Utilities software package from the [NetApp Support Site](#) to your host.
2. Use the following command to install the software package:

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



You can use the configuration settings provided in this document 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

What you'll need

If you decide to use SAN booting, it must be supported by your configuration. You can use the [NetApp 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 is successful.

Multipathing

For SUSE Linux Enterprise Server 15 SP1 the `/etc/multipath.conf` file must exist, but you do not need to make specific changes to the file. SUSE Linux Enterprise Server 15 SP1 is compiled with all settings required to recognize and correctly manage ONTAP LUNs.

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

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

All SAN Array configurations

In All SAN Array (ASA) configurations, all paths to a given LUN are active and optimized. 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
`+- 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
```



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight 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 the higher priorities are Active/Optimized, meaning they are serviced by the controller where the aggregate is located. The paths with the lower priorities are active but are non-optimized because they are served from a different controller. The non-optimized paths are only used when no optimized paths are 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='3 queue_if_no_path pg_init_retries 50' hwhandler='1
alua' wp=rw
|+- policy='service-time 0' prio=50 status=active
| |- 11:0:1:0 sdj 8:144 active ready running
| |- 11:0:2:0 sdr 65:16 active ready running
`+- policy='service-time 0' prio=10 status=enabled
|- 11:0:0:0 sdb 8:i6 active ready running
|- 12:0:0:0 sdz 65:144 active ready running
```



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight paths might cause path issues during storage failures.

Recommended Settings

SUSE Linux Enterprise Server 15 SP1 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, but you can create an empty, zero-byte file by using the following command:

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

The first time you create this file, you might need to enable and start the multipath services:

```
# systemctl enable multipathd
# systemctl start multipathd
```

- There is no requirement to add anything directly to the `multipath.conf` file, unless you have devices that you do not want to be managed by multipath or you have existing settings that override defaults.
- To exclude unwanted devices, add the following syntax to the `multipath.conf` file .

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

Replace the `<DevId>` with the WWID string of the device you want to exclude.

Example

In this example, we are going to determine the WWID of a device and add to the `multipath.conf` file.

Steps

1. Run the following command to determine the WWID:

```
# /lib/udev/scsi_id -gud /dev/sda
360030057024d0730239134810c0cb833
```

sda is the local SCSI disk that we need to add it to the blacklist.

2. Add the 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 for legacy settings, especially in the defaults section, that might be overriding the 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 will need to be corrected by later stanzas in the `multipath.conf` file that apply specifically to ONTAP LUNs. If this is not done, the ONTAP LUNs might not work as expected. These defaults should only be overridden in consultation with NetApp and/or an OS vendor 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	"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.*

Parameter	Setting
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
    }
}
```

Known issues

The SLES 15 SP1 with ONTAP release has the following known issues:

NetApp Bug ID	Title	Description	Bugzilla ID
1246622	Remote ports transit to a blocked state on SLES15SP1 with Emulex LPe12002 8GB FC during storage failover operations.	<p>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."</p> <p>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:</p> <pre> ----- cat/sys/class/fc_host /host*/device/rport*/f c_remote_ports/rport */port_name cat/sys/class/fc_host /host*/device/rport*/f c_remote_ports/rport */port_state ----- </pre>	1139137

Use SUSE Linux Enterprise Server 15 with ONTAP

You can use the ONTAP SAN host configuration settings to configure SUSE Linux Enterprise Server 15 with ONTAP as the target.

Install the Linux Unified Host Utilities

The NetApp Linux Unified Host Utilities software package is available on the [NetApp Support Site](#) in a 32-bit and 64-bit .rpm file. If you do not know which file is right for your configuration, use the [NetApp Interoperability](#)

[Matrix Tool](#) to verify which one you need.

NetApp strongly recommends installing the Linux Unified 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.

What you'll need

If you have a version of Linux Unified Host Utilities currently installed you should upgrade it or, you should remove it and use the following steps to install the latest version.

1. Download the 32-bit or 64-bit Linux Unified Host Utilities software package from the [NetApp Support Site](#) to your host.
2. Use the following command to install the software package:

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



You can use the configuration settings provided in this document 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

What you'll need

If you decide to use SAN booting, it must be supported by your configuration. You can use the [NetApp 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 is successful.

Multipathing

For SUSE Linux Enterprise Server 15 the `/etc/multipath.conf` file must exist, but you do not need to make specific changes to the file. SUSE Linux Enterprise Server 15 is compiled with all settings required to recognize and correctly manage ONTAP LUNs.

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

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

All SAN Array configurations

In All SAN Array (ASA) configurations, all paths to a given LUN are active and optimized. 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
`--+- 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
```



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight 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 the higher priorities are Active/Optimized, meaning they are serviced by the controller where the aggregate is located. The paths with the lower priorities are active but are non-optimized because they are served from a different controller. The non-optimized paths are only used when no optimized paths are 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='3 queue_if_no_path pg_init_retries 50' hwhandler='1
alua' wp=rw
|+- policy='service-time 0' prio=50 status=enabled
| |- 11:0:1:0 sdj 8:144 active ready running
| |- 11:0:2:0 sdr 65:16 active ready running
`-+- policy='service-time 0' prio=10 status=enabled
   |- 11:0:0:0 sdb 8:i6 active ready running
   |- 12:0:0:0 sdz 65:144 active ready running
```



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight paths might cause path issues during storage failures.

Recommended Settings

SUSE Linux Enterprise Server 15 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, but you can create an empty, zero-byte file by using the following command:

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

The first time you create this file, you might need to enable and start the multipath services:

```
# systemctl enable multipathd
# systemctl start multipathd
```

- There is no requirement to add anything directly to the `multipath.conf` file, unless you have devices that you do not want to be managed by multipath or you have existing settings that override defaults.
- To exclude unwanted devices, add the following syntax to the `multipath.conf` file .

```

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

```

Replace the <DevId> with the WWID string of the device you want to exclude.

Example

In this example, we are going to determine the WWID of a device and add to the `multipath.conf` file.

Steps

1. Run the following command to determine the WWID:

```

# /lib/udev/scsi_id -gud /dev/sda
360030057024d0730239134810c0cb833

```

`sda` is the local SCSI disk that we need to add it to the blacklist.

2. Add the 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 for legacy settings, especially in the defaults section, that might be overriding the 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 will need to be corrected by later stanzas in the `multipath.conf` file that apply specifically to ONTAP LUNs. If this is not done, the ONTAP LUNs might not work as expected. These defaults should only be overridden in consultation with NetApp and/or an OS vendor and only when the impact is fully understood.

Parameter	Setting
<code>detect_prio</code>	yes
<code>dev_loss_tmo</code>	"infinity"
<code>failback</code>	immediate
<code>fast_io_fail_tmo</code>	5

Parameter	Setting
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

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
    }
}
```

Known issues

The SLES 15 with ONTAP release has the following known issues:

NetApp Bug ID	Title	Description	Bugzilla ID
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)	1104173

SLES 12

Use SUSE Linux Enterprise Server 12 SP5 with ONTAP

You can use the ONTAP SAN host configuration settings to configure SUSE Linux Enterprise Server 12 SP5 with ONTAP as the target.

Install the Linux Unified Host Utilities

The NetApp Linux Unified Host Utilities software package is available on the [NetApp Support Site](#) in a 32-bit and 64-bit .rpm file. If you do not know which file is right for your configuration, use the [NetApp Interoperability Matrix Tool](#) to verify which one you need.

NetApp strongly recommends installing the Linux Unified 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.

What you'll need

If you have a version of Linux Unified Host Utilities currently installed you should upgrade it or, you should remove it and use the following steps to install the latest version.

1. Download the 32-bit or 64-bit Linux Unified Host Utilities software package from the [NetApp Support Site](#) to your host.
2. Use the following command to install the software package:

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



You can use the configuration settings provided in this document 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) / vserver (cDOT/FlashRay) Product	lun-pathname	device filename	host adapter	protocol	lun size

data_vserver 120.0g cDOT	/vol/vol1/lun1	/dev/sdb	host16	FCP	
data_vserver 120.0g cDOT	/vol/vol1/lun1	/dev/sdc	host15	FCP	
data_vserver 120.0g cDOT	/vol/vol2/lun2	/dev/sdd	host16	FCP	
data_vserver 120.0g cDOT	/vol/vol2/lun2	/dev/sde	host15	FCP	

SAN Booting

What you'll need

If you decide to use SAN booting, it must be supported by your configuration. You can use the [NetApp 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 is successful.

Multipathing

For SUSE Linux Enterprise Server 12 SP5 the `/etc/multipath.conf` file must exist, but you do not need to make specific changes to the file. SUSE Linux Enterprise Server 12 SP5 is compiled with all settings required to recognize and correctly manage ONTAP LUNs.

You can use the `multipath -ll` command to verify the settings for your ONTAP LUNs. The following sections provide sample multipath output for a LUN mapped to ASA and non-ASA personas.

All SAN Array configurations

In All SAN Array (ASA) configurations, all paths to a given LUN are active and optimized. 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
`-+- 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
```



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight 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 the higher priorities are Active/Optimized, meaning they are serviced by the controller where the aggregate is located. The paths with the lower priorities are active but are non-optimized because they are served from a different controller. The non-optimized paths are only used when no optimized paths are 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='3 queue_if_no_path pg_init_retries 50' hwhandler='1
alua' wp=rw
|+- policy='service-time 0' prio=50 status=active
| |- 11:0:1:0 sdj 8:144 active ready running
| |- 11:0:2:0 sdr 65:16 active ready running
`-+- policy='service-time 0' prio=10 status=enabled
   |- 11:0:0:0 sdb 8:i6 active ready running
   |- 12:0:0:0 sdz 65:144 active ready running
```



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight paths might cause path issues during storage failures.

Recommended Settings

SUSE Linux Enterprise Server 12 SP5 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, but you can create an empty, zero-byte file by using the following command:

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

The first time you create this file, you might need to enable and start the multipath services:

```
# systemctl enable multipathd
# systemctl start multipathd
```

- There is no requirement to add anything directly to the `multipath.conf` file, unless you have devices that you do not want to be managed by multipath or you have existing settings that override defaults.
- To exclude unwanted devices, add the following syntax to the `multipath.conf` file .

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

Replace the `<DevId>` with the WWID string of the device you want to exclude.

Example

In this example, we are going to determine the WWID of a device and add to the `multipath.conf` file.

Steps

1. Run the following command to determine the WWID:

```
# /lib/udev/scsi_id -gud /dev/sda
360030057024d0730239134810c0cb833
```

`sda` is the local SCSI disk that we need to add it to the blacklist.

2. Add the 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 for legacy settings, especially in the defaults section, that might be overriding the 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 will need to be corrected by later stanzas in the `multipath.conf` file that apply specifically to ONTAP LUNs. If this is not done, the ONTAP LUNs might not work as expected. These defaults should only be overridden in consultation with NetApp and/or an OS vendor and only when the impact is fully understood.

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

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
  }
}
```

Known issues

The SLES 12 SP5 with ONTAP release has the following known issues:

NetApp Bug ID	Title	Description	Bugzilla ID
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: ffff8aedef723c2c0" module. Locate this event in the vmcore file by finding the following string: "[THREAD_INFO: ffff8aedef723c2c0]". After the kernel disruption, reboot the host OS to enable it to recover. Then restart the applications.	1157966

Use SUSE Linux Enterprise Server 12 SP4 with ONTAP

You can use the ONTAP SAN host configuration settings to configure SUSE Linux Enterprise Server 12 SP4 with ONTAP as the target.

Install the Linux Unified Host Utilities

The NetApp Linux Unified Host Utilities software package is available on the [NetApp Support Site](#) in a 32-bit and 64-bit .rpm file. If you do not know which file is right for your configuration, use the [NetApp Interoperability Matrix Tool](#) to verify which one you need.

NetApp strongly recommends installing the Linux Unified 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.

What you'll need

If you have a version of Linux Unified Host Utilities currently installed you should upgrade it or, you should remove it and use the following steps to install the latest version.

1. Download the 32-bit or 64-bit Linux Unified Host Utilities software package from the [NetApp Support Site](#) to your host.
2. Use the following command to install the software package:

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



You can use the configuration settings provided in this document 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

What you'll need

If you decide to use SAN booting, it must be supported by your configuration. You can use the [NetApp 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 is successful.

Multipathing

For SUSE Linux Enterprise Server 12 SP4 the `/etc/multipath.conf` file must exist, but you do not need to make specific changes to the file. SUSE Linux Enterprise Server 12 SP4 is compiled with all settings required to recognize and correctly manage ONTAP LUNs.

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

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

All SAN Array configurations

In All SAN Array (ASA) configurations, all paths to a given LUN are active and optimized. 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
`--+- 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
```



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight 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 the higher priorities are Active/Optimized, meaning they are serviced by the controller where the aggregate is located. The paths with the lower priorities are active but are non-optimized because they are served from a different controller. The non-optimized paths are only used when no optimized paths are 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='3 queue_if_no_path pg_init_retries 50' hwhandler='1
alua' wp=rw
|+- policy='service-time 0' prio=50 status=active
| |- 11:0:1:0 sdj 8:144 active ready running
| |- 11:0:2:0 sdr 65:16 active ready running
`+- policy='service-time 0' prio=10 status=enabled
|- 11:0:0:0 sdb 8:i6 active ready running
|- 12:0:0:0 sdz 65:144 active ready running
```



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight paths might cause path issues during storage failures.

Recommended Settings

SUSE Linux Enterprise Server 12 SP4 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, but you can create an empty, zero-byte file by using the following command:

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

The first time you create this file, you might need to enable and start the multipath services:

```
# systemctl enable multipathd
# systemctl start multipathd
```

- There is no requirement to add anything directly to the `multipath.conf` file, unless you have devices that you do not want to be managed by multipath or you have existing settings that override defaults.
- To exclude unwanted devices, add the following syntax to the `multipath.conf` file .

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

Replace the `<DevId>` with the WWID string of the device you want to exclude.

Example

In this example, we are going to determine the WWID of a device and add to the `multipath.conf` file.

Steps

1. Run the following command to determine the WWID:

```
# /lib/udev/scsi_id -gud /dev/sda
360030057024d0730239134810c0cb833
```

sda is the local SCSI disk that we need to add it to the blacklist.

2. Add the 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 for legacy settings, especially in the defaults section, that might be overriding the 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 will need to be corrected by later stanzas in the `multipath.conf` file that apply specifically to ONTAP LUNs. If this is not done, the ONTAP LUNs might not work as expected. These defaults should only be overridden in consultation with NetApp and/or an OS vendor 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	"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.*

Parameter	Setting
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
    }
}
```

Known issues

There are no known issues for the SUSE Linux Enterprise Server 12 SP4 with ONTAP release.

Use SUSE Linux Enterprise Server 12 SP3 with ONTAP

You can use the ONTAP SAN host configuration settings to configure SUSE Linux Enterprise Server 12 SP3 with ONTAP as the target.

Install the Linux Unified Host Utilities

The NetApp Linux Unified Host Utilities software package is available on the [NetApp Support Site](#) in a 32-bit and 64-bit .rpm file. If you do not know which file is right for your configuration, use the [NetApp Interoperability Matrix Tool](#) to verify which one you need.

NetApp strongly recommends installing the Linux Unified 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.

What you'll need

If you have a version of Linux Unified Host Utilities currently installed you should upgrade it or, you should remove it and use the following steps to install the latest version.

1. Download the 32-bit or 64-bit Linux Unified Host Utilities software package from the [NetApp Support Site](#) to your host.
2. Use the following command to install the software package:

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



You can use the configuration settings provided in this document 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

What you'll need

If you decide to use SAN booting, it must be supported by your configuration. You can use the [NetApp 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 is successful.

Multipathing

For SUSE Linux Enterprise Server 12 SP3 the `/etc/multipath.conf` file must exist, but you do not need to make specific changes to the file. SUSE Linux Enterprise Server 12 SP3 is compiled with all settings required to recognize and correctly manage ONTAP LUNs.

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

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

All SAN Array configurations

In All SAN Array (ASA) configurations, all paths to a given LUN are active and optimized. 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
`--+- 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
```



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight 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 the higher priorities are Active/Optimized, meaning they are serviced by the controller where the aggregate is located. The paths with the lower priorities are active but are non-optimized because they are served from a different controller. The non-optimized paths are only used when no optimized paths are 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_handler' hwhandler='1 alua' wp=rw
|+- policy='service-time 0' prio=50 status=active
|  |- 11:0:1:0 sdj 8:144 active ready running
|  |- 11:0:2:0 sdr 65:16 active ready running
`+- policy='service-time 0' prio=10 status=enabled
|- 11:0:0:0 sdb 8:i6 active ready running
|- 12:0:0:0 sdz 65:144 active ready running
```



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight paths might cause path issues during storage failures.

Recommended Settings

SUSE Linux Enterprise Server 12 SP3 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, but you can create an empty, zero-byte file by using the following command:

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

The first time you create this file, you might need to enable and start the multipath services:

```
# systemctl enable multipathd
# systemctl start multipathd
```

- There is no requirement to add anything directly to the `multipath.conf` file, unless you have devices that you do not want to be managed by multipath or you have existing settings that override defaults.
- To exclude unwanted devices, add the following syntax to the `multipath.conf` file .

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

Replace the `<DevId>` with the WWID string of the device you want to exclude.

Example

In this example, we are going to determine the WWID of a device and add to the `multipath.conf` file.

Steps

1. Run the following command to determine the WWID:

```
# /lib/udev/scsi_id -gud /dev/sda
360030057024d0730239134810c0cb833
```

sda is the local SCSI disk that we need to add it to the blacklist.

2. Add the 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 for legacy settings, especially in the defaults section, that might be overriding the 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 will need to be corrected by later stanzas in the multipath.conf file that apply specifically to ONTAP LUNs. If this is not done, the ONTAP LUNs might not work as expected. These defaults should only be overridden in consultation with NetApp and/or an OS vendor 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	"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.*

Parameter	Setting
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
    }
}
```

Known issues

The SLES 15 SP3 with ONTAP release has the following known issues:

NetApp Bug ID	Title	Description	Bugzilla ID
1089555	Kernel disruption observed on kernel version SLES12 SP3 with Emulex LPe16002 16GB FC during storage failover operation	<p>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.</p> <p>Example:</p> <p>In the observed case, the kernel disruption was observed in the module "lpfc_sli_ringtxcmpl_put+51" and is logged in the vmcore file</p> <p>– exception RIP: lpfc_sli_ringtxcmpl_put+51.</p> <p>Recover the operating system after the kernel disruption by rebooting the host operating system and restarting the application.</p>	1042847

NetApp Bug ID	Title	Description	Bugzilla ID
1089561	Kernel disruption observed on kernel version SLES12 SP3 with Emulex LPe32002 32GB FC during storage failover operations	<p>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.</p> <p>Example:</p> <p>In the observed case, the kernel disruption was observed in the module "lpfc_sli_free_hbq+76" and is logged in the vmcore file</p> <p>– exception RIP: lpfc_sli_free_hbq+76.</p> <p>Recover the operating system after the kernel disruption by rebooting the host operating system and restarting the application.</p>	1042807

NetApp Bug ID	Title	Description	Bugzilla ID
1117248	Kernel disruption observed on SLES12SP3 with QLogic QLE2562 8GB FC during storage failover operations	<p>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.</p> <p>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"</p> <p>After the kernel disruption, you can recover the operating system by rebooting the Host OS. You can restart the application as required.</p>	1062496

NetApp Bug ID	Title	Description	Bugzilla ID
1117261	Kernel disruption observed on SLES12SP3 with Qlogic QLE2662 16GB FC during storage failover operations	<p>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.</p> <p>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.</p> <p>After kernel disruption, the operating system can be recovered by rebooting the host operating system and restarting the application as required.</p>	1062508

NetApp Bug ID	Title	Description	Bugzilla ID
1117274	Kernel disruption observed on SLES12SP3 with Emulex LPe16002 16GB FC during storage failover operations	<p>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.</p> <p>Example:</p> <p>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:</p> <p>– exception RIP: _raw_spin_lock_irqsave+30.</p> <p>After kernel disruption, the operating system can be recovered by rebooting the host operating system and restarting the application as required.</p>	1062514

Use SUSE Linux Enterprise Server 12 SP2 with ONTAP

You can use the ONTAP SAN host configuration settings to configure SUSE Linux Enterprise Server 12 SP2 with ONTAP as the target.

Install the Linux Unified Host Utilities

The NetApp Linux Unified Host Utilities software package is available on the [NetApp Support Site](#) in a 32-bit and 64-bit .rpm file. If you do not know which file is right for your configuration, use the [NetApp Interoperability Matrix Tool](#) to verify which one you need.

NetApp strongly recommends installing the Linux Unified 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.

What you'll need

If you have a version of Linux Unified Host Utilities currently installed you should upgrade it or, you should remove it and use the following steps to install the latest version.

- 1. Download the 32-bit or 64-bit Linux Unified Host Utilities software package from the [NetApp Support Site](#) to your host.
- 2. Use the following command to install the software package:

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



You can use the configuration settings provided in this document 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) / vserver(cDOT/FlashRay) Product	lun-pathname	device filename	host adapter	lun protocol	size
data_vserver 120.0g cDOT	/vol/vol1/lun1	/dev/sdb	host16	FCP	
data_vserver 120.0g cDOT	/vol/vol1/lun1	/dev/sdc	host15	FCP	
data_vserver 120.0g cDOT	/vol/vol2/lun2	/dev/sdd	host16	FCP	
data_vserver 120.0g cDOT	/vol/vol2/lun2	/dev/sde	host15	FCP	

SAN Booting

What you'll need

If you decide to use SAN booting, it must be supported by your configuration. You can use the [NetApp 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 is successful.

Multipathing

For SUSE Linux Enterprise Server 12 SP2 the `/etc/multipath.conf` file must exist, but you do not need to make specific changes to the file. SUSE Linux Enterprise Server 12 SP2 is compiled with all settings required to recognize and correctly manage ONTAP LUNs.

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

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

All SAN Array configurations

In All SAN Array (ASA) configurations, all paths to a given LUN are active and optimized. 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
`+- 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
```



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight 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 the higher priorities are Active/Optimized, meaning they are serviced by the controller where the aggregate is located. The paths with the lower priorities are active but are non-optimized because they are served from a different controller. The non-optimized paths are only used when no optimized paths are 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='service-time 0' prio=50 status=active
| |- 11:0:1:0 sdj 8:144 active ready running
| |- 11:0:2:0 sdr 65:16 active ready running
`-+- policy='service-time 0' prio=10 status=enabled
|- 11:0:0:0 sdb 8:i6 active ready running
|- 12:0:0:0 sdz 65:144 active ready running
```



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight paths might cause path issues during storage failures.

Recommended Settings

SUSE Linux Enterprise Server 12 SP2 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, but you can create an empty, zero-byte file by using the following command:

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

The first time you create this file, you might need to enable and start the multipath services:

```
# systemctl enable multipathd
# systemctl start multipathd
```

- There is no requirement to add anything directly to the `multipath.conf` file, unless you have devices that you do not want to be managed by multipath or you have existing settings that override defaults.
- To exclude unwanted devices, add the following syntax to the `multipath.conf` file .

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

Replace the `<DevId>` with the WWID string of the device you want to exclude.

Example

In this example, we are going to determine the WWID of a device and add to the `multipath.conf` file.

Steps

1. Run the following command to determine the WWID:

```
# /lib/udev/scsi_id -gud /dev/sda
360030057024d0730239134810c0cb833
```

`sda` is the local SCSI disk that we need to add it to the blacklist.

2. Add the 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 for legacy settings, especially in the defaults section, that might be overriding the 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 will need to be corrected by later stanzas in the `multipath.conf` file that apply specifically to ONTAP LUNs. If this is not done, the ONTAP LUNs might not work as expected. These defaults should only be overridden in consultation with NetApp and/or an OS vendor and only when the impact is fully understood.

Parameter	Setting
<code>detect_prio</code>	<code>yes</code>
<code>dev_loss_tmo</code>	<code>"infinity"</code>
<code>failback</code>	<code>immediate</code>
<code>fast_io_fail_tmo</code>	<code>5</code>
<code>features</code>	<code>"3 queue_if_no_path pg_init_retries 50"</code>
<code>flush_on_last_del</code>	<code>"yes"</code>
<code>hardware_handler</code>	<code>"0"</code>
<code>path_checker</code>	<code>"tur"</code>
<code>path_grouping_policy</code>	<code>"group_by_prio"</code>
<code>path_selector</code>	<code>"service-time 0"</code>
<code>polling_interval</code>	<code>5</code>
<code>prio</code>	<code>"ontap"</code>

Parameter	Setting
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
    }
}
```

Known issues

There are no known issues for the SUSE Linux Enterprise Server 12 SP2 with ONTAP release.

Use SUSE Linux Enterprise Server 12 SP1 with ONTAP

You can use the ONTAP SAN host configuration settings to configure SUSE Linux Enterprise Server 12 SP1 with ONTAP as the target.

Install the Linux Unified Host Utilities

The NetApp Linux Unified Host Utilities software package is available on the [NetApp Support Site](#) in a 32-bit and 64-bit .rpm file. If you do not know which file is right for your configuration, use the [NetApp Interoperability Matrix Tool](#) to verify which one you need.

NetApp strongly recommends installing the Linux Unified 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.

What you'll need

If you have a version of Linux Unified Host Utilities currently installed you should upgrade it or, you should remove it and use the following steps to install the latest version.

1. Download the 32-bit or 64-bit Linux Unified Host Utilities software package from the [NetApp Support Site](#) to your host.
2. Use the following command to install the software package:

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



You can use the configuration settings provided in this document 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) / vserver(cDOT/FlashRay) lun-pathname		device filename	host adapter	lun protocol	size
Product					

data_vserver 120.0g cDOT	/vol/vol1/lun1	/dev/sdb	host16	FCP	
data_vserver 120.0g cDOT	/vol/vol1/lun1	/dev/sdc	host15	FCP	
data_vserver 120.0g cDOT	/vol/vol2/lun2	/dev/sdd	host16	FCP	
data_vserver 120.0g cDOT	/vol/vol2/lun2	/dev/sde	host15	FCP	

SAN Booting

What you'll need

If you decide to use SAN booting, it must be supported by your configuration. You can use the [NetApp 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 is successful.

Multipathing

For SUSE Linux Enterprise Server 12 SP1 the `/etc/multipath.conf` file must exist, but you do not need to make specific changes to the file. SUSE Linux Enterprise Server 12 SP1 is compiled with all settings required to recognize and correctly manage ONTAP LUNs.

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

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

All SAN Array configurations

In All SAN Array (ASA) configurations, all paths to a given LUN are active and optimized. 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
`--+- 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
```



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight 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 the higher priorities are Active/Optimized, meaning they are serviced by the controller where the aggregate is located. The paths with the lower priorities are active but are non-optimized because they are served from a different controller. The non-optimized paths are only used when no optimized paths are 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='service-time 0' prio=50 status=active
| |- 11:0:1:0 sdj 8:144 active ready running
| |- 11:0:2:0 sdr 65:16 active ready running
`+- policy='service-time 0' prio=10 status=enabled
|- 11:0:0:0 sdb 8:i6 active ready running
|- 12:0:0:0 sdz 65:144 active ready running
```



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight paths might cause path issues during storage failures.

Recommended Settings

SUSE Linux Enterprise Server 12 SP1 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, but you can create an empty, zero-byte file by using the following command:

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

The first time you create this file, you might need to enable and start the multipath services:

```
# systemctl enable multipathd
# systemctl start multipathd
```

- There is no requirement to add anything directly to the `multipath.conf` file, unless you have devices that you do not want to be managed by multipath or you have existing settings that override defaults.
- To exclude unwanted devices, add the following syntax to the `multipath.conf` file .

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

Replace the `<DevId>` with the WWID string of the device you want to exclude.

Example

In this example, we are going to determine the WWID of a device and add to the `multipath.conf` file.

Steps

1. Run the following command to determine the WWID:

```
# /lib/udev/scsi_id -gud /dev/sda
360030057024d0730239134810c0cb833
```

sda is the local SCSI disk that we need to add it to the blacklist.

2. Add the 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 for legacy settings, especially in the defaults section, that might be overriding the 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 will need to be corrected by later stanzas in the `multipath.conf` file that apply specifically to ONTAP LUNs. If this is not done, the ONTAP LUNs might not work as expected. These defaults should only be overridden in consultation with NetApp and/or an OS vendor 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"
path_checker	"tur"
path_grouping_policy	"group_by_prio"
path_selector	"service-time 0"
polling_interval	5
prio	"ontap"
product	LUN.*

Parameter	Setting
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
    }
}
```

Known issues

There are no known issues for the SUSE Linux Enterprise Server 12 SP1 with ONTAP release.

Use SUSE Linux Enterprise Server 12 with ONTAP

You can use the ONTAP SAN host configuration settings to configure SUSE Linux Enterprise Server 12 with ONTAP as the target.

Install the Linux Unified Host Utilities

The NetApp Linux Unified Host Utilities software package is available on the [NetApp Support Site](#) in a 32-bit and 64-bit .rpm file. If you do not know which file is right for your configuration, use the [NetApp Interoperability Matrix Tool](#) to verify which one you need.

NetApp strongly recommends installing the Linux Unified 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.

What you'll need

If you have a version of Linux Unified Host Utilities currently installed you should upgrade it or, you should remove it and use the following steps to install the latest version.

1. Download the 32-bit or 64-bit Linux Unified Host Utilities software package from the [NetApp Support Site](#) to your host.
2. Use the following command to install the software package:

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



You can use the configuration settings provided in this document 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

What you'll need

If you decide to use SAN booting, it must be supported by your configuration. You can use the [NetApp 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 is successful.

Multipathing

For SUSE Linux Enterprise Server 12 the `/etc/multipath.conf` file must exist, but you do not need to make specific changes to the file. SUSE Linux Enterprise Server 12 is compiled with all settings required to recognize and correctly manage ONTAP LUNs.

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

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

All SAN Array configurations

In All SAN Array (ASA) configurations, all paths to a given LUN are active and optimized. 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
`--+- 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
```



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight 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 the higher priorities are Active/Optimized, meaning they are serviced by the controller where the aggregate is located. The paths with the lower priorities are active but are non-optimized because they are served from a different controller. The non-optimized paths are only used when no optimized paths are 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='service-time 0' prio=50 status=active
|  |- 11:0:1:0 sdj 8:144 active ready running
|  |- 11:0:2:0 sdr 65:16 active ready running
`-+- policy='service-time 0' prio=10 status=enabled
|- 11:0:0:0 sdb 8:i6 active ready running
|- 12:0:0:0 sdz 65:144 active ready running
```



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight paths might cause path issues during storage failures.

Recommended Settings

SUSE Linux Enterprise Server 12 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, but you can create an empty, zero-byte file by using the following command:

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

The first time you create this file, you might need to enable and start the multipath services:

```
# systemctl enable multipathd
# systemctl start multipathd
```

- There is no requirement to add anything directly to the `multipath.conf` file, unless you have devices that you do not want to be managed by multipath or you have existing settings that override defaults.
- To exclude unwanted devices, add the following syntax to the `multipath.conf` file .

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

Replace the `<DevId>` with the WWID string of the device you want to exclude.

Example

In this example, we are going to determine the WWID of a device and add to the `multipath.conf` file.

Steps

1. Run the following command to determine the WWID:

```
# /lib/udev/scsi_id -gud /dev/sda
360030057024d0730239134810c0cb833
```

sda is the local SCSI disk that we need to add it to the blacklist.

2. Add the 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 for legacy settings, especially in the defaults section, that might be overriding the 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 will need to be corrected by later stanzas in the multipath.conf file that apply specifically to ONTAP LUNs. If this is not done, the ONTAP LUNs might not work as expected. These defaults should only be overridden in consultation with NetApp and/or an OS vendor 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"
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

Parameter	Setting
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
    }
}
```

Known issues

The SLES 12 with ONTAP release has the following known issues:

NetApp Bug ID	Title	Description	Bugzilla ID
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 not loaded during multipathd startup on local boot. Due to this device handler will not be loaded though ALUA is enabled on target side.	908529
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".	903001

NetApp Bug ID	Title	Description	Bugzilla ID
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.	890854

Ubuntu

Use Ubuntu 22.04 with ONTAP

You can use the ONTAP SAN host configuration settings to configure Ubuntu 22.04 with ONTAP as the target.



NetApp Linux Unified Host Utilities software package is not available for Ubuntu 22.04 OS.

SAN booting

What you'll need

If you decide to use SAN booting, it must be supported by your configuration. You can use the [NetApp 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 is successful.

Multipathing

For Ubuntu 22.04, the `/etc/multipath.conf` file must exist, but you do not need to make specific changes to the file. Ubuntu 22.04 is compiled with all the settings required to recognize and correctly manage ONTAP LUNs.

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

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

All SAN Array configurations

In All SAN Array (ASA) configurations, all paths to a given LUN are active and optimized. 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
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
```



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight 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 the higher priorities are Active/Optimized, meaning they are serviced by the controller where the aggregate is located. The paths with the lower priorities are active but are non-optimized because they are served from a different controller. The non-optimized paths are only used when no optimized paths are 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
3600a098038314c4c715d5732674e6141 dm-0 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
| |- 11:0:1:0 sda 8:0 active ready running
| `-- 12:0:2:0 sdd 8:48 active ready running
`-+- policy='service-time 0' prio=10 status=enabled
  |- 11:0:2:0 sdb 8:16 active ready running
  `-- 12:0:1:0 sdc 8:32 active ready running
```



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight paths might cause path issues during storage failures.

Recommended settings

The Ubuntu 22.04 OS is compiled to recognize ONTAP LUNs and automatically set all configuration parameters correctly for both ASA and non-ASA configurations. You can further optimize performance for your host configuration with the following recommended settings.

The `multipath.conf` file must exist for the multipath daemon to start, but you can create an empty, zero-

byte file by using the following command:

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

The first time you create this file, you might need to enable and start the multipath services:

```
# systemctl enable multipathd
# systemctl start multipathd
```

- There is no requirement to add anything directly to the `multipath.conf` file, unless you have devices that you do not want to be managed by multipath or you have existing settings that override defaults.
- To exclude unwanted devices, add the following syntax to the `multipath.conf` file .

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

Replace the `<DevId>` with the WWID string of the device you want to exclude.

Example

In this example, we are going to determine the WWID of a device and add to the `multipath.conf` file.

Steps

1. Run the following command to determine the WWID:

```
# /lib/udev/scsi_id -gud /dev/sda
360030057024d0730239134810c0cb833
```

`sda` is the local SCSI disk that we need to add it to the blacklist.

2. Add the 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 for legacy settings, especially in the defaults

section, that might be overriding the 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 will need to be corrected by later stanzas in the `multipath.conf` file that apply specifically to ONTAP LUNs. If this is not done, the ONTAP LUNs might not work as expected. These defaults should only be overridden in consultation with NetApp and/or an OS vendor and only when the impact is fully understood.

Parameter	Setting
<code>detect_prio</code>	yes
<code>dev_loss_tmo</code>	"infinity"
<code>failback</code>	immediate
<code>fast_io_fail_tmo</code>	5
<code>features</code>	"2 pg_init_retries 50"
<code>flush_on_last_del</code>	"yes"
<code>hardware_handler</code>	"0"
<code>no_path_retry</code>	queue
<code>path_checker</code>	"tur"
<code>path_grouping_policy</code>	"group_by_prio"
<code>path_selector</code>	"service-time 0"
<code>polling_interval</code>	5
<code>prio</code>	"ontap"
<code>product</code>	LUN.*
<code>retain_attached_hw_handler</code>	yes
<code>rr_weight</code>	"uniform"
<code>user_friendly_names</code>	no
<code>vendor</code>	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 other SAN arrays are 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
    }
}

```

KVM settings

You can use the recommended settings to configure Kernel-based Virtual Machine (KVM) as well. There are no changes required to configure KVM as the LUN is mapped to the hypervisor.

Known issues

There are no known issues for the Ubuntu 22.04 with ONTAP release.

Use Ubuntu 20.04 with ONTAP

You can use the ONTAP SAN host configuration settings to configure Ubuntu 20.04 with ONTAP as the target.



NetApp Linux Unified Host Utilities software package is not available for Ubuntu 20.04 OS.

SAN booting

What you'll need

If you decide to use SAN booting, it must be supported by your configuration. You can use the [NetApp 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 is successful.

Multipathing

For Ubuntu 20.04, the `/etc/multipath.conf` file must exist, but you do not need to make specific changes to the file. Ubuntu 20.04 is compiled with all the settings required to recognize and correctly manage ONTAP LUNs.

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

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

All SAN Array configurations

In All SAN Array (ASA) configurations, all paths to a given LUN are active and optimized. 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
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
```



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight 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 the higher priorities are Active/Optimized, meaning they are serviced by the controller where the aggregate is located. The paths with the lower priorities are active but are non-optimized because they are served from a different controller. The non-optimized paths are only used when no optimized paths are 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
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
```



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight paths might cause path issues during storage failures.

Recommended settings

The Ubuntu 20.04 OS is compiled to recognize ONTAP LUNs and automatically set all configuration parameters correctly for both ASA and non-ASA configurations. You can further optimize performance for your host configuration with the following recommended settings.

The `multipath.conf` file must exist for the multipath daemon to start, but you can create an empty, zero-byte file by using the following command:

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

The first time you create this file, you might need to enable and start the multipath services:

```
# systemctl enable multipathd
# systemctl start multipathd
```

- There is no requirement to add anything directly to the `multipath.conf` file, unless you have devices that you do not want to be managed by multipath or you have existing settings that override defaults.
- To exclude unwanted devices, add the following syntax to the `multipath.conf` file .

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

Replace the `<DevId>` with the WWID string of the device you want to exclude.

Example

In this example, we are going to determine the WWID of a device and add to the `multipath.conf` file.

Steps

1. Run the following command to determine the WWID:

```
# /lib/udev/scsi_id -gud /dev/sda
360030057024d0730239134810c0cb833
```

`sda` is the local SCSI disk that we need to add it to the blacklist.

2. Add the 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 for legacy settings, especially in the defaults section, that might be overriding the 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 will need to be corrected by later stanzas in the `multipath.conf` file that apply specifically to ONTAP LUNs. If this is not done, the ONTAP LUNs might not work as expected. These defaults should only be overridden in consultation with NetApp and/or an OS vendor and only when the impact is fully understood.

Parameter	Setting
<code>detect_prio</code>	<code>yes</code>
<code>dev_loss_tmo</code>	<code>"infinity"</code>
<code>failback</code>	<code>immediate</code>
<code>fast_io_fail_tmo</code>	<code>5</code>
<code>features</code>	<code>"2 pg_init_retries 50"</code>
<code>flush_on_last_del</code>	<code>"yes"</code>
<code>hardware_handler</code>	<code>"0"</code>
<code>no_path_retry</code>	<code>queue</code>
<code>path_checker</code>	<code>"tur"</code>
<code>path_grouping_policy</code>	<code>"group_by_prio"</code>
<code>path_selector</code>	<code>"service-time 0"</code>
<code>polling_interval</code>	<code>5</code>

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 `no_path_retry` that are not compatible with ONTAP LUNs. If they cannot be removed because other SAN arrays are 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
    }
}
```

KVM settings

You can use the recommended settings to configure Kernel-based Virtual Machine (KVM) as well. There are no changes required to configure KVM as the LUN is mapped to the hypervisor.

Known issues

There are no known issues for the Ubuntu 20.04 with ONTAP release.

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 (RHCK based) platforms with FC, FCoE, and iSCSI protocols.

Install the Linux Unified Host Utilities

The NetApp Linux Unified Host Utilities software package is available on the [NetApp Support Site](#) in a 64-bit .rpm file.

NetApp strongly recommends installing the Linux Unified 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.

What you'll need

If you have a version of Linux Unified Host Utilities currently installed, you should upgrade or remove it, and then use the following steps to install the latest version.

Steps

1. Download the 64-bit Linux Unified 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 tool kit 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 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      vservers      host:
path         path      path      /dev/      chan:      vservers      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

What you'll need

If you decide to use SAN booting, it must be supported by your configuration. You can use the [NetApp 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 is successful.

Multipathing

You must verify that your configuration meets the system requirements. For more information, see the NetApp Interoperability Matrix Tool and the Veritas HCL Matrix.

Example

In this example, the `vxddmpadm` command is used to verify that the VxDMP Multipath has the ONTAP target array attached.

```
# vxddmpadm listenclosure
ENCLR_NAME    ENCLR_TYPE  ENCLR_SNO      STATUS      ARRAY_TYPE    LUN_COUNT
FIRMWARE
=====
=====
sfrac0        SFRAC       804Xw$PqE52h  CONNECTED   ALUA           43
9800
# vxddmpadm 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.

```
# vxddmpadm 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:

```
# vxddmpadm 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 the higher priorities are Active/Optimized, meaning they are serviced by the controller where the aggregate is located. The paths with the lower priorities are active but are non-optimized because they are served from a different controller. The non-optimized paths are only used when no optimized paths are available.

Example

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

```
# vxddmpadm 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        -
-
```



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

The following Veritas VxDMP tunables are recommended by NetApp 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 `vxddmpadm` command as follows:

```
# vxddmpadm settune dmp_tunable=value
```

The values of these tunable can be verified dynamically by using `#vxddmpadm gettune`.

Example

The following example shows the effective VxDMP tunables on the SAN host.

```
# vxddmpadm 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, please refer to the Veritas Product Administration guide 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 & Oracle Linux (RHCK based) platforms with FC, FCoE and iSCSI protocols.

Install the Linux Unified Host Utilities

The NetApp Linux Unified Host Utilities software package is available on the [NetApp Support Site](#) in a 64-bit .rpm file.

NetApp strongly recommends installing the Linux Unified 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.

What you'll need

If you have a version of Linux Unified Host Utilities currently installed, you should upgrade or remove it, and then use the following steps to install the latest version.

Steps

1. Download the 64-bit Linux Unified 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 tool kit 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 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      vservers      host:
path         path         path         /dev/      chan:      vservers      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

What you'll need

If you decide to use SAN booting, it must be supported by your configuration. You can use the [NetApp 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 is successful.

Multipathing

You must verify that your configuration meets the system requirements. For more information, see the NetApp Interoperability Matrix Tool and the Veritas HCL Matrix.

Example

In this example, the `vxddmpadm` command is used to verify that the VxDMP Multipath has the ONTAP target array attached.

```
# vxddmpadm listenclosure
ENCLR_NAME    ENCLR_TYPE  ENCLR_SNO    STATUS      ARRAY_TYPE   LUN_COUNT
FIRMWARE
=====
=====
sfrac0        SFRAC       804Xw$PqE52h  CONNECTED   ALUA          43
9800
# vxddmpadm 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.

```
# vxddladm 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:

```
# vxddladm 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 configurations

For non-ASA configurations, there should be two groups of paths with different priorities. The paths with the higher priorities are Active/Optimized, meaning they are serviced by the controller where the aggregate is located. The paths with the lower priorities are active but are non-optimized because they are served from a different controller. The non-optimized paths are only used when no optimized paths are available.

Example

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

```
# vxddmpadm 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        -
-
```



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight paths might cause path issues during storage failures.

Recommended Settings

Settings for Veritas Multipath

The following Veritas VxDMP tunables are recommended by NetApp 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 `vxddmpadm` command as follows:

```
# vxddmpadm settune dmp_tunable=value
```

The values of these tunable can be verified dynamically by using `#vxddmpadm gettune`.

Example

The following example shows the effective VxDMP tunables on the SAN host.

```
# vxddmpadm 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, please refer to the Veritas Product Administration guide 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 & Oracle Linux (RHCK based) platforms with FC, FCoE and iSCSI protocols.

Install the Linux Unified Host Utilities

The NetApp Linux Unified Host Utilities software package is available on the [NetApp Support Site](#) in a 64-bit .rpm file.

NetApp strongly recommends installing the Linux Unified 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.

What you'll need

If you have a version of Linux Unified Host Utilities currently installed, you should upgrade or remove it, and then use the following steps to install the latest version.

Steps

1. Download the 64-bit Linux Unified 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 tool kit 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 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      vservers      host:
path         path         path         /dev/      chan:      vservers      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

What you'll need

If you decide to use SAN booting, it must be supported by your configuration. You can use the [NetApp 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 is successful.

Multipathing

You must verify that your configuration meets the system requirements. For more information, see the [NetApp Interoperability Matrix Tool](#) and the Veritas HCL Matrix.

Example

In this example, the `vxddmpadm` command is used to verify that the VxDMP Multipath has the ONTAP target array attached.

```
# vxddmpadm listenclosure
ENCLR_NAME    ENCLR_TYPE  ENCLR_SNO      STATUS      ARRAY_TYPE    LUN_COUNT
FIRMWARE
=====
=====
sfrac0        SFRAC       804Xw$PqE52h  CONNECTED   ALUA          43
9800
```

```
# vxddmpadm 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.

```
# vxddmpadm 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 the higher priorities are Active/Optimized, meaning they are serviced by the controller where the aggregate is located. The paths with the lower priorities are active but are non-optimized because they are served from a different controller. The non-optimized paths are only used when no optimized paths are available.

Example

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

```
# vxddmpadm 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        -
-
```



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight paths might cause path issues during storage failures.

Recommended Settings

Settings for Veritas Multipath

The following Veritas VxDMP tunables are recommended by NetApp 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 `vxddmpadm` command as follows:

```
# vxddmpadm settune dmp_tunable=value
```

The values of these tunable can be verified dynamically by using `#vxddmpadm gettune`.

Example

The following example shows the effective VxDMP tunables on the SAN host.

```
# vxddmpadm 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, please refer to the Veritas Product Administration guide for configuration settings.

Known issues

There are no known issues for the Veritas Storage Foundation 6 for Linux with ONTAP release.

Windows

Using Windows Server 2022 with ONTAP

You can use the ONTAP SAN host configuration settings to configure Windows server 2022 with ONTAP as the target.

Booting the OS

There are two options for booting the operating system: by using either local boot or SAN boot. For local booting, you install the OS on the local hard disk (SSD, SATA, RAID, and so on). For SAN booting, see instructions below.

SAN booting

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

1. Map the SAN boot LUN to the host.
2. Verify multiple paths are available. Remember, multiple paths will only be 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 is successful.

Install Windows hotfixes

NetApp recommends that the **latest cumulative update** is installed on the server.



Go to the [Microsoft Update Catalog 2022](#) website to obtain and install the required Windows hotfixes for your version of Windows.

1. Download hotfixes from the Microsoft support site.



Some hotfixes are not available for direct download. In these cases, you will need to request a given hotfix from Microsoft support personnel.

2. Follow the instructions provided by Microsoft to install the hotfixes.



Many hotfixes require a reboot of your Windows host, but you can opt to wait to reboot the host until *after* you install or upgrade the Host Utilities.

Install the Windows Unified Host Utilities

The Windows Unified Host Utilities (WUHU) 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 installation of the latest utility kit. For WUHU configuration information and instructions, refer to the [Windows Unified Host Utilities documentation](#) and select the installation procedure for your Windows Unified Host Utilities version.

Multipathing

You must install MPIO software and have multipathing set up if your Windows host has more than one path to the storage system. Without MPIO software, the operating system might see each path as a separate disk, which can lead to data corruption. The MPIO software presents a single disk to the operating system for all paths, and a device-specific module (DSM) manages path failover.

On a Windows system, the two main components to any MPIO solution are a DSM and the Windows MPIO. MPIO is not supported for Windows XP or Windows Vista running in a Hyper- V virtual machine.



When you select MPIO support, the Windows Unified Host Utilities enables the included MPIO feature of Windows Server 2022.

SAN configuration

Non-ASA configuration

For non-ASA configuration there should be two groups of paths with different priorities.

The paths with the higher priorities are Active/Optimized, meaning they are serviced by the controller where the aggregate is located.

The paths with the lower priorities are active but are non-optimized because they are served from a different controller.



The non-optimized paths are only used when no optimized paths are available.

Example

The following example displays the correct output for an ONTAP LUN with two active/optimized paths and two active/non-optimized paths.

The screenshot shows the 'NETAPP LUN C-Mode Multi-Path Disk Device Properties' dialog box with the 'MPIO' tab selected. The 'Select the MPIO policy:' dropdown is set to 'Round Robin With Subset'. The 'Description' box explains that this policy executes the round robin policy only on paths designated as active/optimized, and non-active/optimized paths will be tried upon failure of all active/optimized paths. The 'DSM Name:' field is 'Microsoft DSM'. Below, a table lists the paths for the device.

Path Id	Path State	TPG...	TPG State	Wei.
77040001	Active/Unopti...	1003	Active/Unopti...	
77030001	Active/Unopti...	1003	Active/Unopti...	
77040000	Active/Optimi...	1002	Active/Optimi...	

Below the table, there are instructions: 'To edit the path settings for the MPIO policy, select a path and click Edit.' with an 'Edit...' button, and 'To apply the path settings and selected MPIO policy, click Apply.' with an 'Apply' button. At the bottom are 'OK' and 'Cancel' buttons.

All SAN array configuration

For All SAN Array (ASA) configuration, there should be one group of paths with single priorities. All paths are active/optimized; that is, they are serviced by the controller and that the I/O is sent on all the active paths.

NETAPP LUN C-Mode Multi-Path Disk Device Properties

General Policies Volumes MPIO Driver Details Events

Select the MPIO policy: Round Robin With Subset

Description

The round robin with subset policy executes the round robin policy only on paths designated as active/optimized. The non-active/optimized paths will be tried on a round-robin approach upon failure of all active/optimized paths.

DSM Name: Microsoft DSM Details

This device has the following paths:

Path Id	Path State	TPG...	TPG State	Wei. ^
77030000	Active/Optimi...	1001	Active/Optimi...	
77040000	Active/Optimi...	1001	Active/Optimi...	
77030001	Active/Optimi...	1000	Active/Optimi...	

To edit the path settings for the MPIO policy, select a path and click Edit.

To apply the path settings and selected MPIO policy, click Apply.

Edit... Apply OK Cancel



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight paths might cause path issues during storage failures.

Recommended settings

On systems using FC, the following timeout values for Emulex and QLogic FC HBAs are required when MPIO is selected.

For Emulex Fibre Channel HBAs:

Property type	Property value
LinkTimeOut	1
NodeTimeOut	10

For QLogic Fibre Channel HBAs:

Property type	Property value
LinkDownTimeOut	1
PortDownRetryCount	10



Windows Unified Host Utility will set these values. For detailed recommended settings, refer to the [Windows Host Utilities documentation](#) and select the installation procedure for your Windows Unified Host Utilities version.

Known issues

There are no known issues for the Windows Server 2022 with ONTAP release.

Using Windows Server 2019 with ONTAP

You can use the ONTAP SAN host configuration settings to configure Windows server 2019 with ONTAP as the target.

Booting the OS

There are two options for booting the operating system: by using either local boot or SAN boot. For local booting, you install the OS on the local hard disk (SSD, SATA, RAID, and so on). For SAN booting, see instructions below.

SAN booting

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

1. Map the SAN boot LUN to the host.
2. Verify multiple paths are available. Remember, multiple paths will only be 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 is successful.



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

Install Windows hotfixes

NetApp recommends that the **latest cumulative update** is installed on the server.



Go to the [Microsoft Update Catalog 2019](#) website to obtain and install the required Windows hotfixes for your version of Windows.

1. Download hotfixes from the Microsoft support site.



Some hotfixes are not available for direct download. In these cases, you will need to request a given hotfix from Microsoft support personnel.

2. Follow the instructions provided by Microsoft to install the hotfixes.



Many hotfixes require a reboot of your Windows host, but you can opt to wait to reboot the host until *after* you install or upgrade the Host Utilities.

Install the Windows Unified Host Utilities

The Windows Unified Host Utilities (WUHU) 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 installation of the latest utility kit. For WUHU configuration information and instructions, refer to the [Windows Unified Host Utilities documentation](#) and select the installation procedure for your Windows Unified Host Utilities version.

Multipathing

You must install MPIO software and have multipathing set up if your Windows host has more than one path to the storage system. Without MPIO software, the operating system might see each path as a separate disk, which can lead to data corruption. The MPIO software presents a single disk to the operating system for all paths, and a device-specific module (DSM) manages path failover.

On a Windows system, the two main components to any MPIO solution are a DSM and the Windows MPIO. MPIO is not supported for Windows XP or Windows Vista running in a Hyper- V virtual machine.



When you select MPIO support, the Windows Unified Host Utilities enables the included MPIO feature of Windows Server 2019.

SAN configuration

Non-ASA configuration

For non-ASA configuration there should be two groups of paths with different priorities.

The paths with the higher priorities are Active/Optimized, meaning they are serviced by the controller where the aggregate is located.

The paths with the lower priorities are active but are non-optimized because they are served from a different controller.



The non-optimized paths are only used when no optimized paths are available.

Example

The following example displays the correct output for an ONTAP LUN with two active/optimized paths and two active/non-optimized paths.

NETAPP LUN C-Mode Multi-Path Disk Device Properties

General Policies Volumes **MPIO** Driver Details Events

Select the MPIO policy: Round Robin With Subset

Description

The round robin with subset policy executes the round robin policy only on paths designated as active/optimized. The non-active/optimized paths will be tried on a round-robin approach upon failure of all active/optimized paths.

DSM Name: Microsoft DSM Details

This device has the following paths:

Path Id	Path State	TPG...	TPG State	Wei.
77040001	Active/Unopti...	1003	Active/Unopti...	
77030001	Active/Unopti...	1003	Active/Unopti...	
77040000	Active/Optimi...	1002	Active/Optimi...	

To edit the path settings for the MPIO policy, select a path and click Edit.

To apply the path settings and selected MPIO policy, click Apply.

OK Cancel

All SAN array configuration

For All SAN Array (ASA) configuration, there should be one group of paths with single priorities. All paths are active/optimized; that is, they are serviced by the controller and that the I/O is sent on all the active paths.

NETAPP LUN C-Mode Multi-Path Disk Device Properties

General Policies Volumes MPIO Driver Details Events

Select the MPIO policy: Round Robin With Subset

Description

The round robin with subset policy executes the round robin policy only on paths designated as active/optimized. The non-active/optimized paths will be tried on a round-robin approach upon failure of all active/optimized paths.

DSM Name: Microsoft DSM Details

This device has the following paths:

Path Id	Path State	TPG...	TPG State	Wei.
77030000	Active/Optimi...	1001	Active/Optimi...	
77040000	Active/Optimi...	1001	Active/Optimi...	
77030001	Active/Optimi...	1000	Active/Optimi...	

To edit the path settings for the MPIO policy, select a path and click Edit.

To apply the path settings and selected MPIO policy, click Apply.

Edit... Apply OK Cancel



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight paths might cause path issues during storage failures.

Recommended settings

On systems using FC, the following timeout values for Emulex and QLogic FC HBAs are required when MPIO is selected.

For Emulex Fibre Channel HBAs:

Property type	Property value
LinkTimeOut	1
NodeTimeOut	10

For QLogic Fibre Channel HBAs:

Property type	Property value
LinkDownTimeOut	1
PortDownRetryCount	10



Windows Unified Host Utility will set these values. For detailed recommended settings, refer to the [Windows Host Utilities documentation](#) and select the installation procedure for your Windows Unified Host Utilities version.

Known issues

There are no known issues for the Windows Server 2019 with ONTAP release.

Using Windows Server 2016 with ONTAP

You can use the ONTAP SAN host configuration settings to configure Windows server 2016 with ONTAP as the target.

Booting the OS

There are two options for booting the operating system: by using either local boot or SAN boot. For local booting, you install the OS on the local hard disk (SSD, SATA, RAID, and so on). For SAN booting, see instructions below.

SAN booting

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

1. Map the SAN boot LUN to the host.
2. Verify multiple paths are available. Remember, multiple paths will only be 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 is successful.



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

Install Windows hotfixes

NetApp recommends that the **latest cumulative update** is installed on the server.



Go to the [Microsoft Update Catalog 2016](#) website to obtain and install the required Windows hotfixes for your version of Windows.

1. Download hotfixes from the Microsoft support site.



Some hotfixes are not available for direct download. In these cases, you will need to request a given hotfix from Microsoft support personnel.

2. Follow the instructions provided by Microsoft to install the hotfixes.



Many hotfixes require a reboot of your Windows host, but you can opt to wait to reboot the host until *after* you install or upgrade the Host Utilities.

Install the Windows Unified Host Utilities

The Windows Unified Host Utilities (WUHU) 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 installation of the latest utility kit. For WUHU configuration information and instructions, refer to the [Windows Unified Host Utilities documentation](#) and select the installation procedure for your Windows Unified Host Utilities version.

Multipathing

You must install MPIO software and have multipathing set up if your Windows host has more than one path to the storage system. Without MPIO software, the operating system might see each path as a separate disk, which can lead to data corruption. The MPIO software presents a single disk to the operating system for all paths, and a device-specific module (DSM) manages path failover.

On a Windows system, the two main components to any MPIO solution are a DSM and the Windows MPIO. MPIO is not supported for Windows XP or Windows Vista running in a Hyper- V virtual machine.



When you select MPIO support, the Windows Unified Host Utilities enables the included MPIO feature of Windows Server 2016.

SAN configuration

Non-ASA configuration

For non-ASA configuration there should be two groups of paths with different priorities.

The paths with the higher priorities are Active/Optimized, meaning they are serviced by the controller where the aggregate is located.

The paths with the lower priorities are active but are non-optimized because they are served from a different controller.



The non-optimized paths are only used when no optimized paths are available.

Example

The following example displays the correct output for an ONTAP LUN with two active/optimized paths and two active/non-optimized paths.

NETAPP LUN C-Mode Multi-Path Disk Device Properties

General Policies Volumes **MPIO** Driver Details Events

Select the MPIO policy: Round Robin With Subset

Description

The round robin with subset policy executes the round robin policy only on paths designated as active/optimized. The non-active/optimized paths will be tried on a round-robin approach upon failure of all active/optimized paths.

DSM Name: Microsoft DSM Details

This device has the following paths:

Path Id	Path State	TPG...	TPG State	Wei. ^
77040001	Active/Unopti...	1003	Active/Unopti...	
77030001	Active/Unopti...	1003	Active/Unopti...	
77040000	Active/Optimi...	1002	Active/Optimi...	

To edit the path settings for the MPIO policy, select a path and click Edit.

To apply the path settings and selected MPIO policy, click Apply.

OK Cancel

All SAN array configuration

For All SAN Array (ASA) configuration, there should be one group of paths with single priorities. All paths are active/optimized; that is, they are serviced by the controller and that the I/O is sent on all the active paths.

NETAPP LUN C-Mode Multi-Path Disk Device Properties

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77030001	Active/Optimi...	1000	Active/Optimi...	

To edit the path settings for the MPIO policy, select a path and click Edit.

To apply the path settings and selected MPIO policy, click Apply.

Edit... Apply OK Cancel



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight paths might cause path issues during storage failures.

Recommended settings

On systems using FC, the following timeout values for Emulex and QLogic FC HBAs are required when MPIO is selected.

For Emulex Fibre Channel HBAs:

Property type	Property value
LinkTimeOut	1
NodeTimeOut	10

For QLogic Fibre Channel HBAs:

Property type	Property value
LinkDownTimeOut	1
PortDownRetryCount	10



Windows Unified Host Utility will set these values. For detailed recommended settings, refer to the [Windows Host Utilities documentation](#) and select the installation procedure for your Windows Unified Host Utilities version.

Known issues

There are no known issues for the Windows Server 2016 with ONTAP release.

Using Windows Server 2012 R2 with ONTAP

You can use the ONTAP SAN host configuration settings to configure Windows server 2012 R2 with ONTAP as the target.

Booting the OS

There are two options for booting the operating system: by using either local boot or SAN boot. For local booting, you install the OS on the local hard disk (SSD, SATA, RAID, and so on). For SAN booting, see instructions below.

SAN booting

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

1. Map the SAN boot LUN to the host.
2. Verify multiple paths are available. Remember, multiple paths will only be available after the host OS is up and running on the paths.
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4. Reboot the host to verify the boot is successful.



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

Install Windows hotfixes

NetApp recommends that the **latest cumulative update** is installed on the server.



Go to the [Microsoft Update Catalog 2012 R2](#) website to obtain and install the required Windows hotfixes for your version of Windows.

1. Download hotfixes from the Microsoft support site.



Some hotfixes are not available for direct download. In these cases, you will need to request a given hotfix from Microsoft support personnel.

2. Follow the instructions provided by Microsoft to install the hotfixes.



Many hotfixes require a reboot of your Windows host, but you can opt to wait to reboot the host until *after* you install or upgrade the Host Utilities.

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On a Windows system, the two main components to any MPIO solution are a DSM and the Windows MPIO. MPIO is not supported for Windows XP or Windows Vista running in a Hyper- V virtual machine.



When you select MPIO support, the Windows Unified Host Utilities enables the included MPIO feature of Windows Server 2012 R2.

SAN configuration

Non-ASA configuration

For non-ASA configuration there should be two groups of paths with different priorities.

The paths with the higher priorities are Active/Optimized, meaning they are serviced by the controller where the aggregate is located.

The paths with the lower priorities are active but are non-optimized because they are served from a different controller.



The non-optimized paths are only used when no optimized paths are available.

Example

The following example displays the correct output for an ONTAP LUN with two active/optimized paths and two active/non-optimized paths.

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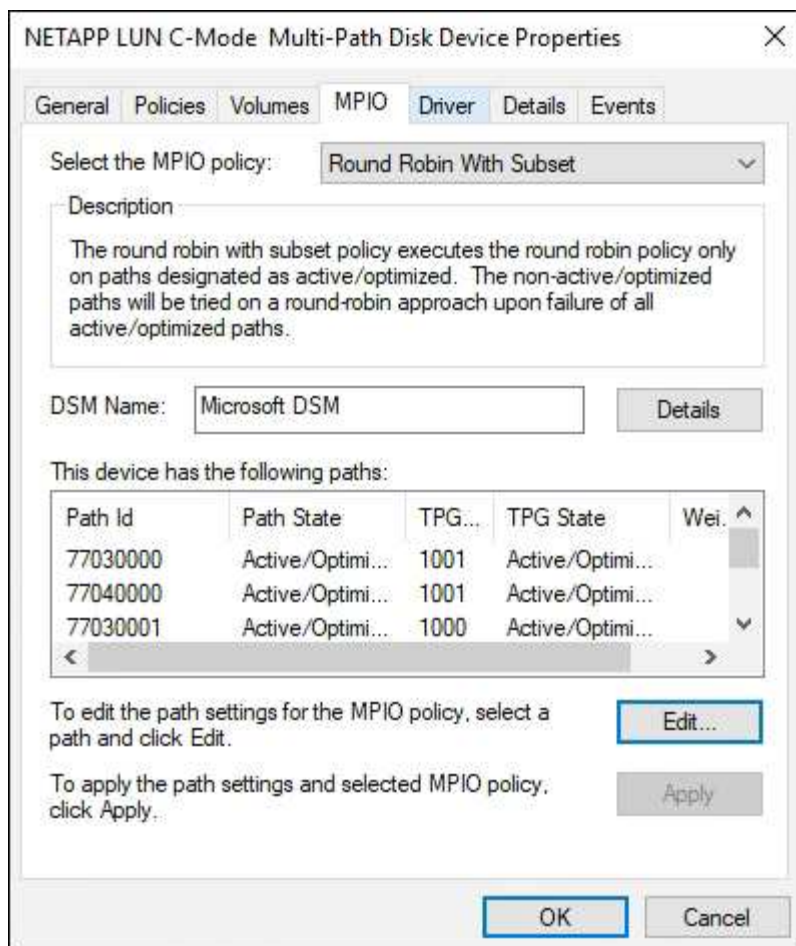
To edit the path settings for the MPIO policy, select a path and click Edit.

To apply the path settings and selected MPIO policy, click Apply.

OK Cancel

All SAN array configuration

For All SAN Array (ASA) configuration, there should be one group of paths with single priorities. All paths are active/optimized; that is, they are serviced by the controller and that the I/O is sent on all the active paths.



Do not use an excessive number of paths to a single LUN. No more than four paths should be required. More than eight paths might cause path issues during storage failures.

Hyper-V VHD requires alignment for best performance

If the data block boundaries of a disk partition do not 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.

Misalignment is caused by the location of the starting sector for each partition defined by the master boot record.



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). Once 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 are not supported. In addition, the PowerShell Toolkit requires a minimum partition size of 4 GB. 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.

The PowerShell Toolkit cmdlet has completed on the VHD file for the virtual machine. This topic applies only to Linux guest operating systems using the GRUB boot loader and `SystemRescueCd`.

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 hung at the GRUB screen, click in the display area to make sure it is active, then click 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, but 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 is not 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
```



Note that `boot_disk`, above, 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

On systems using FC, the following timeout values for Emulex and QLogic FC HBAs are required when MPIO is selected.

For Emulex Fibre Channel HBAs:

Property type	Property value
LinkTimeOut	1
NodeTimeOut	10

For QLogic Fibre Channel HBAs:

Property type	Property value
LinkDownTimeOut	1
PortDownRetryCount	10



Windows Unified Host Utility will set these values. For detailed recommended settings, refer to the [Windows Host Utilities documentation](#) and select the installation procedure for your Windows Unified Host Utilities version.

Known issues

There are no known issues for the Windows Server 2012 R2 with ONTAP release.

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