



# **RHEL 7**

## **SAN hosts and cloud clients**

NetApp  
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# RHEL 7

## Using Red Hat Enterprise Linux 7.9 with NetApp ONTAP

### Installing 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.

Installing the Linux Unified Host Utilities is strongly recommended, 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 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
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 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.

## 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 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:

```
# 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 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:

```
# 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 4 paths should be required. More than 8 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 using the 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.

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. Use the following command to determine the WWID:

```
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 the `/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 may be overriding the default settings.

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 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 may 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
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 Problems and Limitations

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 <a href="#">NetApp Knowledge Base: The filesystem corruption on iSCSI LUN on the Oracle Linux 7.</a>	N/A

## Release Notes

### ASM Mirroring

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.



# Using Red Hat Enterprise Linux 7.8 with NetApp ONTAP

## Installing 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.

Installing the Linux Unified Host Utilities is strongly recommended, 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 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
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 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.

## 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 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:

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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
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  |- 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

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`+- 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

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 using the 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.

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. Use the following command to determine the WWID:

```

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:

```

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360030057024d0730239134810c0cb833

```

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

```

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You should always check your `/etc/multipath.conf` file for legacy settings, especially in the defaults section, that may be overriding the default settings.

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 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 may 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>	"3 queue_if_no_path pg_init_retries 50"
<code>flush_on_last_del</code>	"yes"

Parameter	Setting
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 Problems and Limitations

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## Release Notes

### ASM Mirroring

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.

## Using Red Hat Enterprise Linux 7.7 with NetApp ONTAP

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2. Use the following command to install the software package:

```
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120.0g  cDOT
data_vserver            /vol/vol2/lun2  /dev/sdd  host16    FCP
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## SAN Booting

### What you'll need

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### Steps

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.

## Multipathing

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`-+- 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.

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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.

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  |- 11:0:0:0 sdb 8:i6 active ready running
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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 the `<DevId>` with the WWID string of the device you want to exclude. Use the following command to determine the WWID:

```
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 the `/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 may be overriding the default settings.

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 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 may 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>	"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.*

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 Problems and Limitations

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 <a href="#">NetApp Knowledge Base: The filesystem corruption on iSCSI LUN on the Oracle Linux 7.</a>	N/A
<a href="#">1258856</a>	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.	<a href="#">1743667</a>

NetApp Bug ID	Title	Description	Bugzilla ID
<a href="#">1261474</a>	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.	<a href="#">1745995</a>

## Release Notes

### ASM Mirroring

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.

## Using Red Hat Enterprise Linux 7.6 with NetApp ONTAP

### Installing 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.

Installing the Linux Unified Host Utilities is strongly recommended, 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 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
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 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:

```
# 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 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:

```
# 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 4 paths should be required. More than 8 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 using the 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.

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. Use the following command to determine the WWID:

```
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 the `/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 may be overriding the default settings.

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 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 may 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
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 Problems and Limitations

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 <a href="#">NetApp Knowledge Base: The filesystem corruption on iSCSI LUN on the Oracle Linux 7.</a>	N/A

NetApp Bug ID	Title	Description	Bugzilla ID
<a href="#">1186754</a>	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	<a href="#">1628039</a>
<a href="#">1190698</a>	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	<a href="#">1643459</a>

## Release Notes

### ASM Mirroring

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.

## Using Red Hat Enterprise Linux 7.5 with NetApp ONTAP

### Installing 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.

Installing the Linux Unified Host Utilities is strongly recommended, 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 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
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 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.

## 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 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:

```
# 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 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:

```
# 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 4 paths should be required. More than 8 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 using the 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.

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. Use the following command to determine the WWID:

```
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 the `/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 may be overriding the default settings.

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 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 may 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
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 Problems and Limitations

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 <a href="#">NetApp Knowledge Base: The filesystem corruption on iSCSI LUN on the Oracle Linux 7.</a>	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	<p>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.</p>	1542564

NetApp Bug ID	Title	Description	Bugzilla ID
<a href="#">1138536</a>	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.	<a href="#">1541972</a>

NetApp Bug ID	Title	Description	Bugzilla ID
<a href="#">1148090</a>	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.	<a href="#">1559050</a>

NetApp Bug ID	Title	Description	Bugzilla ID
<a href="#">1146898</a>	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.	<a href="#">1554777</a>

## Release Notes

### ASM Mirroring

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.

## Using Red Hat Enterprise Linux 7.4 with NetApp ONTAP

## Installing 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.

Installing the Linux Unified Host Utilities is strongly recommended, 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 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
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 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.

## 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 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:

```
# 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 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:

```
# 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 4 paths should be required. More than 8 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 using the 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.

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. Use the following command to determine the WWID:



```

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 the `/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 may be overriding the default settings.

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 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 may 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>	"3 queue_if_no_path pg_init_retries 50"
<code>flush_on_last_del</code>	"yes"

Parameter	Setting
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 Problems and Limitations

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 <a href="#">NetApp Knowledge Base: The filesystem corruption on iSCSI LUN on the Oracle Linux 7.</a>	N/A

## Release Notes

### ASM Mirroring

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.

## Using Red Hat Enterprise Linux 7.3 with NetApp ONTAP

### Installing 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.

Installing the Linux Unified Host Utilities is strongly recommended, 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 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
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 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.

## 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 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:

```
# 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 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:

```
# 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 4 paths should be required. More than 8 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 using the 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.

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. Use the following command to determine the WWID:

```
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 the `/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 may be overriding the default settings.

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 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 may 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>	"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.*

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 Problems and Limitations

There are no known issues for RHEL 7.3.

### Release Notes

#### ASM Mirroring

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.



# Using Red Hat Enterprise Linux 7.2 with NetApp ONTAP

## Installing 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.

Installing the Linux Unified Host Utilities is strongly recommended, 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 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
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 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.

## 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 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:

```
# 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 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:

```
# 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 4 paths should be required. More than 8 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 using the 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.

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. Use the following command to determine the WWID:

```

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 the `/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 may be overriding the default settings.

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 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 may 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>	"3 queue_if_no_path pg_init_retries 50"
<code>flush_on_last_del</code>	"yes"

Parameter	Setting
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 Problems and Limitations

There are no known issues for RHEL 7.2.

## Release Notes

### ASM Mirroring

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.

## Using Red Hat Enterprise Linux 7.1 with NetApp ONTAP

### Installing 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.

Installing the Linux Unified Host Utilities is strongly recommended, 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 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
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 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.

## 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 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:

```
# 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 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:

```
# 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 4 paths should be required. More than 8 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 using the 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.

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. Use the following command to determine the WWID:

```
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 the `/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 may be overriding the default settings.

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 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 may 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
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 Problems and Limitations

NetApp Bug ID	Title	Description	Bugzilla ID
<a href="#">799323</a>	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"	<a href="#">1061755</a>

NetApp Bug ID	Title	Description	Bugzilla ID
<a href="#">836875</a>	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.	<a href="#">1114966</a>

## Release Notes

### ASM Mirroring

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.

## Using Red Hat Enterprise Linux 7.0 with NetApp ONTAP

### Installing 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.

Installing the Linux Unified Host Utilities is strongly recommended, 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 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
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 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.

## 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 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:

```
# 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 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:

```
# 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 4 paths should be required. More than 8 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 using the 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.

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. Use the following command to determine the WWID:

```
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 the `/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 may be overriding the default settings.

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 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 may 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>	"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.*



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 Problems and Limitations

NetApp Bug ID	Title	Description	Bugzilla ID
<a href="#">844417</a>	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.	<a href="#">1131393</a>
<a href="#">811587</a>	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.	<a href="#">1079735</a>

NetApp Bug ID	Title	Description	Bugzilla ID
<a href="#">803071</a>	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.	<a href="#">1067895</a>
<a href="#">820163</a>	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.	<a href="#">1090378</a>
<a href="#">799323</a>	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.	<a href="#">1061755</a>
<a href="#">849212</a>	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.	<a href="#">1109274</a>

NetApp Bug ID	Title	Description	Bugzilla ID
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
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

NetApp Bug ID	Title	Description	Bugzilla ID
<a href="#">836657</a>	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.	<a href="#">1114464</a>

## Release Notes

### ASM Mirroring

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.

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