



**SLES**  
SAN Host  
NetApp  
May 25, 2022

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# SLES

## SLES 15

### Using SUSE Linux Enterprise Server 15 SP3 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
```

#### 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 SUSE Linux Enterprise Server 15 SP3 the `/etc/multipath.conf` file must exist, but you do not need to make specific changes to the file. SUSE Linux Enterprise Server 15 SP3 is compiled with all settings required to recognize and correctly manage ONTAP LUNs.

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

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

### All SAN Array 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='3 queue_if_no_path pg_init_retries 50' hwhandler='1
alua' wp=rw
`-+- policy='service-time 0' prio=50 status=active
  |- 3:0:7:9      sdco 69:192  active ready running
  |- 3:0:8:9      sddi 71:0    active ready running
  |- 14:0:8:9     sdjq 65:320  active ready running
  `-- 14:0:7:9    sdiw 8:256   active ready running
```



Do not use an excessive number of paths to a single LUN. No more than 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='3 queue_if_no_path pg_init_retries 50' hwhandler='1
alua' wp=rw
|-+- policy='service-time 0' prio=50 status=active
| |- 3:0:3:0      sdd  8:48    active ready running
| |- 3:0:4:0      sdx  65:112  active ready running
`-+- policy='service-time 0' prio=10 status=enabled
  |- 14:0:2:0     sdfk 130:96   active ready running
  `-- 14:0:5:0    sdgz 132:240  active ready running
```



Do not use an excessive number of paths to a single LUN. No more than 4 paths should be required. More than 8 paths might cause path issues during storage failures.

### Recommended Settings

SUSE Linux Enterprise Server 15 SP3 OS is compiled to recognize ONTAP LUNs and automatically set all configuration parameters correctly for both ASA and non-ASA configuration.

The `multipath.conf` file must exist for the multipath daemon to start, but you can create an empty, zero-byte file 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 `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 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 default settings.

The table below shows the critical `multipathd` parameters for ONTAP LUNs and the required values. If a host is connected to LUNs from other vendors and any of these parameters are overridden, they will need to be corrected by later stanzas in `multipath.conf` that apply specifically to ONTAP LUNs. If this is not done,

the ONTAP LUNs 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	"2 pg_init_retries 50"
flush_on_last_del	"yes"
hardware_handler	"0"
no_path_retry	queue
path_checker	"tur"
path_grouping_policy	"group_by_prio"
path_selector	"service-time 0"
polling_interval	5
prio	"ontap"
product	LUN.*
retain_attached_hw_handler	yes
rr_weight	"uniform"
user_friendly_names	no
vendor	NETAPP

### Example

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

```

defaults {
    path_checker      readsector0
    no_path_retry    fail
}
devices {
    device {
        vendor        "NETAPP  "
        product       "LUN.*"
        no_path_retry queue
        path_checker  tur
    }
}

```

## Known Problems and Limitations

There are no known issues for SUSE Linux Enterprise Server 15 SP3.

## 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 SUSE Linux Enterprise Server 15 SP2 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
```



## 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
vservers(cDOT/FlashRay)  lun-pathname filename  adapter  protocol  size
Product
-----
data_vserver              /vol/vol1/lun1 /dev/sdb    host16    FCP
120.0g cDOT
data_vserver              /vol/vol1/lun1 /dev/sdc    host15    FCP
120.0g cDOT
data_vserver              /vol/vol2/lun2 /dev/sdd    host16    FCP
120.0g cDOT
data_vserver              /vol/vol2/lun2 /dev/sde    host15    FCP
120.0g cDOT
```

## SAN Booting

### What you'll need

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

### Steps

1. Map the SAN boot LUN to the host.
2. Verify 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 SUSE Linux Enterprise Server 15 SP2 the `/etc/multipath.conf` file must exist, but you do not need to make specific changes to the file. SUSE Linux Enterprise Server 15 SP2 is compiled with all settings required to recognize and correctly manage ONTAP LUNs. Use the `multipath -ll` command verify the settings for your ONTAP LUNs.

There should be two groups of paths with different priorities. The paths with the higher priorities are

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

### Example

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

```
# multipath -ll
3600a09803831347657244e527766394e dm-5 NETAPP,LUN C-Mode
size=80G features='3 queue_if_no_path pg_init_retries 50' hwhandler='1
alua' wp=rw
|+- policy='service-time 0' prio=50 status=enabled
| |- 11:0:1:0 sdj 8:144 active ready running
| |- 11:0:2:0 sdr 65:16 active ready running
`+- policy='service-time 0' prio=10 status=enabled
|- 11:0:0:0 sdb 8:i6 active ready running
|- 12:0:0:0 sdz 65:144 active ready running
```

Do not use an excessive number of paths to a single LUN. No more than 4 paths should be required. More than 8 paths might cause path issues during storage failures.

### Recommended Settings

SUSE Linux Enterprise Server 15 SP2 OS is compiled to recognize ONTAP LUNs and automatically set all configuration parameters correctly.

The `multipath.conf` file must exist for the multipath daemon to start, but you can create an empty, zero-byte file 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 `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 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 default settings.

The table below shows the critical `multipathd` parameters for ONTAP LUNs and the required values. If a host is connected to LUNs from other vendors and any of these parameters are overridden, they will need to be corrected by later stanzas in `multipath.conf` that apply specifically to ONTAP LUNs. If this is not done, the ONTAP LUNs 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>	"2 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
    }
}
```

### Known Problems and Limitations

NetApp Bug ID	Title	Description	Bugzilla ID
<a href="#">1308744</a>	iSCSI boot from SAN fails to boot with a static IP configuration after completing an SLES15SP2 OS installation	<p>iSCSI sanbooted LUN failed to boot up after completing an SLES 15 SP2 OS installation with a static IP configuration. Bootup failure occurs every time with the static IP configuration. This leads to the server refusing to continue the boot up process with the following error message:</p> <pre> dracut-cmdline[241]: warning: Empty autoconf values default to dhcp  dracut: FATAL: FATAL: For argument ip=eth4:static, setting client-ip does not make sense for dhcp  dracut: Refusing to continue  reboot: System halted </pre>	<a href="#">1167494</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 SUSE Linux Enterprise Server 15 SP1 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
```

## 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 SUSE Linux Enterprise Server 15 SP1 the `/etc/multipath.conf` file must exist, but you do not need to make specific changes to the file. SUSE Linux Enterprise Server 15 SP1 is compiled with all settings required to recognize and correctly manage ONTAP LUNs.

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

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

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



Do not use an excessive number of paths to a single LUN. No more than 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='3 queue_if_no_path pg_init_retries 50' hwhandler='1
alua' wp=rw
|+- policy='service-time 0' prio=50 status=active
| |- 11:0:1:0 sdj 8:144 active ready running
| |- 11:0:2:0 sdr 65:16 active ready running
`+- policy='service-time 0' prio=10 status=enabled
|- 11:0:0:0 sdb 8:i6 active ready running
|- 12:0:0:0 sdz 65:144 active ready running
```



Do not use an excessive number of paths to a single LUN. No more than 4 paths should be required. More than 8 paths might cause path issues during storage failures.

## Recommended Settings

SUSE Linux Enterprise Server 15 SP1 OS is compiled to recognize ONTAP LUNs and automatically set all configuration parameters correctly.

The `multipath.conf` file must exist for the multipath daemon to start, but you can create an empty, zero-byte file 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 `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 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 default settings.

The table below shows the critical `multipathd` parameters for ONTAP LUNs and the required values. If a host is connected to LUNs from other vendors and any of these parameters are overridden, they will need to be corrected by later stanzas in `multipath.conf` that apply specifically to ONTAP LUNs. If this is not done, the ONTAP LUNs 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>	"2 pg_init_retries 50"
<code>flush_on_last_del</code>	"yes"
<code>hardware_handler</code>	"0"
<code>no_path_retry</code>	queue
<code>path_checker</code>	"tur"
<code>path_grouping_policy</code>	"group_by_prio"
<code>path_selector</code>	"service-time 0"
<code>polling_interval</code>	5
<code>prio</code>	"ontap"
<code>product</code>	LUN.*
<code>retain_attached_hw_handler</code>	yes

Parameter	Setting
rr_weight	"uniform"
user_friendly_names	no
vendor	NETAPP

### Example

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

```
defaults {
    path_checker      readsector0
    no_path_retry     fail
}

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

### Known Problems and Limitations

NetApp Bug ID	Title	Description	Bugzilla ID
<a href="#">1246622</a>	Remote ports transit to a blocked state on SLES15SP1 with Emulex LPe12002 8GB FC during storage failover operations.	<p>Remote ports transit to a blocked state on SLES15SP1 with Emulex LPe12002 8GB Fibre Channel (FC) during storage failover operations. When the storage node returns to an optimal state, the LIFs also come up and the remote port state should read "online."</p> <p>Occasionally, the remote port state might continue to read as "blocked" or "not present." This state can lead to a "failed faulty" path to LUNs at the multipath layer as well as an I/O outage for those LUNs. You can check the remoteport's details against the following sample commands:</p> <pre> ---- cat/sys/class/fc_host /host*/device/rport*/f c_remote_ports/rport */port_name  cat/sys/class/fc_host /host*/device/rport*/f c_remote_ports/rport */port_state ---- </pre>	<a href="#">1139137</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 SUSE Linux Enterprise Server 15 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
```

## 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 SUSE Linux Enterprise Server 15 the `/etc/multipath.conf` file must exist, but you do not need to make specific changes to the file. SUSE Linux Enterprise Server 15 is compiled with all settings required to recognize and correctly manage ONTAP LUNs.

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

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

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



Do not use an excessive number of paths to a single LUN. No more than 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='3 queue_if_no_path pg_init_retries 50' hwhandler='1
  alua' wp=rw
|-+- policy='service-time 0' prio=50 status=enabled
|  |- 11:0:1:0 sdj 8:144 active ready running
|  |- 11:0:2:0 sdr 65:16 active ready running
`-+- policy='service-time 0' prio=10 status=enabled
|  |- 11:0:0:0 sdb 8:i6 active ready running
|  |- 12:0:0:0 sdz 65:144 active ready running
```



Do not use an excessive number of paths to a single LUN. No more than 4 paths should be required. More than 8 paths might cause path issues during storage failures.

### Recommended Settings

SUSE Linux Enterprise Server 15 OS is compiled to recognize ONTAP LUNs and automatically set all configuration parameters correctly.

The `multipath.conf` file must exist for the multipath daemon to start, but you can create an empty, zero-byte file 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 `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 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 default settings.

The table below shows the critical `multipathd` parameters for ONTAP LUNs and the required values. If a host is connected to LUNs from other vendors and any of these parameters are overridden, they will need to be corrected by later stanzas in `multipath.conf` that apply specifically to ONTAP LUNs. If this is not done, the ONTAP LUNs 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>	"2 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
    }
}
```

### Known Problems and Limitations



NetApp Bug ID	Title	Description	Bugzilla ID
<a href="#">1154309</a>	SLES 15 host with more than 20 mapped LUNs might go into maintenance mode after a reboot	SLES 15 host with more than 20 mapped LUNs might go into maintenance mode after a reboot. The maintenance mode becomes single user mode following the message: Give root password for maintenance (or press Control-D to continue)	<a href="#">1104173</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.

## SLES 12

### Using SUSE Linux Enterprise Server 12 SP5 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
```

#### 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 SUSE Linux Enterprise Server 12 SP5 the `/etc/multipath.conf` file must exist, but you do not need to make specific changes to the file. SUSE Linux Enterprise Server 12 SP5 is compiled with all settings required to recognize and correctly manage ONTAP LUNs.

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

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

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



Do not use an excessive number of paths to a single LUN. No more than 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='3 queue_if_no_path pg_init_retries 50' hwhandler='1
alua' wp=rw
|+- policy='service-time 0' prio=50 status=active
| |- 11:0:1:0 sdj 8:144 active ready running
| |- 11:0:2:0 sdr 65:16 active ready running
`-+- policy='service-time 0' prio=10 status=enabled
  |- 11:0:0:0 sdb 8:i6 active ready running
  |- 12:0:0:0 sdz 65:144 active ready running
```



Do not use an excessive number of paths to a single LUN. No more than 4 paths should be required. More than 8 paths might cause path issues during storage failures.

## Recommended Settings

SUSE Linux Enterprise Server 12 SP5 OS is compiled to recognize ONTAP LUNs and automatically set all configuration parameters correctly.

The `multipath.conf` file must exist for the multipath daemon to start, but you can create an empty, zero-byte file 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 `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 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 default settings.

The table below shows the critical `multipathd` parameters for ONTAP LUNs and the required values. If a host is connected to LUNs from other vendors and any of these parameters are overridden, they will need to be corrected by later stanzas in `multipath.conf` that apply specifically to ONTAP LUNs. If this is not done, the ONTAP LUNs 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>	"2 pg_init_retries 50"
<code>flush_on_last_del</code>	"yes"
<code>hardware_handler</code>	"0"
<code>no_path_retry</code>	queue
<code>path_checker</code>	"tur"
<code>path_grouping_policy</code>	"group_by_prio"
<code>path_selector</code>	"service-time 0"
<code>polling_interval</code>	5
<code>prio</code>	"ontap"
<code>product</code>	LUN.*
<code>retain_attached_hw_handler</code>	yes
<code>rr_weight</code>	"uniform"
<code>user_friendly_names</code>	no
<code>vendor</code>	NETAPP

### Example

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

specifically for ONTAP LUNs with a device stanza.

```
defaults {
  path_checker readsector0
  no_path_retry fail
}
devices {
  device {
    vendor "NETAPP "
    product "LUN.*"
    no_path_retry queue
    path_checker tur
  }
}
```

### Known Problems and Limitations

NetApp Bug ID	Title	Description	Bugzilla ID
<a href="#">1284293</a>	Kernel disruption occurs on SLES12 SP5 with QLogic QLE2562 8GB FC HBA during storage failover operations	Kernel disruption occurs during storage failover operations on the SLES12 SP5 kernel with a QLogic QLE2562 Fibre Channel (FC) host bus adapter (HBA). The kernel disruption causes SLES12 SP5 to reboot, leading to application disruption. If the kdump mechanism is enabled, the kernel disruption generates a vmcore file located in the /var/crash/ directory. Check the vmcore file to determine the cause of the disruption. A storage failover with a QLogic QLE2562 HBA event affects the "THREAD_INFO: ffff8aedef723c2c0" module. Locate this event in the vmcore file by finding the following string: "[THREAD_INFO: ffff8aedef723c2c0]". After the kernel disruption, reboot the host OS to enable it to recover. Then restart the applications.	<a href="#">1157966</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 SUSE Linux Enterprise Server 12 SP4 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
```

### 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 SUSE Linux Enterprise Server 12 SP4 the `/etc/multipath.conf` file must exist, but you do not need to make specific changes to the file. SUSE Linux Enterprise Server 12 SP4 is compiled with all settings required to recognize and correctly manage ONTAP LUNs.

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

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

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



Do not use an excessive number of paths to a single LUN. No more than 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='3 queue_if_no_path pg_init_retries 50' hwhandler='1
alua' wp=rw
|+- policy='service-time 0' prio=50 status=active
| |- 11:0:1:0 sdj 8:144 active ready running
| |- 11:0:2:0 sdr 65:16 active ready running
`+- policy='service-time 0' prio=10 status=enabled
  |- 11:0:0:0 sdb 8:i6 active ready running
  |- 12:0:0:0 sdz 65:144 active ready running
```



Do not use an excessive number of paths to a single LUN. No more than 4 paths should be required. More than 8 paths might cause path issues during storage failures.

### Recommended Settings

SUSE Linux Enterprise Server 12 SP4 OS is compiled to recognize ONTAP LUNs and automatically set all configuration parameters correctly.

The `multipath.conf` file must exist for the multipath daemon to start, but you can create an empty, zero-byte file 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 `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 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 default settings.

The table below shows the critical `multipathd` parameters for ONTAP LUNs and the required values. If a host is connected to LUNs from other vendors and any of these parameters are overridden, they will need to be corrected by later stanzas in `multipath.conf` that apply specifically to ONTAP LUNs. If this is not done,

the ONTAP LUNs 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	"2 pg_init_retries 50"
flush_on_last_del	"yes"
hardware_handler	"0"
no_path_retry	queue
path_checker	"tur"
path_grouping_policy	"group_by_prio"
path_selector	"service-time 0"
polling_interval	5
prio	"ontap"
product	LUN.*
retain_attached_hw_handler	yes
rr_weight	"uniform"
user_friendly_names	no
vendor	NETAPP

### Example

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

```
defaults {
  path_checker readsector0
  no_path_retry fail
}
devices {
  device {
    vendor "NETAPP "
    product "LUN.*"
    no_path_retry queue
    path_checker tur
  }
}
```

## Known Problems and Limitations

There are no known issues for SUSE Linux Enterprise Server 12 SP4.

## 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 SUSE Linux Enterprise Server 12 SP3 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
```

## 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 SUSE Linux Enterprise Server 12 SP3 the `/etc/multipath.conf` file must exist, but you do not need to make specific changes to the file. SUSE Linux Enterprise Server 12 SP3 is compiled with all settings required to recognize and correctly manage ONTAP LUNs.

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

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

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



Do not use an excessive number of paths to a single LUN. No more than 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_handler' hwhandler='1 alua' wp=rw
|+- policy='service-time 0' prio=50 status=active
| |- 11:0:1:0 sdj 8:144 active ready running
| |- 11:0:2:0 sdr 65:16 active ready running
`-+- policy='service-time 0' prio=10 status=enabled
  |- 11:0:0:0 sdb 8:i6 active ready running
  |- 12:0:0:0 sdz 65:144 active ready running
```



Do not use an excessive number of paths to a single LUN. No more than 4 paths should be required. More than 8 paths might cause path issues during storage failures.

## Recommended Settings

SUSE Linux Enterprise Server 12 SP3 OS is compiled to recognize ONTAP LUNs and automatically set all configuration parameters correctly.

The `multipath.conf` file must exist for the multipath daemon to start, but you can create an empty, zero-byte file 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 `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 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 default settings.

The table below shows the critical `multipathd` parameters for ONTAP LUNs and the required values. If a host is connected to LUNs from other vendors and any of these parameters are overridden, they will need to be corrected by later stanzas in `multipath.conf` that apply specifically to ONTAP LUNs. If this is not done, the ONTAP LUNs 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>	"2 pg_init_retries 50"
<code>flush_on_last_del</code>	"yes"
<code>hardware_handler</code>	"0"
<code>no_path_retry</code>	queue
<code>path_checker</code>	"tur"
<code>path_grouping_policy</code>	"group_by_prio"
<code>path_selector</code>	"service-time 0"
<code>polling_interval</code>	5
<code>prio</code>	"ontap"
<code>product</code>	LUN.*
<code>retain_attached_hw_handler</code>	yes
<code>rr_weight</code>	"uniform"
<code>user_friendly_names</code>	no
<code>vendor</code>	NETAPP

### Example

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



specifically for ONTAP LUNs with a device stanza.

```
defaults {
  path_checker readsector0
  no_path_retry fail
}
devices {
  device {
    vendor "NETAPP "
    product "LUN.*"
    no_path_retry queue
    path_checker tur
  }
}
```

### **Known Problems and Limitations**

NetApp Bug ID	Title	Description	Bugzilla ID
<a href="#">1089555</a>	Kernel disruption observed on kernel version SLES12 SP3 with Emulex LPe16002 16GB FC during storage failover operation	<p>A kernel disruption might occur during storage failover operations on kernel version SLES12 SP3 with Emulex LPe16002 HBA. The kernel disruption prompts a reboot of the operating system, which in turn causes an application disruption. If the kdump is configured, the kernel disruption generates a vmcore file under /var/crash/directory. You can investigate the cause of the failure in the vmcore file.</p> <p>Example:</p> <p>In the observed case, the kernel disruption was observed in the module “lpfc_sli_ringtxcmpl_put+51” and is logged in the vmcore file</p> <p>– exception RIP: lpfc_sli_ringtxcmpl_put+51.</p> <p>Recover the operating system after the kernel disruption by rebooting the host operating system and restarting the application.</p>	<a href="#">1042847</a>

NetApp Bug ID	Title	Description	Bugzilla ID
<a href="#">1089561</a>	Kernel disruption observed on kernel version SLES12 SP3 with Emulex LPe32002 32GB FC during storage failover operations	<p>A kernel disruption might occur during storage failover operations on kernel version SLES12 SP3 with Emulex LPe32002 HBA. The kernel disruption prompts a reboot of the operating system, which in turn causes an application disruption. If the kdump is configured, the kernel disruption generates a vmcore file under /var/crash/directory. You can investigate the cause of the failure in the vmcore file.</p> <p>Example:</p> <p>In the observed case, the kernel disruption was observed in the module "lpfc_sli_free_hbq+76" and is logged in the vmcore file</p> <p>– exception RIP: lpfc_sli_free_hbq+76.</p> <p>Recover the operating system after the kernel disruption by rebooting the host operating system and restarting the application.</p>	<a href="#">1042807</a>

NetApp Bug ID	Title	Description	Bugzilla ID
<a href="#">1117248</a>	Kernel disruption observed on SLES12SP3 with QLogic QLE2562 8GB FC during storage failover operations	<p>During storage failover operations on the Sles12sp3 kernel (kernel-default-4.4.82-6.3.1) with QLogic QLE2562 HBA, the kernel disruption was observed due to a panic in the kernel. The kernel panic leads to a reboot of the operating system, causing an application disruption. The kernel panic generates the vmcore file under the /var/crash/ directory if kdump is configured. Upon the kernel panic, the vmcore file can be used to understand the cause of the failure.</p> <p>Example: In this case, the panic was observed in the "blk_finish_request+289" module. It is logged in the vmcore file with the following string: "exception RIP: blk_finish_request+289"</p> <p>After the kernel disruption, you can recover the operating system by rebooting the Host OS. You can restart the application as required.</p>	<a href="#">1062496</a>

NetApp Bug ID	Title	Description	Bugzilla ID
1117261	Kernel disruption observed on SLES12SP3 with Qlogic QLE2662 16GB FC during storage failover operations	<p data-bbox="813 157 1149 735">During storage failover operations on Sles12sp3 kernel (kernel-default-4.4.82-6.3.1) with Qlogic QLE2662 HBA, you might observe kernel disruption. This prompts a reboot of the operating system causing application disruption. The kernel disruption generates a vmcore file under /var/crash/ directory if kdump is configured. The vmcore file can be used to understand the cause of the failure.</p> <p data-bbox="813 741 1149 1045">Example: In this case the Kernel disruption was observed in the module "unknown or invalid address" and is logged in vmcore file with the following string - exception RIP: unknown or invalid address.</p> <p data-bbox="813 1081 1149 1283">After kernel disruption, the operating system can be recovered by rebooting the host operating system and restarting the application as required.</p>	1062508

NetApp Bug ID	Title	Description	Bugzilla ID
<a href="#">1117274</a>	Kernel disruption observed on SLES12SP3 with Emulex LPe16002 16GB FC during storage failover operations	<p>During storage failover operations on Sles12sp3 kernel (kernel-default-4.4.87-3.1) with Emulex LPe16002 HBA, you might observe kernel disruption. This prompts a reboot of the operating system causing application disruption. The kernel disruption generates a vmcore file under the /var/crash/ directory if kdump is configured. The vmcore file can be used to understand the cause of the failure.</p> <p>Example:</p> <p>In this case kernel disruption was observed in the module “raw_spin_lock_irqsave+30” and is logged in the vmcore file with the following string:</p> <p>– exception RIP: _raw_spin_lock_irqsave+30.</p> <p>After kernel disruption, the operating system can be recovered by rebooting the host operating system and restarting the application as required.</p>	<a href="#">1062514</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 SUSE Linux Enterprise Server 12 SP2 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
```

## 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 SUSE Linux Enterprise Server 12 SP2 the `/etc/multipath.conf` file must exist, but you do not need to make specific changes to the file. SUSE Linux Enterprise Server 12 SP2 is compiled with all settings required to recognize and correctly manage ONTAP LUNs.

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

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

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



Do not use an excessive number of paths to a single LUN. No more than 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

SUSE Linux Enterprise Server 12 SP2 OS is compiled to recognize ONTAP LUNs and automatically set all configuration parameters correctly.

The `multipath.conf` file must exist for the multipath daemon to start, but you can create an empty, zero-byte file 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 `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 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 default settings.

The table below shows the critical `multipathd` parameters for ONTAP LUNs and the required values. If a host is connected to LUNs from other vendors and any of these parameters are overridden, they will need to be corrected by later stanzas in `multipath.conf` that apply specifically to ONTAP LUNs. If this is not done, the ONTAP LUNs 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>	<code>yes</code>
<code>dev_loss_tmo</code>	<code>"infinity"</code>
<code>failback</code>	<code>immediate</code>
<code>fast_io_fail_tmo</code>	<code>5</code>
<code>features</code>	<code>"3 queue_if_no_path pg_init_retries 50"</code>
<code>flush_on_last_del</code>	<code>"yes"</code>
<code>hardware_handler</code>	<code>"0"</code>
<code>path_checker</code>	<code>"tur"</code>
<code>path_grouping_policy</code>	<code>"group_by_prio"</code>
<code>path_selector</code>	<code>"service-time 0"</code>
<code>polling_interval</code>	<code>5</code>
<code>prio</code>	<code>"ontap"</code>

Parameter	Setting
product	LUN.*
retain_attached_hw_handler	yes
rr_weight	"uniform"
user_friendly_names	no
vendor	NETAPP

### Example

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

```
defaults {
  path_checker readsector0
  detect_prio no
}
devices {
  device {
    vendor "NETAPP "
    product "LUN.*"
    path_checker tur
    detect_prio yes
  }
}
```

### Known Problems and Limitations

There are no known issues for SUSE Linux Enterprise Server 12 SP2.

### 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 SUSE Linux Enterprise Server 12 SP1 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
```

### 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 SUSE Linux Enterprise Server 12 SP1 the `/etc/multipath.conf` file must exist, but you do not need to make specific changes to the file. SUSE Linux Enterprise Server 12 SP1 is compiled with all settings required to recognize and correctly manage ONTAP LUNs.

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

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

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



Do not use an excessive number of paths to a single LUN. No more than 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

SUSE Linux Enterprise Server 12 SP1 OS is compiled to recognize ONTAP LUNs and automatically set all configuration parameters correctly.

The `multipath.conf` file must exist for the multipath daemon to start, but you can create an empty, zero-byte file 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 `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 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 default settings.

The table below shows the critical `multipathd` parameters for ONTAP LUNs and the required values. If a host is connected to LUNs from other vendors and any of these parameters are overridden, they will need to be corrected by later stanzas in `multipath.conf` that apply specifically to ONTAP LUNs. If this is not done, the ONTAP LUNs 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>	<code>yes</code>
<code>dev_loss_tmo</code>	<code>"infinity"</code>
<code>failback</code>	<code>immediate</code>
<code>fast_io_fail_tmo</code>	<code>5</code>
<code>features</code>	<code>"3 queue_if_no_path pg_init_retries 50"</code>
<code>flush_on_last_del</code>	<code>"yes"</code>
<code>hardware_handler</code>	<code>"0"</code>
<code>path_checker</code>	<code>"tur"</code>
<code>path_grouping_policy</code>	<code>"group_by_prio"</code>
<code>path_selector</code>	<code>"service-time 0"</code>
<code>polling_interval</code>	<code>5</code>
<code>prio</code>	<code>"ontap"</code>
<code>product</code>	<code>LUN.*</code>

Parameter	Setting
retain_attached_hw_handler	yes
rr_weight	"uniform"
user_friendly_names	no
vendor	NETAPP

### Example

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

```
defaults {
  path_checker readsector0
  detect_prio no
}
devices {
  device {
    vendor "NETAPP "
    product "LUN.*"
    path_checker tur
    detect_prio yes
  }
}
```

### Known Problems and Limitations

There are no known issues for SUSE Linux Enterprise Server 12 SP1.

### 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 SUSE Linux Enterprise Server 12 with NetApp ONTAP

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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.

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

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Product
-----
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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 SUSE Linux Enterprise Server 12 the `/etc/multipath.conf` file must exist, but you do not need to make specific changes to the file. SUSE Linux Enterprise Server 12 is compiled with all settings required to recognize and correctly manage ONTAP LUNs.

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

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

### All SAN Array 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
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retain_attached_hw_handle' hwhandler='1 alua' wp=rw
|+- policy='round-robin 0' prio=50 status=active
| |- 1:0:8:1 sdb 8:16 active ready running
| `-- 2:0:8:1 sdd 8:48 active ready running
`+- policy='round-robin 0' prio=10 status=enabled
  |- 1:0:9:1 sdc 8:32 active ready running
  `-- 2:0:9:1 sde 8:64 active ready running
```



Do not use an excessive number of paths to a single LUN. No more than 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.

### 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

SUSE Linux Enterprise Server 12 OS is compiled to recognize ONTAP LUNs and automatically set all configuration parameters correctly.

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

```
touch /etc/multipath.conf
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The first time you create this file, you might need to enable and start the multipath services.

```
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There is no requirement to add anything directly to `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 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 default settings.

The table below shows the critical `multipathd` parameters for ONTAP LUNs and the required values. If a host is connected to LUNs from other vendors and any of these parameters are overridden, they will need to be corrected by later stanzas in `multipath.conf` that apply specifically to ONTAP LUNs. If this is not done, the ONTAP LUNs 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>path_checker</code>	"tur"
<code>path_grouping_policy</code>	"group_by_prio"
<code>path_selector</code>	"service-time 0"
<code>polling_interval</code>	5
<code>prio</code>	"ontap"
<code>product</code>	LUN.*
<code>retain_attached_hw_handler</code>	yes
<code>rr_weight</code>	"uniform"

Parameter	Setting
user_friendly_names	no
vendor	NETAPP

### Example

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

```
defaults {
  path_checker readsector0
  detect_prio no
}
devices {
  device {
    vendor "NETAPP "
    product "LUN.*"
    path_checker tur
    detect_prio yes
  }
}
```

### Known Problems and Limitations

NetApp Bug ID	Title	Description	Bugzilla ID
<a href="#">873555</a>	scsi_dh_alua module is not loaded during multipathd startup on local boot	scsi_dh_alua is a Linux ALUA device handler module. This is not loaded during multipathd startup on local boot. Due to this device handler will not be loaded though ALUA is enabled on target side.	<a href="#">908529</a>
<a href="#">863584</a>	The message "conflicting device node '/dev/mapper/360xx' found" appears on the screen when you create a DM device on SLES12	You might observe a failure in creating a link to DM devices under /dev/mapper dir in SLES 12 and see the messages "conflicting device node '/dev/mapper/360xx' found".	<a href="#">903001</a>

NetApp Bug ID	Title	Description	Bugzilla ID
<a href="#">847490</a>	Multipath daemon shows path failures on SLES 12	You might observe path failures on the SLES12 multipath daemon during I/O with storage or fabric faults.	<a href="#">890854</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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