ONTAP SAN Host Configuration

ONTAP SAN Host

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ONTAP SAN Host Configuration

This content provides distribution-specific guidance about how to configure ONTAP SAN hosts for the NVMe, iSCSI, and FC protocols.

For best performance and to ensure successful failover, it is important to correctly configure SAN hosts using ONTAP storage. These documents show how to quickly set up a best practice configuration.

For iSCSI and FC, this documentation replaces the traditional Linux Unified Host Utilities guides. Each document is specific to one distribution and version of Linux, so you see only the information for your exact version. If your distribution and version of Linux is not yet listed, please check back soon.

More information

You can find additional information on SAN configurations in the following documentation:

All SAN Array Software Configuration Guide
SAN Administration Guide
SAN Configuration Guide

NVMe/FC Host Configurations

RHEL

NVMe/FC Host Configuration for RHEL 8.1 with ONTAP

Supportability

NVMe/FC is supported on ONTAP 9.6 or later for the following versions of RHEL:

- RHEL 8.1

RHEL 8.1 host can run both NVMe & SCSI traffic through the same fibre channel initiator adapter ports.
See the Hardware Universe for a list of supported FC adapters and controllers.
For the most current list of supported configurations see the NetApp Interoperability Matrix.

Known limitations

- Native NVMe/FC auto-connect scripts are not available in the nvme-cli package.
  You can use the HBA vendor provided external auto-connect script.
- By default, NVMe multipath is disabled.
  It must be manually enabled. Steps are provided in the section on Enabling NVMe/FC on RHEL 8.1.
- By default, round-robin load balancing is not enabled.
  You must write a udev rule to enable this functionality. Steps are provided in the section on Enabling NVMe/FC on RHEL 8.1.

Enabling NVMe/FC on RHEL 8.1

1. Install Red Hat Enterprise Linux 8.1 on the server.
2. After the installation is complete, verify that you are running the specified Red Hat Enterprise Linux kernel. See the NetApp Interoperability Matrix for the most current list of supported versions.

   ```
   # uname -r
   4.18.0-147.el8.x86_64
   ```

3. Install the nvme-cli-1.8.1-3.el8 package.

   ```
   # rpm -qa|grep nvme-cli
   nvme-cli-1.8.1-3.el8.x86_64
   ```

4. Enable in-kernel NVMe multipath.

```
# grubby □args=nvme_core.multipath=Y □update-kernel /boot/vmlinuz-4.18.0-147.el8.x86_64
```

5. Add the string below as a separate udev rule at /lib/udev/rules.d/71-nvme-iopolicy-netapp-ONTAP.rules. This enables round-robin load balancing for NVMe multipath.

```
# Enable round-robin for NetApp ONTAP
ACTION==□add□, SUBSYSTEM==□nvme-subsystem□, ATTR{model}==□NetApp ONTAP Controller□,
ATTR{iopolicy}=□round-robin
```

6. On the RHEL 8.1 host, check the host NQN string at /etc/nvme/hostnqn and verify that it matches the host NQN string for the corresponding subsystem on the ONTAP array.

```
# cat /etc/nvme/hostnqn
nqn.2014-08.org.nvmexpress:uuid:75953f3b-77fe-4e03-bf3c-09d5a156fbcd
```

```
*> vserver nvme subsystem host show -vserver vs_nvme_10
Vserver Subsystem Host NQN
------- --------- ------------------------------------- -----------
rhel_141_nvme_ss_10_0
nqn.2014-08.org.nvmexpress:uuid:75953f3b-77fe-4e03-bf3c-09d5a156fbcd
```

Note:

If the host NQN strings do not match, you should use the vserver modify command to update the host NQN string on your corresponding ONTAP array subsystem to match to host NQN string from /etc/nvme/hostnqn on the host.

7. Reboot the host.

Configuring the Broadcom FC Adapter for NVMe/FC

1. Verify that you are using the supported adapter. For the most current list of supported adapters see the NetApp Interoperability Matrix.

```
# cat /sys/class/scsi_host/host*/modelname
LPe32002-M2
LPe32002-M2
```

```
# cat /sys/class/scsi_host/host*/modeldesc
Emulex LightPulse LPe32002-M2 2-Port 32Gb Fibre Channel Adapter
Emulex LightPulse LPe32002-M2 2-Port 32Gb Fibre Channel Adapter
```

2. Copy and install the Broadcom lpfc outbox driver and auto-connect scripts.

```
# tar -xvzf elx-lpfc-dd-rhel8-12.4.243.20-ds-1.tar.gz
# cd elx-lpfc-dd-rhel8-12.4.2453.20-ds-1
# ./elx_lpfc_install-sh -i -n
```

Note:

The native drivers that come bundled with the OS are called inbox drivers. If you download the outbox drivers (drivers that are not included with the OS release), an auto-connect script is included in the download and should be installed as part of the driver installation process.

3. Reboot the host.
4. Verify that you are using the recommended Broadcom lpfc firmware, outbox driver & auto-connect package versions.

```
# cat /sys/class/scsi_host/host*/fwrev
12.4.243.20, sil-4.2.c
12.4.243.20, sil-4.2.c
```

```
# cat /sys/module/lpfc/version
0:12.4.243.20
```

```
# rpm -qa | grep nvmefc
nvmefc-connect-12.6.61.0-1.noarch
```

5. Verify that lpfc_enable_fc4_type is set to 3.

```
# cat /sys/module/lpfc/parameters/lpfc_enable_fc4_type
3
```

6. Verify that the initiator ports are up and running.

```
# cat /sys/class/fc_host/host*/port_name
0x10000090fae0ec61
0x10000090fae0ec62
```

```
# cat /sys/class/fc_host/host*/port_state
Online
Online
```

7. Verify that the NVMe/FC initiator ports are enabled, running and able to see the target LIFs.

```
# cat /sys/class/scsi_host/host*/nvme_info
NVME Initiator Enabled
XRI Dist lpfc0 Total 6144 NVME 2947 SCSI 2977 ELS 250
NVME LPORT lpfc0 WWPN x10000090fae0ec61 WWNN x20000090fae0ec61 DID x012000 ONLINE
NVME RPORT WWPN x202d00a098c80f09 WWNN x202c00a098c80f09 DID x010201 TARGET DISCSRVC
ONLINE
NVME RPORT WWPN x203100a098c80f09 WWNN x202c00a098c80f09 DID x010601 TARGET DISCSRVC
ONLINE
NVME Statistics
...
```

Validating NVMe/FC

1. Verify the following NVMe/FC settings.

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

```
# cat /sys/class/nvme-subsystem/nvme-subsys*/model
NetApp ONTAP Controller
NetApp ONTAP Controller
```

```
# cat /sys/class/nvme-subsystem/nvme-subsys*/iopolicy
round-robin
round-robin
```

2. Verify that the namespaces are created.

```
# nvme list
Node SN Model Namespace Usage Format FW Rev
---------------- -------------------- ----------------------
/dev/nvme0n1 80BADBKnB/JvAAAAAAAC NetApp ONTAP Controller 1 53.69 GB / 53.69 GB 4 KiB
+ 0 B FFFFFFFF
```

3. Verify the status of the ANA paths.

```
# nvme list-subsys/dev/nvme0n1
Nvme-subsysf0  NQN=nqn.1992-
08.com.netapp:sn.341541339b9511e8a9b500a098c80f09:subsystem.rhel_141_nvme_ss_10_0
\
+- nvme0 fc traddr=nn-0x202c00a098c80f09:pn-0x202d00a098c80f09 host_traddr=nn-
0x20000090fae0ec61:pn-0x10000090fae0ec61 live optimized
+- nvme1 fc traddr=nn-0x207300a098dfdd91:pn-0x207600a098dfdd91 host_traddr=nn-
0x200000109b1c1204:pn-0x100000109b1c1204 live inaccessible
+- nvme2 fc traddr=nn-0x207300a098dfdd91:pn-0x207500a098dfdd91 host_traddr=nn-
0x200000109b1c1205:pn-0x100000109b1c1205 live optimized
+- nvme3 fc traddr=nn-0x207300a098dfdd91:pn-0x207700a098dfdd91 host traddr=nn-
0x200000109b1c1205:pn-0x100000109b1c1205 live inaccessible
```

4. Verify the NetApp plug-in for ONTAP devices.

```
# nvme netapp ontapdevices -o column
Device   Vserver  Namespace Path             NSID   UUID   Size
-------  -------- -------------------------  ------ ----- -----
/dev/nvme0n1   vs_nvme_10       /vol/rhel_141_vol_10_0/rhel_141_ns_10_0    1
55baf453-f629-4a18-9364-b6aee3f50dad   53.69GB

# nvme netapp ontapdevices -o json
{
   "ONTAPdevices" : [
   {
        Device" : "/dev/nvme0n1",
        "Vserver" : "vs_nvme_10",
        "Namespace_Path" : "/vol/rhel_141_vol_10_0/rhel_141_ns_10_0",
         "NSID" : 1,
         "UUID" : "55baf453-f629-4a18-9364-b6aee3f50dad",
         "Size" : "53.69GB",
         "LBA_Data_Size" : 4096,
         "Namespace_Size" : 13107200
    }
]
```

Enabling 1MB I/O Size for Broadcom NVMe/FC

The lpfc_sg_seg_cnt parameter must be set to 256 in order for the host to issue 1MB size I/O.

1. Set the `lpfc_sg_seg_cnt` parameter to 256.

```
# cat /etc/modprobe.d/lpfc.conf
options lpfc lpfc_sg_seg_cnt=256
```

2. Run a `dracut -f` command, and reboot the host.
3. Verify that `lpfc_sg_seg_cnt` is 256.

```
# cat /sys/module/lpfc/parameters/lpfc_sg_seg_cnt
256
```

LPFC Verbose Logging

1. You can set the lpfc_log_verbose driver setting to any of the following values to log NVMe/FC events.

```
#define LOG_NVME 0x00100000 /* NVME general events. */
#define LOG_NVME_DISC 0x00200000 /* NVME Discovery/Connect events. */
#define LOG_NVME_ABTS 0x00400000 /* NVME ABTS events. */
#define LOG_NVME_IOERR 0x00800000 /* NVME IO Error events. */
```

2. After setting any of these values, run `dracut-f` and reboot host.
3. After rebooting, verify the settings.

```
# cat /etc/modprobe.d/lpfc.conf
lpfc_enable_fc4_type=3 lpfc_log_verbose=0xf00083

# cat /sys/module/lpfc/parameters/lpfc_log_verbose
15728771
```

SUSE

NVMe/FC Host Configuration for SUSE Linux Enterprise Server 15 SP1 with ONTAP

Supportability

NVMe/FC is supported on ONTAP 9.6 or later for the following versions of SLES:

- SLES15 SP1

  SLES15 SP1 host can run both NVMe/FC, & FCP (FC-SCSI) traffic through the same fibre channel initiator adapter ports. See the Hardware Universe for a list of supported FC adapters and controllers.

  For the most current list of supported configurations & versions, see the NetApp Interoperability Matrix.

Known limitations

None. Native NVMe/FC auto-connect scripts are included in the nvme-cli package. You can use the native inbox lpfc driver on SLES15 SP1.

Enabling NVMe/FC on SLES15 SP1

1. Upgrade to SLES15 SP1 MU kernel-default-4.12.14-197.40.1. See the NetApp Interoperability Matrix for the most current list of supported versions.

   ```
   # uname -r
   4.12.14-197.40-default
   ```

2. Upgrade to nvme-cli-1.8.1-6.9.1 MU package.

   This nvme-cli package contains the native NVMe/FC auto-connect scripts, so you do not need to install the external NVMe/FC auto-connect scripts provided by Broadcom on the SLES15 SP1 host. This package also includes the ONTAP udev rule which enables round-robin load balancing for NVMe multipath, and the NetApp plug-in for ONTAP devices.

   ```
   # rpm -qa | grep nvme-cli
   nvme-cli-1.8.1-6.9.1.x86_64
   ```

3. On the SLES15 SP1 host, check the host NQN string at `/etc/nvme/hostnqn` and verify that it matches the host NQN string for the corresponding subsystem on the ONTAP array.

   ```
   # cat /etc/nvme/hostnqn
   nqn.2014-08.org.nvmexpress:uuid:75953f3b-77fe-4e03-bf3c-09d5a156fbcd
   ```

```
*> vserver nvme subsystem host show -vserver vs_nvme_10
Vserver Subsystem Host NQN
------- --------- ------------------------------------ -----------
sles_117_nvme_ss_10_0
nqn.2014-08.org.nvmexpress:uuid:75953f3b-77fe-4e03-bf3c-09d5a156fbcd
```

4. Reboot the host.

Configuring the Broadcom FC Adapter for NVMe/FC

1. Verify that you are using the supported adapter. For the most current list of supported adapters see the NetApp Interoperability Matrix.

```
# cat /sys/class/scsi_host/host*/modelname
LPe32002-M2
LPe32002-M2
```

```
# cat /sys/class/scsi_host/host*/modeldesc
Emulex LightPulse LPe32002-M2 2-Port 32Gb Fibre Channel Adapter
Emulex LightPulse LPe32002-M2 2-Port 32Gb Fibre Channel Adapter
```

2. Verify that you are using the recommended Broadcom lpfc firmware and native inbox driver versions.

```
# cat /sys/class/scsi_host/host*/fwrev
12.4.243.17, sil-4.2.c
12.4.243.17, sil-4.2.c
```

```
# cat /sys/module/lpfc/version
0:12.6.0.0
```

3. Verify that lpfc_enable_fc4_type is set to 3.

```
# cat /sys/module/lpfc/parameters/lpfc_enable_fc4_type
3
```

4. Verify that the initiator ports are up and running.

```
# cat /sys/class/fc_host/host*/port_name
0x10000090fae0ec61
0x10000090fae0ec62
```

```
# cat /sys/class/fc_host/host*/port_state
Online
Online
```

5. Verify that the NVMe/FC initiator ports are enabled, running and able to see the target LIFs.

```
# cat /sys/class/scsi_host/host*/nvme_info
NVME Initiator Enabled
XRI Dist lpfc0 Total 6144 NVME 2947 SCSI 2977 ELS 250
NVME LPORT lpfc0 WWPN x10000090fae0ec61 WWNN x20000090fae0ec61 DID x012000 ONLINE
NVME RPORT WWPN x202d00a098c80f09 WWNN x202c00a098c80f09 DID x010201 TARGET DISCSRVC
ONLINE
NVME RPORT WWPN x203100a098c80f09 WWNN x202c00a098c80f09 DID x010601 TARGET DISCSRVC
ONLINE
NVME Statistics
...
```

Validating NVMe/FC

1. Verify the following NVMe/FC settings.

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

```
# cat /sys/class/nvme-subsystem/nvme-subsys*/model
NetApp ONTAP Controller
NetApp ONTAP Controller
```

```
# cat /sys/class/nvme-subsystem/nvme-subsys*/iopolicy
round-robin
round-robin
```

2. Verify that the namespaces are created.

```
# nvme list
Node SN Model Namespace Usage Format FW Rev
---------------- -------------------- ----------------------
/dev/nvme0n1 80BADBKnB/JvAAAAAAAC NetApp ONTAP Controller 1 53.69 GB / 53.69 GB 4 KiB
+ 0 B FFFFFFFF
```

3. Verify the status of the ANA paths.

```
# nvme list-subsys/dev/nvme0n1
Nvme-subsysf0  NQN=nqn.1992-
08.com.netapp:sn.341541339b9511e8a9b500a098c80f09:subsystem.sles_117_nvme_ss_10_0
\
+- nvme0 fc traddr=nn-0x202c00a098c80f09:pn-0x202d00a098c80f09 host_traddr=nn-
0x20000090fae0ec61:pn-0x10000090fae0ec61 live optimized
+- nvme1 fc traddr=nn-0x207300a098dfdd91:pn-0x207600a098dfdd91 host_traddr=nn-
0x200000109b1c1204:pn-0x100000109b1c1204 live inaccessible
+- nvme2 fc traddr=nn-0x207300a098dfdd91:pn-0x207500a098dfdd91 host_traddr=nn-
0x200000109b1c1205:pn-0x100000109b1c1205 live optimized
+- nvme3 fc traddr=nn-0x207300a098dfdd91:pn-0x207700a098dfdd91 host traddr=nn-
0x200000109b1c1205:pn-0x100000109b1c1205 live inaccessible
```

4. Verify the NetApp plug-in for ONTAP devices.

```
# nvme netapp ontapdevices -o column
Device   Vserver  Namespace Path             NSID   UUID   Size
-------  -------- -------------------------  ------ ----- -----
/dev/nvme0n1   vs_nvme_10       /vol/sles_117_vol_10_0/sles_117_ns_10_0    1
55baf453-f629-4a18-9364-b6aee3f50dad   53.69GB

# nvme netapp ontapdevices -o json
{
   "ONTAPdevices" : [
   {
        Device" : "/dev/nvme0n1",
        "Vserver" : "vs_nvme_10",
        "Namespace_Path" : "/vol/sles_117_vol_10_0/sles_117_ns_10_0",
         "NSID" : 1,
         "UUID" : "55baf453-f629-4a18-9364-b6aee3f50dad",
         "Size" : "53.69GB",
         "LBA_Data_Size" : 4096,
         "Namespace_Size" : 13107200
    }
]
```

Enabling 1MB I/O Size for Broadcom NVMe/FC

The lpfc_sg_seg_cnt parameter must be set to 256 in order for the host to issue 1MB size I/O.

1. Set the `lpfc_sg_seg_cnt` parameter to 256.

```
# cat /etc/modprobe.d/lpfc.conf
options lpfc lpfc_sg_seg_cnt=256
```

2. Run a `dracut -f` command, and reboot the host.
3. Verify that `lpfc_sg_seg_cnt` is 256.

```
# cat /sys/module/lpfc/parameters/lpfc_sg_seg_cnt
256
```

LPFC Verbose Logging

1. You can set the lpfc_log_verbose driver setting to any of the following values to log NVMe/FC events.

```
#define LOG_NVME 0x00100000 /* NVME general events. */
#define LOG_NVME_DISC 0x00200000 /* NVME Discovery/Connect events. */
#define LOG_NVME_ABTS 0x00400000 /* NVME ABTS events. */
#define LOG_NVME_IOERR 0x00800000 /* NVME IO Error events. */
```

2. After setting any of these values, run `dracut-f` and reboot host.
3. After rebooting, verify the settings.

```
# cat /etc/modprobe.d/lpfc.conf
lpfc_enable_fc4_type=3 lpfc_log_verbose=0xf00083

# cat /sys/module/lpfc/parameters/lpfc_log_verbose
15728771
```

Oracle Linux

NVMe/FC Host Configuration for Oracle Linux 7.7 with ONTAP

Supportability

NVMe/FC is supported on ONTAP 9.6 or later for the following versions of Oracle Linux

- OL 7.7

  OL 7.7 host can run both NVMe & SCSI traffic through the same fibre channel initiator adapter ports. See the Hardware Universe for a list of supported FC adapters and controllers.

  For the most current list of supported configurations see the NetApp Interoperability Matrix.

Known limitations

- Native NVMe/FC auto-connect scripts are not available in the nvme-cli package.
  You can use the HBA vendor provided external auto-connect scripts.
- By default, round-robin load balancing is not enabled.
  You must write a udev rule to enable this functionality. Steps are provided in the section on Enabling NVMe/FC on OL 7.7.

Enabling NVMe on OL 7.7

1. Ensure the default Oracle Linux 7.7 kernel is installed.
2. Reboot the host and verify that it boots into specified OL 7.7 kernel.

```
# uname -r
4.14.35-1902.9.2.el7uek
```

3. Upgrade to the nvme-cli-1.8.1-3.el7 package.

```
# rpm -qa|grep nvme-cli
nvme-cli-1.8.1-3.el7.x86_64
```

4. Add the string below as a separate udev rule at `/lib/udev/rules.d/71-nvme-iopolicy-netapp-ONTAP.rules`. This enables round-robin load balancing for NVMe multipath.

```
# Enable round-robin for NetApp ONTAP
ACTION==add, SUBSYSTEM==nvme-subsystem, ATTR{model}==NetApp ONTAP Controller,
ATTR{iopolicy}=round-robin
```

5. On the OL 7.7 host, check the host NQN string at `/etc/nvme/hostnqn` and verify that it matches the host NQN string for the corresponding subsystem on the ONTAP array.

```
# cat /etc/nvme/hostnqn
nqn.2014-08.org.nvmexpress:uuid:75953f3b-77fe-4e03-bf3c-09d5a156fbcd
```

```
*> vserver nvme subsystem host show -vserver vs_nvme_10
Vserver Subsystem Host NQN
------- --------- ------------------------------------ -----------
ol_157_nvme_ss_10_0
nqn.2014-08.org.nvmexpress:uuid:75953f3b-77fe-4e03-bf3c-09d5a156fbcd
```

Note:

If the host NQN strings do not match, you should use the vserver modify command to update the host NQN string on your corresponding ONTAP array subsystem to match to host NQN string from `/etc/nvme/hostnqn` on the host.

1. Reboot the host.

Configuring the Broadcom FC Adapter for NVMe/FC

1. Verify that you are using the supported adapter. For the most current list of supported adapters see the NetApp Interoperability Matrix.

```
# cat /sys/class/scsi_host/host*/modelname
LPe32002-M2
LPe32002-M2
```

```
# cat /sys/class/scsi_host/host*/modeldesc
Emulex LightPulse LPe32002-M2 2-Port 32Gb Fibre Channel Adapter
Emulex LightPulse LPe32002-M2 2-Port 32Gb Fibre Channel Adapter
```

2. Copy and install the Broadcom outbox auto-connect scripts package.

```
# rpm -ivh nvmefc-connect-12.4.65.0-1.noarch.rpm
```

3. Reboot the host.
4. Verify that you are using the recommended Broadcom lpfc firmware, native inbox driver & outbox auto-connect package versions. For a list of supported versions, see the NetApp Interoperability Matrix.

```
# cat /sys/class/scsi_host/host*/fwrev
12.4.243.17, sil-4.2.c
12.4.243.17, sil-4.2.c

# cat /sys/module/lpfc/version
0:12.0.0.10

# rpm -qa | grep nvmefc
nvmefc-connect-12.4.65.0-1.noarch
```

5. Verify that lpfc_enable_fc4_type is set to 3.

```
# cat /sys/module/lpfc/parameters/lpfc_enable_fc4_type
3
```

6. Verify that the initiator ports are up and running.

```
# cat /sys/class/fc_host/host*/port_name
0x10000090fae0ec61
0x10000090fae0ec62
```

```
# cat /sys/class/fc_host/host*/port_state
Online
Online
```

7. Verify that the NVMe/FC initiator ports are enabled, running and able to see the target LIFs.

```
# cat /sys/class/scsi_host/host*/nvme_info
NVME Initiator Enabled
XRI Dist lpfc0 Total 6144 NVME 2947 SCSI 2977 ELS 250
NVME LPORT lpfc0 WWPN x10000090fae0ec61 WWNN x20000090fae0ec61 DID x012000 ONLINE
NVME RPORT WWPN x202d00a098c80f09 WWNN x202c00a098c80f09 DID x010201 TARGET DISCSRVC
ONLINE
NVME RPORT WWPN x203100a098c80f09 WWNN x202c00a098c80f09 DID x010601 TARGET DISCSRVC
ONLINE
NVME Statistics
...
```

Validating NVMe/FC

1. Verify the following NVMe/FC settings.

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

# cat /sys/class/nvme-subsystem/nvme-subsys*/model
NetApp ONTAP Controller
NetApp ONTAP Controller

# cat /sys/class/nvme-subsystem/nvme-subsys*/iopolicy
round-robin
round-robin
```

2. Verify that the namespaces are created.

```
# nvme list
Node SN Model Namespace Usage Format FW Rev
---------------- -------------------- ----------------------
/dev/nvme0n1 80BADBKnB/JvAAAAAAAC NetApp ONTAP Controller 1 53.69 GB / 53.69 GB 4 KiB
+ 0 B FFFFFFFF
```

3. Verify the status of the ANA paths.

```
# nvme list-subsys/dev/nvme0n1
Nvme-subsysf0 □ NQN=nqn.1992-
08.com.netapp:sn.341541339b9511e8a9b500a098c80f09:subsystem.ol_157_nvme_ss_10_0
\
+- nvme0 fc traddr=nn-0x202c00a098c80f09:pn-0x202d00a098c80f09 host_traddr=nn-
0x20000090fae0ec61:pn-0x10000090fae0ec61 live optimized
+- nvme1 fc traddr=nn-0x207300a098dfdd91:pn-0x207600a098dfdd91 host_traddr=nn-
0x200000109b1c1204:pn-0x100000109b1c1204 live inaccessible
+- nvme2 fc traddr=nn-0x207300a098dfdd91:pn-0x207500a098dfdd91 host_traddr=nn-
0x200000109b1c1205:pn-0x100000109b1c1205 live optimized
+- nvme3 fc traddr=nn-0x207300a098dfdd91:pn-0x207700a098dfdd91 host traddr=nn-
0x200000109b1c1205:pn-0x100000109b1c1205 live inaccessible
```

4. Verify the NetApp plug-in for ONTAP devices.

```
# nvme netapp ontapdevices -o column
Device   Vserver  Namespace Path             NSID   UUID   Size
-------  -------- -------------------------  ------ ----- -----
/dev/nvme0n1   vs_nvme_10       /vol/rhel_141_vol_10_0/ol_157_ns_10_0    1
55baf453-f629-4a18-9364-b6aee3f50dad   53.69GB

# nvme netapp ontapdevices -o json
{
   "ONTAPdevices" : [
   {
        Device" : "/dev/nvme0n1",
        "Vserver" : "vs_nvme_10",
        "Namespace_Path" : "/vol/rhel_141_vol_10_0/ol_157_ns_10_0",
         "NSID" : 1,
         "UUID" : "55baf453-f629-4a18-9364-b6aee3f50dad",
         "Size" : "53.69GB",
         "LBA_Data_Size" : 4096,
         "Namespace_Size" : 13107200
    }
]
```

Enabling 1MB I/O Size for Broadcom NVMe/FC

The lpfc_sg_seg_cnt parameter must be set to 256 in order for the host to issue 1MB size I/O.

1. Set the `lpfc_sg_seg_cnt` parameter to 256.

```
# cat /etc/modprobe.d/lpfc.conf
options lpfc lpfc_sg_seg_cnt=256
```

2. Run a `dracut -f` command, and reboot the host.
3. Verify that `lpfc_sg_seg_cnt` is 256.

```
# cat /sys/module/lpfc/parameters/lpfc_sg_seg_cnt
256
```

LPFC Verbose Logging

1. You can set the lpfc_log_verbose driver setting to any of the following values to log NVMe/FC events.

```
#define LOG_NVME 0x00100000 /* NVME general events. */
#define LOG_NVME_DISC 0x00200000 /* NVME Discovery/Connect events. */
#define LOG_NVME_ABTS 0x00400000 /* NVME ABTS events. */
#define LOG_NVME_IOERR 0x00800000 /* NVME IO Error events. */
```

2. After setting any of these values, run `dracut-f` and reboot host.
3. After rebooting, verify the settings.

```
# cat /etc/modprobe.d/lpfc.conf
lpfc_enable_fc4_type=3 lpfc_log_verbose=0xf00083

# cat /sys/module/lpfc/parameters/lpfc_log_verbose
15728771
```

ESXi

NVMe/FC Host Configuration for ESXi 7.0 with ONTAP

Supportability

NVME/FC is supported on ONTAP 9.7 or later for ESXi 7.0.

ESXi initiator host can run both NVMe/FC & FCP traffic through the same adapter ports. See the Hardware Universe for a list of supported FC adapters and controllers. For the most current list of supported configurations & versions, see the NetApp Interoperability Matrix.

Known limitations

The following are not supported:

- RDM mapping
- VVols

Enabling NVMe/FC with ANA

1. Disable the HppManageDegradedPaths parameter for improved interoperability with ONTAP:

```
# esxcfg-advcfg -s 0 /Misc/HppManageDegradedPaths
```

2. Reboot the host.
3. After reboot, verify that the HppManageDegradedPaths parameter is now disabled:

```
# esxcfg-advcfg -g /Misc/HppManageDegradedPaths
Value of HppManageDegradedPaths is 0
```

4. Check the ESXi host NQN string and verify that it matches with the host NQN string for the corresponding subsystem on the ONTAP array.

   Listing 1. Example

```
# esxcli nvme info get
Host NQN: nqn.2014-08.com.vmware:nvme:chat-54-113

*> vserver nvme subsystem host show -vserver co_nv_fc_esx
Vserver Subsystem Host NQN
------- --------- ------------------------------------------------------------
co_nv_fc_esx
        subsys_chat_54_113_nvme
                  nqn.2014-08.com.vmware:nvme:chat-54-113
```

Configuring the Broadcom FC adapter for NVMe/FC

1. Install the recommended lpfc driver by copying it to a temporary folder and then executing the following command:

```
# esxcli software vib install -d /tmp/t/Emulex-FCoE-FC-lpfc-12.4.224.0-offline-bundle-
13621872.zip --no-sig-check
Installation Result
   Message: The update completed successfully, but the system needs to be rebooted for
the changes to be effective.
   Reboot Required: true
   VIBs Installed: EMU_bootbank_lpfc_12.4.224.0-1OEM.688.0.0.13621872
   VIBs Removed: EMU_bootbank_lpfc_12.4.211.6-1OEM.688.0.0.13621872
   VIBs Skipped:
```

2. If necessary, set the lpfc driver parameter `lpfc_enable_fc4_type=3` for enabling NVMe/FC support in the lpfc driver:

> This parameter is set by default for the LPe35000-series adapters. You must perform the following step to set it manually for LPe32000-series & LPe31000-series adapters.

```
# esxcli system module parameters set -m lpfc -p lpfc_enable_fc4_type=3
```

3. Use the elxmgmt utility to upgrade the Broadcom FC adapter firmware to the recommended version:

```
# esxcli software vib install -d /tmp/t/Emulex-elxmgmt-6.8.7-12.4.211.7.zip --no-sig
-check
Installation Result
   Message: The update completed successfully, but the system needs to be rebooted for
the changes to be effective.
   Reboot Required: true
   VIBs Installed: EMU_bootbank_emu-esx-elxmgmt_12.4.211.7-01
   VIBs Removed:
   VIBs Skipped:
...
```

4. Reboot the host.
5. After reboot, verify that the recommended lpfc driver and adapter firmware versions have applied and the initiator ports are online:

```
# esxcli storage san fc list
 Adapter: vmhba3
   Port ID: 010600
   Node Name: 20:00:00:90:fa:e0:ec:8e
   Port Name: 10:00:00:90:fa:e0:ec:8e
   Speed: 32 Gbps
   Port Type: NPort
   Port State: ONLINE
   Model Description: Emulex LightPulse LPe32002-M2 2-Port 32Gb Fibre Channel Adapter
   Hardware Version: 0000000c
   OptionROM Version: 12.4.217.2
   Firmware Version: 12.4.217.2
   Driver Name: lpfc
   DriverVersion: 12.4.224.0

   Adapter: vmhba4
   Port ID: 010F00
   Node Name: 20:00:00:90:fa:e0:ec:8f
   Port Name: 10:00:00:90:fa:e0:ec:8f
   Speed: 32 Gbps
   Port Type: NPort
   Port State: ONLINE
   Model Description: Emulex LightPulse LPe32002-M2 2-Port 32Gb Fibre Channel Adapter
   Hardware Version: 0000000c
   OptionROM Version: 12.4.217.2
   Firmware Version: 12.4.217.2
   Driver Name: lpfc
   DriverVersion: 12.4.224.0
```

Validating NVMe/FC

1. Verify that the ONTAP target NVMe/FC controllers are properly discovered on the ESXi host:

```
# esxcli nvme controller list

Name
Controller Number  Adapter  Transport Type  Is Online
------------------------------------------------------------------------------------
----------------------------------------  -----------------  -------  --------------
---------
nqn.1992-
08.com.netapp:sn.e7f89c2c245d11e9975300a098dfce55:subsystem.interop_57_vm_01#vmhba32#2
04900a098dfe3d1:204a00a098dfe3d1                259  vmhba32  FC
false
nqn.1992-
08.com.netapp:sn.e7f89c2c245d11e9975300a098dfce55:subsystem.interop_57_vm_09#vmhba32#2
04900a098dfe3d1:204a00a098dfe3d1                263  vmhba32  FC
false
nqn.1992-
08.com.netapp:sn.e7f89c2c245d11e9975300a098dfce55:subsystem.interop_57_vm_11#vmhba32#2
04900a098dfe3d1:204a00a098dfe3d1                267  vmhba32  FC
false
nqn.1992-
08.com.netapp:sn.e7f89c2c245d11e9975300a098dfce55:subsystem.interop_57_vm_10#vmhba32#2
04900a098dfe3d1:204a00a098dfe3d1                265  vmhba32  FC
false
nqn.1992-
08.com.netapp:sn.e7f89c2c245d11e9975300a098dfce55:subsystem.interop_57_vm_02#vmhba32#2
04900a098dfe3d1:204a00a098dfe3d1                261  vmhba32  FC
false
```

2. Verify that the NVMe/FC namespaces are properly created:

   The UUIDs in the following example represent the NVMe/FC namespace devices.

```
#esxcfg-mpath -b
uuid.0d12b7cd97344be8a53b7913f8f72f04 : NVMe Fibre Channel Disk
(uuid.0d12b7cd97344be8a53b7913f8f72f04)
   vmhba65:C0:T9:L30 LUN:30 state:active fc Adapter: WWNN: 20:00:00:90:fa:e0:ec:8f
WWPN: 10:00:00:90:fa:e0:ec:8f  Target: WWNN: 20:49:00:a0:98:df:e3:d1 WWPN:
20:4d:00:a0:98:df:e3:d1
   vmhba64:C0:T9:L30 LUN:30 state:active fc Adapter: WWNN: 20:00:00:90:fa:e0:ec:8e
WWPN: 10:00:00:90:fa:e0:ec:8e  Target: WWNN: 20:49:00:a0:98:df:e3:d1 WWPN:
20:4c:00:a0:98:df:e3:d1
   vmhba64:C0:T5:L30 LUN:30 state:standby fc Adapter: WWNN: 20:00:00:90:fa:e0:ec:8e
WWPN: 10:00:00:90:fa:e0:ec:8e  Target: WWNN: 20:49:00:a0:98:df:e3:d1 WWPN:
20:4a:00:a0:98:df:e3:d1
   vmhba65:C0:T0:L30 LUN:30 state:standby fc Adapter: WWNN: 20:00:00:90:fa:e0:ec:8f
WWPN: 10:00:00:90:fa:e0:ec:8f  Target: WWNN: 20:49:00:a0:98:df:e3:d1 WWPN:
20:4b:00:a0:98:df:e3:d1

uuid.49de7683950d47c9898f51443d893910 : NVMe Fibre Channel Disk
(uuid.49de7683950d47c9898f51443d893910)
   vmhba65:C0:T12:L39 LUN:39 state:active fc Adapter: WWNN: 20:00:00:90:fa:e0:ec:8f
WWPN: 10:00:00:90:fa:e0:ec:8f  Target: WWNN: 20:3a:00:a0:98:df:e3:d1 WWPN:
20:27:00:a0:98:df:e3:d1
   vmhba65:C0:T13:L39 LUN:39 state:standby fc Adapter: WWNN: 20:00:00:90:fa:e0:ec:8f
WWPN: 10:00:00:90:fa:e0:ec:8f  Target: WWNN: 20:3a:00:a0:98:df:e3:d1 WWPN:
20:29:00:a0:98:df:e3:d1
   vmhba64:C0:T12:L39 LUN:39 state:active fc Adapter: WWNN: 20:00:00:90:fa:e0:ec:8e
WWPN: 10:00:00:90:fa:e0:ec:8e  Target: WWNN: 20:3a:00:a0:98:df:e3:d1 WWPN:
20:3b:00:a0:98:df:e3:d1
   vmhba64:C0:T13:L39 LUN:39 state:standby fc Adapter: WWNN: 20:00:00:90:fa:e0:ec:8e
WWPN: 10:00:00:90:fa:e0:ec:8e  Target: WWNN: 20:3a:00:a0:98:df:e3:d1 WWPN:
20:28:00:a0:98:df:e3:d1
```

> In ONTAP 9.7, the default block size for a NVMe/FC namespace is 4K. This default size is not compatible with ESXi. Therefore, when creating namespaces for ESXi, you must set the namespace block size 512b. You can do this using the `vserver nvme namespace create` command.

Example

`vserver nvme namespace create -vserver vs_1 -path /vol/nsvol/namespace1 -size 100g -ostype vmware -block-size 512B`

Refer to the ONTAP 9 Command man pages for additional details.

3. Verify the status of the individual ANA paths of the respective NVMe/FC namespace devices:

```
# esxcli storage hpp path list
```

```
fc.20000090fae0ec8f:10000090fae0ec8f-fc.204900a098dfe3d1:204d00a098dfe3d1-
uuid.1aa669c5376240a28ae47d8d549586ea
   Runtime Name: vmhba65:C0:T9:L33
   Device: uuid.1aa669c5376240a28ae47d8d549586ea
   Device Display Name: NVMe Fibre Channel Disk
(uuid.1aa669c5376240a28ae47d8d549586ea)
   Path State: active

fc.20000090fae0ec8e:10000090fae0ec8e-fc.204900a098dfe3d1:204a00a098dfe3d1-
uuid.1aa669c5376240a28ae47d8d549586ea
   Runtime Name: vmhba64:C0:T5:L33
   Device: uuid.1aa669c5376240a28ae47d8d549586ea
   Device Display Name: NVMe Fibre Channel Disk
(uuid.1aa669c5376240a28ae47d8d549586ea)
   Path State: standby


:leveloffset: -1


= Windows

:leveloffset: +1

[[IDe33bc71c427003a80b912e5b177d6b73]]
= NVMe/FC Host Configuration for Windows Server 2019 with ONTAP
:toc: macro
:hardbreaks:
:toclevels: 1
:nofooter:
:icons: font
:linkattrs:
:imagesdir: ./media/

== Supportability

NVMe/FC is supported on ONTAP 9.7 or later for Windows Server 2019.

Note that the Broadcom initiator can serve both NVMe/FC and FCP traffic through the
same 32G FC adapter ports. For FCP and FC/NVMe, use MSDSM as the Microsoft Multipath
I/O (MPIO) option.

See the link:https://hwu.netapp.com/Home/Index[Hardware Universe] for a list of
supported FC adapters and controllers. For the most current list of supported
configurations & versions, see the link:https://mysupport.netapp.com/matrix/[NetApp
Interoperability Matrix].

== Known limitations
```

```
Windows Failover Cluster (WFC) is not supported with ONTAP NVMe/FC because ONTAP does
not currently support persistent reservations with NVMe/FC.

Note that the external driver shipped by Broadcom for Windows NVMe/FC is not a true
NVMe/FC driver but a translational SCSI  NVMe driver. This translational overhead
does not necessarily impact performance, but it does negate the performance benefits
of NVMe/FC. Thus, on Windows servers, NVMe/FC and FCP performance is the same, unlike
on other operating systems such as Linux, where NVMe/FC performance is significantly
better than that of FCP.

== Enabling NVMe/FC on a Windows initiator host

Follow these steps to enable FC/NVMe on the Windows initiator host:

. Install OneCommand Manager utility on the Windows host.

. On each of the HBA initiator ports, set the following HBA driver parameters:
+
* EnableNVMe = 1
* NVMEMode = 0
* LimTransferSize=1
+
. Reboot the host.

== Configuring the Broadcom FC adapter in Windows for NVMe/FC

With the Broadcom adapter for FC/NVMe in a Windows environment, a `+hostnqn+` is
associated with each host bus adapter (HBA) port. The `+hostnqn+` is formatted as
follows.

.Example
 nqn.2017-01.com.broadcom:ecd:nvmf:fc:100000109b1b9765
 nqn.2017-01.com.broadcom:ecd:nvmf:fc:100000109b1b9766

=== Enabling MPIO for NVMe devices on the Windows host


. Install Windows Host Utility Kit 7.1 to set the driver parameters that are common to
both FC and NVMe.
. Open the MPIO properties.
. From the *Discover Multi-Paths* tab, add the device ID listed for NVMe.
+
MPIO becomes aware of the NVMe devices, which are visible under disk management.
+
. Open  *Disk Management* and go to *Disk Properties*.
. From the *MPIO* tab, click *Details*.
. Set the following MSDSM settings:
```

```
+
* PathVerifiedPeriod: *10*
* PathVerifyEnabled: *Enable*
* RetryCount: *6*
* RetryInterval: *1*
* PDORemovedPeriod: *130*
+
. Select the MPIO Policy *Round Robin with Subset*.
. Change the registry values:
+
```

HKLM\SYSTEM\CurrentControlSet\Services\mpio\Parameters\PathRecoveryInterval DWORD → 30

HKLM\SYSTEM\CurrentControlSet\Services\mpio \Parameters\ UseCustomPathRecoveryInterval DWORD→ 1

```
+
. Reboot the host.
+
The NVMe configuration is now complete on the Windows host.

== Validating NVMe/FC


. Validate that the Port Type is FC+NVMe.
+
Now that NVMe is enabled, you should see the `+Port Type+` listed as `+FC+NVMe+`, as
follows.
+
```

PS C:\Program Files\Emulex\Util\OCManager> .\hbacmd listhba

Manageable HBA List

Port WWN : 10:00:00:10:9b:1b:97:65
Node WWN : 20:00:00:10:9b:1b:97:65
Fabric Name : 10:00:c4:f5:7c:a5:32:e0
Flags : 8000e300
Host Name : INTEROP-57-159
Mfg : Emulex Corporation
Serial No. : FC71367217
Port Number : 0
Mode : Initiator
PCI Bus Number : 94
PCI Function : 0

Port Type : FC+NVMe
Model : LPe32002-M2

Port WWN : 10:00:00:10:9b:1b:97:66
Node WWN : 20:00:00:10:9b:1b:97:66
Fabric Name : 10:00:c4:f5:7c:a5:32:e0
Flags : 8000e300
Host Name : INTEROP-57-159
Mfg : Emulex Corporation
Serial No. : FC71367217
Port Number : 1
Mode : Initiator
PCI Bus Number : 94
PCI Function : 1
Port Type : FC+NVMe
Model : LPe32002-M2

```
. Validate that NVMe/FC subsystems have been discovered.
+
The `+nvme-list+` command lists the NVMe/FC discovered subsystems.
+
```

PS C:\Program Files\Emulex\Util\OCManager> .\hbacmd nvme-list 10:00:00:10:9b:1b:97:65

Discovered NVMe Subsystems for 10:00:00:10:9b:1b:97:65

NVMe Qualified Name : nqn.1992-08.com.netapp:sn.a3b74c32db2911eab229d039ea141105:subsystem.win_nvme_interop-57-159
Port WWN : 20:09:d0:39:ea:14:11:04
Node WWN : 20:05:d0:39:ea:14:11:04
Controller ID : 0x0180
Model Number : NetApp ONTAP Controller
Serial Number : 81CGZBPU5T/uAAAAAAAB
Firmware Version : FFFFFFFF
Total Capacity : Not Available
Unallocated Capacity : Not Available

NVMe Qualified Name : nqn.1992-08.com.netapp:sn.a3b74c32db2911eab229d039ea141105:subsystem.win_nvme_interop-57-159
Port WWN : 20:06:d0:39:ea:14:11:04
Node WWN : 20:05:d0:39:ea:14:11:04
Controller ID : 0x0181
Model Number : NetApp ONTAP Controller
Serial Number : 81CGZBPU5T/uAAAAAAAB
Firmware Version : FFFFFFFF

Total Capacity : Not Available
Unallocated Capacity : Not Available
Note: At present Namespace Management is not supported by NetApp Arrays.

```
+
```

PS C:\Program Files\Emulex\Util\OCManager> .\hbacmd nvme-list 10:00:00:10:9b:1b:97:66

Discovered NVMe Subsystems for 10:00:00:10:9b:1b:97:66

NVMe Qualified Name : nqn.1992-08.com.netapp:sn.a3b74c32db2911eab229d039ea141105:subsystem.win_nvme_interop-57-159
Port WWN : 20:07:d0:39:ea:14:11:04
Node WWN : 20:05:d0:39:ea:14:11:04
Controller ID : 0x0140
Model Number : NetApp ONTAP Controller
Serial Number : 81CGZBPU5T/uAAAAAAAB
Firmware Version : FFFFFFFF
Total Capacity : Not Available
Unallocated Capacity : Not Available

NVMe Qualified Name : nqn.1992-08.com.netapp:sn.a3b74c32db2911eab229d039ea141105:subsystem.win_nvme_interop-57-159
Port WWN : 20:08:d0:39:ea:14:11:04
Node WWN : 20:05:d0:39:ea:14:11:04
Controller ID : 0x0141
Model Number : NetApp ONTAP Controller
Serial Number : 81CGZBPU5T/uAAAAAAAB
Firmware Version : FFFFFFFF
Total Capacity : Not Available
Unallocated Capacity : Not Available

Note: At present Namespace Management is not supported by NetApp Arrays.

```
. Validate that namespaces have been created.
+
The `+nvme-list-ns+` command lists the namespaces for a specified NVMe target that lists
the namespaces connected to the host.
+
```

PS C:\Program Files\Emulex\Util\OCManager> .\HbaCmd.exe nvme-list-ns 10:00:00:10:9b:1b:97:66 20:08:d0:39:ea:14:11:04 nq .1992-08.com.netapp:sn.a3b74c32db2911eab229d039ea141105:subsystem.win_nvme_interop-57-159 0

Active Namespaces (attached to controller 0x0141):

```
                                      SCSI          SCSI          SCSI
   NSID          DeviceName        Bus Number    Target Number     OS LUN
-----------  --------------------  ------------  ---------------   ---------
0x00000001   \\.\PHYSICALDRIVE9         0              1              0
0x00000002   \\.\PHYSICALDRIVE10        0              1              1
0x00000003   \\.\PHYSICALDRIVE11        0              1              2
0x00000004   \\.\PHYSICALDRIVE12        0              1              3
0x00000005   \\.\PHYSICALDRIVE13        0              1              4
0x00000006   \\.\PHYSICALDRIVE14        0              1              5
0x00000007   \\.\PHYSICALDRIVE15        0              1              6
0x00000008   \\.\PHYSICALDRIVE16        0              1              7
```

```
[[IDfc64a5a7647082a204b1ac0ea28c07c1]]
= NVMe/FC Host Configuration for Windows Server 2016 with ONTAP
:toc: macro
:hardbreaks:
:toclevels: 1
:nofooter:
:icons: font
:linkattrs:
:imagesdir: ./media/

== Supportability

NVMe/FC is supported on ONTAP 9.7 or later for Windows Server 2016.

Note that the Broadcom initiator can serve both NVMe/FC and FCP traffic through the same
32G FC adapter ports. For FCP and FC/NVMe, use MSDSM as the Microsoft Multipath I/O
(MPIO) option.

See the link:https://hwu.netapp.com/Home/Index[Hardware Universe] for a list of supported
FC adapters and controllers. For the most current list of supported configurations &
versions, see the link:https://mysupport.netapp.com/matrix/[NetApp Interoperability
Matrix].

== Known limitations

Windows Failover Cluster (WFC) is not supported with ONTAP NVMe/FC because ONTAP does not
currently support persistent reservations with NVMe/FC.

Note that the external driver shipped by Broadcom for Windows NVMe/FC is not a true
NVMe/FC driver but a translational SCSI  NVMe driver. This translational overhead does
not necessarily impact performance, but it does negate the performance benefits of
NVMe/FC. Thus, on Windows servers, NVMe/FC and FCP performance is the same, unlike on
```

```
other operating systems such as Linux, where NVMe/FC performance is significantly better
than that of FCP.

== Enabling NVMe/FC on a Windows initiator host

Follow these steps to enable FC/NVMe on the Windows initiator host:

. Install OneCommand Manager utility on the Windows host.

. On each of the HBA initiator ports, set the following HBA driver parameters:
+
* EnableNVMe = 1
* NVMEMode = 0
* LimTransferSize=1
+
. Reboot the host.

== Configuring the Broadcom FC adapter in Windows for NVMe/FC

With the Broadcom adapter for FC/NVMe in a Windows environment, a `+hostnqn+` is
associated with each host bus adapter (HBA) port. The `+hostnqn+` is formatted as
follows.

.Example
 nqn.2017-01.com.broadcom:ecd:nvmf:fc:100000109b1b9765
 nqn.2017-01.com.broadcom:ecd:nvmf:fc:100000109b1b9766

=== Enabling MPIO for NVMe devices on the Windows host


. Install Windows Host Utility Kit 7.1 to set the driver parameters that are common to
both FC and NVMe.
. Open the MPIO properties.
. From the *Discover Multi-Paths* tab, add the device ID listed for NVMe.
+
MPIO becomes aware of the NVMe devices, which are visible under disk management.
+
. Open  *Disk Management* and go to *Disk Properties*.
. From the *MPIO* tab, click *Details*.
. Set the following MSDSM settings:
+
* PathVerifiedPeriod: *10*
* PathVerifyEnabled: *Enable*
* RetryCount: *6*
* RetryInterval: *1*
* PDORemovedPeriod: *130*
+
. Select the MPIO Policy *Round Robin with Subset*.
```

```
. Change the registry values:
+
```

HKLM\SYSTEM\CurrentControlSet\Services\mpio\Parameters\PathRecoveryInterval DWORD → 30

HKLM\SYSTEM\CurrentControlSet\Services\mpio \Parameters\ UseCustomPathRecoveryInterval DWORD→ 1

```
+
. Reboot the host.
+
The NVMe configuration is now complete on the Windows host.

== Validating NVMe/FC


. Validate that the Port Type is FC+NVMe.
+
Now that NVMe is enabled, you should see the `+Port Type+` listed as `+FC+NVMe+`, as
follows.
+
```

PS C:\Program Files\Emulex\Util\OCManager> .\hbacmd listhba

Manageable HBA List

Port WWN : 10:00:00:10:9b:1b:97:65
Node WWN : 20:00:00:10:9b:1b:97:65
Fabric Name : 10:00:c4:f5:7c:a5:32:e0
Flags : 8000e300
Host Name : INTEROP-57-159
Mfg : Emulex Corporation
Serial No. : FC71367217
Port Number : 0
Mode : Initiator
PCI Bus Number : 94
PCI Function : 0
Port Type : FC+NVMe
Model : LPe32002-M2

Port WWN : 10:00:00:10:9b:1b:97:66
Node WWN : 20:00:00:10:9b:1b:97:66
Fabric Name : 10:00:c4:f5:7c:a5:32:e0
Flags : 8000e300
Host Name : INTEROP-57-159

Mfg : Emulex Corporation
Serial No. : FC71367217
Port Number : 1
Mode : Initiator
PCI Bus Number : 94
PCI Function : 1
Port Type : FC+NVMe
Model : LPe32002-M2

```
. Validate that NVMe/FC subsystems have been discovered.
+
The `+nvme-list+` command lists the NVMe/FC discovered subsystems.
+
```

PS C:\Program Files\Emulex\Util\OCManager> .\hbacmd nvme-list 10:00:00:10:9b:1b:97:65

Discovered NVMe Subsystems for 10:00:00:10:9b:1b:97:65

NVMe Qualified Name : nqn.1992-08.com.netapp:sn.a3b74c32db2911eab229d039ea141105:subsystem.win_nvme_interop-57-159
Port WWN : 20:09:d0:39:ea:14:11:04
Node WWN : 20:05:d0:39:ea:14:11:04
Controller ID : 0x0180
Model Number : NetApp ONTAP Controller
Serial Number : 81CGZBPU5T/uAAAAAAAB
Firmware Version : FFFFFFFF
Total Capacity : Not Available
Unallocated Capacity : Not Available

NVMe Qualified Name : nqn.1992-08.com.netapp:sn.a3b74c32db2911eab229d039ea141105:subsystem.win_nvme_interop-57-159
Port WWN : 20:06:d0:39:ea:14:11:04
Node WWN : 20:05:d0:39:ea:14:11:04
Controller ID : 0x0181
Model Number : NetApp ONTAP Controller
Serial Number : 81CGZBPU5T/uAAAAAAAB
Firmware Version : FFFFFFFF
Total Capacity : Not Available
Unallocated Capacity : Not Available
Note: At present Namespace Management is not supported by NetApp Arrays.

```
+
```

PS C:\Program Files\Emulex\Util\OCManager> .\hbacmd nvme-list 10:00:00:10:9b:1b:97:66

Discovered NVMe Subsystems for 10:00:00:10:9b:1b:97:66

NVMe Qualified Name : nqn.1992-08.com.netapp:sn.a3b74c32db2911eab229d039ea141105:subsystem.win_nvme_interop-57-159
Port WWN : 20:07:d0:39:ea:14:11:04
Node WWN : 20:05:d0:39:ea:14:11:04
Controller ID : 0x0140
Model Number : NetApp ONTAP Controller
Serial Number : 81CGZBPU5T/uAAAAAAAB
Firmware Version : FFFFFFFF
Total Capacity : Not Available
Unallocated Capacity : Not Available

NVMe Qualified Name : nqn.1992-08.com.netapp:sn.a3b74c32db2911eab229d039ea141105:subsystem.win_nvme_interop-57-159
Port WWN : 20:08:d0:39:ea:14:11:04
Node WWN : 20:05:d0:39:ea:14:11:04
Controller ID : 0x0141
Model Number : NetApp ONTAP Controller
Serial Number : 81CGZBPU5T/uAAAAAAAB
Firmware Version : FFFFFFFF
Total Capacity : Not Available
Unallocated Capacity : Not Available

Note: At present Namespace Management is not supported by NetApp Arrays.

```
. Validate that namespaces have been created.
+
The `+nvme-list-ns+` command lists the namespaces for a specified NVMe target that lists
the namespaces connected to the host.
+
```

PS C:\Program Files\Emulex\Util\OCManager> .\HbaCmd.exe nvme-list-ns 10:00:00:10:9b:1b:97:66 20:08:d0:39:ea:14:11:04 nq
.1992-08.com.netapp:sn.a3b74c32db2911eab229d039ea141105:subsystem.win_nvme_interop-57-159 0

Active Namespaces (attached to controller 0x0141):

```
                                      SCSI           SCSI           SCSI
   NSID           DeviceName        Bus Number    Target Number     OS LUN
-----------  --------------------  ------------  ---------------   ---------
0x00000001   \\.\PHYSICALDRIVE9         0               1              0
0x00000002   \\.\PHYSICALDRIVE10        0               1              1
0x00000003   \\.\PHYSICALDRIVE11        0               1              2
0x00000004   \\.\PHYSICALDRIVE12        0               1              3
0x00000005   \\.\PHYSICALDRIVE13        0               1              4
0x00000006   \\.\PHYSICALDRIVE14        0               1              5
0x00000007   \\.\PHYSICALDRIVE15        0               1              6
0x00000008   \\.\PHYSICALDRIVE16        0               1              7
```

```
[[ID4fa061668eeebab4a7f62a27c1a18c55]]
= NVMe/FC Host Configuration for Windows Server 2012 R2 with ONTAP
:toc: macro
:hardbreaks:
:toclevels: 1
:nofooter:
:icons: font
:linkattrs:
:imagesdir: ./media/

== Supportability

NVMe/FC is supported on ONTAP 9.7 or later for Windows Server 2016.

Note that the Broadcom initiator can serve both NVMe/FC and FCP traffic through the same
32G FC adapter ports. For FCP and FC/NVMe, use MSDSM as the Microsoft Multipath I/O
(MPIO) option.

See the link:https://hwu.netapp.com/Home/Index[Hardware Universe] for a list of supported
FC adapters and controllers. For the most current list of supported configurations &
versions, see the link:https://mysupport.netapp.com/matrix/[NetApp Interoperability
Matrix].

== Known limitations

Windows Failover Cluster (WFC) is not supported with ONTAP NVMe/FC because ONTAP does not
currently support persistent reservations with NVMe/FC.

Note that the external driver shipped by Broadcom for Windows NVMe/FC is not a true
NVMe/FC driver but a translational SCSI  NVMe driver. This translational overhead does
not necessarily impact performance, but it does negate the performance benefits of
NVMe/FC. Thus, on Windows servers, NVMe/FC and FCP performance is the same, unlike on
other operating systems such as Linux, where NVMe/FC performance is significantly better
than that of FCP.
```

```
== Enabling NVMe/FC on a Windows initiator host

Follow these steps to enable FC/NVMe on the Windows initiator host:

. Install OneCommand Manager utility on the Windows host.

. On each of the HBA initiator ports, set the following HBA driver parameters:
+
* EnableNVMe = 1
* NVMEMode = 0
* LimTransferSize=1
+
. Reboot the host.

== Configuring the Broadcom FC adapter in Windows for NVMe/FC

With the Broadcom adapter for FC/NVMe in a Windows environment, a `+hostnqn+` is
associated with each host bus adapter (HBA) port. The `+hostnqn+` is formatted as
follows.

.Example
 nqn.2017-01.com.broadcom:ecd:nvmf:fc:100000109b1b9765
 nqn.2017-01.com.broadcom:ecd:nvmf:fc:100000109b1b9766

=== Enabling MPIO for NVMe devices on the Windows host


. Install Windows Host Utility Kit 7.1 to set the driver parameters that are common to
both FC and NVMe.
. Open the MPIO properties.
. From the *Discover Multi-Paths* tab, add the device ID listed for NVMe.
+
MPIO becomes aware of the NVMe devices, which are visible under disk management.
+
. Open  *Disk Management* and go to *Disk Properties*.
. From the *MPIO* tab, click *Details*.
. Set the following MSDSM settings:
+
* PathVerifiedPeriod: *10*
* PathVerifyEnabled: *Enable*
* RetryCount: *6*
* RetryInterval: *1*
* PDORemovedPeriod: *130*
+
. Select the MPIO Policy *Round Robin with Subset*.
. Change the registry values:
+
```

HKLM\SYSTEM\CurrentControlSet\Services\mpio\Parameters\PathRecoveryInterval DWORD → 30

HKLM\SYSTEM\CurrentControlSet\Services\mpio \Parameters\ UseCustomPathRecoveryInterval DWORD→ 1

```
+
. Reboot the host.
+
The NVMe configuration is now complete on the Windows host.

== Validating NVMe/FC


. Validate that the Port Type is FC+NVMe.
+
Now that NVMe is enabled, you should see the `+Port Type+` listed as `+FC+NVMe+`, as
follows.
+
```

PS C:\Program Files\Emulex\Util\OCManager> .\hbacmd listhba

Manageable HBA List

Port WWN : 10:00:00:10:9b:1b:97:65
Node WWN : 20:00:00:10:9b:1b:97:65
Fabric Name : 10:00:c4:f5:7c:a5:32:e0
Flags : 8000e300
Host Name : INTEROP-57-159
Mfg : Emulex Corporation
Serial No. : FC71367217
Port Number : 0
Mode : Initiator
PCI Bus Number : 94
PCI Function : 0
Port Type : FC+NVMe
Model : LPe32002-M2

Port WWN : 10:00:00:10:9b:1b:97:66
Node WWN : 20:00:00:10:9b:1b:97:66
Fabric Name : 10:00:c4:f5:7c:a5:32:e0
Flags : 8000e300
Host Name : INTEROP-57-159
Mfg : Emulex Corporation
Serial No. : FC71367217
Port Number : 1

Mode : Initiator
PCI Bus Number : 94
PCI Function : 1
Port Type : FC+NVMe
Model : LPe32002-M2

```
. Validate that NVMe/FC subsystems have been discovered.
+
The `+nvme-list+` command lists the NVMe/FC discovered subsystems.
+
```

PS C:\Program Files\Emulex\Util\OCManager> .\hbacmd nvme-list 10:00:00:10:9b:1b:97:65

Discovered NVMe Subsystems for 10:00:00:10:9b:1b:97:65

NVMe Qualified Name : nqn.1992-08.com.netapp:sn.a3b74c32db2911eab229d039ea141105:subsystem.win_nvme_interop-57-159
Port WWN : 20:09:d0:39:ea:14:11:04
Node WWN : 20:05:d0:39:ea:14:11:04
Controller ID : 0x0180
Model Number : NetApp ONTAP Controller
Serial Number : 81CGZBPU5T/uAAAAAAAB
Firmware Version : FFFFFFFF
Total Capacity : Not Available
Unallocated Capacity : Not Available

NVMe Qualified Name : nqn.1992-08.com.netapp:sn.a3b74c32db2911eab229d039ea141105:subsystem.win_nvme_interop-57-159
Port WWN : 20:06:d0:39:ea:14:11:04
Node WWN : 20:05:d0:39:ea:14:11:04
Controller ID : 0x0181
Model Number : NetApp ONTAP Controller
Serial Number : 81CGZBPU5T/uAAAAAAAB
Firmware Version : FFFFFFFF
Total Capacity : Not Available
Unallocated Capacity : Not Available
Note: At present Namespace Management is not supported by NetApp Arrays.

```
+
```

PS C:\Program Files\Emulex\Util\OCManager> .\hbacmd nvme-list 10:00:00:10:9b:1b:97:66

Discovered NVMe Subsystems for 10:00:00:10:9b:1b:97:66

NVMe Qualified Name : nqn.1992-08.com.netapp:sn.a3b74c32db2911eab229d039ea141105:subsystem.win_nvme_interop-57-159
Port WWN : 20:07:d0:39:ea:14:11:04
Node WWN : 20:05:d0:39:ea:14:11:04
Controller ID : 0x0140
Model Number : NetApp ONTAP Controller
Serial Number : 81CGZBPU5T/uAAAAAAAB
Firmware Version : FFFFFFFF
Total Capacity : Not Available
Unallocated Capacity : Not Available

NVMe Qualified Name : nqn.1992-08.com.netapp:sn.a3b74c32db2911eab229d039ea141105:subsystem.win_nvme_interop-57-159
Port WWN : 20:08:d0:39:ea:14:11:04
Node WWN : 20:05:d0:39:ea:14:11:04
Controller ID : 0x0141
Model Number : NetApp ONTAP Controller
Serial Number : 81CGZBPU5T/uAAAAAAAB
Firmware Version : FFFFFFFF
Total Capacity : Not Available
Unallocated Capacity : Not Available

Note: At present Namespace Management is not supported by NetApp Arrays.

```
. Validate that namespaces have been created.
+
The `+nvme-list-ns+` command lists the namespaces for a specified NVMe target that lists
the namespaces connected to the host.
+
```

PS C:\Program Files\Emulex\Util\OCManager> .\HbaCmd.exe nvme-list-ns 10:00:00:10:9b:1b:97:66 20:08:d0:39:ea:14:11:04 nq
.1992-08.com.netapp:sn.a3b74c32db2911eab229d039ea141105:subsystem.win_nvme_interop-57-159 0

Active Namespaces (attached to controller 0x0141):

```
                                        SCSI           SCSI           SCSI
   NSID           DeviceName        Bus Number    Target Number     OS LUN
-----------  --------------------  ------------  ---------------   ---------
0x00000001   \\.\PHYSICALDRIVE9         0               1              0
0x00000002   \\.\PHYSICALDRIVE10        0               1              1
0x00000003   \\.\PHYSICALDRIVE11        0               1              2
0x00000004   \\.\PHYSICALDRIVE12        0               1              3
0x00000005   \\.\PHYSICALDRIVE13        0               1              4
0x00000006   \\.\PHYSICALDRIVE14        0               1              5
0x00000007   \\.\PHYSICALDRIVE15        0               1              6
0x00000008   \\.\PHYSICALDRIVE16        0               1              7
```

```
:leveloffset: -1


:leveloffset: -1


= FC/iSCSI Host Configurations

:leveloffset: +1


= RHEL

:leveloffset: +1


= RHEL 8

:leveloffset: +1

[[ID89645d47de35892f01576295a0506a42]]
= Using Red Hat Enterprise Linux 8.2 with NetApp ONTAP
:toc: macro
:hardbreaks:
:toclevels: 1
:nofooter:
:icons: font
:linkattrs:
:imagesdir: ./media/

== Installing the Linux Unified Host Utilities

The NetApp Linux Unified Host Utilities software package is available on the
link:https://mysupport.netapp.com/NOW/cgi-bin/software/?product=Host+Utilities+-
```

```
+SAN&platform=Linux[NetApp Support Site^] in a 64-bit .rpm file.

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.

.Before you begin

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.

.   Download the 64-bit Linux Unified Host Utilities software package from the
link:https://mysupport.netapp.com/NOW/cgi-bin/software/?product=Host+Utilities+-
+SAN&platform=Linux[NetApp Support Site^] to your host.
.   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

.Before you begin
If you decide to use SAN booting, it must be supported by your configuration. You can use
```

```
the
link:https://mysupport.netapp.com/matrix/imt.jsp?components=96167;&solution=236&isHWU&src
=IMT[NetApp Interoperability Matrix Tool^] to verify that your OS, HBA, HBA firmware and
the HBA boot BIOS, and ONTAP version are supported.

.   Map the SAN boot LUN to the host.
.   Verify multiple paths are available.
+
Remember, multiple paths will only be available after the host OS is up and running on
the paths.
.   Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is
mapped.
+
For information on how to enable the HBA BIOS, see your vendor-specific documentation.
.   Reboot the host to verify the boot is successful.

== Multipathing

For Red Hat Enterprise Linux (RHEL) 8.2 the /etc/multipath.conf file must exist, but you
do not need to make specific changes to the file. RHEL 8.2 is compiled with all settings
required to recognize and correctly manage ONTAP LUNs.

You can use the `multipath -ll` command to verify the settings for your ONTAP LUNs.
There should be two groups of paths with different priorities. The paths with the higher
priorities are Active/Optimized, meaning they are serviced by the controller where the
aggregate is located. The paths with the lower priorities are active but are non-
optimized because they are served from a different controller. The non-optimized paths
are only used when no optimized paths are available.

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

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

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

```
== Recommended Settings

The RHEL 8.2 OS is compiled to recognize ONTAP LUNs and automatically set all
configuration parameters correctly.
The multipath.conf file must exist for the multipath daemon to start, but you can create
an empty, zero-byte file using the command:
`touch /etc/multipath.conf`
The first time you create this file, you might need to enable and start the multipath
services.
----
[root@jfs0 ~]#systemctl enable multipathd
[root@jfs0 ~]# systemctl start multipathd
----
There is no requirement to add anything directly to multipath.conf, 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.

.Note
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.

.   Run the following command to determine the WWID:
+
....
# /lib/udev/scsi_id -gud /dev/sda
360030057024d0730239134810c0cb833
....
.   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.


[cols=2*,options="header"]
|===
| 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 RHEL 8.2.

== Release Notes

=== ASM Mirroring

ASM mirroring might require changes to the Linux multipath settings to allow ASM to
recognize a problem and switch over to an alternate fail 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
link:https://www.netapp.com/us/media/tr-3633.pdf[Oracle Databases on ONTAP^] for further
information.

[[IDe37bec9796aa166847c5b242755bae2c]]
= Using Red Hat Enterprise Linux 8.1 with NetApp ONTAP
:toc: macro
:hardbreaks:
:toclevels: 1
:nofooter:
:icons: font
:linkattrs:
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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
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+SAN&platform=Linux[NetApp Support Site^] to your host.
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+
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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

.Before you begin
If you decide to use SAN booting, it must be supported by your configuration. You can use
the
link:https://mysupport.netapp.com/matrix/imt.jsp?components=91241;&solution=236&isHWU&src
=IMT[NetApp Interoperability Matrix Tool^] to verify that your OS, HBA, HBA firmware and
the HBA boot BIOS, and ONTAP version are supported.

.   Map the SAN boot LUN to the host.
.   Verify multiple paths are available.
+
Remember, multiple paths will only be available after the host OS is up and running on
the paths.
.   Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is
mapped.
+
For information on how to enable the HBA BIOS, see your vendor-specific documentation.
.   Reboot the host to verify the boot is successful.

== Multipathing

For Red Hat Enterprise Linux (RHEL) 8.1 the /etc/multipath.conf file must exist, but you
do not need to make specific changes to the file. RHEL 8.1 is compiled with all settings
required to recognize and correctly manage ONTAP LUNs.

You can use the `multipath -ll` command to verify the settings for your ONTAP LUNs.
The following sections provide sample multipath output for a LUN mapped to ASA and non-
ASA personas.

=== All SAN Array Configuration

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

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

multipath -ll

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

|- 11:0:9:1 sdiy 8:288 active ready running
|- 11:0:10:1 sdml 69:464 active ready running
|- 11:0:11:1 sdpt 131:304 active ready running

```
.Note
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

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

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

== Recommended Settings

The RHEL 8.1 OS is compiled to recognize ONTAP LUNs and automatically set all
configuration parameters correctly for both ASA and non-ASA configuration.
The multipath.conf file must exist for the multipath daemon to start, but you can create
an empty, zero-byte file 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

[root@jfs0 ~] systemctl start multipathd

```
There is no requirement to add anything directly to multipath.conf, 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.

.Note
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.

.   Run the following command to determine the WWID:
+
....
# /lib/udev/scsi_id -gud /dev/sda
360030057024d0730239134810c0cb833
....
.   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.


[cols=2*,options="header"]
|===
| 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

[cols=4*,options="header"]
|===
| NetApp Bug ID
| Title
| Description
| Bugzilla ID
| link:https://mysupport.netapp.com/NOW/cgi-bin/bol?Type=Detail&Display=1275843[1275843^]
| Kernel disruption might occur on Red Hat Enterprise Linux 8.1 with QLogic QLE2672 16GB
FC HBA during storage failover operation | Kernel disruption might occur during storage
failover operations on the Red Hat Enterprise Linux  8.1 kernel with a QLogic QLE2672
Fibre Channel (FC) host bus adapter (HBA). The kernel disruption causes Red Hat
Enterprise Linux 8.1 to reboot, leading to application disruption. If the kdump mechanism
is enabled, the kernel disruption generates a vmcore file located in the/var/crash/
directory. You can check the vmcore file to determine the cause of the disruption.A
storage failover with the QLogic QLE2672 HBA event affects the "kmem_cache_alloc+131"
module. You can locate the event in the vmcore file by finding the following string: "
[exception RIP: kmem_cache_alloc+131]"After the kernel disruption, reboot the Host OS and
recover the operating system. Then restart the applications |
link:https://bugzilla.redhat.com/show_bug.cgi?id=1760819[1760819^]
| link:https://mysupport.netapp.com/NOW/cgi-bin/bol?Type=Detail&Display=1275838[1275838^]
| Kernel disruption occurs on Red Hat Enterprise Linux 8.1 with QLogic QLE2742 32GB FC
HBA during storage failover operations | Kernel disruption occurs during storage failover
operations on the Red Hat Enterprise Linux 8.1 kernel with a QLogic QLE2742 Fibre Channel
(FC) host bus adapter (HBA). The kernel disruption causes Red Hat Enterprise Linux 8.1 to
reboot, leading to application disruption. If the kdump mechanism is enabled, the kernel
disruption generates a vmcore file located in the/var/crash/ directory. You can check the
vmcore file to determine the cause of the disruption. A storage failover with the QLogic
QLE2742 HBA event affects the "kmem_cache_alloc+131"module. You can locate the event in
the vmcore file by finding the following string:    " [exception RIP:
kmem_cache_alloc+131]"After the kernel disruption, reboot the Host OS and recover the
operating system. Then restart the applications. |
link:https://bugzilla.redhat.com/show_bug.cgi?id=1744082[1744082^]
| link:https://mysupport.netapp.com/NOW/cgi-bin/bol?Type=Detail&Display=1266250[1266250^]
| Login to multiple paths fails during the Red Hat Enterprise Linux 8.1 installation on
iSCSI SAN LUN | You cannot login to multiple paths during the Red Hat Enterprise Linux
8.1 installation on iSCSI SAN LUN multipath devices. Installation is not possible on
multipath iSCSI device and the multipath service is not enabled on the SAN boot device. |
link:https://bugzilla.redhat.com/show_bug.cgi?id=1758504[1758504^]
|===

== 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 fail 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
link:https://www.netapp.com/us/media/tr-3633.pdf[Oracle Databases on ONTAP^] for further
information.

[[IDda1193b46671c643f997a3da8204c7e0]]
= Using Red Hat Enterprise Linux 8.0 with NetApp ONTAP
:toc: macro
:hardbreaks:
:toclevels: 1
:nofooter:
:icons: font
:linkattrs:
:imagesdir: ./media/

== Installing the Linux Unified Host Utilities

The NetApp Linux Unified Host Utilities software package is available on the
link:https://mysupport.netapp.com/NOW/cgi-bin/software/?product=Host+Utilities+-
+SAN&platform=Linux[NetApp Support Site^] in a 64-bit .rpm file.

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.

.Before you begin

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.

.   Download the 64-bit Linux Unified Host Utilities software package from the
link:https://mysupport.netapp.com/NOW/cgi-bin/software/?product=Host+Utilities+-
+SAN&platform=Linux[NetApp Support Site^] to your host.
.   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

.Before you begin
If you decide to use SAN booting, it must be supported by your configuration. You can use
the
link:https://mysupport.netapp.com/matrix/imt.jsp?components=91241;&solution=236&isHWU&src
=IMT[NetApp Interoperability Matrix Tool^] to verify that your OS, HBA, HBA firmware and
the HBA boot BIOS, and ONTAP version are supported.

.   Map the SAN boot LUN to the host.
.   Verify multiple paths are available.
+
Remember, multiple paths will only be available after the host OS is up and running on
the paths.
.   Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is
mapped.
+
For information on how to enable the HBA BIOS, see your vendor-specific documentation.
.   Reboot the host to verify the boot is successful.

== Multipathing

For Red Hat Enterprise Linux (RHEL) 8.0 the /etc/multipath.conf file must exist, but you
do not need to make specific changes to the file. RHEL 8.0 is compiled with all settings
required to recognize and correctly manage ONTAP LUNs.

You can use the `multipath -ll` command to verify the settings for your ONTAP LUNs.
The following sections provide sample multipath output for a LUN mapped to ASA and non-
ASA personas.
```

```
=== All SAN Array Configuration

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

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

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

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

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

== Recommended Settings

The RHEL 8.0 OS is compiled to recognize ONTAP LUNs and automatically set all
configuration parameters correctly for both ASA and non-ASA configuration.
The multipath.conf file must exist for the multipath daemon to start, but you can create
an empty, zero-byte file using the command:
`touch /etc/multipath.conf`
The first time you create this file, you might need to enable and start the multipath
services.
----
[root@jfs0 ~]#systemctl enable multipathd
[root@jfs0 ~]# systemctl start multipathd
----
There is no requirement to add anything directly to multipath.conf, 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.

.Note
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.

.   Run the following command to determine the WWID:
+
....
# /lib/udev/scsi_id -gud /dev/sda
360030057024d0730239134810c0cb833
....
.   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.


[cols=2*,options="header"]
|===
| 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

[cols=4*,options="header"]
|===
| NetApp Bug ID
| Title
| Description
| Bugzilla ID
| link:https://mysupport.netapp.com/NOW/cgi-bin/bol?Type=Detail&Display=1238719[1238719^]
| Kernel disruption on RHEL8 with QLogic QLE2672 16GB FC during storage failover
operations | Kernel disruption might occur during storage failover operations on a Red
Hat Enterprise Linux (RHEL) 8 kernel with a QLogic QLE2672 host bus adapter (HBA). The
kernel disruption causes the operating system to reboot. The reboot causes application
disruption and generates the vmcore file under the /var/crash/directory if kdump is
configured.  Use the vmcore file to identify the cause of the failure. In this case, the
disruption is in the kmem_cache_alloc+160 module. It is logged in the vmcore file with
the following string:    "[exception RIP: kmem_cache_alloc+160]". Reboot the host OS to
recover the operating system and then restart the application. |
link:https://bugzilla.redhat.com/show_bug.cgi?id=1710009[1710009^]
| link:https://mysupport.netapp.com/NOW/cgi-bin/bol?Type=Detail&Display=1226783[1226783^]
| RHEL8 OS boots up to "emergency mode" when more than 204 SCSI devices are mapped on all
Fibre Channel (FC) host bus adapters (HBA) | If a host is mapped with more than 204 SCSI
devices during an operating systemreboot process, the RHEL8 OS fails to boot up to
"normal mode" and enters "emergency mode". This results in most of the host services
becoming unavailable. |
link:https://bugzilla.redhat.com/show_bug.cgi?id=1690356[1690356^]
| link:https://mysupport.netapp.com/NOW/cgi-bin/bol?Type=Detail&Display=1230882[1230882^]
| Creating a partition on an iSCSI multipath device during the RHEL8 installation is not
feasible. | iSCSI SAN LUN multipath devices are not listed in disk selection during RHEL
8 installation. Consequently, the multipath service is not enabled on the SAN boot
```

```
device. | link:https://bugzilla.redhat.com/show_bug.cgi?id=1709995[1709995^]
| link:https://mysupport.netapp.com/NOW/cgi-bin/bol?Type=Detail&Display=1235998[1235998^]
| The "rescan-scsi-bus.sh -a" command does not scan more than 328 devices | If a Red Hat
Enterprise Linux 8 host maps with more than 328 SCSI devices, the host OS command
"rescan-scsi-bus.sh -a" only scans 328 devices. The host does not discover any remaining
mapped devices. | link:https://bugzilla.redhat.com/show_bug.cgi?id=1709995[1709995^]
| link:https://mysupport.netapp.com/NOW/cgi-bin/bol?Type=Detail&Display=1231087[1231087^]
| Remote ports transit to a blocked state on RHEL8 with Emulex LPe16002 16GB FC during
storage failover operations | Remote ports transit to a blocked state on RHEL8 with
Emulex LPe16002 16GB Fibre Channel (FC) during storage failover operations. When the
storage node returns to an optimal state, the LIFs also come up and the remote port state
should read "online".  Occasionally, the remote port state might continue to read as
"blocked" or "not present". This state can lead to a "failed faulty" path to LUNs at the
multipath layer | link:https://bugzilla.redhat.com/show_bug.cgi?id=1702005[1702005^]
| link:https://mysupport.netapp.com/NOW/cgi-bin/bol?Type=Detail&Display=1231098[1231098^]
|Remote ports transit to blocked state on RHEL8 with Emulex LPe32002 32GB FC during
storage failover operations | Remote ports transit to a blocked state on RHEL8 with
Emulex LPe32002 32GBFibre Channel (FC) during storage failover operations. When the
storage node returns to an optimal state, the LIFs also come up and the remote port state
should read "online".  Occasionally, the remote port state might continue to read as
"blocked" or "not present". This state can lead to a "failed faulty" path to LUNs at the
multipath layer. | link:https://bugzilla.redhat.com/show_bug.cgi?id=1705573[1705573^]
|===

== 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 fail 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
link:https://www.netapp.com/us/media/tr-3633.pdf[Oracle Databases on ONTAP^] for further
information.


:leveloffset: -1


= RHEL 7

:leveloffset: +1

[[IDb2d5e69f2deba68ccfbc4b0b031d2d71]]
= Using Red Hat Enterprise Linux 7.8 with NetApp ONTAP
:toc: macro
:hardbreaks:
```

```
:toclevels: 1
:nofooter:
:icons: font
:linkattrs:
:imagesdir: ./media/

== Installing the Linux Unified Host Utilities

The NetApp Linux Unified Host Utilities software package is available on the
link:https://mysupport.netapp.com/NOW/cgi-bin/software/?product=Host+Utilities+-
+SAN&platform=Linux[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
link:https://mysupport.netapp.com/matrix/#welcome[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.

.Before you begin

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.

.   Download the 32-bit or 64-bit Linux Unified Host Utilities software package from the
link:https://mysupport.netapp.com/NOW/cgi-bin/software/?product=Host+Utilities+-
+SAN&platform=Linux[NetApp Support Site^] Site to your host.
.   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

.Before you begin
If you decide to use SAN booting, it must be supported by your configuration. You can use
the
link:https://mysupport.netapp.com/matrix/imt.jsp?components=95803;&solution=1&isHWU&src=I
MT[NetApp Interoperability Matrix Tool^] to verify that your OS, HBA, HBA firmware and
the HBA boot BIOS, and ONTAP version are supported.

.   Map the SAN boot LUN to the host.
.   Verify multiple paths are available.
+
Remember, multiple paths will only be available after the host OS is up and running on
the paths.
.   Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is
mapped.
+
For information on how to enable the HBA BIOS, see your vendor-specific documentation.
.   Reboot the host to verify the boot is successful.

== Multipathing

For Red Hat Enterprise Linux (RHEL) 7.8 the /etc/multipath.conf file must exist, but you
do not need to make specific changes to the file. RHEL 7.8 is compiled with all settings
required to recognize and correctly manage ONTAP LUNs.

You can use the `multipath -ll` command to verify the settings for your ONTAP LUNs.
The following sections provide sample multipath output for a LUN mapped to ASA and non-
ASA personas.

=== All SAN Array Configuration

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

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

multipath -ll

3600a09803831347657244e527766394e dm-5 NETAPP,LUN C-Mode
size=80G features='4 queue_if_no_path pg_init_retries 50 retain_attached_hw_handle' hwhandler='1 alua' wp=rw
`-+- policy='service-time 0' prio=50 status=active
|- 11:0:7:1 sdfi 130:64 active ready running
|- 11:0:9:1 sdiy 8:288 active ready running
|- 11:0:10:1 sdml 69:464 active ready running
|- 11:0:11:1 sdpt 131:304 active ready running

```
.Note
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

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

== Recommended Settings

The RHEL 7.8 OS is compiled to recognize ONTAP LUNs and automatically set all
configuration parameters correctly for both ASA and non-ASA configuration.
The multipath.conf file must exist for the multipath daemon to start, but you can create
an empty, zero-byte file using the command:
`touch /etc/multipath.conf`
The first time you create this file, you might need to enable and start the multipath
services.
```

systemctl enable multipathd
[root@jfs0 ~] systemctl start multipathd

```
There is no requirement to add anything directly to multipath.conf, 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.

.Note
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.

.   Run the following command to determine the WWID:
+
....
# /lib/udev/scsi_id -gud /dev/sda
360030057024d0730239134810c0cb833
....
.   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.


[cols=2*,options="header"]
|===
| Parameter
| Setting
| detect_prio | yes
| dev_loss_tmo | "infinity"
| failback | immediate
| fast_io_fail_tmo | 5
| features | "3 queue_if_no_path pg_init_retries 50"
| flush_on_last_del | "yes"
| hardware_handler | "0"
| no_path_retry | queue
| path_checker | "tur"
| path_grouping_policy | "group_by_prio"
| path_selector | "service-time 0"
| polling_interval | 5
| prio | "ontap"
| product | LUN.*
| retain_attached_hw_handler | yes
| rr_weight | "uniform"
| user_friendly_names | no
| vendor | NETAPP
|===

.Example

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

```
attached to the host, these parameters can be corrected specifically for ONTAP LUNs with
a device stanza.
```

defaults {
path_checker readsector0
no_path_retry fail
}

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

```
== Known Problems and Limitations

There are no known issues for RHEL 7.8.

== 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 fail 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
link:https://www.netapp.com/us/media/tr-3633.pdf[Oracle Databases on ONTAP^] for further
information.

[[ID9c8a47bfb82186badd82a27a8a83a114]]
= Using Red Hat Enterprise Linux 7.7 with NetApp ONTAP
:toc: macro
:hardbreaks:
:toclevels: 1
:nofooter:
:icons: font
:linkattrs:
:imagesdir: ./media/

== Installing the Linux Unified Host Utilities

The NetApp Linux Unified Host Utilities software package is available on the
```

```
link:https://mysupport.netapp.com/NOW/cgi-bin/software/?product=Host+Utilities+-
+SAN&platform=Linux[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
link:https://mysupport.netapp.com/matrix/#welcome[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.

.Before you begin

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.

.   Download the 32-bit or 64-bit Linux Unified Host Utilities software package from the
link:https://mysupport.netapp.com/NOW/cgi-bin/software/?product=Host+Utilities+-
+SAN&platform=Linux[NetApp Support Site^] Site to your host.
.   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

.Before you begin
If you decide to use SAN booting, it must be supported by your configuration. You can use
the
link:https://mysupport.netapp.com/matrix/imt.jsp?components=89085;&solution=1&isHWU&src=I
MT[NetApp Interoperability Matrix Tool^] to verify that your OS, HBA, HBA firmware and
the HBA boot BIOS, and ONTAP version are supported.

.   Map the SAN boot LUN to the host.
.   Verify multiple paths are available.
+
Remember, multiple paths will only be available after the host OS is up and running on
the paths.
.   Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is
mapped.
+
For information on how to enable the HBA BIOS, see your vendor-specific documentation.
.   Reboot the host to verify the boot is successful.

== Multipathing

For Red Hat Enterprise Linux (RHEL) 7.7 the /etc/multipath.conf file must exist, but you
do not need to make specific changes to the file. RHEL 7.7 is compiled with all settings
required to recognize and correctly manage ONTAP LUNs.

You can use the `multipath -ll` command to verify the settings for your ONTAP LUNs.
The following sections provide sample multipath output for a LUN mapped to ASA and non-
ASA personas.

=== All SAN Array Configuration

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

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

----
# multipath -ll
3600a09803831347657244e527766394e dm-5 NETAPP,LUN C-Mode
size=80G  features='4 queue_if_no_path pg_init_retries 50 retain_attached_hw_handle'
hwhandler='1 alua' wp=rw
`-+- policy='service-time 0' prio=50 status=active
  |- 11:0:7:1    sdfi   130:64   active ready running
  |- 11:0:9:1    sdiy  8:288     active ready running
```

```
  |- 11:0:10:1  sdml 69:464   active ready running
  |- 11:0:11:1  sdpt  131:304  active ready running
----

.Note
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
----

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

== Recommended Settings

The RHEL 7.7 OS is compiled to recognize ONTAP LUNs and automatically set all
configuration parameters correctly for both ASA and non-ASA configuration.
The multipath.conf file must exist for the multipath daemon to start, but you can create
an empty, zero-byte file using the command:
`touch /etc/multipath.conf`
The first time you create this file, you might need to enable and start the multipath
services.
----
[root@jfs0 ~]#systemctl enable multipathd
```

```
[root@jfs0 ~]# systemctl start multipathd
----
There is no requirement to add anything directly to multipath.conf, 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.

.Note
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.

.   Run the following command to determine the WWID:
+
....
# /lib/udev/scsi_id -gud /dev/sda
360030057024d0730239134810c0cb833
....
.   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.
```

```
[cols=2*,options="header"]
|===
| Parameter
| Setting
| detect_prio | yes
| dev_loss_tmo | "infinity"
| failback | immediate
| fast_io_fail_tmo | 5
| features | "3 queue_if_no_path pg_init_retries 50"
| flush_on_last_del | "yes"
| hardware_handler | "0"
| no_path_retry | queue
| path_checker | "tur"
| path_grouping_policy | "group_by_prio"
| path_selector | "service-time 0"
| polling_interval | 5
| prio | "ontap"
| product | LUN.*
| retain_attached_hw_handler | yes
| rr_weight | "uniform"
| user_friendly_names | no
| vendor | NETAPP
|===

.Example

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

----
defaults {
   path_checker      readsector0
   no_path_retry      fail
}

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

```
----

== Known Problems and Limitations

[cols=4*,options="header"]
|===
| NetApp Bug ID
| Title
| Description
| Bugzilla ID
| link:https://mysupport.netapp.com/NOW/cgi-bin/bol?Type=Detail&Display=1258856[1258856^]
| Remote ports transit to a blocked state on RHEL7U7 with Emulex LPe16002 16GB FC during
storage failover operations | Remote ports might transit to a blocked state on a RHEL 7.7
host with a LPe16002 16GB FC adapter during storage failover operations. When the storage
node returns to an optimal state, the LIFs also come up and the remote port state should
read "online".  Occasionally, the remote port state might continue to read as "blocked or
"not present". This state can lead to a "failed faulty" path to LUNs at the multipath
layer. | link:https://bugzilla.redhat.com/show_bug.cgi?id=1743667[1743667^]
| link:https://mysupport.netapp.com/NOW/cgi-bin/bol?Type=Detail&Display=1261474[1261474^]
| Remote ports transit to blocked state on RHEL7U7 with Emulex LPe32002 32GB FC | Remote
ports might transit to a blocked state on a RHEL 7.7 host with LPe32002 32GB FC adapter
during storage failover operations. When the storage node returns to an optimal state,
the LIFs also come up and the remote port state should read "online". Occasionally, the
remote port state might continue to read as "blocked or "not present". This state can
lead to a "failed faulty" path to LUNs at the multipath layer. |
link:https://bugzilla.redhat.com/show_bug.cgi?id=1745995[1745995^]
|===

== 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 fail 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
link:https://www.netapp.com/us/media/tr-3633.pdf[Oracle Databases on ONTAP^] for further
information.

[[ID85b128ea4c4f6e898e5d5c4ee508ada7]]
= Using Red Hat Enterprise Linux 7.6 with NetApp ONTAP
:toc: macro
:hardbreaks:
:toclevels: 1
:nofooter:
:icons: font
:linkattrs:
```

```
:imagesdir: ./media/

== Installing the Linux Unified Host Utilities

The NetApp Linux Unified Host Utilities software package is available on the
link:https://mysupport.netapp.com/NOW/cgi-bin/software/?product=Host+Utilities+-
+SAN&platform=Linux[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
link:https://mysupport.netapp.com/matrix/#welcome[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.

.Before you begin

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.

.   Download the 32-bit or 64-bit Linux Unified Host Utilities software package from the
link:https://mysupport.netapp.com/NOW/cgi-bin/software/?product=Host+Utilities+-
+SAN&platform=Linux[NetApp Support Site^] Site to your host.
.   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

.Before you begin
If you decide to use SAN booting, it must be supported by your configuration. You can use
the
link:https://mysupport.netapp.com/matrix/imt.jsp?components=85803;&solution=1&isHWU&src=I
MT[NetApp Interoperability Matrix Tool^] to verify that your OS, HBA, HBA firmware and
the HBA boot BIOS, and ONTAP version are supported.

You can use the `multipath -ll` command to verify the settings for your ONTAP LUNs.
The following sections provide sample multipath output for a LUN mapped to ASA and non-
ASA personas.

=== All SAN Array Configuration

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

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

multipath -ll

3600a09803831347657244e527766394e dm-5 NETAPP,LUN C-Mode
size=80G features='4 queue_if_no_path pg_init_retries 50 retain_attached_hw_handle' hwhandler='1 alua' wp=rw
`-+- policy='service-time 0' prio=50 status=active
|- 11:0:7:1 sdfi 130:64 active ready running
|- 11:0:9:1 sdiy 8:288 active ready running
|- 11:0:10:1 sdml 69:464 active ready running
|- 11:0:11:1 sdpt 131:304 active ready running

```
.Note
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

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

== Recommended Settings

The RHEL 7.6 OS is compiled to recognize ONTAP LUNs and automatically set all
configuration parameters correctly for both ASA and non-ASA configuration.
The multipath.conf file must exist for the multipath daemon to start, but you can create
an empty, zero-byte file using the command:
`touch /etc/multipath.conf`
The first time you create this file, you might need to enable and start the multipath
services.
```

systemctl enable multipathd
[root@jfs0 ~] systemctl start multipathd

```
There is no requirement to add anything directly to multipath.conf, 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.

.Note
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.

.   Run the following command to determine the WWID:
+
....
# /lib/udev/scsi_id -gud /dev/sda
360030057024d0730239134810c0cb833
....
.   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.


[cols=2*,options="header"]
```

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

.Example

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

defaults {
path_checker readsector0
no_path_retry fail
}

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

```
== Known Problems and Limitations
```

```
[cols=4*,options="header"]
|===
| NetApp Bug ID
| Title
| Description
| Bugzilla ID
| link:https://mysupport.netapp.com/NOW/cgi-bin/bol?Type=Detail&Display=1186754[1186754^]
| Remote ports status on RHEL7U6 with QLogic QLE2742 host might be in blocked during host
discovery | During host discovery, FC remote port status on RHEL7U6 host with a QLogic
QLE2742 adapter might enter a blocked state. These blocked remote ports might result in
the paths to LUNs becoming unavailable. During storage failover, the path redundancy
might be reduced and result in I/O outage. You can check the remote port status by
entering the following command:# cat /sys/class/fc_remote_ports/rport-*/port_state |
link:https://bugzilla.redhat.com/show_bug.cgi?id=1628039[1628039^]
| link:https://mysupport.netapp.com/NOW/cgi-bin/bol?Type=Detail&Display=1190698[1190698^]
| Remote port status on RHEL7U6 with QLogic QLE2672 host might be in blocked during
storage failover operations | FC remote ports might be blocked on Red Hat Enterprise
Linux (RHEL) 7U6 with the QLogic QLE2672 host during storage failover operations. Because
the logical interfaces go down when a storage node is down, the remote ports set the
storage node status to blocked. When the storage node returns to its optimal state, the
logical interfaces also come up and the remote ports should be online. However, the
remote portsmight still be blocked. This blocked state registers as failed faulty to LUNS
at the multipath layer. You can verify the remote ports state with the following
command:# cat /sys/class/fc_remote_ports/rport-*/port_state |
link:https://bugzilla.redhat.com/show_bug.cgi?id=1643459[1643459^]
|===

== 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 fail 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
link:https://www.netapp.com/us/media/tr-3633.pdf[Oracle Databases on ONTAP^] for further
information.

[[IDd062d7924b9e0847ba71f97af765d93e]]
= Using Red Hat Enterprise Linux 7.5 with NetApp ONTAP
:toc: macro
:hardbreaks:
:toclevels: 1
:nofooter:
:icons: font
:linkattrs:
```

```
:imagesdir: ./media/

== Installing the Linux Unified Host Utilities

The NetApp Linux Unified Host Utilities software package is available on the
link:https://mysupport.netapp.com/NOW/cgi-bin/software/?product=Host+Utilities+-
+SAN&platform=Linux[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
link:https://mysupport.netapp.com/matrix/#welcome[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.

.Before you begin

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.

.   Download the 32-bit or 64-bit Linux Unified Host Utilities software package from the
link:https://mysupport.netapp.com/NOW/cgi-bin/software/?product=Host+Utilities+-
+SAN&platform=Linux[NetApp Support Site^] Site to your host.
.   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

.Before you begin
If you decide to use SAN booting, it must be supported by your configuration. You can use
the
link:https://mysupport.netapp.com/matrix/imt.jsp?components=82985;&solution=1&isHWU&src=I
MT[NetApp Interoperability Matrix Tool^] to verify that your OS, HBA, HBA firmware and
the HBA boot BIOS, and ONTAP version are supported.

.   Map the SAN boot LUN to the host.
.   Verify multiple paths are available.
+
Remember, multiple paths will only be available after the host OS is up and running on
the paths.
.   Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is
mapped.
+
For information on how to enable the HBA BIOS, see your vendor-specific documentation.
.   Reboot the host to verify the boot is successful.

== Multipathing

For Red Hat Enterprise Linux (RHEL) 7.5 the /etc/multipath.conf file must exist, but you
do not need to make specific changes to the file. RHEL 7.5 is compiled with all settings
required to recognize and correctly manage ONTAP LUNs.

You can use the `multipath -ll` command to verify the settings for your ONTAP LUNs.
The following sections provide sample multipath output for a LUN mapped to ASA and non-
ASA personas.

=== All SAN Array Configuration

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

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

----
# multipath -ll
3600a09803831347657244e527766394e dm-5 NETAPP,LUN C-Mode
```

```
size=80G  features='4 queue_if_no_path pg_init_retries 50 retain_attached_hw_handle'
hwhandler='1 alua' wp=rw
`-+- policy='service-time 0' prio=50 status=active
  |- 11:0:7:1    sdfi   130:64   active ready running
  |- 11:0:9:1    sdiy  8:288     active ready running
  |- 11:0:10:1  sdml 69:464   active ready running
  |- 11:0:11:1  sdpt  131:304  active ready running
----

.Note
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
----

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

== Recommended Settings

The RHEL 7.5 OS is compiled to recognize ONTAP LUNs and automatically set all
configuration parameters correctly for both ASA and non-ASA configuration.
The multipath.conf file must exist for the multipath daemon to start, but you can create
an empty, zero-byte file using the command:
```

```
`touch /etc/multipath.conf`
The first time you create this file, you might need to enable and start the multipath
services.
----
[root@jfs0 ~]#systemctl enable multipathd
[root@jfs0 ~]# systemctl start multipathd
----
There is no requirement to add anything directly to multipath.conf, 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.

.Note
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.

.   Run the following command to determine the WWID:
+
....
# /lib/udev/scsi_id -gud /dev/sda
360030057024d0730239134810c0cb833
....
.   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.


[cols=2*,options="header"]
|===
| Parameter
| Setting
| detect_prio | yes
| dev_loss_tmo | "infinity"
| failback | immediate
| fast_io_fail_tmo | 5
| features | "3 queue_if_no_path pg_init_retries 50"
| flush_on_last_del | "yes"
| hardware_handler | "0"
| no_path_retry | queue
| path_checker | "tur"
| path_grouping_policy | "group_by_prio"
| path_selector | "service-time 0"
| polling_interval | 5
| prio | "ontap"
| product | LUN.*
| retain_attached_hw_handler | yes
| rr_weight | "uniform"
| user_friendly_names | no
| vendor | NETAPP
|===

.Example

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

----
defaults {
   path_checker      readsector0
   no_path_retry      fail
}

devices {
   device {
      vendor         "NETAPP  "
```

```
      product         "LUN.*"
      no_path_retry     queue
      path_checker      tur
   }
}
----

== Known Problems and Limitations

[cols=4*,options="header"]
|===
| NetApp Bug ID
| Title
| Description
| Bugzilla ID
| link:https://mysupport.netapp.com/NOW/cgi-bin/bol?Type=Detail&Display=1139053[1139053^]
| Kernel disruption occurs on RHEL7.5 with QLogic QLE2672 16GB FC during storage failover
operations |During storage failover operations on the RHEL7U5 kernel with QLogic QLE2672
16GB fibre channel host bus adapter, the kernel disruption occurs due to a panic in the
kernel. The kernel panic causes RHEL 7.5 to reboot, which leads to an application
disruption. The kernel panic generates the vmcore file under the /var/crash/directory if
kdump is configured. The vmcore file is used to understand the cause of the failure. In
this case, the panic was observed in the get_next_timer_interrupt+440 module which is
logged in the vmcore file with the following string: " [exception RIP:
get_next_timer_interrupt+440]" After the kernel disruption, you can recover the operating
system by rebooting the host operating system and restarting the application as required.
| link:https://bugzilla.redhat.com/show_bug.cgi?id=1542564[1542564^]
| link:https://mysupport.netapp.com/NOW/cgi-bin/bol?Type=Detail&Display=1138536[1138536^]
| Kernel disruption occurs on RHEL7U5 with QLogic QLE2742 32GB FC during storage failover
operations | During storage failover operations on the Red Hat Enterprise Linux (RHEL)
RHEL7U5 kernel with QLogic QLE2742 HBA, kernel disruption occurs due to a panic in the
kernel. The kernel panic leads to a reboot of the operating system, causing an
application disruption. The kernel panic generates the vmcore file under the /var/crash/
directory if kdump is configured. When the kernel panics, you can use the vmcore file to
investigate the reason for the failure. The following example shows a panic in the
bget_next_timer_interrupt+440b module. The panic is logged in the vmcore file with the
following string: " [exception RIP: get_next_timer_interrupt+440]" You can recover the
operating system by rebooting the host OS and restarting the application as required. |
link:https://bugzilla.redhat.com/show_bug.cgi?id=1541972[1541972^]
| link:https://mysupport.netapp.com/NOW/cgi-bin/bol?Type=Detail&Display=1148090[1148090^]
| Kernel disruption occurs on RHEL 7.5 with QLogic QLE2742 32GB FC HBA during storage
failover operations | During storage failover operations on the Red Hat Enterprise Linux
(RHEL) 7.5 kernel with a QLogic QLE2742 Fibre Channel (FC) host bus adapter (HBA), a
kernel disruption occurs due to a panic in the kernel. The kernel panic causes RHEL 7.5
to reboot, which leads to an application disruption. If the kdump mechanism is enabled,
the kernel panic generates a vmcore file located in the /var/crash/ directory. You can
analyze the vmcore file to determine the cause of the panic.  In this instance, when
storage failover with the QLogic QLE2742 HBA event occurs, the
```

```
"native_queued_spin_lock_slowpath+464" module is affected. You can locate the event in
the vmcore file by finding the following string:     " [exception RIP:
native_queued_spin_lock_slowpath+464]"  After the kernel disruption, you can reboot the
Host OS and recover the operating system, and then you can restart the applications as
required. | link:https://bugzilla.redhat.com/show_bug.cgi?id=1559050[1559050^]
| link:https://mysupport.netapp.com/NOW/cgi-bin/bol?Type=Detail&Display=1146898[1146898^]
| Kernel disruption occurs on RHEL 7.5 with Emulex HBAs during storage failover
operations | During storage failover operations on a Red Hat Enterprise Linux (RHEL) 7.5
system with Emulex LPe32002-M2 32-GB FC host bus adapters (HBAs), a disruption in the
kernel occurs. The kernel disruption causes a reboot of the operating system, which in
turn causes an application disruption.  If you configure kdump, the kernel disruption
generates the vmcore file under the /var/crash/ directory. You can use the vmcore file to
determine the cause of the failure. In the following example, you can see the disruption
in the "lpfc_hba_clean_txcmplq+368" module. This disruption is logged in the vmcore file
with the following string: " [exception RIP: lpfc_hba_clean_txcmplq+368]" After the
kernel disruption, reboot the host OS to recover the operating system. Restart the
application as required. |
link:https://bugzilla.redhat.com/show_bug.cgi?id=1554777[1554777^]
|===

== 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 fail 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
link:https://www.netapp.com/us/media/tr-3633.pdf[Oracle Databases on ONTAP^] for further
information.

[[ID98d584b83089430df8fff85c32bc0aa1]]
= Using Red Hat Enterprise Linux 7.4 with NetApp ONTAP
:toc: macro
:hardbreaks:
:toclevels: 1
:nofooter:
:icons: font
:linkattrs:
:imagesdir: ./media/

== Installing the Linux Unified Host Utilities

The NetApp Linux Unified Host Utilities software package is available on the
link:https://mysupport.netapp.com/NOW/cgi-bin/software/?product=Host+Utilities+-
+SAN&platform=Linux[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
```

```
link:https://mysupport.netapp.com/matrix/#welcome[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.

.Before you begin

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.

.   Download the 32-bit or 64-bit Linux Unified Host Utilities software package from the
link:https://mysupport.netapp.com/NOW/cgi-bin/software/?product=Host+Utilities+-
+SAN&platform=Linux[NetApp Support Site^] Site to your host.
.   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

.Before you begin
If you decide to use SAN booting, it must be supported by your configuration. You can use
the
link:https://mysupport.netapp.com/matrix/imt.jsp?components=79384;&solution=1&isHWU&src=I
MT[NetApp Interoperability Matrix Tool^] to verify that your OS, HBA, HBA firmware and
the HBA boot BIOS, and ONTAP version are supported.

.   Map the SAN boot LUN to the host.
.   Verify multiple paths are available.
+
Remember, multiple paths will only be available after the host OS is up and running on
the paths.
.   Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is
mapped.
+
For information on how to enable the HBA BIOS, see your vendor-specific documentation.
.   Reboot the host to verify the boot is successful.

== Multipathing

For Red Hat Enterprise Linux (RHEL) 7.4 the /etc/multipath.conf file must exist, but you
do not need to make specific changes to the file. RHEL 7.4 is compiled with all settings
required to recognize and correctly manage ONTAP LUNs.

You can use the `multipath -ll` command to verify the settings for your ONTAP LUNs.
The following sections provide sample multipath output for a LUN mapped to ASA and non-
ASA personas.

=== All SAN Array Configuration

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

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

multipath -ll

3600a09803831347657244e527766394e dm-5 NETAPP,LUN C-Mode
size=80G features='4 queue_if_no_path pg_init_retries 50 retain_attached_hw_handle' hwhandler='1 alua' wp=rw
`-+- policy='service-time 0' prio=50 status=active

|- 11:0:7:1 sdfi 130:64 active ready running
|- 11:0:9:1 sdiy 8:288 active ready running
|- 11:0:10:1 sdml 69:464 active ready running
|- 11:0:11:1 sdpt 131:304 active ready running

```
.Note
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

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

== Recommended Settings

The RHEL 7.4 OS is compiled to recognize ONTAP LUNs and automatically set all
configuration parameters correctly for both ASA and non-ASA configuration.
The multipath.conf file must exist for the multipath daemon to start, but you can create
an empty, zero-byte file using the command:
`touch /etc/multipath.conf`
The first time you create this file, you might need to enable and start the multipath
services.
```

systemctl enable multipathd
[root@jfs0 ~] systemctl start multipathd

```
There is no requirement to add anything directly to multipath.conf, 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.

.Note
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.

.   Run the following command to determine the WWID:
+
....
# /lib/udev/scsi_id -gud /dev/sda
360030057024d0730239134810c0cb833
....
.   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.


[cols=2*,options="header"]
|===
| Parameter
| Setting
| detect_prio | yes
| dev_loss_tmo | "infinity"
| failback | immediate
| fast_io_fail_tmo | 5
| features | "3 queue_if_no_path pg_init_retries 50"
| flush_on_last_del | "yes"
| hardware_handler | "0"
| no_path_retry | queue
| path_checker | "tur"
| path_grouping_policy | "group_by_prio"
| path_selector | "service-time 0"
| polling_interval | 5
| prio | "ontap"
| product | LUN.*
| retain_attached_hw_handler | yes
| rr_weight | "uniform"
| user_friendly_names | no
| vendor | NETAPP
|===

.Example

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

defaults {
path_checker readsector0
no_path_retry fail
}

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

```
}
}
```

```
== Known Problems and Limitations

There are no known issues for RHEL 7.4.

== 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 fail 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
link:https://www.netapp.com/us/media/tr-3633.pdf[Oracle Databases on ONTAP^] for further
information.

[[ID79d0d4e58bfb66b2385678602d94e551]]
= Using Red Hat Enterprise Linux 7.3 with NetApp ONTAP
:toc: macro
:hardbreaks:
:toclevels: 1
:nofooter:
:icons: font
:linkattrs:
:imagesdir: ./media/

== Installing the Linux Unified Host Utilities

The NetApp Linux Unified Host Utilities software package is available on the
link:https://mysupport.netapp.com/NOW/cgi-bin/software/?product=Host+Utilities+-
+SAN&platform=Linux[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
link:https://mysupport.netapp.com/matrix/#welcome[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.

.Before you begin

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.

.   Download the 32-bit or 64-bit Linux Unified Host Utilities software package from the
link:https://mysupport.netapp.com/NOW/cgi-bin/software/?product=Host+Utilities+-
+SAN&platform=Linux[NetApp Support Site^] Site to your host.
.   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

.Before you begin
If you decide to use SAN booting, it must be supported by your configuration. You can use
the
link:https://mysupport.netapp.com/matrix/imt.jsp?components=76238;&solution=1&isHWU&src=I
MT[NetApp Interoperability Matrix Tool^] to verify that your OS, HBA, HBA firmware and
the HBA boot BIOS, and ONTAP version are supported.

.   Map the SAN boot LUN to the host.
.   Verify multiple paths are available.
+
Remember, multiple paths will only be available after the host OS is up and running on
the paths.
.   Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is
```

```
mapped.
+
For information on how to enable the HBA BIOS, see your vendor-specific documentation.
.   Reboot the host to verify the boot is successful.

== Multipathing

For Red Hat Enterprise Linux (RHEL) 7.3 the /etc/multipath.conf file must exist, but you
do not need to make specific changes to the file. RHEL 7.3 is compiled with all settings
required to recognize and correctly manage ONTAP LUNs.

You can use the `multipath -ll` command to verify the settings for your ONTAP LUNs.
The following sections provide sample multipath output for a LUN mapped to ASA and non-
ASA personas.

=== All SAN Array Configuration

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

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

----
# multipath -ll
3600a09803831347657244e527766394e dm-5 NETAPP,LUN C-Mode
size=80G  features='4 queue_if_no_path pg_init_retries 50 retain_attached_hw_handle'
hwhandler='1 alua' wp=rw
`-+- policy='service-time 0' prio=50 status=active
  |- 11:0:7:1    sdfi   130:64   active ready running
  |- 11:0:9:1    sdiy  8:288     active ready running
  |- 11:0:10:1  sdml 69:464   active ready running
  |- 11:0:11:1  sdpt  131:304  active ready running
----

.Note
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
----

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

== Recommended Settings

The RHEL 7.3 OS is compiled to recognize ONTAP LUNs and automatically set all
configuration parameters correctly for both ASA and non-ASA configuration.
The multipath.conf file must exist for the multipath daemon to start, but you can create
an empty, zero-byte file using the command:
`touch /etc/multipath.conf`
The first time you create this file, you might need to enable and start the multipath
services.
----
[root@jfs0 ~]#systemctl enable multipathd
[root@jfs0 ~]# systemctl start multipathd
----
There is no requirement to add anything directly to multipath.conf, 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.

.Note
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.

.   Run the following command to determine the WWID:
+
....
# /lib/udev/scsi_id -gud /dev/sda
360030057024d0730239134810c0cb833
....
.   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.


[cols=2*,options="header"]
|===
| Parameter
| Setting
| detect_prio | yes
| dev_loss_tmo | "infinity"
| failback | immediate
| fast_io_fail_tmo | 5
| features | "3 queue_if_no_path pg_init_retries 50"
| flush_on_last_del | "yes"
| hardware_handler | "0"
| no_path_retry | queue
| path_checker | "tur"
```

```
| path_grouping_policy | "group_by_prio"
| path_selector | "service-time 0"
| polling_interval | 5
| prio | "ontap"
| product | LUN.*
| retain_attached_hw_handler | yes
| rr_weight | "uniform"
| user_friendly_names | no
| vendor | NETAPP
|===

.Example

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

----
defaults {
   path_checker      readsector0
   no_path_retry      fail
}

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

== Known Problems and Limitations

There are no known issues for RHEL 7.3.

== Release Notes

=== ASM Mirroring

ASM mirroring might require changes to the Linux multipath settings to allow ASM to
recognize a problem and switch over to an alternate fail 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
```

```
link:https://www.netapp.com/us/media/tr-3633.pdf[Oracle Databases on ONTAP^] for further
information.

[[IDf7d3412373de5f27a304ad988694c256]]
= Using Red Hat Enterprise Linux 7.2 with NetApp ONTAP
:toc: macro
:hardbreaks:
:toclevels: 1
:nofooter:
:icons: font
:linkattrs:
:imagesdir: ./media/

== Installing the Linux Unified Host Utilities

The NetApp Linux Unified Host Utilities software package is available on the
link:https://mysupport.netapp.com/NOW/cgi-bin/software/?product=Host+Utilities+-
+SAN&platform=Linux[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
link:https://mysupport.netapp.com/matrix/#welcome[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.

.Before you begin

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.

.   Download the 32-bit or 64-bit Linux Unified Host Utilities software package from the
link:https://mysupport.netapp.com/NOW/cgi-bin/software/?product=Host+Utilities+-
+SAN&platform=Linux[NetApp Support Site^] Site to your host.
.   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

.Before you begin
If you decide to use SAN booting, it must be supported by your configuration. You can use
the
link:https://mysupport.netapp.com/matrix/imt.jsp?components=71498;&solution=1&isHWU&src=I
MT[NetApp Interoperability Matrix Tool^] to verify that your OS, HBA, HBA firmware and
the HBA boot BIOS, and ONTAP version are supported.

.   Map the SAN boot LUN to the host.
.   Verify multiple paths are available.
+
Remember, multiple paths will only be available after the host OS is up and running on
the paths.
.   Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is
mapped.
+
For information on how to enable the HBA BIOS, see your vendor-specific documentation.
.   Reboot the host to verify the boot is successful.

== Multipathing

For Red Hat Enterprise Linux (RHEL) 7.2 the /etc/multipath.conf file must exist, but you
do not need to make specific changes to the file. RHEL 7.2 is compiled with all settings
required to recognize and correctly manage ONTAP LUNs.

You can use the `multipath -ll` command to verify the settings for your ONTAP LUNs.
The following sections provide sample multipath output for a LUN mapped to ASA and non-
ASA personas.

=== All SAN Array Configuration

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

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

multipath -ll

3600a09803831347657244e527766394e dm-5 NETAPP,LUN C-Mode
size=80G features='4 queue_if_no_path pg_init_retries 50 retain_attached_hw_handle' hwhandler='1 alua' wp=rw
`-+- policy='service-time 0' prio=50 status=active

|- 11:0:7:1 sdfi 130:64 active ready running
|- 11:0:9:1 sdiy 8:288 active ready running
|- 11:0:10:1 sdml 69:464 active ready running
|- 11:0:11:1 sdpt 131:304 active ready running

```
.Note
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

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

== Recommended Settings

The RHEL 7.2 OS is compiled to recognize ONTAP LUNs and automatically set all
configuration parameters correctly for both ASA and non-ASA configuration.
The multipath.conf file must exist for the multipath daemon to start, but you can create
an empty, zero-byte file using the command:
`touch /etc/multipath.conf`
The first time you create this file, you might need to enable and start the multipath
services.
```

systemctl enable multipathd
[root@jfs0 ~] systemctl start multipathd

```
There is no requirement to add anything directly to multipath.conf, 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.

.Note
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.

.   Run the following command to determine the WWID:
+
....
# /lib/udev/scsi_id -gud /dev/sda
360030057024d0730239134810c0cb833
....
.   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.


[cols=2*,options="header"]
|===
| Parameter
| Setting
| detect_prio | yes
| dev_loss_tmo | "infinity"
| failback | immediate
| fast_io_fail_tmo | 5
| features | "3 queue_if_no_path pg_init_retries 50"
| flush_on_last_del | "yes"
| hardware_handler | "0"
| no_path_retry | queue
| path_checker | "tur"
| path_grouping_policy | "group_by_prio"
| path_selector | "service-time 0"
| polling_interval | 5
| prio | "ontap"
| product | LUN.*
| retain_attached_hw_handler | yes
| rr_weight | "uniform"
| user_friendly_names | no
| vendor | NETAPP
|===

.Example

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

defaults {
path_checker readsector0
no_path_retry fail
}

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

```
}
}
```

```
== Known Problems and Limitations

There are no known issues for RHEL 7.2.

== Release Notes

=== ASM Mirroring

ASM mirroring might require changes to the Linux multipath settings to allow ASM to
recognize a problem and switch over to an alternate fail 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
link:https://www.netapp.com/us/media/tr-3633.pdf[Oracle Databases on ONTAP^] for further
information.

[[ID27b3564636e1fd3eb34e732bf3191d9f]]
= Using Red Hat Enterprise Linux 7.1 with NetApp ONTAP
:toc: macro
:hardbreaks:
:toclevels: 1
:nofooter:
:icons: font
:linkattrs:
:imagesdir: ./media/

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link:https://mysupport.netapp.com/NOW/cgi-bin/software/?product=Host+Utilities+-
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know which file is right for your configuration, use the
link:https://mysupport.netapp.com/matrix/#welcome[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.

.Before you begin

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.

.   Download the 32-bit or 64-bit Linux Unified Host Utilities software package from the
link:https://mysupport.netapp.com/NOW/cgi-bin/software/?product=Host+Utilities+-
+SAN&platform=Linux[NetApp Support Site^] Site to your host.
.   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
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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

.Before you begin
If you decide to use SAN booting, it must be supported by your configuration. You can use
the
link:https://mysupport.netapp.com/matrix/imt.jsp?components=70064;&solution=1&isHWU&src=I
MT[NetApp Interoperability Matrix Tool^] to verify that your OS, HBA, HBA firmware and
the HBA boot BIOS, and ONTAP version are supported.

.   Map the SAN boot LUN to the host.
.   Verify multiple paths are available.
+
Remember, multiple paths will only be available after the host OS is up and running on
the paths.
.   Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is
```

```
mapped.
+
For information on how to enable the HBA BIOS, see your vendor-specific documentation.
.   Reboot the host to verify the boot is successful.

== Multipathing

For Red Hat Enterprise Linux (RHEL) 7.1 the /etc/multipath.conf file must exist, but you
do not need to make specific changes to the file. RHEL 7.1 is compiled with all settings
required to recognize and correctly manage ONTAP LUNs.

You can use the `multipath -ll` command to verify the settings for your ONTAP LUNs.
The following sections provide sample multipath output for a LUN mapped to ASA and non-
ASA personas.

=== All SAN Array Configuration

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

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

----
# multipath -ll
3600a09803831347657244e527766394e dm-5 NETAPP,LUN C-Mode
size=80G  features='4 queue_if_no_path pg_init_retries 50 retain_attached_hw_handle'
hwhandler='1 alua' wp=rw
`-+- policy='service-time 0' prio=50 status=active
  |- 11:0:7:1    sdfi   130:64   active ready running
  |- 11:0:9:1    sdiy  8:288     active ready running
  |- 11:0:10:1  sdml 69:464   active ready running
  |- 11:0:11:1  sdpt  131:304  active ready running
----

.Note
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
----

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

== Recommended Settings

The RHEL 7.1 OS is compiled to recognize ONTAP LUNs and automatically set all
configuration parameters correctly for both ASA and non-ASA configuration.
The multipath.conf file must exist for the multipath daemon to start, but you can create
an empty, zero-byte file using the command:
`touch /etc/multipath.conf`
The first time you create this file, you might need to enable and start the multipath
services.
----
[root@jfs0 ~]#systemctl enable multipathd
[root@jfs0 ~]# systemctl start multipathd
----
There is no requirement to add anything directly to multipath.conf, 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.

.Note
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.

.   Run the following command to determine the WWID:
+
....
# /lib/udev/scsi_id -gud /dev/sda
360030057024d0730239134810c0cb833
....
.   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.


[cols=2*,options="header"]
|===
| Parameter
| Setting
| detect_prio | yes
| dev_loss_tmo | "infinity"
| failback | immediate
| fast_io_fail_tmo | 5
| features | "3 queue_if_no_path pg_init_retries 50"
| flush_on_last_del | "yes"
| hardware_handler | "0"
| no_path_retry | queue
| path_checker | "tur"
```

```
| path_grouping_policy | "group_by_prio"
| path_selector | "service-time 0"
| polling_interval | 5
| prio | "ontap"
| product | LUN.*
| retain_attached_hw_handler | yes
| rr_weight | "uniform"
| user_friendly_names | no
| vendor | NETAPP
|===

.Example

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

----
defaults {
   path_checker      readsector0
   no_path_retry      fail
}

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

== Known Problems and Limitations

[cols=4*,options="header"]
|===
| NetApp Bug ID
| Title
| Description
| Bugzilla ID
| link:https://mysupport.netapp.com/NOW/cgi-bin/bol?Type=Detail&Display=799323[799323^] |
Emulex FCoE (OCe10102-FX-D) host hang or path failures observed during I/O with storage
failover operations | You might observe a host hang or path failures on Emulex 10G FCoE
host (OCe10102-FX-D) during I/O with storage failover operations. In such scenarios, you
might see the following message:
```

```
 "driver's buffer pool is empty, IO busied and SCSI Layer I/O Abort Request Status"
| link:https://bugzilla.redhat.com/show_bug.cgi?id=1061755[1061755^]
| link:https://mysupport.netapp.com/NOW/cgi-bin/bol?Type=Detail&Display=836875[836875^] |
IP addresses are not always assigned during the boot of a RHEL 7.0 OS installed on an
iSCSI multipath'd LUN | When you install the root(/) on a iSCSI multipath d LUN, the IP
address for the  Ethernet interfaces are specified in the kernel command line so that the
IP addresses are assigned before the iSCSI service starts. However, dracut cannot assign
IP addresses to all the Ethernet ports during the boot, before the iSCSI service starts.
This causes the iSCSI login to fail on interfaces without IP addresses. You will see the
iSCSI service attempt to login numerous times,  which will cause a delay in the OS boot
time. | link:https://bugzilla.redhat.com/show_bug.cgi?id=1114966[1114966^]
|===

== 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 fail 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
link:https://www.netapp.com/us/media/tr-3633.pdf[Oracle Databases on ONTAP^] for further
information.

[[IDe667973011aa7173c4e1ce01c5b0e167]]
= Using Red Hat Enterprise Linux 7.0 with NetApp ONTAP
:toc: macro
:hardbreaks:
:toclevels: 1
:nofooter:
:icons: font
:linkattrs:
:imagesdir: ./media/

== Installing the Linux Unified Host Utilities

The NetApp Linux Unified Host Utilities software package is available on the
link:https://mysupport.netapp.com/NOW/cgi-bin/software/?product=Host+Utilities+-
+SAN&platform=Linux[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
link:https://mysupport.netapp.com/matrix/#welcome[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.
```

```
.Before you begin

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.

.   Download the 32-bit or 64-bit Linux Unified Host Utilities software package from the
link:https://mysupport.netapp.com/NOW/cgi-bin/software/?product=Host+Utilities+-
+SAN&platform=Linux[NetApp Support Site^] Site to your host.
.   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

.Before you begin
If you decide to use SAN booting, it must be supported by your configuration. You can use
the
link:https://mysupport.netapp.com/matrix/imt.jsp?components=68128;&solution=1&isHWU&src=I
MT[NetApp Interoperability Matrix Tool^] to verify that your OS, HBA, HBA firmware and
the HBA boot BIOS, and ONTAP version are supported.

.   Map the SAN boot LUN to the host.
.   Verify multiple paths are available.
+
Remember, multiple paths will only be available after the host OS is up and running on
the paths.
.   Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is
mapped.
+
For information on how to enable the HBA BIOS, see your vendor-specific documentation.
.   Reboot the host to verify the boot is successful.

== Multipathing

For Red Hat Enterprise Linux (RHEL) 7.0 the /etc/multipath.conf file must exist, but you
do not need to make specific changes to the file. RHEL 7.0 is compiled with all settings
required to recognize and correctly manage ONTAP LUNs.

You can use the `multipath -ll` command to verify the settings for your ONTAP LUNs.
The following sections provide sample multipath output for a LUN mapped to ASA and non-
ASA personas.

=== All SAN Array Configuration

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

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

multipath -ll

3600a09803831347657244e527766394e dm-5 NETAPP,LUN C-Mode
size=80G features='4 queue_if_no_path pg_init_retries 50 retain_attached_hw_handle' hwhandler='1 alua' wp=rw
`-+- policy='service-time 0' prio=50 status=active

|- 11:0:7:1 sdfi 130:64 active ready running
|- 11:0:9:1 sdiy 8:288 active ready running
|- 11:0:10:1 sdml 69:464 active ready running
|- 11:0:11:1 sdpt 131:304 active ready running

```
.Note
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

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

== Recommended Settings

The RHEL 7.0 OS is compiled to recognize ONTAP LUNs and automatically set all
configuration parameters correctly for both ASA and non-ASA configuration.
The multipath.conf file must exist for the multipath daemon to start, but you can create
an empty, zero-byte file using the command:
`touch /etc/multipath.conf`
The first time you create this file, you might need to enable and start the multipath
services.
```

systemctl enable multipathd
[root@jfs0 ~] systemctl start multipathd

```
There is no requirement to add anything directly to multipath.conf, 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.

.Note
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.

.   Run the following command to determine the WWID:
+
....
# /lib/udev/scsi_id -gud /dev/sda
360030057024d0730239134810c0cb833
....
.   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.


[cols=2*,options="header"]
|===
| Parameter
| Setting
| detect_prio | yes
| dev_loss_tmo | "infinity"
| failback | immediate
| fast_io_fail_tmo | 5
| features | "3 queue_if_no_path pg_init_retries 50"
| flush_on_last_del | "yes"
| hardware_handler | "0"
| no_path_retry | queue
| path_checker | "tur"
| path_grouping_policy | "group_by_prio"
| path_selector | "service-time 0"
| polling_interval | 5
| prio | "ontap"
| product | LUN.*
| retain_attached_hw_handler | yes
| rr_weight | "uniform"
| user_friendly_names | no
| vendor | NETAPP
|===

.Example

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

defaults {
path_checker readsector0
no_path_retry fail
}

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

```
}
}
```

```
== Known Problems and Limitations

[cols=4*,options="header"]
|===
| NetApp Bug ID
| Title
| Description
| Bugzilla ID
| link:https://mysupport.netapp.com/NOW/cgi-bin/bol?Type=Detail&Display=844417[844417^] |
Emulex 16G FC (LPe16002B-M6) host crashes during I/O with storage failover operations |
You might observe a 16G FC Emulex (LPe16002B-M6) host crash during I/O with storage
failover operations.
| link:https://bugzilla.redhat.com/show_bug.cgi?id=1131393[1131393^]
| link:https://mysupport.netapp.com/NOW/cgi-bin/bol?Type=Detail&Display=811587[811587^] |
Emulex 16G FC (LPe16002B-M6) host crashes during I/O with storage failover operations |
You might observe a 16G FC Emulex (LPe16002B-M6) host crash during I/O with storage
failover operations. | link:https://bugzilla.redhat.com/show_bug.cgi?id=1079735[1079735^]
| link:https://mysupport.netapp.com/NOW/cgi-bin/bol?Type=Detail&Display=803071[803071^] |
Emulex 16G FC (LPe16002B-M6) host crashes during I/O with storage failover operations |
You might observe a 16G FC Emulex (LPe16002B-M6) host crash during I/O with storage
failover operations. | link:https://bugzilla.redhat.com/show_bug.cgi?id=1067895[1067895^]
| link:https://mysupport.netapp.com/NOW/cgi-bin/bol?Type=Detail&Display=820163[820163^] |
QLogic host hang or path failures observed during I/O with storage failover operations |
You might observe a host hang or path failures on QLogic host during I/O with storage
failover operations. In such scenarios, you might see the following message: "Mailbox cmd
timeout occurred, cmd=0x54, mb[0]=0x54 and Firmware dump saved to temp buffer" messages
which leads to host hung/path failure. |
link:https://bugzilla.redhat.com/show_bug.cgi?id=1090378[1090378^]
| link:https://mysupport.netapp.com/NOW/cgi-bin/bol?Type=Detail&Display=799323[799323^] |
Emulex FCoE (OCe10102-FX-D) host hang or path failures observed during I/O with storage
failover operations | You might observe a host hang or path failures on Emulex 10G FCoE
host (OCe10102-FX-D) during I/O with storage failover operations. In such scenarios, you
might see the following message:  "driver's buffer pool is empty, IO busied and SCSI
Layer I/O Abort Request Status" messages which leads to host hung/path failures. |
link:https://bugzilla.redhat.com/show_bug.cgi?id=1061755[1061755^]
| link:https://mysupport.netapp.com/NOW/cgi-bin/bol?Type=Detail&Display=849212[849212^] |
Emulex 16G FC (LPe16002B-M6) host hang or path failures are observed during I/O with
storage failover operations | You might observe a host hang or path failures on Emulex
16G FC (LPe16002B-M6) host during I/O with storage failover operations. In such
scenarios, you might see the following message:  "RSCN timeout Data and iotag x1301 is
out of range: max iotag" messages which leads to host hung/path failures. |
link:https://bugzilla.redhat.com/show_bug.cgi?id=1109274[1109274^]
| link:https://mysupport.netapp.com/NOW/cgi-bin/bol?Type=Detail&Display=836800[836800^] |
Anaconda displays an iSCSI login failure message although logins are successful during
```

```
RHEL 7.0 OS installation | When you install the root(/) on a iSCSI multipath□d LUN, the IP
address for the  Ethernet interfaces are specified in the kernel command line so that the
IP addresses are assigned before the iSCSI service starts. However, dracut cannot assign
IP addresses to all the Ethernet ports during the boot, before the iSCSI service starts.
This causes the iSCSI login to fail on interfaces without IP addresses. You will see the
iSCSI service attempt to login numerous times,  which will cause a delay in the OS boot
time. | link:https://bugzilla.redhat.com/show_bug.cgi?id=1114966[1114966^]
| link:https://mysupport.netapp.com/NOW/cgi-bin/bol?Type=Detail&Display=836875[836875^] |
IP addresses are not always assigned during the boot of a RHEL 7.0 OS installed on an
iSCSI multipath'd LUN | When you are installing RHEL 7.0, the anaconda installation
screen displays that iSCSI login to multiple target IPs have failed though the iSCSI
logins are successful. Anaconda displays following error message: □Node Login Failed□ You
will observe this error only when you select multiple target IPs for iSCSI login. You can
continue the OS installation by clicking the "ok" button. This bug does not hamper either
the iSCSI or the RHEL 7.0 OS installation. |
link:https://bugzilla.redhat.com/show_bug.cgi?id=1114820[1114820^]
| link:https://mysupport.netapp.com/NOW/cgi-bin/bol?Type=Detail&Display=836657[836657^] |
Anaconda does not add bootdev argument in kernel cmd line to set IP address for RHEL 7.0
OS installed on iSCSI multipath'd LUN | Anaconda does not add a bootdev argument in the
kernel command line where you set the IPv4 address during the RHEL 7.0 OS installation on
an iSCSI multipath'd LUN. This prevents assigning of IP addresses to any of the Ethernet
interfaces that were configured to establish iSCSI sessions with the storage subsystem
during the RHEL 7.0 boot. Since iSCSI sessions are not established, the root LUN is not
discovered when the OS boots and hence the OS boot fails. |
link:https://bugzilla.redhat.com/show_bug.cgi?id=1114464[1114464^]
|===

== 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 fail 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
link:https://www.netapp.com/us/media/tr-3633.pdf[Oracle Databases on ONTAP^] for further
information.


:leveloffset: -1


= RHEL 6

:leveloffset: +1

[[ID4122d3b7990fbe18e6288562a7fdba20]]
```

```
= Using Red Hat Enterprise Linux 6.10 with NetApp ONTAP
:toc: macro
:hardbreaks:
:toclevels: 1
:nofooter:
:icons: font
:linkattrs:
:imagesdir: ./media/

== Installing the Linux Unified Host Utilities

The NetApp Linux Unified Host Utilities software package is available on the
link:https://mysupport.netapp.com/NOW/cgi-bin/software/?product=Host+Utilities+-
+SAN&platform=Linux[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
link:https://mysupport.netapp.com/matrix/#welcome[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.

.Before you begin

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.

.   Download the 32-bit or 64-bit Linux Unified Host Utilities software package from the
link:https://mysupport.netapp.com/NOW/cgi-bin/software/?product=Host+Utilities+-
+SAN&platform=Linux[NetApp Support Site^] Site to your host.
.   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

.Before you begin
If you decide to use SAN booting, it must be supported by your configuration. You can use
the
link:https://mysupport.netapp.com/matrix/imt.jsp?components=84158;&solution=1&isHWU&src=I
MT[NetApp Interoperability Matrix Tool^] to verify that your OS, HBA, HBA firmware and
the HBA boot BIOS, and ONTAP version are supported.

.   Map the SAN boot LUN to the host.
.   Verify multiple paths are available.
+
Remember, multiple paths will only be available after the host OS is up and running on
the paths.
.   Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is
mapped.
+
For information on how to enable the HBA BIOS, see your vendor-specific documentation.
.   Reboot the host to verify the boot is successful.

== Multipathing

For Red Hat Enterprise Linux (RHEL) 6.10 the /etc/multipath.conf file must exist, but you
do not need to make specific changes to the file. RHEL 6.10 is compiled with all settings
required to recognize and correctly manage ONTAP LUNs.
To Enable ALUA Handler, perform the following steps:

.   Create a backup of the initrd-image.
.   Append the following parameter value to the kernel for ALUA and non-ALUA to work:
`rdloaddriver=scsi_dh_alua`
+
.Example
....
kernel /vmlinuz-2.6.32-358.6.1.el6.x86_64 ro root=/dev/mapper/ vg_ibmx355021082-lv_root
rd_NO_LUKS rd_LVM_LV=vg_ibmx355021082/ lv_root LANG=en_US.UTF-8
rd_LVM_LV=vg_ibmx355021082/lv_swap rd_NO_MD SYSFONT=latarcyrheb-sun16 crashkernel=auto
```

```
KEYBOARDTYPE=pc KEYTABLE=us rd_NO_DM rhgb quiet rdloaddriver=scsi_dh_alua
....
.   Use the `mkinitrd` command to recreate the initrd-image.
RHEL 6x and later versions use either:
The command: `mkinitrd -f /boot/ initrd-"uname -r".img uname -r`
Or
The command: `dracut -f`
.   Reboot the host.
.   Verify the output of the `cat /proc/cmdline` command to ensure that the setting is
complete.

You can use the `multipath -ll` command to verify the settings for your ONTAP LUNs.
The following sections provide sample multipath output for a LUN mapped to ASA and non-
ASA personas.

=== All SAN Array Configuration

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

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

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

.Note
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
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
----

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

== Recommended Settings

The RHEL 6.10 OS is compiled to recognize ONTAP LUNs and automatically set all
configuration parameters correctly for both ASA and non-ASA configuration.
The multipath.conf file must exist for the multipath daemon to start, but you can create
an empty, zero-byte file using the command:
`touch /etc/multipath.conf`
The first time you create this file, you might need to enable and start the multipath
services.
----
[root@jfs0 ~]#systemctl enable multipathd
[root@jfs0 ~]# systemctl start multipathd
----
There is no requirement to add anything directly to multipath.conf, 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.

.Note
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.

.   Run the following command to determine the WWID:
+
....
# /lib/udev/scsi_id -gud /dev/sda
360030057024d0730239134810c0cb833
....
.   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.


[cols=2*,options="header"]
|===
| Parameter
| Setting
| detect_prio | yes
| dev_loss_tmo | "infinity"
| failback | immediate
| fast_io_fail_tmo | 5
| features | "3 queue_if_no_path pg_init_retries 50"
| flush_on_last_del | "yes"
| hardware_handler | "0"
| no_path_retry | queue
| path_checker | "tur"
```

```
| path_grouping_policy | "group_by_prio"
| path_selector | "round-robin 0"
| polling_interval | 5
| prio | "ontap"
| product | LUN.*
| retain_attached_hw_handler | yes
| rr_weight | "uniform"
| user_friendly_names | no
| vendor | NETAPP
|===

.Example

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

----
defaults {
   path_checker      readsector0
   no_path_retry      fail
}

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

== Known Problems and Limitations

There are no known issues for RHEL 6.10.

== 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 fail 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
```

```
link:https://www.netapp.com/us/media/tr-3633.pdf[Oracle Databases on ONTAP^] for further
information.

[[ID2d79a539ff39c6fdad744574079b990b]]
= Using Red Hat Enterprise Linux 6.9 with NetApp ONTAP
:toc: macro
:hardbreaks:
:toclevels: 1
:nofooter:
:icons: font
:linkattrs:
:imagesdir: ./media/

== Installing the Linux Unified Host Utilities

The NetApp Linux Unified Host Utilities software package is available on the
link:https://mysupport.netapp.com/NOW/cgi-bin/software/?product=Host+Utilities+-
+SAN&platform=Linux[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
link:https://mysupport.netapp.com/matrix/#welcome[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.

.Before you begin

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.

.   Download the 32-bit or 64-bit Linux Unified Host Utilities software package from the
link:https://mysupport.netapp.com/NOW/cgi-bin/software/?product=Host+Utilities+-
+SAN&platform=Linux[NetApp Support Site^] Site to your host.
.   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

.Before you begin
If you decide to use SAN booting, it must be supported by your configuration. You can use
the
link:https://mysupport.netapp.com/matrix/imt.jsp?components=77603;&solution=1&isHWU&src=I
MT[NetApp Interoperability Matrix Tool^] to verify that your OS, HBA, HBA firmware and
the HBA boot BIOS, and ONTAP version are supported.

.   Map the SAN boot LUN to the host.
.   Verify multiple paths are available.
+
Remember, multiple paths will only be available after the host OS is up and running on
the paths.
.   Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is
mapped.
+
For information on how to enable the HBA BIOS, see your vendor-specific documentation.
.   Reboot the host to verify the boot is successful.

== Multipathing

For Red Hat Enterprise Linux (RHEL) 6.9 the /etc/multipath.conf file must exist, but you
do not need to make specific changes to the file. RHEL 6.9 is compiled with all settings
required to recognize and correctly manage ONTAP LUNs.
To Enable ALUA Handler, perform the following steps:

.   Create a backup of the initrd-image.
.   Append the following parameter value to the kernel for ALUA and non-ALUA to work:
`rdloaddriver=scsi_dh_alua`
+
.Example
....
kernel /vmlinuz-2.6.32-358.6.1.el6.x86_64 ro root=/dev/mapper/ vg_ibmx355021082-lv_root
```

```
rd_NO_LUKS rd_LVM_LV=vg_ibmx355021082/ lv_root LANG=en_US.UTF-8
rd_LVM_LV=vg_ibmx355021082/lv_swap rd_NO_MD SYSFONT=latarcyrheb-sun16 crashkernel=auto
KEYBOARDTYPE=pc KEYTABLE=us rd_NO_DM rhgb quiet rdloaddriver=scsi_dh_alua
....
.   Use the `mkinitrd` command to recreate the initrd-image.
RHEL 6x and later versions use either:
The command: `mkinitrd -f /boot/ initrd-"uname -r".img uname -r`
Or
The command: `dracut -f`
.   Reboot the host.
.   Verify the output of the `cat /proc/cmdline` command to ensure that the setting is
complete.

You can use the `multipath -ll` command to verify the settings for your ONTAP LUNs.
The following sections provide sample multipath output for a LUN mapped to ASA and non-
ASA personas.

=== All SAN Array Configuration

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

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

multipath -ll

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

```
.Note
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

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

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

== Recommended Settings

The RHEL 6.9 OS is compiled to recognize ONTAP LUNs and automatically set all
configuration parameters correctly for both ASA and non-ASA configuration.
The multipath.conf file must exist for the multipath daemon to start, but you can create
an empty, zero-byte file 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
[root@jfs0 ~] systemctl start multipathd

```
There is no requirement to add anything directly to multipath.conf, 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.

.Note
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.

.   Run the following command to determine the WWID:
+
....
# /lib/udev/scsi_id -gud /dev/sda
360030057024d0730239134810c0cb833
....
.   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.


[cols=2*,options="header"]
```

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

.Example

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

defaults {
path_checker readsector0
no_path_retry fail
}

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

```
== Known Problems and Limitations
```

```
[cols=4*,options="header"]
|===
| NetApp Bug ID
| Title
| Description
| Bugzilla ID
| link:https://mysupport.netapp.com/NOW/cgi-bin/bol?Type=Detail&Display=1067272[1067272^]
| Remote port status on EMULEX LPe32002 host might be in 'Blocked' state during storage
failover operations | During storage failover operations, certain remote port status on
RHEL 6.9 host with LPe32002 adapter might get into 'Blocked' state. Because the logical
interfaces go down when a storage node is down, the remote port sets the storage node
status to "Blocked" state.  However, when the storage node comes back to optimal state,
the logical interfaces also comes up and the remote port state is expected to be
'Online'.  But, on certain occasion the remote port continues to be in 'Blocked' state.
This state manifests as 'failed faulty' to LUNS at multipath layer. |
link:https://bugzilla.redhat.com/show_bug.cgi?id=1427496[427496^]
| link:https://mysupport.netapp.com/NOW/cgi-bin/bol?Type=Detail&Display=1076584[1076584^]
| Firmware dumps occur on Red Hat Enterprise Linux 6.9 QLogic QE8362 HBA during storage
failover operations | Firmware dumps can occur during storage failover operations on Red
Hat Enterprise Linux (RHEL) 6.9 hosts with QLogic QLE8362 host bus adapters (HBA),
firmware dumps are observed occasionally. The firmware dumps might manifest as an I/O
outage on the host that can last as long as 1200 seconds. After the adapter completes
dumping the firmware cores, the I/O operation resumes normally.  No further recovery
procedure is required on the host. To indicate the firmware dump, the following message
is displayed in /var/log/ message file: kernel: qla2xxx [0000:0c:00.3]-d001:3: Firmware
dump saved to temp buffer (3/ffffc90018b01000), dump status flags (0x3f) |
link:https://bugzilla.redhat.com/show_bug.cgi?id=1438711[1438711^]
|===

== 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 fail 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
link:https://www.netapp.com/us/media/tr-3633.pdf[Oracle Databases on ONTAP^] for further
information.

[[ID43a91d0d93d84beb80cf1fb3f04bcd32]]
= Using Red Hat Enterprise Linux 6.8 with NetApp ONTAP
:toc: macro
:hardbreaks:
:toclevels: 1
:nofooter:
```

```
:icons: font
:linkattrs:
:imagesdir: ./media/

== Installing the Linux Unified Host Utilities

The NetApp Linux Unified Host Utilities software package is available on the
link:https://mysupport.netapp.com/NOW/cgi-bin/software/?product=Host+Utilities+-
+SAN&platform=Linux[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
link:https://mysupport.netapp.com/matrix/#welcome[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.

.Before you begin

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.

.   Download the 32-bit or 64-bit Linux Unified Host Utilities software package from the
link:https://mysupport.netapp.com/NOW/cgi-bin/software/?product=Host+Utilities+-
+SAN&platform=Linux[NetApp Support Site^] Site to your host.
.   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

.Before you begin
If you decide to use SAN booting, it must be supported by your configuration. You can use
the
link:https://mysupport.netapp.com/matrix/imt.jsp?components=74223;&solution=1&isHWU&src=I
MT[NetApp Interoperability Matrix Tool^] to verify that your OS, HBA, HBA firmware and
the HBA boot BIOS, and ONTAP version are supported.

.   Map the SAN boot LUN to the host.
.   Verify multiple paths are available.
+
Remember, multiple paths will only be available after the host OS is up and running on
the paths.
.   Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is
mapped.
+
For information on how to enable the HBA BIOS, see your vendor-specific documentation.
.   Reboot the host to verify the boot is successful.

== Multipathing

For Red Hat Enterprise Linux (RHEL) 6.8 the /etc/multipath.conf file must exist, but you
do not need to make specific changes to the file. RHEL 6.8 is compiled with all settings
required to recognize and correctly manage ONTAP LUNs.
To Enable ALUA Handler, perform the following steps:

.   Create a backup of the initrd-image.
.   Append the following parameter value to the kernel for ALUA and non-ALUA to work:
`rdloaddriver=scsi_dh_alua`
+
.Example
....
kernel /vmlinuz-2.6.32-358.6.1.el6.x86_64 ro root=/dev/mapper/ vg_ibmx355021082-lv_root
rd_NO_LUKS rd_LVM_LV=vg_ibmx355021082/ lv_root LANG=en_US.UTF-8
rd_LVM_LV=vg_ibmx355021082/lv_swap rd_NO_MD SYSFONT=latarcyrheb-sun16 crashkernel=auto
KEYBOARDTYPE=pc KEYTABLE=us rd_NO_DM rhgb quiet rdloaddriver=scsi_dh_alua
....
.   Use the `mkinitrd` command to recreate the initrd-image.
RHEL 6x and later versions use either:
The command: `mkinitrd -f /boot/ initrd-"uname -r".img uname -r`
Or
```

```
The command: `dracut -f`
.   Reboot the host.
.   Verify the output of the `cat /proc/cmdline` command to ensure that the setting is
complete.

You can use the `multipath -ll` command to verify the settings for your ONTAP LUNs.
The following sections provide sample multipath output for a LUN mapped to ASA and non-
ASA personas.

=== All SAN Array Configuration

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

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

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

.Note
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
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
----

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

== Recommended Settings

The RHEL 6.8 OS is compiled to recognize ONTAP LUNs and automatically set all
configuration parameters correctly for both ASA and non-ASA configuration.
The multipath.conf file must exist for the multipath daemon to start, but you can create
an empty, zero-byte file using the command:
`touch /etc/multipath.conf`
The first time you create this file, you might need to enable and start the multipath
services.
----
[root@jfs0 ~]#systemctl enable multipathd
[root@jfs0 ~]# systemctl start multipathd
----
There is no requirement to add anything directly to multipath.conf, 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.

.Note
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.

.   Run the following command to determine the WWID:
+
....
# /lib/udev/scsi_id -gud /dev/sda
360030057024d0730239134810c0cb833
....
.   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.


[cols=2*,options="header"]
|===
| Parameter
| Setting
| detect_prio | yes
| dev_loss_tmo | "infinity"
| failback | immediate
| fast_io_fail_tmo | 5
| features | "3 queue_if_no_path pg_init_retries 50"
| flush_on_last_del | "yes"
| hardware_handler | "0"
| no_path_retry | queue
| path_checker | "tur"
| path_grouping_policy | "group_by_prio"
| path_selector | "round-robin 0"
| polling_interval | 5
| prio | "ontap"
| product | LUN.*
| retain_attached_hw_handler | yes
```

```
| rr_weight | "uniform"
| user_friendly_names | no
| vendor | NETAPP
|===

.Example

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

----
defaults {
   path_checker      readsector0
   no_path_retry      fail
}

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

== Known Problems and Limitations

There are no known issues for RHEL 6.8.

== 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 fail 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
link:https://www.netapp.com/us/media/tr-3633.pdf[Oracle Databases on ONTAP^] for further
information.

[[ID3f582f2c5ddee72c0a6fd66120383236]]
= Using Red Hat Enterprise Linux 6.7 with NetApp ONTAP
:toc: macro
```

```
:hardbreaks:
:toclevels: 1
:nofooter:
:icons: font
:linkattrs:
:imagesdir: ./media/

== Installing the Linux Unified Host Utilities

The NetApp Linux Unified Host Utilities software package is available on the
link:https://mysupport.netapp.com/NOW/cgi-bin/software/?product=Host+Utilities+-
+SAN&platform=Linux[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
link:https://mysupport.netapp.com/matrix/#welcome[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.

.Before you begin

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.

.   Download the 32-bit or 64-bit Linux Unified Host Utilities software package from the
link:https://mysupport.netapp.com/NOW/cgi-bin/software/?product=Host+Utilities+-
+SAN&platform=Linux[NetApp Support Site^] Site to your host.
.   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

.Before you begin
If you decide to use SAN booting, it must be supported by your configuration. You can use
the
link:https://mysupport.netapp.com/matrix/imt.jsp?components=71102;&solution=1&isHWU&src=I
MT[NetApp Interoperability Matrix Tool^] to verify that your OS, HBA, HBA firmware and
the HBA boot BIOS, and ONTAP version are supported.

.   Map the SAN boot LUN to the host.
.   Verify multiple paths are available.
+
Remember, multiple paths will only be available after the host OS is up and running on
the paths.
.   Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is
mapped.
+
For information on how to enable the HBA BIOS, see your vendor-specific documentation.
.   Reboot the host to verify the boot is successful.

== Multipathing

For Red Hat Enterprise Linux (RHEL) 6.7 the /etc/multipath.conf file must exist, but you
do not need to make specific changes to the file. RHEL 6.7 is compiled with all settings
required to recognize and correctly manage ONTAP LUNs.
To Enable ALUA Handler, perform the following steps:

.   Create a backup of the initrd-image.
.   Append the following parameter value to the kernel for ALUA and non-ALUA to work:
`rdloaddriver=scsi_dh_alua`
+
.Example
....
kernel /vmlinuz-2.6.32-358.6.1.el6.x86_64 ro root=/dev/mapper/ vg_ibmx355021082-lv_root
rd_NO_LUKS rd_LVM_LV=vg_ibmx355021082/ lv_root LANG=en_US.UTF-8
rd_LVM_LV=vg_ibmx355021082/lv_swap rd_NO_MD SYSFONT=latarcyrheb-sun16 crashkernel=auto
KEYBOARDTYPE=pc KEYTABLE=us rd_NO_DM rhgb quiet rdloaddriver=scsi_dh_alua
....
.   Use the `mkinitrd` command to recreate the initrd-image.
RHEL 6x and later versions use either:
The command: `mkinitrd -f /boot/ initrd-"uname -r".img uname -r`
Or
```

```
The command: `dracut -f`
.   Reboot the host.
.   Verify the output of the `cat /proc/cmdline` command to ensure that the setting is
complete.

You can use the `multipath -ll` command to verify the settings for your ONTAP LUNs.
The following sections provide sample multipath output for a LUN mapped to ASA and non-
ASA personas.

=== All SAN Array Configuration

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

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

multipath -ll

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

```
.Note
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

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

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

== Recommended Settings

The RHEL 6.7 OS is compiled to recognize ONTAP LUNs and automatically set all
configuration parameters correctly for both ASA and non-ASA configuartion.
The multipath.conf file must exist for the multipath daemon to start, 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
[root@jfs0 ~] systemctl start multipathd

```
There is no requirement to add anything directly to multipath.conf, 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.

.Note
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.

.   Run the following command to determine the WWID:
+
....
# /lib/udev/scsi_id -gud /dev/sda
360030057024d0730239134810c0cb833
....
.   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.


[cols=2*,options="header"]
|===
| Parameter
| Setting
| detect_prio | yes
| dev_loss_tmo | "infinity"
| failback | immediate
| fast_io_fail_tmo | 5
| features | "3 queue_if_no_path pg_init_retries 50"
| flush_on_last_del | "yes"
| hardware_handler | "0"
| no_path_retry | queue
| path_checker | "tur"
| path_grouping_policy | "group_by_prio"
| path_selector | "round-robin 0"
| polling_interval | 5
| prio | "ontap"
| product | LUN.*
```

```
| retain_attached_hw_handler | yes
| rr_weight | "uniform"
| user_friendly_names | no
| vendor | NETAPP
|===

.Example

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

defaults {
path_checker readsector0
no_path_retry fail
}

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

```
== Known Problems and Limitations

There are no known issues for RHEL 6.7.

== 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 fail 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
link:https://www.netapp.com/us/media/tr-3633.pdf[Oracle Databases on ONTAP^] for further
information.

[[IDa0c69befeae9f1b3b97d150c9f3ee55c]]
= Using Red Hat Enterprise Linux 6.6 with NetApp ONTAP
```

```
:toc: macro
:hardbreaks:
:toclevels: 1
:nofooter:
:icons: font
:linkattrs:
:imagesdir: ./media/

== Installing the Linux Unified Host Utilities

The NetApp Linux Unified Host Utilities software package is available on the
link:https://mysupport.netapp.com/NOW/cgi-bin/software/?product=Host+Utilities+-
+SAN&platform=Linux[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
link:https://mysupport.netapp.com/matrix/#welcome[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.

.Before you begin

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.

.   Download the 32-bit or 64-bit Linux Unified Host Utilities software package from the
link:https://mysupport.netapp.com/NOW/cgi-bin/software/?product=Host+Utilities+-
+SAN&platform=Linux[NetApp Support Site^] Site to your host.
.   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

.Before you begin
If you decide to use SAN booting, it must be supported by your configuration. You can use
the
link:https://mysupport.netapp.com/matrix/imt.jsp?components=68653;&solution=1&isHWU&src=I
MT[NetApp Interoperability Matrix Tool^] to verify that your OS, HBA, HBA firmware and
the HBA boot BIOS, and ONTAP version are supported.

.   Map the SAN boot LUN to the host.
.   Verify multiple paths are available.
+
Remember, multiple paths will only be available after the host OS is up and running on
the paths.
.   Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is
mapped.
+
For information on how to enable the HBA BIOS, see your vendor-specific documentation.
.   Reboot the host to verify the boot is successful.

== Multipathing

For Red Hat Enterprise Linux (RHEL) 6.6 the /etc/multipath.conf file must exist, but you
do not need to make specific changes to the file. RHEL 6.6 is compiled with all settings
required to recognize and correctly manage ONTAP LUNs.
To Enable ALUA Handler, perform the following steps:

.   Create a backup of the initrd-image.
.   Append the following parameter value to the kernel for ALUA and non-ALUA to work:
`rdloaddriver=scsi_dh_alua`
+
.Example
....
kernel /vmlinuz-2.6.32-358.6.1.el6.x86_64 ro root=/dev/mapper/ vg_ibmx355021082-lv_root
rd_NO_LUKS rd_LVM_LV=vg_ibmx355021082/ lv_root LANG=en_US.UTF-8
rd_LVM_LV=vg_ibmx355021082/lv_swap rd_NO_MD SYSFONT=latarcyrheb-sun16 crashkernel=auto
```

```
KEYBOARDTYPE=pc KEYTABLE=us rd_NO_DM rhgb quiet rdloaddriver=scsi_dh_alua
....
.   Use the `mkinitrd` command to recreate the initrd-image.
RHEL 6x and later versions use either:
The command: `mkinitrd -f /boot/ initrd-"uname -r".img uname -r`
Or
The command: `dracut -f`
.   Reboot the host.
.   Verify the output of the `cat /proc/cmdline` command to ensure that the setting is
complete.

You can use the `multipath -ll` command to verify the settings for your ONTAP LUNs.
The following sections provide sample multipath output for a LUN mapped to ASA and non-
ASA personas.

=== All SAN Array Configuration

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

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

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

.Note
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
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
----

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

== Recommended Settings

The RHEL 6.6 OS is compiled to recognize ONTAP LUNs and automatically set all
configuration parameters correctly for both ASA and non-ASA configuration.
The multipath.conf file must exist for the multipath daemon to start, but you can create
an empty, zero-byte file using the command:
`touch /etc/multipath.conf`
The first time you create this file, you might need to enable and start the multipath
services.
----
[root@jfs0 ~]#systemctl enable multipathd
[root@jfs0 ~]# systemctl start multipathd
----
There is no requirement to add anything directly to multipath.conf, 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.

.Note
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.

.   Run the following command to determine the WWID:
+
....
# /lib/udev/scsi_id -gud /dev/sda
360030057024d0730239134810c0cb833
....
.   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.


[cols=2*,options="header"]
|===
| Parameter
| Setting
| detect_prio | yes
| dev_loss_tmo | "infinity"
| failback | immediate
| fast_io_fail_tmo | 5
| features | "3 queue_if_no_path pg_init_retries 50"
| flush_on_last_del | "yes"
| hardware_handler | "0"
| no_path_retry | queue
| path_checker | "tur"
```

```
| path_grouping_policy | "group_by_prio"
| path_selector | "round-robin 0"
| polling_interval | 5
| prio | "ontap"
| product | LUN.*
| retain_attached_hw_handler | yes
| rr_weight | "uniform"
| user_friendly_names | no
| vendor | NETAPP
|===

.Example

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

----
defaults {
   path_checker      readsector0
   no_path_retry      fail
}

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

== Known Problems and Limitations

[cols=4*,options="header"]
|===
| NetApp Bug ID
| Title
| Description
| Bugzilla ID
| link:https://mysupport.netapp.com/NOW/cgi-bin/bol?Type=Detail&Display=863878[863878^] |
Kernel crash occurs with RHEL 6U6 host during storage failures | You might observe kernel
crash on RHEL 6U6 host during storage/fabric. |
link:https://bugzilla.redhat.com/show_bug.cgi?id=1158363[1158363^]
| link:https://mysupport.netapp.com/NOW/cgi-bin/bol?Type=Detail&Display=852674[1076584^]
```

```
| IO stall up to 300 sec seen with QLogic 16G FC (QLE2672) host during storage failures
in RHEL 6U4 |You might observe an IO stall up to 300 sec on QLogic 16G FC (QLE2672) host
during storage/fabric failures. |
link:https://bugzilla.redhat.com/show_bug.cgi?id=1135962[1135962^]
| link:https://mysupport.netapp.com/NOW/cgi-bin/bol?Type=Detail&Display=795684[795684^] |
RHEL6 U5 multipathd incorrectly group multipath maps during MoD and storage failover
fault operations |You might observe an incorrect path grouping on LUNs during LUN move on
demand operation along with storage faults. During LUN move operation multipath path
priorities will change and multipath is unable to reloads the device table due to device
failure caused by storage fault. This leads to incorrect path grouping. |
link:https://bugzilla.redhat.com/show_bug.cgi?id=1151020[1151020^]
|===

== 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 fail 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
link:https://www.netapp.com/us/media/tr-3633.pdf[Oracle Databases on ONTAP^] for further
information.

[[ID59052ce6f11d3897f1411d27e8611a37]]
= Using Red Hat Enterprise Linux 6.5 with NetApp ONTAP
:toc: macro
:hardbreaks:
:toclevels: 1
:nofooter:
:icons: font
:linkattrs:
:imagesdir: ./media/

== Installing the Linux Unified Host Utilities

The NetApp Linux Unified Host Utilities software package is available on the
link:https://mysupport.netapp.com/NOW/cgi-bin/software/?product=Host+Utilities+-
+SAN&platform=Linux[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
link:https://mysupport.netapp.com/matrix/#welcome[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.
```

```
.Before you begin

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.

.   Download the 32-bit or 64-bit Linux Unified Host Utilities software package from the
link:https://mysupport.netapp.com/NOW/cgi-bin/software/?product=Host+Utilities+-
+SAN&platform=Linux[NetApp Support Site^] Site to your host.
.   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

.Before you begin
If you decide to use SAN booting, it must be supported by your configuration. You can use
the
link:https://mysupport.netapp.com/matrix/imt.jsp?components=67197;&solution=1&isHWU&src=I
MT[NetApp Interoperability Matrix Tool^] to verify that your OS, HBA, HBA firmware and
the HBA boot BIOS, and ONTAP version are supported.

.   Map the SAN boot LUN to the host.
.   Verify multiple paths are available.
+
```

```
Remember, multiple paths will only be available after the host OS is up and running on
the paths.
.   Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is
mapped.
+
For information on how to enable the HBA BIOS, see your vendor-specific documentation.
.   Reboot the host to verify the boot is successful.

== Multipathing

For Red Hat Enterprise Linux (RHEL) 6.5 the /etc/multipath.conf file must exist, but you
do not need to make specific changes to the file. RHEL 6.5 is compiled with all settings
required to recognize and correctly manage ONTAP LUNs.
To Enable ALUA Handler, perform the following steps:

.   Create a backup of the initrd-image.
.   Append the following parameter value to the kernel for ALUA and non-ALUA to work:
`rdloaddriver=scsi_dh_alua`
+
.Example
....
kernel /vmlinuz-2.6.32-358.6.1.el6.x86_64 ro root=/dev/mapper/ vg_ibmx355021082-lv_root
rd_NO_LUKS rd_LVM_LV=vg_ibmx355021082/ lv_root LANG=en_US.UTF-8
rd_LVM_LV=vg_ibmx355021082/lv_swap rd_NO_MD SYSFONT=latarcyrheb-sun16 crashkernel=auto
KEYBOARDTYPE=pc KEYTABLE=us rd_NO_DM rhgb quiet rdloaddriver=scsi_dh_alua
....
.   Use the `mkinitrd` command to recreate the initrd-image.
RHEL 6x and later versions use either:
The command: `mkinitrd -f /boot/ initrd-"uname -r".img uname -r`
Or
The command: `dracut -f`
.   Reboot the host.
.   Verify the output of the `cat /proc/cmdline` command to ensure that the setting is
complete.

You can use the `multipath -ll` command to verify the settings for your ONTAP LUNs.
The following sections provide sample multipath output for a LUN mapped to ASA and non-
ASA personas.

=== All SAN Array Configuration

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

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

multipath -ll

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

```
.Note
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

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

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

== Recommended Settings

The RHEL 6.5 OS is compiled to recognize ONTAP LUNs and automatically set all
configuration parameters correctly for both ASA and non-ASA configuration.
The multipath.conf file must exist for the multipath daemon to start, but you can create
an empty, zero-byte file 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
[root@jfs0 ~] systemctl start multipathd

```
There is no requirement to add anything directly to multipath.conf, 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.

.Note
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.

.   Run the following command to determine the WWID:
+
....
# /lib/udev/scsi_id -gud /dev/sda
360030057024d0730239134810c0cb833
....
.   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.


[cols=2*,options="header"]
|===
| Parameter
| Setting
| detect_prio | yes
| dev_loss_tmo | "infinity"
| failback | immediate
| fast_io_fail_tmo | 5
| features | "3 queue_if_no_path pg_init_retries 50"
| flush_on_last_del | "yes"
| hardware_handler | "0"
| no_path_retry | queue
| path_checker | "tur"
| path_grouping_policy | "group_by_prio"
| path_selector | "round-robin 0"
| polling_interval | 5
| prio | "ontap"
| product | LUN.*
| retain_attached_hw_handler | yes
| rr_weight | "uniform"
| user_friendly_names | no
| vendor | NETAPP
|===

.Example

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

```
attached to the host, these parameters can be corrected specifically for ONTAP LUNs with
a device stanza.
```

defaults {
path_checker readsector0
no_path_retry fail
}

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

```
== Known Problems and Limitations

[cols=4*,options="header"]
|===
| NetApp Bug ID
| Title
| Description
| Bugzilla ID
| link:https://mysupport.netapp.com/NOW/cgi-bin/bol?Type=Detail&Display=760515[760515^] |
Path failures or host hangs were observed in RHEL 6.5 8G Qlogic FC SAN host during
storage failover operations | Path failures or host hangs were observed in RHEL 6.5 8G
Qlogic FC SAN host during storage failover operations. |
link:https://bugzilla.redhat.com/show_bug.cgi?id=1033136[1033136^]
| link:https://mysupport.netapp.com/NOW/cgi-bin/bol?Type=Detail&Display=758271[758271^] |
bnx2 firmware fails to load when booting with custom initrd (dracut -f) | Broadcom
NetXtreme II Gigabit controller ports will not ping due to bnx2 firmware fails to load
during boot with custom initrd. |
link:https://bugzilla.redhat.com/show_bug.cgi?id=1007463[1007463^]
| link:https://mysupport.netapp.com/NOW/cgi-bin/bol?Type=Detail&Display=799394[799394^] |
RHEL 6U5: Emulex 16G FC (LPe16002B-M6) host crash is seen during I/O with storage
failover operations | 16G FC Emulex (LPe16002B-M6) host crash is seen during I/O with
storage failover operations. |
link:https://bugzilla.redhat.com/show_bug.cgi?id=1063699[1063699^]
| link:https://mysupport.netapp.com/NOW/cgi-bin/bol?Type=Detail&Display=786571[786571^] |
QLogic FCoE host hangs/path failures observed in RHEL 6.5 during I/O with storage
failover operations | QLogic FCoE (QLE8242) host hangs/path failures are observed in RHEL
6.5 during I/O with storage failover operations. In such scenarios, you might see the
following message: "Mailbox cmd timeout occurred, cmd=0x54, mb[0]=0x54. Scheduling ISP
abort" messages which leads to host hung/path failures. |
```

```
link:https://bugzilla.redhat.com/show_bug.cgi?id=1068619[1068619^]
| link:https://mysupport.netapp.com/NOW/cgi-bin/bol?Type=Detail&Display=801580[801580^] |
QLogic 16G FC host hangs or path failures observed in RHEL 6.5 during I/O with storage
failover operations | The I/O delays of more than 600 seconds are observed with QLogic
16G FC host (QLE2672) during storage failover operations. In such scenarios, the
following message is displayed: "Failed mbx[0]=54, mb[1]=0, mb[2]=76b9, mb[3]=5200,
cmd=54" | link:https://bugzilla.redhat.com/show_bug.cgi?id=1068622[1068622]
|===

== 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 fail 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
link:https://www.netapp.com/us/media/tr-3633.pdf[Oracle Databases on ONTAP^] for further
information.

[[IDa47006a7e755066fbfc127d613453ba4]]
= Using Red Hat Enterprise Linux 6.4 with NetApp ONTAP
:toc: macro
:hardbreaks:
:toclevels: 1
:nofooter:
:icons: font
:linkattrs:
:imagesdir: ./media/

== Installing the Linux Unified Host Utilities

The NetApp Linux Unified Host Utilities software package is available on the
link:https://mysupport.netapp.com/NOW/cgi-bin/software/?product=Host+Utilities+-
+SAN&platform=Linux[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
link:https://mysupport.netapp.com/matrix/#welcome[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.

.Before you begin

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.

.   Download the 32-bit or 64-bit Linux Unified Host Utilities software package from the
link:https://mysupport.netapp.com/NOW/cgi-bin/software/?product=Host+Utilities+-
+SAN&platform=Linux[NetApp Support Site^] Site to your host.
.   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

.Before you begin
If you decide to use SAN booting, it must be supported by your configuration. You can use
the
link:https://mysupport.netapp.com/matrix/imt.jsp?components=63797;&solution=1&isHWU&src=I
MT[NetApp Interoperability Matrix Tool^] to verify that your OS, HBA, HBA firmware and
the HBA boot BIOS, and ONTAP version are supported.

.   Map the SAN boot LUN to the host.
.   Verify multiple paths are available.
+
Remember, multiple paths will only be available after the host OS is up and running on
the paths.
```

```
.   Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is
mapped.
+
For information on how to enable the HBA BIOS, see your vendor-specific documentation.
.   Reboot the host to verify the boot is successful.

== Multipathing

For Red Hat Enterprise Linux (RHEL) 6.4 the /etc/multipath.conf file must exist, but you
do not need to make specific changes to the file. RHEL 6.4 is compiled with all settings
required to recognize and correctly manage ONTAP LUNs.
To Enable ALUA Handler, perform the following steps:

.   Create a backup of the initrd-image.
.   Append the following parameter value to the kernel for ALUA and non-ALUA to work:
`rdloaddriver=scsi_dh_alua`
+
.Example
....
kernel /vmlinuz-2.6.32-358.6.1.el6.x86_64 ro root=/dev/mapper/ vg_ibmx355021082-lv_root
rd_NO_LUKS rd_LVM_LV=vg_ibmx355021082/ lv_root LANG=en_US.UTF-8
rd_LVM_LV=vg_ibmx355021082/lv_swap rd_NO_MD SYSFONT=latarcyrheb-sun16 crashkernel=auto
KEYBOARDTYPE=pc KEYTABLE=us rd_NO_DM rhgb quiet rdloaddriver=scsi_dh_alua
....
.   Use the `mkinitrd` command to recreate the initrd-image.
RHEL 6x and later versions use either:
The command: `mkinitrd -f /boot/ initrd-"uname -r".img uname -r`
Or
The command: `dracut -f`
.   Reboot the host.
.   Verify the output of the `cat /proc/cmdline` command to ensure that the setting is
complete.

You can use the `multipath -ll` command to verify the settings for your ONTAP LUNs.
The following sections provide sample multipath output for a LUN mapped to ASA and non-
ASA personas.

=== All SAN Array Configuration

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

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

----
```

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

.Note
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
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
----

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

== Recommended Settings

The RHEL 6.4 OS is compiled to recognize ONTAP LUNs and automatically set all
configuration parameters correctly for both ASA and non-ASA configuration.
```

```
The multipath.conf file must exist for the multipath daemon to start, but you can create
an empty, zero-byte file using the command:
`touch /etc/multipath.conf`
The first time you create this file, you might need to enable and start the multipath
services.
----
[root@jfs0 ~]#systemctl enable multipathd
[root@jfs0 ~]# systemctl start multipathd
----
There is no requirement to add anything directly to multipath.conf, 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.

.Note
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.

.   Run the following command to determine the WWID:
+
....
# /lib/udev/scsi_id -gud /dev/sda
360030057024d0730239134810c0cb833
....
.   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.


[cols=2*,options="header"]
|===
| Parameter
| Setting
| detect_prio | yes
| dev_loss_tmo | "infinity"
| failback | immediate
| fast_io_fail_tmo | 5
| features | "3 queue_if_no_path pg_init_retries 50"
| flush_on_last_del | "yes"
| hardware_handler | "0"
| no_path_retry | queue
| path_checker | "tur"
| path_grouping_policy | "group_by_prio"
| path_selector | "round-robin 0"
| polling_interval | 5
| prio | "ontap"
| product | LUN.*
| retain_attached_hw_handler | yes
| rr_weight | "uniform"
| user_friendly_names | no
| vendor | NETAPP
|===

.Example

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

----
defaults {
   path_checker      readsector0
   no_path_retry      fail
}

devices {
```

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

== Known Problems and Limitations

[cols=4*,options="header"]
|===
| NetApp Bug ID
| Title
| Description
| Bugzilla ID
| link:https://mysupport.netapp.com/NOW/cgi-bin/bol?Type=Detail&Display=673009[673009^] |
Creating ext4 file system on LV striped across 15 or more discard-enabled, thinly
provisioned multipath devices triggers "request botched" kernel errors | "Request
blotched" kernel errors have been seen when users attempt to create an ext4 file system
on discard-enabled, thinly provisioned multipath devices. As a result, creating the ext4
file system might take longer to complete and occasional disruption occurs. This issue
has occurred only when users attempt to create the ext4 file system on a LV striped
across 15 or more discard-enabled multipath devices on systems running Red Hat Enterprise
Linux 6.x and Data ONTAP 8.1.3 and later operating in 7-Mode. The issue happens because
the kernel erroneously attempts to merge discard requests, which is not supported on Red
Hat Enterprise Linux 6.x at this time. When this issue occurs, multiple instances of the
following message are written to syslog (/var/log/messages):  kernel: blk: request
botched. As a result, file system creation might take longer time to complete than
expected. | link:https://bugzilla.redhat.com/show_bug.cgi?id=907844[907844^]
|===

== 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 fail 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
link:https://www.netapp.com/us/media/tr-3633.pdf[Oracle Databases on ONTAP^] for further
information.


:leveloffset: -1
```

```
:leveloffset: -1


= SUSE

:leveloffset: +1


= SUSE 15

:leveloffset: +1

[[ID691dfd7b461cea9da1b1db50d8ac9ff0]]
= Using SUSE Linux Enterprise Server 15 with NetApp ONTAP
:toc: macro
:hardbreaks:
:toclevels: 1
:nofooter:
:icons: font
:linkattrs:
:imagesdir: ./media/

== Installing the Linux Unified Host Utilities

The NetApp Linux Unified Host Utilities software package is available on the
link:https://mysupport.netapp.com/NOW/cgi-bin/software/?product=Host+Utilities+-
+SAN&platform=Linux[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
link:https://mysupport.netapp.com/matrix/#welcome[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.

.Before you begin

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.

.   Download the 32-bit or 64-bit Linux Unified Host Utilities software package from the
link:https://mysupport.netapp.com/NOW/cgi-bin/software/?product=Host+Utilities+-
+SAN&platform=Linux[NetApp Support Site^] Site to your host.
.   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

.Before you begin
If you decide to use SAN booting, it must be supported by your configuration. You can use
the
link:https://mysupport.netapp.com/matrix/imt.jsp?components=84067;&solution=1&isHWU&src=I
MT[NetApp Interoperability Matrix Tool^] to verify that your OS, HBA, HBA firmware and
the HBA boot BIOS, and ONTAP version are supported.

.   Map the SAN boot LUN to the host.
.   Verify multiple paths are available.
+
Remember, multiple paths will only be available after the host OS is up and running on
the paths.
.   Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is
mapped.
+
For information on how to enable the HBA BIOS, see your vendor-specific documentation.
.   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

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

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

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

```
.Note
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

```
.Note
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

[root@jfs0 ~] systemctl start multipathd

```
There is no requirement to add anything directly to multipath.conf, 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.

.Note
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.

.   Run the following command to determine the WWID:
+
....
# /lib/udev/scsi_id -gud /dev/sda
360030057024d0730239134810c0cb833
....
.   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.


[cols=2*,options="header"]
|===
| 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

[cols=4*,options="header"]
|===
| NetApp Bug ID
| Title
| Description
| Bugzilla ID
| link:https://mysupport.netapp.com/NOW/cgi-bin/bol?Type=Detail&Display=1154309[1154309^]
| SLES 15 host with more than 20 mapped LUNs might go into maintenance mode after a
reboot | SLES 15 host with more than 20 mapped LUNs might go into maintenance mode after
a reboot. The maintenance mode becomes single user mode following the message:
`Give root password for maintenance (or press Control-D to continue)` |
link:https://bugzilla.suse.com/show_bug.cgi?id=1104173[1104173^]
|===

== 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 fail 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
link:https://www.netapp.com/us/media/tr-3633.pdf[Oracle Databases on ONTAP^] for further
information.

[[ID3979d66f2081531cbc798d91982e70d5]]
= Using SUSE Linux Enterprise Server 15 SP1 with NetApp ONTAP
:toc: macro
:hardbreaks:
:toclevels: 1
:nofooter:
:icons: font
:linkattrs:
:imagesdir: ./media/

== Installing the Linux Unified Host Utilities

The NetApp Linux Unified Host Utilities software package is available on the
link:https://mysupport.netapp.com/NOW/cgi-bin/software/?product=Host+Utilities+-
+SAN&platform=Linux[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
link:https://mysupport.netapp.com/matrix/#welcome[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.

.Before you begin

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.

.   Download the 32-bit or 64-bit Linux Unified Host Utilities software package from the
link:https://mysupport.netapp.com/NOW/cgi-bin/software/?product=Host+Utilities+-
+SAN&platform=Linux[NetApp Support Site^] Site to your host.
.   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

.Before you begin
If you decide to use SAN booting, it must be supported by your configuration. You can use
```

```
the
link:https://mysupport.netapp.com/matrix/imt.jsp?components=84067;&solution=1&isHWU&src=I
MT[NetApp Interoperability Matrix Tool^] to verify that your OS, HBA, HBA firmware and
the HBA boot BIOS, and ONTAP version are supported.

.   Map the SAN boot LUN to the host.
.   Verify multiple paths are available.
+
Remember, multiple paths will only be available after the host OS is up and running on
the paths.
.   Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is
mapped.
+
For information on how to enable the HBA BIOS, see your vendor-specific documentation.
.   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

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

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

----
# 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
----
```

```
.Note
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
----

.Note
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.
----
[root@jfs0 ~]#systemctl enable multipathd
[root@jfs0 ~]# systemctl start multipathd
----
There is no requirement to add anything directly to multipath.conf, 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.

.Note
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.

.   Run the following command to determine the WWID:
+
....
# /lib/udev/scsi_id -gud /dev/sda
360030057024d0730239134810c0cb833
....
.   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.


[cols=2*,options="header"]
|===
```

```
| 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
```

```
[cols=4,options="header" width="80%"]
|===
| NetApp Bug ID
| Title
| Description
| Bugzilla ID
| link:https://mysupport.netapp.com/NOW/cgi-bin/bol?Type=Detail&Display=1246622[1246622^]
| Remote ports transit to a blocked state on SLES15SP1 with Emulex LPe12002 8GB FC during
storage failover operations. | Remote ports transit to a blocked state on SLES15SP1 with
Emulex LPe12002 8GB Fibre Channel (FC) during storage failover operations. When the
storage node returns to an optimal state, the LIFs also come up and the remote port state
should read "online." Occasionally, the remote port state might continue to read as
"blocked or "not present." This state can lead to a "failed faulty" path to LUNs at the
multipath layer as well as an I/O outage for those LUNs. You can check the remoteport's
details against the following sample commands:

----
cat/sys/class/fc_host/host*/device/rport*/fc_remote_ports/rport*/port_name

cat/sys/class/fc_host/host*/device/rport*/fc_remote_ports/rport*/port_state
----


| link:https://bugzilla.suse.com/show_bug.cgi?id=1139137[1139137^]
|===

== 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 fail 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
link:https://www.netapp.com/us/media/tr-3633.pdf[Oracle Databases on ONTAP^] for further
information.

[[ID77e2af2d8e419d7fa94bbea33ef5d7c5]]
= Using SUSE Linux Enterprise Server 15 SP2 with NetApp ONTAP
:toc: macro
:hardbreaks:
:toclevels: 1
:nofooter:
:icons: font
:linkattrs:
:imagesdir: ./media/
```

```
== Installing the Linux Unified Host Utilities

The NetApp Linux Unified Host Utilities software package is available on the
link:https://mysupport.netapp.com/NOW/cgi-bin/software/?product=Host+Utilities+-
+SAN&platform=Linux[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
link:https://mysupport.netapp.com/matrix/#welcome[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.

.Before you begin

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.

.   Download the 32-bit or 64-bit Linux Unified Host Utilities software package from the
link:https://mysupport.netapp.com/NOW/cgi-bin/software/?product=Host+Utilities+-
+SAN&platform=Linux[NetApp Support Site^] Site to your host.
.   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

.Before you begin
If you decide to use SAN booting, it must be supported by your configuration. You can use
the
link:https://mysupport.netapp.com/matrix/imt.jsp?components=84067;&solution=1&isHWU&src=I
MT[NetApp Interoperability Matrix Tool^] to verify that your OS, HBA, HBA firmware and
the HBA boot BIOS, and ONTAP version are supported.

.   Map the SAN boot LUN to the host.
.   Verify multiple paths are available.
+
Remember, multiple paths will only be available after the host OS is up and running on
the paths.
.   Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is
mapped.
+
For information on how to enable the HBA BIOS, see your vendor-specific documentation.
.   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
[root@jfs0 ~] systemctl start multipathd

```
There is no requirement to add anything directly to multipath.conf, 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.

.Note
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.

.   Run the following command to determine the WWID:
+
....
# /lib/udev/scsi_id -gud /dev/sda
360030057024d0730239134810c0cb833
....
.   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.

[cols=2]
[options="header"]
|===
| 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
[cols="1,1,3,1"]
[options="header"]
|===
| NetApp Bug ID
| Title
| Description
| Bugzilla ID

| link:https://mysupport.netapp.com/NOW/cgi-bin/bol?Type=Detail&Display=1308744[1308744^]

| iSCSI boot from SAN fails to boot with a static IP configuration after completing an
SLES15SP2 OS installation

a| 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:
```

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

```
| link:https://bugzilla.suse.com/show_bug.cgi?id=1167494[1167494^]
```

```
|===

== 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 fail 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
link:https://www.netapp.com/us/media/tr-3633.pdf[Oracle Databases on ONTAP^] for further
information.


:leveloffset: -1


= SUSE 12

:leveloffset: +1

[[IDce27c13abe7384e5e2bccf8b6a8f7c66]]
= Using SUSE Linux Enterprise Server 12 SP5 with NetApp ONTAP
:toc: macro
:hardbreaks:
:toclevels: 1
:nofooter:
:icons: font
:linkattrs:
:imagesdir: ./media/

== Installing the Linux Unified Host Utilities

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link:https://mysupport.netapp.com/NOW/cgi-bin/software/?product=Host+Utilities+-
+SAN&platform=Linux[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
link:https://mysupport.netapp.com/matrix/#welcome[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.

.Before you begin
```

```
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.

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link:https://mysupport.netapp.com/NOW/cgi-bin/software/?product=Host+Utilities+-
+SAN&platform=Linux[NetApp Support Site^] Site to your host.
.   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

.Before you begin
If you decide to use SAN booting, it must be supported by your configuration. You can use
the
link:https://mysupport.netapp.com/matrix/imt.jsp?components=91704;&solution=1&isHWU&src=I
MT[NetApp Interoperability Matrix Tool^] to verify that your OS, HBA, HBA firmware and
the HBA boot BIOS, and ONTAP version are supported.

.   Map the SAN boot LUN to the host.
.   Verify multiple paths are available.
+
Remember, multiple paths will only be available after the host OS is up and running on
```

```
the paths.
.   Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is
mapped.
+
For information on how to enable the HBA BIOS, see your vendor-specific documentation.
.   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

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

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

----
# 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
----

.Note
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
----

.Note
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.
----
[root@jfs0 ~]#systemctl enable multipathd
[root@jfs0 ~]# systemctl start multipathd
----
There is no requirement to add anything directly to multipath.conf, 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.

.Note
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.

.   Run the following command to determine the WWID:
+
....
# /lib/udev/scsi_id -gud /dev/sda
360030057024d0730239134810c0cb833
....
.   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.


[cols=2*,options="header"]
|===
| 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

[cols=4*,options="header"]
|===
| NetApp Bug ID
| Title
| Description
| Bugzilla ID
| link:https://mysupport.netapp.com/NOW/cgi-bin/bol?Type=Detail&Display=1284293[1284293^]
| Kernel disruption occurs on SLES12 SP5 with QLogic QLE2562 8GB FC HBA during storage
failover operations | Kernel disruption occurs during storage failover operations on the
SLES12 SP5 kernel with a QLogic QLE2562 Fibre Channel (FC) host bus adapter (HBA). The
```

```
kernel disruption causes SLES12 SP5 to reboot, leading to application disruption. If the
kdump mechanism is enabled, the kernel disruption generates a vmcore file located in the
/var/crash/ directory. Check the vmcore file to determine the cause of the disruption. A
storage failover with a QLogic QLE2562 HBA event affects the "THREAD_INFO:
ffff8aedf723c2c0" module. Locate this event in the vmcore file by finding the following
string: " [THREAD_INFO: ffff8aedf723c2c0]".
After the kernel disruption, reboot the host OS to enable it to recover. Then restart the
applications.
 | link:http://bugzilla.suse.com/show_bug.cgi?id=1157966[1157966^]
|===

== 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 fail 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
link:https://www.netapp.com/us/media/tr-3633.pdf[Oracle Databases on ONTAP^] for further
information.

[[IDec45c3ef58fa635d69fd1f82255fee2f]]
= Using SUSE Linux Enterprise Server 12 SP4 with NetApp ONTAP
:toc: macro
:hardbreaks:
:toclevels: 1
:nofooter:
:icons: font
:linkattrs:
:imagesdir: ./media/

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+SAN&platform=Linux[NetApp Support Site^] in a 32-bit and 64-bit .rpm file. If you do not
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link:https://mysupport.netapp.com/matrix/#welcome[NetApp Interoperability Matrix Tool^]
to verify which one you need.

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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
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.Before you begin
```

```
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
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link:https://mysupport.netapp.com/NOW/cgi-bin/software/?product=Host+Utilities+-
+SAN&platform=Linux[NetApp Support Site^] Site to your host.
.   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

.Before you begin
If you decide to use SAN booting, it must be supported by your configuration. You can use
the
link:https://mysupport.netapp.com/matrix/imt.jsp?components=86528;&solution=1&isHWU&src=I
MT[NetApp Interoperability Matrix Tool^] to verify that your OS, HBA, HBA firmware and
the HBA boot BIOS, and ONTAP version are supported.

.   Map the SAN boot LUN to the host.
.   Verify multiple paths are available.
+
Remember, multiple paths will only be available after the host OS is up and running on
the paths.
.   Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is
mapped.
+
For information on how to enable the HBA BIOS, see your vendor-specific documentation.
.   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

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

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

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

```
.Note
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

```
.Note
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
[root@jfs0 ~] systemctl start multipathd

```
There is no requirement to add anything directly to multipath.conf, 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.

.Note
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.

.   Run the following command to determine the WWID:
+
....
# /lib/udev/scsi_id -gud /dev/sda
360030057024d0730239134810c0cb833
....
.   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.
```

```
[cols=2*,options="header"]
|===
| 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 fail 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
link:https://www.netapp.com/us/media/tr-3633.pdf[Oracle Databases on ONTAP^] for further
information.

[[ID337141fb0248d47963b94d60abe54a0f]]
= Using SUSE Linux Enterprise Server 12 SP3 with NetApp ONTAP
:toc: macro
:hardbreaks:
:toclevels: 1
:nofooter:
:icons: font
:linkattrs:
:imagesdir: ./media/

== Installing the Linux Unified Host Utilities

The NetApp Linux Unified Host Utilities software package is available on the
link:https://mysupport.netapp.com/NOW/cgi-bin/software/?product=Host+Utilities+-
+SAN&platform=Linux[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
link:https://mysupport.netapp.com/matrix/#welcome[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.

.Before you begin

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.

.   Download the 32-bit or 64-bit Linux Unified Host Utilities software package from the
link:https://mysupport.netapp.com/NOW/cgi-bin/software/?product=Host+Utilities+-
+SAN&platform=Linux[NetApp Support Site^] Site to your host.
```

```
.   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

.Before you begin
If you decide to use SAN booting, it must be supported by your configuration. You can use
the
link:https://mysupport.netapp.com/matrix/imt.jsp?components=80043;&solution=1&isHWU&src=I
MT[NetApp Interoperability Matrix Tool^] to verify that your OS, HBA, HBA firmware and
the HBA boot BIOS, and ONTAP version are supported.

.   Map the SAN boot LUN to the host.
.   Verify multiple paths are available.
+
Remember, multiple paths will only be available after the host OS is up and running on
the paths.
.   Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is
mapped.
+
For information on how to enable the HBA BIOS, see your vendor-specific documentation.
.   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

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

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

----
# 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
----

.Note
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
----

.Note
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.
----
[root@jfs0 ~]#systemctl enable multipathd
[root@jfs0 ~]# systemctl start multipathd
----
There is no requirement to add anything directly to multipath.conf, 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.

.Note
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.

.   Run the following command to determine the WWID:
+
....
# /lib/udev/scsi_id -gud /dev/sda
360030057024d0730239134810c0cb833
....
.   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.


[cols=2*,options="header"]
|===
| 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

[cols=4*,options="header"]
|===
| NetApp Bug ID
| Title
| Description
| Bugzilla ID
| link:https://https://mysupport.netapp.com/NOW/cgi-
bin/bol?Type=Detail&Display=1089555[1089555^] | Kernel disruption observed on kernel
version SLES12 SP3 with Emulex LPe16002 16GB FC during storage failover operation | A
kernel disruption might occur during storage failover operations on kernel version SLES12
SP3 with Emulex LPe16002 HBA. The kernel disruption prompts a reboot of the operating
system, which in turn causes an application disruption. If the kdump is configured, the
kernel disruption generates a vmcore file under /var/crash/directory. You can investigate
the cause of the failure in the vmcore file.
Example:
In the observed case, the kernel disruption was observed in the module
```

```
lpfc_sli_ringtxcmpl_put+51 and is logged in the vmcore file
 exception RIP: lpfc_sli_ringtxcmpl_put+51.

Recover the operating system after the kernel disruption by rebooting the host operating
system and restarting the application. |
link:http://bugzilla.suse.com/show_bug.cgi?id=1042847[1042847^]
| link:https://mysupport.netapp.com/NOW/cgi-bin/bol?Type=Detail&Display=1089561[1089561^]
| Kernel disruption observed on kernel version SLES12 SP3 with Emulex LPe32002 32GB FC
during storage failover operations | A kernel disruption might occur during storage
failover operations on kernel version SLES12 SP3 with Emulex LPe32002 HBA. The kernel
disruption prompts a reboot of the operating system, which in turn causes an application
disruption. If the kdump is configured, the kernel disruption generates a vmcore file
under /var/crash/directory. You can investigate the cause of the failure in the vmcore
file.
Example:
In the observed case, the kernel disruption was observed in the module
lpfc_sli_free_hbq+76 and is logged in the vmcore file
 exception RIP: lpfc_sli_free_hbq+76.

Recover the operating system after the kernel disruption by rebooting the host operating
system and restarting the application. |
link:http://bugzilla.suse.com/show_bug.cgi?id=1042807[1042807^]
| link:https://mysupport.netapp.com/NOW/cgi-bin/bol?Type=Detail&Display=1117248[1117248^]
| Kernel disruption observed on SLES12SP3 with QLogic QLE2562 8GB FC during storage
failover operations |  During storage failover operations on the Sles12sp3 kernel
(kernel-default-4.4.82-6.3.1) with QLogic QLE2562 HBA, the kernel disruption was observed
due to a panic in the kernel. The kernel panic leads to a reboot of the operating system,
causing an application disruption. The kernel panic generates the vmcore file under the
/var/crash/ directory if kdump is configured. Upon the kernel panic, the vmcore file can
be used to understand the cause of the failure.
Example:
In this case, the panic was observed in the blk_finish_request+289 module.
It is logged in the vmcore file with the following string:
"exception RIP: blk_finish_request+289"

After the kernel disruption, you can recover the operating system  by rebooting the Host
OS. You can restart the application as required. |
link:http://bugzilla.suse.com/show_bug.cgi?id=1062496[1062496^]
| link:https://mysupport.netapp.com/NOW/cgi-bin/bol?Type=Detail&Display=1117261[1117261^]
| Kernel disruption observed on SLES12SP3 with Qlogic QLE2662 16GB FC during storage
failover operations | During storage failover operations on Sles12sp3 kernel (kernel-
default-4.4.82-6.3.1) with Qlogic QLE2662 HBA, you might observe kernel disruption. This
prompts a reboot of the operating system causing application disruption. The kernel
disruption generates a vmcore file under /var/crash/ directory if kdump is configured.
The vmcore file can be used to understand the cause of the failure.
Example:
In this case the Kernel disruption was observed in the module "unknown or invalid
address" and is logged in vmcore file with the following string - exception RIP: unknown
```

```
or invalid address.

After kernel disruption, the operating system can be recovered by rebooting the host
operating system and restarting the application as required. |
link:http://bugzilla.suse.com/show_bug.cgi?id=1062508[1062508^]
| link:https://mysupport.netapp.com/NOW/cgi-bin/bol?Type=Detail&Display=1117274[1117274^]
| Kernel disruption observed on SLES12SP3 with Emulex LPe16002 16GB FC during storage
failover operations | During storage failover operations on Sles12sp3 kernel (kernel-
default-4.4.87-3.1) with Emulex LPe16002 HBA, you might observe kernel disruption. This
prompts a reboot of the operating system causing application disruption. The kernel
disruption
generates a vmcore file under the /var/crash/ directory if kdump is configured. The
vmcore file can be used to understand the cause
of the failure.
Example:
In this case kernel disruption was observed in the module raw_spin_lock_irqsave+30 and
is logged in the vmcore file with the following string:
 exception RIP: _raw_spin_lock_irqsave+30.

After kernel disruption, the operating system can be recovered by rebooting the host
operating system and restarting the application as required. |
link:http://bugzilla.suse.com/show_bug.cgi?id=1062514[1062514^]
|===

== 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 fail 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
link:https://www.netapp.com/us/media/tr-3633.pdf[Oracle Databases on ONTAP^] for further
information.

[[ID8a601b577cdd058f9fbf960230c324f4]]
= Using SUSE Linux Enterprise Server 12 SP2 with NetApp ONTAP
:toc: macro
:hardbreaks:
:toclevels: 1
:nofooter:
:icons: font
:linkattrs:
:imagesdir: ./media/

== Installing the Linux Unified Host Utilities
```

```
The NetApp Linux Unified Host Utilities software package is available on the
link:https://mysupport.netapp.com/NOW/cgi-bin/software/?product=Host+Utilities+-
+SAN&platform=Linux[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
link:https://mysupport.netapp.com/matrix/#welcome[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.

.Before you begin

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.

.   Download the 32-bit or 64-bit Linux Unified Host Utilities software package from the
link:https://mysupport.netapp.com/NOW/cgi-bin/software/?product=Host+Utilities+-
+SAN&platform=Linux[NetApp Support Site^] Site to your host.
.   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

.Before you begin
If you decide to use SAN booting, it must be supported by your configuration. You can use
the
link:https://mysupport.netapp.com/matrix/imt.jsp?components=77284;&solution=1&isHWU&src=I
MT[NetApp Interoperability Matrix Tool^] to verify that your OS, HBA, HBA firmware and
the HBA boot BIOS, and ONTAP version are supported.

.   Map the SAN boot LUN to the host.
.   Verify multiple paths are available.
+
Remember, multiple paths will only be available after the host OS is up and running on
the paths.
.   Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is
mapped.
+
For information on how to enable the HBA BIOS, see your vendor-specific documentation.
.   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

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

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

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

```
.Note
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

```
.Note
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
[root@jfs0 ~] systemctl start multipathd

```
There is no requirement to add anything directly to multipath.conf, 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.

.Note
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.

.   Run the following command to determine the WWID:
+
....
# /lib/udev/scsi_id -gud /dev/sda
360030057024d0730239134810c0cb833
....
.   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.


[cols=2*,options="header"]
|===
| Parameter
| Setting
| detect_prio | yes
| dev_loss_tmo | "infinity"
| failback | immediate
| fast_io_fail_tmo | 5
| features | "3 queue_if_no_path pg_init_retries 50"
| flush_on_last_del | "yes"
| hardware_handler | "0"
| path_checker | "tur"
| path_grouping_policy | "group_by_prio"
| path_selector | "service-time 0"
| polling_interval | 5
| prio | "ontap"
| product | LUN.*
| retain_attached_hw_handler | yes
| 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 fail 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
link:https://www.netapp.com/us/media/tr-3633.pdf[Oracle Databases on ONTAP^] for further
information.

[[ID3c2503311abf4b544bfb7391c3809967]]
= Using SUSE Linux Enterprise Server 12 SP1 with NetApp ONTAP
:toc: macro
:hardbreaks:
:toclevels: 1
:nofooter:
:icons: font
:linkattrs:
:imagesdir: ./media/

== Installing the Linux Unified Host Utilities

The NetApp Linux Unified Host Utilities software package is available on the
link:https://mysupport.netapp.com/NOW/cgi-bin/software/?product=Host+Utilities+-
+SAN&platform=Linux[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
link:https://mysupport.netapp.com/matrix/#welcome[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.

.Before you begin

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.
```

```
.   Download the 32-bit or 64-bit Linux Unified Host Utilities software package from the
link:https://mysupport.netapp.com/NOW/cgi-bin/software/?product=Host+Utilities+-
+SAN&platform=Linux[NetApp Support Site^] Site to your host.
.   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

.Before you begin
If you decide to use SAN booting, it must be supported by your configuration. You can use
the
link:https://mysupport.netapp.com/matrix/imt.jsp?components=71679;&solution=1&isHWU&src=I
MT[NetApp Interoperability Matrix Tool^] to verify that your OS, HBA, HBA firmware and
the HBA boot BIOS, and ONTAP version are supported.

.   Map the SAN boot LUN to the host.
.   Verify multiple paths are available.
+
Remember, multiple paths will only be available after the host OS is up and running on
the paths.
.   Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is
mapped.
```

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

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

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

----
# 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
----

.Note
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
----

.Note
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.
----
[root@jfs0 ~]#systemctl enable multipathd
[root@jfs0 ~]# systemctl start multipathd
----
There is no requirement to add anything directly to multipath.conf, 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.

.Note
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.

.   Run the following command to determine the WWID:
+
....
# /lib/udev/scsi_id -gud /dev/sda
360030057024d0730239134810c0cb833
....
.   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.


[cols=2*,options="header"]
|===
| Parameter
| Setting
| detect_prio | yes
| dev_loss_tmo | "infinity"
| failback | immediate
| fast_io_fail_tmo | 5
| features | "3 queue_if_no_path pg_init_retries 50"
| flush_on_last_del | "yes"
| hardware_handler | "0"
| path_checker | "tur"
| path_grouping_policy | "group_by_prio"
```

```
| path_selector | "service-time 0"
| polling_interval | 5
| prio | "ontap"
| product | LUN.*
| retain_attached_hw_handler | yes
| 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 fail 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
link:https://www.netapp.com/us/media/tr-3633.pdf[Oracle Databases on ONTAP^] for further
information.
```

```
[[IDa3dca7c5c81d9d3ed29db2aa89763546]]
= Using SUSE Linux Enterprise Server 12 with NetApp ONTAP
:toc: macro
:hardbreaks:
:toclevels: 1
:nofooter:
:icons: font
:linkattrs:
:imagesdir: ./media/

== Installing the Linux Unified Host Utilities

The NetApp Linux Unified Host Utilities software package is available on the
link:https://mysupport.netapp.com/NOW/cgi-bin/software/?product=Host+Utilities+-
+SAN&platform=Linux[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
link:https://mysupport.netapp.com/matrix/#welcome[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.

.Before you begin

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.

.   Download the 32-bit or 64-bit Linux Unified Host Utilities software package from the
link:https://mysupport.netapp.com/NOW/cgi-bin/software/?product=Host+Utilities+-
+SAN&platform=Linux[NetApp Support Site^] Site to your host.
.   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

.Before you begin
If you decide to use SAN booting, it must be supported by your configuration. You can use
the
link:https://mysupport.netapp.com/matrix/imt.jsp?components=68964;&solution=1&isHWU&src=I
MT[NetApp Interoperability Matrix Tool^] to verify that your OS, HBA, HBA firmware and
the HBA boot BIOS, and ONTAP version are supported.

.   Map the SAN boot LUN to the host.
.   Verify multiple paths are available.
+
Remember, multiple paths will only be available after the host OS is up and running on
the paths.
.   Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is
mapped.
+
For information on how to enable the HBA BIOS, see your vendor-specific documentation.
.   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

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

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

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

```
.Note
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

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

systemctl enable multipathd
[root@jfs0 ~] systemctl start multipathd

```
There is no requirement to add anything directly to multipath.conf, 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.

.Note
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.

.   Run the following command to determine the WWID:
+
....
# /lib/udev/scsi_id -gud /dev/sda
360030057024d0730239134810c0cb833
....
.   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.


[cols=2*,options="header"]
|===
| Parameter
| Setting
| detect_prio | yes
| dev_loss_tmo | "infinity"
| failback | immediate
| fast_io_fail_tmo | 5
| features | "3 queue_if_no_path pg_init_retries 50"
| flush_on_last_del | "yes"
| hardware_handler | "0"
| path_checker | "tur"
| path_grouping_policy | "group_by_prio"
| path_selector | "service-time 0"
| polling_interval | 5
| prio | "ontap"
| product | LUN.*
| retain_attached_hw_handler | yes
| 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

[cols=4*,options="header"]
|===
| NetApp Bug ID
| Title
| Description
| Bugzilla ID
| link:https://mysupport.netapp.com/NOW/cgi-bin/bol?Type=Detail&Display=873555[873555^] |
scsi_dh_alua module is not loaded during multipathd startup on local boot | scsi_dh_alua
is a Linux ALUA device handler module. This is is not loaded during multipathd startup on
local boot. Due to this device handler will not be loaded though ALUA is enabled on
target side. | link:https://bugzilla.suse.com/show_bug.cgi?id=908529[908529^]
| link:https://mysupport.netapp.com/NOW/cgi-bin/bol?Type=Detail&Display=863584[863584^] |
The message "conflicting device node '/dev/mapper/360xx' found" appears on the screen
when you create a DM device on SLES12 | You might observe a failure in creating a link to
DM devices under /dev/mapper dir in SLES 12 and see the messages
"conflicting device node '/dev/mapper/360xx' found". |
link:https://bugzilla.suse.com/show_bug.cgi?id=903001[903001^]
| link:https://mysupport.netapp.com/NOW/cgi-bin/bol?Type=Detail&Display=847490[847490^] |
Multipath daemon shows path failures on SLES 12 | You might observe path failures on the
SLES12 multipath daemon during I/O with storage or fabric faults. |
link:https://bugzilla.novell.com/show_bug.cgi?id=890854[890854^]
|===

== 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 fail 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
link:https://www.netapp.com/us/media/tr-3633.pdf[Oracle Databases on ONTAP^] for further
information.


:leveloffset: -1


:leveloffset: -1


= Oracle Linux
```

```
:leveloffset: +1


= OL 8

:leveloffset: +1

[[ID3c917ac4a5bb3955f52a5a347208bf23]]
= Using Oracle Linux 8.2 with NetApp ONTAP
:toc: macro
:hardbreaks:
:toclevels: 1P
:nofooter:
:icons: font
:linkattrs:
:imagesdir: ./media/

== Installing the Linux Unified Host Utilities

The NetApp Linux Unified Host Utilities software package is available on the
link:https://mysupport.netapp.com/NOW/cgi-bin/software/?product=Host+Utilities+-
+SAN&platform=Linux[NetApp Support Site^] in a 64-bit .rpm file.

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.

.Before you begin

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.

.   Download the 64-bit Linux Unified Host Utilities software package from the
link:https://mysupport.netapp.com/NOW/cgi-bin/software/?product=Host+Utilities+-
+SAN&platform=Linux[NetApp Support Site^] to your host.
.   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

.Before you begin
If you decide to use SAN booting, it must be supported by your configuration. You can use
the
link:https://mysupport.netapp.com/matrix/imt.jsp?components=91863;&solution=1&isHWU&src=I
MT[NetApp Interoperability Matrix Tool^] to verify that your OS, HBA, HBA firmware and
the HBA boot BIOS, and ONTAP version are supported.

.   Map the SAN boot LUN to the host.
.   Verify multiple paths are available.
+
Remember, multiple paths will only be available after the host OS is up and running on
the paths.
.   Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is
mapped.
+
For information on how to enable the HBA BIOS, see your vendor-specific documentation.
.   Reboot the host to verify the boot is successful.

== Multipathing

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

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

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

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

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

== Recommended Settings

The Oracle Linux 8.2 OS is compiled to recognize ONTAP LUNs and automatically set all
configuration parameters correctly for both ASA and non-ASA configuration.
The multipath.conf file must exist for the multipath daemon to start, but you can create
an empty, zero-byte file using the command:
`touch /etc/multipath.conf`
The first time you create this file, you might need to enable and start the multipath
services.
----
[root@jfs0 ~]#systemctl enable multipathd
[root@jfs0 ~]# systemctl start multipathd
----
There is no requirement to add anything directly to multipath.conf, 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.

.Note
```

```
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.

.   Run the following command to determine the WWID:
+
....
# /lib/udev/scsi_id -gud /dev/sda
360030057024d0730239134810c0cb833
....
.   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.


[cols=2*,options="header"]
|===
| 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 (No open BURTs)

There are no known issues for Oracle Linux 8.2.
For ASA Oracle Linux 8.2, see the table below.

[cols=4*,options="header"]
|===
| NetApp Bug ID
```

```
| Title
| Description
| Bugzilla ID
| link:https://mysupport.netapp.com/NOW/cgi-bin/bol?Type=Detail&Display=1328944[1328944^]
| I/O delays observed during storage failover with Emulex LPe16002(16G) host | I/O
operations might fail to continue through existing active paths during storage failover
operations on Oracle Linux 7.8 kernel (5.4.17-2011.1.2.el7uek.x86_64) with QLogic
Lpe32002 32G HBA. If I/O progress stops due to failure in continuing through existing
active paths during storage failover, the I/O operation might not resume causing an I/O
delay. The I/O operation resumes only after the completion of the storage failover
giveback operation. |
link:https://bugzilla.oracle.com/bugzilla/show_bug.cgi?id=17319[17319^]
| link:https://mysupport.netapp.com/NOW/cgi-bin/bol?Type=Detail&Display=1328943[1328943^]
| I/O delays observed during storage failover with Emulex LPe32002(32G) host | I/O
operations might fail to continue through existing active paths during storage failover
operations on Oracle Linux 7.8 kernel (5.4.17-2011.1.2.el8uek.x86_64) with QLogic
Lpe32002 32G HBA. If I/O progress stops due to failure in continuing through existing
active paths during storage failover, the I/O operation might not resume causing an I/O
delay. The I/O operation resumes only after the completion of the storage failover
giveback operation. |
link:https://bugzilla.oracle.com/bugzilla/show_bug.cgi?id=17319[17319^]
|===

[[ID1c2de3104dda31f701acf150eac48d84]]
= Using Oracle Linux 8.1 with NetApp ONTAP
:toc: macro
:hardbreaks:
:toclevels: 1
:nofooter:
:icons: font
:linkattrs:
:imagesdir: ./media/

== Installing the Linux Unified Host Utilities

The NetApp Linux Unified Host Utilities software package is available on the
link:https://mysupport.netapp.com/NOW/cgi-bin/software/?product=Host+Utilities+-
+SAN&platform=Linux[NetApp Support Site^] in a 64-bit .rpm file.

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.

.Before you begin

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.

.   Download the 64-bit Linux Unified Host Utilities software package from the
link:https://mysupport.netapp.com/NOW/cgi-bin/software/?product=Host+Utilities+-
+SAN&platform=Linux[NetApp Support Site^] to your host.
.   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

.Before you begin
If you decide to use SAN booting, it must be supported by your configuration. You can use
the
link:https://mysupport.netapp.com/matrix/imt.jsp?components=91863;&solution=1&isHWU&src=I
MT[NetApp Interoperability Matrix Tool^] to verify that your OS, HBA, HBA firmware and
the HBA boot BIOS, and ONTAP version are supported.

.   Map the SAN boot LUN to the host.
.   Verify multiple paths are available.
+
Remember, multiple paths will only be available after the host OS is up and running on
the paths.
.   Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is
mapped.
+
For information on how to enable the HBA BIOS, see your vendor-specific documentation.
.   Reboot the host to verify the boot is successful.

== Multipathing

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

You can use the `multipath -ll` command to verify the settings for your ONTAP LUNs.
There should be two groups of paths with different priorities. The paths with the higher
priorities are Active/Optimized, meaning they are serviced by the controller where the
aggregate is located. The paths with the lower priorities are active but are non-
optimized because they are served from a different controller. The non-optimized paths
are only used when no optimized paths are available.

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

multipath -ll

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

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

== Recommended Settings

The Oracle Linux 8.1 OS is compiled to recognize ONTAP LUNs and automatically set all
configuration parameters correctly.
The multipath.conf file must exist for the multipath daemon to start, but you can create
an empty, zero-byte file 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
[root@jfs0 ~] systemctl start multipathd

```
There is no requirement to add anything directly to multipath.conf, 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.

.Note
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.

.   Run the following command to determine the WWID:
+
....
# /lib/udev/scsi_id -gud /dev/sda
360030057024d0730239134810c0cb833
....
.   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.


[cols=2*,options="header"]
|===
| 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 Oracle Linux 8.1.

.Note
For Oracle Linux (Red Hat compatible kernel) known issues, see the Known Issues section
in the corresponding
https://mysupport.netapp.com/documentation/productlibrary/index.html?productID=63146[Red
Hat Enterprise Linux release^] documentation.

== 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 fail 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
link:https://www.netapp.com/us/media/tr-3633.pdf[Oracle Databases on ONTAP^] for further
information.

[[ID088d1c335c1dbece5ecd1d8ed90463d8]]
= Using Oracle Linux 8.0 with NetApp ONTAP
:toc: macro
:hardbreaks:
:toclevels: 1
:nofooter:
:icons: font
:linkattrs:
```

```
:imagesdir: ./media/

== Installing the Linux Unified Host Utilities

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link:https://mysupport.netapp.com/NOW/cgi-bin/software/?product=Host+Utilities+-
+SAN&platform=Linux[NetApp Support Site^] in a 64-bit .rpm file.

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.

.Before you begin

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.

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link:https://mysupport.netapp.com/NOW/cgi-bin/software/?product=Host+Utilities+-
+SAN&platform=Linux[NetApp Support Site^] to your host.
.   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

.Before you begin
If you decide to use SAN booting, it must be supported by your configuration. You can use
the
link:https://mysupport.netapp.com/matrix/imt.jsp?components=89523;&solution=1&isHWU&src=I
MT[NetApp Interoperability Matrix Tool^] to verify that your OS, HBA, HBA firmware and
the HBA boot BIOS, and ONTAP version are supported.

.   Map the SAN boot LUN to the host.
.   Verify multiple paths are available.
+
Remember, multiple paths will only be available after the host OS is up and running on
the paths.
.   Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is
mapped.
+
For information on how to enable the HBA BIOS, see your vendor-specific documentation.
.   Reboot the host to verify the boot is successful.

== Multipathing

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

You can use the `multipath -ll` command to verify the settings for your ONTAP LUNs.
There should be two groups of paths with different priorities. The paths with the higher
priorities are Active/Optimized, meaning they are serviced by the controller where the
aggregate is located. The paths with the lower priorities are active but are non-
optimized because they are served from a different controller. The non-optimized paths
are only used when no optimized paths are available.

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

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

```
|- 15:0:1:35 sdbx 68:176 active ready running
----

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

== Recommended Settings

The Oracle Linux 8.0 OS is compiled to recognize ONTAP LUNs and automatically set all
configuration parameters correctly.
The multipath.conf file must exist for the multipath daemon to start, but you can create
an empty, zero-byte file using the command:
`touch /etc/multipath.conf`
The first time you create this file, you might need to enable and start the multipath
services.
----
[root@jfs0 ~]#systemctl enable multipathd
[root@jfs0 ~]# systemctl start multipathd
----
There is no requirement to add anything directly to multipath.conf, 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.

.Note
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.

.   Run the following command to determine the WWID:
+
....
# /lib/udev/scsi_id -gud /dev/sda
360030057024d0730239134810c0cb833
....
.   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.


[cols=2*,options="header"]
|===
| 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 Oracle Linux 8.0.

.Note
For Oracle Linux (Red Hat compatible kernel) known issues, see the Known Issues section
in the corresponding
https://mysupport.netapp.com/documentation/productlibrary/index.html?productID=63146[Red
Hat Enterprise Linux release^] documentation.

== 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 fail 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
link:https://www.netapp.com/us/media/tr-3633.pdf[Oracle Databases on ONTAP^] for further
information.


:leveloffset: -1


= OL 7

:leveloffset: +1
```

```
[[IDeb3e6aa6e40856803f3f17d42f10f497]]
= Using Oracle Linux 7.7 with NetApp ONTAP
:toc: macro
:hardbreaks:
:toclevels: 1
:nofooter:
:icons: font
:linkattrs:
:imagesdir: ./media/

== Installing the Linux Unified Host Utilities

The NetApp Linux Unified Host Utilities software package is available on the
link:https://mysupport.netapp.com/NOW/cgi-bin/software/?product=Host+Utilities+-
+SAN&platform=Linux[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
link:https://mysupport.netapp.com/matrix/#welcome[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.

.Before you begin

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.

.   Download the 32-bit or 64-bit Linux Unified Host Utilities software package from the
link:https://mysupport.netapp.com/NOW/cgi-bin/software/?product=Host+Utilities+-
+SAN&platform=Linux[NetApp Support Site^] Site to your host.
.   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

.Before you begin
If you decide to use SAN booting, it must be supported by your configuration. You can use
the
link:https://mysupport.netapp.com/matrix/imt.jsp?components=90144;&solution=1&isHWU&src=I
MT[NetApp Interoperability Matrix Tool^] to verify that your OS, HBA, HBA firmware and
the HBA boot BIOS, and ONTAP version are supported.

.   Map the SAN boot LUN to the host.
.   Verify multiple paths are available.
+
Remember, multiple paths will only be available after the host OS is up and running on
the paths.
.   Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is
mapped.
+
For information on how to enable the HBA BIOS, see your vendor-specific documentation.
.   Reboot the host to verify the boot is successful.

== Multipathing

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

You can use the `multipath -ll` command to verify the settings for your ONTAP LUNs.
There should be two groups of paths with different priorities. The paths with the higher
priorities are Active/Optimized, 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

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

== Recommended Settings

The Oracle Linux 7.7 OS is compiled to recognize ONTAP LUNs and automatically set all
configuration parameters correctly.
The multipath.conf file must exist for the multipath daemon to start, but you can create
an empty, zero-byte file 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
[root@jfs0 ~] systemctl start multipathd

```
There is no requirement to add anything directly to multipath.conf, 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.

.Note
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.

.   Run the following command to determine the WWID:
+
....
# /lib/udev/scsi_id -gud /dev/sda
360030057024d0730239134810c0cb833
....
.   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.


[cols=2*,options="header"]
|===
| Parameter
| Setting
| detect_prio | yes
| dev_loss_tmo | "infinity"
| failback | immediate
| fast_io_fail_tmo | 5
| features | "3 queue_if_no_path pg_init_retries 50"
| flush_on_last_del | "yes"
| hardware_handler | "0"
| path_checker | "tur"
| path_grouping_policy | "group_by_prio"
| path_selector | "service-time 0"
| polling_interval | 5
| prio | "ontap"
| product | LUN.*
| retain_attached_hw_handler | yes
```

```
| 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 Oracle Linux 7.7.

.Note
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```

```
information.

[[ID9eac4d1d9a85297f8bca71563b5ed29d]]
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know which file is right for your configuration, use the
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.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

.Before you begin
If you decide to use SAN booting, it must be supported by your configuration. You can use
the
link:https://mysupport.netapp.com/matrix/imt.jsp?components=86309;&solution=1&isHWU&src=I
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.   Map the SAN boot LUN to the host.
.   Verify multiple paths are available.
+
Remember, multiple paths will only be available after the host OS is up and running on
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.   Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is
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+
For information on how to enable the HBA BIOS, see your vendor-specific documentation.
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optimized because they are served from a different controller. The non-optimized paths
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```

```
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The following example displays the correct output for an ONTAP LUN with two
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----
# 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
----

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

== Recommended Settings

The Oracle Linux 7.6 OS is compiled to recognize ONTAP LUNs and automatically set all
configuration parameters correctly.
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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.
----
[root@jfs0 ~]#systemctl enable multipathd
[root@jfs0 ~]# systemctl start multipathd
----
There is no requirement to add anything directly to multipath.conf, 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.

.Note
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.

.   Run the following command to determine the WWID:
+
....
# /lib/udev/scsi_id -gud /dev/sda
360030057024d0730239134810c0cb833
....
.   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.


[cols=2*,options="header"]
|===
| Parameter
| Setting
| detect_prio | yes
| dev_loss_tmo | "infinity"
| failback | immediate
| fast_io_fail_tmo | 5
| features | "3 queue_if_no_path pg_init_retries 50"
| flush_on_last_del | "yes"
| hardware_handler | "0"
| path_checker | "tur"
| path_grouping_policy | "group_by_prio"
| path_selector | "service-time 0"
```

```
| polling_interval | 5
| prio | "ontap"
| product | LUN.*
| retain_attached_hw_handler | yes
| 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

[cols=4*,options="header"]
|===
| NetApp Bug ID
| Title
| Description
| Bugzilla ID
| link:https://mysupport.netapp.com/NOW/cgi-bin/bol?Type=Detail&Display=1202736[1202736]
| LUNs might not be available during host discovery due to "Not Present" state of remote
ports on a OL7U6 host with QLogic QLE2742 adapter |During host discovery, the status of
Fibre Channel (FC) remote ports on a OL7U6 host with a QLogic QLE2742 adapter might enter
into "Not Present" state. Remote ports with a "Not Present" state might cause paths to
LUNs to become unavailable. During storage failover, the path redundancy might be reduced
and result in an I/O outage.
You can check the remote port status by entering the following command:
```

```
# cat /sys/class/fc_remote_ports/rport-*/port_state
The following is an example of the output that is displayed:
  Online
  Online
  Not Present
  Online
  Online | link:https://bugzilla.oracle.com/bugzilla/show_bug.cgi?id=16613[16613^]
| link:https://mysupport.netapp.com/NOW/cgi-bin/bol?Type=Detail&Display=1204078[1204078^]
| Kernel disruption occurs on Oracle Linux 7.6 running with Qlogic(QLE2672) 16GB FC HBA
during storage failover operations | During storage failover operations on the Oracle
Linux 7.6 with a Qlogic QLE2672 Fibre Channel (FC) host bus adapter (HBA), a kernel
disruption occurs due to a panic in the kernel. The kernel panic causes Oracle Linux 7.6
to reboot, which leads to an application disruption.   If the kdump mechanism is enabled,
the kernel panic generates a vmcore file located in the /var/crash/ directory. You can
analyze the vmcore file to determine the cause of the panic.  After the kernel
disruption, you can reboot the host OS and recover the operating system, and then you can
restart any applications as required. |
link:https://bugzilla.oracle.com/bugzilla/show_bug.cgi?id=16606[16606]
| link:https://mysupport.netapp.com/NOW/cgi-bin/bol?Type=Detail&Display=1204351[1204351^]
| Kernel disruption might occur on Oracle Linux 7.6 running with Qlogic(QLE2742) 32GB FC
HBA during storage failover operations | During storage failover operations on the Oracle
Linux 7.6 with a Qlogic QLE2742 Fibre Channel (FC) host bus adapter (HBA), a kernel
disruption might occur due to a panic in the kernel. The kernel panic causes Oracle Linux
7.6 to reboot, which leads to an application disruption. If the kdump mechanism is
enabled, the kernel panic generates a vmcore file located in the /var/crash/ directory.
You can analyze the vmcore file to determine the cause of the panic.
After the kernel disruption, you can reboot the host OS and recover the operating system,
and then you can restart any applications as required. |
link:https://bugzilla.oracle.com/bugzilla/show_bug.cgi?id=16605[16605]
| link:https://mysupport.netapp.com/NOW/cgi-bin/bol?Type=Detail&Display=1204352[1204352^]
| Kernel disruption might occur on Oracle Linux 7.6 running with Emulex (LPe32002-M2)32GB
FC HBA during storage failover operations | During storage failover operations on the
Oracle Linux 7.6 with an Emulex LPe32002-M2 Fibre Channel (FC) host bus adapter (HBA), a
kernel disruption might occur due to a panic in the kernel. The kernel panic causes
Oracle Linux 7.6 to reboot, which leads to an application disruption.
 If the kdump mechanism is enabled, the kernel panic generates a vmcore file located in
the /var/crash/ directory. You can analyze the vmcore file to determine the cause of the
panic.
After the kernel disruption, you can reboot the host OS and recover the operating system,
and then you can restart any applications as required. |
link:https://bugzilla.oracle.com/bugzilla/show_bug.cgi?id=16607[16607]
| link:https://mysupport.netapp.com/NOW/cgi-
bin/bol?Type=Detail&Display=1246134[11246134^] | No I/O progress on Oracle Linux 7.6 with
UEK5U2 kernel, running with an Emulex LPe16002B-M6 16G FC HBA during storage failover
operations | During storage failover operations on the Oracle Linux 7.6 with the UEK5U2
kernel running with an Emulex LPe16002B-M6 16G Fibre Channel (FC) host bus adapter (HBA),
I/O progress might stop due to reports getting blocked. The storage failover operation
reports change from an "online" state to a "blocked" state, causing a delay in read and
```

```
write operations. After the operation has completed successfully, the reports fail to
move back to an "online" state and continue to remain in a "blocked" state. |
link:https://bugzilla.oracle.com/bugzilla/show_bug.cgi?id=16852[16852]
| link:https://mysupport.netapp.com/NOW/cgi-bin/bol?Type=Detail&Display=1246327[1246327^]
| Remote port status on QLogic QLE2672 16G host blocked during storage failover
operations | Fibre Channel (FC) remote ports might be blocked on Red Hat Enterprise Linux
(RHEL) 7.6 with the QLogic QLE2672 16G host during storage failover operations. Because
the logical interfaces go down when a storage node is down, the remote ports set the
storage node status to blocked. IO progress might stop due to the blocked ports if you
are running both a QLogic QLE2672 16G host and a QLE2742 32GB Fibre Channel (FC) host bus
adapter (HBA).
When the storage node returns to its optimal state, the logical interfaces also come up
and the remote ports should be online. However, the remote ports might still be blocked.
This blocked state registers as failed faulty to LUNS at the multipath layer. You can
verify the state of the remote ports with the following command:
 # cat /sys/class/fc_remote_ports/rport-*/port_stat
 You should see the following output:
 Blocked
 Blocked
 Blocked
 Blocked
 Online
 Online | link:https://bugzilla.oracle.com/bugzilla/show_bug.cgi?id=16853[16853^]
|===
.Note
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[[IDb84ccc345ce0ad7d3cc1361f55a451c6]]
= Using Oracle Linux 7.5 with NetApp ONTAP
:toc: macro
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:toclevels: 1
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```
:icons: font
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# 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

.Before you begin
If you decide to use SAN booting, it must be supported by your configuration. You can use
the
link:https://mysupport.netapp.com/matrix/imt.jsp?components=83635;&solution=1&isHWU&src=I
MT[NetApp Interoperability Matrix Tool^] to verify that your OS, HBA, HBA firmware and
the HBA boot BIOS, and ONTAP version are supported.

.   Map the SAN boot LUN to the host.
.   Verify multiple paths are available.
+
Remember, multiple paths will only be available after the host OS is up and running on
the paths.
.   Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is
mapped.
+
For information on how to enable the HBA BIOS, see your vendor-specific documentation.
.   Reboot the host to verify the boot is successful.

== Multipathing

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

You can use the `multipath -ll` command to verify the settings for your ONTAP LUNs.
There should be two groups of paths with different priorities. The paths with the higher
priorities are Active/Optimized, 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

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

== Recommended Settings

The Oracle Linux 7.5 OS is compiled to recognize ONTAP LUNs and automatically set all
configuration parameters correctly.
The multipath.conf file must exist for the multipath daemon to start, but you can create
an empty, zero-byte file 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
[root@jfs0 ~] systemctl start multipathd

```
There is no requirement to add anything directly to multipath.conf, 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.

.Note
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.

.   Run the following command to determine the WWID:
+
....
```

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


[cols=2*,options="header"]
|===
| Parameter
| Setting
| detect_prio | yes
| dev_loss_tmo | "infinity"
| failback | immediate
| fast_io_fail_tmo | 5
| features | "3 queue_if_no_path pg_init_retries 50"
| flush_on_last_del | "yes"
| hardware_handler | "0"
| path_checker | "tur"
| path_grouping_policy | "group_by_prio"
| path_selector | "service-time 0"
| polling_interval | 5
| prio | "ontap"
| product | LUN.*
| retain_attached_hw_handler | yes
| 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

[cols=4*,options="header"]
|===
| NetApp Bug ID
| Title
| Description
| Bugzilla ID
| link:https://mysupport.netapp.com/NOW/cgi-bin/bol?Type=Detail&Display=1177239[1177239^]
| Kernel disruption observed on OL7.5 with Qlogic QLE2672 16G FC during storage failover
operations |During storage failover operations on Oracle Linux 7 (OL7.5) with kernel
4.1.12-112.16.4.el7uek.x86_64 and the Qlogic QLE2672 HBA, you might observe kernel
disruption. This prompts a reboot of the operating system which causes an application
disruption.
If kdump is configured, the kernel disruption creates a vmcore file in the  /var/crash/
directory. This disruption can be observed in the module kmem_cache_alloc+118, which is
logged in the vmcore file and identified with the string "exception RIP:
kmem_cache_alloc+118."
After a kernel disruption, you can recover by rebooting the host operating system and
restarting the application. |
|===
.Note
For Oracle Linux (Red Hat compatible kernel) known issues, see the Known Issues section
in the corresponding
https://mysupport.netapp.com/documentation/productlibrary/index.html?productID=63146[Red
Hat Enterprise Linux release^] documentation.
```

```
== 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 fail 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
link:https://www.netapp.com/us/media/tr-3633.pdf[Oracle Databases on ONTAP^] for further
information.

[[ID092ebb7b525db888d5a76fbd16366121]]
= Using Oracle Linux 7.4 with NetApp ONTAP
:toc: macro
:hardbreaks:
:toclevels: 1
:nofooter:
:icons: font
:linkattrs:
:imagesdir: ./media/

== Installing the Linux Unified Host Utilities

The NetApp Linux Unified Host Utilities software package is available on the
link:https://mysupport.netapp.com/NOW/cgi-bin/software/?product=Host+Utilities+-
+SAN&platform=Linux[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
link:https://mysupport.netapp.com/matrix/#welcome[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.

.Before you begin

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.

.   Download the 32-bit or 64-bit Linux Unified Host Utilities software package from the
link:https://mysupport.netapp.com/NOW/cgi-bin/software/?product=Host+Utilities+-
+SAN&platform=Linux[NetApp Support Site^] Site to your host.
.   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

.Before you begin
If you decide to use SAN booting, it must be supported by your configuration. You can use
the
link:https://mysupport.netapp.com/matrix/imt.jsp?components=80004;&solution=1&isHWU&src=I
MT[NetApp Interoperability Matrix Tool^] to verify that your OS, HBA, HBA firmware and
the HBA boot BIOS, and ONTAP version are supported.

.   Map the SAN boot LUN to the host.
.   Verify multiple paths are available.
+
Remember, multiple paths will only be available after the host OS is up and running on
the paths.
.   Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is
mapped.
+
For information on how to enable the HBA BIOS, see your vendor-specific documentation.
.   Reboot the host to verify the boot is successful.

== Multipathing
```

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

You can use the `multipath -ll` command to verify the settings for your ONTAP LUNs.
There should be two groups of paths with different priorities. The paths with the higher
priorities are Active/Optimized, 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
----

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

== Recommended Settings

The Oracle Linux 7.4 OS is compiled to recognize ONTAP LUNs and automatically set all
configuration parameters correctly.
The multipath.conf file must exist for the multipath daemon to start, but you can create
an empty, zero-byte file using the command:
`touch /etc/multipath.conf`
The first time you create this file, you might need to enable and start the multipath
services.
----
[root@jfs0 ~]#systemctl enable multipathd
[root@jfs0 ~]# systemctl start multipathd
----
There is no requirement to add anything directly to multipath.conf, 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.

.Note
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.

.   Run the following command to determine the WWID:
+
....
# /lib/udev/scsi_id -gud /dev/sda
360030057024d0730239134810c0cb833
....
.   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.


[cols=2*,options="header"]
|===
| Parameter
```

```
| Setting
| detect_prio | yes
| dev_loss_tmo | "infinity"
| failback | immediate
| fast_io_fail_tmo | 5
| features | "3 queue_if_no_path pg_init_retries 50"
| flush_on_last_del | "yes"
| hardware_handler | "0"
| path_checker | "tur"
| path_grouping_policy | "group_by_prio"
| path_selector | "service-time 0"
| polling_interval | 5
| prio | "ontap"
| product | LUN.*
| retain_attached_hw_handler | yes
| 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

[cols=4*,options="header"]
|===
| NetApp Bug ID
```

```
| Title
| Description
| Bugzilla ID
| link:https://mysupport.netapp.com/NOW/cgi-bin/bol?Type=Detail&Display=1109468[1109468^]
| Firmware dumps observed on an OL7.4 Hypervisor with QLE8362 card |During storage
failover operations on an OL7.4 Hypervisor with QLE8362 card,  the firmware dumps are
observed occasionally. The firmware dumps might result in an I/O outage on the host,
which might go up to 500 seconds. After the adapter completes the firmware dump, the I/O
operation resumes in the normal manner. No further recovery procedure is required on the
host. To indicate the firmware dump, the following message is displayed in the
/var/log/message file:
 qla2xxx [0000:0c:00.3]-d001:8: Firmware dump saved to temp buffer (8/ffffc90008901000),
dump status flags (0x3f)
| link:https://bugzilla.oracle.com/bugzilla/show_bug.cgi?id=16039[16039^]
|===
.Note
For Oracle Linux (Red Hat compatible kernel) known issues, see the Known Issues section
in the corresponding
https://mysupport.netapp.com/documentation/productlibrary/index.html?productID=63146[Red
Hat Enterprise Linux release^] documentation.

== 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 fail 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
link:https://www.netapp.com/us/media/tr-3633.pdf[Oracle Databases on ONTAP^] for further
information.

[[ID995210a8d9969ed0ecfad4ce5dc470ca]]
= Using Oracle Linux 7.3 with NetApp ONTAP
:toc: macro
:hardbreaks:
:toclevels: 1
:nofooter:
:icons: font
:linkattrs:
:imagesdir: ./media/

== Installing the Linux Unified Host Utilities

The NetApp Linux Unified Host Utilities software package is available on the
link:https://mysupport.netapp.com/NOW/cgi-bin/software/?product=Host+Utilities+-
+SAN&platform=Linux[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
link:https://mysupport.netapp.com/matrix/#welcome[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.

.Before you begin

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.

.   Download the 32-bit or 64-bit Linux Unified Host Utilities software package from the
link:https://mysupport.netapp.com/NOW/cgi-bin/software/?product=Host+Utilities+-
+SAN&platform=Linux[NetApp Support Site^] Site to your host.
.   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

.Before you begin
If you decide to use SAN booting, it must be supported by your configuration. You can use
the
https://mysupport.netapp.com/matrix/imt.jsp?components=77396;&solution=1&isHWU&src=IMT[Ne
tApp Interoperability Matrix Tool^] to verify that your OS, HBA, HBA firmware and the HBA
boot BIOS, and ONTAP version are supported.

.   Map the SAN boot LUN to the host.
.   Verify multiple paths are available.
+
Remember, multiple paths will only be available after the host OS is up and running on
the paths.
.   Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is
mapped.
+
For information on how to enable the HBA BIOS, see your vendor-specific documentation.
.   Reboot the host to verify the boot is successful.

== Multipathing

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

You can use the `multipath -ll` command to verify the settings for your ONTAP LUNs.
There should be two groups of paths with different priorities. The paths with the higher
priorities are Active/Optimized, 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

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

== Recommended Settings

The Oracle Linux 7.3 OS is compiled to recognize ONTAP LUNs and automatically set all
configuration parameters correctly.
The multipath.conf file must exist for the multipath daemon to start, but you can create
an empty, zero-byte file 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
[root@jfs0 ~] systemctl start multipathd

```
There is no requirement to add anything directly to multipath.conf, 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.

.Note
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.

.   Run the following command to determine the WWID:
+
....
# /lib/udev/scsi_id -gud /dev/sda
360030057024d0730239134810c0cb833
....
.   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.


[cols=2*,options="header"]
|===
| Parameter
| Setting
| detect_prio | yes
| dev_loss_tmo | "infinity"
| failback | immediate
| fast_io_fail_tmo | 5
| features | "3 queue_if_no_path pg_init_retries 50"
| flush_on_last_del | "yes"
| hardware_handler | "0"
| path_checker | "tur"
| path_grouping_policy | "group_by_prio"
| path_selector | "service-time 0"
| polling_interval | 5
| prio | "ontap"
| product | LUN.*
| retain_attached_hw_handler | yes
| 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 Oracle Linux 7.3.

.Note
For Oracle Linux (Red Hat compatible kernel) known issues, see the Known Issues section
in the corresponding
https://mysupport.netapp.com/documentation/productlibrary/index.html?productID=63146[Red
Hat Enterprise Linux release^] documentation.

== 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 fail 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
link:https://www.netapp.com/us/media/tr-3633.pdf[Oracle Databases on ONTAP^] for further
information.

[[ID0abd94e846905ca5eed065ab64bd11a0]]
= Using Oracle Linux 7.2 with NetApp ONTAP
:toc: macro
:hardbreaks:
:toclevels: 1
:nofooter:
:icons: font
:linkattrs:
:imagesdir: ./media/
```

```
== Installing the Linux Unified Host Utilities

The NetApp Linux Unified Host Utilities software package is available on the
link:https://mysupport.netapp.com/NOW/cgi-bin/software/?product=Host+Utilities+-
+SAN&platform=Linux[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
link:https://mysupport.netapp.com/matrix/#welcome[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.

.Before you begin

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.

.   Download the 32-bit or 64-bit Linux Unified Host Utilities software package from the
link:https://mysupport.netapp.com/NOW/cgi-bin/software/?product=Host+Utilities+-
+SAN&platform=Linux[NetApp Support Site^] Site to your host.
.   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

.Before you begin
If you decide to use SAN booting, it must be supported by your configuration. You can use
the
https://mysupport.netapp.com/matrix/imt.jsp?components=72764;72763;&solution=1&isHWU&src=
IMT[NetApp Interoperability Matrix Tool^] to verify that your OS, HBA, HBA firmware and
the HBA boot BIOS, and ONTAP version are supported.

.   Map the SAN boot LUN to the host.
.   Verify multiple paths are available.
+
Remember, multiple paths will only be available after the host OS is up and running on
the paths.
.   Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is
mapped.
+
For information on how to enable the HBA BIOS, see your vendor-specific documentation.
.   Reboot the host to verify the boot is successful.

== Multipathing

Oracle Linux 7.2 supports Unbreakable Enterprise Kernel (UEK) R3 and UEK R4. The OS boots
with UEK R3 kernel by default.

.Oracle Linux 7.2 UEK R3 Configuration

For Oracle Linux 7.2 UEK R3, create an empty multipath.conf file. The settings for Oracle
Linux 7.2 UEK with and without ALUA update automatically by default. To Enable ALUA
Handler, perform the following steps:

.   Create a backup of the initrd-image.
.   Append the following parameter value to the kernel for ALUA and non-ALUA to work:
`rdloaddriver=scsi_dh_alua`
+
.Example
....
kernel /vmlinuz-3.8.13-68.1.2.el6uek.x86_64 ro root=/dev/mapper/vg_ibmx3550m421096-
lv_root rd_NO_LUKSrd_LVM_LV=vg_ibmx3550m421096/lv_root LANG=en_US.UTF-8
rd_NO_MDSYSFONT=latarcyrheb-sun16 crashkernel=256M KEYBOARDTYPE=pc KEYTABLE=us
rd_LVM_LV=vg_ibmx3550m421096/lv_swap rd_NO_DM rhgb quiet rdloaddriver=scsi_dh_alua
....

.   Use the `dracut -f` command to recreate the initrd-image.
```

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

.Oracle Linux 7.2 UEK R4 Configuration

For Oracle Linux 7.2 UEK R4 the /etc/multipath.conf file must exist, but you do not need
to make specific changes to the file. Oracle Linux 7.2 is compiled with all settings
required to recognize and correctly manage ONTAP LUNs.

You can use the `multipath -ll` command to verify the settings for your ONTAP LUNs.
There should be two groups of paths with different priorities. The paths with the higher
priorities are Active/Optimized, 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
----

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

== Recommended Settings

The Oracle Linux 7.2 OS is compiled to recognize ONTAP LUNs and automatically set all
configuration parameters correctly.
The multipath.conf file must exist for the multipath daemon to start, but you can create
an empty, zero-byte file using the command:
`touch /etc/multipath.conf`
The first time you create this file, you might need to enable and start the multipath
services.
```

```
----
[root@jfs0 ~]#systemctl enable multipathd
[root@jfs0 ~]# systemctl start multipathd
----
There is no requirement to add anything directly to multipath.conf, 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.

.Note
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.

.   Run the following command to determine the WWID:
+
....
# /lib/udev/scsi_id -gud /dev/sda
360030057024d0730239134810c0cb833
....
.   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.


[cols=2*,options="header"]
|===
| Parameter
| Setting
| detect_prio | yes
| dev_loss_tmo | "infinity"
| failback | immediate
| fast_io_fail_tmo | 5
| features | "3 queue_if_no_path pg_init_retries 50"
| flush_on_last_del | "yes"
| hardware_handler | "0"
| path_checker | "tur"
| path_grouping_policy | "group_by_prio"
| path_selector | "service-time 0"
| polling_interval | 5
| prio | "ontap"
| product | LUN.*
| retain_attached_hw_handler | yes
| 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 Oracle Linux 7.2.

.Note
For Oracle Linux (Red Hat compatible kernel) known issues, see the Known Issues section
in the corresponding
https://mysupport.netapp.com/documentation/productlibrary/index.html?productID=63146[Red
Hat Enterprise Linux release^] documentation.

== 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 fail 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
link:https://www.netapp.com/us/media/tr-3633.pdf[Oracle Databases on ONTAP^] for further
information.

[[ID37c3c263fd5d0fa16a5fce31df702475]]
= Using Oracle Linux 7.1 with NetApp ONTAP
:toc: macro
:hardbreaks:
:toclevels: 1
:nofooter:
:icons: font
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link:https://mysupport.netapp.com/NOW/cgi-bin/software/?product=Host+Utilities+-
+SAN&platform=Linux[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
link:https://mysupport.netapp.com/matrix/#welcome[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.
```

```
.Before you begin

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.

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link:https://mysupport.netapp.com/NOW/cgi-bin/software/?product=Host+Utilities+-
+SAN&platform=Linux[NetApp Support Site^] Site to your host.
.   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

.Before you begin
If you decide to use SAN booting, it must be supported by your configuration. You can use
the
https://mysupport.netapp.com/matrix/imt.jsp?components=70671;&solution=1&isHWU&src=IMT[Ne
tApp Interoperability Matrix Tool^] to verify that your OS, HBA, HBA firmware and the HBA
boot BIOS, and ONTAP version are supported.

.   Map the SAN boot LUN to the host.
.   Verify multiple paths are available.
+
Remember, multiple paths will only be available after the host OS is up and running on
```

```
the paths.
.   Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is
mapped.
+
For information on how to enable the HBA BIOS, see your vendor-specific documentation.
.   Reboot the host to verify the boot is successful.

== Multipathing

Oracle Linux 7.1 supports Unbreakable Enterprise Kernel (UEK) R3 and UEK R4. The OS boots
with UEK R3 kernel by default.

.Oracle Linux 7.1 UEK R3 Configuration

For Oracle Linux 7.1 UEK R3, create an empty multipath.conf file. The settings for Oracle
Linux 7.1 UEK with and without ALUA update automatically by default. To Enable ALUA
Handler, perform the following steps:

.   Create a backup of the initrd-image.
.   Append the following parameter value to the kernel for ALUA and non-ALUA to work:
`rdloaddriver=scsi_dh_alua`
+
.Example
....
kernel /vmlinuz-3.8.13-68.1.2.el6uek.x86_64 ro root=/dev/mapper/vg_ibmx3550m421096-
lv_root rd_NO_LUKSrd_LVM_LV=vg_ibmx3550m421096/lv_root LANG=en_US.UTF-8
rd_NO_MDSYSFONT=latarcyrheb-sun16 crashkernel=256M KEYBOARDTYPE=pc KEYTABLE=us
rd_LVM_LV=vg_ibmx3550m421096/lv_swap rd_NO_DM rhgb quiet rdloaddriver=scsi_dh_alua
....

.   Use the `dracut -f` command to recreate the initrd-image.

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

.Oracle Linux 7.1 UEK R4 Configuration

For Oracle Linux 7.1 UEK R4 the /etc/multipath.conf file must exist, but you do not need
to make specific changes to the file. Oracle Linux 7.1 is compiled with all settings
required to recognize and correctly manage ONTAP LUNs.
You can use the `multipath -ll` command to verify the settings for your ONTAP LUNs.
There should be two groups of paths with different priorities. The paths with the higher
priorities are Active/Optimized, 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

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

== Recommended Settings

The Oracle Linux 7.1 OS is compiled to recognize ONTAP LUNs and automatically set all
configuration parameters correctly.

The multipath.conf file must exist for the multipath daemon to start, but you can create
an empty, zero-byte file 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
[root@jfs0 ~] systemctl start multipathd

```
There is no requirement to add anything directly to multipath.conf, 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.

.Note
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.

.   Run the following command to determine the WWID:
+
....
# /lib/udev/scsi_id -gud /dev/sda
360030057024d0730239134810c0cb833
....
.   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]*"
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You should always check your `/etc/multipath.conf` file for legacy settings, especially
in the defaults section, that may be overriding default settings.
The table below shows the critical `multipathd` parameters for ONTAP LUNs and the
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with NetApp and/or OS vendor and only when the impact is fully understood.


[cols=2*,options="header"]
|===
| Parameter
| Setting
| detect_prio | yes
| dev_loss_tmo | "infinity"
| failback | immediate
| fast_io_fail_tmo | 5
| features | "3 queue_if_no_path pg_init_retries 50"
| flush_on_last_del | "yes"
| hardware_handler | "0"
| path_checker | "tur"
| path_grouping_policy | "group_by_prio"
```

```
| path_selector | "service-time 0"
| polling_interval | 5
| prio | "ontap"
| product | LUN.*
| retain_attached_hw_handler | yes
| 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
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}
devices {
device {
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}
}

```
== Known Problems and Limitations

There are no known issues for Oracle Linux 7.1.
.Note
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ASM mirroring might require changes to the Linux multipath settings to allow ASM to
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```

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on ONTAP use external redundancy, which means that data protection is provided by the
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[[ID81ecdad1597b78625e89f676d9d7655b]]
= Using Oracle Linux 7.0 with NetApp ONTAP
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+SAN&platform=Linux[NetApp Support Site^] Site to your host.
.   Use the following command to install the software package:
+
`rpm -ivh netapp_linux_unified_host_utilities-7-1.x86_64`

== SAN Toolkit

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```

```
multipathing, and information necessary to create initiator groups.

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```

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

.Before you begin
If you decide to use SAN booting, it must be supported by your configuration. You can use
the
https://mysupport.netapp.com/matrix/imt.jsp?components=68625;&solution=1&isHWU&src=IMT[Ne
tApp Interoperability Matrix Tool^] to verify that your OS, HBA, HBA firmware and the HBA
boot BIOS, and ONTAP version are supported.

.   Map the SAN boot LUN to the host.
.   Verify multiple paths are available.
+
Remember, multiple paths will only be available after the host OS is up and running on
the paths.
.   Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is
mapped.
+
For information on how to enable the HBA BIOS, see your vendor-specific documentation.
.   Reboot the host to verify the boot is successful.

== Multipathing

For Oracle Linux 7.0 the /etc/multipath.conf file must exist, but you do not need to make
specific changes to the file. Oracle Linux 7.0 is compiled with all settings required to
recognize and correctly manage ONTAP LUNs. To Enable ALUA Handler, perform the following
steps:

.   Create a backup of the initrd-image.
.   Append the following parameter value to the kernel for ALUA and non-ALUA to work:
```

```
`rdloaddriver=scsi_dh_alua`
+
.Example
....
kernel /vmlinuz-3.8.13-68.1.2.el6uek.x86_64 ro root=/dev/mapper/vg_ibmx3550m421096-
lv_root rd_NO_LUKSrd_LVM_LV=vg_ibmx3550m421096/lv_root LANG=en_US.UTF-8
rd_NO_MDSYSFONT=latarcyrheb-sun16 crashkernel=256M KEYBOARDTYPE=pc KEYTABLE=us
rd_LVM_LV=vg_ibmx3550m421096/lv_swap rd_NO_DM rhgb quiet rdloaddriver=scsi_dh_alua
....
.   Recreate the initrd-image with the `dracut -f` command.
.   Reboot the host.
.   Verify the output of the `cat /proc/cmdline` command to ensure that the setting is
complete.

You can use the `multipath -ll` command to verify the settings for your ONTAP LUNs.
There should be two groups of paths with different priorities. The paths with the higher
priorities are Active/Optimized, 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
----

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

== Recommended Settings

The Oracle Linux 7.0 OS is compiled to recognize ONTAP LUNs and automatically set all
configuration parameters correctly.

The multipath.conf file must exist for the multipath daemon to start, but you can create
```

```
an empty, zero-byte file using the command:
`touch /etc/multipath.conf`
The first time you create this file, you might need to enable and start the multipath
services.
----
[root@jfs0 ~]#systemctl enable multipathd
[root@jfs0 ~]# systemctl start multipathd
----
There is no requirement to add anything directly to multipath.conf, 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.

.Note
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.

.   Run the following command to determine the WWID:
+
....
# /lib/udev/scsi_id -gud /dev/sda
360030057024d0730239134810c0cb833
....
.   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.


[cols=2*,options="header"]
|===
| Parameter
| Setting
| detect_prio | yes
| dev_loss_tmo | "infinity"
| failback | immediate
| fast_io_fail_tmo | 5
| features | "3 queue_if_no_path pg_init_retries 50"
| flush_on_last_del | "yes"
| hardware_handler | "0"
| path_checker | "tur"
| path_grouping_policy | "group_by_prio"
| path_selector | "service-time 0"
| polling_interval | 5
| prio | "ontap"
| product | LUN.*
| retain_attached_hw_handler | yes
| 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


[cols=4*,options="header"]
|===
| NetApp Bug ID
| Title
| Description
| Bugzilla ID
| link:https://mysupport.netapp.com/NOW/cgi-bin/bol?Type=Detail&Display=901558[901558^] |
OL7.0 : Host loses all paths to the lun and hangs due to "RSCN timeout" error on OL 7.0
UEK r3U5 Beta on Emulex 8G(LPe12002) host | You might observe that the Emulex
8G(LPe12002) host hangs and there is a high I/O outage during storage failover operations
with I/O. You might observe paths not recovering, which is a result of the RSCN timeout,
due to which the host loses all the paths and hangs. Probability of hitting this issue is
high. | link:https://bugzilla.redhat.com/show_bug.cgi?id=14898[14898^]
| link:https://mysupport.netapp.com/NOW/cgi-bin/bol?Type=Detail&Display=901557[901557^] |
OL 7.0: High IO outage observed on QLogic 8G FC (QLE2562) SAN host during storage
failover operations with IO | You might observe high IO outage on QLogic 8G FC (QLE2562)
host during storage failover operations with IO. Aborts and Device resets manifests as IO
outage on the host. Probability of hitting this IO outage is high. |
link:https://bugzilla.redhat.com/show_bug.cgi?id=14894[14894^]
| link:https://mysupport.netapp.com/NOW/cgi-bin/bol?Type=Detail&Display=894766[894766^] |
OL7.0: Dracut fails to include scsi_dh_alua.ko module in initramfs on UEKR3U5 alpha | The
scsi_dh_alua module might not load even after adding the parameter
"rdloaddriver=scsi_dh_alua" in the kernel command line and creating Dracut. As a result,
ALUA is not enabled for NetApp LUNs as recommended. |
link:https://bugzilla.oracle.com/bugzilla/show_bug.cgi?id=14860[14860^]
| link:https://mysupport.netapp.com/NOW/cgi-bin/bol?Type=Detail&Display=894796[894796^] |
Anaconda displays an iSCSI login failure message although logins are successful during OL
7.0 OS installation |  When you are installing OL 7.0, the anaconda installation screen
displays that iSCSI login to multiple target IPs have failed though the iSCSI logins are
successful. Anaconda displays following error message:
 "Node Login Failed"
 You will observe this error only when you select multiple target IPs for iSCSI login.
 You can continue the OS installation by clicking the "ok" button. This bug does not
hamper either the iSCSI or the OL 7.0 OS installation. |
link:https://bugzilla.oracle.com/bugzilla/show_bug.cgi?id=14870[14870^]
| link:https://mysupport.netapp.com/NOW/cgi-bin/bol?Type=Detail&Display=894771[894771^] |
OL7.0 : Anaconda does not add bootdev argument in kernel cmd line to set IP address for
iSCSI SANboot OS install | Anaconda does not add a bootdev argument in the kernel command
line where you set the IPv4 address during the OL 7.0 OS installation on an iSCSI
```

```
multipath'd LUN. Owing to this, you cannot assign IP addresses to any of the Ethernet
interfaces that were configured to establish iSCSI sessions with the storage subsystem
during the OL 7.0 boot. Since iSCSI sessions are not established, the root LUN is not
discovered when the OS boots and hence the OS boot fails. |
link:https://bugzilla.oracle.com/bugzilla/show_bug.cgi?id=14871[14871^]
| link:https://mysupport.netapp.com/NOW/cgi-bin/bol?Type=Detail&Display=916501[916501^] |
Qlogic 10G FCoE (QLE8152) host kernel crash observed during storage failover operations
with IO | You may observe a kernel crash in Qlogic driver module on 10G FCoE Qlogic
(QLE8152) host. The crash occurs during storage failover operations with IO. Probability
of hitting this crash is high which leads to longer IO outage on the host. |
link:https://bugzilla.oracle.com/bugzilla/show_bug.cgi?id=15019[15019^]
|===
.Note
For Oracle Linux (Red Hat compatible kernel) known issues, see the Known Issues section
in the corresponding
https://mysupport.netapp.com/documentation/productlibrary/index.html?productID=63146[Red
Hat Enterprise Linux release^] documentation.


== 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 fail 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
link:https://www.netapp.com/us/media/tr-3633.pdf[Oracle Databases on ONTAP^] for further
information.


:leveloffset: -1


= OL 6

:leveloffset: +1

[[IDbf5b58aacca93fe1c9734efe16563c3f]]
= Using Oracle Linux 6.10 with NetApp ONTAP
:toc: macro
:hardbreaks:
:toclevels: 1
:nofooter:
:icons: font
:linkattrs:
:imagesdir: ./media/
```

```
== Installing the Linux Unified Host Utilities

The NetApp Linux Unified Host Utilities software package is available on the
link:https://mysupport.netapp.com/NOW/cgi-bin/software/?product=Host+Utilities+-
+SAN&platform=Linux[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
link:https://mysupport.netapp.com/matrix/#welcome[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.

.Before you begin

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.

.   Download the 32-bit or 64-bit Linux Unified Host Utilities software package from the
link:https://mysupport.netapp.com/NOW/cgi-bin/software/?product=Host+Utilities+-
+SAN&platform=Linux[NetApp Support Site^] Site to your host.
.   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

.Before you begin
If you decide to use SAN booting, it must be supported by your configuration. You can use
the
https://mysupport.netapp.com/matrix/imt.jsp?components=84284;84283;&solution=1&isHWU&src=
IMT[NetApp Interoperability Matrix Tool^] to verify that your OS, HBA, HBA firmware and
the HBA boot BIOS, and ONTAP version are supported.

.   Map the SAN boot LUN to the host.
.   Verify multiple paths are available.
+
Remember, multiple paths will only be available after the host OS is up and running on
the paths.
.   Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is
mapped.
+
For information on how to enable the HBA BIOS, see your vendor-specific documentation.
.   Reboot the host to verify the boot is successful.

== Multipathing

For Oracle Linux 6.10 the /etc/multipath.conf file must exist, but you do not need to
make specific changes to the file. Oracle Linux 6.10 is compiled with all settings
required to recognize and correctly manage ONTAP LUNs.
To Enable ALUA Handler, perform the following steps:

.   Create a backup of the initrd-image.
.   Append the following parameter value to the kernel for ALUA and non-ALUA to work:
`rdloaddriver=scsi_dh_alua`
+
.Example
....
kernel /vmlinuz-3.8.13-68.1.2.el6uek.x86_64 ro root=/dev/mapper/vg_ibmx3550m421096-
lv_root rd_NO_LUKSrd_LVM_LV=vg_ibmx3550m421096/lv_root LANG=en_US.UTF-8
rd_NO_MDSYSFONT=latarcyrheb-sun16 crashkernel=256M KEYBOARDTYPE=pc KEYTABLE=us
rd_LVM_LV=vg_ibmx3550m421096/lv_swap rd_NO_DM rhgb quiet rdloaddriver=scsi_dh_alua
....
.   Use the `mkinitrd` command to recreate the initrd-image.
Oracle 6x and later versions use either:
The command: `mkinitrd -f /boot/ initrd-"uname -r".img uname -r`
Or
The command: `dracut -f`
.   Reboot the host.
.   Verify the output of the `cat /proc/cmdline` command to ensure that the setting is
complete.
You can use the `multipath -ll` command to verify the settings for your ONTAP LUNs.
```

```
There should be two groups of paths with different priorities. The paths with the higher
priorities are Active/Optimized, 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='round-robin 0' prio=50 status=active | |- 0:0:26:37 sdje 8:384 active ready running | |- 0:0:25:37 sdik 135:64 active ready running `-- policy='round-robin 0' prio=10 status=enabled
|- 0:0:18:37 sdda 70:128 active ready running
|- 0:0:19:37 sddu 71:192 active ready running

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

== Recommended Settings

The Oracle Linux 6.10 OS is compiled to recognize ONTAP LUNs and automatically set all
configuration parameters correctly.

The multipath.conf file must exist for the multipath daemon to start, but you can create
an empty, zero-byte file using the command:
`touch /etc/multipath.conf`
The first time you create this file, you might need to enable and start the multipath
services.
```

[root@jfs0 ~]# chkconfig multipathd on
[root@jfs0 ~]#/etc/init.d/multipathd start

```
There is no requirement to add anything directly to multipath.conf, 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.

.Note
```

```
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.

.   Run the following command to determine the WWID:
+
....
# /lib/udev/scsi_id -gud /dev/sda
360030057024d0730239134810c0cb833
....
.   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.


[cols=2*,options="header"]
|===
| Parameter
| Setting
| detect_prio | yes
| dev_loss_tmo | "infinity"
| failback | immediate
```

```
| fast_io_fail_tmo | 5
| features | "3 queue_if_no_path pg_init_retries 50"
| flush_on_last_del | "yes"
| hardware_handler | "0"
| no_path_retry | queue
| path_checker | "tur"
| path_grouping_policy | "group_by_prio"
| path_selector | "round-robin 0"
| polling_interval | 5
| prio | "ontap"
| product | LUN.*
| retain_attached_hw_handler | yes
| rr_weight | "uniform"
| user_friendly_names | no
| vendor | NETAPP
|===

.Example

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

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

```
== Known Problems and Limitations

There are no known issues for Oracle 6.10.

.Note
For Oracle Linux (Red Hat compatible kernel) known issues, see the Known Issues section
in the corresponding
https://mysupport.netapp.com/documentation/productlibrary/index.html?productID=63146[Red
```

```
Hat Enterprise Linux release^] documentation.

== 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 fail 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
link:https://www.netapp.com/us/media/tr-3633.pdf[Oracle Databases on ONTAP^] for further
information.

[[ID6839a3ebab2f165dde62a1ab9c7e5b3d]]
= Using Oracle Linux 6.9 with NetApp ONTAP
:toc: macro
:hardbreaks:
:toclevels: 1
:nofooter:
:icons: font
:linkattrs:
:imagesdir: ./media/

== Installing the Linux Unified Host Utilities

The NetApp Linux Unified Host Utilities software package is available on the
link:https://mysupport.netapp.com/NOW/cgi-bin/software/?product=Host+Utilities+-
+SAN&platform=Linux[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
link:https://mysupport.netapp.com/matrix/#welcome[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.

.Before you begin

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.

.   Download the 32-bit or 64-bit Linux Unified Host Utilities software package from the
link:https://mysupport.netapp.com/NOW/cgi-bin/software/?product=Host+Utilities+-
+SAN&platform=Linux[NetApp Support Site^] Site to your host.
.   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

.Before you begin
If you decide to use SAN booting, it must be supported by your configuration. You can use
the
https://mysupport.netapp.com/matrix/imt.jsp?components=78284;78283;&solution=1&isHWU&src=
IMT[NetApp Interoperability Matrix Tool^] to verify that your OS, HBA, HBA firmware and
the HBA boot BIOS, and ONTAP version are supported.

.   Map the SAN boot LUN to the host.
.   Verify multiple paths are available.
+
Remember, multiple paths will only be available after the host OS is up and running on
the paths.
.   Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is
mapped.
+
For information on how to enable the HBA BIOS, see your vendor-specific documentation.
.   Reboot the host to verify the boot is successful.

== Multipathing
```

```
For Oracle Linux 6.9 the /etc/multipath.conf file must exist, but you do not need to make
specific changes to the file. Oracle Linux 6.9 is compiled with all settings required to
recognize and correctly manage ONTAP LUNs.
To Enable ALUA Handler, perform the following steps:

.   Create a backup of the initrd-image.
.   Append the following parameter value to the kernel for ALUA and non-ALUA to work:
`rdloaddriver=scsi_dh_alua`
+
.Example
....
kernel /vmlinuz-3.8.13-68.1.2.el6uek.x86_64 ro root=/dev/mapper/vg_ibmx3550m421096-
lv_root rd_NO_LUKSrd_LVM_LV=vg_ibmx3550m421096/lv_root LANG=en_US.UTF-8
rd_NO_MDSYSFONT=latarcyrheb-sun16 crashkernel=256M KEYBOARDTYPE=pc KEYTABLE=us
rd_LVM_LV=vg_ibmx3550m421096/lv_swap rd_NO_DM rhgb quiet rdloaddriver=scsi_dh_alua
....
.   Use the `mkinitrd` command to recreate the initrd-image.
Oracle 6x and later versions use either:
The command: `mkinitrd -f /boot/ initrd-"uname -r".img uname -r`
Or
The command: `dracut -f`
.   Reboot the host.
.   Verify the output of the `cat /proc/cmdline` command to ensure that the setting is
complete.
You can use the `multipath -ll` command to verify the settings for your ONTAP LUNs.
There should be two groups of paths with different priorities. The paths with the higher
priorities are Active/Optimized, 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='round-robin 0' prio=50 status=active
| |- 0:0:26:37 sdje 8:384   active ready running
| |- 0:0:25:37 sdik 135:64  active ready running
`-+- policy='round-robin 0' prio=10 status=enabled
  |- 0:0:18:37 sdda 70:128  active ready running
  |- 0:0:19:37 sddu 71:192  active ready running
```

```
----

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

== Recommended Settings

The Oracle Linux 6.9 OS is compiled to recognize ONTAP LUNs and automatically set all
configuration parameters correctly.

The multipath.conf file must exist for the multipath daemon to start, but you can create
an empty, zero-byte file using the command:
`touch /etc/multipath.conf`
The first time you create this file, you might need to enable and start the multipath
services.
----
[root@jfs0 ~]# chkconfig multipathd on
[root@jfs0 ~]#/etc/init.d/multipathd start
----
There is no requirement to add anything directly to multipath.conf, 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.

.Note
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.

.   Run the following command to determine the WWID:
+
....
# /lib/udev/scsi_id -gud /dev/sda
360030057024d0730239134810c0cb833
....
.   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.


[cols=2*,options="header"]
|===
| Parameter
| Setting
| detect_prio | yes
| dev_loss_tmo | "infinity"
| failback | immediate
| fast_io_fail_tmo | 5
| features | "3 queue_if_no_path pg_init_retries 50"
| flush_on_last_del | "yes"
| hardware_handler | "0"
| no_path_retry | queue
| path_checker | "tur"
| path_grouping_policy | "group_by_prio"
| path_selector | "round-robin 0"
| polling_interval | 5
| prio | "ontap"
| product | LUN.*
| retain_attached_hw_handler | yes
| rr_weight | "uniform"
| user_friendly_names | no
| vendor | NETAPP
|===

.Example

The following example shows how to correct an overridden default. In this case, the
`multipath.conf` file defines values for `path_checker` and `detect_prio` that are not
```

```
compatible with ONTAP LUNs.
If they cannot be removed because of other SAN arrays still attached to the host, these
parameters can be corrected specifically for ONTAP LUNs with a device stanza.

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

== Known Problems and Limitations

[cols=4*,options="header"]
|===
| NetApp Bug ID
| Title
| Description
| Bugzilla ID
| link:https://mysupport.netapp.com/NOW/cgi-bin/bol?Type=Detail&Display=1082780[1082780^]
| Firmware dumps are observed occasionally on OL6.9 hypervisor with the QLE8362 card |
During storage failover operations on OL6.9 hypervisor with QLE8362 card, the firmware
dumps are observed occasionally. The firmware dumps might result in an I/O outage on the
host which might go up to a thousand seconds. After the adapter completes the firmware
dump, the I/O operation resumes in the normal manner. No further recovery procedure is
required on the host. To indicate the firmware dump, the following message is displayed
in the /var/log/message file:
 qla2xxx [0000:0c:00.3]-d001:3: Firmware dump saved to temp buffer (3/ffffc90008901000),
dump status flags (0x3f).
| link:https://bugzilla.oracle.com/bugzilla/show_bug.cgi?id=16039[16039^]
|===

.Note
For Oracle Linux (Red Hat compatible kernel) known issues, see the Known Issues section
in the corresponding
https://mysupport.netapp.com/documentation/productlibrary/index.html?productID=63146[Red
Hat Enterprise Linux release^] documentation.

== 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 fail 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
link:https://www.netapp.com/us/media/tr-3633.pdf[Oracle Databases on ONTAP^] for further
information.

[[ID76c4226e02e421997be097a10ee4d2a7]]
= Using Oracle Linux 6.8 with NetApp ONTAP
:toc: macro
:hardbreaks:
:toclevels: 1
:nofooter:
:icons: font
:linkattrs:
:imagesdir: ./media/

== Installing the Linux Unified Host Utilities

The NetApp Linux Unified Host Utilities software package is available on the
link:https://mysupport.netapp.com/NOW/cgi-bin/software/?product=Host+Utilities+-
+SAN&platform=Linux[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
link:https://mysupport.netapp.com/matrix/#welcome[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.

.Before you begin

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.

.   Download the 32-bit or 64-bit Linux Unified Host Utilities software package from the
link:https://mysupport.netapp.com/NOW/cgi-bin/software/?product=Host+Utilities+-
+SAN&platform=Linux[NetApp Support Site^] Site to your host.
.   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

.Before you begin
If you decide to use SAN booting, it must be supported by your configuration. You can use
the
https://mysupport.netapp.com/matrix/imt.jsp?components=74908;74907;&solution=1&isHWU&src=
IMT[NetApp Interoperability Matrix Tool^] to verify that your OS, HBA, HBA firmware and
the HBA boot BIOS, and ONTAP version are supported.

.   Map the SAN boot LUN to the host.
.   Verify multiple paths are available.
+
Remember, multiple paths will only be available after the host OS is up and running on
the paths.
.   Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is
mapped.
+
For information on how to enable the HBA BIOS, see your vendor-specific documentation.
.   Reboot the host to verify the boot is successful.

== Multipathing

For Oracle Linux 6.8 the /etc/multipath.conf file must exist, but you do not need to make
specific changes to the file. Oracle Linux 6.8 is compiled with all settings required to
recognize and correctly manage ONTAP LUNs.
To Enable ALUA Handler, perform the following steps:
```

```
.   Create a backup of the initrd-image.
.   Append the following parameter value to the kernel for ALUA and non-ALUA to work:
`rdloaddriver=scsi_dh_alua`
+
.Example
....
kernel /vmlinuz-3.8.13-68.1.2.el6uek.x86_64 ro root=/dev/mapper/vg_ibmx3550m421096-
lv_root rd_NO_LUKSrd_LVM_LV=vg_ibmx3550m421096/lv_root LANG=en_US.UTF-8
rd_NO_MDSYSFONT=latarcyrheb-sun16 crashkernel=256M KEYBOARDTYPE=pc KEYTABLE=us
rd_LVM_LV=vg_ibmx3550m421096/lv_swap rd_NO_DM rhgb quiet rdloaddriver=scsi_dh_alua
....
.   Use the `mkinitrd` command to recreate the initrd-image.
Oracle 6x and later versions use either:
The command: `mkinitrd -f /boot/ initrd-"uname -r".img uname -r`
Or
The command: `dracut -f`
.   Reboot the host.
.   Verify the output of the `cat /proc/cmdline` command to ensure that the setting is
complete.
You can use the `multipath -ll` command to verify the settings for your ONTAP LUNs.
There should be two groups of paths with different priorities. The paths with the higher
priorities are Active/Optimized, 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='round-robin 0' prio=50 status=active | |- 0:0:26:37 sdje 8:384 active ready running | |- 0:0:25:37 sdik 135:64 active ready running `-- policy='round-robin 0' prio=10 status=enabled
|- 0:0:18:37 sdda 70:128 active ready running
|- 0:0:19:37 sddu 71:192 active ready running

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

== Recommended Settings

The Oracle Linux 6.8 OS is compiled to recognize ONTAP LUNs and automatically set all
configuration parameters correctly.

The multipath.conf file must exist for the multipath daemon to start, but you can create
an empty, zero-byte file using the command:
`touch /etc/multipath.conf`
The first time you create this file, you might need to enable and start the multipath
services.
```

[root@jfs0 ~]# chkconfig multipathd on
[root@jfs0 ~]#/etc/init.d/multipathd start

```
There is no requirement to add anything directly to multipath.conf, 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.

.Note
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.

.   Run the following command to determine the WWID:
+
....
# /lib/udev/scsi_id -gud /dev/sda
360030057024d0730239134810c0cb833
....
.   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.


[cols=2*,options="header"]
|===
| Parameter
| Setting
| detect_prio | yes
| dev_loss_tmo | "infinity"
| failback | immediate
| fast_io_fail_tmo | 5
| features | "3 queue_if_no_path pg_init_retries 50"
| flush_on_last_del | "yes"
| hardware_handler | "0"
| no_path_retry | queue
| path_checker | "tur"
| path_grouping_policy | "group_by_prio"
| path_selector | "round-robin 0"
| polling_interval | 5
| prio | "ontap"
| product | LUN.*
| retain_attached_hw_handler | yes
| rr_weight | "uniform"
| user_friendly_names | no
| vendor | NETAPP
|===

.Example

The following example shows how to correct an overridden default. In this case, the
`multipath.conf` file defines values for `path_checker` and `detect_prio` that are not
```

```
compatible with ONTAP LUNs.
If they cannot be removed because of other SAN arrays still attached to the host, these
parameters can be corrected specifically for ONTAP LUNs with a device stanza.
```

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

```
== Known Problems and Limitations

There are no known issues for Oracle 6.8.

.Note
For Oracle Linux (Red Hat compatible kernel) known issues, see the Known Issues section
in the corresponding
https://mysupport.netapp.com/documentation/productlibrary/index.html?productID=63146[Red
Hat Enterprise Linux release^] documentation.

== 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 fail 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
link:https://www.netapp.com/us/media/tr-3633.pdf[Oracle Databases on ONTAP^] for further
information.

[[ID657f687c98553495e2286e4de4b4e0af]]
= Using Oracle Linux 6.7 with NetApp ONTAP
:toc: macro
:hardbreaks:
:toclevels: 1
:nofooter:
:icons: font
```

```
:linkattrs:
:imagesdir: ./media/

== Installing the Linux Unified Host Utilities

The NetApp Linux Unified Host Utilities software package is available on the
link:https://mysupport.netapp.com/NOW/cgi-bin/software/?product=Host+Utilities+-
+SAN&platform=Linux[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
link:https://mysupport.netapp.com/matrix/#welcome[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.

.Before you begin

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.

.   Download the 32-bit or 64-bit Linux Unified Host Utilities software package from the
link:https://mysupport.netapp.com/NOW/cgi-bin/software/?product=Host+Utilities+-
+SAN&platform=Linux[NetApp Support Site^] Site to your host.
.   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

.Before you begin
If you decide to use SAN booting, it must be supported by your configuration. You can use
the
https://mysupport.netapp.com/matrix/imt.jsp?components=74908;74907;71545;71546;&solution=
1&isHWU&src=IMT[NetApp Interoperability Matrix Tool^] to verify that your OS, HBA, HBA
firmware and the HBA boot BIOS, and ONTAP version are supported.

.   Map the SAN boot LUN to the host.
.   Verify multiple paths are available.
+
Remember, multiple paths will only be available after the host OS is up and running on
the paths.
.   Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is
mapped.
+
For information on how to enable the HBA BIOS, see your vendor-specific documentation.
.   Reboot the host to verify the boot is successful.

== Multipathing

For Oracle Linux 6.7 the /etc/multipath.conf file must exist, but you do not need to make
specific changes to the file. Oracle Linux 6.7 is compiled with all settings required to
recognize and correctly manage ONTAP LUNs.
To Enable ALUA Handler, perform the following steps:

.   Create a backup of the initrd-image.
.   Append the following parameter value to the kernel for ALUA and non-ALUA to work:
`rdloaddriver=scsi_dh_alua`
+
.Example
....
kernel /vmlinuz-3.8.13-68.1.2.el6uek.x86_64 ro root=/dev/mapper/vg_ibmx3550m421096-
lv_root rd_NO_LUKSrd_LVM_LV=vg_ibmx3550m421096/lv_root LANG=en_US.UTF-8
rd_NO_MDSYSFONT=latarcyrheb-sun16 crashkernel=256M KEYBOARDTYPE=pc KEYTABLE=us
rd_LVM_LV=vg_ibmx3550m421096/lv_swap rd_NO_DM rhgb quiet rdloaddriver=scsi_dh_alua
....
.   Use the `mkinitrd` command to recreate the initrd-image.
Oracle 6x and later versions use either:
The command: `mkinitrd -f /boot/ initrd-"uname -r".img uname -r`
Or
```

```
The command: `dracut -f`
.   Reboot the host.
.   Verify the output of the `cat /proc/cmdline` command to ensure that the setting is
complete.
You can use the `multipath -ll` command to verify the settings for your ONTAP LUNs.
There should be two groups of paths with different priorities. The paths with the higher
priorities are Active/Optimized, 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='round-robin 0' prio=50 status=active
| |- 0:0:26:37 sdje 8:384   active ready running
| |- 0:0:25:37 sdik 135:64  active ready running
`-+- policy='round-robin 0' prio=10 status=enabled
  |- 0:0:18:37 sdda 70:128  active ready running
  |- 0:0:19:37 sddu 71:192  active ready running
----

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

== Recommended Settings

The Oracle Linux 6.7 OS is compiled to recognize ONTAP LUNs and automatically set all
configuration parameters correctly.

The multipath.conf file must exist for the multipath daemon to start, but you can create
an empty, zero-byte file using the command:
`touch /etc/multipath.conf`
The first time you create this file, you might need to enable and start the multipath
services.
----
[root@jfs0 ~]# chkconfig multipathd on
[root@jfs0 ~]#/etc/init.d/multipathd start
----
There is no requirement to add anything directly to multipath.conf, 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.

.Note
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.

.   Run the following command to determine the WWID:
+
....
# /lib/udev/scsi_id -gud /dev/sda
360030057024d0730239134810c0cb833
....
.   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.


[cols=2*,options="header"]
```

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

.Example

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

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

== Known Problems and Limitations
```

```
There are no known issues for Oracle 6.7.

.Note
For Oracle Linux (Red Hat compatible kernel) known issues, see the Known Issues section
in the corresponding
https://mysupport.netapp.com/documentation/productlibrary/index.html?productID=63146[Red
Hat Enterprise Linux release^] documentation.

== 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 fail 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
link:https://www.netapp.com/us/media/tr-3633.pdf[Oracle Databases on ONTAP^] for further
information.

[[IDb100239bc7c560d17d86c06a89cbedf1]]
= Using Oracle Linux 6.6 with NetApp ONTAP
:toc: macro
:hardbreaks:
:toclevels: 1
:nofooter:
:icons: font
:linkattrs:
:imagesdir: ./media/

== Installing the Linux Unified Host Utilities

The NetApp Linux Unified Host Utilities software package is available on the
link:https://mysupport.netapp.com/NOW/cgi-bin/software/?product=Host+Utilities+-
+SAN&platform=Linux[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
link:https://mysupport.netapp.com/matrix/#welcome[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.

.Before you begin

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.

.   Download the 32-bit or 64-bit Linux Unified Host Utilities software package from the
link:https://mysupport.netapp.com/NOW/cgi-bin/software/?product=Host+Utilities+-
+SAN&platform=Linux[NetApp Support Site^] Site to your host.
.   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

.Before you begin
If you decide to use SAN booting, it must be supported by your configuration. You can use
the
https://mysupport.netapp.com/matrix/imt.jsp?components=74908;74907;71545;71546;69941;6993
9;69940;&solution=1&isHWU&src=IMT[NetApp Interoperability Matrix Tool^] to verify that
your OS, HBA, HBA firmware and the HBA boot BIOS, and ONTAP version are supported.

.   Map the SAN boot LUN to the host.
.   Verify multiple paths are available.
+
Remember, multiple paths will only be available after the host OS is up and running on
the paths.
.   Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is
mapped.
+
```

```
For information on how to enable the HBA BIOS, see your vendor-specific documentation.
.   Reboot the host to verify the boot is successful.

== Multipathing

For Oracle Linux 6.6 the /etc/multipath.conf file must exist, but you do not need to make
specific changes to the file. Oracle Linux 6.6 is compiled with all settings required to
recognize and correctly manage ONTAP LUNs.
To Enable ALUA Handler, perform the following steps:

.   Create a backup of the initrd-image.
.   Append the following parameter value to the kernel for ALUA and non-ALUA to work:
`rdloaddriver=scsi_dh_alua`
+
.Example
....
kernel /vmlinuz-3.8.13-68.1.2.el6uek.x86_64 ro root=/dev/mapper/vg_ibmx3550m421096-
lv_root rd_NO_LUKSrd_LVM_LV=vg_ibmx3550m421096/lv_root LANG=en_US.UTF-8
rd_NO_MDSYSFONT=latarcyrheb-sun16 crashkernel=256M KEYBOARDTYPE=pc KEYTABLE=us
rd_LVM_LV=vg_ibmx3550m421096/lv_swap rd_NO_DM rhgb quiet rdloaddriver=scsi_dh_alua
....
.   Use the `mkinitrd` command to recreate the initrd-image.
Oracle 6x and later versions use either:
The command: `mkinitrd -f /boot/ initrd-"uname -r".img uname -r`
Or
The command: `dracut -f`
.   Reboot the host.
.   Verify the output of the `cat /proc/cmdline` command to ensure that the setting is
complete.
You can use the `multipath -ll` command to verify the settings for your ONTAP LUNs.
There should be two groups of paths with different priorities. The paths with the higher
priorities are Active/Optimized, 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='round-robin 0' prio=50 status=active | |- 0:0:26:37 sdje 8:384 active ready running | |- 0:0:25:37 sdik 135:64 active ready running `-- policy='round-robin 0' prio=10 status=enabled

|- 0:0:18:37 sdda 70:128 active ready running
|- 0:0:19:37 sddu 71:192 active ready running

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

== Recommended Settings

The Oracle Linux 6.6 OS is compiled to recognize ONTAP LUNs and automatically set all
configuration parameters correctly.

The multipath.conf file must exist for the multipath daemon to start, but you can create
an empty, zero-byte file using the command:
`touch /etc/multipath.conf`
The first time you create this file, you might need to enable and start the multipath
services.
```

[root@jfs0 ~]# chkconfig multipathd on
[root@jfs0 ~]#/etc/init.d/multipathd start

```
There is no requirement to add anything directly to multipath.conf, 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.

.Note
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.

.   Run the following command to determine the WWID:
+
....
# /lib/udev/scsi_id -gud /dev/sda
```

```
360030057024d0730239134810c0cb833
....
.   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.


[cols=2*,options="header"]
|===
| Parameter
| Setting
| detect_prio | yes
| dev_loss_tmo | "infinity"
| failback | immediate
| fast_io_fail_tmo | 5
| features | "3 queue_if_no_path pg_init_retries 50"
| flush_on_last_del | "yes"
| hardware_handler | "0"
| no_path_retry | queue
| path_checker | "tur"
| path_grouping_policy | "group_by_prio"
| path_selector | "round-robin 0"
| polling_interval | 5
| prio | "ontap"
| product | LUN.*
| retain_attached_hw_handler | yes
| rr_weight | "uniform"
| user_friendly_names | no
| vendor | NETAPP
|===

.Example
```

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

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

```
== Known Problems and Limitations

There are no known issues for Oracle 6.6.

.Note
For Oracle Linux (Red Hat compatible kernel) known issues, see the Known Issues section
in the corresponding
https://mysupport.netapp.com/documentation/productlibrary/index.html?productID=63146[Red
Hat Enterprise Linux release^] documentation.

== 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 fail 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
link:https://www.netapp.com/us/media/tr-3633.pdf[Oracle Databases on ONTAP^] for further
information.

[[IDacff254abecabd2479f50d05de83176e]]
= Using Oracle Linux 6.5 with NetApp ONTAP
:toc: macro
:hardbreaks:
```

```
:toclevels: 1
:nofooter:
:icons: font
:linkattrs:
:imagesdir: ./media/

== Installing the Linux Unified Host Utilities

The NetApp Linux Unified Host Utilities software package is available on the
link:https://mysupport.netapp.com/NOW/cgi-bin/software/?product=Host+Utilities+-
+SAN&platform=Linux[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
link:https://mysupport.netapp.com/matrix/#welcome[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.

.Before you begin

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.

.   Download the 32-bit or 64-bit Linux Unified Host Utilities software package from the
link:https://mysupport.netapp.com/NOW/cgi-bin/software/?product=Host+Utilities+-
+SAN&platform=Linux[NetApp Support Site^] Site to your host.
.   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

.Before you begin
If you decide to use SAN booting, it must be supported by your configuration. You can use
the
https://mysupport.netapp.com/matrix/imt.jsp?components=68083;67438;67437;&solution=1&isHW
U&src=IMT[NetApp Interoperability Matrix Tool^] to verify that your OS, HBA, HBA firmware
and the HBA boot BIOS, and ONTAP version are supported.

.   Map the SAN boot LUN to the host.
.   Verify multiple paths are available.
+
Remember, multiple paths will only be available after the host OS is up and running on
the paths.
.   Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is
mapped.
+
For information on how to enable the HBA BIOS, see your vendor-specific documentation.
.   Reboot the host to verify the boot is successful.

== Multipathing

For Oracle Linux 6.5 the /etc/multipath.conf file must exist, but you do not need to make
specific changes to the file. Oracle Linux 6.5 is compiled with all settings required to
recognize and correctly manage ONTAP LUNs.
To Enable ALUA Handler, perform the following steps:

.   Create a backup of the initrd-image.
.   Append the following parameter value to the kernel for ALUA and non-ALUA to work:
`rdloaddriver=scsi_dh_alua`
+
.Example
....
kernel /vmlinuz-3.8.13-68.1.2.el6uek.x86_64 ro root=/dev/mapper/vg_ibmx3550m421096-
lv_root rd_NO_LUKSrd_LVM_LV=vg_ibmx3550m421096/lv_root LANG=en_US.UTF-8
rd_NO_MDSYSFONT=latarcyrheb-sun16 crashkernel=256M KEYBOARDTYPE=pc KEYTABLE=us
rd_LVM_LV=vg_ibmx3550m421096/lv_swap rd_NO_DM rhgb quiet rdloaddriver=scsi_dh_alua
....
.   Use the `mkinitrd` command to recreate the initrd-image.
```

```
Oracle 6x and later versions use either:
The command: `mkinitrd -f /boot/ initrd-"uname -r".img uname -r`
Or
The command: `dracut -f`
.   Reboot the host.
.   Verify the output of the `cat /proc/cmdline` command to ensure that the setting is
complete.
You can use the `multipath -ll` command to verify the settings for your ONTAP LUNs.
There should be two groups of paths with different priorities. The paths with the higher
priorities are Active/Optimized, 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='round-robin 0' prio=50 status=active
| |- 0:0:26:37 sdje 8:384   active ready running
| |- 0:0:25:37 sdik 135:64  active ready running
`-+- policy='round-robin 0' prio=10 status=enabled
  |- 0:0:18:37 sdda 70:128  active ready running
  |- 0:0:19:37 sddu 71:192  active ready running
----

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

== Recommended Settings

The Oracle Linux 6.5 OS is compiled to recognize ONTAP LUNs and automatically set all
configuration parameters correctly.

The multipath.conf file must exist for the multipath daemon to start, but you can create
an empty, zero-byte file using the command:
`touch /etc/multipath.conf`
The first time you create this file, you might need to enable and start the multipath
services.
----
[root@jfs0 ~]# chkconfig multipathd on
```

```
[root@jfs0 ~]#/etc/init.d/multipathd start
----
There is no requirement to add anything directly to multipath.conf, 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.

.Note
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.

.   Run the following command to determine the WWID:
+
....
# /lib/udev/scsi_id -gud /dev/sda
360030057024d0730239134810c0cb833
....
.   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.
```

```
[cols=2*,options="header"]
|===
| Parameter
| Setting
| detect_prio | yes
| dev_loss_tmo | "infinity"
| failback | immediate
| fast_io_fail_tmo | 5
| features | "3 queue_if_no_path pg_init_retries 50"
| flush_on_last_del | "yes"
| hardware_handler | "0"
| no_path_retry | queue
| path_checker | "tur"
| path_grouping_policy | "group_by_prio"
| path_selector | "round-robin 0"
| polling_interval | 5
| prio | "ontap"
| product | LUN.*
| retain_attached_hw_handler | yes
| rr_weight | "uniform"
| user_friendly_names | no
| vendor | NETAPP
|===

.Example

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

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

```
== Known Problems and Limitations

There are no known issues for Oracle 6.5.

.Note
For Oracle Linux (Red Hat compatible kernel) known issues, see the Known Issues section
in the corresponding
https://mysupport.netapp.com/documentation/productlibrary/index.html?productID=63146[Red
Hat Enterprise Linux release^] documentation.

== 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 fail 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
link:https://www.netapp.com/us/media/tr-3633.pdf[Oracle Databases on ONTAP^] for further
information.

[[IDb7b0bc32e4687fd0362ab44ad8fb4bef]]
= Using Oracle Linux 6.4 with NetApp ONTAP
:toc: macro
:hardbreaks:
:toclevels: 1
:nofooter:
:icons: font
:linkattrs:
:imagesdir: ./media/

== Installing the Linux Unified Host Utilities

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link:https://mysupport.netapp.com/NOW/cgi-bin/software/?product=Host+Utilities+-
+SAN&platform=Linux[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
link:https://mysupport.netapp.com/matrix/#welcome[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.

.Before you begin
```

```
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.

.   Download the 32-bit or 64-bit Linux Unified Host Utilities software package from the
link:https://mysupport.netapp.com/NOW/cgi-bin/software/?product=Host+Utilities+-
+SAN&platform=Linux[NetApp Support Site^] Site to your host.
.   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

.Before you begin
If you decide to use SAN booting, it must be supported by your configuration. You can use
the
https://mysupport.netapp.com/matrix/imt.jsp?components=65623;64703;&solution=1&isHWU&src=
IMT[NetApp Interoperability Matrix Tool^] to verify that your OS, HBA, HBA firmware and
the HBA boot BIOS, and ONTAP version are supported.

.   Map the SAN boot LUN to the host.
.   Verify multiple paths are available.
+
Remember, multiple paths will only be available after the host OS is up and running on
the paths.
```

```
.   Enable SAN booting in the server BIOS for the ports to which the SAN boot LUN is
mapped.
+
For information on how to enable the HBA BIOS, see your vendor-specific documentation.
.   Reboot the host to verify the boot is successful.

== Multipathing

For Oracle Linux 6.4 the /etc/multipath.conf file must exist, but you do not need to make
specific changes to the file. Oracle Linux 6.4 is compiled with all settings required to
recognize and correctly manage ONTAP LUNs.
To Enable ALUA Handler, perform the following steps:

.   Create a backup of the initrd-image.
.   Append the following parameter value to the kernel for ALUA and non-ALUA to work:
`rdloaddriver=scsi_dh_alua`
+
.Example
....
kernel /vmlinuz-3.8.13-68.1.2.el6uek.x86_64 ro root=/dev/mapper/vg_ibmx3550m421096-
lv_root rd_NO_LUKSrd_LVM_LV=vg_ibmx3550m421096/lv_root LANG=en_US.UTF-8
rd_NO_MDSYSFONT=latarcyrheb-sun16 crashkernel=256M KEYBOARDTYPE=pc KEYTABLE=us
rd_LVM_LV=vg_ibmx3550m421096/lv_swap rd_NO_DM rhgb quiet rdloaddriver=scsi_dh_alua
....
.   Use the `mkinitrd` command to recreate the initrd-image.
Oracle 6x and later versions use either:
The command: `mkinitrd -f /boot/ initrd-"uname -r".img uname -r`
Or
The command: `dracut -f`
.   Reboot the host.
.   Verify the output of the `cat /proc/cmdline` command to ensure that the setting is
complete.
You can use the `multipath -ll` command to verify the settings for your ONTAP LUNs.
There should be two groups of paths with different priorities. The paths with the higher
priorities are Active/Optimized, 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='round-robin 0' prio=50 status=active | |- 0:0:26:37 sdje 8:384 active ready running | |- 0:0:25:37 sdik 135:64 active ready running `-- policy='round-robin 0' prio=10 status=enabled
|- 0:0:18:37 sdda 70:128 active ready running
|- 0:0:19:37 sddu 71:192 active ready running

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

== Recommended Settings

The Oracle Linux 6.4 OS is compiled to recognize ONTAP LUNs and automatically set all
configuration parameters correctly.

The multipath.conf file must exist for the multipath daemon to start, but you can create
an empty, zero-byte file using the command:
`touch /etc/multipath.conf`
The first time you create this file, you might need to enable and start the multipath
services.
```

[root@jfs0 ~]# chkconfig multipathd on
[root@jfs0 ~]#/etc/init.d/multipathd start

```
There is no requirement to add anything directly to multipath.conf, 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.

.Note
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.
```

```
.   Run the following command to determine the WWID:
+
....
# /lib/udev/scsi_id -gud /dev/sda
360030057024d0730239134810c0cb833
....
.   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.


[cols=2*,options="header"]
|===
| Parameter
| Setting
| detect_prio | yes
| dev_loss_tmo | "infinity"
| failback | immediate
| fast_io_fail_tmo | 5
| features | "3 queue_if_no_path pg_init_retries 50"
| flush_on_last_del | "yes"
| hardware_handler | "0"
| no_path_retry | queue
| path_checker | "tur"
| path_grouping_policy | "group_by_prio"
| path_selector | "round-robin 0"
| polling_interval | 5
| prio | "ontap"
| product | LUN.*
| retain_attached_hw_handler | yes
| rr_weight | "uniform"
| user_friendly_names | no
```

```
| vendor | NETAPP
|===

.Example

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

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

```
== Known Problems and Limitations

[cols=4*,options="header"]
|===
| NetApp Bug ID
| Title
| Description
| Bugzilla ID
| link:https://mysupport.netapp.com/NOW/cgi-bin/bol?Type=Detail&Display=713555[713555^] |
QLogic adapter resets are seen on OL6.4 and OL5.9 with UEK2 on controller faults such as
takeover/giveback, and reboot | QLogic adapter resets are seen on OL6.4 hosts with UEK2
(kernel-uek-2.6.39-400.17.1.el6uek) or OL5.9 hosts with UEK2 (kernel-uek-2.6.39
400.17.1.el5uek) when controller faults happen (such as takeover, giveback, and reboots).
These resets are intermittent. When these adapter resets happen, a prolonged I/O outage
(sometimes, more than 10 minutes) might occur until the adapter resets succeed and the
paths' status are updated by dm-multipath.

 In /var/log/messages, messages similar to the following are seen when this bug
 is hit:
 kernel: qla2xxx [0000:11:00.0]-8018:0: ADAPTER RESET ISSUED nexus=0:2:13.

 This is observed with the kernel version:
```

```
 On OL6.4: kernel-uek-2.6.39-400.17.1.el6uek
 On OL5.9: kernel-uek-2.6.39-400.17.1.el5uek
| link:https://bugzilla.oracle.com/bugzilla/show_bug.cgi?id=13999[13999^]
| xref:htthttps://mysupport.netapp.com/NOW/cgi-
bin/bol?Type=Detail&Display=715217[715217^] |    Delay in path recovery on OL6.4 or OL5.9
hosts with UEK2 may result in delayed I/O resumption on controller or fabric faults |
When a controller fault (storage failover or giveback, reboots and so on) or a fabric
fault (FC port disable or enable) occurs with I/O on Oracle Linux 6.4 or Oracle Linux 5.9
hosts with UEK2 Kernel, the path recovery by DM-Multipath takes a long time (4mins. to 10
mins).
Sometimes, during the paths recovering to active state, the following lpfc driver errors
are also seen:
 kernel: sd 0:0:8:3: [sdlt]  Result: hostbyte=DID_ERROR driverbyte=DRIVER_OK

 Due to this delay in path recovery during fault events, the I/O resumption also delays.

 OL 6.4 Versions:
 device-mapper-1.02.77-9.el6
 device-mapper-multipath-0.4.9-64.0.1.el6
 kernel-uek-2.6.39-400.17.1.el6uek

 OL 5.9 Versions:
 device-mapper-1.02.77-9.el5
 device-mapper-multipath-0.4.9-64.0.1.el5
 kernel-uek-2.6.39-400.17.1.el5uek
| link:https://bugzilla.oracle.com/bugzilla/show_bug.cgi?id=14001[14001^]
| link:https://mysupport.netapp.com/NOW/cgi-bin/bol?Type=Detail&Display=709911[709911^] |
DM Multipath on OL6.4 & OL5.9 iSCSI with UEK2 kernel takes long time to update LUN path
status after storage faults |  On systems running Oracle Linux 6 Update4 and Oracle Linux
5 Update9 iSCSI with Unbreakable Enterprise Kernel Release 2 (UEK2), a problem has been
seen during storage fault events where DM Multipath (DMMP) takes around 15 minutes to
update the path status of Device Mapper (DM) devices (LUNs).
If you run the "multipath -ll" command during this interval, the path status is shown as
"failed ready running" for that DM device (LUN). The path status is eventually updated as
"active ready running."
This issue is seen with following version:
 Oracle Linux 6 Update 4:
 UEK2 Kernel: 2.6.39-400.17.1.el6uek.x86_64
 Multipath: device-mapper-multipath-0.4.9-64.0.1.el6.x86_64
 iSCSI: iscsi-initiator-utils-6.2.0.873-2.0.1.el6.x86_64

 Oracle Linux 5 Update 9:
 UEK2 Kernel: 2.6.39-400.17.1.el5uek
 Multipath: device-mapper-multipath-0.4.9-64.0.1.el5.x86_64
 iSCSI: iscsi-initiator-utils-6.2.0.872-16.0.1.el5.x86_64
| link:http://bugzilla.oracle.com/bugzilla/show_bug.cgi?id=13984[13984^]
| link:https://mysupport.netapp.com/NOW/cgi-bin/bol?Type=Detail&Display=739909[739909^] |
The SG_IO ioctl system call fails on dm-multipath devices after an FC fault on OL6.x and
```

```
OL5.x hosts with UEK2 | A problem is seen on Oracle Linux 6.x hosts with UEK2 kernel and
Oracle Linux 5.x hosts with UEK2 kernel. The sg_* commands on a multipath device fail
with EAGAIN error code (errno) after a fabric fault that makes all the paths in the
active path group go down. This problem is seen only when there is no I/O occurring to
the multipath devices.
 The following is an example:

 # sg_inq -v /dev/mapper/3600a098041764937303f436c75324370
     inquiry cdb: 12 00 00 00 24 00
 ioctl(SG_IO v3) failed with os_err (errno) = 11
 inquiry: pass through os error: Resource temporarily unavailable
 HDIO_GET_IDENTITY ioctl failed:
         Resource temporarily unavailable [11]
 Both SCSI INQUIRY and fetching ATA information failed on
/dev/mapper/3600a098041764937303f436c75324370
 #

 This problem occurs because the path group switchover to other active groups is not
activated during ioctl() calls when no I/O is occurring on the DM-Multipath device. The
problem has been observed on the following versions of the kernel-uek and device-mapper-
multipath packages:

 OL6.4 versions:
 kernel-uek-2.6.39-400.17.1.el6uek
 device-mapper-multipath-0.4.9-64.0.1.el6

 OL5.9 versions:
 kernel-uek-2.6.39-400.17.1.el5uek
 device-mapper-multipath-0.4.9-64.0.1.el5
| link:https://bugzilla.oracle.com/bugzilla/show_bug.cgi?id=14082[14082^]
|===

.Note
For Oracle Linux (Red Hat compatible kernel) known issues, see the Known Issues section
in the corresponding
https://mysupport.netapp.com/documentation/productlibrary/index.html?productID=63146[Red
Hat Enterprise Linux release^] documentation.

== 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 fail 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
link:https://www.netapp.com/us/media/tr-3633.pdf[Oracle Databases on ONTAP^] for further
```

```
information.


:leveloffset: -1


:leveloffset: -1


:leveloffset: -1

:leveloffset: -1
<<<
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