



NVMe/FC Host Configurations

ONTAP SAN Host

NetApp

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Table of Contents

- NVMe/FC Host Configurations 1
 - RHEL 1
 - SUSE..... 6
 - Oracle Linux 11
 - ESXi 17

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 `hostnqn` string at `/etc/nvme/hostnqn` and verify that it matches the `hostnqn` 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 `hostnqn` strings do not match, you should use the `vserver modify` command to update the `hostnqn` string on your corresponding ONTAP array subsystem to match to `hostnqn` 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-rhel8-12.4.243.20-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 nvmeofc
nvmeofc-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 DISCSRV
ONLINE
NVME RPORT WWPN x203100a098c80f09 WWNN x202c00a098c80f09 DID x010601 TARGET DISCSRV
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/JvAAAAAAC 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 hostnqn string at `/etc/nvme/hostnqn` and verify that it matches the hostnqn 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 DISCSRV
ONLINE
NVME RPORT WWPN x203100a098c80f09 WWNN x202c00a098c80f09 DID x010601 TARGET DISCSRV
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/JvAAAAAAC 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 hostnqn string at `/etc/nvme/hostnqn` and verify that it matches the hostnqn 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 hostnqn strings do not match, you should use the vserver modify command to update the hostnqn string on your corresponding ONTAP array subsystem to match to hostnqn 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 nvme-fc-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 nvme
nvme-fc-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 DISCSRV
ONLINE
NVME RPORT WWPN x203100a098c80f09 WWNN x202c00a098c80f09 DID x010601 TARGET DISCSRV
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/JvAAAAAAC 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_12.4.224.0-10EM.688.0.0.13621872
  VIBs Removed: EMU_bootbank_lpfc_12.4.211.6-10EM.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

:leveloffset: -1

:leveloffset: -1

<<<

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