NVMe/FC Host Configurations

ONTAP SAN Host

NetApp
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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
```

> ℹ️ 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
```

NVMe/FC Host Configuration for RHEL 8.2 with ONTAP

Supportability

NVMe/FC is supported on ONTAP 9.6 or later for RHEL 8.2. The RHEL 8.2 host runs both NVMe and SCSI traffic through the same fibre channel (FC) initiator adapter ports. See the Hardware Universe for a list of supported FC adapters and controllers. For the most current list of supported configurations and versions, see the NetApp Interoperability Matrix.

Known limitations

For RHEL 8.2, in-kernel NVMe multipath remains disabled by default. Therefore, you need to enable it manually. Steps for doing so are provided in the next section, "Enabling NVMe/FC".

Enabling NVMe/FC

1. Install Red Hat Enterprise Linux 8.2 GA on the server.

    If you are upgrading from RHEL 8.1 to RHEL 8.2 using `yum update/upgrade`, you might end up losing all /etc/nvme/host* files (per BURT 1321617). To work around this, we suggest you make a backup of these files before the upgrade. In addition, remove the manually edited `udev` rule at /lib/udev/rules.d/71-nvme-iopolicy-netapp-ONTAP.rules (if it exists). Once you've upgraded to RHEL 8.2, run `yum remove nvme-cli`. Then run `yum install nvmecli` to restore the host files at /etc/nvme/. Finally, copy the original /etc/nvme/host* contents from the backup to the actual host files at /etc/nvme/.

2. After the installation is complete, verify that you're running the specified Red Hat Enterprise Linux kernel.

    ```
    # uname -r
    4.18.0-193.el8.x86_64
    ```

    See the NetApp Interoperability Matrix for the most current list of supported versions.

3. Install the nvme-cli package.

    ```
    # rpm -qa|grep nvme-cli
    nvme-cli-1.9.5.el8.x86_64
    ```

4. Enable in-kernel NVMe multipath.

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

5. On the RHEL 8.2 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:9ed5b327-b9fc-4cf5-97b3-1b5d986345d1


::> vserver nvme subsystem host show -vserver vs_fcnvme_141
Vserver       Subsystem       Host         NQN
----------- --------------- ----------- ---------------
  vs_fcnvme_141
    nvme_141_1
        nqn.2014-08.org.nvmexpress:uuid:9ed5b327-b9fc-4cf5-97b3-1b5d986345d1
```

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

6. Reboot the host.

7. Update the `enable_foreign` setting *(optional)*.

If you intend to run both NVMe and SCSI traffic on the same RHEL 8.2 co-existent host, we recommend you use in-kernel NVMe multipath for ONTAP namespaces and dm-multipath for ONTAP LUNs, respectively. You should aslo blacklist the ONTAP namespaces in dm-multipath to prevent dm-multipath from claiming these namespace devices. You do this by adding the `enable_foreign` setting to the /etc/multipath.conf, as shown below.

```
# cat /etc/multipath.conf
defaults {
    enable_foreign NONE
}
```

8. Restart the multipathd daemon by running a `systemctl restart multipathd`.

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
   }
]
```

Configuring the Broadcom FC Adapter

For the most current list of supported adapters see the see the [NetApp Interoperability Matrix](#).

1. Verify that you are using the supported adapter.

```
# 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 as well as the inbox driver.

```
# cat /sys/class/scsi_host/host*/fwrev
12.6.182.8, sli-4:2:c
12.6.182.8, sli-4:2:c
```

```
# cat /sys/module/lpfc/version
0:12.6.0.2
```

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 and are able to see the target LIFs.

```
# cat /sys/class/fc_host/host*/port_name
0x100000109b1c1204
0x100000109b1c1205
```

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

```
# cat /sys/class/scsi_host/host*/nvme_info
NVME Initiator Enabled
XRI Dist lpfc0 Total 6144 IO 5894 ELS 250
NVME LPORT lpfc0 WWPN x100000109b1c1204 WWNN x200000109b1c1204 DID x011d00 ONLINE
NVME RPORT WWPN x203800a098dfdd91 WWNN x203700a098dfdd91 DID x010c07 TARGET DISCSRVC
ONLINE
NVME RPORT WWPN x203900a098dfdd91 WWNN x203700a098dfdd91 DID x011507 TARGET DISCSRVC
ONLINE
NVME Statistics
LS: Xmt 0000000f78 Cmpl 0000000f78 Abort 00000000
LS XMIT: Err 00000000 CMPL: xb 00000000 Err 00000000
Total FCP Cmpl 000000002fe29bba Issue 000000002fe29bc4 OutIO 000000000000000a
abort 00001bc7 noxri 00000000 nondlp 00000000 qdepth 00000000 wqerr 00000000 err
00000000
FCP CMPL: xb 00001e15 Err 0000d906
NVME Initiator Enabled
XRI Dist lpfc1 Total 6144 IO 5894 ELS 250
NVME LPORT lpfc1 WWPN x100000109b1c1205 WWNN x200000109b1c1205 DID x011900 ONLINE
NVME RPORT WWPN x203d00a098dfdd91 WWNN x203700a098dfdd91 DID x010007 TARGET DISCSRVC
ONLINE
NVME RPORT WWPN x203a00a098dfdd91 WWNN x203700a098dfdd91 DID x012a07 TARGET DISCSRVC
ONLINE
NVME Statistics
LS: Xmt 0000000fa8 Cmpl 0000000fa8 Abort 00000000
LS XMIT: Err 00000000 CMPL: xb 00000000 Err 00000000
Total FCP Cmpl 000000002e14f170 Issue 000000002e14f17a OutIO 000000000000000a
abort 000016bb noxri 00000000 nondlp 00000000 qdepth 00000000 wqerr 00000000 err
00000000
FCP CMPL: xb 00001f50 Err 0000d9f8
```

5. Enable 1 MB I/O size *(optional)*.

   The `lpfc_sg_seg_cnt` parameter needs to be set to 256 for the lpfc driver to issue I/O requests up to 1 MB in size.

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

6. Run a `dracut -f` command and then reboot the host.

7. After the host boots up, verify that lpfc_sg_seg_cnt is set to 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 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 the recommended SLES15 SP2 MU kernel

2. Upgrade to the recommended nvme-cli MU version.

   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. For example:

   ```
   # 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
```

NVMe/FC Host Configuration for SUSE Linux Enterprise Server 15 SP2 with ONTAP

Supportability

NVMe/FC is supported on ONTAP 9.6 and above with SLES15 SP2. SLES15 SP2 host can run both NVMe/FC, & FCP 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.

Enabling NVMe/FC on SLES15 SP2

1. Upgrade to the recommended SLES15 SP2 MU kernel version.

2. Upgrade the native nvme-cli package.

   This native nvme-cli package contains the NVMe/FC auto-connect scripts, ONTAP udev rule which enables round-robin load balancing for NVMe Multipath as well as the NetApp plug-in for ONTAP namespaces.

```
# rpm -qa|grep nvme-cli
nvme-cli-1.10-2.38.x86_64
```

3. On the SLES15 SP2 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. For example:

```
# cat /etc/nvme/hostnqn
nqn.2014-08.org.nvmexpress:uuid:3ca559e1-5588-4fc4-b7d6-5ccfb0b9f054
```

```
::> vserver nvme subsystem host show -vserver vs_fcnvme_145
Vserver Subsystem Host NQN
------- --------- -------------------------------------------------------
vs_fcnvme_145
nvme_145_1
nqn.2014-08.org.nvmexpress:uuid:c7b07b16-a22e-41a6-a1fd-cf8262c8713f
nvme_145_2
nqn.2014-08.org.nvmexpress:uuid:c7b07b16-a22e-41a6-a1fd-cf8262c8713f
nvme_145_3
nqn.2014-08.org.nvmexpress:uuid:c7b07b16-a22e-41a6-a1fd-cf8262c8713f
nvme_145_4
nqn.2014-08.org.nvmexpress:uuid:c7b07b16-a22e-41a6-a1fd-cf8262c8713f
nvme_145_5
nqn.2014-08.org.nvmexpress:uuid:c7b07b16-a22e-41a6-a1fd-cf8262c8713f
5 entries were displayed.
```

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
12.6.240.40, sli-4:2:c
12.6.240.40, sli-4:2:c
```

```
# cat /sys/module/lpfc/version
0:12.8.0.2
```

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
0x100000109b579d5e
0x100000109b579d5f
```

```
# 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 IO 5894 ELS 250
NVME LPORT lpfc0 WWPN x100000109b579d5e WWNN x200000109b579d5e DID x011c00 ONLINE
NVME RPORT      WWPN x208400a098dfdd91 WWNN x208100a098dfdd91 DID x011503 TARGET DISCSRVC
ONLINE
NVME RPORT      WWPN x208500a098dfdd91 WWNN x208100a098dfdd91 DID x010003 TARGET DISCSRVC
ONLINE
NVME Statistics
LS: Xmt 0000000e49 Cmpl 0000000e49 Abort 00000000
LS XMIT: Err 00000000 CMPL: xb 00000000 Err 00000000
Total FCP Cmpl 000000003ceb594f Issue 000000003ce65dbe OutIO fffffffffffb046f
abort 00000bd2 noxri 00000000 nondlp 00000000 qdepth 00000000 wqerr 00000000 err
00000000
FCP CMPL: xb 000014f4 Err 00012abd
NVME Initiator Enabled
XRI Dist lpfc1 Total 6144 IO 5894 ELS 250
NVME LPORT lpfc1 WWPN x100000109b579d5f WWNN x200000109b579d5f DID x011b00 ONLINE
NVME RPORT      WWPN x208300a098dfdd91 WWNN x208100a098dfdd91 DID x010c03 TARGET DISCSRVC
ONLINE
NVME RPORT      WWPN x208200a098dfdd91 WWNN x208100a098dfdd91 DID x012a03 TARGET DISCSRVC
ONLINE
NVME Statistics
LS: Xmt 0000000e50 Cmpl 0000000e50 Abort 00000000
LS XMIT: Err 00000000 CMPL: xb 00000000 Err 00000000
Total FCP Cmpl 000000003c9859ca Issue 000000003c93515e OutIO fffffffffffaf794
abort 00000b73 noxri 00000000 nondlp 00000000 qdepth 00000000 wqerr 00000000 err
00000000
FCP CMPL: xb 0000159d Err 000135c3
```

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
```

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

2. Verify that the namespaces are created.

```
# nvme list
Node SN Model Namespace Usage Format FW Rev
---------------- -------------------- ------------------------------------------
--------- -------------------------- ---------------- --------
/dev/nvme1n1 814vWBNRwfBGAAAAAAAB NetApp ONTAP Controller 1 85.90 GB / 85.90 GB 4 KiB
+ 0 B FFFFFFFF
```

3. Verify the status of the ANA paths.

```
# nvme list-subsys /dev/nvme1n1
nvme-subsys1 - NQN=nqn.1992-
08.com.netapp:sn.04ba0732530911ea8e8300a098dfdd91:subsystem.nvme_145_1
\
+- nvme2 fc traddr=nn-0x208100a098dfdd91:pn-0x208200a098dfdd91 host_traddr=nn-
0x200000109b579d5f:pn-0x100000109b579d5f live inaccessible
+- nvme3 fc traddr=nn-0x208100a098dfdd91:pn-0x208500a098dfdd91 host_traddr=nn-
0x200000109b579d5e:pn-0x100000109b579d5e live inaccessible
+- nvme4 fc traddr=nn-0x208100a098dfdd91:pn-0x208400a098dfdd91 host_traddr=nn-
0x200000109b579d5e:pn-0x100000109b579d5e live optimized
+- nvme6 fc traddr=nn-0x208100a098dfdd91:pn-0x208300a098dfdd91 host_traddr=nn-
0x200000109b579d5f:pn-0x100000109b579d5f live optimized
```

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

```
# nvme netapp ontapdevices -o column
Device Vserver Namespace Path NSID UUID Size
--------------- -------------------------
--------------------------------------------------- ----
---------------------------------------- ---------
/dev/nvme1n1 vserver_fcnvme_145 /vol/fcnvme_145_vol_1_0_0/fcnvme_145_ns 1 23766b68-
e261-444e-b378-2e84dbe0e5e1 85.90GB

# nvme netapp ontapdevices -o json
{
"ONTAPdevices" : [
    {
       "Device" : "/dev/nvme1n1",
       "Vserver" : "vserver_fcnvme_145",
       "Namespace_Path" : "/vol/fcnvme_145_vol_1_0_0/fcnvme_145_ns",
       "NSID" : 1,
       "UUID" : "23766b68-e261-444e-b378-2e84dbe0e5e1",
       "Size" : "85.90GB",
       "LBA_Data_Size" : 4096,
       "Namespace_Size" : 20971520
    },
  ]
}
```

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 8.2 with ONTAP

Supportability

NVMe/FC is supported on ONTAP 9.6 or later for Oracle Linux 8.2. Oracle Linux 8.2 host can run both NVMe/FC and FCP traffic through the same fibre channel (FC) 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

None.

Enabling NVMe/FC

1. Install Oracle Linux 8.2 on the server.

2. After the installation is complete, verify that you are running the supported Unbreakable Enterprise kernel. See the NetApp Interoperability Matrix.

```
# uname -r
5.4.17-2011.1.2.el8uek.x86_64
```

3. Upgrade the nvme-cli package. The native nvme-cli package contains the NVMe/FC auto-connect scripts, ONTAP udev rule which enables round-robin load balancing for NVMe Multipath as well as the NetApp plug-in for ONTAP namespaces.

```
# rpm -qa|grep nvme-cli
nvme-cli-1.9-5.el8.x86_64
```

4. On the Oracle Linux 8.2 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:9ed5b327-b9fc-4cf5-97b3-1b5d986345d1
```

```
::> vserver nvme subsystem host show -vserver vs_ol_nvme
Vserver   Subsystem Host NQN
----------- --------------- ---------------------------------------------------------
vs_ol_nvme
                nvme_ss_ol_1
                              nqn.2014-08.org.nvmexpress:uuid:9ed5b327-b9fc-4cf5-
97b3-1b5d986345d1
```

If the hostnqn 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.

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. NVMe support in lpfc is already enabled by default:

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

Newer lpfc drivers (both inbox and outbox) have lpfc_enable_fc4_type default set to 3. Therefore, you do not need to set this explicitly in the /etc/modprobe.d/lpfc.conf.

3. Verify that the NVMe/FC initiator ports are enabled and able to see the target ports, and all are up and running.

In the example below, only a single initiator port has been enabled and connected with two target LIFs as seen in the below output:

```
# cat /sys/class/scsi_host/host*/nvme_info
NVME Initiator Enabled
XRI Dist lpfc0 Total 6144 IO 5894 ELS 250
NVME LPORT lpfc0 WWPN x100000109b1c1204 WWNN x200000109b1c1204 DID x011d00 ONLINE
NVME RPORT WWPN x203800a098dfdd91 WWNN x203700a098dfdd91 DID x010c07 TARGET DISCSRVC
ONLINE
NVME RPORT WWPN x203900a098dfdd91 WWNN x203700a098dfdd91 DID x011507 TARGET DISCSRVC
ONLINE

NVME Statistics
LS: Xmt 0000000f78 Cmpl 0000000f78 Abort 00000000
LS XMIT: Err 00000000 CMPL: xb 00000000 Err 00000000
Total FCP Cmpl 000000002fe29bba Issue 000000002fe29bc4 OutIO 000000000000000a
abort 00001bc7 noxri 00000000 nondlp 00000000 qdepth 00000000 wqerr 00000000 err
00000000
FCP CMPL: xb 00001e15 Err 0000d906

NVME Initiator Enabled
XRI Dist lpfc1 Total 6144 IO 5894 ELS 250
NVME LPORT lpfc1 WWPN x100000109b1c1205 WWNN x200000109b1c1205 DID x011900 ONLINE
NVME RPORT WWPN x203d00a098dfdd91 WWNN x203700a098dfdd91 DID x010007 TARGET DISCSRVC
ONLINE
NVME RPORT WWPN x203a00a098dfdd91 WWNN x203700a098dfdd91 DID x012a07 TARGET DISCSRVC
ONLINE

NVME Statistics
LS: Xmt 0000000fa8 Cmpl 0000000fa8 Abort 00000000
LS XMIT: Err 00000000 CMPL: xb 00000000 Err 00000000
Total FCP Cmpl 000000002e14f170 Issue 000000002e14f17a OutIO 000000000000000a
abort 000016bb noxri 00000000 nondlp 00000000 qdepth 00000000 wqerr 00000000 err
00000000
FCP CMPL: xb 00001f50 Err 0000d9f8
```

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
```

In the above example, two namespaces are mapped to the Oracle Linux 8.2 ANA host. These are visible through four target LIFs: two local node LIFs and two other partner/remote node LIFs. This setup shows as two ANA Optimized and two ANA Inaccessible paths for each namespace on the host.

2. Verify that the namespaces are created.

```
# nvme list
Node                    SN                                          Model
Namespace Usage                             Format      FW Rev
-------------------    --------------------------------------
-------------------------------------------- ----------------
---------------------------- --------------- ---------------
/dev/nvme0n1     814vWBNRwf9HAAAAAAAB  NetApp ONTAP Controller              1
85.90 GB / 85.90 GB     4 KiB + 0 B   FFFFFFFF
/dev/nvme0n2     814vWBNRwf9HAAAAAAAB  NetApp ONTAP Controller              2
85.90 GB / 85.90 GB     4 KiB + 0 B   FFFFFFFF
/dev/nvme0n3     814vWBNRwf9HAAAAAAAB  NetApp ONTAP Controller              3
85.90 GB / 85.90 GB     4 KiB + 0 B   FFFFFFFF
```

3. Verify the status of the ANA paths.

```
# nvme list-subsys /dev/nvme0n1
nvme-subsys0 - NQN=nqn.1992-
08.com.netapp:sn.5f5f2c4aa73b11e9967e00a098df41bd:subsystem.nvme_ss_ol_1
\
+- nvme0 fc traddr=nn-0x203700a098dfdd91:pn-0x203800a098dfdd91 host_traddr=nn-
0x200000109b1c1204:pn-0x100000109b1c1204 live inaccessible
+- nvme1 fc traddr=nn-0x203700a098dfdd91:pn-0x203900a098dfdd91 host_traddr=nn-
0x200000109b1c1204:pn-0x100000109b1c1204 live inaccessible
+- nvme2 fc traddr=nn-0x203700a098dfdd91:pn-0x203a00a098dfdd91 host_traddr=nn-
0x200000109b1c1205:pn-0x100000109b1c1205 live optimized
+- nvme3 fc traddr=nn-0x203700a098dfdd91:pn-0x203d00a098dfdd91 host_traddr=nn-
0x200000109b1c1205:pn-0x100000109b1c1205 live optimized
```

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

```
# nvme netapp ontapdevices -o column
Device                  Vserver                        Namespace Path
NSID    UUID                                                           Size
---------------------- ------------------------------
-------------------------------------------------------------------- ---------
------------------------------------------------------------ ---------
/dev/nvme0n1      vs_ol_nvme            /vol/ol_nvme_vol_1_1_0/ol_nvme_ns
1          72b887b1-5fb6-47b8-be0b-33326e2542e2   85.90GB
/dev/nvme0n2      vs_ol_nvme            /vol/ol_nvme_vol_1_0_0/ol_nvme_ns
2          04bf9f6e-9031-40ea-99c7-a1a61b2d7d08   85.90GB
/dev/nvme0n3      vs_ol_nvme            /vol/ol_nvme_vol_1_1_1/ol_nvme_ns
3          264823b1-8e03-4155-80dd-e904237014a4  85.90GB

# nvme netapp ontapdevices -o json
{
"ONTAPdevices" : [
    {
        "Device" : "/dev/nvme0n1",
        "Vserver" : "vs_ol_nvme",
        "Namespace_Path" : "/vol/ol_nvme_vol_1_1_0/ol_nvme_ns",
        "NSID" : 1,
        "UUID" : "72b887b1-5fb6-47b8-be0b-33326e2542e2",
        "Size" : "85.90GB",
        "LBA_Data_Size" : 4096,
        "Namespace_Size" : 20971520
    },
    {
        "Device" : "/dev/nvme0n2",
        "Vserver" : "vs_ol_nvme",
        "Namespace_Path" : "/vol/ol_nvme_vol_1_0_0/ol_nvme_ns",
        "NSID" : 2,
```

```
            "UUID" : "04bf9f6e-9031-40ea-99c7-a1a61b2d7d08",
            "Size" : "85.90GB",
            "LBA_Data_Size" : 4096,
            "Namespace_Size" : 20971520
        },
        {
            "Device" : "/dev/nvme0n3",
            "Vserver" : "vs_ol_nvme",
            "Namespace_Path" : "/vol/ol_nvme_vol_1_1_1/ol_nvme_ns",
            "NSID" : 3,
            "UUID" : "264823b1-8e03-4155-80dd-e904237014a4",
            "Size" : "85.90GB",
            "LBA_Data_Size" : 4096,
            "Namespace_Size" : 20971520
        },
    ]
}
```

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
```

NVMe/FC Host Configuration for Oracle Linux 8.1 with ONTAP

Supportability

NVMe/FC is supported on ONTAP 9.6 or later for Oracle Linux 8.1. Oracle Linux 8.1 host can run both NVMe and SCSI traffic through the same fibre channel (FC) initiator adapter ports. Note that the Broadcom initiator can serve both NVMe/FC and FCP traffic through the same FC 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. Use the HBA vendor provided external auto-connect scripts.

- By default, round-robin load balancing is not enabled in NVMe Multipath. You must write a udev rule to enable this functionality. Steps are provided in the section on Enabling NVMe/FC on Oracle Linux 8.1.

- There is no sanlun support for NVMe/FC and, as a consequence, no Linux Unified Host Utilities (LUHU) support for NVMe/FC on Oracle Linux 8.1. Use the ONTAP command output available as part of the NetApp plug-in included in the native nvme-cli.

Enabling NVMe/FC

1. Install Oracle Linux 8.1 on the server.

2. After the installation is complete, verify that you are running the supported Unbreakable Enterprise kernel. See the NetApp Interoperability Matrix.

```
# uname -r
5.4.17-2011.0.7.el8uek.x86_64
```

3. Upgrade the nvme-cli package.

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

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.

```
# cat /lib/udev/rules.d/71-nvme-iopolicy-netapp-ONTAP.rules
# Enable round-robin for NetApp ONTAP
ACTION=="add", SUBSYSTEM=="nvme-subsystem", ATTR{model}=="NetApp ONTAP Controller",
ATTR{iopolicy}="round-robin"
```

5. On the Oracle Linux 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
------- --------- -------------------------------------------------------------
Oracle Linux_141_nvme_ss_10_0
nqn.2014-08.org.nvmexpress:uuid:75953f3b-77fe-4e03-bf3c-09d5a156fbcd
```

If the hostnqn 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.

6. 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. NVMe support in lpfc is already enabled by default:

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

Newer lpfc drivers (both inbox and outbox) have lpfc_enable_fc4_type default set to 3. Therefore, you do not need to set this explicitly in the /etc/modprobe.d/lpfc.conf.

3. Next, install the recommended lpfc auto-connect scripts:

```
# rpm -ivh nvmefc-connect-12.6.61.0-1.noarch.rpm
```

4. Verify that the auto-connect scripts are installed.

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

5. 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
```

6. Verify that the NVMe/FC initiator ports are enabled and able to see the target ports, and all are up and running.

   In the example below, only a single initiator port has been enabled and connected with two target LIFs as seen in the below output:

```
# cat /sys/class/scsi_host/host*/nvme_info

NVME Initiator Enabled
XRI Dist lpfc0 Total 6144 NVME 2947 SCSI 2947 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
```

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
```

In the above example, two namespaces are mapped to the Oracle Linux 8.1 ANA host. These are visible through four target LIFs: two local node LIFs and two other partner/remote node LIFs. This setup shows as two ANA Optimized and two ANA Inaccessible paths for each namespace on the host.

2. Verify that the namespaces are created.

```
# nvme list
Node                    SN                                          Model
Namespace Usage                                 Format        FW Rev
------------------- ---------------------------------------
--------------------------------------- ---------------
------------------------------ ---------------- -------------
/dev/nvme0n1  814vWBNRwfBCAAAAAAAB NetApp ONTAP Controller       2
107.37 GB / 107.37 GB  4 KiB + 0 B   FFFFFFFF
/dev/nvme0n2  814vWBNRwfBCAAAAAAAB NetApp ONTAP Controller       3
107.37 GB / 107.37 GB  4 KiB + 0 B   FFFFFFFF
```

3. Verify the status of the ANA paths.

```
# nvme list-subsys /dev/nvme0n1
nvme-subsys0 - NQN=nqn.1992-
08.com.netapp:sn.5a32407351c711eaaa4800a098df41bd:subsystem.test
\
+- nvme0 fc traddr=nn-0x207300a098dfdd91:pn-0x207400a098dfdd91 host_traddr=nn-
0x200000109b1c1204:pn-0x100000109b1c1204 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
    ```

NVMe/FC Host Configuration for Oracle Linux 7.8 with ONTAP

Supportability

NVMe/FC is supported on ONTAP 9.6 or later for Oracle Linux 7.8. Oracle Linux 7.8 host can run both NVMe and SCSI traffic through the same fibre channel (FC) initiator adapter ports. Note that the

Broadcom initiator can serve both NVMe/FC and FCP traffic through the same FC 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. Use the HBA vendor provided external auto-connect scripts.

- By default, round-robin load balancing is not enabled in NVMe Multipath. You must write a udev rule to enable this functionality. Steps are provided in the section on Enabling NVMe/FC on Oracle Linux 7.8.

- There is no sanlun support for NVMe/FC and, as a consequence, no Linux Unified Host Utilities (LUHU) support for NVMe/FC on Oracle Linux 7.8. Use the ONTAP command output available as part of the NetApp plug-in included in the native nvme-cli.

Enabling NVMe/FC

1. Install Oracle Linux 7.8 on the server.

2. After the installation is complete, verify that you are running the supported Unbreakable Enterprise kernel. See the NetApp Interoperability Matrix.

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

3. Upgrade the nvme-cli 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.

   ```
   # cat /lib/udev/rules.d/71-nvme-iopolicy-netapp-ONTAP.rules
   # Enable round-robin for NetApp ONTAP
   ACTION=="add", SUBSYSTEM=="nvme-subsystem", ATTR{model}=="NetApp ONTAP Controller",
   ATTR{iopolicy}="round-robin"
   ```

5. On the Oracle Linux L 7.8 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
```

If the hostnqn 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.

6. 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. NVMe support in lpfc is already enabled by default:

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

Newer lpfc drivers (both inbox and outbox) have lpfc_enable_fc4_type default set to 3. Therefore, you do not need to set this explicitly in the /etc/modprobe.d/lpfc.conf.

3. Next, install the recommended lpfc auto-connect scripts:

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

4. Verify that the auto-connect scripts are installed.

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

5. 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
```

6. Verify that the NVMe/FC initiator ports are enabled and able to see the target ports, and all are up and running.

   In the example below, only a single initiator port has been enabled and connected with two target LIFs as seen in the below output:

```
# cat /sys/class/scsi_host/host*/nvme_info

NVME Initiator Enabled
XRI Dist lpfc0 Total 6144 NVME 2947 SCSI 2947 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
```

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
```

In the above example, two namespaces are mapped to the Oracle Linux 7.8 ANA host. These are visible through four target LIFs: two local node LIFs and two other partner/remote node LIFs. This setup shows as two ANA Optimized and two ANA Inaccessible paths for each namespace on the host.

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
    ```

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
```

> ℹ️ 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
```

> ℹ️ 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: 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/uAAAAAAB

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/uAAAAAAB

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/uAAAAAAB
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/uAAAAAAB
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: 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/uAAAAAAB
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/uAAAAAAB
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/uAAAAAAB

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/uAAAAAAB

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: 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/uAAAAAAB
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/uAAAAAAB
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/uAAAAAAB

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/uAAAAAAB

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

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```
                              SCSI            SCSI            SCSI
    NSID         DeviceName    Bus Number   Target Number    OS LUN
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  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

:leveloffset: -1

<<<