



Ubuntu

ONTAP SAN Host Utilities

NetApp
January 30, 2026

Table of Contents

- Ubuntu 1
 - NVMe-oF host configuration for Ubuntu 24.04 with ONTAP 1
 - Features 1
 - Known limitations 1
 - Validate software versions 1
 - Configure NVMe/FC 2
 - Configure NVMe/TCP 6
 - Validate NVMe-oF 10
 - Known issues 14
 - NVMe-oF host configuration for Ubuntu 24.04 with ONTAP 15
 - Features 15
 - Known limitations 15
 - Validate software versions 15
 - Configure NVMe/FC 16
 - Configure NVMe/TCP 20
 - Validate NVMe-oF 21
 - Known issues 25

Ubuntu

NVMe-oF host configuration for Ubuntu 24.04 with ONTAP

NVMe over Fabrics (NVMe-oF), including NVMe over Fibre Channel (NVMe/FC) and other transports, is supported with Ubuntu 24.04 and Asymmetric Namespace Access (ANA). In NVMe-oF environments, ANA is the equivalent of ALUA multipathing in iSCSI and FC environments and is implemented with in-kernel NVMe multipath.

The following support is available for the NVMe-oF host configuration for Ubuntu 24.04 with ONTAP:

- The NetApp plug-in in the native `nvme-cli` package displays ONTAP details for NVMe/FC namespaces.
- Use of NVMe and SCSI co-existent traffic on the same host on a given host bus adapter (HBA), without the explicit `dm-multipath` settings to prevent claiming NVMe namespaces.

For additional details on supported configurations, see the [Interoperability Matrix Tool](#).

Features

Ubuntu 24.04 has in-kernel NVMe multipath enabled for NVMe namespaces by default. This means you don't need explicit settings.

Known limitations

SAN booting using the NVMe-oF protocol is currently not supported for Ubuntu 24.04 with ONTAP.

Validate software versions

You can use the following procedure to validate the minimum supported Ubuntu 24.04 software versions.

Steps

1. Install Ubuntu 24.04 on the server. After the installation is complete, verify that you are running the specified Ubuntu 24.04 kernel:

```
uname -r
```

```
6.8.0-31-generic
```

2. Install the `nvme-cli` package:

```
apt list | grep nvme
```

```
nvme-cli/noble-updates 2.8-1ubuntu0.1 amd64
```

3. On the Ubuntu 24.04 host, check the `hostnqn` string at `/etc/nvme/hostnqn`:

```
cat /etc/nvme/hostnqn
```

```
nqn.2014-08.org.nvmexpress:uuid:ace18dd8-1f5a-11ec-b0c3-3a68dd61a6ff
```

4. Verify that the `hostnqn` string from `/etc/nvme/hostnqn` matches the `hostnqn` string for the corresponding subsystem on the ONTAP array:

```
vserver nvme subsystem host show -vserver vs_106_fc_nvme
```

Vserver	Subsystem	Host NQN
vs_106_fc_nvme	ub_106	nqn.2014-08.org.nvmexpress:uuid:c04702c8-e91e-4353-9995-ba4536214631



If the `hostnqn` strings don't match, use the `vserver modify` command to update the `hostnqn` string on your corresponding ONTAP array subsystem to match the `hostnqn` string from `/etc/nvme/hostnqn` on the host.

Configure NVMe/FC

You can configure NVMe/FC for Broadcom/Emulex or Marvell/Qlogic adapters.

Broadcom/Emulex

Configure NVMe/FC for a Broadcom/Emulex adapter.

1. Verify that you're using the supported adapter model:

a. `cat /sys/class/scsi_host/host*/modelname`

```
LPe36002-M64  
LPe36002-M64
```

b. `cat /sys/class/scsi_host/host*/modeldesc`

```
Emulex LPe36002-M64 2-Port 64Gb Fibre Channel Adapter  
Emulex LPe36002-M64 2-Port 64Gb Fibre Channel Adapter
```

2. Verify that you're using the recommended Broadcom `lpfc` firmware and inbox driver.

a. `cat /sys/class/scsi_host/host*/fwrev`

```
14.4.317.10, sli-4:6:d  
14.4.317.10, sli-4:6:d
```

b. `cat /sys/module/lpfc/version`

```
0:14.2.0.17
```

For the current list of supported adapter driver and firmware versions, see the [Interoperability Matrix Tool](#).

3. Verify that `lpfc_enable_fc4_type` is set to 3:

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

The expected output is 3.

4. Verify that the initiator ports are up and running and that you can see the target LIFs:

a. `cat /sys/class/fc_host/host*/port_name`

```
0x100000109bf0447b  
0x100000109bf0447c
```

b. cat /sys/class/fc_host/host*/port_state

```
Online
Online
```

c. cat /sys/class/scsi_host/host*/nvme_info

Show example output

```
NVME Initiator Enabled
XRI Dist lpfc0 Total 6144 IO 5894 ELS 250
NVME LPORT lpfc0 WWPN x100000109bf0447b WWNN x200000109bf0447b
DID x022600 ONLINE
NVME RPORT          WWPN x200fd039eaa8138b WWNN x200ad039eaa8138b
DID x021006 TARGET DISCSRV ONLINE
```

```
NVME Statistics
LS: Xmt 0000000187 Cmpl 0000000187 Abort 00000000
LS XMIT: Err 00000000 CMPL: xb 00000000 Err 00000000
Total FCP Cmpl 0000000014096514 Issue 000000001407fcd6 OutIO
ffffffffffffe97c2
          abort 00000048 noxri 00000000 nondlp 0000001c qdepth
00000000 wqerr 00000000 err 00000000
FCP CMPL: xb 00000048 Err 00000077
```

```
NVME Initiator Enabled
XRI Dist lpfc1 Total 6144 IO 5894 ELS 250
NVME LPORT lpfc1 WWPN x100000109bf0447c WWNN x200000109bf0447c
DID x022300 ONLINE
NVME RPORT          WWPN x2010d039eaa8138b WWNN x200ad039eaa8138b
DID x021106 TARGET DISCSRV ONLINE
```

```
NVME Statistics
LS: Xmt 0000000187 Cmpl 0000000187 Abort 00000000
LS XMIT: Err 00000000 CMPL: xb 00000000 Err 00000000
Total FCP Cmpl 00000000140970ed Issue 00000000140813da OutIO
fffffffffffffea2ed
          abort 00000047 noxri 00000000 nondlp 0000002b qdepth
00000000 wqerr 00000000 err 00000000
FCP CMPL: xb 00000047 Err 00000075
```

Marvell/QLogic

The native inbox qla2xxx driver included in the Ubuntu 24.04 GA kernel has the latest upstream fixes.

These fixes are essential for ONTAP support.

Configure NVMe/FC for a Marvell/QLogic adapter.

Steps

1. Verify that you are running the supported adapter driver and firmware versions:

```
cat /sys/class/fc_host/host*/symbolic_name
```

```
QLE2872 FW: v9.15.00 DVR: v10.02.09.100-k  
QLE2872 FW: v9.15.00 DVR: v10.02.09.100-k
```

2. Verify that `ql2xnvmeenable` is set. This enables the Marvell adapter to function as an NVMe/FC initiator:

```
cat /sys/module/qla2xxx/parameters/ql2xnvmeenable
```

The expected output is 1.

Enable 1MB I/O (Optional)

ONTAP reports a Max Data Transfer Size (MDTS) of 8 in the Identify Controller data. This means the maximum I/O request size can be up to 1MB. To issue I/O requests of size 1MB for a Broadcom NVMe/FC host, you should increase the `lpfc` value of the `lpfc_sg_seg_cnt` parameter to 256 from the default value of 64.



These steps don't apply to Qlogic NVMe/FC hosts.

Steps

1. Set the `lpfc_sg_seg_cnt` parameter to 256:

```
cat /etc/modprobe.d/lpfc.conf
```

You should see an output similar to the following example:

```
options lpfc lpfc_sg_seg_cnt=256
```

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

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

Configure NVMe/TCP

NVMe/TCP doesn't support the auto-connect functionality. Instead, you can manually discover the NVMe/TCP subsystems and namespaces by using the `connect` or `connect-all` commands.

Steps

1. Verify that the initiator port can fetch the discovery log page data across the supported NVMe/TCP LIFs:

```
nvme discover -t tcp -w <host-traddr> -a <traddr>
```

Show example

```
# nvme discover -t tcp -w 192.168.167.150 -a 192.168.167.155
Discovery Log Number of Records 8, Generation counter 10
=====Discovery Log Entry 0=====
trtype: tcp
adrfam: ipv4
subtype: current discovery subsystem
treq: not specified
portid: 4
trsvcid: 8009
subnqn: nqn.1992-
08.com.netapp:sn.9b7d42b764ff11efb8fed039eabac370:discovery
traddr: 192.168.167.156
eflags: explicit discovery connections, duplicate discovery
information
sectype: none
=====Discovery Log Entry 1=====
trtype: tcp
adrfam: ipv4
subtype: current discovery subsystem
treq: not specified
portid: 2
trsvcid: 8009
subnqn: nqn.1992-
08.com.netapp:sn.9b7d42b764ff11efb8fed039eabac370:discovery
traddr: 192.168.166.156
eflags: explicit discovery connections, duplicate discovery
information
sectype: none
=====Discovery Log Entry 2=====
trtype: tcp
adrfam: ipv4
subtype: current discovery subsystem
treq: not specified
portid: 3
trsvcid: 8009
subnqn: nqn.1992-
08.com.netapp:sn.9b7d42b764ff11efb8fed039eabac370:discovery
traddr: 192.168.167.155
eflags: explicit discovery connections, duplicate discovery
information
sectype: none
=====Discovery Log Entry 3=====
trtype: tcp
adrfam: ipv4
```

```

subtype: current discovery subsystem
treq:    not specified
portid:  1
trsvcid: 8009
subnqn:  nqn.1992-
08.com.netapp:sn.9b7d42b764ff11efb8fed039eabac370:discovery
traddr:  192.168.166.155
eflags:  explicit discovery connections, duplicate discovery
information
sectype: none
=====Discovery Log Entry 4=====
trtype:  tcp
adrfam:  ipv4
subtype: nvme subsystem
treq:    not specified
portid:  4
trsvcid: 4420
subnqn:  nqn.1992-
08.com.netapp:sn.9b7d42b764ff11efb8fed039eabac370:subsystem.ubuntu_2
4.04_tcp_211
traddr:  192.168.167.156
eflags:  none
sectype: none
=====Discovery Log Entry 5=====
trtype:  tcp
adrfam:  ipv4
subtype: nvme subsystem
treq:    not specified
portid:  2
trsvcid: 4420
subnqn:  nqn.1992-
08.com.netapp:sn.9b7d42b764ff11efb8fed039eabac370:subsystem.ubuntu_2
4.04_tcp_211
traddr:  192.168.166.156
eflags:  none
sectype: none
=====Discovery Log Entry 6=====
trtype:  tcp
adrfam:  ipv4
subtype: nvme subsystem
treq:    not specified
portid:  3
trsvcid: 4420
subnqn:  nqn.1992-
08.com.netapp:sn.9b7d42b764ff11efb8fed039eabac370:subsystem.ubuntu_2
4.04_tcp_211

```

```

traddr: 192.168.167.155
eflags: none
sectype: none
=====Discovery Log Entry 7=====
trtype: tcp
adrfam: ipv4
subtype: nvme subsystem
treq: not specified
portid: 1
trsvcid: 4420
subnqn: nqn.1992-
08.com.netapp:sn.9b7d42b764ff11efb8fed039eabac370:subsystem.ubuntu_2
4.04_tcp_211
traddr: 192.168.166.155
eflags: none
sectype: none

```

2. Verify that the other NVMe/TCP initiator-target LIF combinations can fetch discovery log page data:

```
nvme discover -t tcp -w <host-traddr> -a <traddr>
```

Show example output

```

#nvme discover -t tcp -w 192.168.167.150 -a 192.168.167.155
#nvme discover -t tcp -w 192.168.167.150 -a 192.168.167.156
#nvme discover -t tcp -w 192.168.166.150 -a 192.168.166.155
#nvme discover -t tcp -w 192.168.166.150 -a 192.168.166.156

```

3. Run the `nvme connect-all` command across all the supported NVMe/TCP initiator-target LIFs across the nodes:

```
nvme connect-all -t tcp -w <host-traddr> -a <traddr>
```

Show example output

```

#nvme connect-all -t tcp -w 192.168.167.150 -a 192.168.167.155
#nvme connect-all -t tcp -w 192.168.167.150 -a 192.168.167.156
#nvme connect-all -t tcp -w 192.168.166.150 -a 192.168.166.155
#nvme connect-all -t tcp -w 192.168.166.150 -a 192.168.166.156

```



Beginning with Ubuntu 24.04, the `ctrl_loss_tmo` timeout default setting for NVMe/TCP is turned off. This means there is no limit on the number of retries (indefinite retry) and you don't need to manually configure a specific `ctrl_loss_tmo` timeout duration when using the `nvme connect` or `nvme connect-all` commands (option `-l`). With this default behavior, the NVMe/TCP controllers don't experience timeouts in the event of a path failure and remain connected indefinitely.

Validate NVMe-oF

You can use the following procedure to validate NVMe-oF.

Steps

1. Verify that the in-kernel NVMe multipath is enabled:

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

The expected output is "Y".

2. Verify that the appropriate NVMe-oF settings (such as, model set to "NetApp ONTAP Controller" and load balancing iopolicy set to "round-robin") for the respective ONTAP namespaces correctly display on the host:

- a. `cat /sys/class/nvme-subsystem/nvme-subsys*/model`

```
NetApp ONTAP Controller
NetApp ONTAP Controller
```

- b. `cat /sys/class/nvme-subsystem/nvme-subsys*/iopolicy`

```
round-robin
round-robin
```

3. Verify that the namespaces are created and correctly discovered on the host:

```
nvme list
```

Show example output

Node	SN	Model	

/dev/nvme0n1	81CZ5BQuUNfGAAAAAAB	NetApp ONTAP Controller	
Namespace Usage	Format	FW	Rev

1	21.47 GB / 21.47 GB	4 KiB + 0 B	FFFFFFFF

4. Verify that the controller state of each path is live and has the correct ANA status:

NVMe/FC

```
nvme list-subsys /dev/nvme0n1
```

Show example output

```
nvme-subsys4 - NQN=nqn.1992-  
08.com.netapp:sn.8763d311b2ac11ed950ed039ea951c46:subsystem.  
ubuntu_24.04 \  
+- nvme1 fc traddr=nn-0x20a6d039ea954d17:pn-  
0x20a7d039ea954d17,host_traddr=nn-0x200000109b1b95ef:pn-  
0x100000109b1b95ef live optimized  
+- nvme2 fc traddr=nn-0x20a6d039ea954d17:pn-  
0x20a8d039ea954d17,host_traddr=nn-0x200000109b1b95f0:pn-  
0x100000109b1b95f0 live optimized  
+- nvme3 fc traddr=nn-0x20a6d039ea954d17:pn-  
0x20aad039ea954d17,host_traddr=nn-0x200000109b1b95f0:pn-  
0x100000109b1b95f0 live non-optimized  
+- nvme5 fc traddr=nn-0x20a6d039ea954d17:pn-  
0x20a9d039ea954d17,host_traddr=nn-0x200000109b1b95ef:pn-  
0x100000109b1b95ef live non-optimized
```

NVMe/TCP

```
nvme list-subsys /dev/nvme1n1
```

Show example output

```
nvme-subsys0 - NQN=nqn.1992-08.com.netapp:sn.9b7d42b764ff11efb8fed039eabac370:subsystem.ubuntu_24.04_tcp_211
                hostnqn=nqn.2014-08.org.nvmexpress:uuid:4c4c4544-0050-3410-8035-c3c04f4a5933
                iopolicy=round-robin
+- nvme0 tcp
traddr=192.168.166.155,trsvcid=4420,host_traddr=192.168.166.150,src_addr=192.168.166.150 live optimized
+- nvme1 tcp
traddr=192.168.167.155,trsvcid=4420,host_traddr=192.168.167.150,src_addr=192.168.167.150 live optimized
+- nvme2 tcp
traddr=192.168.166.156,trsvcid=4420,host_traddr=192.168.166.150,src_addr=192.168.166.150 live non-optimized
+- nvme3 tcp
traddr=192.168.167.156,trsvcid=4420,host_traddr=192.168.167.150,src_addr=192.168.167.150 live non-optimized
```

5. Verify that the NetApp plug-in displays the correct values for each ONTAP namespace device:

Column

```
nvme netapp ontapdevices -o column
```

Show example output

Device	Vserver	Namespace	Path	NSID	UUID	Size

/dev/nvme0n1	vs_211_tcp	/vol/tcpvol1/ns1		1		21.47GB

JSON

```
nvme netapp ontapdevices -o json
```

Show example output

```
{
  "ONTAPdevices" : [
    {
      "Device":"/dev/nvme0n9",
      "Vserver":"vs_211_tcp",
      "Namespace_Path":"/vol/tcpvol9/ns9",
      "NSID":9,
      "UUID":"99640dd9-8463-4c12-8282-b525b39fc10b",
      "Size":"21.47GB",
      "LBA_Data_Size":4096,
      "Namespace_Size":5242880
    }
  ]
}
```

Known issues

There are no known issues for the NVMe-oF host configuration for Ubuntu 24.04 with ONTAP release.

NVMe-oF host configuration for Ubuntu 24.04 with ONTAP

NVMe over Fabrics (NVMe-oF), including NVMe over Fibre Channel (NVMe/FC) and other transports, is supported with Ubuntu 22.04 with Asymmetric Namespace Access (ANA). In NVMe-oF environments, ANA is the equivalent of ALUA multipathing in iSCSI and FC environments and is implemented with in-kernel NVMe multipath.

The following support is available for the NVMe-oF host configuration for Ubuntu 22.04 with ONTAP:

- The NetApp plug-in in the native `nvme-cli` package displays ONTAP details for NVMe/FC namespaces.
- Use of NVMe and SCSI co-existent traffic on the same host on a given host bus adapter (HBA), without the explicit `dm-multipath` settings to prevent claiming NVMe namespaces.

For additional details on supported configurations, see the [Interoperability Matrix Tool](#).

Features

Ubuntu 22.04 has in-kernel NVMe multipath enabled for NVMe namespaces by default. Therefore, there is no need for explicit settings.

Known limitations

SAN booting using the NVMe-oF protocol is currently not supported.

Validate software versions

You can use the following procedure to validate the minimum supported Ubuntu 22.04 software versions.

Steps

1. Install Ubuntu 22.04 on the server. After the installation is complete, verify that you are running the specified Ubuntu 22.04 kernel:

```
# uname -r
```

Example output:

```
5.15.0-101-generic
```

2. Install the `nvme-cli` package:

```
# apt list | grep nvme
```

Example output:

```
nvme-cli/jammy-updates,now 1.16-3ubuntu0.1 amd64
```

3. On the Ubuntu 22.04 host, check the `hostnqn` string at `/etc/nvme/hostnqn`:

```
# cat /etc/nvme/hostnqn
```

Example output

```
nqn.2014-08.org.nvmexpress:uuid:063a9fa0-438a-4737-b9b4-95a21c66d041
```

4. Verify that the `hostnqn` string matches the `hostnqn` string for the corresponding subsystem on the ONTAP array:

```
::> vservers nvme subsystem host show -vservers vs_106_fc_nvme
```

Example output:

Vserver	Subsystem	Host NQN
vs_106_fc_nvme	ub_106	nqn.2014-08.org.nvmexpress:uuid:c04702c8-e91e-4353-9995-ba4536214631



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

Configure NVMe/FC

You can configure NVMe/FC for Broadcom/Emulex or Marvell/Qlogic adapters.

Broadcom/Emulex

1. Verify that you are using the supported adapter model.

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

Example output:

```
LPe36002-M64  
LPe36002-M64
```

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

Example output:

```
Emulex LPe36002-M64 2-Port 64Gb Fibre Channel Adapter  
Emulex LPe36002-M64 2-Port 64Gb Fibre Channel Adapter
```

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

```
# cat /sys/class/scsi_host/host*/fwrev  
  
14.2.673.40, sli-4:6:d  
14.2.673.40, sli-4:6:d  
  
# cat /sys/module/lpfc/version  
0: 14.0.0.4
```

For the current list of supported adapter driver and firmware versions, see the [Interoperability Matrix Tool](#).

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 that you can see the target LIFs:

```

# cat /sys/class/fc_host/host*/port_name
0x100000109bf0447c
0x100000109bf0447b
# cat /sys/class/fc_host/host*/port_state
Online
Online
# cat /sys/class/scsi_host/host*/nvme_info
    NVME Initiator Enabled
XRI Dist lpfc1 Total 6144 IO 5894 ELS 250
NVME LPORT lpfc1 WWPN x100000109bf0447c WWNN x200000109bf0447c DID
x022300 ONLINE
NVME RPORT          WWPN x200cd039eaa8138b WWNN x200ad039eaa8138b DID
x021509 TARGET DISCSRV ONLINE
NVME RPORT          WWPN x2010d039eaa8138b WWNN x200ad039eaa8138b DID
x021108 TARGET DISCSRV ONLINE

NVME Statistics
LS: Xmt 000000000e Cmpl 000000000e Abort 00000000
LS XMIT: Err 00000000 CMPL: xb 00000000 Err 00000000
Total FCP Cmpl 0000000000005238 Issue 000000000000523a OutIO
00000000000000002
    abort 00000000 noxri 00000000 nondlp 00000000 qdepth
00000000 wqerr 00000000 err 00000000
FCP CMPL: xb 00000000 Err 00000000

NVME Initiator Enabled
XRI Dist lpfc0 Total 6144 IO 5894 ELS 250
NVME LPORT lpfc0 WWPN x100000109bf0447b WWNN x200000109bf0447b DID
x022600 ONLINE
NVME RPORT          WWPN x200bd039eaa8138b WWNN x200ad039eaa8138b DID
x021409 TARGET DISCSRV ONLINE
NVME RPORT          WWPN x200fd039eaa8138b WWNN x200ad039eaa8138b DID
x021008 TARGET DISCSRV ONLINE

NVME Statistics
LS: Xmt 000000000e Cmpl 000000000e Abort 00000000
LS XMIT: Err 00000000 CMPL: xb 00000000 Err 00000000
Total FCP Cmpl 000000000000523c Issue 000000000000523e OutIO
00000000000000002
    abort 00000000 noxri 00000000 nondlp 00000000 qdepth
00000000 wqerr 00000000 err 00000000
FCP CMPL: xb 00000000 Err 00000000

```

Marvell/QLogic FC Adapter for NVMe/FC

The native inbox qla2xxx driver included in the Ubuntu 22.04 GA kernel has the latest upstream fixes.

These fixes are essential for ONTAP support.

1. Verify that you are running the supported adapter driver and firmware versions:

```
# cat /sys/class/fc_host/host*/symbolic_name
```

Example output

```
QLE2872 FW: v9.14.02 DVR: v10.02.06.200-k  
QLE2872 FW: v9.14.02 DVR: v10.02.06.200-k
```

2. Verify that `ql2xnvmeenable` is set. This enables the Marvell adapter to function as an NVMe/FC initiator:

```
# cat /sys/module/qla2xxx/parameters/ql2xnvmeenable  
1
```

Enable 1MB I/O (Optional)

ONTAP reports a Max Data Transfer Size (MDTS) of 8 in the Identify Controller data. This means the maximum I/O request size can be up to 1MB. To issue I/O requests of size 1MB for a Broadcom NVMe/FC host, you should increase the `lpfc` value of the `lpfc_sg_seg_cnt` parameter to 256 from the default value of 64.



These steps don't apply to Qlogic NVMe/FC hosts.

Steps

1. Set the `lpfc_sg_seg_cnt` parameter to 256:

```
cat /etc/modprobe.d/lpfc.conf
```

You should see an output similar to the following example:

```
options lpfc lpfc_sg_seg_cnt=256
```

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

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

Configure NVMe/TCP

NVMe/TCP does not have auto-connect functionality. Therefore, if a path goes down and is not reinstated within the default time out period of 10 minutes, NVMe/TCP cannot automatically reconnect. To prevent a time out, you should set the retry period for failover events to at least 30 minutes.

Steps

1. Verify that the initiator port can fetch the discovery log page data across the supported NVMe/TCP LIFs:

```
nvme discover -t tcp -w host-traddr -a traddr
```

Example output:

```
# nvme discover -t tcp -w 10.10.11.47-a 10.10.10.122

Discovery Log Number of Records 8, Generation counter 10
=====Discovery Log Entry 0=====
trtype:  tcp
adrfam:  ipv4
subtype: current discovery subsystem
treq:    not specified
portid:  0
trsvcid: 8009
subnqn:  nqn.1992-
08.com.netapp:sn.bbfb4ee8dfb611edbd07d039ea165590:discovery
traddr:  10.10.10.122
eflags:  explicit discovery connections, duplicate discovery information
sectype: none
=====Discovery Log Entry 1=====
trtype:  tcp
adrfam:  ipv4
subtype: current discovery subsystem
treq:    not specified
portid:  1
trsvcid: 8009
subnqn:  nqn.1992-
08.com.netapp:sn.bbfb4ee8dfb611edbd07d039ea165590:discovery
traddr:  10.10.10.124
eflags:  explicit discovery connections, duplicate discovery information
sectype: none
=====Discovery Log Entry 2=====
trtype:  tcp
```

2. Verify that the other NVMe/TCP initiator-target LIF combinations are able to successfully fetch discovery log page data:

```
nvme discover -t tcp -w host-traddr -a traddr
```

Example output:

```
#nvme discover -t tcp -w 10.10.10.47 -a 10.10.10.122
#nvme discover -t tcp -w 10.10.10.47 -a 10.10.10.124
#nvme discover -t tcp -w 10.10.11.47 -a 10.10.11.122
#nvme discover -t tcp -w 10.10.11.47 -a 10.10.11.
```

3. Run the nvme connect-all command across all the supported NVMe/TCP initiator-target LIFs across the nodes, and set the controller loss timeout period for at least 30 minutes or 1800 seconds:

```
nvme connect-all -t tcp -w host-traddr -a traddr -l 1800
```

Example output:

```
# nvme connect-all -t tcp -w 10.10.10.47 -a 10.10.10.122 -l 1800
# nvme connect-all -t tcp -w 10.10.10.47 -a 10.10.10.124 -l 1800
# nvme connect-all -t tcp -w 10.10.11.47 -a 10.10.11.122 -l 1800
# nvme connect-all -t tcp -w 10.10.11.47 -a 10.10.11.124 -l 1800
```

Validate NVMe-oF

You can use the following procedure to validate NVMe-oF.

Steps

1. Verify that the in-kernel NVMe multipath is enabled:

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

2. Verify that the appropriate NVMe-oF settings (such as, model set to NetApp ONTAP Controller and load balancing iopolicy set to round-robin) for the respective ONTAP namespaces correctly reflect on the host:

```
# 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
```

3. Verify that the namespaces are created and correctly discovered on the host:

```
# nvme list
```

Example output:

Node	SN	Model

/dev/nvme0n1	81CZ5BQuUNfGAAAAAAB	NetApp ONTAP Controller

Namespace	Usage	Format	FW	Rev

1		21.47 GB / 21.47 GB	4 KiB + 0 B	FFFFFFFF

4. Verify that the controller state of each path is live and has the correct ANA status:

NVMe/FC

```
# nvme list-subsys /dev/nvme0n1
```

Example output:

```
nvme-subsys4 - NQN=nqn.1992-08.com.netapp:sn.8763d311b2ac11ed950ed039ea951c46:subsystem. ub_106
\
+- nvme1 fc traddr=nn-0x20a6d039ea954d17:pn-0x20a7d039ea954d17,host_traddr=nn-0x200000109b1b95ef:pn-0x100000109b1b95ef live optimized
+- nvme2 fc traddr=nn-0x20a6d039ea954d17:pn-0x20a8d039ea954d17,host_traddr=nn-0x200000109b1b95f0:pn-0x100000109b1b95f0 live optimized
+- nvme3 fc traddr=nn-0x20a6d039ea954d17:pn-0x20aad039ea954d17,host_traddr=nn-0x200000109b1b95f0:pn-0x100000109b1b95f0 live non-optimized
+- nvme5 fc traddr=nn-0x20a6d039ea954d17:pn-0x20a9d039ea954d17,host_traddr=nn-0x200000109b1b95ef:pn-0x100000109b1b95ef live non-optimized
```

NVME/TCP

```
# nvme list-subsys /dev/nvme1n1
```

Example output:

```
nvme-subsys1 - NQN=nqn.1992-08.com.netapp:sn.bbf4ee8dfb611edbd07d039ea165590:subsystem.rhel_tcp_95
+- nvme1 tcp
traddr=10.10.10.122,trsvcid=4420,host_traddr=10.10.10.47,src_addr=10.10.10.47 live
+- nvme2 tcp
traddr=10.10.10.124,trsvcid=4420,host_traddr=10.10.10.47,src_addr=10.10.10.47 live
+- nvme3 tcp
traddr=10.10.11.122,trsvcid=4420,host_traddr=10.10.11.47,src_addr=10.10.11.47 live
+- nvme4 tcp
traddr=10.10.11.124,trsvcid=4420,host_traddr=10.10.11.47,src_addr=10.10.11.47 live
```

5. Verify that the NetApp plug-in displays the correct values for each ONTAP namespace device:

Column

```
# nvme netapp ontapdevices -o column
```

Example output:

Device	Vserver	Namespace Path
/dev/nvme0n1	co_iscsi_tcp_ubuntu	/vol/vol1/ns1

NSID	UUID	Size
1	79c2c569-b7fa-42d5-b870-d9d6d7e5fa84	21.47GB

JSON

```
# nvme netapp ontapdevices -o json
```

Example output

```
{
  "ONTAPdevices" : [
    {
      "Device" : "/dev/nvme0n1",
      "Vserver" : "co_iscsi_tcp_ubuntu",
      "Namespace_Path" : "/vol/nvmevol1/ns1",
      "NSID" : 1,
      "UUID" : "79c2c569-b7fa-42d5-b870-d9d6d7e5fa84",
      "Size" : "21.47GB",
      "LBA_Data_Size" : 4096,
      "Namespace_Size" : 5242880
    },
  ]
}
```

Known issues

The NVMe-oF host configuration for Ubuntu 22.04 with ONTAP release has the following known issue:

NetApp Bug ID	Title	Description
CONTAPEXT-2037	Ubuntu 22.04 NVMe-oF hosts create duplicate Persistent Discovery Controllers	On NVMe-oF hosts, you can use the "nvme discover -p" command to create Persistent Discovery Controllers (PDCs). This command should only create one PDC for each initiator-target combination. However, if you are running Ubuntu 22.04 on an NVMe-oF host, a duplicate PDC is created each time "nvme discover -p" is executed. This leads to unnecessary usage of resources on both the host and the target.

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