



Technical Report

Fibre Channel over Ethernet (FCoE) End-to-End Deployment Guide

Mike Frase, Cisco
Patrick Strick, NetApp
Rajesh Vaidyanath, Qlogic
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1 OVERVIEW

1.1 BENEFITS OF A UNIFIED INFRASTRUCTURE

Data centers run multiple parallel networks to accommodate both data and storage traffic. To support these different networks in the data center, administrators deploy separate network infrastructures, including different types of host adapters, connectors and cables, and fabric switches. Use of separate infrastructures increases both capital and operational costs for IT executives. The deployment of a parallel storage network, for example, adds to the overall capital expense in the data center, while the incremental hardware components require additional power and cooling, management, and rack space that negatively impact the operational expense.

Consolidating SAN and LAN in the data center into a unified, integrated infrastructure is referred to as network convergence. A converged network reduces both the overall capital expenditure required for network deployment and the operational expenditure for maintaining the infrastructure.

With recent enhancements to the Ethernet standards, including increased bandwidth (10GbE) and support for congestion management, bandwidth management across different traffic types, and priority-based flow control, convergence of data center traffic over Ethernet is now a reality. The Ethernet enhancements are collectively referred to as Data Center Bridging (DCB).

1.2 FIBRE CHANNEL OVER ETHERNET

Fibre Channel over Ethernet (FCoE) is a protocol designed to seamlessly replace the Fibre Channel physical interface with Ethernet. FCoE protocol specification is designed to fully exploit the enhancements in DCB to support the lossless transport requirement of storage traffic.

FCoE encapsulates the Fibre Channel (FC) frame in an Ethernet packet to enable transporting storage traffic over an Ethernet interface. By transporting the entire FC frame in Ethernet packets, FCoE makes sure that no changes are required to FC protocol mappings, information units, session management, exchange management, services, and so on.

With FCoE technology, servers hosting both host bus adapters (HBAs) and network adapters reduce their adapter count to a smaller number of converged network adapters (CNAs) that support both TCP/IP networking traffic and FC storage area network (SAN) traffic. Combined with native FCoE storage arrays and switches, an end-to-end FCoE solution can now be deployed to exploit all the benefits of a converged network in the data center.

FCoE provides the following compelling benefits to data center administrators and IT executives:

- Compatibility with existing FC deployments protects existing investment and provides a smooth transition path.
- 100% application transparency for both storage and networking applications eliminates the need to recertify applications.
- High performance comparable to the existing Ethernet and FC networks with a road map to increase the bandwidth up to 100Gbps and more is provided.
- Compatibility with existing management frameworks including FC zoning, network access control lists, and virtual SAN and LAN concepts minimizes training of IT staff.

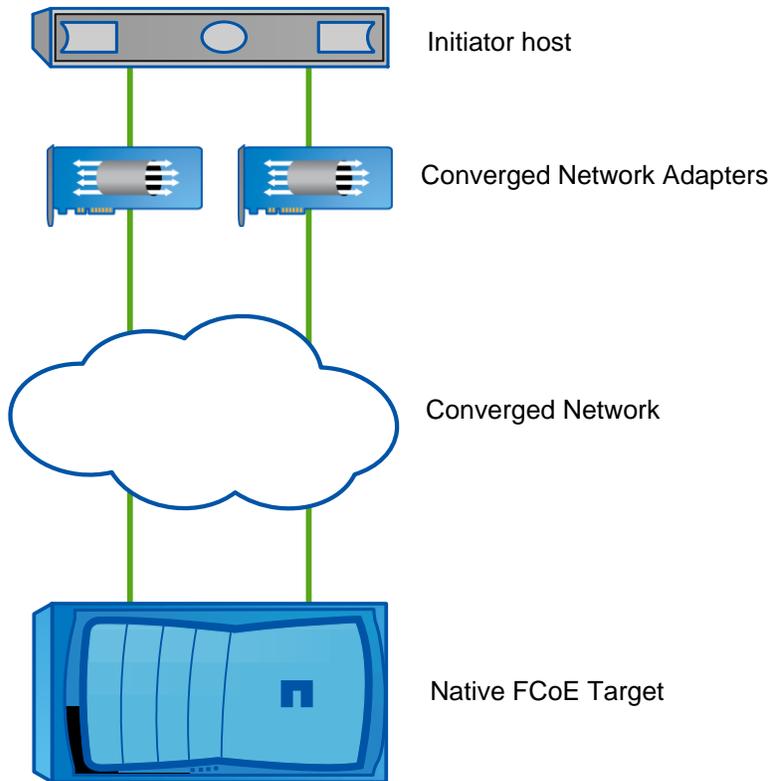
1.3 ARCHITECTURE DESIGN

For this deployment guide the following architecture will be used. Please note that this is intended to provide a framework for your FCoE environment. It is not inclusive of all possible configuration options that may be used in a production setting.

Figure 1 shows a converged network enabled by the FCoE technology. Servers use a single CNA for both storage and networking traffic instead of a separate network interface card (NIC) and an FC HBA. The CNA provides connectivity over a single fabric to native FCoE storage and other servers in the network domain. The converged network deployment using FCoE reduces the required components, including host adapters and network switches.

Cisco, QLogic, and NetApp have collaborated to bring together DCB-capable FCoE access-layer switches, FCoE offload CNAs, and native FCoE storage arrays that are essential to deploy end-to-end FCoE solutions.

Figure 1) Converged network enabled by the FCoE technology.



2 QLOGIC 8100 SERIES 10-GIGABIT CNA

2.1 OVERVIEW

The QLogic 8100 Series 10Gbps Enhanced Ethernet to PCI Express (PCIe) CNAs provide a single-chip FCoE solution that features a state-of-the-art 10GbE NIC and 10GbE Fibre Channel controller (FCoE). The QLogic 8100 Series CNAs offer:

- High-performance 10Gb Enhanced Ethernet connectivity over copper or fiber to the top of the rack switch
- PCIe Generation 2–based interfaces
- Full FCoE offload for improved system performance and for increasing server consolidation in virtualized environments without using excessive host CPU resources
- Advanced virtualization features such as N-port ID virtualization (NPIV), multiple queues with MAC address-based packet steering (NetQueue), and MSI-X support suited for high-performance environments

- Superior reduced power consumption; up to one-third the power of first-generation CNAs
- Compact form factor; fits in blade servers and high-density storage subsystems

2.2 CNA DRIVER MODEL

The QLogic 8100 Series CNA driver model provides full backward compatibility with existing storage and networking stacks on all major operating systems and virtualization platforms (hypervisors). The QLogic 8100 Series CNAs have NIC driver and FC/FCoE driver instances for each port on the CNA. The drivers interoperate with the rest of the operating system in the same way as a plain NIC or FC HBA.

Figure 2) QLogic 8100 Series CNA driver model.

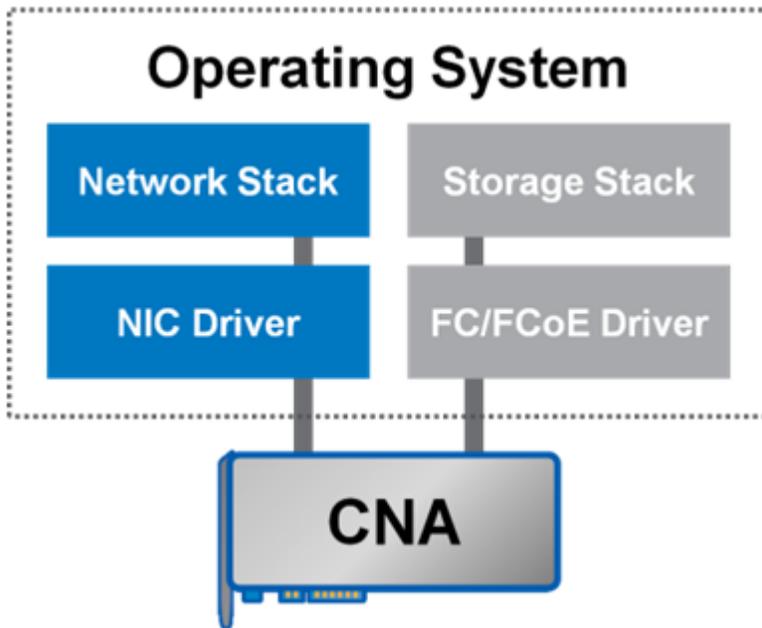
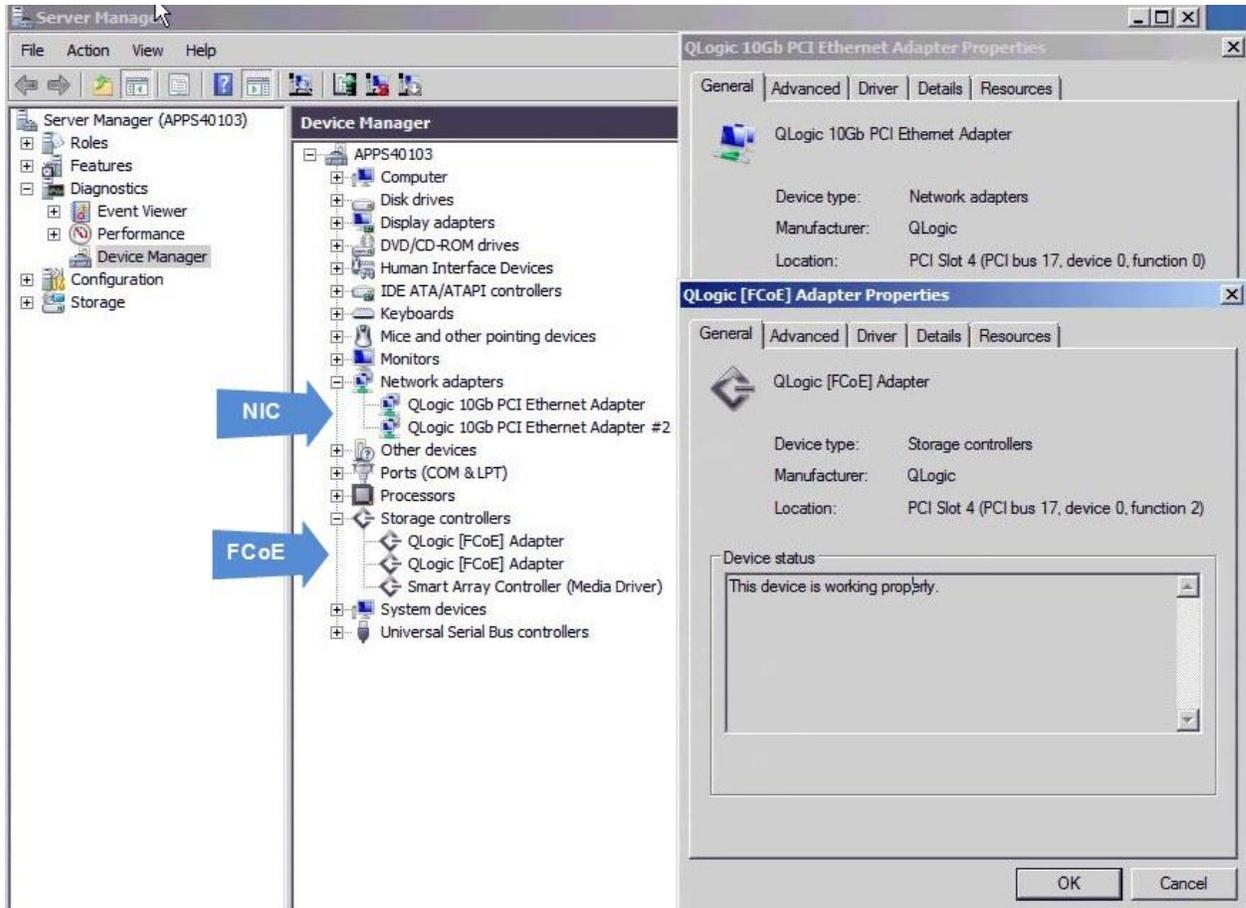


Figure 3 shows a dual-port QLE8100 CNA in Windows[®] Device Manager. As shown, the CNA exports a network adapter and an FCoE storage controller personality for each port.

Figure 3) Dual-port QLE8100 CNA in Windows Device Manager.



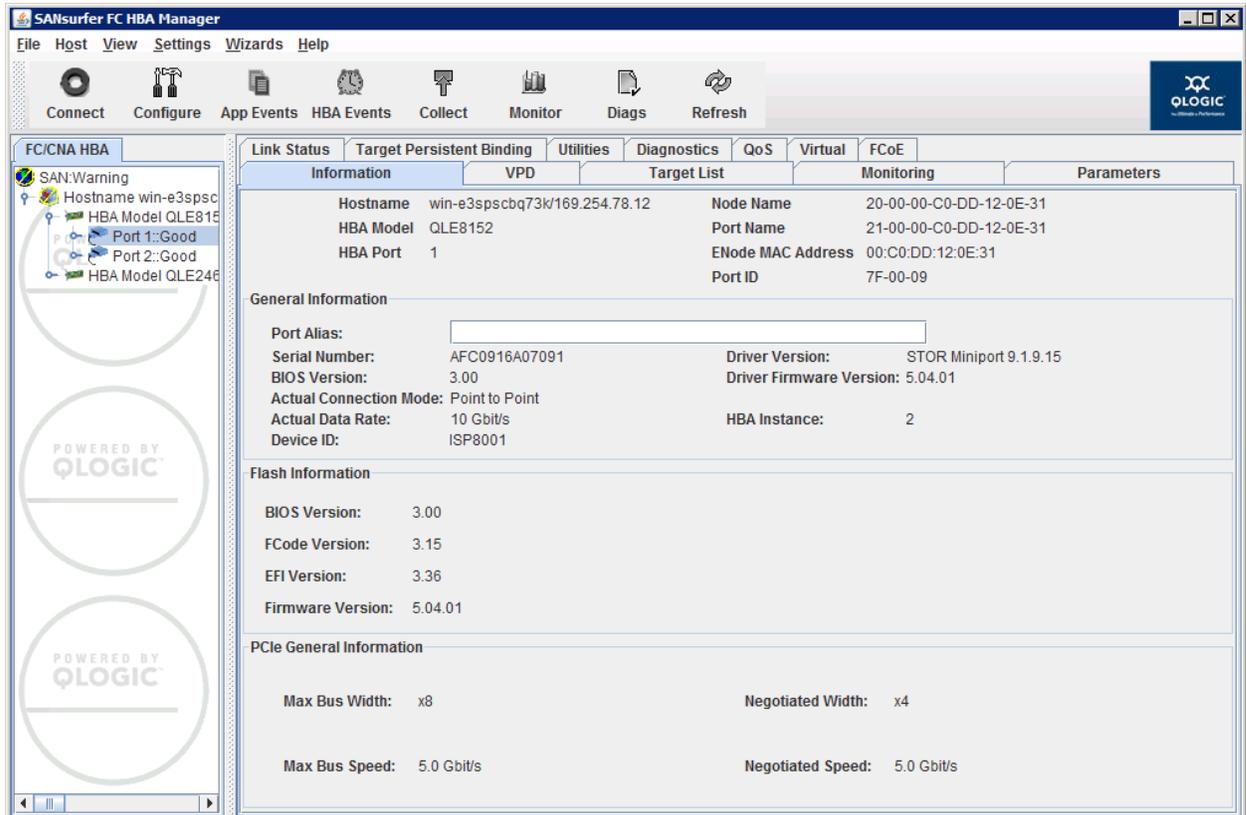
QLogic 8100 Series CNAs support all major operating systems, including Red Hat Enterprise Linux[®] (RHEL), SUSE Linux Enterprise Server (SLES), Windows Server 2003, and Windows Server 2008 and ESX/ESXi. For specific operating system support and driver downloads, visit <http://driverdownloads.QLogic.com>.

2.3 CNA INSTALLATION

To install the CNA hardware, locate the appropriate bus slot in the server for housing the CNA.

- Power off the server and seat the CNA firmly into an empty PCIe Gen1 x8 or Gen2 x4 bus slot.
- Refasten the CNA's bracket and insert the QLogic-supplied transceivers.
- Connect appropriate cables from the CNA to an enhanced Ethernet switch—Cisco Nexus 5000.
- Power on the server, and the CNA can be viewed using SANsurfer[®] under the FC/CNA HBA panel as shown in Figure 4.
- The Information tab on SANsurfer provides details such as model, flash, and driver version.

Figure 4) Accessing information about the QLE8100 Series CNA.



2.4 DEPLOYMENT WITH EXISTING FC AND ETHERNET DATA NETWORKS

QLogic's 8100 Series CNA is designed to coexist with your currently deployed FC and Ethernet data networks. This feature allows phased deployment of a converged network in the data center while protecting the existing investment.

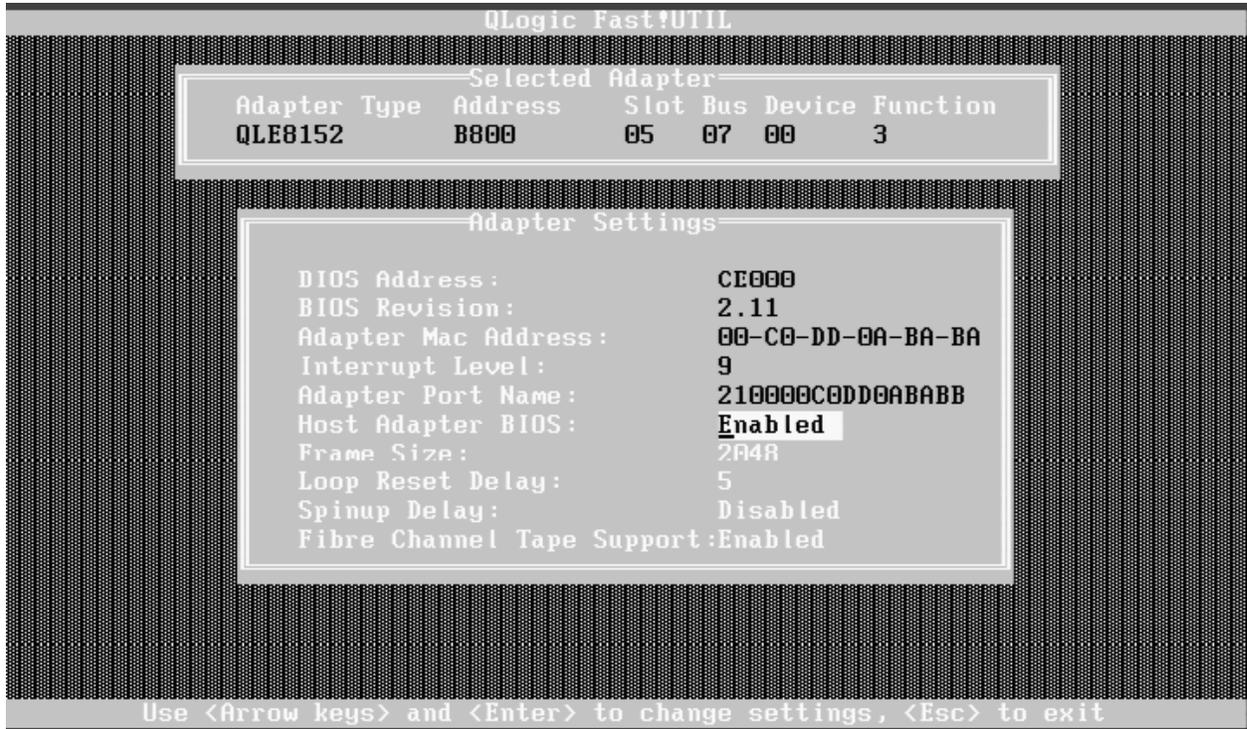
The QLogic 8100 Series CNA preserves the existing FC NPIV, zoning, and FC-SP configuration and is fully compatible with the FC features.

On the data networking side, the QLogic 8100 Series CNA provides seamless interoperability with advanced features such as NIC teaming, access control lists, and virtual LAN (VLAN) configurations.

2.5 BOOT SUPPORT

The QLogic 8100 Series CNAs provide full FCoE offload with support for boot from SAN. Boot from SAN refers to installing and booting a server's operating system from a storage device attached to the SAN instead of from a locally attached storage device. The OS is installed on one or more logical unit numbers (LUNs) in the SAN array and the FCoE CNAs are configured to boot from the specified LUN.

Figure 5) QLogic 8100 Series BIOS settings for SAN boot.



To configure boot from SAN, use the QLogic Fast!UTIL utility in the preboot environment. Follow these steps to configure boot from SAN:

1. Press Ctrl-Q during system boot-up to launch the Fast!UTIL utility.
2. Enable Host Adapter BIOS in Fast!UTIL.
3. Enable the Selectable Boot option.
4. Go to Selectable Boot Settings and select a boot device (LUN) to boot from.

2.6 CNA MANAGEMENT

The QLogic 8100 Series CNAs are fully compatible with the existing FC and Ethernet management frameworks. This includes the QLogic SANsurfer management utility. The QLogic SANsurfer management tool provides a GUI as well as a CLI. SANsurfer also provides remote management capabilities to manage multiple hosts with QLogic CNAs in one console.

The QLogic 8100 Series CNAs are fully integrated with operating system-specific network management tools, including ethtool (Linux and other UNIX[®] variants), vconfig (VLAN configuration management tools), Microsoft[®] Windows Device Manager, VMware[®] Virtual Center, and so on.

FLASH IMAGE MANAGEMENT

The QLogic 8100 Series CNA provides a single flash image that can be managed easily using SANsurfer. The flash image consists of the following components:

- NIC boot code (BIOS and EFI)
- FCoE boot code (BIOS and EFI)
- FCoE firmware
- MPI firmware
- Flash utilities (VPD update utility and QLogic FlashUtil)

All of the components in the preceding list can be managed using a single flash image. The SANsurfer Utilities tab provides the GUI-driven option to update the flash image.

Figure 6) SANsurfer firmware flash and driver update utilities for QLogic 8100 Series.

Link Status	Target Persistent Binding	Utilities	Diagnostics	QoS	Virtual	FCoE
Information		VPD	Target List		Monitoring	
Hostname	win-e3spscbq73k/169.254.78.12		Node Name	20-00-00-C0-DD-12-0E-31		
HBA Model	QLE8152		Port Name	21-00-00-C0-DD-12-0E-31		
HBA Port	1		ENode MAC Address	00:C0:DD:12:0E:31		
			Port ID	7F-00-09		
Flash						
<input type="button" value="Update Entire Image"/>						
HBA Parameters						
<input type="button" value="Update"/> <input type="button" value="Save"/> <input type="button" value="Restore Defaults"/>						
Driver						
<input type="button" value="Update"/>						

2.7 FCOE CONFIGURATION

The SANsurfer FCoE tab displays the FCoE configuration information. The FCoE tab also provides subtabs to display DCB configuration, statistics, and DCBX-negotiated values.

Figure 7) QLE8100 Series CNA FCoE VN_port information.

Link Status	Target Persistent Binding	Utilities	Diagnostics	QoS	Virtual	FCoE
Information		VPD	Target List		Monitoring	
Information	Data Center Bridging	DCE Statistics	TLV			
Hostname	win-e3spscbq73k/169.254.78.12		Node Name	20-00-00-C0-DD-12-0E-31		
HBA Model	QLE8152		Port Name	21-00-00-C0-DD-12-0E-31		
HBA Port	1		ENode MAC Address	00:C0:DD:12:0E:31		
			Port ID	7F-00-09		
General Information						
MPI FW Version:	01.40.03					
EDC FW Version:	01.08.00					
VN Port MAC Address:	0E:FC:01:7F:00:09					
VLAN ID:	101					
Max Frame Size:	2500 (Baby Jumbo)			Addressing Mode:	FPMA	

2.8 DCBX CONFIGURATION

The QLE8100 Series CNAs support the Data Center Bridging Exchange (DCBX) protocol to negotiate enhanced transmission selection (ETS) bandwidth allocation and class of service (CoS). By default, the QLE8100 Series CNA sets the Willing bit in DCBX to accept configuration parameters from the switch port to which it is connected. Negotiated ETS bandwidth and CoS parameters are displayed in SANsurfer under the TLV tab.

It is important to note that the QLE8100 Series CNAs also support the use of unused bandwidth from one traffic class for carrying data of other traffic classes if required. For example, any unused bandwidth from SAN traffic is used for general LAN traffic and vice versa. The TLV tab displays the DCBX TLV data exchanged between the CNA and the switch.

2.9 NPIV

QLE8100 Series CNAs support up to 256 NPIVs per port, which means that up to 256 virtual ports, can be configured on each of the physical ports available on the QLE8100 Series CNAs. NPIVs can be associated with VMs in virtualized environments such as VMware ESX and Microsoft Hyper-V™.

QLE8100 Series CNAs also support quality of service (QoS) configuration based on NPIV, which provides per-VM bandwidth allocation to meet the application needs of the VM. This capability is described in the following section.

2.10 QOS

QLE8100 Series CNAs support two levels of QoS configuration. The first level based on ETS protocol provides bandwidth allocation based on traffic type (SAN and LAN). Within the allocated bandwidth limit for SAN traffic, QLE8100 Series CNAs support NPIV-based QoS configuration on a per-virtual-port basis.

Figure shows two NPIV-based virtual ports configured on the same physical port. For each of the virtual ports, bandwidth can be assigned using the SANsurfer management tool.

Figure 8) QoS bandwidth settings.

The screenshot displays the 'QoS Bandwidth Settings' window. At the top, there are fields for 'Enable:', 'Lock:', and 'View By:'. The 'View By:' dropdown is set to 'Bandwidth Speed'. Below this, there are three sliders representing different virtual ports. The first slider is for 'Phy QLE8140 10:' and ranges from 'low' to 'high'. The second slider is for 'Virt QLE8140 0:' and ranges from '0.00 Mbps' to '8.50 Gbps', with a current setting of '5.10 Gbps'. The third slider is for 'Virt QLE8140 1:' and ranges from '0.00 Mbps' to '8.50 Gbps', with a current setting of '3.40 Gbps'. At the bottom of the window, there are 'Save' and 'Cancel' buttons.

NPIV-based QoS configuration is a powerful feature, especially in virtualized environments such as VMware ESX and Microsoft Hyper-V. This capability provides QoS configuration on a per-virtual VM basis. Virtual ports can be associated with a VM, which in turn can be allocated a bandwidth percentage or absolute bandwidth (Gbps) based on the application needs of the VM.

3 CISCO NEXUS 5000

3.1 OVERVIEW

The Cisco Nexus 5000 switches are 10GbE-FCoE-DCB-capable access-layer switches that route FCoE and IP traffic and can bridge FC switch and storage infrastructure into FCoE/DCB host and network configurations. Cisco Nexus 5000 switches connect directly to native FCoE storage, as well as use optional FC expansion modules in the Cisco Nexus 5000 for connections to traditional FC storage.

This guide presents the proper operational configurations to configure a Cisco Nexus 5000 switch for pre-T11 FCoE standard and the T11 FCoE standard end systems. Configuration settings depend on which version of NXOS code is loaded and running on the Cisco Nexus 5000, and the type of CNA that is installed in the ENode and if it is running in pre-T11 standard to T11 FCoE standard FCoE Initialization Protocol (FIP) mode.

3.2 INITIAL CONFIGURATION

Configurations are shown using the switch CLI. Some configuration settings can also be set using the Cisco Device Manager GUI that comes with the switch.

Configurations are based on the network topology shown in Figure 1.

The Cisco NXOS release used in this paper is 5.0(2)N2(1). The basic steps for configuring FCoE are the same as for prior versions and this document can be used as a guide. However, 5.0(2)N2(1) does include some features not available in earlier versions and some steps may have minor changes. Please consult the Cisco Nexus documentation for your version of NXOS for specifics.

The Cisco Nexus 5000 series switch requires a console connected to the switch for the first time to apply the hostname and password for the new switch. The typical local console connection is 9600 8N1. After the initial setup script is complete, SSH, telnet, or the Cisco Device Manager GUI can be used to access the Cisco Nexus 5000 switch and complete the FCoE configuration.

Note: Text in bold depicts user-entered commands.

INITIAL SETUP SCRIPT

```
Enter the password for "admin": password
Confirm the password for "admin": password
    ---- Basic System Configuration Dialog ----
Would you like to enter the basic configuration dialog (yes/no): yes
Create another login account (yes/no) [n]: n
Configure read-only SNMP community string (yes/no) [n]:
Configure read-write SNMP community string (yes/no) [n]:
Enter the switch name : CISCO-N5K
Continue with Out-of-band (mgmt0) management configuration? (yes/no) [y]:
Mgmt0 IPv4 address : 10.61.179.31
Mgmt0 IPv4 netmask : 255.255.255.0
Configure the default gateway? (yes/no) [y]:
IPv4 address of the default gateway : 10.61.179.1
Enable the telnet service? (yes/no) [y]:
Enable the ssh service? (yes/no) [n]: y
Type of ssh key you would like to generate (dsa/rsa) : dsa
Number of key bits <768-2048> : 1024
Configure the ntp server? (yes/no) [n]:
Enter basic FC configurations (yes/no) [n]: y
Configure default physical FC switchport interface state (shut/noshut) [shut]:
Configure default physical FC switchport trunk mode (on/off/auto) [on]:
    Configure default zone policy (permit/deny) [deny]:
    Enable full zoneset distribution? (yes/no) [n]:
The following configuration will be applied:
switchname CISCO-N5K
interface mgmt0
ip address 10.61.179.31 255.255.255.0
no shutdown
exit
vrf context management
ip route 0.0.0.0/0 10.61.179.1
exit
telnet server enable
ssh key dsa 1024 force
ssh server enable
system default switchport shutdown
system default switchport trunk mode on
no system default zone default-zone permit
no system default zone distribute full
Would you like to edit the configuration? (yes/no) [n]: no
Use this configuration and save it? (yes/no) [y]: yes
```

```
[#####] 100%
```

Note: Key items in the preceding example were configured when the setup script was used. If the script is not used, you need to use the CLI to configure these key items.

SNMP MANAGEMENT

```
CISCO-N5K-A(config)# snmp-server user admin network-admin auth md5
0x2e54a976620cfd7ef00eb700ef78881f priv 0x2e54a976620cfd7ef00eb700ef78881f
localizedkey
```

VRF DEFAULT ROUTE FOR OOB MANAGEMENT NETWORK

```
CISCO-N5K-A(config)# vrf context management
CISCO-N5K-A(config)# ip route 0.0.0.0/0 10.61.179.1
```

3.3 LICENSE INSTALLATION

An FCoE license is required to keep FCoE enabled if running past the 90-day grace period.

```
CISCO-N5K-A# install license bootflash://license.lic
```

3.4 ENABLE FCOE

```
CISCO-N5K-A# show feature
```

Feature Name	Instance	State
-----	-----	-----
fcoe	1	disabled
fex	1	disabled
interface-vlan	1	disabled
lACP	1	disabled
lldp	1	enabled
private-vlan	1	disabled
sshServer	1	enabled
tacacs	1	disabled
telnetServer	1	disabled
udld	1	disabled
vpc	1	disabled
vtp	1	disabled

```
CISCO-N5K-A# configure terminal
```

```
CISCO-N5K-A(config)# feature fcoe
```

```
FC license checked out successfully
fc_plugin extracted successfully
FC plugin loaded successfully
FCoE manager enabled successfully
FC enabled on all modules successfully
```

```
CISCO-N5K-A(config)# end
```

```
CISCO-N5K-A# show feature
```

Feature Name	Instance	State
-----	-----	-----
cimserver	1	disabled
fabric-binding	1	disabled
fc-port-security	1	disabled

```

fcoe          1      enabled
fcsp          1      disabled
fex           1      disabled
fport-channel-trunk 1      disabled
http-server   1      disabled
interface-vlan 1      disabled
lacp          1      disabled
lldp          1      enabled
npiv          1      disabled
npv           1      disabled
port_track   1      disabled
private-vlan  1      disabled
sshServer     1      enabled
tacacs        1      disabled
telnetServer  1      disabled
udld          1      disabled
vpc           1      disabled
vtp           1      disabled

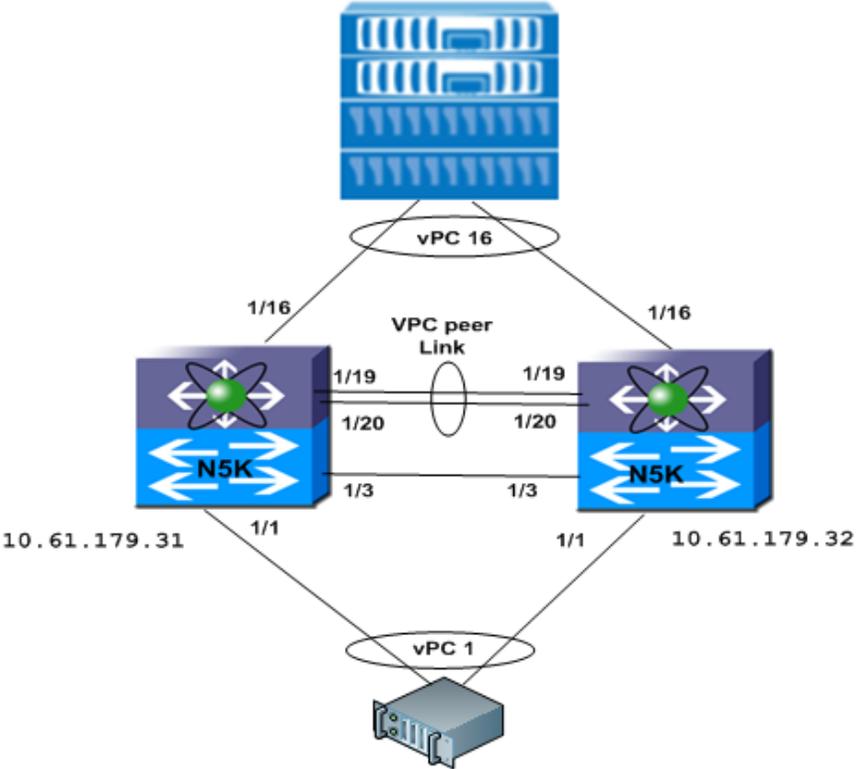
```

CISCO-N5K-A(config)# **show license usage**

Feature	Ins	Lic	Status	Expiry	Date	Comments
		Count				
FM_SERVER_PKG	Yes	-	Unused	Never		-
ENTERPRISE_PKG	Yes	-	Unused	Never		-
FC_FEATURES_PKG	Yes	-	In use	Never		-

3.5 VIRTUAL PORTCHANNELS

A virtual PortChannel (vPC) allows links on separate physical switches to be aggregated together as in a standard Etherchannel. The virtual PortChannel can be configured either as a static link aggregate (LAG) or as an 802.1AX-2008 (previously 802.3ad) LACP LAG. This allows the standard Ethernet traffic from the host or storage system to have redundancy, but also maintains separate A / B fabrics for the Fibre Channel environment.



ENABLE VPC AND LACP

The LACP feature must be enabled to use LACP-style PortChannels. LACP is recommended over static PortChannels due to improved link-state checking.

```
CISCO-N5K-A# feature lacp
CISCO-N5K-A# feature vpc
```

Repeat on the second vPC member switch.

CONFIGURE THE VPC PEER LINK

These commands set up the virtual PortChannel domain and peer links. Multiple peer links are recommended for redundancy.

Note: Determine that the vPC peer link is not configured to transport any VLANs associated with FCoE VSANs.

```
CISCO-N5K-A# vpc domain 1000
CISCO-N5K-A# peer-keepalive destination 10.61.179.32
CISCO-N5K-A# interface port-channel 100
CISCO-N5K-A# vpc peer-link

CISCO-N5K-A# interface Ethernet 1/19-20
CISCO-N5K-A# switchport mode trunk
CISCO-N5K-A# switchport trunk allowed vlan 1
CISCO-N5K-A# channel-group 100 mode active
```

Repeat on the second switch, using the appropriate IP address and Ethernet interfaces.

CREATE VPC MEMBER PORTS

Create a PortChannel for each host or storage array that utilizes virtual PortChannels. In this example the NetApp® storage array is connected to Ethernet port 1/16 on each Cisco Nexus switch and the QLogic CNA in the host is connected to Ethernet port 1/1 on each switch.

```
CISCO-N5K-A# interface port-channel 1
CISCO-N5K-A# vpc 1
CISCO-N5K-A# switchport mode trunk
CISCO-N5K-A# switchport trunk allowed vlan 1,1000
CISCO-N5K-A# no shut

CISCO-N5K-A# interface Ethernet 1/1
CISCO-N5K-A# switchport mode trunk
CISCO-N5K-A# channel-group 1 mode active

CISCO-N5K-A# interface port-channel 16
CISCO-N5K-A# vpc 16
CISCO-N5K-A# switchport mode trunk
CISCO-N5K-A# switchport trunk allowed vlan 1,1000
CISCO-N5K-A# no shut

CISCO-N5K-A# interface Ethernet 1/16
CISCO-N5K-A# switchmode trunk
CISCO-N5K-A# channel-group 16 mode active
```

Create member ports on the vPC peer switch, determining that the configured vPC number is the same for both legs of a host's adapter.

Note: The FCoE VLAN and VSAN must be different on each vPC member switch. See the following sections on FCoE VSAN and VLAN mapping for examples.

3.6 CREATE VSAN

As noted in section 3.5, if using virtual PortChannels, each member switch must be configured with unique VLAN and VSAN IDs. We will use VLAN and VSAN 1000 for the switch CISCO-N5K-A and 1001 for the CISCO-N5K-B. In further sections we show examples from only one switch. Just remember that the other switch in the vPC pair must be configured correspondingly.

CREATE VSAN ON SWITCH A

```
CISCO-N5K-A# show vsan

vsan 1 information
  name:VSAN0001 state:active
  interoperability mode:default
  loadbalancing:src-id/dst-id/oxid
  operational state:down

vsan 4079:evfp_isolated_vsan

vsan 4094:isolated_vsan

CISCO-N5K-A# configure terminal

CISCO-N5K-A(config)# vsan database

CISCO-N5K-A(config-vsan-db)# vsan 1000

CISCO-N5K-A(config-vsan-db)# end

CISCO-N5K-A# show vsan

vsan 1 information
  name:VSAN0001 state:active
  interoperability mode:default
  loadbalancing:src-id/dst-id/oxid
  operational state:down

vsan 1000 information
  name:VSAN1000 state:active
  interoperability mode:default
  loadbalancing:src-id/dst-id/oxid
  operational state:down

vsan 4079:evfp_isolated_vsan

vsan 4094:isolated_vsan
```

CREATE VSAN ON SWITCH B

```
CISCO-N5K-B# show vsan

vsan 1 information
  name:VSAN0001 state:active
  interoperability mode:default
  loadbalancing:src-id/dst-id/oxid
  operational state:down

vsan 4079:evfp_isolated_vsan

vsan 4094:isolated_vsan

CISCO-N5K-B# configure terminal
```

```

CISCO-N5K-B(config)# vsan database
CISCO-N5K-B(config-vsan-db)# vsan 1001
CISCO-N5K-B(config-vsan-db)# end
CISCO-N5K-B# show vsan

vsan 1 information
  name:VSAN0001  state:active
  interoperability mode:default
  loadbalancing:src-id/dst-id/oxid
  operational state:down

vsan 1000 information
  name:VSAN1001  state:active
  interoperability mode:default
  loadbalancing:src-id/dst-id/oxid
  operational state:down

vsan 4079:evfp_isolated_vsan

vsan 4094:isolated_vsan

```

3.7 CREATE VLAN AND MAP TO VSAN

Note: VLAN and VSAN do not have to use the same identifying number, but using the same identifying number improves manageability.

CREATE VLAN ON SWITCH A

```

CISCO-N5K-A# show vlan

VLAN Name                Status    Ports
-----
1    default                active    Eth1/1, Eth1/2, Eth1/3, Eth1/4
Eth1/5, Eth1/6, Eth1/7, Eth1/8
Eth1/9, Eth1/10, Eth1/11
Eth1/12, Eth1/13, Eth1/14
Eth1/15, Eth1/16, Eth1/17
Eth1/18, Eth1/19, Eth1/20

Remote SPAN VLANs
-----

Primary  Secondary  Type          Ports
-----
CISCO-N5K-A# configure terminal
CISCO-N5K-A(config)# vlan 1000
CISCO-N5K-A(config-vlan)# fcoe vsan 1000
CISCO-N5K-A(config-vlan)# end
CISCO-N5K-A# show vlan

VLAN Name                Status    Ports
-----

```

```

1      default                active  Eth1/1, Eth1/2, Eth1/3, Eth1/4
                                           Eth1/5, Eth1/6, Eth1/7, Eth1/8
                                           Eth1/9, Eth1/10, Eth1/11
                                           Eth1/12, Eth1/13, Eth1/14
                                           Eth1/15, Eth1/16, Eth1/17
                                           Eth1/18, Eth1/19, Eth1/20

1000  VLAN1000              active
VLAN Name                Status      Ports
-----
Remote SPAN VLANs
-----

Primary  Secondary  Type          Ports
-----
CISCO-N5K-A# show vlan fcoe

VLAN      VSAN      Status
-----
1000      1000      Operational

```

CREATE VLAN ON SWITCH B

```

CISCO-N5K-B# show vlan

VLAN Name                Status      Ports
-----
1      default                active  Eth1/1, Eth1/2, Eth1/3, Eth1/4
                                           Eth1/5, Eth1/6, Eth1/7, Eth1/8
                                           Eth1/9, Eth1/10, Eth1/11
                                           Eth1/12, Eth1/13, Eth1/14
                                           Eth1/15, Eth1/16, Eth1/17
                                           Eth1/18, Eth1/19, Eth1/20

Remote SPAN VLANs
-----

Primary  Secondary  Type          Ports
-----
CISCO-N5K-B# configure terminal

CISCO-N5K-B(config)# vlan 1001

CISCO-N5K-B(config-vlan)# fcoe vsan 1001

CISCO-N5K-B(config-vlan)# end

CISCO-N5K-B# show vlan

VLAN Name                Status      Ports
-----
1      default                active  Eth1/1, Eth1/2, Eth1/3, Eth1/4
                                           Eth1/5, Eth1/6, Eth1/7, Eth1/8
                                           Eth1/9, Eth1/10, Eth1/11
                                           Eth1/12, Eth1/13, Eth1/14
                                           Eth1/15, Eth1/16, Eth1/17
                                           Eth1/18, Eth1/19, Eth1/20

1001  VLAN1001              active
VLAN Name                Status      Ports
-----

```

```
-----  
Remote SPAN VLANs  
-----
```

```
Primary   Secondary   Type           Ports  
-----  
-----
```

```
CISCO-N5K-B# show vlan fcoe
```

```
VLAN      VSAN      Status  
-----  
1001     1001     Operational
```

3.8 CREATE VFC FOR INITIATOR

Note: A virtual Fibre Channel (vFC) port can be bound to a specific Ethernet port, and this is done when a vPC is not in the design. A virtual Fibre Channel port can be bound to a specific World Wide Port Name (WWPN) when a FIP snooping bridge is attached. In the case of a vPC we are binding to a PortChannel as a requirement for vPC and LACP to work with the CNA. The vFC number does not have to match the physical port number, but doing so improves manageability.

```
CISCO-N5K-A# configure terminal  
CISCO-N5K-A(config)# interface vfc 1  
CISCO-N5K-A(config-if)# bind interface ethernet port-channel 1  
CISCO-N5K-A(config-if)# end
```

3.9 CREATE VFC FOR TARGET

```
CISCO-N5K-A# configure terminal  
CISCO-N5K-A(config)# interface vfc 16  
CISCO-N5K-A(config-if)# bind interface ethernet port-channel 16  
CISCO-N5K-A(config-if)# end
```

3.10 ADD VFCS TO VSAN

Note: If you have FC interfaces that communicate with these FCoE interfaces, add them to the VSAN as well.

```
CISCO-N5K-A# configure terminal  
CISCO-N5K-A(config)# vsan database  
CISCO-N5K-A(config-vsan-db)# vsan 1000 interface vfc 1  
CISCO-N5K-A(config-vsan-db)# vsan 1000 interface vfc 16  
CISCO-N5K-A(config-vsan-db)# end  
CISCO-N5K-A# show vsan membership  
vsan 1 interfaces:  
    fc2/1           fc2/2           fc2/3           fc2/4
```

```
fc2/5          fc2/6          fc2/7          fc2/8
vsan 1000 interfaces:
  vfc1          vfc16
vsan 4079(evfp_isolated_vsan) interfaces:
vsan 4094(isolated_vsan) interfaces:
```

3.11 CREATE ZONESETS AND ZONES

```
CISCO-N5K-A# configure terminal

CISCO-N5K-A(config)# show flogi database vsan 1000
-----
INTERFACE          VSAN    FCID          PORT NAME          NODE NAME
-----
vfc1                1000    0x470000     21:00:00:c0:dd:12:04:cf  20:00:00:c0:dd:12:04:cf
vfc16               1000    0x470001     50:0a:09:85:89:8b:4f:5c  50:0a:09:80:89:8b:4f:5c

Total number of flogi = 2.

CISCO-N5K-A(config)# show fcns database vsan 1000

VSAN 1000:
-----
FCID      TYPE  PWWN          (VENDOR)          FC4-TYPE:FEATURE
-----
0x470000  N     21:00:00:c0:dd:12:04:cf (Qlogic)          scsi-fcp:init
0x470001  N     50:0a:09:85:89:8b:4f:5c (NetApp)          scsi-fcp:target

Total number of entries = 2

CISCO-N5K-A(config)# zone name fcoezone1 vsan 1000

CISCO-N5K-A(config-zone)# member pwn 21:00:00:c0:dd:12:04:cf

CISCO-N5K-A(config-zone)# member pwn 50:0a:09:85:89:8b:4f:5c
CISCO-N5K-A(config-zone)# zoneset name fcoe vsan 1000

CISCO-N5K-A(config-zoneset)# zone name fcoezone1

CISCO-N5K-A(config-zoneset-zone)# zoneset activate name fcoe vsan 1000

Zoneset activation initiated. check zone status

CISCO-N5K-A(config)# end

CISCO-N5K-A# show zoneset active vsan 1000

zoneset name fcoe vsan 1000
  zone name fcoezone1 vsan 1000
  * fcid 0x470000 [pwn 10:00:00:00:c9:9c:6c:93]
  * fcid 0x470001 [pwn 50:0a:09:85:89:8b:4f:5c]
```

Note: Repeat steps 3.8, 3.9, 3.10, and 3.11 on both Cisco Nexus switches in the vPC configuration.

3.12 DATA CENTER BRIDGING AND FCOE INITIALIZATION PROTOCOL

DCBX protocol is used to signal the following link-level parameters:

- QoS parameters (like per-priority pause, scheduling parameters, maximum transmission unit [MTU])
- FCoE CoS: 802.1p value to be used for FCoE frames
- Ethernet logical link state up/down

FIP frames are used to perform the following actions:

- FIP VLAN discovery
- FIP discovery

- FCoE virtual link instantiation
- FCoE virtual link maintenance

DCB PROTOCOL

The DCBX protocol provides a set of exchanges to accept operational parameters from the switch in the form of TLV messages. These messages can be viewed in the QLogic management software and from the Cisco Nexus 5000 switch.

```
CISCO-N5K-A# sh lldp dcbx interface ethernet 1/1

Local DCBXP Control information:
Operation version: 00 Max version: 00 Seq no: 2 Ack no: 1
Type/
Subtype   Version   En/Will/Adv Config
003/000   000      Y/N/Y     0808
004/000   000      Y/N/Y     8906001b21 08
002/000   000      Y/N/Y     0001000014 50000000 00000002

Peer's DCBXP Control information:
Operation version: 00 Max version: 00 Seq no: 1 Ack no: 2
Type/      Max/Oper
Subtype   Version   En/Will/Err Config
002/000   000/000   Y/Y/N     0001000032 32000000 00000002
003/000   000/000   Y/Y/N     0808
004/000   000/000   Y/Y/N     8906001b21 08
```

FCOE INITIALIZATION PROTOCOL

At completion of the Link Layer Discovery Protocol (LLDP) DCB exchange, the FIP does a discovery to determine the location of the Cisco Nexus switch on the network. Log in and get a fabric-assigned address, then determine the FCoE VLAN ID. After Fibre Channel ID (FCID) is known, the CNA can port login to the name server and you can then see the host in the name server to zone.

Table 1) Ethernet frames sent during FCoE initialization protocol.

Source	Destination	Protocol	Description of Frame	VLAN
NetApp MAC address	LLDP multicast	LLDP	LLDP Advertisement	
Cisco MAC address	LLDP multicast	LLDP	LLDP Advertisement	
NetApp ENode MAC	All-FCF-MACs multicast	FIP	FIP VLAN Request	
Cisco ENode MAC	NetApp ENode MAC	FIP	FIP VLAN Notification	
NetApp ENode MAC	All-FCF-MACs multicast	FIP	FIP Discovery Solicitation	101
NetApp ENode MAC	NetApp ENode MAC	FIP	FIP Discovery Advertisement	101
NetApp ENode MAC	Cisco ENode MAC	FIP	Virtual Link Instantiation Request (FLOGI)	101
Cisco ENode MAC	NetApp FPMA	FIP	Virtual Link Instantiation Reply (Accept FLOGI)	101
NetApp FPMA	Cisco ENode MAC	FC	PLOGI	101
Cisco ENode MAC	NetApp FPMA	FC	Accept PLOGI	101

CONFIGURING FCOE OPTIONS ON CISCO NEXUS 5000 SWITCH

The `show fcoe` command presents you with several parameters that can be changed as required. Parameter changes from default are not needed in the direct connect topology because this configuration addresses FCoE-specific parameters.

```
CISCO-N5K-A# show fcoe
Global FCF details
    FCF-MAC is 00:0d:ec:a4:02:80
    FC-MAP is 0e:fc:00 (configurable in the switch)
    FCF Priority is 128 (configurable in the switch)
    FKA Advertisement period for FCF is 8 seconds (configurable in the switch)
CISCO-N5K-A(config)# fcoe fcmmap ?
<0xefc00-0xefcff> Enter FCMAP
CISCO-N5K-A(config)# fcoe fcf-priority ?
<0-255> Enter FCF priority
CISCO-N5K-A(config)# fcoe fka-adv-period ?
<4-60> Enter FKA Advertisement Period
```

3.13 QOS

FCOE SYSTEM CLASS

All FC and FCoE control and data traffic is automatically classified into the FCoE system class, which provides a no-drop service. On the Cisco Nexus 5010 and 5020 this class is created automatically when the system starts up (the class is named `class-fcoe` in the CLI). You cannot delete this class and you can only modify the IEEE 802.1p CoS value to associate with this class. This class is identified by `qos-group 1`. The switch classifies packets into the FCoE system class as follows:

- FCoE traffic is classified based on EtherType.
- Native FC traffic is classified based on the physical interface type.

On the Cisco Nexus 5548, `class-fcoe` must be created after enabling feature `fcoe`. This is done with the following commands.

```
NEXUS-5548# configure terminal
NEXUS-5548(config)# system qos
NEXUS-5548(config-sys-qos)# service-policy type qos input fcoe-default-in-policy
NEXUS-5548(config-sys-qos)# service-policy type queuing input fcoe-default-in-policy
NEXUS-5548(config-sys-qos)# service-policy type queuing output fcoe-default-out-policy
NEXUS-5548(config-sys-qos)# service-policy type network-qos fcoe-default-nq-policy
NEXUS-5548(config-sys-qos)# end
```

MTU

MTU is specified per system class. You cannot configure MTU on the interfaces.

FCoE MTU is 2,158 bytes across the switch. As a result, the `rxbufsize` for FC interfaces is fixed at 2,158 bytes. If the Cisco Nexus 5000 Series switch receives an `rxbufsize` from a peer different than 2,158 bytes, it fails the Fibre Channel Exchange Link Parameters (ELP) negotiation and does not bring up the link. This is the standard size for FCoE and it cannot be modified.

For non-FCoE traffic, system MTU size can be configured by setting the class-default network QoS policy map. Details are in the [Cisco Nexus 5000 Series NX-OS Quality of Service Configuration Guide](#).

ETS AND PFC CONFIGURATION

Note: Bandwidth allocation for FCoE and default traffic should be set based on your environment and application needs. The values below are an example only.

```
CISCO-N5K-A# show policy-map
```

```
Type qos policy-maps  
=====
```

```
policy-map type qos default-in-policy  
  class type qos class-fcoe  
    set qos-group 1  
  class type qos class-default  
    set qos-group 0
```

```
Type queuing policy-maps  
=====
```

```
policy-map type queuing default-in-policy  
  class type queuing class-fcoe  
    bandwidth percent 50  
  class type queuing class-default  
    bandwidth percent 50  
policy-map type queuing default-out-policy  
  class type queuing class-fcoe  
    bandwidth percent 50  
  class type queuing class-default  
    bandwidth percent 50
```

```
Type network-qos policy-maps  
=====
```

```
policy-map type network-qos default-nq-policy  
  class type network-qos class-fcoe  
    pause no-drop  
    mtu 2158  
  class type network-qos class-default  
    mtu 1500
```

```
CISCO-N5K-A# configure terminal
```

```
CISCO-N5K-A(config)# policy-map type queuing fcoe-80
```

```
CISCO-N5K-A(config-pmap-que)# class type queuing class-fcoe
```

```
CISCO-N5K-A(config-pmap-c-que)# bandwidth percent 80
```

```
CISCO-N5K-A(config-pmap-c-que)# class type queuing class-default
```

```
CISCO-N5K-A(config-pmap-c-que)# bandwidth percent 20
```

```
CISCO-N5K-A(config-pmap-c-que)# exit
```

```
CISCO-N5K-A(config-pmap-que)# exit
```

```
CISCO-N5K-A(config)# system qos
```

```
CISCO-N5K-A(config-sys-qos)# service-policy type queuing input fcoe-80
```

```
CISCO-N5K-A(config-sys-qos)# service-policy type queuing output fcoe-80
```

```
CISCO-N5K-A(config-sys-qos)# end
```

```
CISCO-N5K-A# show policy-map system
```

```

Type network-qos policy-maps
=====

policy-map type network-qos default-nq-policy
  class type network-qos class-fcoe      match qos-group 1
    pause no-drop
    mtu 2158
  class type network-qos class-default    match qos-group 0
    mtu 1500

Service-policy (qos) input:  default-in-policy
policy statistics status:  enabled

Class-map (qos):  class-fcoe (match-any)
  Match: cos 3
  set qos-group 1

Class-map (qos):  class-default (match-any)
  Match: any
  set qos-group 0

Service-policy (queuing) input:  fcoe-80
policy statistics status:  disabled

Class-map (queuing):  class-fcoe (match-any)
  Match: qos-group 1
  bandwidth percent 80

Class-map (queuing):  class-default (match-any)
  Match: qos-group 0
  bandwidth percent 20

Service-policy (queuing) output:  fcoe-80
policy statistics status:  disabled

Class-map (queuing):  class-fcoe (match-any)
  Match: qos-group 1
  bandwidth percent 80

Class-map (queuing):  class-default (match-any)
  Match: qos-group 0
  bandwidth percent 20

```

4 NETAPP UNIFIED CONNECT

4.1 OVERVIEW

FCoE extends Fibre Channel into the Ethernet environment by combining two leading technologies, the FC protocol and Ethernet, to provide more options for SAN connectivity and networking. NetApp has improved upon its leadership position in unified storage as the first storage vendor to support FCoE. FCoE is a logical progression in the NetApp unified storage approach of offering FC, iSCSI, and NAS in its enterprise systems and provides an evolutionary path for FC SAN customers to migrate over time to an Ethernet-based infrastructure. NetApp's ability to support FCoE, iSCSI, NFS, and CIFS concurrently over a shared 10GbE port is called Unified Connect.

4.2 FCOE TARGET AND UNIFIED CONNECT REQUIREMENTS

Starting with Data ONTAP® 7.3.2, FCoE is available through our Unified Target Adapters (UTAs) in the Data ONTAP 7.3 family. In Data ONTAP 8.0.1 and later, FCoE and all other Ethernet protocols normally available from NetApp storage (CIFS, NFS, iSCSI, and so on) are supported concurrently. The FC protocol license is required for FCoE functionality. For other protocols, the relevant license is required. When a UTA is installed in a NetApp storage controller running Data ONTAP 8.0.1, a dual-port 10Gb/s network interface card (NIC) and a 10Gb/s FCoE target adapter are presented for each UTA installed in the controller. See the sysconfig output in section 4.4 below for an example. This is the same way that a CNA is presented on the host.

The UTA is supported on all current platforms that have a PCIe expansion slot. See the [System Configuration Guide](#) for details on the number of cards supported on a particular platform.

4.3 HOST AND STORAGE SYSTEM CONFIGURATION

Configuration of the FCoE side of the Unified Target Adapter in Data ONTAP is the same as it is for a traditional Fibre Channel target adapter. The storage controller determines the appropriate DCB settings and VLAN to use for FCoE from the upstream FCF with no user involvement needed. See section 3.13 for details on FCoE link configuration.

From that point, igroups can be created with the hosts' initiator WWPNs, and LUNs can be mapped to the igroups the same way as with traditional FC. An igroup can even include a mixture of traditional FC and FCoE initiator WWPNs if the host or cluster has both. Also, a host (FC or FCoE) can connect to a LUN presented on the NetApp storage controller over both the storage controller's FC and FCoE ports. These options can be useful when migrating from a traditional FC environment to an FCoE environment.

See the [Fibre Channel and iSCSI Configuration Guide](#) for details and examples of different supported connectivity options. For explicit instructions on creating LUNs and igroups, please see the [Block Access Management Guide for iSCSI and FC](#) for your version of Data ONTAP.

NetApp also provides a set of software programs and documentation that enable host operating systems to be connected to NetApp storage systems called host utilities.

The host utilities include the following components:

- An installation program that sets required parameters on the host computer and CNA or HBA
- Diagnostic programs for displaying important information about the host, CNAs, FCoE and FC switches, and storage systems in the network

Before installing the host utilities, verify that the host utilities version supports the host and storage system configuration. The NetApp [Interoperability Matrix Tool](#) (IMT) lists all supported configurations. For x86 and x86-64 industry-standard hosts, individual computer models are not listed. Instead, hosts are qualified based on the CPU architecture. The following configuration items must be verified:

- Host CPU architecture
- Operating system version, service pack level, and required hotfixes
- FC/FCoE switch model and firmware version
- Multipathing software
- Data ONTAP version
- Software such as SnapDrive® for Windows

There are also important notes and warnings for many configurations listed in the IMT that we found through our certification testing. Please take the time to read these when they apply to your configuration. They will be called out as a hyperlink in the IMT row of your configuration.

Specific host and storage system configuration steps can be found in the host utilities [Installation and Administration Guides](#) and the [Data ONTAP Block Access Management Guide for iSCSI and FC](#) for your version of Data ONTAP.

4.4 TROUBLESHOOTING COMMANDS

Use the `sysconfig -v` command to verify that the Unified Target Adapter is installed properly in the NetApp storage controller and to see details such as SFP+ module type and speeds, WWPN, and WWNN. In the following example, the slot in which the card is installed was specified to limit the output.

```
NETAPP> sysconfig -v 2
slot 2: Dual 10G Ethernet Controller CNA SFP+
        (Dual-port, QLogic CNA 8112(8152) rev. 2)
e2a MAC Address: 00:c0:dd:12:0e:28 (auto-10g_twinax-fd-up)
e2b MAC Address: 00:c0:dd:12:0e:2a (auto-10g_twinax-fd-up)
Device Type:    ISP8112
slot 2: Fibre Channel Target Host Adapter 2a
        (Dual-channel, QLogic CNA 8112 (8152) rev. 2, <ONLINE>)
Firmware rev: 5.3.4
Host Port Addr: 000000
Cacheline size: 16
SRAM parity: Yes
FC Nodename: 50:0a:09:80:89:8b:4f:5c (500a0980898b4f5c)
FC Portname: 50:0a:09:84:89:8b:4f:5c (500a0984898b4f5c)
Connection: No link
SFP Vendor Name: XXXXXX
SFP Vendor P/N: 00-0000
SFP Vendor Rev: A
SFP Serial No.: ABC1234567890
SFP Connector: Passive Copper
SFP Capabilities: 1, 2, 4, 8, 10 Gbit
slot 2: Fibre Channel Target Host Adapter 2b
        (Dual-channel, QLogic CNA 8112 (8152) rev. 2, <ONLINE>)
Firmware rev: 5.3.4
Host Port Addr: 000000
Cacheline size: 16
SRAM parity: Yes
FC Nodename: 50:0a:09:80:89:8b:4f:5c (500a0980898b4f5c)
FC Portname: 50:0a:09:85:89:8b:4f:5c (500a0985898b4f5c)
Connection: No link
SFP Vendor Name: XXXXXX
SFP Vendor P/N: 00-0000
SFP Vendor Rev: A
SFP Serial No.: ABC1234567890
SFP Connector: Passive Copper
SFP Capabilities: 1, 2, 4, 8, 10 Gbit/Sec
```

There are two logical devices on this dual-port UTA:

- A dual-port 10Gb Ethernet NIC with ports e2a and e2b
- A dual-port 10Gb FCoE target adapter with ports 2a and 2b

Physical ports A and B on the UTA act as both standard 10Gb NIC ports and FCoE target ports.

Two new commands in Data ONTAP 8.0.1 are `dcb show` and `dcb priority show`. These display the current QoS configurations obtained from the switch during the DCB exchange. The output below shows what one would see after configuring the switch queuing policies as in the example in section 3.13.

```

NETAPP> dcb show
Interface  PGID  Priority          Application          Bandwidth
-----  -
e2a
          0    0 1 2 4 5 6 7    unassigned          20%
          1    3                FCoE                 80%
e2b
          0    0 1 2 4 5 6 7    unassigned          20%
          1    3                FCoE                 80%

NETAPP> dcb priority show
Interface  Priority PGID Flow Control      Application
-----  -
e2a
          0    0  disabled          unassigned
          1    0  disabled          unassigned
          2    0  disabled          unassigned
          3    1  enabled           FCoE
          4    0  disabled          unassigned
          5    0  disabled          unassigned
          6    0  disabled          unassigned
          7    0  disabled          unassigned
e2b
          0    0  disabled          unassigned
          1    0  disabled          unassigned
          2    0  disabled          unassigned
          3    1  enabled           FCoE
          4    0  disabled          unassigned
          5    0  disabled          unassigned
          6    0  disabled          unassigned
          7    0  disabled          unassigned

```

For details on DCB features, see [TR-3888: Unified Connect Overview and Best Practices](#).

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