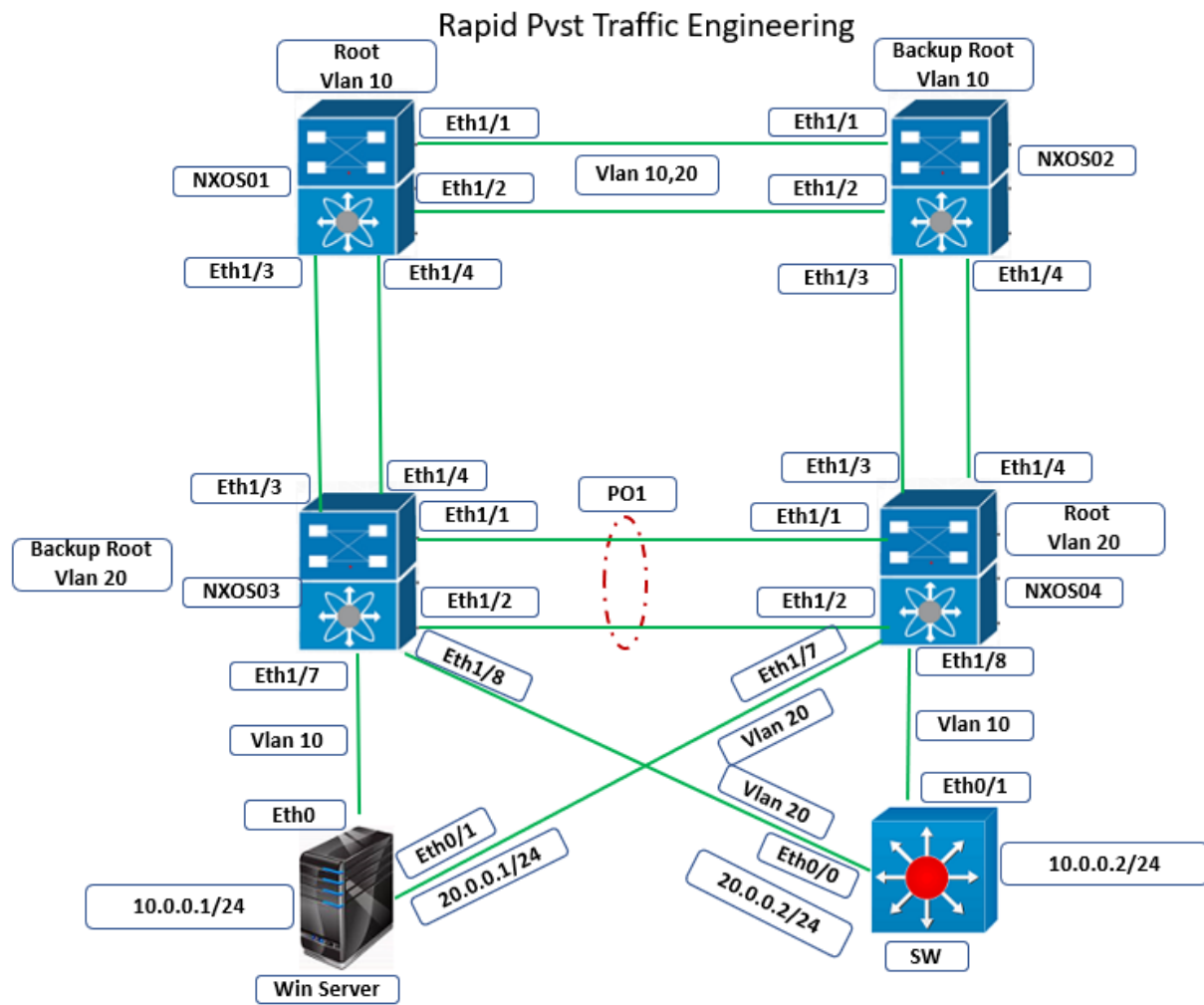


## Rapid PVST Traffic Engineering

Platform: <https://racks.uninets.com>

Lab Name: CCIE DC

### Topology



### Task

- Erase the previous configuration on switches NXOS01, NXOS02, NXOS03 and NXOS04 using command "write erase" and reload both switches, assign hostname the same hostname to both switches. Use provisioning documents if required

- Configure all links connecting NXOS01, NXOS02, NXOS03, and NXOS04 as 802.1Q trunk ports.
- Configure the links connecting NXOS03 and NXOS04 as a port channel 1.
- Create VLANs 10 and 20 on all switches, and assign them as follows:
  - Win Server's link to NXOS03 should be in VLAN 10 and use the IP address 10.0.0.1/24.
  - Win Server's link to NXOS04 should be in VLAN 20 and use the IP address 20.0.0.1/24.
  - SW's link to NXOS03 should be in VLAN 20 and use the IP address 20.0.0.2/24.
  - SW's link to NXOS04 should be in VLAN 10 and use the IP address 10.0.0.2/24.
- Configure Spanning-Tree Protocol between the switches as follows:
  - All switches should use 32 bits for spanning-tree port path costs.
  - NXOS01 should be the STP Root Bridge for VLAN 10, with NXOS02 being the backup Root Bridge.
  - NXOS04 should be the STP Root Bridge for VLAN 20, with NXOS03 being the backup Root Bridge.
  - Win Server's VLAN 10 traffic to SW should follow the path of NXOS03 ->NXOS02 ->NXOS01 ->NXOS04 ->SW.
  - SW's VLAN 20 traffic to Win Server should follow the path of NXOS03 ->NXOS01 ->NXOS02 ->NXOS04 -> Server 1.
- Keep saving your configuration using command "copy run start"

## Configuration

### NXOS03:

```

!
vlan 10,20
!
spanning-tree pathcost method long
!
spanning-tree vlan 20 priority 8192
!
interface Ethernet1/1-2
  switchport
  switchport mode trunk
  channel-group 1
  no shutdown
!
interface port-channel1
  switchport mode trunk
  spanning-tree vlan 10,20 cost 99999
!
interface Ethernet1/3-4

```

```
switchport
switchport mode trunk
 spanning-tree vlan 10 cost 99999
 no shutdown
!
interface Ethernet1/5-6
 switchport
 switchport mode trunk
 spanning-tree vlan 20 cost 99999
 no shutdown
!
interface Ethernet1/7
 switchport
 switchport access vlan 10
 no shutdown
!
interface Ethernet1/8
 switchport
 switchport access vlan 20
 no shutdown
!
```

#### **NXOS04:**

```
!
vlan 10,20
!
spanning-tree pathcost method long
!
spanning-tree vlan 20 priority 4096
!
interface Ethernet1/1-2
 switchport
 switchport mode trunk
 channel-group 1
 no shutdown
!
interface port-channel1
 switchport mode trunk
!
interface Ethernet1/3-6
 switchport
 switchport mode trunk
 no shutdown
!
interface Ethernet1/7
```

```
switchport
switchport access vlan 20
no shutdown
!
interface Ethernet1/8
switchport
switchport access vlan 10
no shutdown
!
```

#### **NXOS01:**

```
vlan 10,20
!
spanning-tree pathcost method long
!
spanning-tree vlan 10 priority 4096
!
interface Ethernet1/1-2
switchport
switchport mode trunk
no shutdown
!
interface Ethernet1/3-4
switchport
switchport mode trunk
spanning-tree vlan 10 cost 99999
no shutdown
!
interface Ethernet1/5-6
switchport
switchport mode trunk
spanning-tree vlan 20 cost 99999
no shutdown
!
```

#### **NXOS02:**

```
!
vlan 10,20
!
spanning-tree pathcost method long
!
spanning-tree vlan 10 priority 8192
!
interface Ethernet1/1-6
 switchport
 switchport mode trunk
 no shutdown
!
```

### SW:

```
!
hostname SW
!
Interface Eth0/0
 no switchport
 ip address 20.0.0.2 255.255.255.0
 no shutdown
!
Interface Eth0/1
 no switchport
 ip address 10.0.0.2 255.255.255.0
 no shutdown
!
```

### Verification

Assign IP addresses to Win Server on its both interfaces

```

Ethernet adapter Local Area Connection 2:

    Connection-specific DNS Suffix . . . . . : 
    Link-local IPv6 Address . . . . . : fe80::b025:5e78:99fa:be03%13
    IPv4 Address. . . . . : 20.0.0.1
    Subnet Mask . . . . . : 255.255.255.0
    Default Gateway . . . . . : 

Ethernet adapter Local Area Connection:

    Connection-specific DNS Suffix . . . . . : 
    Link-local IPv6 Address . . . . . : fe80::ec0d:b4cd:88d3:d93%11
    IPv4 Address. . . . . : 10.0.0.1
    Subnet Mask . . . . . : 255.255.255.0
    Default Gateway . . . . . : 

```

Notice the Mac address of both the interfaces on Win Server interfaces. Marked in yellow.

```

Ethernet adapter Local Area Connection:

    Connection-specific DNS Suffix . . . . . : 
    Description . . . . . : Intel(R) PRO/1000 MT Network Connection
    Physical Address. . . . . : 50-00-00-05-00-00
    DHCP Enabled. . . . . : No
    Autoconfiguration Enabled . . . . . : Yes
    Link-local IPv6 Address . . . . . : fe80::ec0d:b4cd:88d3:d93%11(Preferred)
    IPv4 Address. . . . . : 10.0.0.1(Preferred)
    Subnet Mask . . . . . : 255.255.255.0
    Default Gateway . . . . . : 
    DHCPv6 IAID . . . . . : 240123904
    DHCPv6 Client DUID. . . . . : 00-01-00-01-22-AD-F2-29-50-00-00-08-00-00

```

```

Ethernet adapter Local Area Connection 2:

    Connection-specific DNS Suffix . . . . . : 
    Description . . . . . : Intel(R) PRO/1000 MT Network Connection
    Physical Address. . . . . : 50-00-00-05-00-01
    DHCP Enabled. . . . . : No
    Autoconfiguration Enabled . . . . . : Yes
    Link-local IPv6 Address . . . . . : fe80::b025:5e78:99fa:be03%13(Preferred)
    IPv4 Address. . . . . : 20.0.0.1(Preferred)
    Subnet Mask . . . . . : 255.255.255.0
    Default Gateway . . . . . : 

```

Notice the Mac addresses on SW interfaces

```

SW#show interfaces eth0/0
Ethernet0/0 is up, line protocol is up (connected)
Hardware is Ethernet, address is aabb.cc00.6000 (bia aabb.cc00.6000)
Internet address is 20.0.0.2/24

```

```

SW#show interfaces eth0/1
Ethernet0/1 is up, line protocol is up (connected)
Hardware is Ethernet, address is aabb.cc00.6010 (bia aabb.cc00.6010)

```

NX-OS runs Rapid Per-VLAN Spanning-Tree Protocol by default. This means that for each VLAN that is created, a separate instance of STP is created, with each of these running the 802.1w RSTP algorithm. Beyond this, the default behavior of STP on NX-OS is essentially identical to that of Catalyst IOS.

For the purposes of traffic engineering, the Root Bridge election can be modified on a per-VLAN basis by changing the STP Bridge-ID Priority value (lower is preferred), and the Root Port election can be modified on a per-port per-VLAN basis by changing either the STP Port Cost or STP Port Priority. Changing the Port Cost is the more common modification, as the Port Priority only comes into play when you are choosing between multiple links with the same Root Path Cost, and the links connect to the same upstream switch.

Note that in this example the range of STP cost values was increased from a 16-bit field to a 32-bit field (the long path cost method), as newer higher-speed links such as 10GigE, 40GigE, 100GigE, and beyond start to look the same from a cost point of view when the default short path cost method is used. Also note that this command is applicable only when running Rapid PVST on NX-OS, as Multiple Spanning-Tree (MST) always uses the longer path cost length.

Verification of this task can be performed by viewing the Root Bridge and Root Port election on a per-switch basis, or by viewing the MAC address table, as the STP topology ultimately controls which interfaces can participate in MAC address learning. Below we see that for VLAN 10, NXOS01 is elected the Root Bridge. This implies that all of its VLAN 10 links will be Designated ports in the Forwarding state.

```
NXOS01# show spanning-tree vlan 10

VLAN0010
Spanning tree enabled protocol rstp
Root ID Priority 4106
Address 5000.0001.0007
This bridge is the root
Hello Time 2 sec Max Age 20 sec Forward Delay 15 sec

Bridge ID Priority 4106 (priority 4096 sys-id-ext 10)
Address 5000.0001.0007
Hello Time 2 sec Max Age 20 sec Forward Delay 15 sec

Interface Role Sts Cost Prio.Nbr Type
-----
Eth1/1 Desg FWD 20000 128.1 P2p
Eth1/2 Desg FWD 20000 128.2 P2p
Eth1/3 Desg FWD 99999 128.3 P2p
Eth1/4 Desg FWD 99999 128.4 P2p
```

```
Eth1/5      Desg FWD 20000  128.5  P2p
Eth1/6      Desg FWD 20000  128.6  P2p
```

Try to send PING traffic from SW to Win Server or vice versa. In case traffic dies out, use continuous ping to generate traffic.

```
SW#ping 10.0.0.1
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 10.0.0.1, timeout is 2 seconds:
.!!!!
Success rate is 80 percent (4/5), round-trip min/avg/max = 21/24/31 ms
SW#ping 20.0.0.1
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 20.0.0.1, timeout is 2 seconds:
.!!!!
Success rate is 80 percent (4/5), round-trip min/avg/max = 26/30/36 ms
```

```
C:\Users\Administrator>ping 10.0.0.2

Pinging 10.0.0.2 with 32 bytes of data:
Reply from 10.0.0.2: bytes=32 time=62ms TTL=255
Reply from 10.0.0.2: bytes=32 time=24ms TTL=255
Reply from 10.0.0.2: bytes=32 time=22ms TTL=255
Reply from 10.0.0.2: bytes=32 time=27ms TTL=255

Ping statistics for 10.0.0.2:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
    Approximate round trip times in milli-seconds:
        Minimum = 22ms, Maximum = 62ms, Average = 33ms

C:\Users\Administrator>ping 20.0.0.2

Pinging 20.0.0.2 with 32 bytes of data:
Reply from 20.0.0.2: bytes=32 time=63ms TTL=255
Reply from 20.0.0.2: bytes=32 time=29ms TTL=255
Reply from 20.0.0.2: bytes=32 time=25ms TTL=255
Reply from 20.0.0.2: bytes=32 time=26ms TTL=255

Ping statistics for 20.0.0.2:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
    Approximate round trip times in milli-seconds:
        Minimum = 25ms, Maximum = 63ms, Average = 35ms
```

MAC addresses for VLAN 10 are being learned in ports Eth2/5 and Eth1/1, which implies that NXOS04 and NXOS02 on the other end of these links, respectively, have chosen those ports as their Root Ports.



```
NXOS01# show system internal l2fwder mac
```

Legend:

\* - primary entry, G - Gateway MAC, (R) - Routed MAC, O - Overlay MAC  
age - seconds since last seen,+ - primary entry using vPC Peer-Link,  
(T) - True, (F) - False, C - ControlPlane MAC

VLAN	MAC Address	Type	age	Secure	NTFY	Ports
* 10	5000.0005.0000	dynamic	00:10:18	F	F	Eth1/1
* 10	aabb.cc00.6010	dynamic	00:10:22	F	F	Eth1/5

Use command “show mac address-table dynamic vlan 10” on physical switch which represents the same output.

Per the output below, NXOS02 chose E1/1 as the Root Port to reach NXOS01. Although all ports have the same cost of 2000, E1/1 has the lowest Port ID (port priority and port number) on the other end of the link.

```
NXOS02# show spanning-tree vlan 10
```

VLAN0010

Spanning tree enabled protocol rstp

Root ID Priority 4106

Address 5000.0001.0007

Cost 20000

Port 1 (Ethernet1/1)

Hello Time 2 sec Max Age 20 sec Forward Delay 15 sec

Bridge ID Priority 8202 (priority 8192 sys-id-ext 10)

Address 5000.0002.0007

Hello Time 2 sec Max Age 20 sec Forward Delay 15 sec

Interface	Role	Sts	Cost	Prio.Nbr	Type
-----------	------	-----	------	----------	------

<b>Eth1/1</b>	<b>Root</b>	<b>FWD</b>	<b>20000</b>	<b>128.1</b>	<b>P2p</b>
Eth1/2	Altn	BLK	20000	128.2	P2p
Eth1/3	Desg	FWD	20000	128.3	P2p
Eth1/4	Desg	FWD	20000	128.4	P2p
Eth1/5	Desg	FWD	20000	128.5	P2p
Eth1/6	Desg	FWD	20000	128.6	P2p

Per the view of the CAM table below, we see that NXOS02 learns MAC addresses for VLAN 10 in Eth1/1, its root port, and Eth2/5, the downstream link connecting to NXOS03.

Look on for mac addresses in VLAN 10

```
NXOS02# show system internal l2fwder mac
```

Legend:

\* - primary entry, G - Gateway MAC, (R) - Routed MAC, O - Overlay MAC  
age - seconds since last seen,+ - primary entry using vPC Peer-Link,  
(T) - True, (F) - False, C - ControlPlane MAC

VLAN	MAC Address	Type	age	Secure	NTFY	Ports
* 10	5000.0005.0000	dynamic	00:17:28	F	F	Eth1/5
* 10	aabb.cc00.6010	dynamic	00:17:32	F	F	Eth1/1

Use command “show mac address-table dynamic vlan 10” on physical switch which represents the same output.

On the next downstream switch, NXOS03, we see that it has chosen Eth1/8, a link to NXOS02, as its Root Port. This is because other possible paths to the Root Bridge have had their cost raised to 99999. The end result is that traffic received from Win Server in VLAN 10 going to SW is first forwarded to NXOS02, then to NXOS01, then to NXOS04, and finally to SW.

```
NXOS03# show spanning-tree vlan 10
```

VLAN0010

Spanning tree enabled protocol rstp

Root ID Priority 4106

Address 5000.0001.0007

Cost 40000

Port 5 (Ethernet1/5)

Hello Time 2 sec Max Age 20 sec Forward Delay 15 sec

Bridge ID Priority 32778 (priority 32768 sys-id-ext 10)

Address 5000.0003.0007

Hello Time 2 sec Max Age 20 sec Forward Delay 15 sec

Interface	Role	Sts	Cost	Prio.Nbr	Type
-----------	------	-----	------	----------	------

Po1	Altn	BLK	99999	128.4096	P2p
-----	------	-----	-------	----------	-----

Eth1/3	Altn	BLK	99999	128.3	P2p
--------	------	-----	-------	-------	-----

```

Eth1/4    Altn BLK 99999    128.4    P2p
Eth1/5    Root FWD 20000   128.5    P2p
Eth1/6    Altn BLK 20000   128.6    P2p
Eth1/7    Desg FWD 20000   128.7    P2p

```

```
NXOS03# show system internal l2fwd mac
```

Legend:

\* - primary entry, G - Gateway MAC, (R) - Routed MAC, O - Overlay MAC  
age - seconds since last seen,+ - primary entry using vPC Peer-Link,  
(T) - True, (F) - False, C - ControlPlane MAC

VLAN	MAC Address	Type	age	Secure	NTFY	Ports
* 10	5000.0005.0000	dynamic	00:21:31	F	F	Eth1/7
* 10	aabb.cc00.6010	dynamic	00:21:36	F	F	Eth1/5

Note: Use command “show mac address-table dynamic vlan 10” on physical switch which represents the same output.

Likewise, traffic in VLAN 20 from SW can be verified to follow the path of NXOS03 ->NXOS01 ->NXOS02 ->NXOS04 ->Win Server by the CAM tables below.

Look only for mac addresses in VLAN 20

```
NXOS03# show system internal l2fwd mac
```

Legend:

\* - primary entry, G - Gateway MAC, (R) - Routed MAC, O - Overlay MAC  
age - seconds since last seen,+ - primary entry using vPC Peer-Link,  
(T) - True, (F) - False, C - ControlPlane MAC

VLAN	MAC Address	Type	age	Secure	NTFY	Ports
* 20	5000.0005.0001	dynamic	00:00:07	F	F	Eth1/3
* 20	aabb.cc00.6000	dynamic	00:00:07	F	F	Eth1/8

```
NXOS01# show system internal l2fwd mac
```

Legend:

\* - primary entry, G - Gateway MAC, (R) - Routed MAC, O - Overlay MAC  
age - seconds since last seen,+ - primary entry using vPC Peer-Link,  
(T) - True, (F) - False, C - ControlPlane MAC

VLAN	MAC Address	Type	age	Secure	NTFY	Ports
* 20	5000.0005.0001	dynamic	00:01:29	F	F	Eth1/1
* 20	aabb.cc00.6000	dynamic	00:01:29	F	F	Eth1/3

NXOS02# show system internal l2fwder mac

Legend:

\* - primary entry, G - Gateway MAC, (R) - Routed MAC, O - Overlay MAC  
age - seconds since last seen,+ - primary entry using vPC Peer-Link,  
(T) - True, (F) - False, C - ControlPlane MAC

VLAN	MAC Address	Type	age	Secure	NTFY	Ports
* 20	5000.0005.0001	dynamic	00:06:05	F	F	Eth1/3
* 20	aabb.cc00.6000	dynamic	00:06:05	F	F	Eth1/1

NXOS04# show system internal l2fw mac

Legend:

\* - primary entry, G - Gateway MAC, (R) - Routed MAC, O - Overlay MAC  
age - seconds since last seen,+ - primary entry using vPC Peer-Link,  
(T) - True, (F) - False, C - ControlPlane MAC

VLAN	MAC Address	Type	age	Secure	NTFY	Ports
* 20	5000.0005.0001	dynamic	00:07:44	F	F	Eth1/7
* 20	aabb.cc00.6000	dynamic	00:07:44	F	F	Eth1/3