Dell Networking and Cisco Spanning-Tree Interoperability

Spanning-Tree interoperability between Dell FTOS and Cisco Nexus OS using VLT and vPC

A Dell Technical White Paper

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Executive Summary

Spanning-tree continues to play an important role in today's networks. Despite the inherent issues of inefficient use of bandwidth, scalability limitations, and overall management complexity, it is one of the most basic implementations deployed on existing legacy networks.

Because of this large install base, any major networking vendor's end-to-end solution must be able to seamlessly integrate its products and solutions into an existing deployment running any basic or enhanced spanning-tree modes such as RSTP (Rapid Spanning-Tree also known as 802.1w) or MST (Multiple Spanning-Tree also known as 802.1s).

The Dell Networking product portfolio brings this value to the customer by having a complete set of spanning-tree features that fully interoperate and integrate into an existing deployment. This interoperability document runs through several of the most common spanning-tree deployments and shows how Dell's implementations provide great performance – less than 0.001% packet loss - and high-availability – less than 0.001 seconds of switchover - during a link failure in the network.

Introduction

The creation of the following interoperability document is a result engagements taking place between Cisco switches and Dell switches running similar as well as different spanning-tree modes in the enterprise environment.

This document characterizes and provides some insight into the network traffic behavior when different flavors of spanning tree and device redundancy configurations are deployed between a Cisco environment and a Dell switching environment.

The intended audience of this document is the network architect, system engineer, or network administrator. The results of the tests that will be performed could be used as a reference point for new designs or integration purposes.

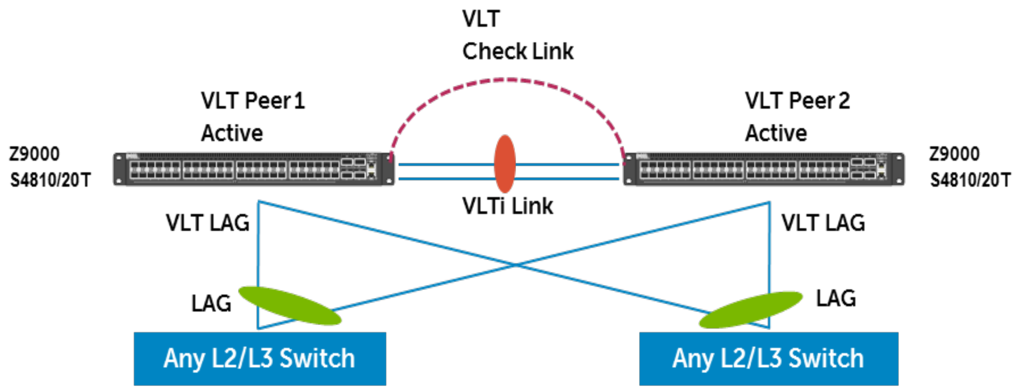
There are two major technologies that will be covered in this interoperability exercise:

1. Device Redundancy
    a. Dell FTOS VLT (Virtual Link Trunk)
    b. Cisco vPC (Virtual Port-Channel)
2. Spanning-Tree Protocol

Dell FTOS VLT - Virtual Link Trunk (VLT) allows physical links between two chassis to appear as a single virtual link to the network core or other switches such as Edge, Access or ToR. VLT reduces the role of Spanning Tree protocols by allowing LAG terminations on two separate distribution or core switches where these switches can be from any other networking vendor supporting standard LAG implementation, and by supporting a loop free topology. (A Spanning Tree protocol is still needed to prevent the initial loop that may occur prior to VLT being established. After VLT is established, RSTP may be used to prevent loops from forming with new links that are incorrectly connected and outside the VLT domain.) VLT provides Layer 2 multi-pathing, creating redundancy through increased bandwidth, enabling multiple parallel paths between nodes and load-balancing traffic where alternative paths exist.

Figure 1: Dell VLT Topology, shows the typical physical network layout with Dell's VLT.

Figure 1: Dell VLT Topology

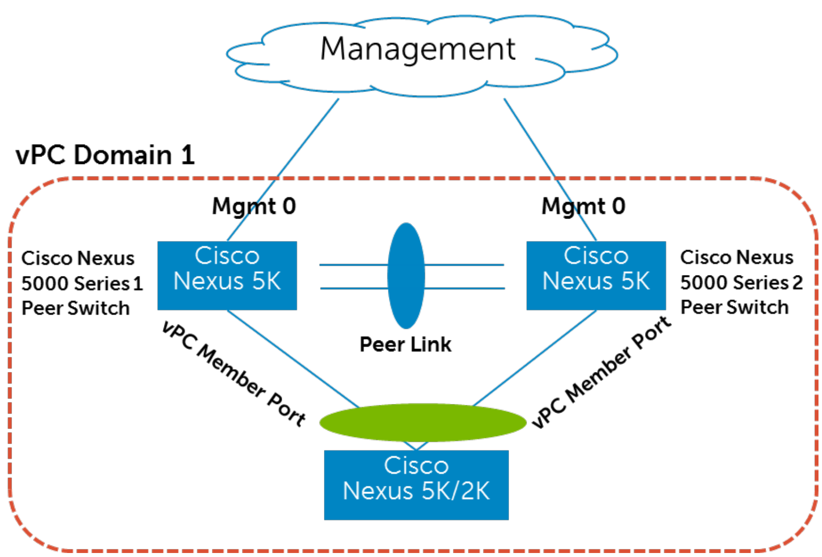


Cisco vPC - A Virtual Port-Channel (vPC) allows links that are physically connected to two different Cisco Nexus™ 5000 Series devices to appear as a single Port-Channel to a third device. The third device can be a Cisco Nexus 2000 Series Fabric Extender or a switch, server, or any other networking device. A vPC can provide Layer 2 multi-pathing, which allows you to create redundancy by increasing bandwidth, enabling multiple parallel paths between nodes and load-balancing traffic where alternative paths exist.

The vPC domain includes both vPC peer devices, the vPC peer keepalive link, the vPC peer link, and all the Port-Channels in the vPC domain connected to the downstream device. You can have only one vPC domain ID on each device.

Figure 2: Cisco vPC Typical Deployment shows the typical Cisco vPC deployment running the Nexus Operating System. Notice how half of the links from the member switch connect to each vPC member switch.

Figure 2: Cisco vPC Typical Deployment



Spanning-Tree Protocol - The **Spanning -Tree Protocol** (**STP**) is a network protocol that ensures a loop-free topology for any bridged Ethernet local area network. The basic function of STP is to prevent bridge loops and the broadcast storms that result from these loops. Spanning-tree also allows a network design to include spare (redundant) links to provide automatic backup paths if an active link fails without the danger of creating any bridge loops, or the need for manual enabling/disabling of these backup links.

Several enhancements or extensions have been made to the original spanning-tree (IEEE 802.1D) implementation. These are:

- **RSTP (802.1w)** – In 2001, the IEEE standards body introduced Rapid Spanning Tree as 802.1w. This enhancement provides significant faster spanning tree convergence after a network topology change has taken place.

  While Spanning Tree can take between 30-50 seconds to respond to a topology change, RSTP is typically able to respond to changes within 6 seconds or milliseconds to a physical link failure. RSTP is backwards compatible with legacy spanning tree.

- **MSTP** (**802.1s)** - MSTP is an extension to RSTP which adds efficiency to the legacy spanning tree instance per vlan. Prior to MSTP, every vlan on a network required a spanning tree instance. With the introduction of MSTP, a group of vlans can now be assigned to a single spanning tree instance and therefore reducing CPU resources from having to create multiple spanning tree instances. The benefits of MSTP are more evident when the network environment consists of 1000s of vlans.

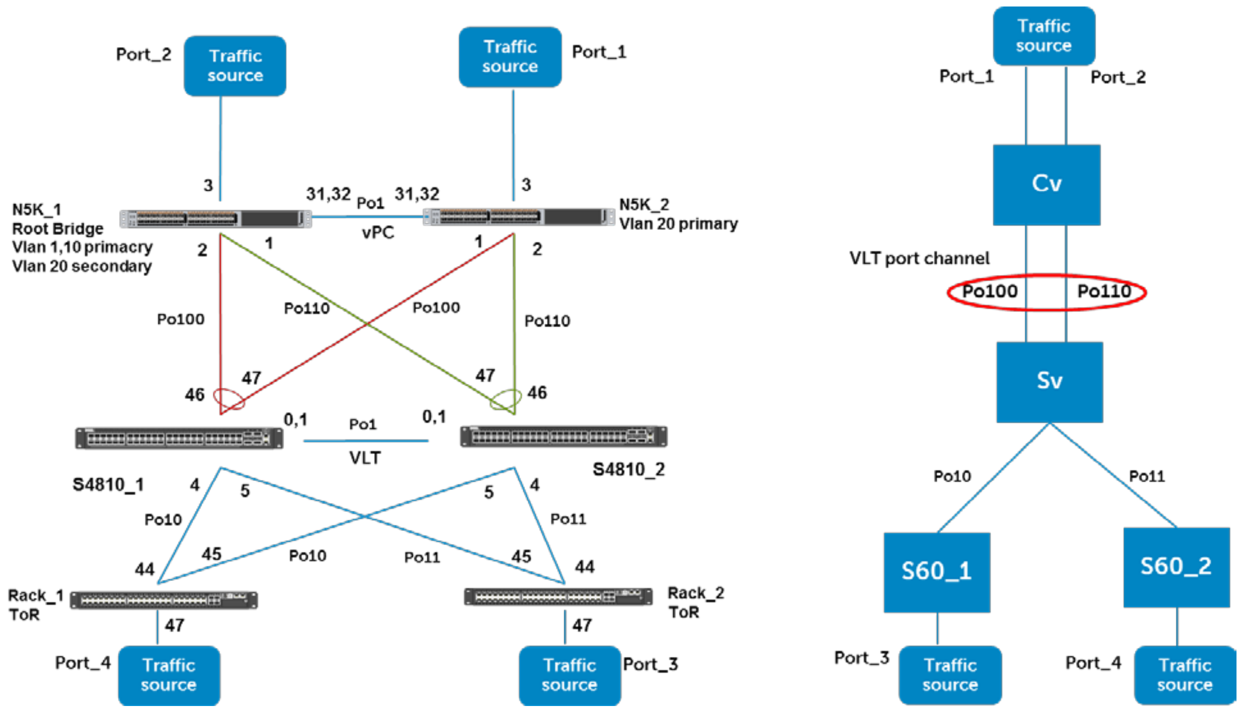
  MSTP is fully backwards compatible with RSTP.

- **PVST+** - PVST+ is a Cisco proprietary Layer 2 protocol used to create separate spanning tree instances on a per vlan basis. Creating separate per vlan spanning tree instances allows for the usage of different network links potentially providing load balancing capabilities.

  There are multiple networking vendors such as Dell, Extreme Networks, and Avaya just to mention some that support this protocol.

Figure 3 shows the reference test-bed diagram used for our first set of tests.

Figure 3 : Physical and logical reference network Test-Bed



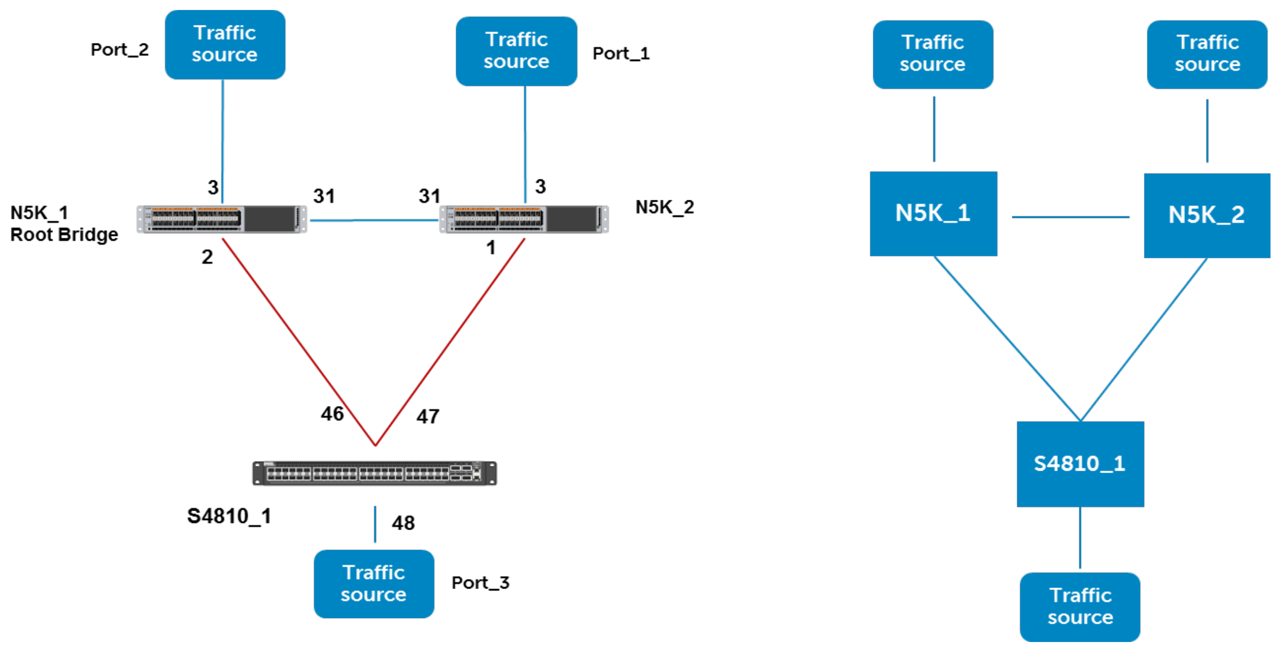
Notice when vPC and VLT are configured, the logical network topology it creates is a very straight-forward simple pair of switches connected back to back via a quad member port-channel link.

The quad member port channel link comes from the dual homed links from each switch (Cisco 5548s and Dell S4810s) where the Cisco single port-channel links are marked in red and green from each switch, and the Dell dual port-channel links marked by a circle icon.

Once spanning-tree is turned on and the Spanning-Tree Algorithm (STA) runs, the port –channel goes into the forwarding mode because to spanning-tree, this is a single port-channel with 4 links. It is not two separate individual port-channels where one needs to be blocked in order to avoid a loop in the network.

Figure 4 shows the reference test-bed diagram used for the second set of tests.

Figure 4 : Test setup without vPC and VLT



Test Methodology

Using the network diagrams mentioned in Figure 4, our test methodology consisted of three key steps:

1. Enable or disable the redundant device technology
2. Configure spanning-tree and the different modes and test interoperability
3. And simulate a link failure between the devices

Tagged traffic was generated and transmitted from either ends of the network. Some test cases sourced traffic from ports 2 or 1 to ports 3 and 4, and others sourced traffic from port 3 to ports 2 and 1.

NOTE:

1. **For all tests, the Cisco switch (N5K_1) is configured as the root of the network. All test results obtained are based on the Cisco switch being the root switch.**
2. **Spanning Tree is not on by default on Dell FTOS. Cisco uses RPVST+ as the default spanning tree mode.**

Two sets of tests were performed using the following configurations:

1. VLT and vPC
    a. RSTP Dell) and RPVST+ (Cisco)
    b. RSTP (Dell) and MST (Cisco)
2. No VLT and no vPC
    a. PVST+ (Dell) and RPVST+ (Cisco)
    b. RSTP (Dell) and RPVST+ (Cisco)
    c. MSTP (Dell) and MST (Cisco)
    d. RSTP (Dell) and MST (Cisco)

The following hardware and software was used for this exercise:

Hardware

- Dell S4810 (2)
- Dell S60 (2)
- Cisco 5548UP (2)
- Traffic source : IXIA XM2 Chassis with 4-10GE Module

Software

- FTOS-SE-9-1-0-0.bin
- FTOS-SC-8.3.3.9.bin
- Cisco 5.1(3)N2 (1)

The following formulae were used to calculate the packet loss and packet loss duration:

- Packet Loss = (Total Frames sent – (Total Frames Received))/Total Frames sent
- Packet Loss Duration(s) = (Total Frames sent – (Total Frames Received))/Frames sent rate

Tests – VLT (Aggregation) and vPC (Core)

Test Case #1 – RSTP (Dell S4810s) and RPVST+ (Cisco 5548UP)

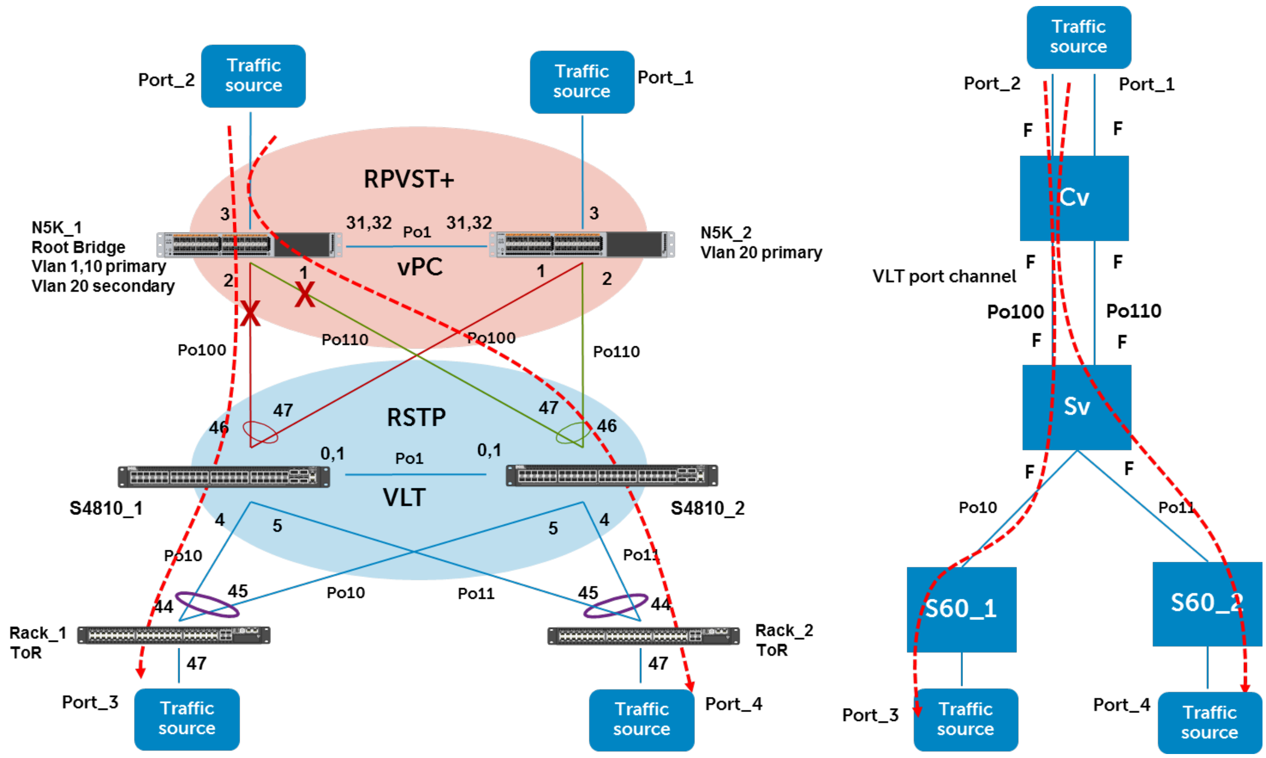
In this particular test, the Dell switches and Cisco switches have been configured with their respective device redundancy technologies.

RPVST+ is configured on the Cisco switches and on the Dell switches, RSTP is configured.

Note: With VLT, RSTP is the only spanning-tree flavor supported currently.

Figure 5 describes the traffic flow for the respective vlans configured and the links that will be disabled (marked with an "X") to simulate a fail-over scenario on vlan 10. Notice N5K_1 is the primary or root bridge for vlan 10.

Figure 5 : Physical and Logical Network Topology - vlan 20



Test Steps:

1. Create two tagged streams with vlan id 10 being sourced from port 2 with MAC address "2" and destination ports 3 & 4 with MAC destination addresses "3" and "4" respectively.
2. Ensure that tagged vlan 20 traffic from the traffic source port 2 is going through the N5K_1 Cisco switch as per the diagram.
3. Interface counters on N5K_2 should read zero.
4. Shut down both port-channels 100 & 110 on N5K_1 to simulate a fail-over scenario and check for any traffic disruption. Data flow from port 2 to ports 3 and 4 now flow through the vPC port-channel to N5K_2 and down through each respective link.
5. Recover both ports and check for any traffic disruption and make sure N5K_1 becomes the root bridge.
6. Shut down individual ports 1& 2 and check for any traffic disruptions.
7. Repeat the steps 4 – 6, and source traffic from port 3 with destination ports 2 & 1.

Results: Traffic disruption measured in micro-seconds was less than 0.02. Packet loss was less than 0.0001%. The same results were achieved for all the different tests mentioned in steps 4 – 6. Figure 5 is a snapshot of the test results during a fail-over and recovery from ports 1 to ports 3 & 4.

- **Packet Loss % = 0.0001**
- **Packet Loss Duration = 0.02**

In order to understand the results achieved, we need to dissect and take a look at the interconnections between the Cisco switches and the Dell switches. When vPC and VLT is configured on the Cisco and Dell switches respectively, a 4-member port-channel link is created between the switches.

From the S4810_1, Po100 is bundled with Po110 through the ***vlt-lag-peer <port-channel>*** command. In this case, Po100 and Po110 are bundled to form a pseudo-master-VLT channel.

From the Cisco switch perspective, the four individual links are configured under the same virtual port channel number and thus creating the 4-member port-channel link.

Figure 6 shows the local and remote port channel relationship on S4810_1. In other words, shutting down the local port-channel on the switch does not affect its forwarding capability since the remote port-channel member remains up and running. By shutting down Po100 locally, Po110 continues to forward the traffic since both port-channels are continuously forwarding.

VLT ports, similar to vPC ports, are always in the forwarding by default as per the feature implementation. This is not to say that VLT ports don't go into blocking mode. If a loop is detected on the VLT ports, they will surely go into blocking mode.

Figure 6 : VLT LAG Peer Status

```
S4810_1_convg_rack(conf-if-vl-20)# do sh vlt det
Local LAG Id  Peer LAG Id  Local Status  Peer Status  Active VLANs
------------  -----------  ------------  -----------  ------------
100              110          UP          UP             1, 10, 20
S4810_1_convg_rack(conf-if-vl-20)#
```

Figure 7 and Figure 8 show the spanning-tree link status for all four switches. Notice, they are all forwarding.

Figure 7: Cisco RPVST+ link status

```
Cisco_N5K_2# sh spanning-tree

VLAN0001
Interface       Role Sts Cost      Prio.Nbr Type
---------------- ---- --- --------- -------- --------------------------------
Po1             Root FWD 1         128.4096 (vPC peer-link) Network P2p
Po100           Root FWD 1         128.4195 (vPC) P2p
Po110           Desg FWD 1         128.4205 (vPC) P2p
Eth1/3          Desg FWD 2         128.131  P2p

VLAN0010

Interface       Role Sts Cost      Prio.Nbr Type
---------------- ---- --- --------- -------- --------------------------------
Po1             Root FWD 1         128.4096 (vPC peer-link) Network P2p
Po100           Desg FWD 1         128.4195 (vPC) P2p
Po110           Desg FWD 1         128.4205 (vPC) P2p
Eth1/3          Desg FWD 2         128.131  P2p

VLAN0020
 Spanning tree enabled protocol rstp

Interface       Role Sts Cost      Prio.Nbr Type
---------------- ---- --- --------- -------- --------------------------------
Po1             Desg FWD 1         128.4096 (vPC peer-link) Network P2p
Po100           Desg FWD 1         128.4195 (vPC) P2p
Po110           Desg FWD 1         128.4205 (vPC) P2p
Eth1/3          Desg FWD 2         128.131  P2p
```

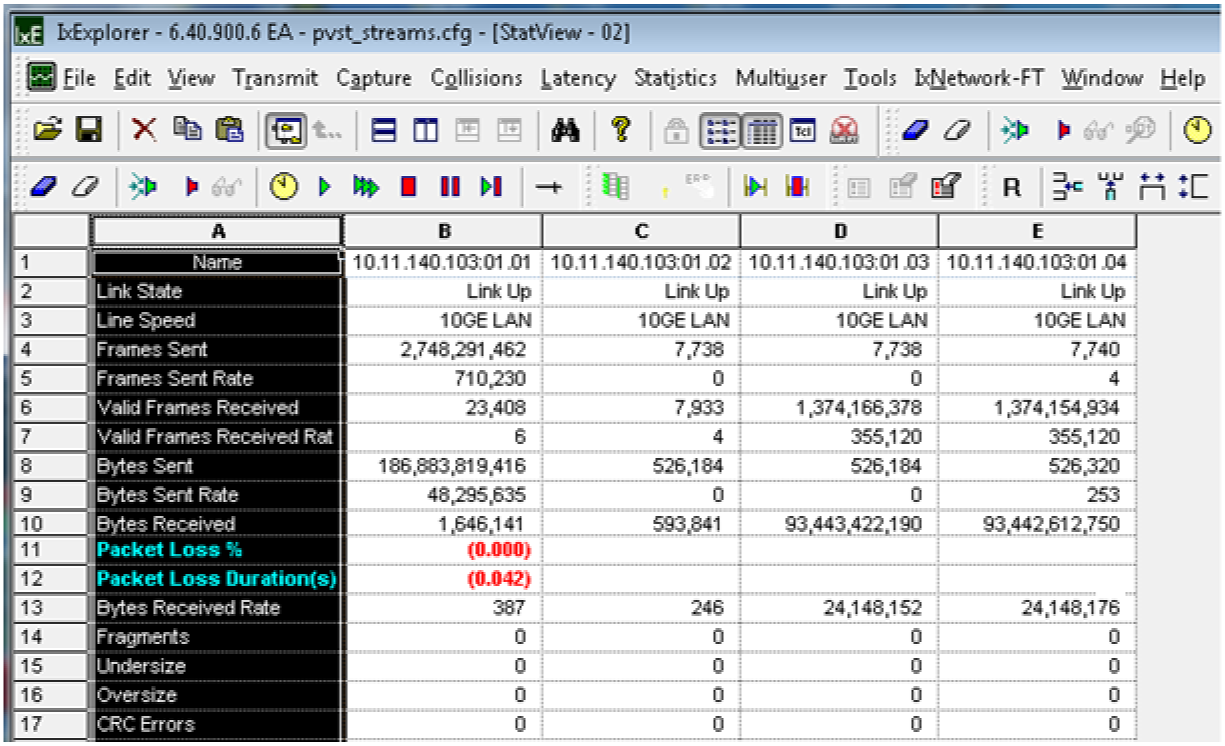
```
Cisco_N5K_1(config-if-range)# sh spanning-tree brie

VLAN0001

Interface       Role Sts Cost      Prio.Nbr Type
---------------- ---- --- --------- -------- --------------------------------
Po1             Desg FWD 1         128.4096 (vPC peer-link) Network P2p
Po100           Root FWD 1         128.4195 (vPC) P2p
Po110           Desg FWD 1         128.4205 (vPC) P2p
Eth1/3          Desg FWD 2         128.131  P2p
Eth1/4          Desg FWD 2         128.132  P2p

VLAN0010

Interface       Role Sts Cost      Prio.Nbr Type
---------------- ---- --- --------- -------- --------------------------------
Po1             Desg FWD 1         128.4096 (vPC peer-link) Network P2p
Po100           Desg FWD 1         128.4195 (vPC) P2p
Po110           Desg FWD 1         128.4205 (vPC) P2p
Eth1/3          Desg FWD 2         128.131  P2p

VLAN0020

Interface       Role Sts Cost      Prio.Nbr Type
---------------- ---- --- --------- -------- --------------------------------
Po1             Root FWD 1         128.4096 (vPC peer-link) Network P2p
Po100           Desg FWD 1         128.4195 (vPC) P2p
Po110           Desg FWD 1         128.4205 (vPC) P2p
Eth1/3          Desg FWD 2         128.131  P2p
```

Figure 8: S4810s RSTP link status

```
S4810_1_convg_rack(conf-if-vl-20)# do sh spanning-tree rs bri

Interface                          Designated
 Name    PortID  Prio Cost   Sts      Cost     Bridge ID
PortID
---------- -------- ---- ------- ----------- ------- -------------------- --------
Po 1     128.2    128  1800    FWD(vltl)  0      0
Po 100   128.101  128  1400    FWD(vlt)   0      0
Te 0/4   128.134  128  2000    FWD        0      0
Te 0/5   128.135  128  200000  DIS        0      32768

Interface
 Name    Role  PortID  Prio Cost   Sts      Cost   Link-type
Edge
---------- ------ -------- ---- ------- ----------- ------- --------- ----
Po 1     Desg  128.2    128  1800    FWD      0     (vltl)P2P
No
Po 100   Desg  128.101  128  1400    FWD      0     (vlt) P2P
No
Te 0/4   Desg  128.134  128  2000    FWD      0     P2P
Yes
Te 0/5   Dis   128.135  128  200000  DIS      0     P2P      No
S4810_1_convg_rack(conf-if-vl-20)#
```

```
S4810_2_convg_rack(conf-if-po-110)#do sh spanning-tree rs bri

Interface                          Designated
 Name    PortID  Prio Cost   Sts      Cost     Bridge ID
PortID
---------- -------- ---- ------- ----------- ------- -------------------- --------
Po 1     128.2    128  1800    FWD(vltl)  1800   0
Po 110   128.111  128  1400    FWD(vlt)   1800   32768
Te 0/4   128.134  128  20000   FWD        1800   32768

Interface
 Name    Role  PortID  Prio Cost   Sts      Cost   Link-type Edge
---------- ------ -------- ---- ------- ----------- ------- --------- ----
Po 1     Root  128.2    128  1800    FWD      1800   (vltl)P2P No
Po 110   Desg  128.111  128  1400    FWD      1800   (vlt) P2P
No
Te 0/4   Desg  128.134  128  20000   FWD      1800   P2P
No
S4810_2_convg_rack(conf-if-po-110)#
```

Figure 9: Stream Statistics for Vlan 10



	A	B	C	D	E
1	Name	10.11.140.103:01.01	10.11.140.103:01.02	10.11.140.103:01.03	10.11.140.103:01.04
2	Link State	Link Up	Link Up	Link Up	Link Up
3	Line Speed	10GE LAN	10GE LAN	10GE LAN	10GE LAN
4	Frames Sent	2,748,291,462	7,738	7,738	7,740
5	Frames Sent Rate	710,230	0	0	4
6	Valid Frames Received	23,408	7,933	1,374,166,378	1,374,154,934
7	Valid Frames Received Rat	6	4	355,120	355,120
8	Bytes Sent	186,883,819,416	526,184	526,184	526,320
9	Bytes Sent Rate	48,295,635	0	0	253
10	Bytes Received	1,646,141	593,841	93,443,422,190	93,442,612,750
11	Packet Loss %	(0.000)			
12	Packet Loss Duration(s)	(0.042)			
13	Bytes Received Rate	387	246	24,148,152	24,148,176
14	Fragments	0	0	0	0
15	Undersize	0	0	0	0
16	Oversize	0	0	0	0
17	CRC Errors	0	0	0	0

The cells in red indicate the packet loss percentage and packet loss duration measurements.

Test Case #2 – RSTP (Dell S4810s) and MST (Cisco 5548UP)

Using the same setup as in Figure 4, we configured MSTP on the Cisco switches, and re-ran the same set of tests as in Test #1.

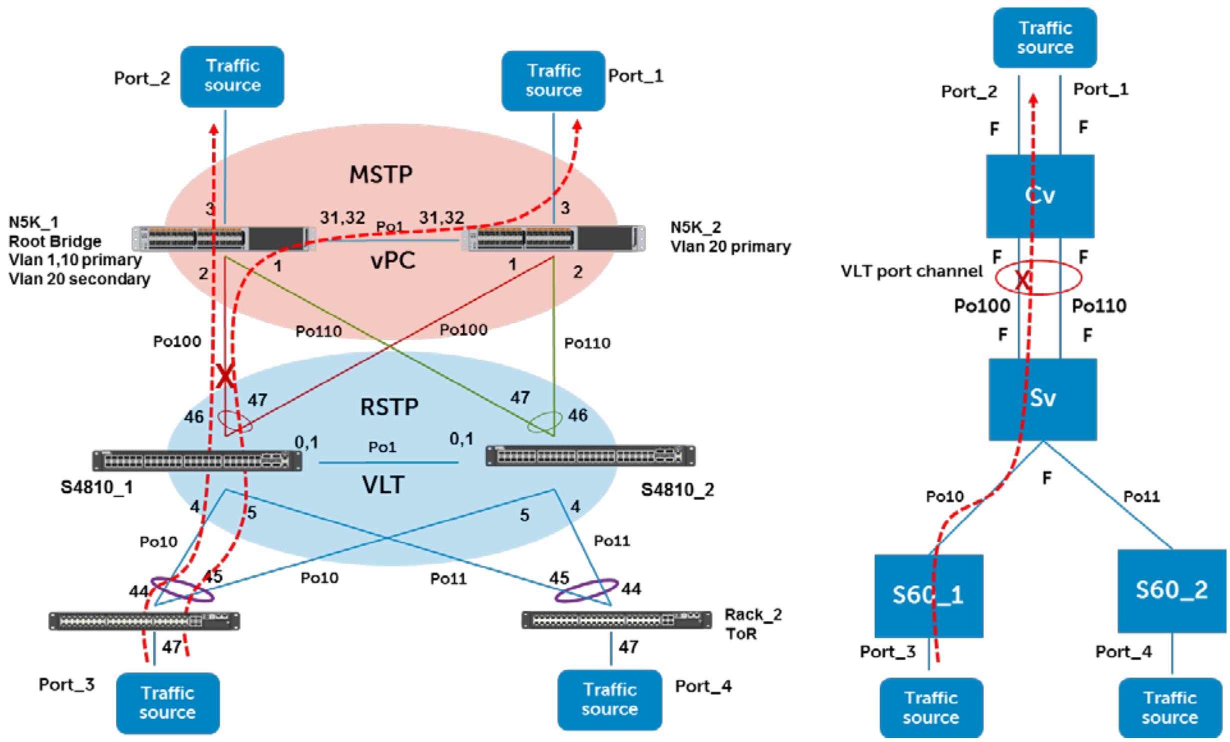
With RSTP and MST enabled, considering that MST runs or uses RSTP's convergence timers, and the fact that only a single spanning-tree instance is running between the two different regions, we should expect to get convergence times ranging between 1-2 seconds or possibly less.

Figure 10 describes how the traffic flow sent from port 3 to ports 2 and 1 traverse the network and the link that will be shut-down and brought up again.

Notice how the traffic for port 1 flows through the root bridge and across the internal vPC channel to the secondary switch and then finally to port 1.

In addition, Figure 10 describes the initial test that will be performed by shutting down Po100 (Port-Channel 100) on the Cisco N5K_1 switch.

Figure 10 : Physical and Logical Network Topology



Test Steps:

1. Create two tagged streams with vlan id 20 with source mac port 3, destination ports 1 and 2.
2. Ensure that vlan 20 traffic from port 3 is going through the N5K_1 since this is the common spanning-tree root bridge.
3. Interface counters on N5K_2 ports 1 and 2 should read zero. The only interface on N5K_2 incrementing should be the internal vPC channel and port 3 transmit counter.
4. Shut down port-channel 100 on N5K_1 to simulate a fail-over scenario and check for any traffic disruption.
5. Recover Po100 on N5K_1and check for any traffic disruption and make sure N5K_1 becomes the root bridge.
6. Shut down individual ports 46 and 47 on S4810_1 and check for any traffic disruptions. Traffic should switch-over to Po110 on S4810_2 and continue without measurable disruption
7. Recover ports 46 and 47 and check for any measurable traffic disruption.

Results: Great numbers. With VLT and vPC, the group of four switches created a simple pair of switches connected via a 4 member port-channel link. (See Logical Network Topology Figure 10).

- **Packet Loss % = 0.0001**
- **Packet Loss Duration = 0.006 seconds**

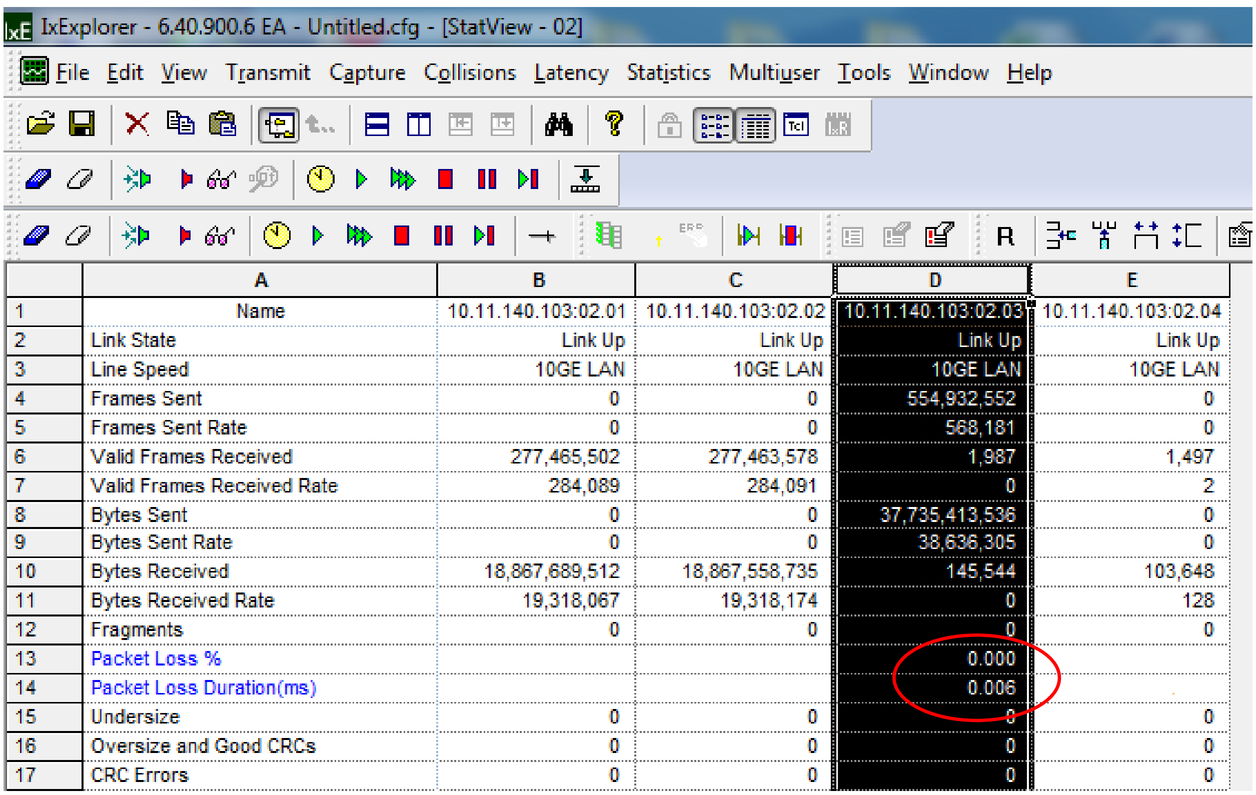
As expected, because of vPC and VLT, the links between the Dell S4810s and Cisco 5548s create an actual 4 member port-channel link. This means that by shutting down Port-channel 100 on the Cisco N5K_1 traffic should not be interrupted because there are still 3 available links that are still forwarding.

This is confirmed once we look at Te0/47 counters. Initially, Te0/47 reads "0" on transmit; however, when Po100 is shut down on the Cisco N5K_1 switch, Te0/47 counters begin to increment confirming the switch-over.

Shutting down the individual links on the Dell S4810_1 switch made no difference on the results. This is because as far as the switch is concerned, shutting down an individual link that is part of the Port-channel is a non-issue as long as there is a redundant link. In our case, there are 3 other links available and forwarding.

Figure 11 shows a snapshot of the counters (in red) during and after switch-over failures.

Figure 11: Traffic port statistics during link fail-over



	A	B	C	D	E
1	Name	10.11.140.103:02.01	10.11.140.103:02.02	10.11.140.103:02.03	10.11.140.103:02.04
2	Link State	Link Up	Link Up	Link Up	Link Up
3	Line Speed	10GE LAN	10GE LAN	10GE LAN	10GE LAN
4	Frames Sent	0	0	554,932,552	0
5	Frames Sent Rate	0	0	568,181	0
6	Valid Frames Received	277,465,502	277,463,578	1,987	1,497
7	Valid Frames Received Rate	284,089	284,091	0	2
8	Bytes Sent	0	0	37,735,413,536	0
9	Bytes Sent Rate	0	0	38,636,305	0
10	Bytes Received	18,867,689,512	18,867,558,735	145,544	103,648
11	Bytes Received Rate	19,318,067	19,318,174	0	128
12	Fragments	0	0	0	0
13	Packet Loss %			0.000	
14	Packet Loss Duration(ms)			0.006	
15	Undersize	0	0	0	0
16	Oversize and Good CRCs	0	0	0	0
17	CRC Errors	0	0	0	0

Tests – no VLT (Aggregation) no vPC (Core)

The next set of tests will focus on running different spanning-tree interations, with no vPC and VLT configured. The purpose of this is to demonstrate that in a typical triangle deployment, running simple Layer 2 links with no specific vendor features; standard based spanning-tree modes interoperate with no issues.

Test Case # 1 - RSTP (Dell S4810s) and RPVST+ (Cisco 5548UP)

Figure 12, shows the traffic flow at steady state. Each Cisco N5K is a root for vlans 10 and 20 respectively. The black arrow describes the traffic flow for vlans 10 and 20. See the logical spanning-tree network topology. Te0/46 is forwarding and Te0/47 is being blocked. This is the normal behavior of a having a single spanning tree instance for all vlans (Dell RSTP), on the other hand, with the Cisco running RPVST+, two different spanning tree instances are created.

From the N5K_1 switch perspective, the root of vlan 20 traffic is N5K_2 and it creates a separate instance pointing to N5K_2 as the root switch (see Figure 13). From the N5K_2 switch perspective, the root of vlan 10 traffic is N5K_1 and it creates a separate instance pointing to N5K_1 as the root switch (see Figure 14).

Figure 12: Physical Network Topology RSTP (Dell) and RPVST+ (Cisco)

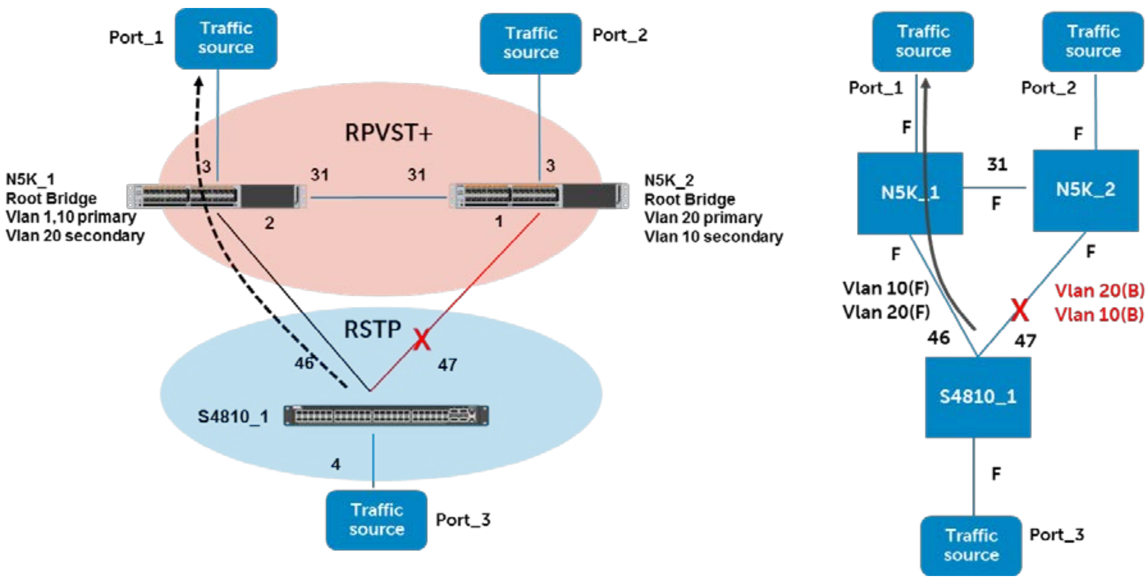


Figure 13 : Vlan 20 spanning tree instance N5K_1

```
VLAN0020
  Spanning tree enabled protocol rstp
  Root ID    Priority    24596
             Address     547f.eeac.13c1  << N5K_2 MAC Address
             Cost        2
             Port        159 (Ethernet1/31)
             Hello Time  2  sec  Max Age 20 sec  Forward Delay 15 sec

  Bridge ID  Priority    28692  (priority 28672 sys-id-ext 20)
             Address     547f.eeab.dbbc
             Hello Time  2  sec  Max Age 20 sec  Forward Delay 15 sec

Interface        Role Sts Cost      Prio.Nbr Type
---------------- ---- --- --------- -------- --------------------------------
Eth1/2           Desg FWD 2         128.130  P2p
Eth1/3           Desg FWD 2         128.131  P2p
Eth1/31          Root FWD 2         128.159  P2p     << Pointing to N5K_2 as the root switch

N5K_1#
```

Figure 14 : Vlan 10 spanning tree instance N5K_2

```
VLAN0010
  Spanning tree enabled protocol rstp
  Root ID    Priority    24586
             Address     547f.eeab.dbbc   << N5K_1 MAC Address
             Cost        2
             Port        159 (Ethernet1/31)
             Hello Time  2  sec  Max Age 20 sec  Forward Delay 15 sec
  Bridge ID  Priority    28682  (priority 28672 sys-id-ext 10)
             Address     547f.eeac.13c1
             Hello Time  2  sec  Max Age 20 sec  Forward Delay 15 sec
Interface        Role Sts Cost      Prio.Nbr Type
---------------- ---- --- --------- -------- --------------------------------
Eth1/1           Desg FWD 2         128.129  P2p
Eth1/3           Desg FWD 2         128.131  P2p
Eth1/31          Root FWD 2         128.159  P2p   << Pointing to N5K_1 as the root switch
N5K_2#
```

Test Steps:

1. Create two tagged streams with vlan id 20 with source mac port 3, destination ports 1 and 2.
2. Shut down Te0/46 on S4810_1 to simulate a fail-over scenario and check for any traffic disruption.
3. Recover Te0/46 on S4810_1 and check for any traffic disruption.

Results: As expected, in this particular test, there are two different spanning-tree modes, one is a purely vendor proprietary implementation (RPVST+), and the other standard based (RSTP). Because of this, we expected some issues in terms of interoperability. Below are the test results of this run:

1. When shutting down Te0/46:
   - **Packet Loss % = 0.003**
   - **Packet Loss Duration (s) = 0.224**

When Te0/46 is disabled, the ALTR (Alternate root port Te0/47 on the S4810) moves to the forwarding mode immediately. This is the expected behavior as per the implementation of an alternate root port inside RSTP. Since the alternate root port is the backup root port, there is no BPDU exchange that takes place within the network specified on Figure 12. Because of this the switchover and forwarding times are extremely fast.

2. After recovering Te0/46
   - **Packet Loss % = 40-50**
   - **Packet Loss Duration = 30 seconds**

With RSTP, a direct message exchange takes place between point to point links. This exchange consists of an RSTP BPDU proposal message and an agreement message. With RPVST+, the same message exchange takes place; however, these messages are being generated on a per-vlan basis. RPVST+ is a Cisco proprietary implementation and the way it works, is by generating and sending these exchange messages to a specific multicast address (See Figure 15 or 16) for any other vlan other than vlan 1, and this multicast address is understood ***only*** by the Cisco switch.

In the case of the test performed, the RSTP BPDUs for vlans 10 and 20 go unanswered by the Dell S4810 (See Figure 15).

Because of the mismatched RSTP implementations, the Cisco switches do not receive an agreement based on their BPDU proposal message which in turn forces the Cisco switches to revert back to the legacy spanning tree behavior and wait for at least twice the forward-delay timer (15 seconds)

Figure 15 : RSTP BPDU for vlan 10

RSTP BPDU FOR VLAN 10 on Port 1/2 all Cisco reserved Multicast address in red

```
2013 Jul 19 16:50:38.073188 stp: RSTP(10): transmitting RSTP BPDU on Ethernet1/2
2013 Jul 19 16:50:38.073203 stp: vb_vlan_shim_send_bpdu(1977): VDC 1 Vlan 10 port Ethernet1/2
enc_type 1 len 42
2013 Jul 19 16:50:38.073225 stp: BPDU TX: vb 1 vlan 10 port Ethernet1/2 len 42 ->01000ccccccd CFG
P:0000 V:02 T:02 F:0e R:60:0a:54:7f:ee:ab:db:bc 00000000 B:60:0a:54:7f:ee:ab:db:bc 8082 A:0000
M:0014 H:0002 F:000f     T:0000 L:0002 D:0a
```

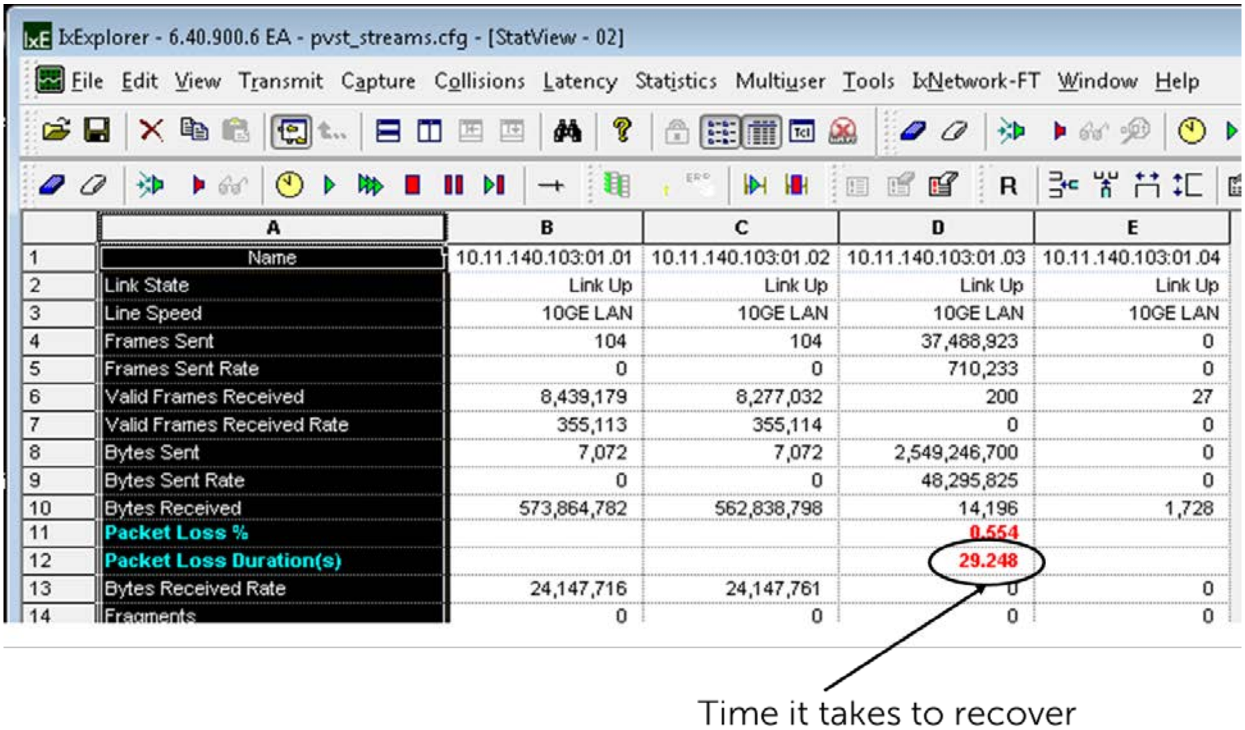
Figure 16 show how the Cisco N5Ks are transmitting RSTP BPDUs for the specific vlans to the specific multicast addresses. Notice the well-known IEEE standard based address (0180.C200.0000) and the Cisco reserved address (0100.0CCC.CCCD) for vlan 1. On the other hand, for vlan 10, only the Cisco reserved address is used which the Dell S4810 simply drops.

Figure 16: Cisco RPVST+ Spanning-Tree Debug

```
Cisco_N5K_1# debu spanning-tree all
2013 Jun 28 21:54:54.162746 stp: RSTP(1): transmitting RSTP BPDU on Ethernet1/2
2013 Jun 28 21:54:54.162769 stp: vb_vlan_shim_send_bpdu(1977): VDC 1 Vlan 1 port
Ethernet1/2 enc_type 2 len 36
2013 Jun 28 21:54:54.162794 stp: BPDU TX: vb 1 vlan 1 port Ethernet1/2 len 36 ->
0180c2000000 CFG P:0000 V:02 T:02 F:3c R:20:01:54:7f:ee:ab:db:bc 00000000 B:20:0
1:54:7f:ee:ab:db:bc 8082 A:0000 M:0014 H:0002 F:000f
2013 Jun 28 21:54:54.162807 stp: vb_vlan_shim_send_bpdu(1977): VDC 1 Vlan 1 port
Ethernet1/2 enc_type 1 len 42
2013 Jun 28 21:54:54.162828 stp: BPDU TX: vb 1 vlan 1 port Ethernet1/2 len 42 ->
01000ccccccd CFG P:0000 V:02 T:02 F:3c R:20:01:54:7f:ee:ab:db:bc 00000000 B:20:0
1:54:7f:ee:ab:db:bc 8082 A:0000 M:0014 H:0002 F:000f     T:0000 L:0002 D:01
2013 Jun 28 21:54:54.162841 stp: RSTP(1): transmitting RSTP BPDU on Ethernet1/31
2013 Jun 28 21:54:54.162860 stp: vb_vlan_shim_send_bpdu(1977): VDC 1 Vlan 1 port
Ethernet1/31 enc_type 2 len 36

2013 Jun 28 21:54:54.163122 stp: BPDU TX: vb 1 vlan 10 port Ethernet1/2 len 42 -
>01000ccccccd CFG P:0000 V:02 T:02 F:3c R:20:0a:54:7f:ee:ab:db:bc 00000000 B:20:
0a:54:7f:ee:ab:db:bc 8082 A:0000 M:0014 H:0002 F:000f
```

Figure 17 shows the traffic outage duration upon restoring the port-channel link.

Figure 17 : Screen shot during fail-over



	A	B	C	D	E
1	Name	10.11.140.103:01.01	10.11.140.103:01.02	10.11.140.103:01.03	10.11.140.103:01.04
2	Link State	Link Up	Link Up	Link Up	Link Up
3	Line Speed	10GE LAN	10GE LAN	10GE LAN	10GE LAN
4	Frames Sent	104	104	37,488,923	0
5	Frames Sent Rate	0	0	710,233	0
6	Valid Frames Received	8,439,179	8,277,032	200	27
7	Valid Frames Received Rate	355,113	355,114	0	0
8	Bytes Sent	7,072	7,072	2,549,246,700	0
9	Bytes Sent Rate	0	0	48,295,825	0
10	Bytes Received	573,864,782	562,838,798	14,196	1,728
11	Packet Loss %			0.554	
12	Packet Loss Duration(s)			29.248	
13	Bytes Received Rate	24,147,716	24,147,761	0	0
14	Fragments	0	0	0	0

Test Case # 2 - PVST+ (Dell S4810s) and RPVST+ (Cisco 5548UP)

Figure 15 depict the physical and logical network topology respectively. Notice how vlan 10 is being forwarded on Te 0/46 and blocked on Te0/47, and vice-versa for vlan 20.

Figure 18: Physical and logical network topology - RPVST+ & PVST+

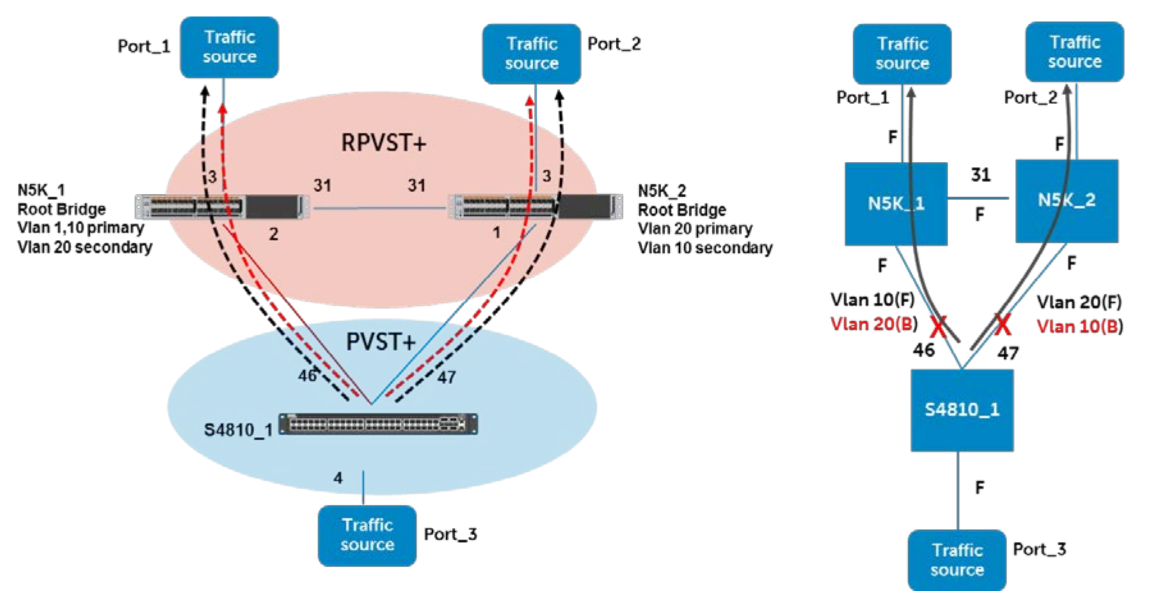


Figure 16 and Figure 17 show the port state on the Dell S4810 as per PVST+.

Figure 19: Vlan 10 S4810 link status per spanning-tree

```
S4810_1_convg_rack(conf-if-vl-20)#do sh spanning-tree pvst vlan 10 bri
VLAN 10
Executing IEEE compatible Spanning Tree Protocol
Root ID     Priority 8202, Address 547f.eeab.dbbc
Root Bridge hello time 2, max age 20, forward delay 15
Bridge ID     Priority 32768, Address 0001.e88a.f033
Configured hello time 2, max age 20, forward delay 15

!
!
!
Interface
 Name      Role   PortID   Prio Cost    Sts       Cost   Link-type Edge
---------- ------ -------- ---- ------- --------- ------- --------- ----
Te 0/4     Desg   128.134  128  20000   FWD       2000    P2P      No
Te 0/46    Root   128.176  128  2000    FWD       2000    P2P      No
Te 0/47    Altr   128.177  128  2000    BLK       2000    P2P      No
S4810_1_convg_rack(conf-if-vl-20)#
```

Figure 20 : Vlan 20 traffic spanning-tree

```
S4810_1_convg_rack(conf-if-vl-20)#do sh spanning-tree pvst vlan 20 bri
VLAN 10
Executing IEEE compatible Spanning Tree Protocol
Root ID    Priority 8202, Address 547f.eeab.dbbc
Root Bridge hello time 2, max age 20, forward delay 15
Bridge ID    Priority 32768, Address 0001.e88a.f033
Configured hello time 2, max age 20, forward delay 15

!
!
!
Interface
 Name      Role  PortID   Prio Cost   Sts       Cost   Link-type Edge
---------- ------ -------- ---- ------- ---------- ------- --------- ----
Te 0/4     Desg   128.134  128  20000  FWD       2000   P2P      No
Te 0/46    Altr   128.176  128  2000   BLK       2000   P2P      No
Te 0/47    Root  128.177  128  2000    FWD       2000   P2P      No
S4810_1_convg_rack(conf-if-vl-20)#
```

Test Steps:

1. Create two tagged streams with vlan id 10 and 20 with source mac port 3, destination ports 1 and 2.
2. Shut down Te0/46 on S4810_1 to simulate a fail-over scenario and check for any traffic disruption.
3. Recover Te0/46 on S4810_1 and check for any traffic disruption and make sure N5K_1 becomes the root bridge.
4. Repeat steps 2 and 3 for Te0/47 on the S4810_1 switch.

Results: As expected, the blocked vlans started to forward right away upon a link failure. Different per-VLAN spanning-tree instances were created. Upon failing the links between the S4810_1 and each respective N5K the timers observed were:

- **Packet Loss % = 0.0**
- **Packet Loss Duration = 0.1 seconds, upon each link fail-over**

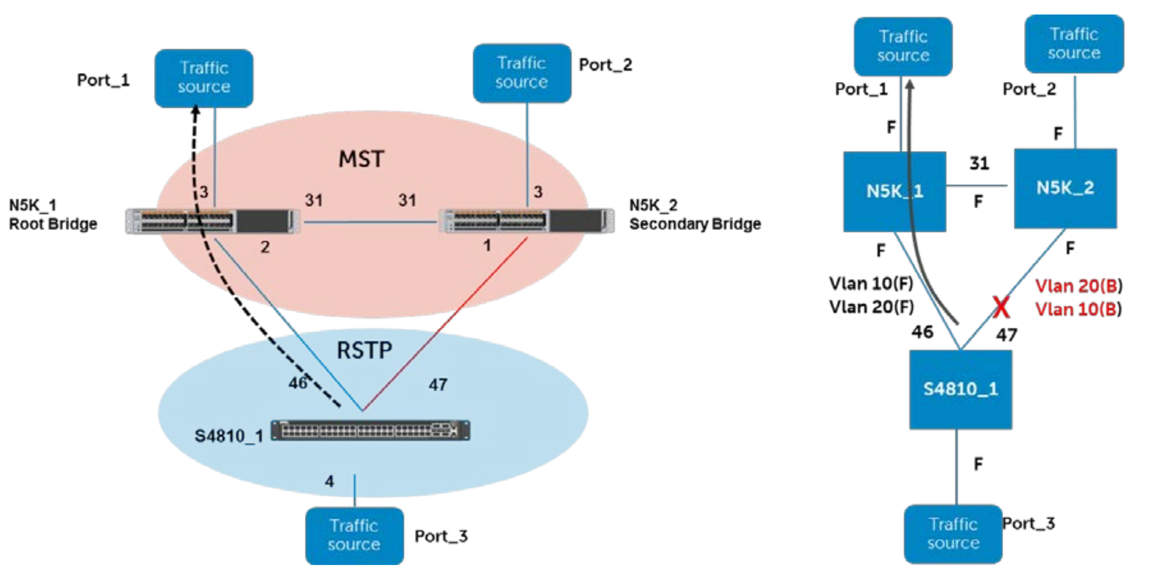
Test Case # 3 - RSTP (Dell S4810s) and MST (Cisco 5548UP)

For this particular test, two sets of tests were performed using the following configuration:

1. Default common/single spanning-tree instance created by MST and RSTP
2. Create two spanning-tree instances on the Cisco switches and assign vlans 10 and 20 to each instance respectively and perform the test.

Figure 18 describes the physical and logical spanning-tree view of the network under a common/single spanning-tree configuration.

Figure 21 : Physical and logical network topology



Common/single spanning-tree instance

The following screen-shots show the spanning-tree link status on the Cisco switches and Dell S4810s under a single spanning-tree instance for the entire network.

Figure 19 and Figure 20 show how both Cisco switches share the same spanning-tree region, same instance, and RSTP running under-the-hood, therefore it is reasonable to expect great convergence times.

Figure 22: Cisco link status per MST

```
N5K_1# sh spanning-tree brief

MST0000
 Spanning tree enabled protocol mstp
 Root ID    Priority    0
            Address     547f.eeab.dbbc
            This bridge is the root
            Hello Time  2  sec  Max Age 20 sec  Forward Delay 15 sec

 Bridge ID  Priority    0      (priority 0 sys-id-ext 0)
            Address     547f.eeab.dbbc
            Hello Time  2  sec  Max Age 20 sec  Forward Delay 15 sec

Interface        Role Sts Cost      Prio.Nbr Type
---------------- ---- --- --------- -------- --------------------------------
Eth1/2           Desg FWD 2000      128.130  P2p
Eth1/3           Desg FWD 2000      128.131  P2p
Eth1/31          Desg FWD 2000      128.159  P2p

N5K_1#
```

```
N5K_2# sh spanning-tree brief

MST0000
 Spanning tree enabled protocol mstp
 Root ID    Priority    0
            Address     547f.eeab.dbbc
            Cost        0
            Port        159 (Ethernet1/31)
            Hello Time  2  sec  Max Age 20 sec  Forward Delay 15 sec

 Bridge ID  Priority    28672  (priority 28672 sys-id-ext 0)
            Address     547f.eeac.13c1
            Hello Time  2  sec  Max Age 20 sec  Forward Delay 15 sec

Interface        Role Sts Cost      Prio.Nbr Type
---------------- ---- --- --------- -------- --------------------------------
Eth1/1           Desg FWD 2000      128.129  P2p
Eth1/3           Desg FWD 2000      128.131  P2p
Eth1/31          Root FWD 2000      128.159  P2p

N5K_2#
```

Figure 23 : Dell S4810 RSTP link status

```
S4810_1_convg_rack#sh spanning-tree rstp  bri
Executing IEEE compatible Spanning Tree Protocol
Root ID    Priority 0, Address 547f.eeab.dbbc
Root Bridge hello time 2, max age 20, forward delay 15
Bridge ID    Priority 61440, Address 0001.e88a.f033
Configured hello time 2, max age 20, forward delay 15
Interface                                Designated
 Name      PortID   Prio Cost    Sts       Cost     Bridge ID          PortID
---------- -------- ---- ------- ----------- ------- -------------------- --------
Te 0/4     128.134  128  2000    FWD       2000    61440 0001.e88a.f033 128.134
Te 0/46    128.176  128  2000    FWD       2000    0     547f.eeab.dbbc 128.130
Te 0/47    128.177  128  2000    BLK       2000    28672 547f.eeac.13c1 128.129
Interface
 Name      Role   PortID   Prio Cost    Sts       Cost    Link-type Edge
---------- ------ -------- ---- ------- ----------- ------- --------- ----
Te 0/4     Desg   128.134  128  2000    FWD       2000    P2P       No
Te 0/46    Root   128.176  128  2000    FWD       2000    P2P       No
Te 0/47    Altr   128.177  128  2000    BLK       2000    P2P       No
S4810_1_convg_rack#
```

Test Steps:

1. Create two tagged streams with vlans 10 and 20 from port 3 to ports 1 and 2.
2. Shut down Te0/46 on the S4810_1 switch and measure traffic loss and duration of traffic loss.
3. Recover Te0/46 on the S4810 and measure traffic loss and duration of traffic loss.

Ideally, traffic disruption should be negligible due to the fact that all switches are under the same spanning-tree region.

Results: Upon shutting down Te0/46, the blocked link (Te0/47) moves into the forwarding state immediately. Below are the test results:

- **Packet Loss % = 0.015**
- **Packet Loss Duration = 0.3 seconds**

When we restore Te0/46, Te0/47 goes into a blocking status. Below are the test results of this run:

- **Packet Loss % = 0.009**
- **Packet Loss Duration = 0.5 seconds**

When the S4810_1 switch converged initially, it recognized Te0/47 as the "ALTR" or alternate port. This port is the backup root port ready to take over should Te0/46 (Root) port fails. When this transition takes place, no BPDUs are transmitted since there is no interaction with another switch; therefore the only events that take place are related to the link operational status (Te0/46 and Te0/47) and the RSTP timers when transitioning form "Discarding" to the "Forwarding" status.

In this case, when using RSTP, transitioning from the DISCARDING →LEARNING→ FORWARDING is almost instantaneously. Figure 21, shows the port state transitions captured on the S4810_1 with debugs enabled when port 2 on the Cisco switch is shut down and brought up.

Figure 24 : Port transition S4810_1 RSTP

Shutting down e1/2 on the Cisco N5K_1 (root) port

```
1w0d1h: %STKUNIT0-M:CP %IFMGR-5-OSTATE_DN: Changed interface state to
down: Te 0/46

1w0d1h : RSTP: astpProcessIfmOperDnMsg: PORT OPER DOWN, port 176
1w0d1h : RSTP: STSM: Port 176: Inst 0: Moved to state DISCARDING
1w0d1h : RSTP: STSM: Port 177: Inst 0: Moved to LEARNING
1w0d1h : RSTP: Topology Change detected on port Te 0/47
1w0d1h : RSTP: STSM: Port 177: Inst 0: Moved to FORWARDING
```

Restoring e1/2 on the Cisco N5K_1 (root) port

```
INST 2: Flags: 0x4e, Reg Root: 24576:547f.eeac.13c1, Int Root Cost: 2000
        Brg/Port Prio: 32768/128, Rem Hops: 19
1w0d3h : RSTP: STSM: Port 177: Inst 0: Moved to state DISCARDING
1w0d3h : RSTP: STSM: Port 176: Inst 0: Moved to LEARNING
1w0d3h : RSTP: Topology Change detected on port Te 0/46
1w0d3h : RSTP: STSM: Port 176: Inst 0: Moved to FORWARDING
```

Multiple spanning-tree instance

For this test, multiple spanning-tree instances were configured on the Cisco switches. Vlan 10 was assigned to instance 1 and N5K_1 switch was configured as the root switch for this instance.

Vlan 20 was assigned to instance 2 and N5K_2 switch was configured as the root switch for this instance.

Although multiple spanning-tree instances have been configured on the Cisco switches, we expect the results to be identical as when having as single spanning-tree instance.

Figure 22 and Figure 23 show the spanning-tree instances on the Cisco switches.

Figure 25 : Cisco MST port state

```
N5K_1# sh spanning-tree mst 1

##### MST1    vlans mapped:   10
Bridge      address 547f.eeab.dbbc  priority      1     (0 sysid 1)
Root        this switch for MST1

Interface        Role Sts Cost      Prio.Nbr Type
---------------- ---- --- --------- -------- --------------------------------
Eth1/2           Desg FWD 2000      128.130  P2p
Eth1/3           Desg FWD 2000      128.131  P2p
Eth1/31          Desg FWD 2000      128.159  P2p

N5K_1#
```

```
N5K_2# sh spanning-tree mst 1

##### MST1    vlans mapped:   10
Bridge      address 547f.eeac.13c1  priority      28673 (28672 sysid 1)
Root        address 547f.eeab.dbbc  priority      1     (0 sysid 1)
            port    Eth1/31         cost          2000      rem hops 19

Interface        Role Sts Cost      Prio.Nbr Type
---------------- ---- --- --------- -------- --------------------------------
Eth1/1           Desg FWD 2000      128.129  P2p
Eth1/3           Desg FWD 2000      128.131  P2p
Eth1/31          Root FWD 2000      128.159  P2p

N5K_2#
```

Figure 26 : Cisco MST port state

```
N5K_1# sh spanning-tree mst 2

##### MST2    vlans mapped:   20
Bridge      address 547f.eeab.dbbc  priority      32770 (32768 sysid 2)
Root        address 547f.eeac.13c1  priority      24578 (24576 sysid 2)
            port    Eth1/31         cost          2000      rem hops 19

Interface        Role Sts Cost      Prio.Nbr Type
---------------- ---- --- --------- -------- --------------------------------
Eth1/2           Desg FWD 2000      128.130  P2p
Eth1/3           Desg FWD 2000      128.131  P2p
Eth1/31          Root FWD 2000      128.159  P2p

N5K_1#
```

```
N5K_2# sh spanning-tree mst 2

##### MST2    vlans mapped:   20
Bridge      address 547f.eeac.13c1  priority      24578 (24576 sysid 2)
Root        this switch for MST2

Interface        Role Sts Cost      Prio.Nbr Type
---------------- ---- --- --------- -------- --------------------------------
Eth1/1           Desg FWD 2000      128.129  P2p
Eth1/3           Desg FWD 2000      128.131  P2p
Eth1/31          Desg FWD 2000      128.159  P2p

N5K_2#
```

Test Steps:

1. Create two streams, tagged with vlans 10 and 20 from port 3 to ports 1 and 2.
2. Shut down Te0/46 on the S4810_1 switch and measure traffic loss and duration of traffic loss.
3. Recover Te0/46 on the S4810 and measure traffic loss and duration of traffic loss.

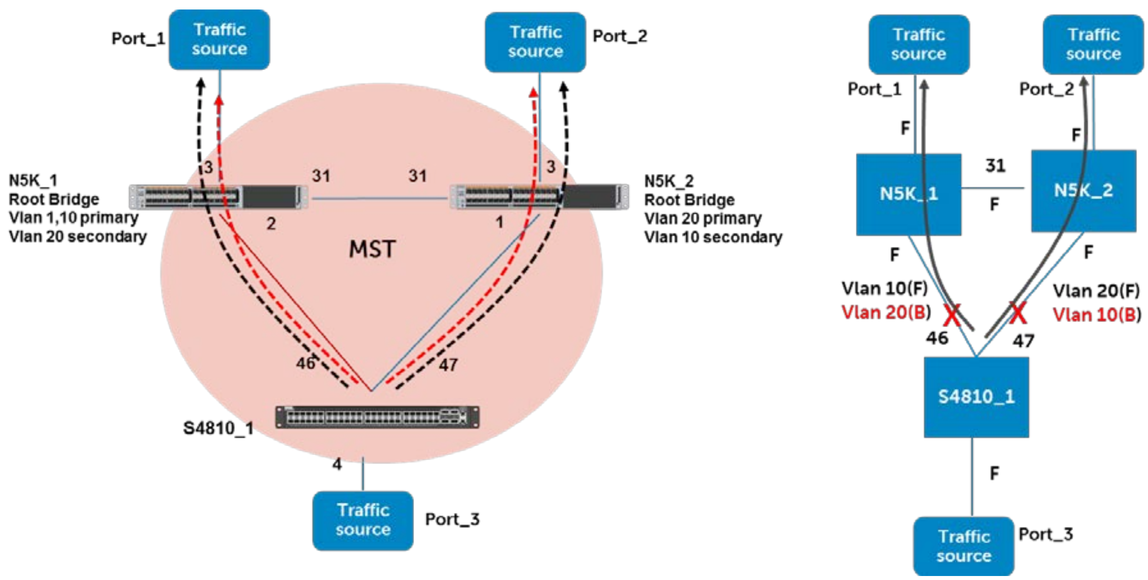
Results: As expected, the results were identical as having a single spanning-tree instance. MST uses RSTP timers; therefore it only makes sense that the convergence times should be identical.

Test Case # 4 - MSTP (Dell S4810s) and MST (Cisco 5548UP)

For this test, all three switches were placed in the same spanning-tree region with both Cisco switches acting as root for a particular vlan.

Figure 24 shows our reference test diagram under a common spanning-tree mode. For this test we created multiple spanning-tree instances on all switches matching the vlan to instance as well as region name.

Figure 27 : Physical and logical network topology



Test Steps:

1. Create two tagged streams with vlan id 10 and 20 with source mac port 3 and destination ports 1 and 2.
2. Shut down Te0/46 on S4810_1 to simulate a fail-over scenario and check for any traffic disruption.
3. Recover Te0/46 on S4810_1 and check for any traffic disruption and make sure N5K_1 becomes the root bridge.
4. Repeat steps 2 and 3 for Te0/47 on the S4810_1 switch.

5. Place the S4810_1 in a different spanning-tree region by configuring a different region name on the S4810_1 and repeat all tests.

Results: As expected, the blocked vlans started to forward right away upon a link failure. Different per-VLAN spanning-tree instances were created. Upon failing the links between the S4810_1 and each respective N5K the timers observed were:

- **Packet Loss % = 0.0 – 0.004**
- **Packet Loss Duration = 0.1 – 0.7 seconds, upon each link fail-over**

Summary

Running a mixed spanning-tree environment although not recommended, it is good to know that the current Dell FTOS spanning-tree options and device redundancy feature provide a solid performance and interoperability capability

The results of our tests (see Table 1), prove that Dell's spanning-tree implementations, can indeed seamlessly and in a particular configuration integrate into an existing environment provided a clear understanding is obtained prior to doing any network migration.

Based on the test results, matching the spanning tree flavor or mode is the most efficient recommended type of deployment.

Table 1: Spanning-Tree Traffic Convergence Results

Dell FTOS	**Cisco (NX_OS)**	
	vPC (RPVST+)	**vPC (MST)**
VLT (RSTP)	Packet Loss % = 0.0 Packet Loss Duration = 0.02 **Advantage:** Most efficient and simpler deployment due to the back to back port channel links between both logical domains. **Disadvantage:** It requires that both switches have a device redundancy technology in order to achieve the simple deployment model.	Packet Loss % = 0.001 Packet Loss Duration = 0.006 **Advantage:** Both spanning tree versions interoperate 100% due to MST's underlying use of RSTP's timer convergence timers. **Disadvantage:** Convergence timers can become unpredictable when the size of the Layer 2 domain increases in the number of links.
	No vPC (RPVST+)	**No vPC (MST)**
No VLT (RSTP)	Packet Loss % = 40-50 Packet Loss Duration = 29-30 seconds **Advantage:** NONE. Due to the proprietary implementation nature of RPVST+, interoperabilitiy issues are non-existent between RPVST+ and RSTP.	Packet Loss % = 0.009 Packet Loss Duration = 0.5 seconds **Advantage:** Same advantages as stated above with the exception that vPC and VLT are not configured.
No VLT (MST)	N/A – scenario not seen	Packet Loss % = 0.004 Packet Loss Duration = 0.7 seconds

Dell FTOS	Cisco (NX_OS)	
		Advantage: Same mode, 100% interoperable. RSTP timers will be used when a spanning tree event takes place. **Disadvantage:** The number of spanning tree instances is limited therefore the size of the Layer 2 domain will be limited.
No VLT (PVST+)	Packet Loss % = 0.0 Packet Loss Duration = 0.1 seconds **Advantage:** With RPVST+ and PVST+, vlan load balancing is possible. Both spanning tree modes use the same convergence timers therefore convergence times upon link failures are quick.	N/A – scenario not seen

Miscellaneous – Switch Configurations

Cisco 5548UP - RPVST+ with vPC

The running configuration will not show RPVST+, this is due to the fact that the Cisco 5548UP runs RPVST+ by default.

```
Cisco_N5K_1# sh run


!Command: show running-config
!Time: Tue Jul  2 17:33:38 2013

version 5.1(3)N2(1)
hostname Cisco_N5K_1

feature telnet
no feature http-server
cfs eth distribute
feature lacp
feature vpc
feature lldp
!
vrf context management
  ip route 0.0.0.0/0 10.11.131.254
vlan 1,10,20
vpc domain 1
  role priority 1
  peer-keepalive destination 10.11.129.56

interface port-channel1
  description vpc_peer_channel
  switchport mode trunk
  spanning-tree port type network
  speed 10000
  vpc peer-link

interface port-channel100
  switchport mode trunk
  vpc 10

interface port-channel110
  switchport mode trunk
  speed 10000
  vpc 20
!
interface Ethernet1/1
  description link_2_S4810_1
  switchport mode trunk
  channel-group 110 mode active

interface Ethernet1/2
  description link_2_S4810_2
  switchport mode trunk
  channel-group 100 mode active

interface Ethernet1/3
  switchport mode trunk

interface Ethernet1/4
!
interface Ethernet1/31
  description Links_between_N5Ks
  switchport mode trunk
  channel-group 1 mode active

interface Ethernet1/32
  description Links_between_N5Ks
  switchport mode trunk
  channel-group 1 mode active

interface mgmt0
  ip address 10.11.129.55/22
line console
line vty
boot kickstart bootflash:/n5000-uk9-kickstart.5.1.3.N2.1.bin
boot system bootflash:/n5000-uk9.5.1.3.N2.1.bin
mac address-table aging-time 1000000


Cisco_N5K_1#
```

Dell S4810 – RSTP with VLT

```
sh run
Current Configuration ...
! Version 9-1(0-0)
! Last configuration change at Tue Jun 11 23:27:20 2013 by
admin
protocol spanning-tree rstp
 no disable
 bridge-priority 61440
!
protocol spanning-tree rstp
 no disable
!
vlt domain 1
 peer-link port-channel 1
 primary-priority 1
!
stack-unit 0 provision S4810
!
interface TenGigabitEthernet 0/0
 description vlt_link_members
 no ip address
 flowcontrol rx on tx off
 no shutdown
!
interface TenGigabitEthernet 0/1
 description vlt_link_members
 no ip address
 flowcontrol rx on tx off
 no shutdown
!
interface TenGigabitEthernet 0/46
 description channel_member_2_Cisco
 no ip address
 flowcontrol rx on tx off
!
 port-channel-protocol LACP
  port-channel 100 mode active
 no shutdown
!
interface TenGigabitEthernet 0/47
 description channel_member_2_Cisco
 no ip address
 flowcontrol rx on tx off
!
 port-channel-protocol LACP
  port-channel 100 mode active
 no shutdown
!
interface ManagementEthernet 0/0
 ip address 10.11.129.20/22
 no shutdown
!
interface Port-channel 1
 description vlt_peer_LAG
 no ip address
 channel-member TenGigabitEthernet 0/0-1
 no shutdown
!
interface Port-channel 100
 no ip address
 switchport
 no shutdown
!
interface Port-channel 120
 no ip address
 switchport
 vlt-peer-lag port-channel 120
 no shutdown
!
interface Vlan 1
!untagged Port-channel 1,100,120
management route 0.0.0.0/0 10.11.131.254
!
protocol lldp
 advertise management-tlv system-description system-name
!
end
S4810_1_convg_rack#
```