MSTP INTEROPERABILITY OF THE DELL™ POWERCONNECT™ 6200 SERIES SWITCHES

WITH CISCO IOS OR CISCO CATOS BASED SWITCHES

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FIGURES

INTRODUCTION

This paper describes the Multiple Spanning Tree Protocol (MSTP) support for Dell PowerConnect 62xx devices, which include the PC6224, PC6248, PC6224P, PC6248P, PC6224F, and M6220 switches. This document also explains how to configure PowerConnect 62xx switches to interoperate and connect with Cisco IOS and CatOS based switches when using the MSTP industry standards. MSTP is defined in the IEEE 802.1s specification.

This document addresses the following topics:

- MSTP and its support in Dell PowerConnect 62xx devices
- Network operation of MSTP with configuration help for both Dell PowerConnect and Cisco switches (Cisco Cat 3750 is taken as reference)

IEEE 802.1S MULTIPLE SPANNING TREE PROTOCOL OVERVIEW

IEEE 802.1s MSTP supports multiple instances of Spanning Tree Protocol (STP) to efficiently channel VLAN traffic over different interfaces. Each spanning tree instance behaves in the manner specified in IEEE 802.1w (Rapid Spanning Tree) with slight modifications in the operation but not the end result.

The difference between RSTP and traditional STP (IEEE 802.1d) is that RSTP can configure and recognize full duplex connectivity and ports that are connected to end stations. This allows RSTP to perform a rapid transition of the port to the "Forwarding" state and to suppress Topology Change Notifications. These features are represented by the parameters *pointtopoint* and *edgeport*.

MSTP is compatible with both RSTP and STP and behaves appropriately with STP and RSTP bridges. You can configure an MSTP bridge to behave entirely as an RSTP bridge or an STP bridge. This means that an IEEE 802.1s bridge also supports IEEE 802.1w and IEEE 802.1d.

DELL POWERCONNECT 62XX MSTP FUNCTIONAL DESCRIPTION

The MSTP algorithm and protocol provides simple and full connectivity for frames assigned to any given VLAN throughout a bridged LAN comprising arbitrarily interconnected networking devices, each operating MSTP, STP or RSTP. MSTP allows frames assigned to different VLANs to follow separate paths, each based on an independent Multiple Spanning Tree Instance (MSTI), within Multiple Spanning Tree (MST) Regions composed of LANs or MSTP Bridges. These regions and the other bridges and LANs are connected into a single Common Spanning Tree (CST). [IEEE DRAFT P802.1s/D13]

MSTP connects all bridges and LANs with a single Common and Internal Spanning Tree (CIST). The CIST supports the automatic determination of each MST region, choosing its maximum possible extent. The connectivity calculated for the CIST provides the CST for interconnecting these regions, and an Internal Spanning Tree (IST) within each region. MSTP ensures that frames with a given VLAN ID (VID) are assigned to one and only one of the MSTIs or the IST within the region, that that assignment is consistent among all the networking devices in the region, and that the stable connectivity of each MSTI and IST at the boundary of the Region matches that of the CST. The stable active topology of the Bridged LAN with respect to frames consistently classified as belonging to any given VLAN thus simply and fully connects all LANs and networking devices throughout the network, though frames belonging to different VLANs can take different paths within any region. [IEEE DRAFT P802.1s/D13]

All bridges, whether they use STP, RSTP or MSTP, send information in Configuration Messages via BPDUs to assign Port Roles that determine each port's participation in a fully and simply connected active topology based on one or more spanning trees. The information communicated is known as the *spanning tree priority vector.* The BPDU structure for each protocol is different. An MSTP bridge transmits the appropriate BPDU depending on the received type of BPDU from a particular port.

An MST region has one or more MSTP bridges with the same MST Configuration Identifier. MSTI regions use the same MST instance, and all bridges in the region must be able to send and receive MSTP BPDUs.

The MST Configuration Identifier consists of the following components:

- Configuration Identifier Format Selector – 1 byte value encoded as zero
- Configuration Name – 32 byte string
- Configuration Revision Level – 2 byte value
- Configuration Digest – 16 byte signature of type HMAC-MD5 created from the MST Configuration Table (a VID to MSTID mapping)

As there are multiple instances of Spanning Tree, there is an MSTP state maintained on a per-port, per-instance basis (or on a per-port, per-VLAN basis – as any VLAN can be in one and only one MSTI or CIST). For example, port A can be forwarding for instance 1 while discarding for instance 2.

The port states have changed since the publication of the IEEE 802.1d specification. The following table shows the port states for STP (802.1d) vs. MSTP (802.1s):

STP Port State (IEEE 802.1d)	Admin Port State	MSTP Port State (IEEE 802.1s)	Active Topology (Port Role)
Disabled	Disabled	Discarding	Excluded (Disabled)
Disabled	Enabled	Discarding	Excluded (Disabled)
Blocking	Enabled	Discarding	Excluded (Alternate, Backup)
Listening	Enabled	Discarding	Included (Root, Designated)
Learning	Enabled	Learning	Included (Root, Designated)
Forwarding	Enabled	Forwarding	Included (Root, Designated, Master)

In order to support multiple spanning trees, an MSTP bridge must be configured with an unambiguous assignment of VIDs to spanning trees. This is achieved by:

1. Ensuring that the allocation of VIDs to filtering IDs (FIDs) is unambiguous.

   The Dell PowerConnect 62xx series switch implements this with a fixed VID to FID assignment. Every VID is assigned to one and only one FID.

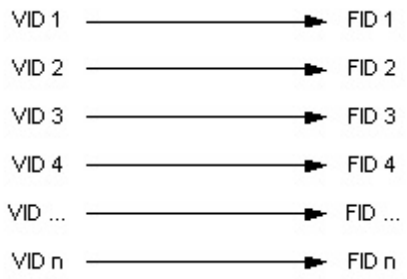


Figure 1: VID to FID Allocation

2. Ensuring that each FID supported by the Bridge is allocated to exactly one Spanning Tree Instance.

The Dell PowerConnect 62xx series switch implements this through the FID to MSTI Allocation Table. The following diagram shows an example configuration:

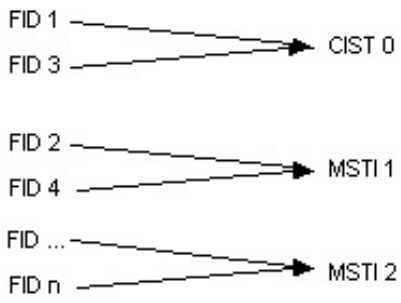


Figure 2: Example FID to MSTI Allocation

The combination of VID to FID and then FID to MSTI allocation defines a mapping of VIDs to spanning tree instances, represented by the MST Configuration Table. The following diagram shows an example configuration:

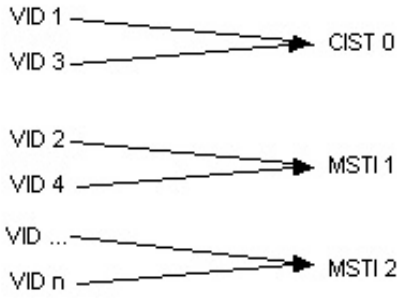


Figure 3: Example Resultant VID to MSTI Allocation

With this allocation, we ensure that every VLAN is assigned to one and only one MSTI. The CIST is also an instance of spanning tree with an MSTID of 0. We can have an instance which has no VIDs allocated to it but every VLAN must be allocated to one of the other instances of spanning tree.

The portion of the active topology of the network that connects any two bridges in the same MST region traverses only MST bridges and LANs in that region and never bridges of any kind outside the region. In other words, connectivity within the region is independent of external connectivity.

ACTIVE TOPOLOGY ENFORCEMENT

Each received frame is allocated to a spanning tree instance by the forwarding process using the VID. The forwarding process selects each port as a potential transmission port if, and only if all of the following conditions are met:

1. The port on which the frame was received is in forwarding mode for that spanning tree instance.
2. The port considered for transmission is in a forwarding state for that spanning tree instance.
3. The port considered for transmission is not the same port on which the frame was received.

For each port not selected as a potential transmission port, the frame is discarded.

CONTROL PACKET BEHAVIOR

BPDU: Always transmitted as untagged. The port receives and transmits BPDUs in all three MSTP states: Discarding, Learning and Forwarding. If MSTP is disabled for the device (manual forwarding on all ports), BPDUs received are switched.

GVRP: Always transmitted as untagged. GVRP PDUs are received and transmitted only when the port is in Forwarding state.

GMRP: GMRP PDUs are transmitted tagged or untagged as per the port's tag setting. They follow the ingress and egress rules.

LACPDU: LACPDUs are always transmitted untagged and are received and transmitted in all three MSTP states. These frames are never switched whether MSTP is enabled or not.

Pause Frames: Pause frames are never tagged or switched. The port receives and transmits Pause frames in all three MSTP states. In other words, the STP state of the port has no bearing on the transmission and reception of Pause Frames.

Other Frames to and from the CPU: All other frames are received and transmitted only if the port is in Forwarding state.

All BPDUs (ST, TCN, RST, MST, etc.) use the unique MAC address of the transmitting port in their Source MAC address field and comply with IEEE Std. 802.1D-2004 sub-clauses 7.12 and 7.13.

The unique MAC address for a stacking switch is the base MAC address of the stack unit plus the port number.

MSTP CLI COMMANDS

You can configure MSTP on the Dell PowerConnect 62xx series switch by using the Web interface or the Command-Line Interface (CLI). The following spanning tree and MSTP CLI commands are available:

```
spanning-tree
spanning-tree mode
spanning-tree forward-time
spanning-tree hello-time
spanning-tree max-age
spanning-tree priority
spanning-tree disable
spanning-tree cost
spanning-tree port-priority
spanning-tree portfast
spanning-tree link-type
clear spanning-tree detected-protocols
spanning-tree mst priority
spanning-tree mst max-hops
spanning-tree mst port-priority
spanning-tree mst cost
spanning-tree mst configuration
instance (mst)
name (mst)
revision (mst)
show (mst)
exit (mst)
abort (mst)
show spanning-tree
```

For more information about each command, including the syntax and variables, see the *Dell PowerConnect 62xx System CLI Command Reference*.

Configure MSTP by using the Web interface on the pages under the **Switching > Spanning Tree** menu.

OPERATION IN THE NETWORK

In the following diagram of a small, 802.1d bridged network, STP is necessary to create an environment with full connectivity and without loops:

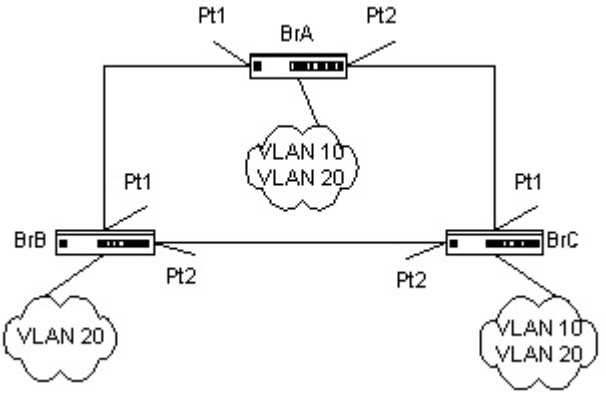


Figure 4: Small Bridged Network

Assume that bridge BrA is elected to be the Root Bridge, and Port Pt1 on bridge BrB and BrC are calculated to be the root ports for those bridges, Port Pt2 on bridge BrB and BrC would be placed into Blocking State. A loop-free topology would then exist. End stations in VLAN 10 could talk to other devices in VLAN 10 and end stations in VLAN 20 would only have a single path to communicate with other VLAN 20 devices. The logical single STP network topology would look something like this:

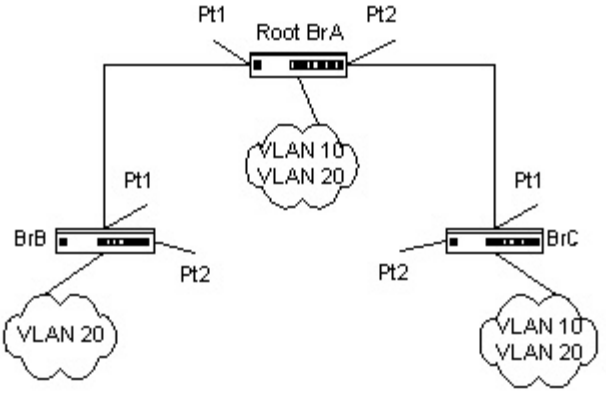


Figure 5: Single STP Topology

For VLAN 10, this Single STP Topology is fine and presents no limitations or inefficiencies. On the other hand, VLAN 20's traffic pattern is inefficient. All frames from bridge BrB will have to traverse a path through bridge BrA before arriving at bridge BrC. If the ports Pt2 on bridge BrB and BrC could be used, these inefficiencies could be eliminated. MSTP does just that by allowing the configuration of MSTIs based upon a VLAN or groups of VLANs.

In this simple case, VLAN 10 could be associated with MSTI 1 with an active topology similar to Figure 5, and VLAN 20 could be associated with MSTI 2 where port Pt1 on both bridge BrA and BrB begin discarding and all others begin forwarding. This simple modification creates an active topology with a better distribution of network traffic and an increase in available bandwidth. The logical representation of the MSTP environment for these 3 bridges is shown in Figure 6.

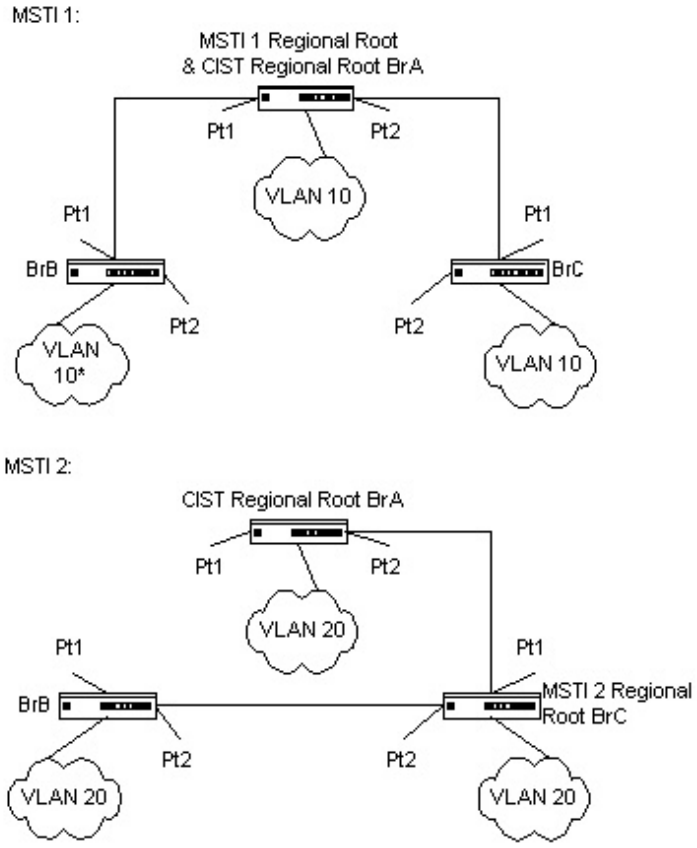


Figure 6: Logical MSTP Environment

In order for MSTP to correctly establish the different MSTIs that Figure 6 shows, some additional changes are required. For example, the configuration would have to be the same on each and every bridge. That means that bridge BrB would have to add VLAN 10 to its list of supported VLANs (shown in Figure 6 with an "*"). This is necessary with MSTP to allow the formation of regions made up of all bridges that exchange the same MST Configuration Identifier. It is only within these MST regions that multiple instances can exist. It will also allow the election of Regional Root Bridges for each instance. One CIST Regional Root for the CIST and an MSTI Regional Root Bridge per instance will enable the possibility of alternate paths through each Region. Above bridge BrA is elected as both the MSTI 1 Regional Root and the CIST Regional Root Bridge, and after adjusting the Bridge Priority on bridge BrC in MSTI 2, it would be elected as the MSTI 2 Regional Root.

SAMPLE SETUP AND CONFIGURATIONS

This section contains the CLI commands you would use to configure MSTP on the switches in Figure 6 where two bridges are Dell PowerConnect switches, and the third bridge is a Cisco Catalyst switch.

The three switches in the figure are as follows:

- BrA: Dell PowerConnect 6248
- BrB: Dell PowerConnect 6248
- BrC: CiscoCatalyst3750series

BrA is the root bridge for MSTP instance 1, and BrC is the root bridge for MSTP instance 2.

CONFIGURING BRIDGE BrA (CLI)

Use the commands in this section to configure the Dell PowerConnect 6248 as bridge BrA as shown in Figure 6.

```
Dell_BrA(config)#vlan database
Dell_BrA(config-vlan)#vlan 10,20
Dell_BrA(config-vlan)#exit
Dell_BrA(config)#interface ethernet 1/g1
Dell_BrA(config-if-1/g1)#switchport mode trunk
Dell_BrA(config-if-1/g1)#switchport trunk allowed vlan add 10,20
Dell_BrA(config-if-1/g1)#switchport trunk allowed vlan remove 1
Dell_BrA(config-if-1/g1)#exit
Dell_BrA(config)#interface ethernet 1/g2
Dell_BrA(config-if-1/g1)#switchport mode trunk
Dell_BrA(config-if-1/g1)#switchport trunk allowed vlan add 10,20
Dell_BrA(config-if-1/g1)#switchport trunk allowed vlan remove 1
Dell_BrA(config-if-1/g1)#exit
Dell_BrA(config)#spanning-tree mode mstp
Dell_BrA(config)#spanning-tree mst 1 priority 0
Dell_BrA(config)#spanning-tree mst configuration
Dell_BrA(config-mst)#name Dell
Dell_BrA(config-mst)#instance 1 add vlan 10
Dell_BrA(config-mst)#instance 2 add vlan 20
Dell_BrA(config-mst)#exit
```

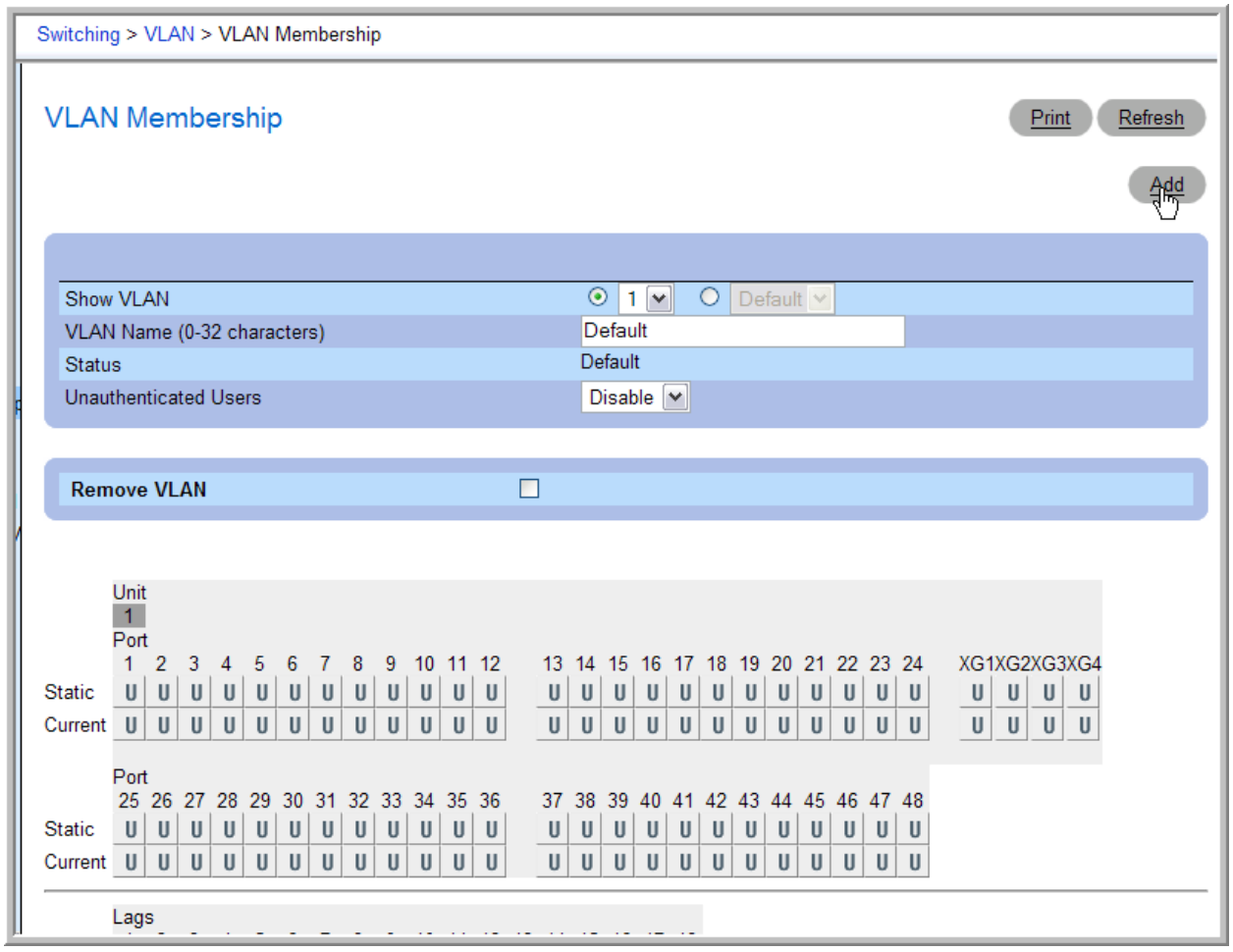
Command	Description
`vlan database`	Enter VLAN command mode
`vlan 10, 20`	Create VLANs 10 and 20
`exit`	Exit to configuration mode
`interface Ethernet 1/g1`	Enter interface configuration mode for the Ethernet interface on slot 1, port 1
`switchport mode trunk`	Configure the VLAN membership mode for the port as a trunk (a trunk port connects two switches)
`switchport trunk allowed vlan add 10, 20`	Add VLANs 10 and 20 to the trunk port
`switchport trunk allowed vlan remove 1`	Remove VLAN 1 (the default VLAN) from the trunk port

Command	Description
`exit`	Exit to configuration mode
`interface ethernet 1/g2`	Enter interface configuration mode for the Ethernet interface on slot 1, port 2
`switchport mode trunk`	Configure the VLAN membership mode for the port as a trunk (a trunk port connects two switches)
`switchport trunk allowed vlan add 10, 20`	Add VLANs 10 and 20 to the trunk port
`switchport trunk allowed vlan remove 1`	Remove VLAN 1 (the default VLAN) from the trunk port
`exit`	Exit to configuration mode
`spanning-tree mode mstp`	Enable MSTP mode on the switch
`spanning-tree mst 1 priority 0`	Sets the switch priority for MSTP instance 1 to zero, which essentially sets the switch as the root bridge for MSTP instance 1.
`spanning-tree mst configuration`	Enter the MST configuration name
`name Dell`	Create Dell as the MST configuration name
`instance 1 add vlan 10`	Map VLAN 10 to MST instance 1
`instance 2 add vlan 20`	Map VLAN 20 to MST instance 2
`exit`	Exit to configuration mode

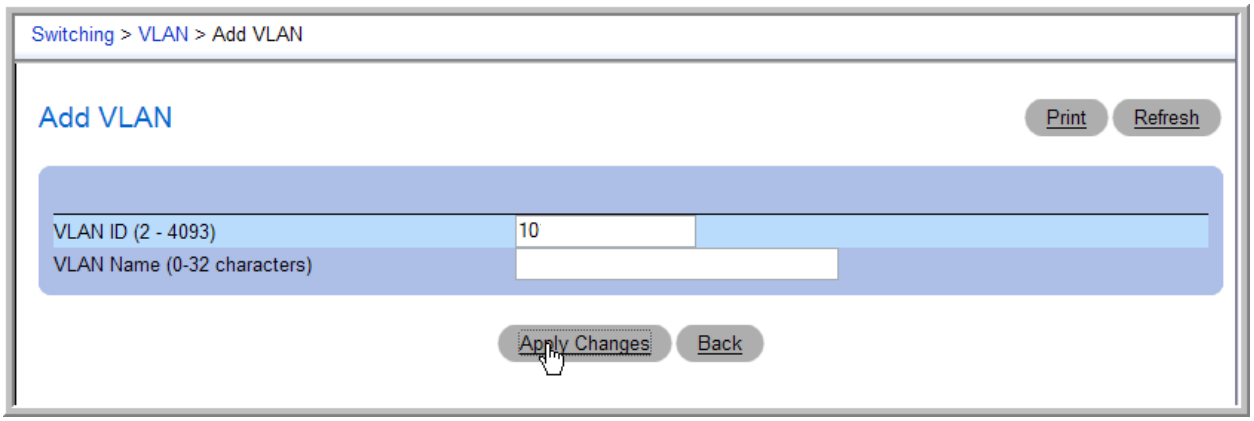
CONFIGURING BRIDGE BrA (WEB INTERFACE)

Use the following procedures to configure the Dell PowerConnect 6248 as bridge BrA as shown in Figure 6 by using the Web interface.

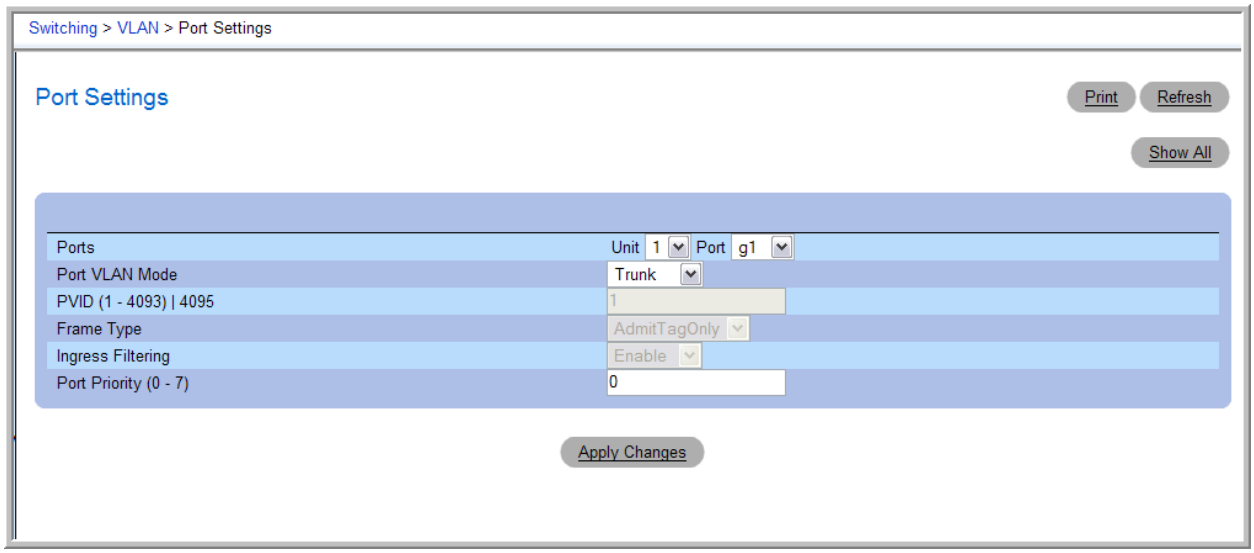
1. From the Switching > VLAN > VLAN Membership page, click Add.



2. From the **Add VLAN** page, enter 10 in the **VLAN ID** field and click **Apply Changes**.

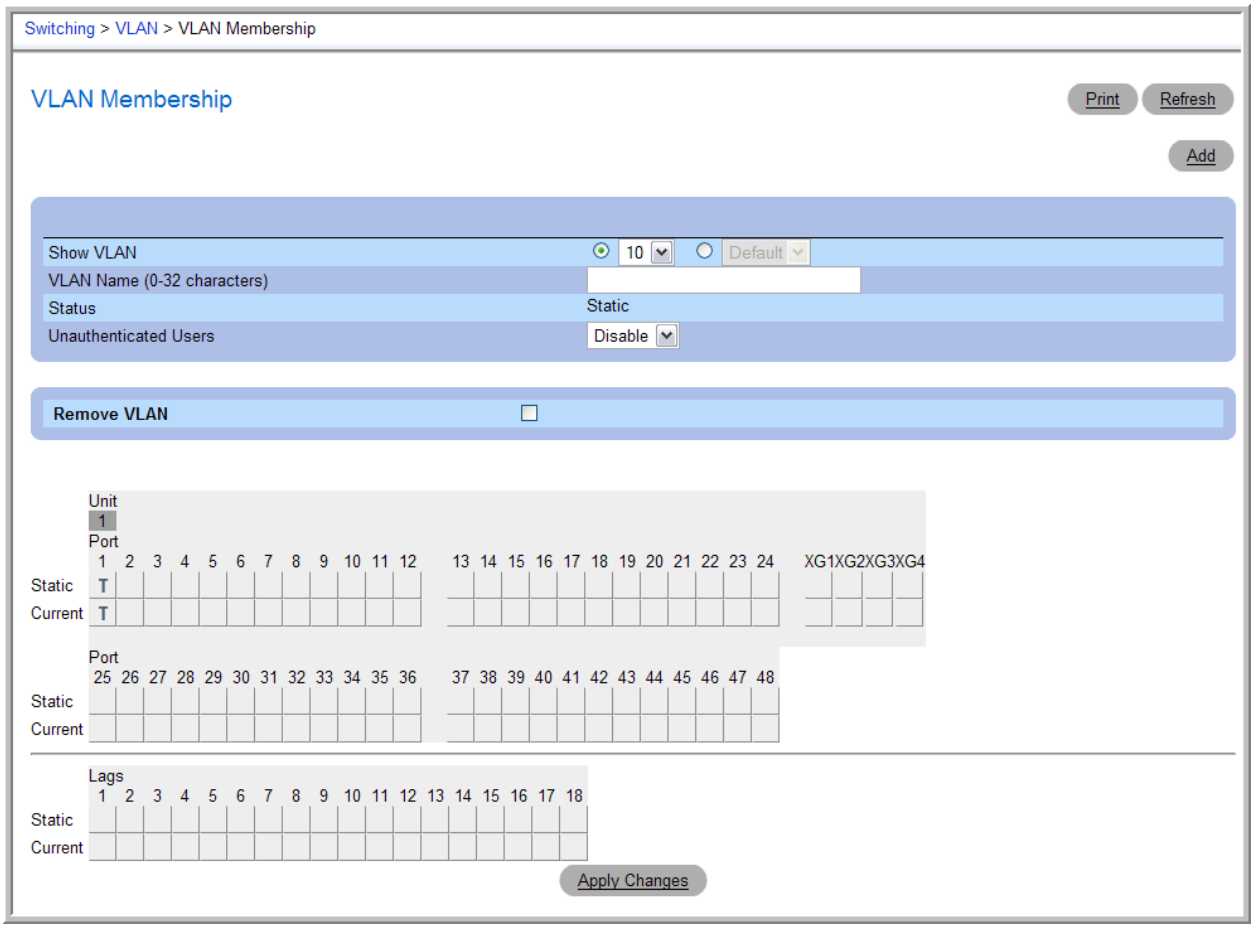


3. Add VLAN 20.
4. To configure Port g1 as a trunk port, go to the **Switching > VLAN > Port Settings** page, select Trunk from the **Port VLAN Mode** menu for Port g1, and click **Apply Changes**.



5. On the **Switching > VLAN > VLAN Membership** page, select VLAN 10 from the **Show VLAN** menu.

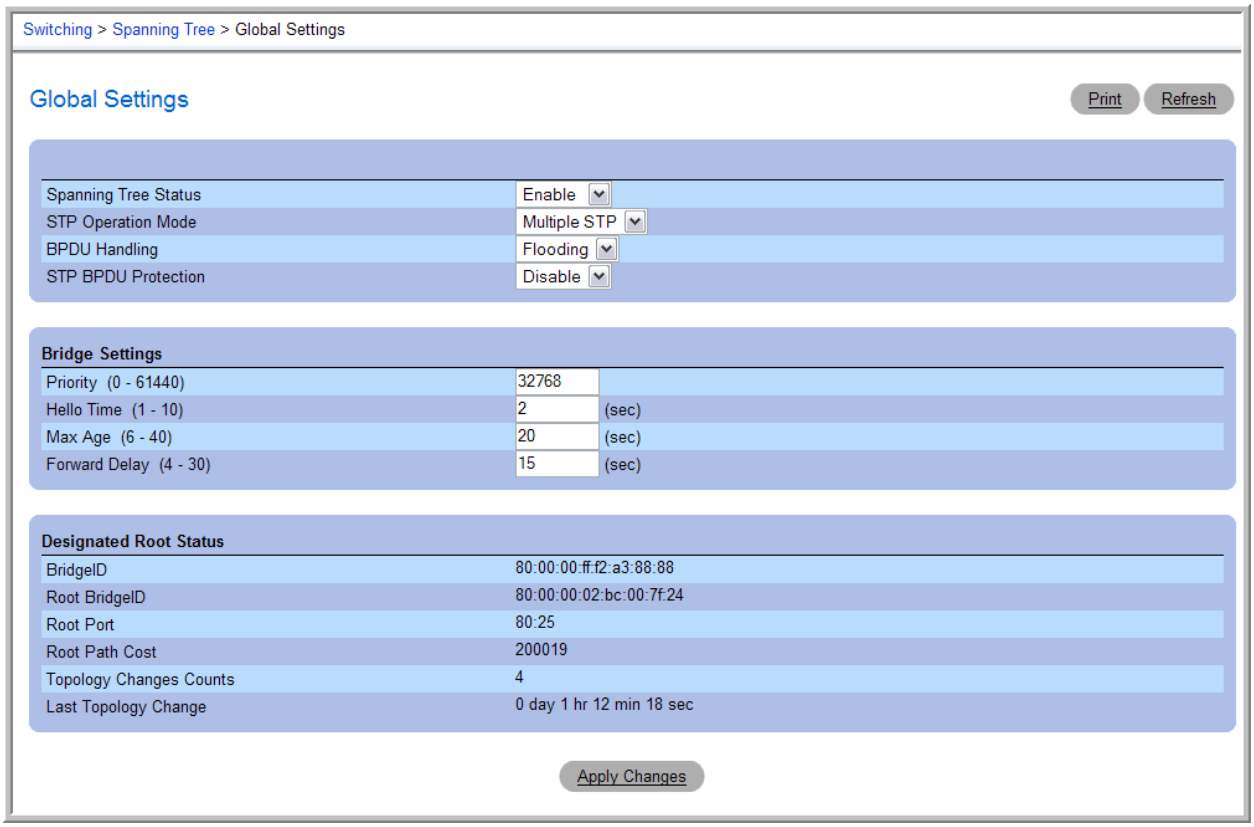
6. Add port 1 to VLAN 10 as a tagged interface.



7. Select VLAN 20 from the Show VLAN menu and add port 1 as a tagged interface.

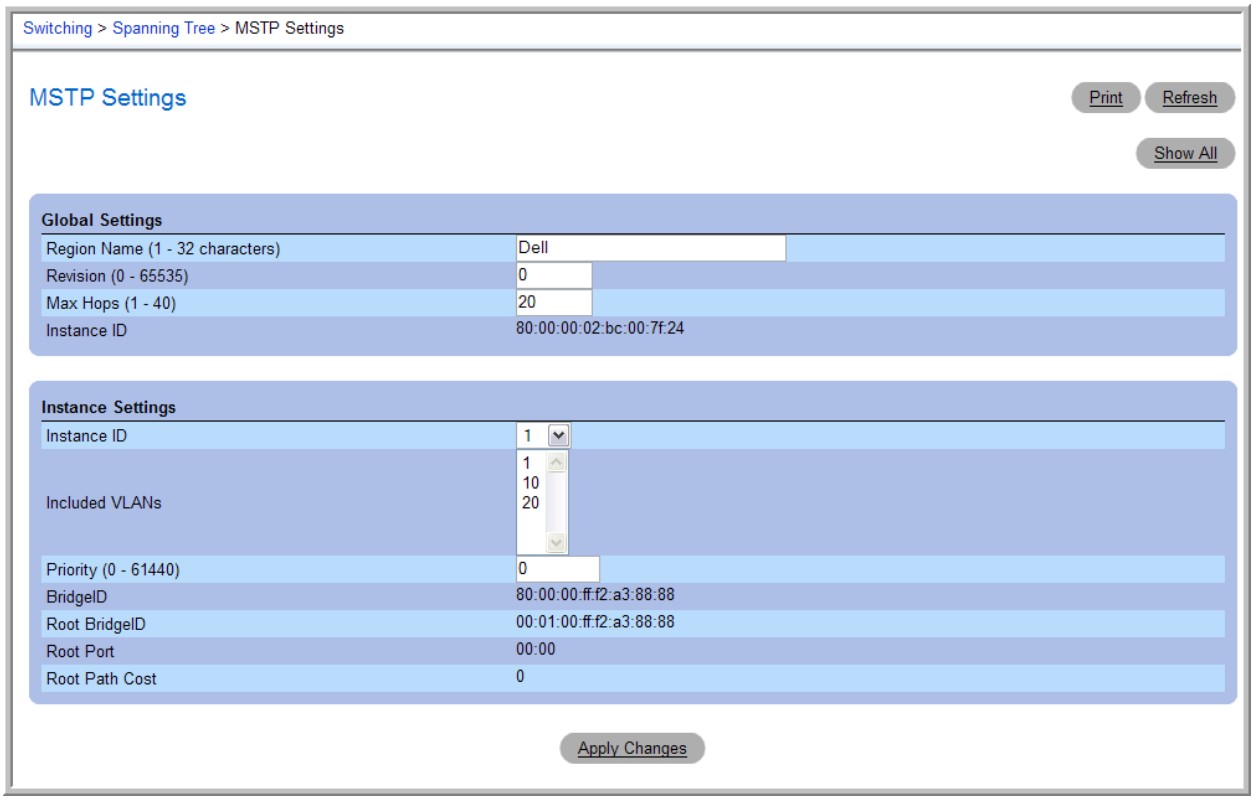
8. Repeat steps 4-7 to configure Port 2 as a Trunk port with VLAN members 10 and 20.

9. From the **Switching > Spanning Tree > Global Settings** page, enable MSTP and select Multiple STP from the **STP Operation Mode** menu.



10. Click **Apply Changes.**

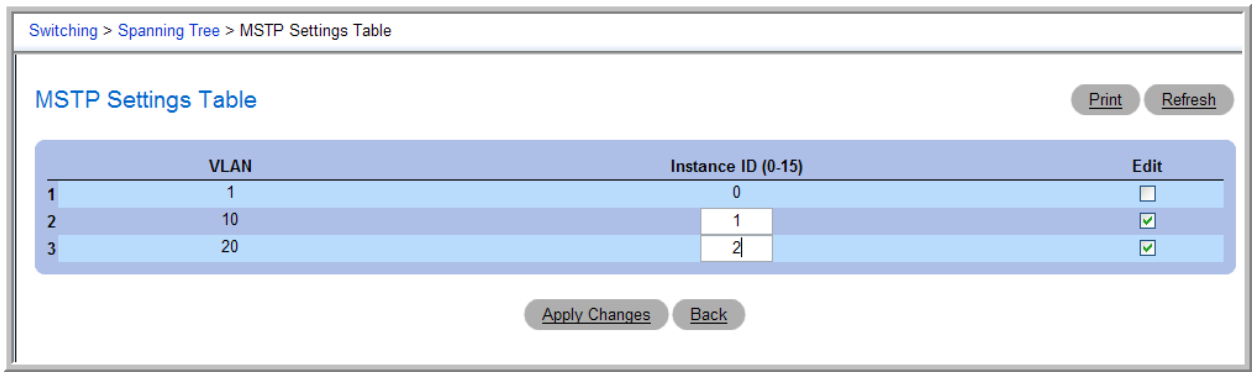
11. On the **Switching > Spanning Tree > MSTP Settings** page, enter Dell as the **Region Name**, 0 as the **Priority**, and click **Apply Changes**.



12. Click **Show All** to access the **MSTP Settings Table**.

13. Click the Edit option for VLANs 10 and 20.

14. To map the VLANs to the appropriate MSTP instances, enter 1 in the Instance ID field for VLAN 10 and 2 in the Instance ID field for VLAN 20, and then click **Apply Changes**.



CONFIGURING BRIDGE BrB

To configure Bridge BrB, use the same commands as you used to configure Bridge BrA with one exception: do not use the **`spanning-tree mst 1 priority 0`** command on Bridge BrB because it is not a root bridge for any instance. If you use the Web interface to configure Bridge BrB, do not enter a new value in the Priority field on the **Switching > Spanning Tree > MSTP Settings** page.

CONFIGURING BRIDGE BrC

Use the commands in this section to configure the Cisco Catalyst3750 switch as bridge BrA.

```
Cisco3750_BrC(vlan)#vlan 10
VLAN 10 added:
  Name: VLAN010
Cisco3750_BrC(vlan)#vlan 20
VLAN 20 added:
  Name: VLAN020
Cisco3750_BrC(vlan)#exit
APPLY completed.
Exiting....
Cisco3750_BrC#configure terminal
Cisco3750_BrC(config)#interface GigabitEthernet 1/0/1
Cisco3750_BrC(config-if)#switchport trunk encapsulation dot1q
Cisco3750_BrC(config-if)#switchport trunk allowed vlan 10,20
Cisco3750_BrC(config-if)#switchport mode trunk
Cisco3750_BrC(config-if)#exit
Cisco3750_BrC(config)#interface GigabitEthernet 1/0/2
Cisco3750_BrC(config-if)#switchport trunk encapsulation dot1q
Cisco3750_BrC(config-if)#switchport trunk allowed vlan 10,20
Cisco3750_BrC(config-if)#switchport mode trunk
Cisco3750_BrC(config-if)#exit
Cisco3750_BrC(config)#spanning-tree mst configuration
Cisco3750_BrC(config-mst)#name Dell
Cisco3750_BrC(config-mst)#instance 1 vlan 10
Cisco3750_BrC(config-mst)#instance 2 vlan 20
Cisco3750_BrC(config-mst)#exit
Cisco3750_BrC(config)#spanning-tree mst 2 priority 0
Cisco3750_BrC(config)#exit
Cisco3750_BrC#exit
```

Command	Description
`vlan 10`	Create VLAN 10
`vlan 20`	Create VLAN 20
`exit`	Exit to privileged EXEC mode
`configure terminal`	Enter configuration mode
`interface GigabitEthernet 1/0/1`	Enter configuration mode for the interface on slot 1, port 1
`switchport trunk encapsulation dot1q`	Set the trunking encapsulation format to 802.1Q
`switchport trunk allowed vlan 10,20`	Add VLANs 10 and 20 to the trunk port

Command	Description
`switchport mode trunk`	Enable trunking on the interface
`exit`	Exit to configuration mode
`interface GigabitEthernet 1/0/2`	Enter configuration mode for the interface on slot 1, port 2
`switchport trunk encapsulation dot1q`	Set the trunking encapsulation format to 802.1Q
`switchport trunk allowed vlan 10,20`	Add VLANs 10 and 20 to the trunk port
`switchport mode trunk`	Enable trunking on the interface
`exit`	Exit to configuration mode
`spanning-tree mst configuration`	Enter the configuration mode for MST
`name Dell`	Create Dell as the MST configuration name
`instance 1 vlan 10`	Map VLAN 10 to MST instance 1
`instance 2 vlan 20`	Map VLAN 20 to MST instance 2
`exit`	Exit to configuration mode
`spanning-tree mst 2 priority 0`	Sets the switch priority for MSTP instance 2 to zero, which essentially sets this switch as the root bridge for MSTP instance 2
`exit`	Exit to Privileged EXEC mode

CONFIGURING EDGE DEVICES

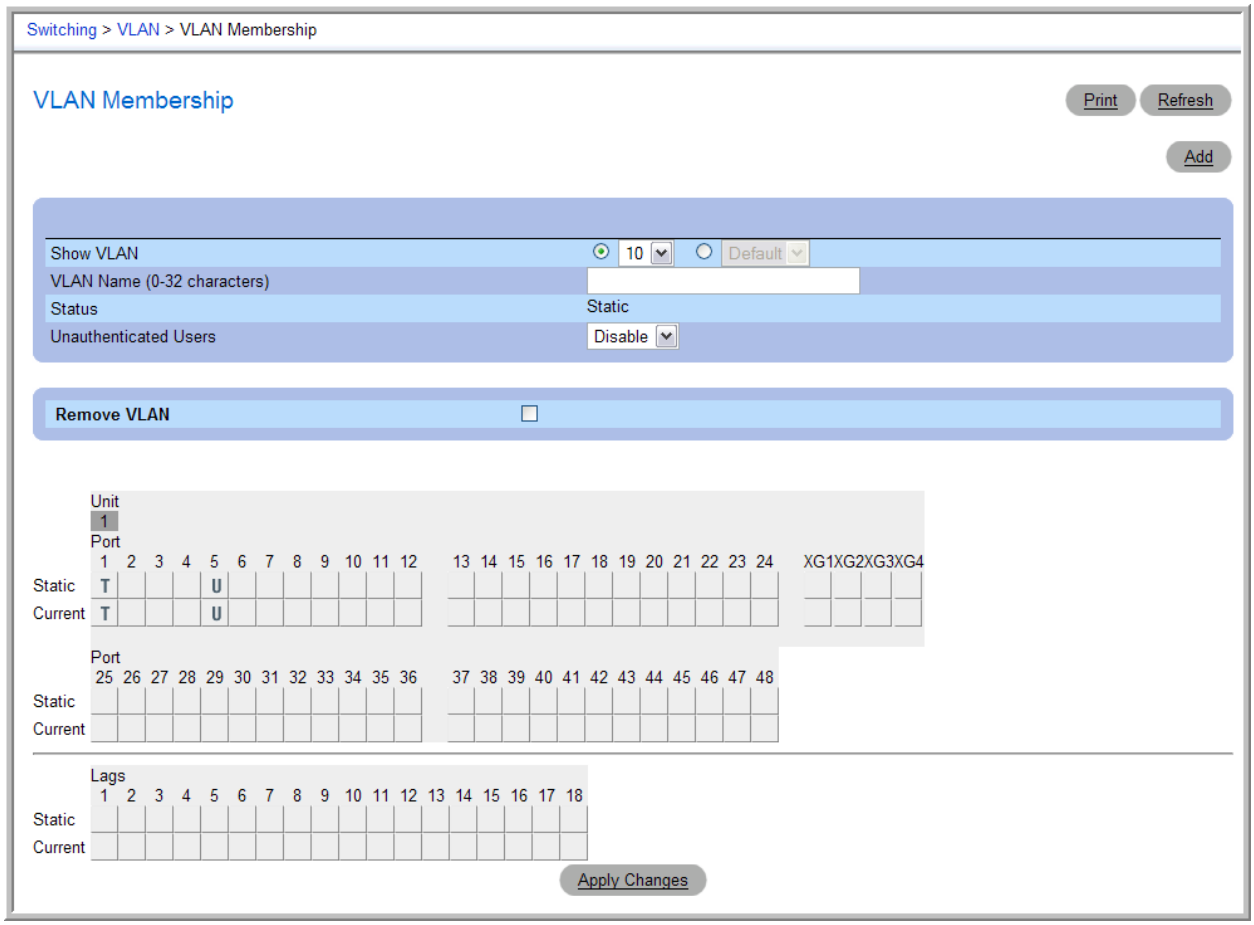
The configuration examples for BrA, BrB, and BrC show trunk ports between bridges. To configure a port to any VLAN-unaware devices or edge devices, you must add the ports in access mode. An access port connects to a single end station belonging to a single VLAN.

The following commands, executed on the Dell PowerConnect switch BrB, show how to send untagged traffic into port 1/g5 that must pass through vlan 10 or MSTP instance 1.

```
Dell_BrB(config)#interface ethernet 1/g5
Dell_BrB(config-if-1/g5)#switchport mode access
Dell_BrB(config-if-1/g5)#switchport access vlan 10
Dell_BrB(config-if-1/g5)#exit
```

Command	Description
`interface ethernet 1/g5`	Enter configuration mode for the interface on slot 1, port 5
`switchport mode access`	Configure the VLAN membership mode of the port as access
`switchport access vlan 10`	Configure the VLAN ID to use when the interface is in access mode. This also sets port PVID to 10
`exit`	Exit to configuration mode

To perform the same configuration by using the Web interface, go to the **Switching > VLAN > VLAN Membership** page, and add port 5 as an access ports in VLAN 10. Ethernet traffic on this port will be untagged.



VIEWING THE MSTP STATUS

You can view the MSTP Region configuration on the three bridges by using the following command:

```
show spanning-tree mst configuration
```

The command is the same on the Dell and Cisco switches.

Bridge BrA (Dell)

```
Dell_BrA#show spanning-tree mst-configuration

Name: Dell
Revision: 0

    Instance   Vlan Mapped
    --------   -----------
    0          1
    1          10
    2          20
```

Bridge BrB (Dell)

```
Dell_BrB#show spanning-tree mst-configuration

Name: Dell
Revision: 0

    Instance   Vlan Mapped
    --------   -----------
    0          1
    1          10
    2          20
```

Bridge BrC (Cisco)

```
Cisco3750_BrC#show spanning-tree mst configuration
Name   [Dell]
Revision 0   Instances configured 3

    Instance   Vlan Mapped
    --------   -----------
    0          1-9,11-19,21-4094
    1          10
    2          20
```

ADDITIONAL MSTP STATUS INFORMATION

You can also view information about MSTP states with the following command:

```
show spanning-tree active
```

The command is the same on the Dell and Cisco switches.

Bridge BrC (Cisco)

```
Cisco3750_BrC#show spanning-tree active

MST0
    Spanning tree enabled protocol mstp
    Root ID     Priority       32768
                Address        0000.0000.0fff
                Cost           0
                Port           1 (GigabitEthernet1/0/1)
                Hello Time     2 sec
                Max Age        20 sec
                Forward Delay  15 sec

    Bridge ID   Priority       32768
                               (priority 32768 sys-id-ext 0)
                Address    0015.6210.2900
                Hello Time     2 sec
                Max Age        20 sec
                Forward Delay  15 sec

    Interface   Role    Sts     Cost    Prio.Nbr    Type
    ----------- ----    ---     -----   --------    -----
    Gi1/0/1     Root    FWD     20000   128.1       P2p
    Gi1/0/2     Desg    FWD     20000   128.2       P2p


MST1
    Spanning tree enabled protocol mstp
    Root ID     Priority       32769
                Address        0000.0000.0fff
                Cost           20000
                Port           1 (GigabitEthernet1/0/1)
                Hello Time     2 sec
                Max Age        20 sec
                Forward Delay  15 sec

    Bridge ID   Priority       32769
                               (priority 32768 sys-id-ext 1)
                Address        0015.6210.2900
                Hello Time     2 sec
                Max Age        20 sec
                Forward Delay  15 sec

    Interface   Role    Sts     Cost    Prio.Nbr    Type
    ----------- ----    ---     -----   --------    -----
    Gi1/0/1     Root    FWD     20000   128.1       P2p
    Gi1/0/2     Desg    FWD     20000   128.2       P2p

MST2
    Spanning tree enabled protocol mstp
    Root ID  Priority     2
        Address    0015.6210.2900
        This bridge is the root
        Hello Time     2 sec
                Max Age        20 sec
                Forward Delay  15 sec

    Bridge ID Priority    2
                               (priority 0 sys-id-ext 2)
        Address        0015.6210.2900
        Hello Time     2 sec
                Max Age        20 sec
                Forward Delay  15 sec
```

```
    Interface  Role    Sts     Cost    Prio.Nbr    Type
    ---------- ----    ---     -----   --------    -----
    Gi1/0/1    Desg    FWD     20000   128.1   P2p
    Gi1/0/2    Desg    FWD     20000   128.2   P2p

Cisco3750_BrC#
```

Bridge BrA (Dell)

```
Dell_BrA# show spanning-tree active
Spanning tree Enabled mode mstp
CST Regional Root: 80:00:00:00:00:00:0F:FF
Regional Root Path Cost: 0

###### MST 0 Vlan Mapped:  1
ROOT ID
            Address        80:00:00:00:00:00:0F:FF
            This Switch is the Root.
            Hello Time     2 Sec
            Max Age        20 sec
            Forward Delay  15 sec

    Interfaces

    Name    State    Prio.Nbr   Cost    Sts     Role    PortFast    RootPort
    ------  -----    --------   -----   ----    -----   --------    -------
    1/g1    Enabled  128.1      20000   FWD     Desg    No          No
    1/g2    Enabled  128.2      20000   FWD     Desg    No          No

###### MST 1 Vlan Mapped:  10
ROOT ID
            Address        80:01:00:00:00:00:0F:FF
            This Switch is the Root.
            Hello Time     2 Sec
            Max Age        20 sec
            Forward Delay  15 sec
Interfaces

    Name    State    Prio.Nbr   Cost    Sts     Role    PortFast    RootPort
    ------  -----    --------   -----   ----    -----   --------    -------
    1/g1    Enabled 128.1      20000   FWD     Desg    No          No
    1/g2    Enabled 128.2      20000   FWD     Desg    No          No

###### MST 2 Vlan Mapped:  20
ROOT ID
            Address        00:02:00:15:62:10:29:00
            Path Cost      20000
            Root Port      1/g1
            Hello Time     2 Sec
            Max Age        20 sec
            Forward Delay  15 sec
Bridge ID
            Priority       32768
            Address        80:02:00:00:00:00:0F:FF
            Hello Time     2 Sec
            Max Age        20 sec
            Forward Delay  15 sec
Interfaces

 Name  State  Prio.Nbr  Cost    Sts Role PortFast RootPort
------ -------- --------- ---------- ---- ----- -------- -------
1/g1   Enabled 128.1     20000  FWD Root   No   No
1/g2   Enabled 128.2     20000  FWD Desg   No   No

Dell_BrA#
```

Bridge BrB (Dell)

```
Dell_BrB#show spanning-tree active
Spanning tree Enabled mode mstp
CST Regional Root: 80:00:00:00:00:00:0F:FF
Regional Root Path Cost: 20000

###### MST 0 Vlan Mapped:  1
    ROOT ID
        Address        80:00:00:00:00:00:0F:FF
        Path Cost      0
        Root Port   1/g1
        Hello Time     2 Sec
        Max Age        20 sec
        Forward Delay  15 sec

    Bridge ID
        Priority       32768
        Address        80:00:00:84:00:00:0F:FF
        Hello Time     2 Sec
        Max Age        20 sec
        Forward Delay  15 sec

Interfaces

    Name    State    Prio.Nbr   Cost    Sts     Role    PortFast    RootPort
    ------  -----    --------   -----   ----    -----   --------    -------
    1/g1    Enabled  128.1      20000   FWD     Root    No          No
    1/g2    Enabled  128.2      20000   DSC     Altn    No          No

###### MST 1 Vlan Mapped:  10
    ROOT ID
        Address        80:01:00:00:00:00:0F:FF
        Path Cost      20000
        Root Port      1/g1
        Hello Time     2 Sec
        Max Age        20 sec
        Forward Delay  15 sec

    Bridge ID
        Priority       32768
        Address        80:01:00:84:00:00:0F:FF
        Hello Time     2 Sec
        Max Age        20 sec
        Forward Delay  15 sec

Interfaces

    Name    State    Prio.Nbr   Cost    Sts     Role    PortFast    RootPort
    ------  -----    --------   -----   ----    -----   --------    -------
    1/g1    Enabled  128.1      20000   FWD     Root    No          No
    1/g2    Enabled  128.2      20000   DSC     Altn    No          No
```

```
###### MST 2 Vlan Mapped:  20
    ROOT ID
        Address        00:02:00:15:62:10:29:00
        Path Cost      20000
        Root Port      1/g2
        Hello Time     2 Sec
        Max Age        20 sec
        Forward Delay  15 sec

    Bridge ID
        Priority       32768
        Address        80:02:00:84:00:00:0F:FF
        Hello Time     2 Sec
        Max Age        20 sec
        Forward Delay  15 sec

Interfaces

    Name    State    Prio.Nbr   Cost    Sts     Role    PortFast    RootPort
    ------  -----    --------   -----   ----    -----   --------    -------
    1/g1    Enabled  128.1      20000   DSC     Altn    No          No
    1/g2    Enabled  128.2      20000   FWD     Root    No          No

Dell_BrB#
```

ADDITIONAL INFORMATION AND SCALABILITY WITH MORE REGIONS

To further illustrate the full connectivity in an MSTP active topology, the following rules apply:

- Each Bridge or LAN is in one and only one MSTP region.
- Every frame is associated with one and only one VID.
- Frames are allocated either to the IST or MSTI within any given region.
- The IST and each MSTI provides full and simple connectivity between all LANs and bridges in a region.
- All bridges within a region reach a consistent agreement as to which ports interconnect that region to a different region and label those as *boundary ports*.
- At the boundary ports, frames allocated to the CIST or MSTIs are forwarded or not forwarded alike.
- The CIST provides full and simple connectivity between all LANs and bridges in the network.

Frames with VIDs not allocated to an + MSTI will be implicitly assigned to the CIST (or IST within the region), and they will be processed or passed on through the region. For example, in Figure 7, VLAN 30 is not explicitly assigned to any instance but by default, it will still rely on the CIST since the two bridges define a region (MST Region 2). Since the two bridges process frames internal to Region 2, an MSTI Regional Root Bridge must again be elected. In this example, Bridge BrA2 is chosen since it has the lowest external root path cost through a boundary port.

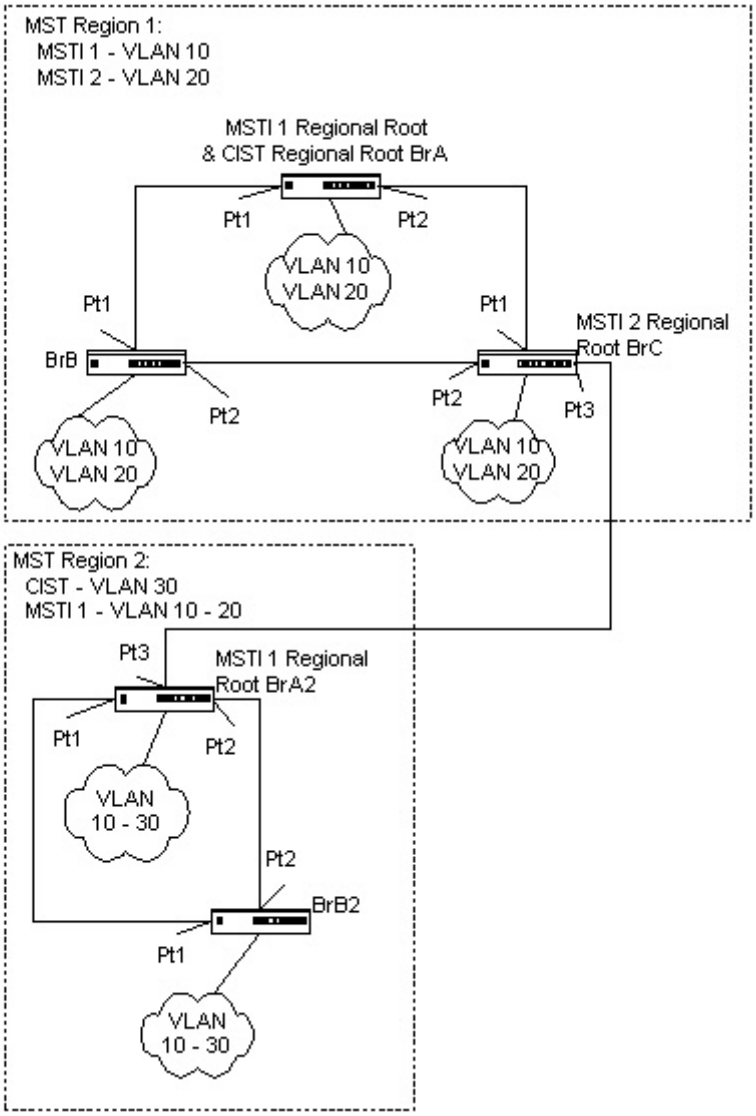


Figure 7: Multiple MSTP Regions

In Figure 8, a third region has been added to the topology. Even though this new region only consists of one bridge and has an MST Configuration Identifier that matches the bridges in Region 1, it will still be isolated into a region by itself. This is due to the fact that the only connection between Region 1 and Region 3 is through a different region.

The path of a frame for VLAN 20 can be traced through the MST active topology. A frame originating on an end station on bridge BrA in Region 1 will traverse the MSTI 2 active topology since its VID has been allocated to that instance. In looking for a destination match with a device in Region 3, it will pass through the boundary port in bridge BrC and continue through Region 2 using the instance MSTI 1. Assuming that port Pt2 on both bridge BrA2 and BrB2 are forwarding for the MSTI 1, the frame would arrive at the boundary port on bridge BrB2 and then be sent to Region 3. Upon arriving in Region 3, the frame would traverse MSTI 2 to the destination device.

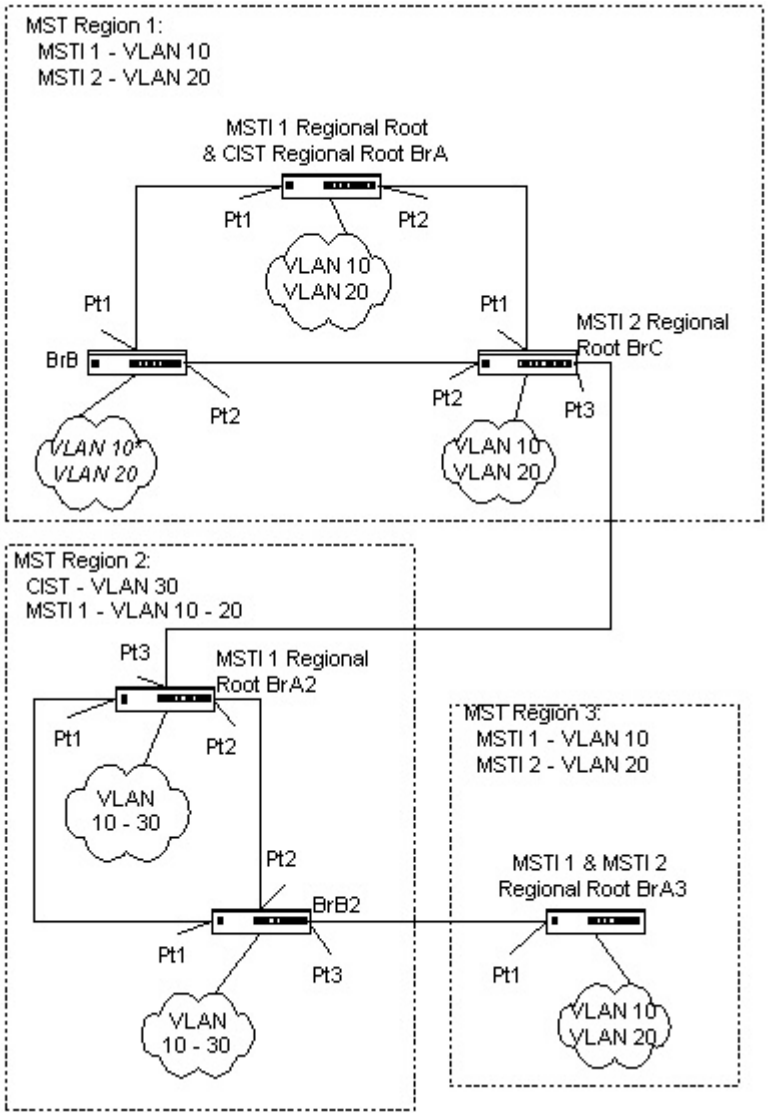


Figure 8: Multiple MSTP Region Interactions