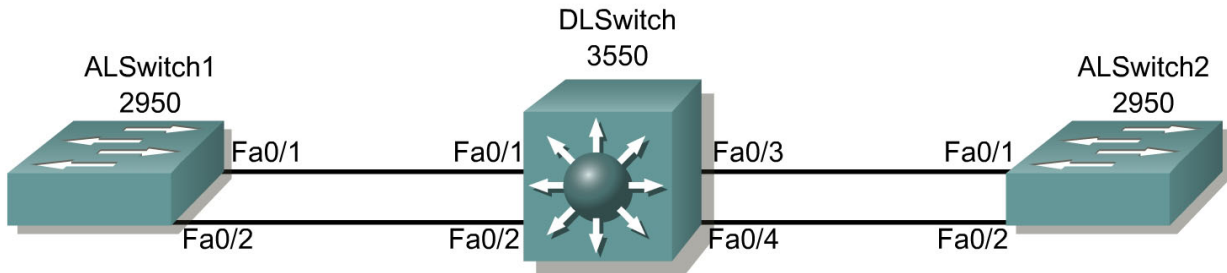


### Lab 3.10.3 Advanced PVST+ Configuration



#### Objective

The purpose of this lab is to modify the default per-VLAN spanning tree plus (PVST+) configuration to control the spanning tree behavior.

#### Scenario

A switched network has just been installed. By default, Cisco IOS uses per-VLAN spanning tree (PVST). The network administrator would like the distribution layer switch to be the root spanning-tree switch. The administrator would like to use port priorities to control which links are elected as the active links. Convergence time will be decreased by adjusting the spanning-tree timers.

#### Step 1

The same set up and basic configurations used in Lab 3.10.1 can be used for this lab. If necessary, clear the configurations by deleting the vlan.dat and startup configuration files, power cycle the switches, and reenter the basic configurations into each switch as follows:

- Configure hostnames for the respective switches according to the diagram.
- Configure all switches with the secret password "class".
- Configure all switches with the login console password "cisco".
- Connect the switches according to the diagram.

Remember that the output for each switch will be different from the sample outputs in relation to MAC addresses and which switch is the Root Bridge.

Console into the DLSwitch. View the spanning-tree output.

```

DLSwitch#show spanning-tree

VLAN0001
  Spanning tree enabled protocol ieee
  Root ID    Priority    32769
             Address     0009.430f.a400
             Cost        19
             Port        3 (FastEthernet0/3)
             Hello Time  2 sec    Max Age 20 sec    Forward Delay 15 sec

  Bridge ID  Priority    32769 (priority 32768 sys-id-ext 1)
             Address     000a.b701.f700
  
```

```

Hello Time 2 sec Max Age 20 sec Forward Delay 15 sec
Aging Time 300

```

Interface Name	Port ID Prio.Nbr	Cost	Sts	Designated Cost	Bridge ID	Port ID Prio.Nbr
Fa0/1	128.1	19	FWD	19	32769 000a.b701.f700	128.1
Fa0/2	128.2	19	FWD	19	32769 000a.b701.f700	128.2
Fa0/3	128.3	19	FWD	0	32769 0009.430f.a400	128.1
Fa0/4	128.4	19	BLK	0	32769 0009.430f.a400	128.2

Console into the ALSwitch1. View the spanning-tree output.

```
ALSwitch1#show spanning-tree
```

```

VLAN0001
Spanning tree enabled protocol ieee
Root ID    Priority    32769
           Address    0009.430f.a400
           Cost      38
           Port      1 (FastEthernet0/1)
           Hello Time 2 sec Max Age 20 sec Forward Delay 15 sec

Bridge ID  Priority    32769 (priority 32768 sys-id-ext 1)
           Address    000a.8afc.dd80
           Hello Time 2 sec Max Age 20 sec Forward Delay 15 sec
           Aging Time 300

```

Interface Name	Port ID Prio.Nbr	Cost	Sts	Designated Cost	Bridge ID	Port ID Prio.Nbr
Fa0/1	128.1	19	FWD	19	32769 000a.b701.f700	128.1
Fa0/2	128.2	19	BLK	19	32769 000a.b701.f700	128.2

Console into the ALSwitch2. View the spanning-tree output.

```
ALSwitch2#show spanning-tree
```

```

VLAN0001
Spanning tree enabled protocol ieee
Root ID    Priority    32769
           Address    0009.430f.a400
           This bridge is the root
           Hello Time 2 sec Max Age 20 sec Forward Delay 15 sec

Bridge ID  Priority    32769 (priority 32768 sys-id-ext 1)
           Address    0009.430f.a400
           Hello Time 2 sec Max Age 20 sec Forward Delay 15 sec
           Aging Time 300

```

Interface Name	Port ID Prio.Nbr	Cost	Sts	Designated Cost	Bridge ID	Port ID Prio.Nbr
Fa0/1	128.1	19	FWD	0	32769 0009.430f.a400	128.1
Fa0/2	128.2	19	FWD	0	32769 0009.430f.a400	128.2

In the sample outputs above, note that ALSwitch2 is the Root Bridge and the active links between the switches have the lower port numbers.

## Step 2

Configure the DLSwitch to be the primary Root Bridge. This will also lower the bridge priority automatically.

The switch with the lower Bridge ID (BID) is used to determine the root bridge priority. The BID consists of the root bridge priority and the MAC address assigned to the switch. The BID is not a real number. The root bridge priority is expressed in decimal form and the MAC address is expressed in HEX. The default bridge priority has a value of 32768. The current Root Bridge in the above sample output is ALSwitch2 because it has a lower MAC address.

The root bridge priority is at the beginning of the BID. The bridge priority is a very large number. The root bridge priority will always determine the length of the BID because the MAC address is a fixed length.

Newer Cisco switches default to PVST. VLAN 1 will be used for this configuration. The available priority value range is 0 to 61440 in increments of 4096. The default value is 32768. The lower the number, the more likely the switch will be chosen as the root switch. Valid priority values are 0, 4096, 8192, 12288, 16384, 20480, 24576, 28672, 32768, 36864, 40960, 45056, 49152, 53248, 57344, and 61440. All other values are rejected.

For Catalyst 3550 switches with the extended system ID release 12.1(8)EA1 and later, the **spanning-tree vlan 1 root primary** command can be used to set the switch priority to 24576. If all other switches in the VLAN have the default priority, this switch will become the root bridge for VLAN 1.

Console into the DLSwitch. Configure the DLSwitch to be the primary Root Bridge as shown below even if the DLSwitch is already the Root Bridge.

```
DLSwitch(config)#spanning-tree vlan 1 root primary
vlan 1 bridge priority set to 24576
vlan 1 bridge max aging time unchanged at 20
vlan 1 bridge hello time unchanged at 2
vlan 1 bridge forward delay unchanged at 15
```

With the **show spanning-tree** command, verify that the DLSwitch is or became the Root Bridge and the Bridge Priority changed to 24577 as shown in the sample output below.

```
DLSwitch#show spanning-tree
```

```
VLAN0001
Spanning tree enabled protocol ieee
Root ID    Priority    24577
           Address    000a.b701.f700
           This bridge is the root
           Hello Time 2 sec  Max Age 20 sec  Forward Delay 15 sec

Bridge ID  Priority    24577 (priority 24576 sys-id-ext 1)
           Address    000a.b701.f700
           Hello Time 2 sec  Max Age 20 sec  Forward Delay 15 sec
           Aging Time 300
```

Interface Name	Port ID Prio.Nbr	Cost	Sts	Designated Cost	Bridge ID	Port ID Prio.Nbr
Fa0/1	128.1	19	FWD	0 24577	000a.b701.f700	128.1
Fa0/2	128.2	19	FWD	0 24577	000a.b701.f700	128.2
Fa0/3	128.3	19	FWD	0 24577	000a.b701.f700	128.3
Fa0/4	128.4	19	FWD	0 24577	000a.b701.f700	128.4

Notice that all the port status are forwarding. All ports on a root bridge become designated ports. Designated ports are always in the forwarding state.

Console into the ALSwitch1. Verify the spanning-tree status.

```

ALSwitch1#show spanning-tree

VLAN0001
  Spanning tree enabled protocol ieee
  Root ID    Priority    24577
             Address    000a.b701.f700
             Cost      19
             Port      1 (FastEthernet0/1)
             Hello Time 2 sec  Max Age 20 sec  Forward Delay 15 sec

  Bridge ID  Priority    32769 (priority 32768 sys-id-ext 1)
             Address    000a.8afc.dd80
             Hello Time 2 sec  Max Age 20 sec  Forward Delay 15 sec
             Aging Time 300

Interface      Port ID      Designated      Port ID
Name           Prio.Nbr    Cost Sts        Cost Bridge ID      Prio.Nbr
-----
Fa0/1          128.1      19 FWD           0 24577 000a.b701.f700 128.1
Fa0/2          128.2      19 BLK           0 24577 000a.b701.f700 128.2

```

Notice that the root bridge priority is now 24577.

Console into ALSwitch2. Verify the spanning-tree status.

```

ALSwitch2#show spanning-tree

VLAN0001
  Spanning tree enabled protocol ieee
  Root ID    Priority    24577
             Address    000a.b701.f700
             Cost      19
             Port      1 (FastEthernet0/1)
             Hello Time 2 sec  Max Age 20 sec  Forward Delay 15 sec

  Bridge ID  Priority    32769 (priority 32768 sys-id-ext 1)
             Address    0009.430f.a400
             Hello Time 2 sec  Max Age 20 sec  Forward Delay 15 sec
             Aging Time 300

Interface      Port ID      Designated      Port ID
Name           Prio.Nbr    Cost Sts        Cost Bridge ID      Prio.Nbr
-----
Fa0/1          128.1      19 FWD           0 24577 000a.b701.f700 128.3
Fa0/2          128.2      19 BLK           0 24577 000a.b701.f700 128.4

```

### Step 3

Force interface FastEthernet 0/2 to be the active link between DLSwitch and ALSwitch1. The active link is currently interface FastEthernet 0/1.

Console into ALSwitch1. Verify the current port status.

```

ALSwitch1#show spanning-tree

VLAN0001
  Spanning tree enabled protocol ieee
  Root ID    Priority    24577
             Address    000a.b701.f700
             Cost      19
             Port      1 (FastEthernet0/1)
             Hello Time 2 sec  Max Age 20 sec  Forward Delay 15 sec

  Bridge ID  Priority    32769 (priority 32768 sys-id-ext 1)

```

```

Address      000a.8afc.dd80
Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec
Aging Time   300

```

Interface Name	Port ID Prio.Nbr	Cost	Sts	Designated Cost	Bridge ID	Port ID Prio.Nbr
Fa0/1	128.1	19	FWD	0 24577	000a.b701.f700	128.1
Fa0/2	128.2	19	BLK	0 24577	000a.b701.f700	128.2

The higher number port, which is fa 0/2, is the port that is in a blocking state. Both links have port costs of 19.

1. How is Port Path Cost determined? \_\_\_\_\_

Configure port cost to force interface FastEthernet 0/2 to become the active uplink. As with the bridge priority, the lower cost is preferred when selecting the active link. Set the link that is currently blocked to a cost of 1 and the other link to a cost of 100. Note that either value can be changed to produce the desired results.

Change the port cost on the ALSwitch1.

```

ALSwitch1(config-if)#interface fastethernet 0/1
ALSwitch1(config-if)#spanning-tree cost 100
ALSwitch1(config-if)#interface fastethernet 0/2
ALSwitch1(config-if)#spanning-tree cost 1

```

Verify that the port cost and interface status has changed as shown in the sample output below.

```

ALSwitch1#show spanning-tree

VLAN0001
Spanning tree enabled protocol ieee
Root ID    Priority    24577
Address    000a.b701.f700
Cost       19
Port       2 (FastEthernet0/2)
Hello Time 2 sec  Max Age 20 sec  Forward Delay 15 sec

Bridge ID  Priority    32769 (priority 32768 sys-id-ext 1)
Address    000a.8afc.dd80
Hello Time 2 sec  Max Age 20 sec  Forward Delay 15 sec
Aging Time 300

Interface  Port ID    Designated      Port ID
Name       Prio.Nbr   Cost Sts         Cost Bridge ID     Prio.Nbr
-----
Fa0/1     128.1     100 BLK          0 24577 000a.b701.f700 128.1
Fa0/2     128.2     1 FWD          0 24577 000a.b701.f700 128.2

```

2. What changed? \_\_\_\_\_

Console into DLSwitch and configure the same changes for consistency.

```

DLSwitch(config-if)#interface fastethernet 0/1
DLSwitch(config-if)#spanning-tree cost 100
DLSwitch(config-if)#interface fastethernet 0/2
DLSwitch(config-if)#spanning-tree cost 1

```

Use the **show spanning-tree** command to view STP configuration changes.

```
DLSwitch#show spanning-tree
```

```
VLAN0001
```

```
Spanning tree enabled protocol ieee  
Root ID    Priority    24577  
Address    000a.b701.f700  
This bridge is the root  
Hello Time 2 sec    Max Age 20 sec    Forward Delay 15 sec
```

```
Bridge ID  Priority    24577 (priority 24576 sys-id-ext 1)  
Address    000a.b701.f700  
Hello Time 2 sec    Max Age 20 sec    Forward Delay 15 sec  
Aging Time 300
```

Interface Name	Port ID Prio.Nbr	Cost	Sts	Designated Cost	Bridge ID	Port ID Prio.Nbr
Fa0/1	128.1	100	FWD	0 24577	000a.b701.f700	128.1
Fa0/2	128.2	1	FWD	0 24577	000a.b701.f700	128.2
Fa0/3	128.3	19	FWD	0 24577	000a.b701.f700	128.3
Fa0/4	128.4	19	FWD	0 24577	000a.b701.f700	128.4

Interface FastEthernet 0/2 has been forced to become the active link.

#### Step 4

PVST+ is automatically enabled on 802.1Q trunks. No user configuration is required. The external spanning-tree behavior on access ports and Inter-Switch Link (ISL) trunks is not affected by PVST+. Cisco IOS supports a maximum of 128 spanning-tree instances.

Console into DLSwitch. Add additional VLANs then use the **show spanning-tree** command to monitor spanning-tree behavior.

```
DLSwitch#vlan database  
DLSwitch(vlan)#vlan 10 name Accounting  
VLAN 10 added:  
Name: Accounting  
DLSwitch(vlan)#vlan 20 name Marketing  
VLAN 20 added:  
Name: Marketing  
DLSwitch(vlan)#exit  
APPLY completed.  
Exiting....
```

```
DLSwitch#show spanning-tree
```

```
VLAN0001
```

```
Spanning tree enabled protocol ieee  
Root ID    Priority    24577  
Address    000a.b701.f700  
This bridge is the root  
Hello Time 2 sec    Max Age 20 sec    Forward Delay 15 sec
```

```
Bridge ID  Priority    24577 (priority 24576 sys-id-ext 1)  
Address    000a.b701.f700  
Hello Time 2 sec    Max Age 20 sec    Forward Delay 15 sec  
Aging Time 300
```

Interface Name	Port ID Prio.Nbr	Cost	Sts	Designated Cost	Bridge ID	Port ID Prio.Nbr
Fa0/1	128.1	100	FWD	0 24577	000a.b701.f700	128.1
Fa0/2	128.2	1	FWD	0 24577	000a.b701.f700	128.2

```

Fa0/3          128.3          19 FWD          0 24577 000a.b701.f700 128.3
Fa0/4          128.4          19 FWD          0 24577 000a.b701.f700 128.4

```

VLAN0010

Spanning tree enabled protocol ieee

```

Root ID      Priority      32778
Address      0009.430f.a400
Cost         19
Port         3 (FastEthernet0/3)
Hello Time   2 sec    Max Age 20 sec    Forward Delay 15 sec

```

```

Bridge ID    Priority      32778 (priority 32768 sys-id-ext 10)
Address      000a.b701.f700
Hello Time   2 sec    Max Age 20 sec    Forward Delay 15 sec
Aging Time   300

```

Interface Name	Port ID Prio.Nbr	Cost Sts	Designated Cost Bridge ID	Port ID Prio.Nbr
Fa0/1	128.1	100 FWD	19 32778 000a.b701.f700	128.1
Fa0/2	128.2	1 FWD	19 32778 000a.b701.f700	128.2
Fa0/3	128.3	19 FWD	0 32778 0009.430f.a400	128.1
Fa0/4	128.4	19 BLK	0 32778 0009.430f.a400	128.2

VLAN0020

Spanning tree enabled protocol ieee

```

Root ID      Priority      32788
Address      0009.430f.a400
Cost         19
Port         3 (FastEthernet0/3)
Hello Time   2 sec    Max Age 20 sec    Forward Delay 15 sec

```

```

Bridge ID    Priority      32788 (priority 32768 sys-id-ext 20)
Address      000a.b701.f700
Hello Time   2 sec    Max Age 20 sec    Forward Delay 15 sec
Aging Time   300

```

Interface Name	Port ID Prio.Nbr	Cost Sts	Designated Cost Bridge ID	Port ID Prio.Nbr
Fa0/1	128.1	100 FWD	19 32788 000a.b701.f700	128.1
Fa0/2	128.2	1 FWD	19 32788 000a.b701.f700	128.2
Fa0/3	128.3	19 FWD	0 32788 0009.430f.a400	128.1
Fa0/4	128.4	19 BLK	0 32788 0009.430f.a400	128.2

There are now three instances of Spanning-Tree, but DLSwitch may not be the Root Bridge for all the VLANs as in the sample output above. However, port cost is effective on all VLANs because it is applied to the interface.

## Step 5

The STP hello timers can be adjusted to decrease the convergence time. Use the **diameter** keyword to specify the Layer 2 network diameter. The diameter is the maximum number of switch hops between any two end stations in the Layer 2 network. When the network diameter is specified, the switch automatically sets an optimal hello time, forward-delay time, and maximum-age time for the network. This can significantly reduce STP convergence time. Use the **hello** keyword to override the automatically calculated hello time.

Use the **show spanning-tree vlan 1 bridge** command to check the current STP timers.

```
DLSwitch#show spanning-tree vlan 1 bridge
```

Vlan	Bridge ID	Hello Time	Max Age	Fwd Dly	Protocol
VLAN0001	24577 (24576,1) 000a.b701.f700	2	20	15	ieee

Use the `spanning-tree vlan 1 root primary diameter` command to change the timer.

```
DLSwitch(config)#spanning-tree vlan 1 root primary diameter 2
% This switch is already the root bridge of the VLAN0001 spanning tree
vlan 1 bridge priority unchanged at 24576
vlan 1 bridge max aging time set to 10
vlan 1 bridge hello time unchanged at 2
vlan 1 bridge forward delay set to 7
```

Use the `show spanning-tree vlan 1 bridge` command to check the current STP timers.

```
DLSwitch#show spanning-tree vlan 1 bridge
```

Vlan	Bridge ID	Hello Time	Max Age	Fwd Dly	Protocol
VLAN0001	24577 (24576,1) 000a.b701.f700	2	10	7	ieee

Only the forward delay and the max aging times were changed. The `root` command with the `diameter` option should be used to change the STP timers. Default STP timers should not be changed without careful consideration, and if changed, they should be changed only from the Root Bridge. The following commands can be used to change the STP timers:

- `spanning-tree vlan vlan-id hello-time seconds`
- `spanning-tree vlan vlan-id forward-time seconds`
- `spanning-tree vlan vlan-id max-age seconds`