



Configuring STP and MST

This chapter describes how to configure the Spanning Tree Protocol (STP). This chapter also describes how to configure the IEEE 802.1s Multiple Spanning Tree (MST) protocol. MST is an IEEE standard derived from Cisco's proprietary Multi-Instance Spanning-Tree Protocol (MISTP) implementation. With MST, you can map a single spanning-tree instance to several VLANs.

It includes the following major sections:

- [About STP, page 22-1](#)
- [Default STP Configuration, page 22-7](#)
- [Configuring STP, page 22-7](#)
- [About MST, page 22-22](#)
- [MST Configuration Restrictions and Guidelines, page 22-28](#)
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- [About MST-to-PVST+ Interoperability \(PVST+ Simulation\), page 22-35](#)
- [Configuring PVST+ Simulation, page 22-36](#)
- [About Detecting Unidirectional Link Failure, page 22-40](#)



Note

For complete syntax and usage information for the switch commands used in this chapter, see the [Cisco IOS Command Reference Guides for the Catalyst 4500 Series Switch](#).

If a command is not in the *Cisco Catalyst 4500 Series Switch Command Reference*, you can locate it in the [Cisco IOS Master Command List, All Releases](#).

About STP

STP is a Layer 2 link management protocol that provides path redundancy while preventing undesirable loops in the network. For a Layer 2 Ethernet network to function properly, only one active path can exist between any two stations. A loop-free subset of a network topology is called a spanning tree. The operation of a spanning tree is transparent to end stations, which cannot detect whether they are connected to a single LAN segment or a switched LAN of multiple segments.

Beginning in Cisco IOS Release 15.2(4)E and Cisco IOS Release 3.8.0E, Cisco Catalyst 4500 series, Cisco Catalyst 4900M, Cisco Catalyst 4948E and Cisco Catalyst 4948F switches., by default, use STP (the IEEE 802.1w RSTP) on all VLANs. By default, a single spanning tree runs on each configured VLAN (provided you do not manually disable the spanning tree). You can enable and disable a spanning tree on a per-VLAN basis.

When you create fault-tolerant internetworks, you must have a loop-free path between all nodes in a network. The spanning tree algorithm calculates the best loop-free path throughout a switched Layer 2 network. Switches send and receive spanning tree frames at regular intervals. The switches do not forward these frames, but use the frames to construct a loop-free path.

Multiple active paths between end stations cause loops in the network. If a loop exists in the network, end stations might receive duplicate messages and switches might learn end station MAC addresses on multiple Layer 2 interfaces. These conditions result in an unstable network.

A spanning tree defines a tree with a root switch and a loop-free path from the root to all switches in the Layer 2 network. A spanning tree forces redundant data paths into a standby (blocked) state. If a network segment in the spanning tree fails and a redundant path exists, the spanning tree algorithm recalculates the spanning tree topology and activates the standby path.

When two ports on a switch are part of a loop, the spanning tree port priority and port path cost setting determine which port is put in the forwarding state and which port is put in the blocking state. The spanning tree port priority value represents the location of an interface in the network topology and how well located it is to pass traffic. The spanning tree port path cost value represents media speed.

These sections describe STP:

- [Understanding the Bridge ID, page 22-2](#)
- [Bridge Protocol Data Units, page 22-3](#)
- [Election of the Root Bridge, page 22-4](#)
- [STP Timers, page 22-4](#)
- [Creating the STP Topology, page 22-5](#)
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- [MAC Address Allocation, page 22-6](#)
- [STP and IEEE 802.1Q Trunks, page 22-6](#)
- [Per-VLAN Rapid Spanning Tree, page 22-6](#)

Understanding the Bridge ID

Each VLAN on each network device has a unique 64-bit bridge ID consisting of a bridge priority value, an extended system ID, and an STP MAC address allocation.

Bridge Priority Value

The bridge priority value determines whether a given redundant link is given priority and considered part of a given span in a spanning tree. Preference is given to lower values, and if you want to manually configure a preference, assign a lower bridge priority value to a link than to its redundant possibility. With Cisco IOS releases prior to 12.1(12c)EW, the bridge priority is a 16-bit value (see [Table 22-1](#)). With Cisco IOS Release 12.1(12c)EW and later releases, the bridge priority is a 4-bit value when the extended system ID is enabled (see [Table 22-2](#)). See the “[Configuring the Bridge Priority of a VLAN](#)” section on [page 22-17](#).

Extended System ID

Extended system IDs are VLAN IDs between 1025 and 4096. Cisco IOS Releases 12.1(12c)EW and later releases support a 12-bit extended system ID field as part of the bridge ID (see [Table 22-2](#)). Chassis that support only 64 MAC addresses always use the 12-bit extended system ID. On chassis that support 1024 MAC addresses, you can enable use of the extended system ID. STP uses the VLAN ID as the extended system ID. See the “[Enabling the Extended System ID](#)” section on page 22-9.

Table 22-1 Bridge Priority Value with the Extended System ID Disabled

| Bridge Priority Value | | | | | | | | | | | | | | | |
|-----------------------|--------|--------|--------|--------|--------|--------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| Bit 16 | Bit 15 | Bit 14 | Bit 13 | Bit 12 | Bit 11 | Bit 10 | Bit 9 | Bit 8 | Bit 7 | Bit 6 | Bit 5 | Bit 4 | Bit 3 | Bit 2 | Bit 1 |
| 32768 | 16384 | 8192 | 4096 | 2048 | 1024 | 512 | 256 | 128 | 64 | 32 | 16 | 8 | 4 | 2 | 1 |

Table 22-2 Bridge Priority Value and Extended System ID with the Extended System ID Enabled

| Bridge Priority Value | | | | Extended System ID (Set Equal to the VLAN ID) | | | | | | | | | | | |
|-----------------------|--------|--------|--------|---|--------|--------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| Bit 16 | Bit 15 | Bit 14 | Bit 13 | Bit 12 | Bit 11 | Bit 10 | Bit 9 | Bit 8 | Bit 7 | Bit 6 | Bit 5 | Bit 4 | Bit 3 | Bit 2 | Bit 1 |
| 32768 | 16384 | 8192 | 4096 | VLAN ID | | | | | | | | | | | |

STP MAC Address Allocation

A Catalyst 4500 series switch chassis has either 64 or 1024 MAC addresses available to support software features like STP. Enter the **show module** command to view the MAC address range on your chassis.

Cisco IOS Release 12.1(12c)EW and later releases support chassis with 64 or 1024 MAC addresses. For chassis with 64 MAC addresses, STP uses the extended system ID plus a MAC address to make the bridge ID unique for each VLAN.

Earlier releases support chassis with 1024 MAC addresses. With earlier releases, STP uses one MAC address per-VLAN to make the bridge ID unique for each VLAN.

Bridge Protocol Data Units

The following elements determine the stable active spanning tree topology of a switched network:

- The unique bridge ID (bridge priority and MAC address) associated with each VLAN on each switch
- The spanning tree path cost (or bridge priority value) to the root bridge
- The port identifier (port priority and MAC address) associated with each Layer 2 interface

Bridge protocol data units (BPDUs) contain information about the transmitting bridge and its ports, including the bridge and MAC addresses, bridge priority, port priority, and path cost. The system computes the spanning tree topology by transmitting BPDUs among connecting switches, and in one direction from the root switch. Each configuration BPDU contains at least the following:

- The unique bridge ID of the switch that the transmitting switch believes to be the root switch
- The spanning tree path cost to the root
- The bridge ID of the transmitting bridge
- The age of the message

- The identifier of the transmitting port
- Values for the *hello*, *forward delay*, and *max-age* protocol timers

When a switch transmits a BPDU frame, all switches connected to the LAN on which the frame is transmitted receive the BPDU. When a switch receives a BPDU, it does not forward the frame but instead uses the information in the frame to calculate a BPDU and, if the topology changes, initiate a BPDU transmission.

A BPDU exchange results in the following:

- One switch is elected as the root bridge.
- The shortest distance to the root bridge is calculated for each switch based on the path cost.
- A designated bridge for each LAN segment is selected. It is the switch closest to the root bridge through which frames are forwarded to the root.
- A root port is selected. It is the port providing the best path from the bridge to the root bridge.
- Ports included in the spanning tree are selected.

Election of the Root Bridge

For each VLAN, the switch with the highest bridge priority (the lowest numerical priority value) is elected as the root bridge. If all switches are configured with the default priority value (32,768), the switch with the lowest MAC address in the VLAN becomes the root bridge.

The spanning tree root bridge is the logical center of the spanning tree topology in a switched network. All paths that are not required to reach the root bridge from anywhere in the switched network are placed in spanning tree blocking mode.

A spanning tree uses the information provided by BPDUs to elect the root bridge and root port for the switched network, as well as the root port and designated port for each switched segment.

STP Timers

Table 22-3 describes the STP timers that affect the performance of the entire spanning tree.

Table 22-3 Spanning Tree Protocol Timers

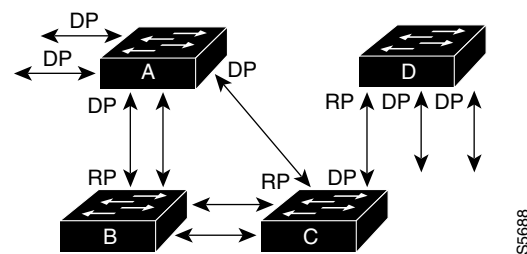
| Variable | Description |
|---------------------|---|
| <i>hello_time</i> | Determines how often the switch broadcasts hello messages to other switches. |
| <i>forward_time</i> | Determines how long each of the listening and learning states last before the port begins forwarding. |
| <i>max_age</i> | Determines the amount of time that protocol information received on a port is stored by the switch. |

Creating the STP Topology

The goal of the spanning tree algorithm is to make the most direct link the root port. When the spanning tree topology is calculated based on default parameters, the path between source and destination end stations in a switched network might not be optimal according to link speed. For instance, connecting higher-speed links to a port that has a higher number than the current root port can cause a root-port change.

In [Figure 22-1](#), Switch A is elected as the root bridge. (This could happen if the bridge priority of all the switches is set to the default value [32,768] and Switch A has the lowest MAC address.) However, due to traffic patterns, the number of forwarding ports, or link types, Switch A might not be the ideal root bridge. By increasing the STP port priority (lowering the numerical value) of the ideal switch so that it becomes the root bridge, you force a spanning tree recalculation to form a new spanning tree topology with the ideal switch as the root.

Figure 22-1 Spanning Tree Topology



RP = Root Port
DP = Designated Port

For example, assume that one port on Switch B is a fiber-optic link, and another port on Switch B (an unshielded twisted-pair [UTP] link) is the root port. Network traffic might be more efficient over the high-speed fiber-optic link. By changing the spanning tree port priority on the fiber-optic port to a higher priority (lower numerical value) than the priority set for the root port, the fiber-optic port becomes the new root port.

STP Port States

Propagation delays can occur when protocol information passes through a switched LAN. As a result, topology changes can take place at different times and at different places in a switched network. When a Layer 2 interface transitions directly from nonparticipation in the spanning tree topology to the forwarding state, it can create temporary data loops. Ports must wait for new topology information to propagate through the switched LAN before starting to forward frames. They must allow the frame lifetime to expire for frames that have been forwarded under the old topology.

Each Layer 2 interface on a switch that uses spanning tree exists in one of the following five states:

- **Blocking**—In this state, the Layer 2 interface does not participate in frame forwarding.
- **Listening**—This state is the first transitional state after the blocking state when spanning tree determines that the Layer 2 interface should participate in frame forwarding.
- **Learning**—In this state, the Layer 2 interface prepares to participate in frame forwarding.
- **Forwarding**—In this state, the Layer 2 interface forwards frames.

- Disabled—In this state, the Layer 2 interface does not participate in spanning tree and does not forward frames.

MAC Address Allocation

The supervisor engine has a pool of 1024 MAC addresses that are used as the bridge IDs for the VLAN spanning trees. Use the **show module** command to view the MAC address range (allocation range for the supervisor) that the spanning tree uses for the algorithm.

MAC addresses for the Catalyst 4506 switch are allocated sequentially, with the first MAC address in the range assigned to VLAN 1, the second MAC address in the range assigned to VLAN 2, and so forth. For example, if the MAC address range is 00-e0-1e-9b-2e-00 to 00-e0-1e-9b-31-ff, the VLAN 1 bridge ID is 00-e0-1e-9b-2e-00, the VLAN 2 bridge ID is 00-e0-1e-9b-2e-01, the VLAN 3 bridge ID is 00-e0-1e-9b-2e-02, and so on. On other Catalyst 4500 series platforms, all VLANs map to the same MAC address rather than mapping to separate MAC addresses.

STP and IEEE 802.1Q Trunks

802.1Q VLAN trunks impose some limitations on the spanning tree strategy for a network. In a network of Cisco switches connected through 802.1Q trunks, the switches maintain one instance of spanning tree for each VLAN allowed on the trunks. However, non-Cisco 802.1Q switches maintain only one instance of spanning tree for all VLANs allowed on the trunks.

When you connect a Cisco switch to a non-Cisco device (that supports 802.1Q) through an 802.1Q trunk, the Cisco switch combines the spanning tree instance of the 802.1Q native VLAN of the trunk with the spanning tree instance of the non-Cisco 802.1Q switch. However, all per-VLAN spanning tree information is maintained by Cisco switches separated by a network of non-Cisco 802.1Q switches. The non-Cisco 802.1Q network separating the Cisco switches is treated as a single trunk link between the switches.

**Note**

For more information on 802.1Q trunks, see [Chapter 18, “Configuring Layer 2 Ethernet Interfaces.”](#)

Per-VLAN Rapid Spanning Tree

Beginning in Cisco IOS XE Release 3.8.0E and Cisco IOS Release 15.2(4)E, Per-VLAN Rapid Spanning Tree (PVRST+) is the default STP mode on Cisco Catalyst 4500 series, Cisco Catalyst 4900M, Cisco Catalyst 4948E and Cisco Catalyst 4948F switches.

Per-VLAN Rapid Spanning Tree is the same as PVST+, although PVRST+ utilizes a rapid STP based on IEEE 802.1w rather than 802.1D to provide faster convergence. PVRST+ uses roughly the same configuration as PVST+ and needs only minimal configuration. In PVRST+, dynamic CAM entries are flushed immediately on a per-port basis when any topology change is made. UplinkFast and BackboneFast are enabled but not active in this mode, because the functionality is built into the Rapid STP. PVRST+ provides for rapid recovery of connectivity following the failure of a bridge, bridge port, or LAN.

Like per-VLAN Spanning Tree (PVST+), per-VLAN Rapid Spanning Tree (PVRST+) instances are equal to the number of vlans configured on the switch and can go up to a maximum of 4094 instances.

For enabling information, see “Enabling Per-VLAN Rapid Spanning Tree” on page 20.

Default STP Configuration

Table 22-4 shows the default spanning tree configuration.

Table 22-4 Spanning Tree Default Configuration Values

| Feature | Default Value |
|---|--|
| Enable state | Spanning tree enabled for all VLANs |
| Bridge priority value | 32,768 |
| Spanning tree port priority value (configurable on a per-interface basis—used on interfaces configured as Layer 2 access ports) | 128 |
| Spanning tree port cost (configurable on a per-interface basis—used on interfaces configured as Layer 2 access ports) | <ul style="list-style-type: none"> • 10-Gigabit Ethernet: 2 • Gigabit Ethernet: 4 • Fast Ethernet: 19 |
| Spanning tree VLAN port priority value (configurable on a per-VLAN basis—used on interfaces configured as Layer 2 trunk ports) | 128 |
| Spanning tree VLAN port cost (configurable on a per-VLAN basis—used on interfaces configured as Layer 2 trunk ports) | <ul style="list-style-type: none"> • 10-Gigabit Ethernet: 2 • Gigabit Ethernet: 4 • Fast Ethernet: 19 |
| Hello time | 2 sec |
| Forward delay time | 15 sec |
| Maximum aging time | 20 sec |

Configuring STP

The following sections describe how to configure spanning tree on VLANs:

- [Enabling STP, page 22-8](#)
- [Enabling the Extended System ID, page 22-9](#)
- [Configuring the Root Bridge, page 22-9](#)
- [Configuring a Secondary Root Switch, page 22-12](#)
- [Configuring STP Port Priority, page 22-13](#)
- [Configuring STP Port Cost, page 22-15](#)
- [Configuring the Bridge Priority of a VLAN, page 22-17](#)
- [Configuring the Hello Time, page 22-17](#)
- [Configuring the Maximum Aging Time for a VLAN, page 22-18](#)
- [Configuring the Forward-Delay Time for a VLAN, page 22-19](#)
- [Disabling Spanning Tree Protocol, page 22-20](#)
- [Enabling Per-VLAN Rapid Spanning Tree, page 22-20](#)

**Note**

The spanning tree commands described in this chapter can be configured on any interface except those configured with the **no switchport** command.

Enabling STP

**Note**

By default, spanning tree is enabled on all the VLANs.

You can enable a spanning tree on a per-VLAN basis. The switch maintains a separate instance of spanning tree for each VLAN (except on VLANs on which you have disabled a spanning tree).

To enable a spanning tree on a per-VLAN basis, perform this task:

| | Command | Purpose |
|--------|--|--|
| Step 1 | Switch# configure terminal | Enters global configuration mode. |
| Step 2 | Switch(config)# spanning-tree vlan <i>vlan_ID</i> | Enables spanning tree for VLAN <i>vlan_id</i> . The <i>vlan_ID</i> value can range from 1 to 4094. |
| Step 3 | Switch(config)# end | Exits configuration mode. |
| Step 4 | Switch# show spanning-tree vlan <i>vlan_ID</i> | Verifies that spanning tree is enabled. |

This example shows how to enable a spanning tree on VLAN 200:

```
Switch# configure terminal
Switch(config)# spanning-tree vlan 200
Switch(config)# end
Switch#
```

**Note**

Because spanning tree is enabled by default, entering a **show running** command to view the resulting configuration does not display the command you entered to enable spanning tree.

This example shows how to verify that spanning tree is enabled on VLAN 200:

```
Switch# show spanning-tree vlan 200

VLAN200 is executing the ieee compatible Spanning Tree protocol
Bridge Identifier has priority 32768, address 0050.3e8d.6401
Configured hello time 2, max age 20, forward delay 15
Current root has priority 16384, address 0060.704c.7000
Root port is 264 (FastEthernet5/8), cost of root path is 38
Topology change flag not set, detected flag not set
Number of topology changes 0 last change occurred 01:53:48 ago
Times: hold 1, topology change 24, notification 2
      hello 2, max age 14, forward delay 10
Timers: hello 0, topology change 0, notification 0

Port 264 (FastEthernet5/8) of VLAN200 is forwarding
Port path cost 19, Port priority 128, Port Identifier 129.9.
Designated root has priority 16384, address 0060.704c.7000
Designated bridge has priority 32768, address 00e0.4fac.b000
Designated port id is 128.2, designated path cost 19
Timers: message age 3, forward delay 0, hold 0
Number of transitions to forwarding state: 1
```



```
BPDU: sent 3, received 3417
```

```
Switch#
```

Enabling the Extended System ID



Note

The extended system ID is enabled permanently on chassis that support 64 MAC addresses.

Use the **spanning-tree extend system-id** command to enable the extended system ID on chassis that support 1024 MAC addresses. See the “[Understanding the Bridge ID](#)” section on page 22-2.

To enable the extended system ID, perform this task:

| | Command | Purpose |
|--------|---|--|
| Step 1 | Switch(config)# spanning-tree extend system-id | Enables the extended system ID. Disables the extended system ID. Note You cannot disable the extended system ID on chassis that support 64 MAC addresses or when you have configured extended range VLANs (see Table 22-4 on page 22-7). |
| Step 2 | Switch(config)# end | Exits configuration mode. |
| Step 3 | Switch# show spanning-tree vlan <i>vlan_ID</i> | Verifies the configuration. |



Note

When you enable or disable the extended system ID, the bridge IDs of all active STP instances are updated, which might change the spanning tree topology.

This example shows how to enable the extended system ID:

```
Switch# configure terminal
Switch(config)# spanning-tree extend system-id
Switch(config)# end
Switch#
```

This example shows how to verify the configuration:

```
Switch# show spanning-tree summary | include extended
Extended system ID is enabled.
```

Configuring the Root Bridge

A Catalyst 4500 series switch maintains an instance of spanning tree for each active VLAN configured on the switch. A bridge ID, consisting of the bridge priority and the bridge MAC address, is associated with each instance. For each VLAN, the switch with the lowest bridge ID becomes the root bridge for that VLAN. Whenever the bridge priority changes, the bridge ID also changes, resulting in the recomputation of the root bridge for the VLAN.

To configure a switch to become the root bridge for the specified VLAN, use the **spanning-tree vlan *vlan-ID* root** command to modify the bridge priority from the default value (32,768) to a significantly lower value. The bridge priority for the specified VLAN is set to 8192 if this value causes the switch to become the root for the VLAN. If any bridge for the VLAN has a priority lower than 8192, the switch sets the priority to 1 less than the lowest bridge priority.

For example, assume that all the switches in the network have the bridge priority for VLAN 100 set to the default value of 32,768. Entering the **spanning-tree vlan 100 root primary** command on a switch sets the bridge priority for VLAN 100 to 8192, causing this switch to become the root bridge for VLAN 100.

**Note**

The root switch for each instance of spanning tree should be a backbone or distribution switch. Do not configure an access switch as the spanning tree primary root.

Use the **diameter** keyword to specify the Layer 2 network diameter (the maximum number of bridge hops between any two end stations in the network). When you specify the network diameter, a switch automatically picks an optimal hello time, forward delay time, and maximum age time for a network of that diameter. This action can significantly reduce the spanning tree convergence time.

Use the **hello-time** keyword to override the automatically calculated hello time.

**Note**

We recommend that you avoid manually configuring the hello time, forward delay time, and maximum age time after configuring the switch as the root bridge.

To configure a switch as the root switch, perform this task:

| | Command | Purpose |
|--------|---|--|
| Step 1 | Switch(config)# [no] spanning-tree vlan <i>vlan_ID</i> root primary [diameter <i>hops</i> [hello-time <i>seconds</i>]] | Configures a switch as the root switch. |
| | | Use the no keyword to restore the defaults. |
| Step 2 | Switch(config)# end | Exits configuration mode. |

This example shows how to configure a switch as the root bridge for VLAN 10, with a network diameter of 4:

```
Switch# configure terminal
Switch(config)# spanning-tree vlan 10 root primary diameter 4
Switch(config)# end
Switch#
```

This example shows how the configuration changes when a switch becomes a spanning tree root. This configuration is the one before the switch becomes the root for VLAN 1:

```
Switch# show spanning-tree vlan 1

VLAN1 is executing the ieee compatible Spanning Tree protocol
 Bridge Identifier has priority 32768, address 0030.94fc.0a00
 Configured hello time 2, max age 20, forward delay 15
 Current root has priority 32768, address 0001.6445.4400
 Root port is 323 (FastEthernet6/3), cost of root path is 19
 Topology change flag not set, detected flag not set
 Number of topology changes 2 last change occurred 00:02:19 ago
   from FastEthernet6/1
 Times: hold 1, topology change 35, notification 2
       hello 2, max age 20, forward delay 15
```

```
Timers:hello 0, topology change 0, notification 0, aging 300
```

```
Port 323 (FastEthernet6/3) of VLAN1 is forwarding
  Port path cost 19, Port priority 128, Port Identifier 129.67.
  Designated root has priority 32768, address 0001.6445.4400
  Designated bridge has priority 32768, address 0001.6445.4400
  Designated port id is 129.67, designated path cost 0
  Timers:message age 2, forward delay 0, hold 0
  Number of transitions to forwarding state:1
  BPDU:sent 3, received 91
```

```
Port 324 (FastEthernet6/4) of VLAN1 is blocking
  Port path cost 19, Port priority 128, Port Identifier 129.68.
  Designated root has priority 32768, address 0001.6445.4400
  Designated bridge has priority 32768, address 0001.6445.4400
  Designated port id is 129.68, designated path cost 0
  Timers:message age 2, forward delay 0, hold 0
  Number of transitions to forwarding state:0
  BPDU:sent 1, received 89
```

You can set the switch as the root:

```
Switch# configure terminal
Switch(config)# spanning-tree vlan 1 root primary
Switch(config)# spanning-tree vlan 1 root primary
  VLAN 1 bridge priority set to 8192
  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
Switch(config)# end
```

This configuration is the one after the switch becomes the root:

```
Switch# show spanning-tree vlan 1

VLAN1 is executing the ieee compatible Spanning Tree protocol
  Bridge Identifier has priority 8192, address 0030.94fc.0a00
  Configured hello time 2, max age 20, forward delay 15
  We are the root of the spanning tree
  Topology change flag set, detected flag set
  Number of topology changes 3 last change occurred 00:00:09 ago
  Times: hold 1, topology change 35, notification 2
         hello 2, max age 20, forward delay 15
  Timers:hello 0, topology change 25, notification 0, aging 15

Port 323 (FastEthernet6/3) of VLAN1 is forwarding
  Port path cost 19, Port priority 128, Port Identifier 129.67.
  Designated root has priority 8192, address 0030.94fc.0a00
  Designated bridge has priority 8192, address 0030.94fc.0a00
  Designated port id is 129.67, designated path cost 0
  Timers:message age 0, forward delay 0, hold 0
  Number of transitions to forwarding state:1
  BPDU:sent 9, received 105

Port 324 (FastEthernet6/4) of VLAN1 is listening
  Port path cost 19, Port priority 128, Port Identifier 129.68.
  Designated root has priority 8192, address 0030.94fc.0a00
  Designated bridge has priority 8192, address 0030.94fc.0a00
  Designated port id is 129.68, designated path cost 0
  Timers:message age 0, forward delay 5, hold 0
  Number of transitions to forwarding state:0
  BPDU:sent 6, received 102

Switch#
```

**Note**

Because the bridge priority is now set at 8192, this switch becomes the root of the spanning tree.

Configuring a Secondary Root Switch

When you configure a switch as the secondary root, the spanning tree bridge priority is modified from the default value (32,768) to 16,384. This means that the switch is likely to become the root bridge for the specified VLANs if the primary root bridge fails (assuming the other switches in the network use the default bridge priority of 32,768).

You can run this command on more than one switch to configure multiple backup root switches. Use the same network diameter and hello time values that you used when configuring the primary root switch.

**Note**

We recommend that you avoid manually configuring the hello time, forward delay time, and maximum age time after configuring the switch as the root bridge.

To configure a switch as the secondary root switch, perform this task:

| | Command | Purpose |
|--------|--|---|
| Step 1 | Switch(config)# [no] spanning-tree vlan vlan_ID root secondary [diameter hops [hello-time seconds]] | Configures a switch as the secondary root switch. Use the no keyword to restore the defaults. |
| Step 2 | Switch(config)# end | Exits configuration mode. |

This example shows how to configure the switch as the secondary root switch for VLAN 10, with a network diameter of 4:

```
Switch# configure terminal
Switch(config)# spanning-tree vlan 10 root secondary diameter 4
VLAN 10 bridge priority set to 16384
VLAN 10 bridge max aging time set to 14
VLAN 10 bridge hello time unchanged at 2
VLAN 10 bridge forward delay set to 10
Switch(config)# end
Switch#
```

This example shows how to verify the configuration of VLAN 1:

```
Switch#sh spanning-tree vlan 1

VLAN0001
  Spanning tree enabled protocol ieee
  Root ID    Priority    32768
            Address    0003.6b10.e800
            This bridge is the root
            Hello Time  2 sec    Max Age 20 sec    Forward Delay 15 sec

  Bridge ID  Priority    32768
            Address    0003.6b10.e800
            Hello Time  2 sec    Max Age 20 sec    Forward Delay 15 sec
            Aging Time 300

Interface          Role Sts Cost          Prio.Nbr Status
-----
Fa3/1              Desg FWD 19           128.129 P2p
```

```

Fa3/2          Desg FWD 19          128.130 P2p
Fa3/48         Desg FWD 19          128.176 Edge P2p

Switch#

```

Configuring STP Port Priority

In the event of a loop, a spanning tree considers port priority when selecting an interface to put into the forwarding state. You can assign higher priority values to interfaces that you want a spanning tree to select first and lower priority values to interfaces that you want a spanning tree to select last. If all interfaces have the same priority value, a spanning tree puts the interface with the lowest interface number in the forwarding state and blocks other interfaces. The possible priority range is 0 through 240, configurable in increments of 16 (the default is 128).



Note

The Cisco IOS software uses the port priority value when the interface is configured as an access port and uses VLAN port priority values when the interface is configured as a trunk port.

To configure the spanning tree port priority of an interface, perform this task:

| | Command | Purpose |
|--------|--|---|
| Step 1 | Switch(config)# interface {{ fastethernet gigabitethernet tengigabitethernet } <i>slot/port</i> { port-channel <i>port_channel_number</i> } | Specifies an interface to configure. |
| Step 2 | Switch(config-if)# [no] spanning-tree port-priority <i>port_priority</i> | Configures the port priority for an interface. The <i>port_priority</i> value can be from 0 to 240, in increments of 16. Use the no keyword to restore the defaults. |
| Step 3 | Switch(config-if)# [no] spanning-tree vlan <i>vlan_ID</i> port-priority <i>port_priority</i> | Configures the VLAN port priority for an interface. The <i>port_priority</i> value can be from 0 to 240, in increments of 16. Use the no keyword to restore the defaults. |
| Step 4 | Switch(config-if)# end | Exits configuration mode. |
| Step 5 | Switch# show spanning-tree interface {{ fastethernet gigabitethernet } <i>slot/port</i> { port-channel <i>port_channel_number</i> } show spanning-tree vlan <i>vlan_ID</i> | Verifies the configuration. |

This example shows how to configure the spanning tree port priority of a Fast Ethernet interface:

```

Switch# configure terminal
Switch(config)# interface fastethernet 5/8
Switch(config-if)# spanning-tree port-priority 100
Switch(config-if)# end
Switch#

```

This example shows how to verify the configuration of a Fast Ethernet interface when it is configured as an access port:

```

Switch# show spanning-tree interface fastethernet 3/1

Vlan                Role Sts Cost          Prio.Nbr Status

```

```

-----
VLAN0001      Desg FWD 19      128.129 P2p
VLAN1002      Desg FWD 19      128.129 P2p
VLAN1003      Desg FWD 19      128.129 P2p
VLAN1004      Desg FWD 19      128.129 P2p
VLAN1005      Desg FWD 19      128.129 P2p
Switch#

```

This example shows how to display the details of the interface configuration when the interface is configured as an access port:

```

Switch# show spanning-tree interface fastethernet 3/1 detail
Port 129 (FastEthernet3/1) of VLAN0001 is forwarding
  Port path cost 19, Port priority 128, Port Identifier 128.129.
  Designated root has priority 32768, address 0003.6b10.e800
  Designated bridge has priority 32768, address 0003.6b10.e800
  Designated port id is 128.129, designated path cost 0
  Timers:message age 0, forward delay 0, hold 0
  Number of transitions to forwarding state:1
  Link type is point-to-point by default
  BPDU:sent 187, received 1

Port 129 (FastEthernet3/1) of VLAN1002 is forwarding
  Port path cost 19, Port priority 128, Port Identifier 128.129.
  Designated root has priority 32768, address 0003.6b10.ebe9
  Designated bridge has priority 32768, address 0003.6b10.ebe9
  Designated port id is 128.129, designated path cost 0
  Timers:message age 0, forward delay 0, hold 0
  Number of transitions to forwarding state:1
  Link type is point-to-point by default
  BPDU:sent 94, received 2

Port 129 (FastEthernet3/1) of VLAN1003 is forwarding
  Port path cost 19, Port priority 128, Port Identifier 128.129.
  Designated root has priority 32768, address 0003.6b10.ebea
  Designated bridge has priority 32768, address 0003.6b10.ebea
  Designated port id is 128.129, designated path cost 0
  Timers:message age 0, forward delay 0, hold 0
  Number of transitions to forwarding state:1
  Link type is point-to-point by default
  BPDU:sent 94, received 2

Port 129 (FastEthernet3/1) of VLAN1004 is forwarding
  Port path cost 19, Port priority 128, Port Identifier 128.129.
  Designated root has priority 32768, address 0003.6b10.ebeb
  Designated bridge has priority 32768, address 0003.6b10.ebeb
  Designated port id is 128.129, designated path cost 0
  Timers:message age 0, forward delay 0, hold 0
  Number of transitions to forwarding state:1
  Link type is point-to-point by default
  BPDU:sent 95, received 2

Port 129 (FastEthernet3/1) of VLAN1005 is forwarding
  Port path cost 19, Port priority 128, Port Identifier 128.129.
  Designated root has priority 32768, address 0003.6b10.ebec
  Designated bridge has priority 32768, address 0003.6b10.ebec
  Designated port id is 128.129, designated path cost 0
  Timers:message age 0, forward delay 0, hold 0
  Number of transitions to forwarding state:1
  Link type is point-to-point by default
  BPDU:sent 95, received 2
Switch#

```

**Note**

The **show spanning-tree port-priority** command displays only information for ports with an active link. If there is no port with an active link, enter a **show running-config interface** command to verify the configuration.

This example shows how to configure the spanning tree VLAN port priority of a Fast Ethernet interface:

```
Switch# configure terminal
Switch(config)# interface fastethernet 5/8
Switch(config-if)# spanning-tree vlan 200 port-priority 64
Switch(config-if)# end
Switch#
```

This example shows how to verify the configuration of VLAN 200 on the interface when it is configured as a trunk port:

```
Switch# show spanning-tree vlan 200
<...output truncated...>

Port 264 (FastEthernet5/8) of VLAN200 is forwarding
Port path cost 19, Port priority 64, Port Identifier 129.8.
  Designated root has priority 32768, address 0010.0d40.34c7
  Designated bridge has priority 32768, address 0010.0d40.34c7
  Designated port id is 128.1, designated path cost 0
  Timers: message age 2, forward delay 0, hold 0
  Number of transitions to forwarding state: 1
  BPDU: sent 0, received 13513

<...output truncated...>
Switch#
```

Configuring STP Port Cost

The default value for spanning tree port path cost is derived from the interface media speed. In the event of a loop, spanning tree considers port cost when selecting an interface to put into the forwarding state. You can assign lower cost values to interfaces that you want spanning tree to select first, and higher cost values to interfaces that you want spanning tree to select last. If all interfaces have the same cost value, spanning tree puts the interface with the lowest interface number in the forwarding state and blocks other interfaces. The possible cost range is 1 through 200,000,000 (the default is media-specific).

Spanning tree uses the port cost value when the interface is configured as an access port and uses VLAN port cost values when the interface is configured as a trunk port.

To configure the spanning tree port cost of an interface, perform this task:

| | Command | Purpose |
|--------|---|---|
| Step 1 | Switch(config)# interface {{fastethernet gigabitethernet tengigabitethernet} slot/port} {port-channel port_channel_number} | Specifies an interface to configure. |
| Step 2 | Switch(config-if)# [no] spanning-tree cost port_cost | Configures the port cost for an interface. The <i>port_cost</i> value can be from 1 to 200,000,000. Use the no keyword to restore the defaults. |

| | Command | Purpose |
|--------|---|--|
| Step 3 | Switch(config-if)# [no] spanning-tree vlan <i>vlan_ID cost port_cost</i> | Configures the VLAN port cost for an interface. The <i>port_cost</i> value can be from 1 to 200,000,000. Use the no keyword to restore the defaults. |
| Step 4 | Switch(config-if)# end | Exits configuration mode. |
| Step 5 | Switch# show spanning-tree interface { fastethernet gigabitethernet } <i>slot/port</i> { port-channel <i>port_channel_number</i> } show spanning-tree vlan <i>vlan_ID</i> | Verifies the configuration. |

This example shows how to change the spanning tree port cost of a Fast Ethernet interface:

```
Switch# configure terminal
Switch(config)# interface fastethernet 5/8
Switch(config-if)# spanning-tree cost 18
Switch(config-if)# end
Switch#
```

This example shows how to verify the configuration of the interface when it is configured as an access port:

```
Switch# show spanning-tree interface fastethernet 5/8
Port 264 (FastEthernet5/8) of VLAN200 is forwarding
  Port path cost 18, Port priority 100, Port Identifier 129.8.
  Designated root has priority 32768, address 0010.0d40.34c7
  Designated bridge has priority 32768, address 0010.0d40.34c7
  Designated port id is 128.1, designated path cost 0
  Timers: message age 2, forward delay 0, hold 0
  Number of transitions to forwarding state: 1
  BPDUs: sent 0, received 13513
Switch#
```

This example shows how to configure the spanning tree VLAN port cost of a Fast Ethernet interface:

```
Switch# configure terminal
Switch(config)# interface fastethernet 5/8
Switch(config-if)# spanning-tree vlan 200 cost 17
Switch(config-if)# end
Switch#
```

This example shows how to verify the configuration of VLAN 200 on the interface when it is configured as a trunk port:

```
Switch# show spanning-tree vlan 200
<...output truncated...>
Port 264 (FastEthernet5/8) of VLAN200 is forwarding
  Port path cost 17, Port priority 64, Port Identifier 129.8.
  Designated root has priority 32768, address 0010.0d40.34c7
  Designated bridge has priority 32768, address 0010.0d40.34c7
  Designated port id is 128.1, designated path cost 0
  Timers: message age 2, forward delay 0, hold 0
  Number of transitions to forwarding state: 1
  BPDUs: sent 0, received 13513

<...output truncated...>
Switch#
```


**Note**

The **show spanning-tree** command displays only information for ports with an active link (green light is on). If there is no port with an active link, you can issue a **show running-config** command to confirm the configuration.

Configuring the Bridge Priority of a VLAN

**Note**

Exercise care when configuring the bridge priority of a VLAN. In most cases, we recommend that you enter the **spanning-tree vlan *vlan_ID* root primary** and the **spanning-tree vlan *vlan_ID* root secondary** commands to modify the bridge priority.

To configure the spanning tree bridge priority of a VLAN, perform this task:

| | Command | Purpose |
|--------|---|--|
| Step 1 | Switch(config)# [no] spanning-tree vlan <i>vlan_ID</i> priority <i>bridge_priority</i> | Configures the bridge priority of a VLAN. The <i>bridge_priority</i> value can be from 1 to 65,534. Use the no keyword to restore the defaults. |
| Step 2 | Switch(config)# end | Exits configuration mode. |
| Step 3 | Switch# show spanning-tree vlan <i>vlan_ID</i> bridge [brief] | Verifies the configuration. |

This example shows how to configure the bridge priority of VLAN 200 to 33,792:

```
Switch# configure terminal
Switch(config)# spanning-tree vlan 200 priority 33792
Switch(config)# end
Switch#
```

This example shows how to verify the configuration:

```
Switch# show spanning-tree vlan 200 bridge brief
Vlan                Bridge ID           Hello Time  Max Age  Fwd Delay  Protocol
-----
VLAN200             33792 0050.3e8d.64c8  2         20        15        ieee
Switch#
```

Configuring the Hello Time

**Note**

Exercise care when configuring the hello time. In most cases, we recommend that you use the **spanning-tree vlan *vlan_ID* root primary** and the **spanning-tree vlan *vlan_ID* root secondary** commands to modify the hello time.

To configure the spanning tree hello time of a VLAN, perform this task:

| | Command | Purpose |
|--------|---|---|
| Step 1 | Switch(config)# [no] spanning-tree vlan <i>vlan_ID</i> hello-time <i>hello_time</i> | Configures the hello time of a VLAN. The <i>hello_time</i> value can be from 1 to 10 seconds. Use the no keyword to restore the defaults. |
| Step 2 | Switch(config)# end | Exits configuration mode. |
| Step 3 | Switch# show spanning-tree vlan <i>vlan_ID</i> bridge [brief] | Verifies the configuration. |

This example shows how to configure the hello time for VLAN 200 to 7 seconds:

```
Switch# configure terminal
Switch(config)# spanning-tree vlan 200 hello-time 7
Switch(config)# end
Switch#
```

This example shows how to verify the configuration:

```
Switch# show spanning-tree vlan 200 bridge brief
Vlan                Bridge ID           Hello Max  Fwd
Time  Age Delay  Protocol
-----
VLAN200            49152 0050.3e8d.64c8   7   20   15  ieee
Switch#
```

Configuring the Maximum Aging Time for a VLAN



Note

Exercise care when configuring aging time. In most cases, we recommend that you use the **spanning-tree vlan** *vlan_ID* **root primary** and the **spanning-tree vlan** *vlan_ID* **root secondary** commands to modify the maximum aging time.

To configure the spanning tree maximum aging time for a VLAN, perform this task:

| | Command | Purpose |
|--------|---|--|
| Step 1 | Switch(config)# [no] spanning-tree vlan <i>vlan_ID</i> max-age <i>max_age</i> | Configures the maximum aging time of a VLAN. The <i>max_age</i> value can be from 6 to 40 seconds. Use the no keyword to restore the defaults. |
| Step 2 | Switch(config)# end | Exits configuration mode. |
| Step 3 | Switch# show spanning-tree vlan <i>vlan_ID</i> bridge [brief] | Verifies the configuration. |

This example shows how to configure the maximum aging time for VLAN 200 to 36 seconds:

```
Switch# configure terminal
Switch(config)# spanning-tree vlan 200 max-age 36
Switch(config)# end
Switch#
```

This example shows how to verify the configuration:

```
Switch# show spanning-tree vlan 200 bridge brief
Hello Max Fwd
Vlan          Bridge ID      Time Age Delay Protocol
-----
VLAN200      49152 0050.3e8d.64c8  2  36  15  ieee
Switch#
```

Configuring the Forward-Delay Time for a VLAN



Note

Exercise care when configuring forward-delay time. In most cases, we recommend that you use the **spanning-tree vlan *vlan_ID* root primary** and the **spanning-tree vlan *vlan_ID* root secondary** commands to modify the forward delay time.

To configure the spanning tree forward delay time for a VLAN, perform this task:

| | Command | Purpose |
|--------|--|---|
| Step 1 | Switch(config)# [no] spanning-tree vlan <i>vlan_ID</i> forward-time <i>forward_time</i> | Configures the forward time of a VLAN. The <i>forward_time</i> value can be from 4 to 30 seconds. Use the no keyword to restore the defaults. |
| Step 2 | Switch(config)# end | Exits configuration mode. |
| Step 3 | Switch# show spanning-tree vlan <i>vlan_ID</i> bridge [brief] | Verifies the configuration. |

This example shows how to configure the forward delay time for VLAN 200 to 21 seconds:

```
Switch# configure terminal
Switch(config)# spanning-tree vlan 200 forward-time 21
Switch(config)# end
Switch#
```

This example shows how to verify the configuration:

```
Switch# show spanning-tree vlan 200 bridge brief
Hello Max Fwd
Vlan          Bridge ID      Time Age Delay Protocol
-----
VLAN200      49152 0050.3e8d.64c8  2  20  21  ieee
Switch#
```

This example shows how to display spanning tree information for the bridge:

```
Switch# show spanning-tree bridge

Vlan          Bridge ID      Hello Time Max Age Fwd Dly Protocol
-----
VLAN200      49152 0050.3e8d.64c8  2  20  15  ieee
VLAN202      49152 0050.3e8d.64c9  2  20  15  ieee
VLAN203      49152 0050.3e8d.64ca  2  20  15  ieee
VLAN204      49152 0050.3e8d.64cb  2  20  15  ieee
VLAN205      49152 0050.3e8d.64cc  2  20  15  ieee
VLAN206      49152 0050.3e8d.64cd  2  20  15  ieee
Switch#
```

Disabling Spanning Tree Protocol

To disable spanning tree on a per-VLAN basis, perform this task:

| | Command | Purpose |
|--------|---|---|
| Step 1 | Switch(config)# no spanning-tree vlan <i>vlan_ID</i> | Disables spanning tree on a per-VLAN basis. |
| Step 2 | Switch(config)# end | Exits configuration mode. |
| Step 3 | Switch# show spanning-tree vlan <i>vlan_ID</i> | Verifies that spanning tree is disabled. |

This example shows how to disable spanning tree on VLAN 200:

```
Switch# configure terminal
Switch(config)# no spanning-tree vlan 200
Switch(config)# end
Switch#
```

This example shows how to verify the configuration:

```
Switch# show spanning-tree vlan 200
Spanning tree instance for VLAN 200 does not exist.
Switch#
```

Enabling Per-VLAN Rapid Spanning Tree

Per-VLAN Rapid Spanning Tree (PVRST+) uses the existing PVST+ framework for configuration purposes and for interaction with other features. It also supports some of the PVST+ extensions.



Note

Beginning in Cisco IOS XE Release 3.8.0E and Cisco IOS Release 15.2(4)E, Per-VLAN Rapid Spanning Tree (PVRST+) is the default STP mode on Cisco Catalyst 4500 series, Cisco Catalyst 4900M, Cisco Catalyst 4948E and Cisco Catalyst 4948F switches.

To enable PVRST+, perform this task:

:

| | Command | Purpose |
|--------|---|---|
| Step 1 | Switch(config)# [no] spantree mode rapid-pvst | Enables PVRST+. |
| Step 2 | Switch(config)# interface <i>interface/port</i> | Switches to interface configuration mode. |
| Step 3 | Switch(config-if)# spanning-tree link-type point-to-point | Sets the link-type to point-to-point mode for the port. |
| Step 4 | Switch(config-if)# exit | Exits interface mode. |
| Step 5 | Switch(config)# exit | Exits configuration mode. |
| Step 6 | Switch(config-if)# clear spantree detected-protocols <i>mod/port</i> | Detects any legacy bridges on the port |
| Step 7 | Switch# show spanning-tree summary totals | Verifies the PVRST+ configuration. |

The following example shows how to configure PVRST+:

```
Switch# config t
Enter configuration commands, one per line. End with CNTL/Z.
```

```
Switch(config)# spanning-tree mode rapid-pvst
Switch(config)# int fa 6/4
Switch(config-if)# spanning-tree link-type point-to-point
Switch(config-if)# end
Switch(config)# end
Switch#
23:55:32:%SYS-5-CONFIG_I:Configured from console by console
Switch# clear spanning-tree detected-protocols
```

The following example shows how to verify the configuration:

```
Switch# show spanning-tree summary totals
Switch is in rapid-pvst mode
Root bridge for:VLAN0001
Extended system ID          is disabled
Portfast Default            is disabled
PortFast BPDU Guard Default is disabled
Portfast BPDU Filter Default is disabled
Loopguard Default           is disabled
EtherChannel misconfig guard is enabled
UplinkFast                  is disabled
BackboneFast                 is disabled
Pathcost method used        is short
Name                         Blocking Listening Learning Forwarding STP Active
-----
1 vlan                        0          0          0          2          2
Switch#
```

Specifying the Link Type

Rapid connectivity is established only on point-to-point links. Spanning tree views a point-to-point link as a segment connecting only two switches running the spanning tree algorithm. Because the switch assumes that all full-duplex links are point-to-point links and that half-duplex links are shared links, you can avoid explicitly configuring the link type. To configure a specific link type, use the **spanning-tree linktype** command.

Restarting Protocol Migration

A switch running both MSTP and RSTP supports a built-in protocol migration process that enables the switch to interoperate with legacy 802.1D switches. If this switch receives a legacy 802.1D configuration BPDU (a BPDU with the protocol version set to 0), it sends only 802.1D BPDUs on that port. When an MSTP switch receives a legacy BPDU, it can also detect the following:

- A port is at the boundary of a region
- An MST BPDU (version 3) that is associated with a different region
- An RST BPDU (version 2)

The switch, however, does not automatically revert to the MSTP mode if it no longer receives 802.1D BPDUs because it cannot determine whether or not the legacy switch has been removed from the link unless the legacy switch is the designated switch. A switch also might continue to assign a boundary role to a port when the switch to which it is connected has joined the region.

To restart the protocol migration process on the entire switch (that is, to force renegotiation with neighboring switches), use the **clear spanning-tree detected-protocols** commands in privileged EXEC mode. To restart the protocol migration process on a specific interface, enter the **clear spanning-tree detected-protocols interface** *command in interface-id* privileged EXEC mode.

About MST

The following sections describe how MST works on a Catalyst 4500 series switch:

- [IEEE 802.1s MST, page 22-22](#)
- [IEEE 802.1w RSTP, page 22-23](#)
- [MST-to-SST Interoperability, page 22-24](#)
- [Common Spanning Tree, page 22-25](#)
- [MST Instances, page 22-26](#)
- [MST Configuration Parameters, page 22-26](#)
- [MST Regions, page 22-26](#)
- [Message Age and Hop Count, page 22-28](#)

IEEE 802.1s MST

MST extends the IEEE 802.1w rapid spanning tree (RST) algorithm to multiple spanning trees. This extension provides both rapid convergence and load balancing in a VLAN environment. MST converges faster than per-VLAN Spanning Tree Plus (PVST+) and is backward compatible with 802.1D STP, 802.1w (Rapid Spanning Tree Protocol [RSTP]), and the Cisco PVST+ architecture.

MST allows you to build multiple spanning trees over trunks. You can group and associate VLANs to spanning tree instances. Each instance can have a topology independent of other spanning tree instances. This architecture provides multiple forwarding paths for data traffic and enables load balancing. Network fault tolerance is improved because a failure in one instance (forwarding path) does not affect other instances.

In large networks, you can more easily administer the network and use redundant paths by locating different VLAN and spanning tree instance assignments in different parts of the network. A spanning tree instance can exist only on bridges that have compatible VLAN instance assignments. You must configure a set of bridges with the same MST configuration information, which allows them to participate in a specific set of spanning tree instances. Interconnected bridges that have the same MST configuration are referred to as an *MST region*.

MST uses the modified RSTP, MSTP. MST has the following characteristics:

- MST runs a variant of spanning tree called Internal Spanning Tree (IST). IST augments Common Spanning Tree (CST) information with internal information about the MST region. The MST region appears as a single bridge to adjacent single spanning tree (SST) and MST regions.
- A bridge running MST provides interoperability with SST bridges as follows:
 - MST bridges run IST, which augments CST information with internal information about the MST region.
 - IST connects all the MST bridges in the region and appears as a subtree in the CST that includes the whole bridged domain. The MST region appears as a virtual bridge to adjacent SST bridges and MST regions.
 - The Common and Internal Spanning Tree (CIST) is the collection of the following: ISTs in each MST region, the CST that interconnects the MST regions, and the SST bridges. CIST is identical to an IST inside an MST region and identical to a CST outside an MST region. The STP, RSTP, and MSTP together elect a single bridge as the root of the CIST.

- MST establishes and maintains additional spanning trees within each MST region. These spanning trees are termed MST instances (MSTIs). The IST is numbered 0, and the MSTIs are numbered 1, 2, 3, and so on. Any MSTI is local to the MST region and is independent of MSTIs in another region, even if the MST regions are interconnected.

MST instances combine with the IST at the boundary of MST regions to become the CST as follows:

- Spanning tree information for an MSTI is contained in an MSTP record (M-record).

M-records are always encapsulated within MST bridge protocol data units (BPDUs). The original spanning trees computed by MSTP are called M-trees, which are active only within the MST region. M-trees merge with the IST at the boundary of the MST region and form the CST.

- MST provides interoperability with PVST+ by generating PVST+ BPDUs for the non-CST VLANs.
- MST supports some of the PVST+ extensions in MSTP as follows:
 - UplinkFast and BackboneFast are not available in MST mode; they are part of RSTP.
 - PortFast is supported.
 - BPDU filter and BPDU guard are supported in MST mode.
 - Loop guard and root guard are supported in MST. MST preserves the VLAN 1 disabled functionality except that BPDUs are still transmitted in VLAN 1.
 - MST switches operate as if MAC reduction is enabled.
 - For private VLANs (PVLANS), you must map a secondary VLAN to the same instance as the primary.

IEEE 802.1w RSTP

RSTP, specified in 802.1w, supersedes STP specified in 802.1D, but remains compatible with STP. You configure RSTP when you configure the MST feature. For more information, see the [“Configuring MST” section on page 22-28](#).

RSTP provides the structure on which the MST operates, significantly reducing the time to reconfigure the active topology of a network when its physical topology or configuration parameters change. RSTP selects one switch as the root of a spanning-tree-connected active topology and assigns port roles to individual ports of the switch, depending on whether that port is part of the active topology.

RSTP provides rapid connectivity following the failure of a switch, switch port, or a LAN. A new root port and the designated port on the other side of the bridge transition to the forwarding state through an explicit handshake between them. RSTP allows switch port configuration so the ports can transition to forwarding directly when the switch reinitializes.

RSTP provides backward compatibility with 802.1D bridges as follows:

- RSTP selectively sends 802.1D-configured BPDUs and Topology Change Notification (TCN) BPDUs on a per-port basis.
- When a port initializes, the migration delay timer starts and RSTP BPDUs are transmitted. While the migration delay timer is active, the bridge processes all BPDUs received on that port.
- If the bridge receives an 802.1D BPDU after a port’s migration delay timer expires, the bridge assumes it is connected to an 802.1D bridge and starts using only 802.1D BPDUs.
- When RSTP uses 802.1D BPDUs on a port and receives an RSTP BPDU after the migration delay expires, RSTP restarts the migration delay timer and begins using RSTP BPDUs on that port.

RSTP Port Roles

In RSTP, the port roles are defined as follows:

- **Root**—A forwarding port elected for the spanning tree topology.
- **Designated**—A forwarding port elected for every switched LAN segment.
- **Alternate**—An alternate path to the root bridge to that provided by the current root port.
- **Backup**—A backup for the path provided by a designated port toward the leaves of the spanning tree. Backup ports can exist only where two ports are connected together in a loopback mode or bridge with two or more connections to a shared LAN segment.
- **Disabled**—A port that has no role within the operation of spanning tree.

The system assigns port roles as follows:

- A root port or designated port role includes the port in the active topology.
- An alternate port or backup port role excludes the port from the active topology.

RSTP Port States

The port state controls the forwarding and learning processes and provides the values of discarding, learning, and forwarding. [Table 22-5](#) shows the STP port states and RSTP port states.

Table 22-5 Comparison Between STP and RSTP Port States

| Operational Status | STP Port State | RSTP Port State | Port Included in Active Topology |
|--------------------|-----------------------|-------------------------|----------------------------------|
| Enabled | Blocking ¹ | Discarding ² | No |
| Enabled | Listening | Discarding | No |
| Enabled | Learning | Learning | Yes |
| Enabled | Forwarding | Forwarding | Yes |
| Disabled | Disabled | Discarding | No |

1. IEEE 802.1D port state designation.

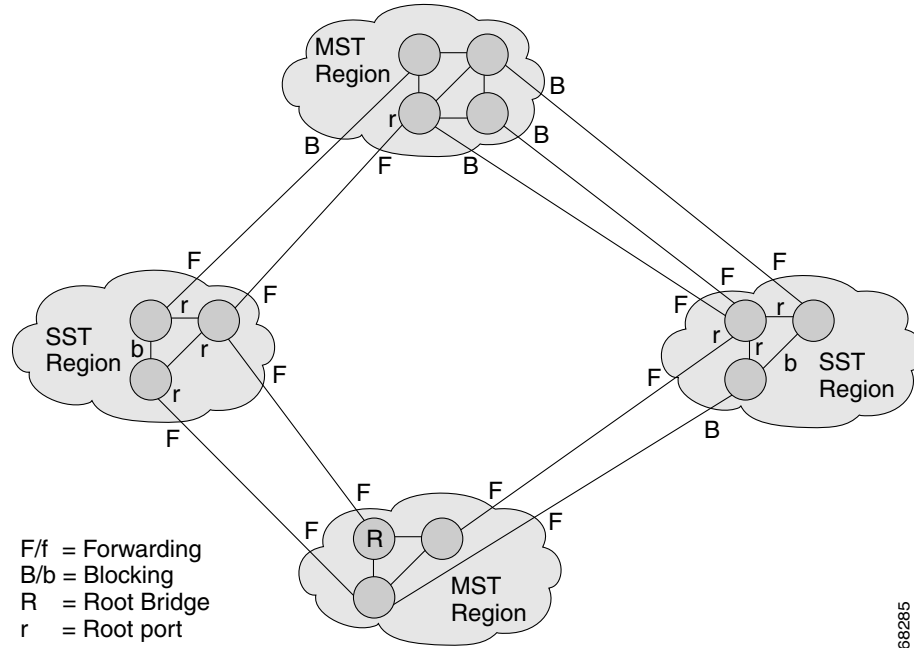
2. IEEE 802.1w port state designation. Discarding is the same as blocking in MST.

In a stable topology, RSTP ensures that every root port and designated port transitions to the forwarding state while all alternate ports and backup ports are always in the discarding state.

MST-to-SST Interoperability

A virtual bridged LAN may contain interconnected regions of SST and MST bridges. [Figure 22-2](#) shows this relationship.

Figure 22-2 Network with Interconnected SST and MST Regions



To STP running in the SST region, an MST region appears as a single SST or pseudobridge, which operates as follows:

- Although the values for root identifiers and root path costs match for all BPDUs in all pseudobridges, a pseudobridge differs from a single SST bridge as follows:
 - The pseudobridge BPDUs have different bridge identifiers. This difference does not affect STP operation in the neighboring SST regions because the root identifier and root cost are the same.
 - BPDUs sent from the pseudobridge ports may have significantly different message ages. Because the message age increases by one second for each hop, the difference in the message age is measured in seconds.
- Data traffic from one port of a pseudobridge (a port at the edge of a region) to another port follows a path entirely contained within the pseudobridge or MST region. Data traffic belonging to different VLANs might follow different paths within the MST regions established by MST.
- The system prevents looping by doing either of the following:
 - Blocking the appropriate pseudobridge ports by allowing one forwarding port on the boundary and blocking all other ports.
 - Setting the CST partitions to block the ports of the SST regions.

Common Spanning Tree

CST (802.1Q) is a single spanning tree for all the VLANs. On a Catalyst 4500 series switch running PVST+, the VLAN 1 spanning tree corresponds to CST. On a Catalyst 4500 series switch running MST, IST (instance 0) corresponds to CST.

MST Instances

We support 65 instances including instance 0. Each spanning tree instance is identified by an instance ID that ranges from 0 to 4094. Instance 0 is mandatory and is always present. Rest of the instances are optional.

MST Configuration Parameters

The MST configuration includes these three parts:

- Name—A 32-character string (null padded) that identifies the MST region.
- Revision number—An unsigned 16-bit number that identifies the revision of the current MST configuration.

**Note**

You must set the revision number when required as part of the MST configuration. The revision number is not incremented automatically each time you commit the MST configuration.

- MST configuration table—An array of 4096 bytes. Each byte, interpreted as an unsigned integer, corresponds to a VLAN. The value is the instance number to which the VLAN is mapped. The first byte that corresponds to VLAN 0 and the 4096th byte that corresponds to VLAN 4095 are unused and always set to zero.

You must configure each byte manually. Use SNMP or the CLI to perform the configuration.

MST BPDUs contain the MST configuration ID and the checksum. An MST bridge accepts an MST BPDU only if the MST BPDU configuration ID and the checksum match its own MST region configuration ID and checksum. If either value is different, the MST BPDU is considered to be an SST BPDU.

MST Regions

These sections describe MST regions:

- [MST Region Overview, page 22-26](#)
- [Boundary Ports, page 22-27](#)
- [IST Master, page 22-27](#)
- [Edge Ports, page 22-27](#)
- [Link Type, page 22-28](#)

MST Region Overview

Interconnected bridges that have the same MST configuration are referred to as an MST region. There is no limit on the number of MST regions in the network.

To form an MST region, bridges can be either of the following:

- An MST bridge that is the only member of the MST region.
- An MST bridge interconnected by a LAN. A LAN's designated bridge has the same MST configuration as an MST bridge. All the bridges on the LAN can process MST BPDUs.

If you connect two MST regions with different MST configurations, the MST regions do the following:

- Load balance across redundant paths in the network. If two MST regions are redundantly connected, all traffic flows on a single connection with the MST regions in a network.
- Provide an RSTP handshake to enable rapid connectivity between regions. However, the handshaking is not as fast as between two bridges. To prevent loops, all the bridges inside the region must agree upon the connections to other regions. This situation introduces a delay. We do not recommend partitioning the network into a large number of regions.

Boundary Ports

A boundary port is a port that connects to a LAN, the designated bridge of which is either an SST bridge or a bridge with a different MST configuration. A designated port knows that it is on the boundary if it detects an STP bridge or receives an agreement message from an RST or MST bridge with a different configuration.

At the boundary, the role of MST ports do not matter; their state is forced to be the same as the IST port state. If the boundary flag is set for the port, the MSTP Port Role selection mechanism assigns a port role to the boundary and the same state as that of the IST port. The IST port at the boundary can take up any port role except a backup port role.

IST Master

The IST master of an MST region is the bridge with the lowest bridge identifier and the least path cost to the CST root. If an MST bridge is the root bridge for CST, then it is the IST master of that MST region. If the CST root is outside the MST region, then one of the MST bridges at the boundary is selected as the IST master. Other bridges on the boundary that belong to the same region eventually block the boundary ports that lead to the root.

If two or more bridges at the boundary of a region have an identical path to the root, you can set a slightly lower bridge priority to make a specific bridge the IST master.

The root path cost and message age inside a region stay constant, but the IST path cost is incremented and the IST remaining hops are decremented at each hop. Enter the **show spanning-tree mst** command to display the information about the IST master, path cost, and remaining hops for the bridge.

Edge Ports

A port that is connected to a nonbridging device (for example, a host or a switch) is an edge port. A port that connects to a hub is also an edge port if the hub or any LAN that is connected to it does not have a bridge. An edge port can start forwarding as soon as the link is up.

MST requires that you configure each port connected to a host. To establish rapid connectivity after a failure, you need to block the non-edge designated ports of an intermediate bridge. If the port connects to another bridge that can send back an agreement, then the port starts forwarding immediately. Otherwise, the port needs twice the forward delay time to start forwarding again. You must explicitly configure the ports that are connected to the hosts and switches as edge ports while using MST.

To prevent a misconfiguration, the PortFast operation is turned off if the port receives a BPDU. You can display the configured and operational status of PortFast by using the **show spanning-tree mst interface** command.

Link Type

Rapid connectivity is established only on point-to-point links. You must configure ports explicitly to a host or switch. However, cabling in most networks meets this requirement. By entering the **spanning-tree linktype** command to treating all full-duplex links as point-to-point links, you can avoid explicit configuration.

Message Age and Hop Count

IST and MST instances do not use the message age and maximum age timer settings in the BPDU. IST and MST use a separate hop count mechanism that is very similar to the IP time-to live (TTL) mechanism. You can configure each MST bridge with a maximum hop count. The root bridge of the instance sends a BPDU (or M-record) with the remaining hop count that is equal to the maximum hop count. When a bridge receives a BPDU (or M-record), it decrements the received remaining hop count by one. The bridge discards the BPDU (M-record) and ages out the information held for the port if the count reaches zero after decrementing. The nonroot bridges propagate the decremented count as the remaining hop count in the BPDUs (M-records) they generate.

The message age and maximum age timer settings in the RST portion of the BPDU remain the same throughout the region, and the same values are propagated by the region's designated ports at the boundary.

MST Configuration Restrictions and Guidelines

Follow these restrictions and guidelines to avoid configuration problems:

- Do not disable spanning tree on any VLAN in any of the PVST bridges.
- Do not use PVST bridges as the root of CST.
- Do not connect switches with access links because access links may partition a VLAN.
- Ensure that all PVST root bridges have lower, (numerically higher) priority than the CST root bridge.
- Ensure that trunks carry all of the VLANs mapped to an instance or do not carry any VLANs at all for this instance.
- Complete any MST configuration that incorporates a large number of either existing or new logical VLAN ports during a maintenance window because the complete MST database gets reinitialized for any incremental change (such as adding new VLANs to instances or moving VLANs across instances).

Configuring MST

The following sections describe how to configure MST:

- [Enabling MST, page 22-29](#)

- [Configuring MST Instance Parameters, page 22-30](#)
- [Configuring MST Instance Port Parameters, page 22-31](#)
- [Restarting Protocol Migration, page 22-32](#)
- [Displaying MST Configurations, page 22-32](#)

Enabling MST

To enable and configure MST on a switch, perform this task:

| | Command | Purpose |
|--------|---|---|
| Step 1 | Switch(config)# spanning-tree mode mst | Enters MST mode. |
| Step 2 | Switch(config)# spanning-tree mst configuration | Enters MST configuration submode. Use the no keyword to clear the MST configuration. |
| Step 3 | Switch(config-mst)# show current | Displays the current MST configuration. |
| Step 4 | Switch(config-mst)# name name | Sets the MST region name. |
| Step 5 | Switch(config-mst)# revision revision_number | Sets the MST configuration revision number. |
| Step 6 | Switch(config-mst)# instance instance_number vlan vlan_range | Maps the VLANs to an MST instance. If you do not specify the vlan keyword, use the no keyword to unmap all the VLANs that were mapped to an MST instance. If you specify the vlan keyword, use the no keyword to unmap a specified VLAN from an MST instance. |
| Step 7 | Switch(config-mst)# show pending | Displays the new MST configuration to be applied. |
| Step 8 | Switch(config-mst)# end | Applies the configuration and exit MST configuration submode. |
| Step 9 | Switch# show spanning-tree mst configuration | Displays the current MST configuration. |

This example show how to enable MST:

```
Switch# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Switch(config)# spanning-tree mode mst

Switch(config)# spanning-tree mst configuration

Switch(config-mst)# show current
Current MST configuration
Name      []
Revision  0
Instance  Vlans mapped
-----
0         1-4094
-----

Switch(config-mst)# name cisco
Switch(config-mst)# revision 2
Switch(config-mst)# instance 1 vlan 1
Switch(config-mst)# instance 2 vlan 1-1000
Switch(config-mst)# show pending
Pending MST configuration
```

```

Name      [cisco]
Revision  2
Instance  Vlans mapped
-----
0         1001-4094
2         1-1000
-----
Switch(config-mst)# no instance 2
Switch(config-mst)# show pending
Pending MST configuration
Name      [cisco]
Revision  2
Instance  Vlans mapped
-----
0         1-4094
-----
Switch(config-mst)# instance 1 vlan 2000-3000
Switch(config-mst)# no instance 1 vlan 1500
Switch(config-mst)# show pending
Pending MST configuration
Name      [cisco]
Revision  2
Instance  Vlans mapped
-----
0         1-1999,2500,3001-4094
1         2000-2499,2501-3000
-----
Switch(config-mst)# end
Switch(config)# no spanning-tree mst configuration
Switch(config)# end
Switch# show spanning-tree mst configuration
Name      []
Revision  0
Instance  Vlans mapped
-----
0         1-4094
-----

```

Configuring MST Instance Parameters

To configure MST instance parameters, perform this task:

| | Command | Purpose |
|--------|---|--|
| Step 1 | Switch(config)# spanning-tree mst X priority Y | Configures the priority for an MST instance. |
| Step 2 | Switch(config)# spanning-tree mst X root [primary secondary] | Configures the bridge as root for an MST instance. |
| Step 3 | Switch(config)# Ctrl-Z | Exits configuration mode. |
| Step 4 | Switch# show spanning-tree mst | Verifies the configuration. |

This example shows how to configure MST instance parameters:

```

Switch(config)# spanning-tree mst 1 priority ?
<0-61440> bridge priority in increments of 4096

Switch(config)# spanning-tree mst 1 priority 1
% Bridge Priority must be in increments of 4096.
% Allowed values are:

```

```

0      4096  8192  12288 16384 20480 24576 28672
32768 36864 40960 45056 49152 53248 57344 61440

Switch(config)# spanning-tree mst 1 priority 49152
Switch(config)#

Switch(config)# spanning-tree mst 0 root primary
mst 0 bridge priority set to 24576
mst bridge max aging time unchanged at 20
mst bridge hello time unchanged at 2
mst bridge forward delay unchanged at 15
Switch(config)# ^Z
Switch#

Switch# show spanning-tree mst

##### MST00          vlans mapped: 11-4094
Bridge      address 00d0.00b8.1400  priority 24576 (24576 sysid 0)
Root        this switch for CST and IST
Configured  hello time 2, forward delay 15, max age 20, max hops 20

Interface    Role Sts Cost      Prio.Nbr Status
-----
Fa4/4        Back BLK 1000    240.196 P2p
Fa4/5        Desg FWD 200000    128.197 P2p
Fa4/48       Desg FWD 200000    128.240 P2p Bound(STP)

##### MST01          vlans mapped: 1-10
Bridge      address 00d0.00b8.1400  priority 49153 (49153 sysid 1)
Root        this switch for MST01

Interface    Role Sts Cost      Prio.Nbr Status
-----
Fa4/4        Back BLK 1000    160.196 P2p
Fa4/5        Desg FWD 200000    128.197 P2p
Fa4/48       Boun FWD 200000    128.240 P2p Bound(STP)

Switch#

```

Configuring MST Instance Port Parameters

To configure MST instance port parameters, perform this task:

| | Command | Purpose |
|--------|---|--|
| Step 1 | Switch(config-if)# spanning-tree mst x cost y | Configures the MST instance port cost. |
| Step 2 | Switch(config-if)# spanning-tree mst x port-priority y | Configures the MST instance port priority. |
| Step 3 | Switch(config-if)# Ctrl-Z | Exits configuration mode. |
| Step 4 | Switch# show spanning-tree mst x interface y | Verifies the configuration. |

This example shows how to configure MST instance port parameters:

```

Switch(config)# interface fastethernet 4/4
Switch(config-if)# spanning-tree mst 1 ?
cost          Change the interface spanning tree path cost for an instance
port-priority Change the spanning tree port priority for an instance

Switch(config-if)# spanning-tree mst 1 cost 1234567

```

```

Switch(config-if)# spanning-tree mst 1 port-priority 240
Switch(config-if)# ^Z

Switch# show spanning-tree mst 1 interface fastethernet 4/4

FastEthernet4/4 of MST01 is backup blocking
Edge port:no                (default)          port guard :none          (default)
Link type:point-to-point (auto)          bpdu filter:disable      (default)
Boundary :internal          bpdu guard :disable      (default)
Bpdus (MRecords) sent 125, received 1782

Instance Role Sts Cost      Prio.Nbr Vlans mapped
-----
1          Back BLK 1234567 240.196 1-10

Switch#

```

Restarting Protocol Migration

RSTP and MST have built-in compatibility mechanisms that allow them to interact properly with other regions or other versions of IEEE spanning-tree. For example, an RSTP bridge connected to a legacy bridge can send 802.1D BPDUs on one of its ports. Similarly, when an MST bridge receives a legacy BPDU or an MST BPDU associated with a different region, it is also to detect that a port is at the boundary of a region.

Unfortunately, these mechanisms cannot always revert to the most efficient mode. For example, an RSTP bridge designated for a legacy 802.1D stays in 802.1D mode even after the legacy bridge has been removed from the link. Similarly, an MST port still assumes that it is a boundary port when the bridge(s) to which it is connected have joined the same region. To force a Catalyst 4500 series switch to renegotiate with the neighbors (that is, to restart protocol migration), you must enter the **clear spanning-tree detected-protocols** command, as follows:

```

Switch# clear spanning-tree detected-protocols fastethernet 4/4
Switch#

```

Displaying MST Configurations

To display MST configurations, perform this task:

| | Command | Purpose |
|--------|--|---|
| Step 1 | Switch# show spanning-tree mst configuration | Displays the active region configuration information. |
| Step 2 | Switch# show spanning-tree mst [detail] | Displays detailed MST protocol information. |
| Step 3 | Switch# show spanning-tree mst <i>instance-id</i> [detail] | Displays information about a specific MST instance. |
| Step 4 | Switch# show spanning-tree mst interface <i>interface</i> [detail] | Displays information for a given port. |
| Step 5 | Switch# show spanning-tree mst <i>instance-id</i> interface <i>interface</i> [detail] | Displays MST information for a given port and a given instance. |
| Step 6 | Switch# show spanning-tree vlan <i>vlan_ID</i> | Displays VLAN information in MST mode. |

The following examples show how to display spanning tree VLAN configurations in MST mode:

```
Switch(config)# spanning-tree mst configuration
Switch(config-mst)# instance 1 vlan 1-10
Switch(config-mst)# name cisco
Switch(config-mst)# revision 1
Switch(config-mst)# Ctrl-D

Switch# show spanning-tree mst configuration
Name      [cisco]
Revision  1
Instance  Vlans mapped
-----
0         11-4094
1         1-10
-----

Switch# show spanning-tree mst

##### MST00          vlans mapped: 11-4094
Bridge     address 00d0.00b8.1400  priority 32768 (32768 sysid 0)
Root      address 00d0.004a.3c1c  priority 32768 (32768 sysid 0)
          port Fa4/48          path cost 203100
IST master this switch
Operational hello time 2, forward delay 15, max age 20, max hops 20
Configured  hello time 2, forward delay 15, max age 20, max hops 20

Interface      Role Sts Cost      Prio.Nbr Status
-----
Fa4/4          Back BLK 1000    240.196 P2p
Fa4/5          Desg FWD 200000    128.197 P2p
Fa4/48        Root FWD 200000    128.240 P2p Bound(STP)

##### MST01          vlans mapped: 1-10
Bridge     address 00d0.00b8.1400  priority 32769 (32768 sysid 1)
Root      this switch for MST01

Interface      Role Sts Cost      Prio.Nbr Status
-----
Fa4/4          Back BLK 1000    240.196 P2p
Fa4/5          Desg FWD 200000    128.197 P2p
Fa4/48        Boun FWD 200000    128.240 P2p Bound(STP)

Switch# show spanning-tree mst 1

##### MST01          vlans mapped: 1-10
Bridge     address 00d0.00b8.1400  priority 32769 (32768 sysid 1)
Root      this switch for MST01

Interface      Role Sts Cost      Prio.Nbr Status
-----
Fa4/4          Back BLK 1000    240.196 P2p
Fa4/5          Desg FWD 200000    128.197 P2p
Fa4/48        Boun FWD 200000    128.240 P2p Bound(STP)
```

```
Switch# show spanning-tree mst interface fastethernet 4/4
```

```
FastEthernet4/4 of MST00 is backup blocking
Edge port:no          (default)          port guard :none      (default)
Link type:point-to-point (auto)          bpdu filter:disable  (default)
Boundary :internal    bpdu guard :disable  (default)
Bpdus sent 2, received 368
```

| Instance | Role | Sts | Cost | Prio.Nbr | Vlans mapped |
|----------|------|-----|------|----------|--------------|
| 0 | Back | BLK | 1000 | 240.196 | 11-4094 |
| 1 | Back | BLK | 1000 | 240.196 | 1-10 |

```
Switch# show spanning-tree mst 1 interface fastethernet 4/4
```

```
FastEthernet4/4 of MST01 is backup blocking
Edge port:no          (default)          port guard :none      (default)
Link type:point-to-point (auto)          bpdu filter:disable  (default)
Boundary :internal    bpdu guard :disable  (default)
Bpdus (MRecords) sent 2, received 364
```

| Instance | Role | Sts | Cost | Prio.Nbr | Vlans mapped |
|----------|------|-----|------|----------|--------------|
| 1 | Back | BLK | 1000 | 240.196 | 1-10 |

```
Switch# show spanning-tree mst 1 detail
```

```
##### MST01          vlans mapped: 1-10
Bridge          address 00d0.00b8.1400 priority 32769 (32768 sysid 1)
Root            this switch for MST01
```

```
FastEthernet4/4 of MST01 is backup blocking
Port info          port id          240.196 priority 240 cost 1000
Designated root    address 00d0.00b8.1400 priority 32769 cost 0
Designated bridge   address 00d0.00b8.1400 priority 32769 port id 128.197
Timers:message expires in 5 sec, forward delay 0, forward transitions 0
Bpdus (MRecords) sent 123, received 1188
```

```
FastEthernet4/5 of MST01 is designated forwarding
Port info          port id          128.197 priority 128 cost 200000
Designated root    address 00d0.00b8.1400 priority 32769 cost 0
Designated bridge   address 00d0.00b8.1400 priority 32769 port id 128.197
Timers:message expires in 0 sec, forward delay 0, forward transitions 1
Bpdus (MRecords) sent 1188, received 123
```

```
FastEthernet4/48 of MST01 is boundary forwarding
Port info          port id          128.240 priority 128 cost 200000
Designated root    address 00d0.00b8.1400 priority 32769 cost 0
Designated bridge   address 00d0.00b8.1400 priority 32769 port id 128.240
Timers:message expires in 0 sec, forward delay 0, forward transitions 1
Bpdus (MRecords) sent 78, received 0
```

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

```
MST01
Spanning tree enabled protocol mstp
Root ID          Priority 32769
Address          00d0.00b8.1400
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      00d0.00b8.1400
Hello Time   2 sec Max Age 20 sec Forward Delay 15 sec

Interface      Role Sts Cost      Prio.Nbr Status
-----
Fa4/4          Back BLK 1000    240.196 P2p
Fa4/5          Desg FWD 200000   128.197 P2p

Switch# show spanning-tree summary
Root bridge for:MST01
EtherChannel misconfiguration guard is enabled
Extended system ID is enabled
Portfast is disabled by default
PortFast BPDU Guard is disabled by default
Portfast BPDU Filter is disabled by default
Loopguard is disabled by default
UplinkFast is disabled
BackboneFast is disabled
Pathcost method used is long

Name              Blocking Listening Learning Forwarding STP Active
-----
MST00              1          0          0          2          3
MST01              1          0          0          2          3
-----
2 msts             2          0          0          4          6
Switch#

```

About MST-to-PVST+ Interoperability (PVST+ Simulation)

The PVST+ simulation feature enables seamless interoperability between MST and Rapid PVST+. You can enable or disable this per port, or globally. PVST+ simulation is enabled by default.

However, you may want to control the connection between MST and Rapid PVST+ to protect against accidentally connecting an MST-enabled port to a Rapid PVST+-enabled port. Because Rapid PVST+ is the default STP mode, you may encounter many Rapid PVST+-enabled connections.

Disabling this feature causes the switch to stop the MST region from interacting with PVST+ regions. The MST-enabled port moves to a PVST peer inconsistent (blocking) state once it detects it is connected to a Rapid PVST+-enabled port. This port remains in the inconsistent state until the port stops receiving Shared Spanning Tree Protocol (SSTP) BPDUs, and then the port resumes the normal STP transition process.

You can for instance, disable PVST+ simulation, to prevent an incorrectly configured switch from connecting to a network where the STP mode is not MSTP (the default mode is PVST+).

Observe these guidelines when you configure MST switches (in the same region) to interact with PVST+ switches:

- Configure the root for all VLANs inside the MST region as shown in this example:

```

Switch# show spanning-tree mst interface gigabitethernet 1/1

GigabitEthernet1/1 of MST00 is root forwarding
Edge port: no (trunk) port guard : none (default)
Link type: point-to-point (auto) bpdu filter: disable (default)
Boundary : boundary (PVST) bpdu guard : disable (default)
Bpdus sent 10, received 310

```

| Instance | Role | Sts | Cost | Prio. | Nbr Vlans mapped |
|----------|------|-----|-------|-------|------------------------|
| 0 | Root | FWD | 20000 | 128.1 | 1-2, 4-2999, 4000-4094 |
| 3 | Boun | FWD | 20000 | 128.1 | 3, 3000-3999 |

The ports that belong to the MST switch at the boundary simulate PVST+ and send PVST+ BPDUs for all the VLANs.

If you enable loop guard on the PVST+ switches, the ports might change to a loop-inconsistent state when the MST switches change their configuration. To correct the loop-inconsistent state, you must disable and re-enable loop guard on that PVST+ switch.

- Do not locate the root for some or all of the VLANs inside the PVST+ side of the MST switch because when the MST switch at the boundary receives PVST+ BPDUs for all or some of the VLANs on its designated ports, root guard sets the port to the blocking state.
- When you connect a PVST+ switch to two different MST regions, the topology change from the PVST+ switch does not pass beyond the first MST region. In such a case, the topology changes are propagated only in the instance to which the VLAN is mapped. The topology change stays local to the first MST region, and the Cisco Access Manager (CAM) entries in the other region are not flushed. To make the topology change visible throughout other MST regions, you can map that VLAN to IST or connect the PVST+ switch to the two regions through access links.
- When you disable the PVST+ simulation, note that the PVST+ peer inconsistency can also occur while the port is already in other states of inconsistency. For example, the root bridge for all STP instances must all be in either the MST region or the Rapid PVST+ side. If the root bridge for all STP instances are not on one side or the other, the software moves the port into a PVST+ simulation-inconsistent state.



Note We recommend that you put the root bridge for all STP instances in the MST region.

Configuring PVST+ Simulation

PVST+ simulation is enabled by default. This means that all ports automatically interoperate with a connected device that is running in Rapid PVST+ mode. If you disabled the feature and want to re-configure it, refer to the following tasks.

To enable PVST+ simulation globally, perform this task:

| | Command | Purpose |
|--------|--|---|
| Step 1 | Switch# configure terminal | Enters the global configuration mode. |
| Step 2 | Switch(config)# [no] spanning-tree mst simulate pvst global | Enables PVST+ simulation globally. To prevent the switch from automatically interoperating with a connecting switch that is running Rapid PVST+, enter the no version of the command. |

This example shows how to prevent the switch from automatically interoperating with a connecting switch that is running Rapid PVST+:

```
Switch# configure terminal
Switch(config)# no spanning-tree mst simulate pvst global
```

To enable PVST+ simulation on a port, perform this task:

| | Command | Purpose |
|--------|---|--|
| Step 1 | Switch# configure terminal | Enters the global configuration mode. |
| Step 2 | Switch(config)# interface {type slot/port} | Selects a port to configure. |
| Step 3 | Switch(config-if)# spanning-tree mst simulate pvst | Enables PVST+ simulation on the specified interface. To prevent a specified interface from automatically interoperating with a connecting switch that is not running MST, enter the spanning-tree mst simulate pvst disable command. |

This example shows how to prevent a port from automatically interoperating with a connecting device that is running Rapid PVST+:

```
Switch(config)# interface gi3/13
Switch(config-if)# spanning-tree mst simulate pvst disable
```

The following sample output shows the system message you receive when a SSTP BPDU is received on a port and PVST+ simulation is disabled:

```
Message
SPANTREE_PVST_PEER_BLOCK: PVST BPDU detected on port %s [port number].
```

```
Severity
Critical
```

```
Explanation
A PVST+ peer was detected on the specified interface on the switch. PVST+ simulation feature is disabled, as a result of which the interface was moved to the spanning tree Blocking state.
```

```
Action
Identify the PVST+ switch from the network which might be configured incorrectly.
```

The following sample output shows the system message you receive when peer inconsistency on the interface is cleared:

```
Message
SPANTREE_PVST_PEER_UNBLOCK: Unblocking port %s [port number].
```

```
Severity
Critical
```

```
Explanation
The interface specified in the error message has been restored to normal spanning tree state.
```

```
Action
None.
```

This example shows the spanning tree status when port Gi3/14 has been configured to disable PVST+ simulation and is currently in the peer type inconsistent state:

```
Switch# show spanning-tree
VLAN0010
  Spanning tree enabled protocol mstp
  Root ID    Priority    32778
            Address    0002.172c.f400
            This bridge is the root
            Hello Time  2 sec  Max Age 20 sec  Forward Delay 15 sec

  Bridge ID  Priority    32778 (priority 32768 sys-id-ext 10)
            Address    0002.172c.f400
            Hello Time  2 sec  Max Age 20 sec  Forward Delay 15 sec
            Aging Time 300

Interface          Role Sts Cost          Prio.Nbr Type
-----
Gi3/14             Desg BKN*4          128.270 P2p *PVST_Peer_Inc
```

This example shows the spanning tree summary when PVST+ simulation is enabled in the MSTP mode:

```
Switch# show spanning-tree summary
Switch is in mst mode (IEEE Standard)
Root bridge for: MST0
EtherChannel misconfig guard is enabled
Extended system ID          is enabled
Portfast Default            is disabled
PortFast BPDU Guard Default is disabled
Portfast BPDU Filter Default is disabled
Loopguard Default          is disabled
UplinkFast                  is disabled
BackboneFast                is disabled
Pathcost method used        is long
PVST Simulation Default     is enabled

Name          Blocking Listening Learning Forwarding STP Active
-----
MST0          2          0          0          0          2
1 mst         2          0          0          0          2
```

This example shows the spanning tree summary when PVST+ simulation is disabled in any STP mode:

```
Switch# show spanning-tree summary
Switch is in mst mode (IEEE Standard)
Root bridge for: MST0
EtherChannel misconfig guard is enabled
Extended system ID          is enabled
Portfast Default            is disabled
PortFast BPDU Guard Default is disabled
Portfast BPDU Filter Default is disabled
Loopguard Default          is disabled
UplinkFast                  is disabled
BackboneFast                is disabled
Pathcost method used        is long
PVST Simulation Default     is disabled

Name          Blocking Listening Learning Forwarding STP Active
-----
MST0          2          0          0          0          2
1 mst         2          0          0          0          2
```

This example shows the spanning tree summary when the switch is not in MSTP mode, that is, the switch is in PVST or Rapid-PVST mode. The output string displays the current STP mode:

```
Switch# show spanning-tree summary
Switch is in rapid-pvst mode
Root bridge for: VLAN0001, VLAN2001-VLAN2002
EtherChannel misconfig guard is enabled
Extended system ID is enabled
Portfast Default is disabled
PortFast BPDU Guard Default is disabled
Portfast BPDU Filter Default is disabled
Loopguard Default is disabled
UplinkFast is disabled
BackboneFast is disabled
Pathcost method used is short
PVST Simulation Default is enabled but inactive in rapid-pvst mode
```

| Name | Blocking | Listening | Learning | Forwarding | STP Active |
|----------|----------|-----------|----------|------------|------------|
| VLAN0001 | 2 | 0 | 0 | 0 | 2 |
| VLAN2001 | 2 | 0 | 0 | 0 | 2 |
| VLAN2002 | 2 | 0 | 0 | 0 | 2 |
| 3 vlans | 6 | 0 | 0 | 0 | 6 |

This example shows the interface details when PVST+ simulation is globally enabled, or the default configuration:

```
Switch# show spanning-tree interface gi3/13 detail
Port 269 (GigabitEthernet3/13) of VLAN0002 is forwarding
  Port path cost 4, Port priority 128, Port Identifier 128.297.
  Designated root has priority 32769, address 0013.5f20.01c0
  Designated bridge has priority 32769, address 0013.5f20.01c0
  Designated port id is 128.297, designated path cost 0
  Timers: message age 0, forward delay 0, hold 0
  Number of transitions to forwarding state: 1
  Link type is point-to-point by default
  PVST Simulation is enabled by default
  BPDU: sent 132, received 1
```

This example shows the interface details when PVST+ simulation is globally disabled:

```
Switch# show spanning-tree interface gi3/13 detail
Port 269 (GigabitEthernet3/13) of VLAN0002 is forwarding
  Port path cost 4, Port priority 128, Port Identifier 128.297.
  Designated root has priority 32769, address 0013.5f20.01c0
  Designated bridge has priority 32769, address 0013.5f20.01c0
  Designated port id is 128.297, designated path cost 0
  Timers: message age 0, forward delay 0, hold 0
  Number of transitions to forwarding state: 1
  Link type is point-to-point by default
  PVST Simulation is disabled by default
  BPDU: sent 132, received 1
```

This example shows the interface details when PVST+ simulation is explicitly enabled on the port:

```
Switch# show spanning-tree interface gi3/13 detail
Port 269 (GigabitEthernet3/13) of VLAN0002 is forwarding
  Port path cost 4, Port priority 128, Port Identifier 128.297.
  Designated root has priority 32769, address 0013.5f20.01c0
  Designated bridge has priority 32769, address 0013.5f20.01c0
  Designated port id is 128.297, designated path cost 0
  Timers: message age 0, forward delay 0, hold 0
  Number of transitions to forwarding state: 1
```

```
Link type is point-to-point by default
PVST Simulation is enabled
BPDU: sent 132, received 1
```

This example shows the interface details when the PVST+ simulation feature is disabled and a PVST Peer inconsistency has been detected on the port:

```
Switch# show spanning-tree interface gi3/13 detail
Port 269 (GigabitEthernet3/13) of VLAN0002 is broken (PVST Peer Inconsistent)
  Port path cost 4, Port priority 128, Port Identifier 128.297.
  Designated root has priority 32769, address 0013.5f20.01c0
  Designated bridge has priority 32769, address 0013.5f20.01c0
  Designated port id is 128.297, designated path cost 0
  Timers: message age 0, forward delay 0, hold 0
  Number of transitions to forwarding state: 1
  Link type is point-to-point by default
  PVST Simulation is disabled
  BPDU: sent 132, received 1
```

About Detecting Unidirectional Link Failure

The dispute mechanism that detects unidirectional link failures is included in the IEEE 802.1D-2004 RSTP and IEEE 802.1Q-2005 MSTP standard, and requires no user configuration.

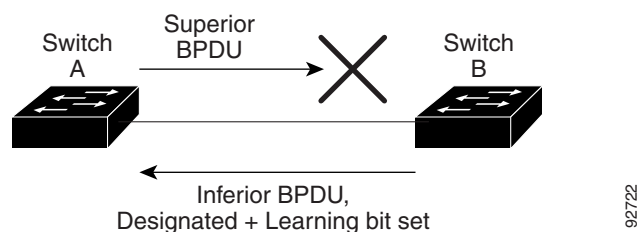
The switch checks the consistency of the port role and state in the BPDUs it receives, to detect unidirectional link failures that could cause bridging loops. When a designated port detects a conflict, it keeps its role, but reverts to a discarding (blocking) state because disrupting connectivity in case of inconsistency is preferable to opening a bridging loop.

For example, in [Figure 22-3](#), Switch A is the root bridge and Switch B is the designated port. BPDUs from Switch A are lost on the link leading to switch B.

Since Rapid PVST+ (802.1w) and MST BPDUs include the role and state of the sending port, Switch A detects (from the inferior BPDUs), that switch B does not react to the superior BPDUs it sends, because switch B has the role of a designated port and not the root bridge.

As a result, switch A blocks (or keeps blocking) its port, thus preventing the bridging loop.

Figure 22-3 Detecting Unidirectional Link Failure

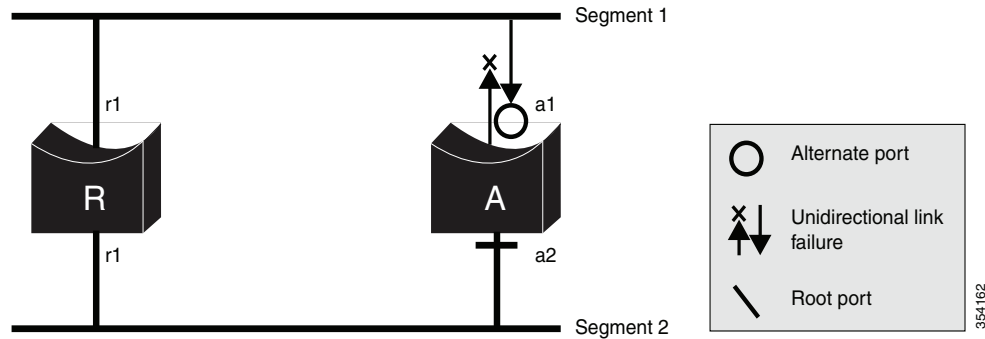


Note these guidelines and limitations relating to the dispute mechanism:

- It works only on switches running RSTP or MST, because the dispute mechanism requires reading the role and state of the port initiating the BPDUs.

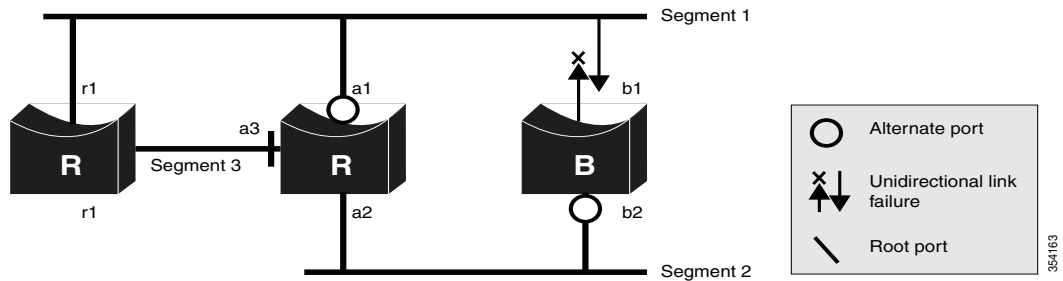
- It may result in loss of connectivity. For example, in Figure 22-4, Bridge A cannot transmit on the port it elected as a root port. As a result of this situation, there is loss of connectivity (r1 and r2 are designated, a1 is root and a2 is alternate. There is only a one way connectivity between A and R).

Figure 22-4 Loss of Connectivity



- It may cause permanent bridging loops on shared segments. For example, in Figure 22-5, suppose that bridge R has the best priority, and that port b1 cannot receive any traffic from the shared segment 1 and sends inferior designated information on segment 1. Both r1 and a1 can detect this inconsistency. However, with the current dispute mechanism, only r1 will revert to discarding while the root port a1 opens a permanent loop. However, this problem does not occur in Layer 2 switched networks that are connected by point-to-point links.

Figure 22-5 Bridging Loops on Shared Segments



This example shows the spanning tree status when port Gi3/14 has been configured to disable PVST+ simulation and the port is currently in the peer type inconsistent state:

```
Switch# show spanning-tree
VLAN0010
Spanning tree enabled protocol rstp
Root ID    Priority    32778
           Address    0002.172c.f400
           This bridge is the root
           Hello Time 2 sec  Max Age 20 sec  Forward Delay 15 sec
Bridge ID  Priority    32778 (priority 32768 sys-id-ext 10)
           Address    0002.172c.f400
           Hello Time 2 sec  Max Age 20 sec  Forward Delay 15 sec
           Aging Time 300
Interface  Role Sts Cost      Prio.Nbr Type
-----
Gi3/14    Desg BKN 4        128.270  P2p Dispute
```

This example shows the interface details when a dispute condition is detected:

```
Switch# show spanning-tree interface gi3/13 detail
Port 269 (GigabitEthernet3/13) of VLAN0002 is designated blocking (dispute)
  Port path cost 4, Port priority 128, Port Identifier 128.297.
  Designated root has priority 32769, address 0013.5f20.01c0
  Designated bridge has priority 32769, address 0013.5f20.01c0
  Designated port id is 128.297, designated path cost 0
  Timers: message age 0, forward delay 0, hold 0
  Number of transitions to forwarding state: 1
  Link type is point-to-point by default
  BPDU: sent 132, received 1
```