CHAPTER

7

Configuring Spanning Tree

This chapter describes the IEEE 802.1D bridge Spanning Tree Protocol (STP) and how to use and configure Cisco's proprietary STPs, Per VLAN Spanning Tree + (PVST+), and Multi-Instance Spanning Tree Protocol (MISTP) on the Catalyst enterprise LAN switches.

> **Note** For information on configuring the spanning tree PortFast, UplinkFast, and BackboneFast features, see Chapter 8, "Configuring Spanning Tree PortFast, BPDU Guard, BPDU Filter, UplinkFast, BackboneFast, and Loop Guard."

This chapter consists of these sections:

- Understanding How STPs Work, page 7-2
- Understanding How PVST+ and MISTP Modes Work, page 7-11
- Understanding How Bridge Identifiers Work, page 7-13
- Understanding How MST Works, page 7-14
- Using MISTP-PVST+ or MISTP, page 7-30
- Configuring a Root Switch, page 7-39
- Configuring Spanning Tree Timers, page 7-44
- Understanding How BPDU Skewing Works, page 7-22
- Configuring Spanning Tree BPDU Skewing, page 7-57
- Configuring MST, page 7-46

> **Note** For complete syntax and usage information for the commands that are used in this chapter, refer to the *Catalyst 4500 Series, Catalyst 2948G, Catalyst 2948G-GE-TX, and Catalyst 2980G Switches Command Reference*.

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Understanding How STPs Work

This section describes the specific functions that are common to all spanning tree protocols. The Cisco proprietary spanning tree protocols, PVST+ and MISTP, are based on the IEEE 802.1D STP. (See the "Understanding How PVST+ and MISTP Modes Work" section on page 7-11 for information about PVST+ and MISTP.) The 802.1D STP is a Layer 2 management protocol that provides path redundancy in a network while preventing undesirable loops. All spanning tree protocols use an algorithm that calculates the best loop-free path through the network.

STP uses a distributed algorithm that selects one bridge of a redundantly connected network as the root of a spanning tree-connected active topology. STP assigns roles to each port depending on what the port's function is in the active topology. Port roles are as follows:

- Root—A forwarding port that is elected for the spanning tree topology
- Designated—A forwarding port that is elected for every switched LAN segment
- Alternate—A blocked port providing an alternate path to the root port in the spanning tree
- Backup—A blocked port in a loopback configuration

Switches that have ports with these assigned roles are called root or designated switches. For more information, see the "Understanding How a Topology Is Created" section on page 7-2.

In Ethernet networks, only one active path may exist between any two stations. Multiple active paths between stations can cause loops in the network. When loops occur, some switches recognize stations on both sides of the switch. This situation causes the forwarding algorithm to malfunction allowing duplicate frames to be forwarded.

Spanning tree algorithms provide path redundancy by defining a tree that spans all of the switches in an extended network and then forces certain redundant data paths into a standby (blocked) state. At regular intervals, the switches in the network send and receive spanning tree packets which they use to identify the active path. If one network segment becomes unreachable, or if spanning tree costs change, the spanning tree algorithm reconfigures the spanning tree topology and reestablishes the link by activating a standby path.

Spanning tree operation is transparent to end stations, which do not detect whether they are connected to a single LAN segment or a switched LAN of multiple segments.

Understanding How a Topology Is Created

All switches in an extended LAN participating in a spanning tree gather information about other switches in the network through an exchange of data messages known as bridge protocol data units (BPDUs). This exchange of messages results in the following actions:

- A unique root switch is elected for the spanning tree network topology.
- A designated switch is elected for every switched LAN segment.
- Any loops in the switched network are eliminated by placing redundant switch ports in a backup state; all paths that are not needed to reach the root switch from anywhere in the switched network are placed in STP-blocked mode.

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The following three things determine the topology of an active switched network:

- The unique switch identifier (MAC address of the switch) that is associated with each switch
- The path cost to the root that is associated with each switch port
- The port identifier (MAC address of the port) that is associated with each switch port

In a switched network, the root switch is the logical center of the spanning tree topology. A spanning tree protocol uses BPDUs to elect the root switch and root port for the switched network and the root port and designated port for each switched segment.

Understanding How a Switch or Port Becomes the Root Switch or Root Port

If all switches in a network are enabled with default settings, the switch with the lowest MAC address becomes the root switch. In Figure 7-1, Switch A, with the lowest MAC address, is the root switch. However, due to traffic patterns, number of forwarding ports, or line types, Switch A might not be the ideal root switch. You can force a switch to become the root switch by increasing the priority (lowering the priority number) on the preferred switch. This action causes the spanning tree to recalculate the topology and make the selected switch the root switch.

Figure 7-1   Configuring a Loop-Free Topology
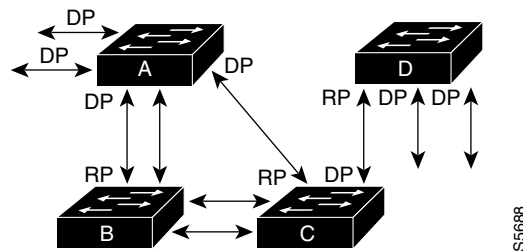
RP = Root Port
DP = Designated Port

You can also change the priority of a port to make it the root port. When the spanning tree topology is based on default parameters, the path between the source and the destination stations in a switched network might not be ideal. The goal is to make the fastest link the root port, connecting higher-speed links to a port that has a higher number than the current root port can cause a root-port change.

For example, assume that a port on Switch B is a fiber-optic link. Also, 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 Port Priority parameter for the UTP port to a higher priority (lower numerical value) than the fiber-optic port, the UTP port becomes the root port. You could also accomplish this scenario by changing the port cost parameter for the UTP port to a lower value than that of the fiber-optic port.

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Understanding BPDUs

BPDUs contain configuration information about the transmitting switch and its ports, including switch and port MAC addresses, switch priority, port priority, and port cost. Each configuration BPDU contains this information:

- The unique identifier of the switch that the transmitting switch believes to be the root switch

- The cost of the path to the root from the transmitting port

- The identifier of the transmitting port

The switch sends configuration BPDUs to communicate with and compute the spanning tree topology. A MAC frame conveying a BPDU sends the switch group address to the destination address field. All switches connected to the LAN on which the frame is transmitted receive the BPDU. BPDUs are not directly forwarded by the switch, but the receiving switch uses the information in the frame to calculate a BPDU. If the topology changes, the receiving switch initiates a BPDU transmission.

A BPDU exchange results in the following:

- One switch is elected as the root switch.

- The shortest distance to the root switch is calculated for each switch.

- A designated switch is selected. This is the switch that is closest to the root switch through which frames will be forwarded to the root.

- A port for each switch is selected. This is the port that provides the best path from the switch to the root switch.

- Ports included in the STP are selected.

Calculating and Assigning Port Costs

By calculating and assigning the port cost of the switch ports, you can ensure that the shortest (lowest cost) distance to the root switch is used to transmit data. You can calculate and assign lower path cost values (port costs) to higher bandwidth ports by using either the short method (which is the default) or the long method. The short method uses a 16-bit format that yields values from 1–65535. The long method uses a 32-bit format that yields values from 1–200,000,000. For more information on setting the default cost mode, see the "Configuring the PVST+ Default Port Cost Mode" section on page 7-26.

Note   You should configure all switches in your network to use the same method for calculating port cost. The short method (default) will be used to calculate the port cost unless you specify the long method. You can specify the calculation method using the CLI.

Calculating the Port Cost Using the Short Method

The IEEE 802.1D specification assigns 16-bit (short) default port cost values to each port that is based on bandwidth. You can also manually assign port costs between 1–65535. The 16-bit values are only used for ports that have not been specifically configured for port cost. Table 7-1 shows the default port cost values that are assigned by the switch for each type of port when you use the short method to calculate the port cost.

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Table 7-1   Default Port Cost Values Using the Short Method

Port Speed	Default Cost Value	Default Range
10 Mbps	100	1 to 65535
100 Mbps	19	1 to 65535
1 Gbps	4	1 to 65535

Calculating the Port Cost Using the Long Method

802.1t assigns 32-bit (long) default port cost values to each port using a formula that is based on the port bandwidth. You can also manually assign port costs between 1–200,000,000. The formula for obtaining default 32-bit port costs is to divide the bandwidth of the port by 200,000,000. Table 7-2 shows the default port cost values that are assigned by the switch and the recommended cost values and ranges for each type of port when you use the long method to calculate port cost.

Table 7-2   Default Port Cost Values Using the Long Method

Port Speed	Recommended Value	Recommended Range	Available Range
≤100 kbps	200000000	20000000 to 200000000	1 to 200000000
1 Mbps	20000000	2000000 to 200000000	1 to 200000000
10 Mbps	2000000	200000 to 20000000	1 to 200000000
100 Mbps	200000	20000 to 2000000	1 to 200000000
1 Gbps	20000	2000 to 200000	1 to 200000000
10 Gbps	2000	200 to 20000	1 to 200000000

Calculating the Port Cost for Aggregate Links

As individual links are added or removed from an aggregate link (port bundle), the bandwidth of the aggregate link increases or decreases. These changes in bandwidth lead to the recalculation of the default port cost for the aggregated port. Changes to the default port cost or changes resulting from links that autonegotiate their bandwidth could lead to recalculation of the spanning tree topology. Recalculation may not be desirable, especially if the added or removed link is of little consequence to the bandwidth of the aggregate link (for example, if a 10-Mbps link is removed from a 10-Gbps aggregate link). Because of the limitations that are presented by automatically recalculating the topology, 802.1t states that changes in bandwidth will not result in changes to the cost of the port concerned. Therefore, the aggregated port uses the same port cost parameters as a standalone port.

Understanding Spanning Tree Port States

Topology changes can take place in a switched network due to a link coming up or going down (failing). When a switch port transitions directly from nonparticipation in the topology to the forwarding state, it can create temporary data loops. Ports must wait for new topology information to propagate through the switches in the LAN before they can start forwarding frames. They must also allow the frame lifetime to expire for frames that have been forwarded using the old topology.

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At any given time, each port on a switch using STP is in one of these states:
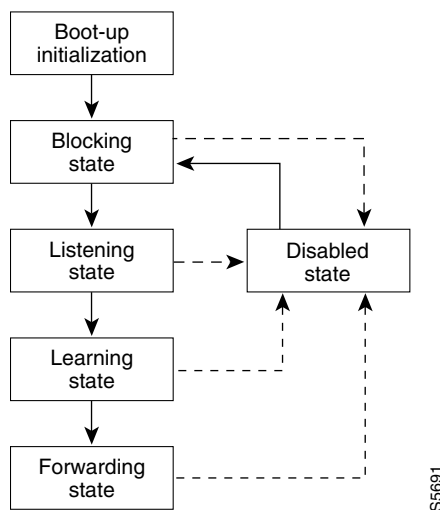
- Blocking
- Listening
- Learning
- Forwarding
- Disabled

A port moves through these states:

- From initialization to blocking
- From blocking to either listening or disabled
- From listening to either listening or disabled
- From learning to either forwarding or disabled
- From forwarding to disabled

Figure 7-2 illustrates how a port moves through the states.

Figure 7-2   STP Port States

You can modify each port state by using management software, such as the VLAN Trunking Protocol (VTP). When you enable spanning tree, every switch in the network goes through the blocking state and the transitory states of listening and learning at power up. If properly configured, each port stabilizes into the forwarding or blocking state.

When the spanning tree algorithm places a port in the forwarding state, the following occurs:

- The port is put into the listening state while it waits for protocol information that suggests it should go to the blocking state
- The port waits for the expiration of a protocol timer that moves the port to the learning state
- In the learning state, the port continues to block frame forwarding as it learns station location information for the forwarding database
- The expiration of a protocol timer moves the port to the forwarding state, where both learning and forwarding are enabled

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Blocking State

A port in the blocking state, such as Port 2 in Figure 7-3, does not participate in frame forwarding. After initialization, a BPDU is sent to each port in the switch. A switch initially assumes that it is the root until it exchanges BPDUs with other switches. This exchange establishes which switch in the network is really the root. If only one switch resides in the network, no exchange occurs, the forward delay timer expires, and the ports move to the listening state. A switch always enters the blocking state following switch initialization.

Figure 7-3   Port 2 in Blocking State
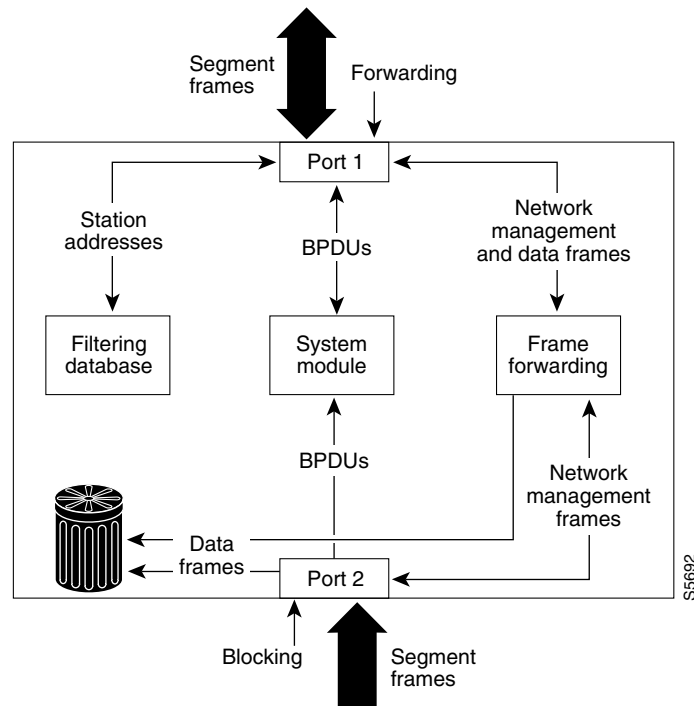
A port in the blocking state performs as follows:

- Discards frames that are received from the attached segment
- Discards frames that are switched from another port for forwarding
- Does not incorporate station location into its address database (there is no learning on a blocking port, so there is no address database update)
- Receives BPDUs and directs them to the system module
- Does not transmit BPDUs that are received from the system module
- Receives and responds to network management messages

Listening State

The listening state is the first transitional state that a port enters after the blocking state. The port enters this state when the spanning tree determines that the port should participate in frame forwarding. Learning is disabled in the listening state. Figure 7-4 shows a port in the listening state.

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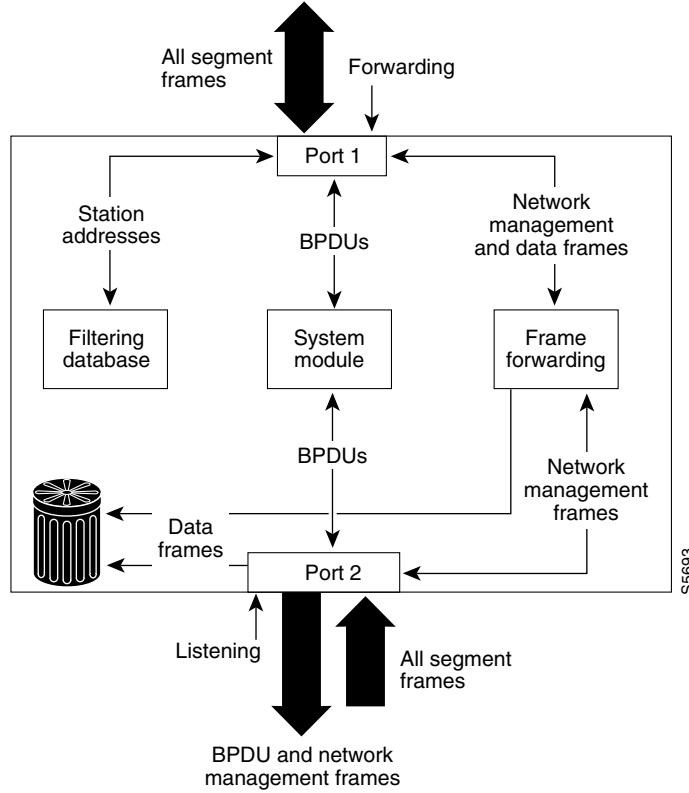
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Figure 7-4   Port 2 in Listening State

A port in the listening state performs as follows:

- Discards frames that are received from the attached segment
- Discards frames that are switched from another port for forwarding
- Does not incorporate station location into its address database (there is no learning at this point, so there is no address database update)
- Receives BPDUs and directs them to the system module
- Processes BPDUs that are received from the system module
- Receives and responds to network management messages

Learning State

A port in the learning state prepares to participate in frame forwarding. The port enters the learning state from the listening state. Figure 7-5 shows a port in the learning state.

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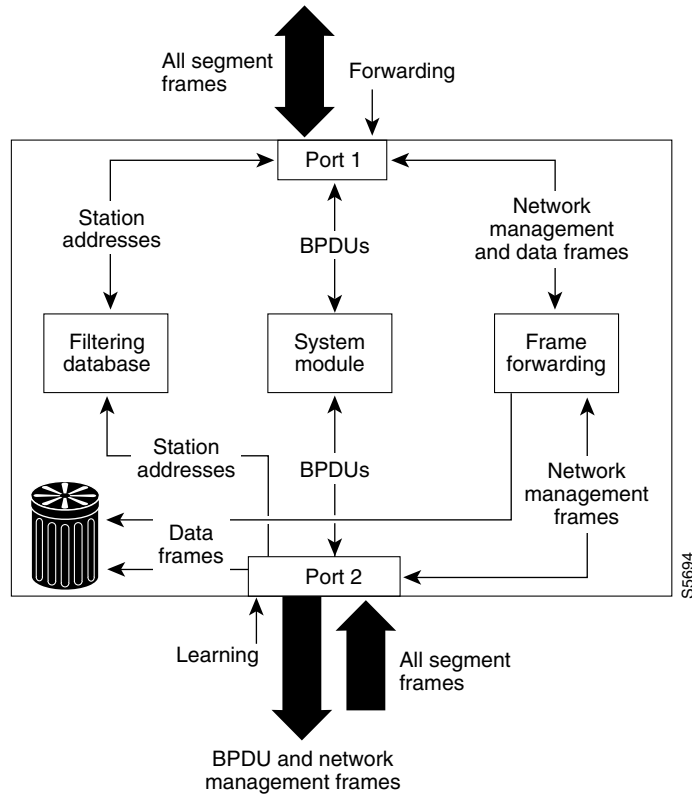78-15908-01

Figure 7-5   Port 2 in Learning State

A port in the learning state performs as follows:

- Discards frames that are received from the attached segment
- Discards frames that are switched from another port for forwarding
- Incorporates station location into its address database
- Receives BPDUs and directs them to the system module
- Receives, processes, and transmits BPDUs that are received from the system module
- Receives and responds to network management messages

Forwarding State

A port in the forwarding state forwards frames, as shown in Figure 7-6. The port enters the forwarding state from the learning state.

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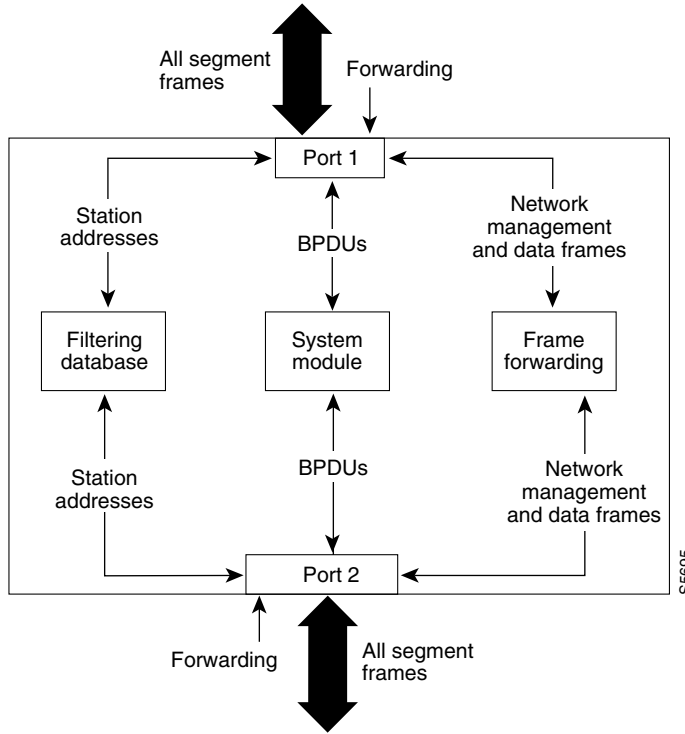**7-9**

Figure 7-6   Port 2 in Forwarding State

A port in the forwarding state performs as follows:

- Forwards frames that are received from the attached segment
- Forwards frames that are switched from another port for forwarding
- Incorporates station location information into its address database
- Receives BPDUs and directs them to the system module
- Processes BPDUs that are received from the system module
- Receives and responds to network management messages

⚠️
Caution   Use spanning tree PortFast mode only on ports that are directly connected to individual workstations to allow these ports to come up and go directly to the forwarding state, instead of going through the entire spanning tree initialization. To prevent illegal topologies, enable spanning tree on ports that are connected to switches or other devices that forward messages. For more information on PortFast, see Chapter 8, "Configuring Spanning Tree PortFast, BPDU Guard, BPDU Filter, UplinkFast, BackboneFast, and Loop Guard."

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Disabled State

A port in the disabled state does not participate in frame forwarding or STP, as shown in Figure 7-7. A port in the disabled state is virtually nonoperational.

Figure 7-7   Port 2 in Disabled State
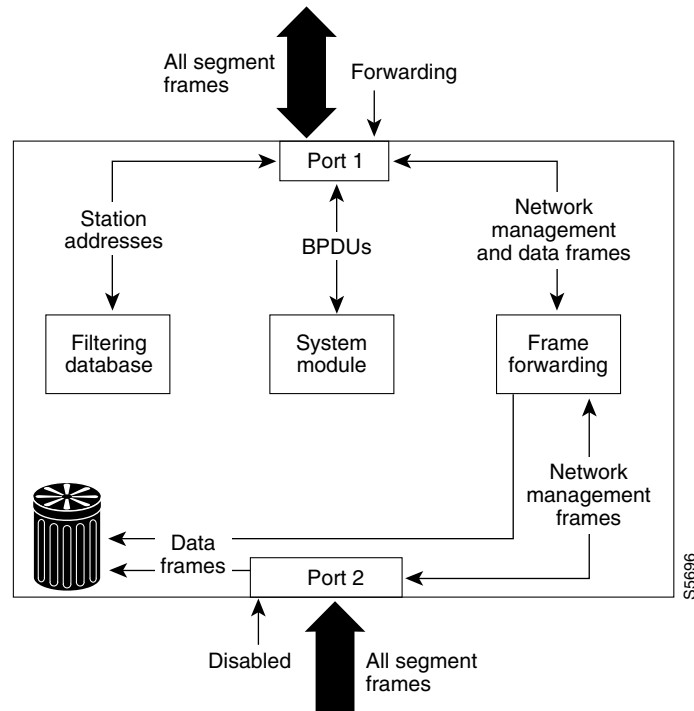
A disabled port performs as follows:

- Discards frames that are received from the attached segment
- Discards frames that are switched from another port for forwarding
- Does not incorporate station location into its address database (there is no learning, so there is no address database update)
- Receives BPDUs but does not direct them to the system module
- Does not receive BPDUs for transmission from the system module
- Receives and responds to network management messages

Understanding How PVST+ and MISTP Modes Work

Catalyst 4500 series switches provide two proprietary spanning tree modes based on the IEEE 802.1D standard and one mode that is a combination of the two modes:

- Per VLAN Spanning Tree (PVST+)
- Rapid PVST+
- Multi-Instance Spanning Tree Protocol (MISTP)
- MISTP-PVST+ (combination mode)

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The following sections provide an overview of each mode.

⚠
Caution   If your network currently uses PVST+ and you plan to use MISTP on any switch, you must first enable MISTP-PVST+ on the switch and configure an MISTP instance to avoid causing network loops.

PVST+ Mode

PVST+ is the default STP used on all Ethernet, Fast Ethernet, and Gigabit Ethernet port-based VLANs on Catalyst 4500 series switches. PVST+ runs on each VLAN on the switch, ensuring that each has a loop-free path through the network.

PVST+ provides Layer 2 load balancing for the VLAN on which it runs; you can create different logical topologies using the VLANs on your network to ensure that all of your links will be used but no one link will be oversubscribed.

Each instance of PVST+ on a VLAN has a single root switch. This root switch propagates the spanning tree information that is associated with that VLAN to all other switches in the network. Because each switch has the same knowledge about the network, this process ensures that the network topology is maintained.

Rapid PVST+

Rapid PVST+ is the same as PVST+, except that Rapid PVST+ utilizes a Rapid STP that is based on IEEE 802.1w instead of 802.1D. Rapid PVST+ uses the same configuration as PVST+, and you need only minimal extra configuration. With Rapid PVST+, dynamic CAM entries are flushed immediately per port upon any topology change. UplinkFast and BackboneFast are enabled but not active in this mode, because the functionality is built into the rapid STP. This method provides for quick recovery of connectivity following the failure of a bridge, bridge port, or LAN.

MISTP Mode

MISTP is an optional STP that runs on Catalyst 4500 series switches. MISTP allows you to group multiple VLANs under a single instance of spanning tree (an MISTP instance). MISTP combines the Layer 2 load-balancing benefits of PVST+ with the lower CPU load of IEEE 802.1Q.

An MISTP instance is a virtual logical topology that is defined by a set of bridge and port parameters; an MISTP instance becomes a real topology when VLANs are mapped to it. Each MISTP instance has its own root switch and a different set of forwarding links (that is, different bridge and port parameters).

Each MISTP instance has a single root switch, which propagates the information that is associated with that instance of MISTP to all other switches in the network. This process ensures that the network topology is maintained because each switch has the same knowledge about the network.

MISTP builds MISTP instances by exchanging MISTP BPDUs with peer entities in the network. There is only one BPDU for each MISTP instance, rather than for each VLAN as in PVST+. There are fewer BPDUs in an MISTP network; therefore, there is less overhead in the network. MISTP discards any PVST+ BPDUs that it sees.

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An MISTP instance can have any number of VLANs that are mapped to it, but a VLAN can only be mapped to a single MISTP instance. You can easily move a VLAN (or VLANs) in an MISTP topology to another MISTP instance if it has converged. (However, if ports are added at the same time that the VLAN is moved, convergence time is required.)

MISTP-PVST+ Mode

MISTP-PVST+ is a transition spanning tree mode that allows you to use the MISTP functionality on Catalyst 4500 series switches while continuing to communicate with the older Catalyst 5000 family and 6500 series switches in your network that use PVST+. A switch using PVST+ mode and a switch using MISTP mode connected together cannot see the BPDUs of the other switch, a condition that can cause loops in the network. MISTP-PVST+ allows interoperability between PVST+ and pure MISTP, because it detects the BPDUs of both modes. If you wish to convert your network to MISTP, you can use MISTP-PVST+ to transition the network from PVST+ to MISTP to avoid problems.

MISTP-PVST+ conforms to the limits of PVST+; for example, you can only configure the amount of VLAN ports on your MISTP-PVST+ switches that you configure on your PVST+ switches.

Understanding How Bridge Identifiers Work

The next two sections explain how MAC addresses are used in PVST+ and MISTP as unique bridge identifiers.

MAC Address Allocation

Catalyst 4000 series switches have a pool of 1024 MAC addresses that can be used as bridge identifiers for VLANs running under PVST+ or for MISTP instances. The Catalyst 4500 series switches have a pool of only 64 MAC addresses. You can use the **show module** command to view the MAC address range.

MAC addresses are allocated sequentially, with the first MAC address in the range assigned to VLAN 1, the second in the range assigned to VLAN 2, and so forth. The last MAC address in the range is assigned to the supervisor engine in-band (sc0) management interface.

For example, if the MAC address range for the supervisor engine 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 forth. The in-band (sc0) interface MAC address is 00-e0-1e-9b-31-ff.

MAC Address Reduction

MAC address reduction is used on Catalyst 6500 series switches to enable extended-range VLAN identification. If you have a Catalyst 6500 series switch in your network and you have MAC address reduction enabled on it, you should also enable MAC address reduction on all your Catalyst 4500 series switches to avoid problems in the spanning tree topology. When MAC address reduction is enabled on Catalyst 4500 series switches, it disables the pool of MAC addresses that are used for the VLAN spanning tree, leaving a single MAC address that identifies the switch. For detailed information on MAC address reduction, refer to the *Catalyst 6500 Series Switch Software Configuration Guide*.

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MAC address reduction is always enabled on the Catalyst 4500 series switches; however, it may or may not be enabled on a Catalyst 4006 switch; this can affect the selection of the root bridge after you migrate your supervisor engine. Here are two scenarios to consider:

- The Catalyst 4006 switch is not a root switch

    In this case, the spanning tree topology does not change. If you add a Catalyst 4500 series switch with MAC address reduction enabled and its default spanning tree bridge ID priority set to 32,768 to the network, the bridge ID priority of the new switch becomes the bridge ID priority that is added to the system ID extension. The system ID extension is the VLAN number and can vary from 1 to 4094. If the switch is in VLAN 1, the new bridge ID priority will be 32,769. Because 32,769 is greater than 32,768, this switch cannot become the root switch.

- The Catalyst 4006 is a root switch

    In this case, the spanning tree topology might change. If the other switches in the network are not running MAC address reduction, the topology will change after you replace the chassis with a Catalyst 4500 series switch. The bridge ID priority of the new Catalyst 4500 series switch increments in the same manner as in the previous scenario (bridge ID priority + VLAN number). If the switch is in VLAN 1, the new bridge ID will be 32,769. Because 32,769 is greater than 32,768, this switch cannot become the root switch. The network designates a new root switch; the spanning tree topology also changes to reflect the new root switch.

    If the bridge priority of the Catalyst 4006 has been lowered administratively and you use the same configuration in the new Catalyst 4500 series switch, then the switch remains the root switch and the spanning tree topology does not change.

For more information on migrating your supervisor engine from a Catalyst 4006 switch to a Catalyst 4500 series switch, see the .

Understanding How MST Works

The Multiple Spanning Tree (MST) feature is the IEEE 802.1s and is an amendment to 802.1Q. MST extends the 802.1w Rapid Spanning Tree (RST) algorithm to multiple spanning trees. This extension provides for both rapid convergence and load balancing in a VLAN environment. The MST protocol is currently being further developed; the MST feature for this release is based on a draft version of the IEEE standard. The protocol, as implemented in this release, is backward compatible with 802.1D STP, 802.1w, the Rapid Spanning Tree Protocol (RSTP), and the Cisco PVST+ architecture.

MST allows you to build multiple spanning trees over VLAN trunks. You can group and associate VLANs to spanning tree instances. Each instance can have a topology independent of other spanning tree instances. This new 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 (forwarding paths).

In large networks, having different VLAN-spanning tree instance assignments that are located in different parts of the network makes it easier to administrate and utilize redundant paths. However, a spanning tree instance can exist only on bridges that have compatible VLAN-instance assignments. MST requires that you configure a set of bridges with the same MST configuration information, allowing them to participate in a given set of spanning tree instances. Interconnected bridges that have the same MST configuration are referred to as an MST region.

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MST uses the modified RSTP version called the Multiple Spanning Tree Protocol (MSTP). The MST feature has these characteristics:

- MST runs a variant of spanning tree called Internal Spanning Tree (IST). IST augments the 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 single spanning tree bridges as follows:

  - MST bridges run a variant of STP (IST) that augments the Common Spanning Tree (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 encompasses the whole bridged domain. The MST region appears as a virtual bridge to adjacent SST bridges and MST regions.

  - The collection of ISTs in each MST region, the CST that interconnects the MST regions, and the SST bridges define Common and Internal Spanning Tree (CIST). CIST is the same as an IST inside an MST region and the same as CST outside an MST region. The STP, RSTP, and MSTP together elect a single bridge as the root of CIST.

- MST establishes and maintains additional spanning trees within each MST region. These spanning trees are referred to as MST instances (MSTIs). The IST is numbered 0, and the MSTIs are numbered 1, 2, 3,... and so on. Any given MSTI is local to the MST region that 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 BPDUs (MST BPDUs). The original spanning trees computed by MSTP are called M-trees. M-trees 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 filtering 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 behave as if MAC reduction is enabled.

  - For private VLANs, secondary VLANs are mapped to the same instance as the primary.

Note the following guidelines when using MST:

- Do not disable spanning tree on any VLAN in any of the PVST bridges.

- Ensure that all PVST spanning tree root bridges have lower (numerically higher) priority than the CST root bridge.

- Do not use PVST bridges as the root of CST.

- Ensure that trunks carry all of the VLANs that are mapped to an instance or do not carry any VLANs at all.

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- Do not connect switches with access links because access links may partition a VLAN.

- Any MST configuration involving a large number of either existing or new logical VLAN ports should be carried out during the maintenance window. This action should be taken because the complete MST database gets reinitialized for any incremental changes (such as adding new VLANs to instances or moving VLANs across instances).

Rapid Spanning Tree Protocol

RSTP significantly reduces the time that it takes you to reconfigure the active topology of the network when changes to the physical topology or its configurations parameters occur. 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 forwarding through an explicit handshake between them. RSTP allows switch port configuration so that the ports can transition to forwarding directly when the switch reinitializes.

RSTP, specified in 802.1w, supersedes STP, which is specified in 802.1D, while retaining compatibility with STP. RSTP provides the structure on which the MST operates. You configure RSTP when you configure the MST feature. For more information, see the "Configuring MST" section on page 7-46.

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 that are received on that port. RSTP BPDUs are not visible on the port. Only version 3 BPDUs are visible on the port.

- If the bridge receives an 802.1D BPDU after a port's Migration Delay timer expires, the bridge assumes that 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

RSTP uses the following definitions for port roles:

- Root—A forwarding port that is elected for the spanning tree topology.

- Designated—A forwarding port that is 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 that is 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 by a point-to-point link 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.

Port roles are assigned 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.

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RSTP Port States

The port state controls the forwarding and learning processes and provides the values of discarding, learning, and forwarding. See Table 7-3 for a comparison between STP port states and RSTP port states.

Table 7-3   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. In this publication, discarding is the same as blocking in MST.

In a stable topology, RSTP ensures that every root port and designated port transition to forwarding 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. See Figure 7-8.

Figure 7-8   Network with Interconnected SST and MST Regions

F/f = Forwarding
B/b = Blocking
R   = Root Bridge
r   = Root port

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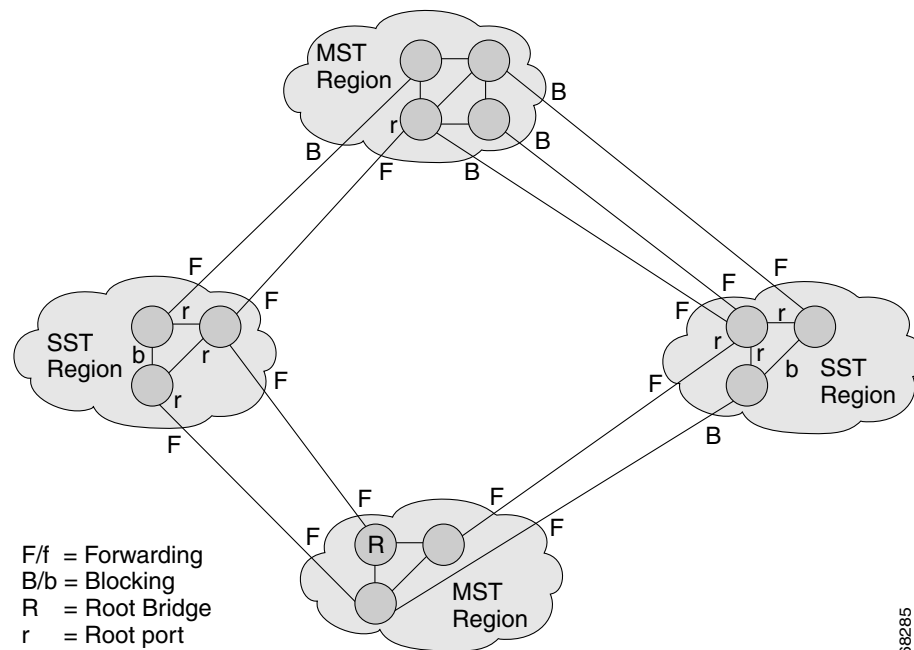
To the spanning tree protocol running in the SST region, an MST region appears as a single SST or pseudobridge. Pseudobridges operate as follows:

- The same values for root identifiers and root path costs are sent in all BPDUs of all the pseudobridge ports. Pseudobridges differ 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 that are sent from the pseudobridge ports may have significantly different message ages. Because the message age increases by 1 second for each hop, the difference in the message age is in the order of seconds.

- Data traffic from one port of a pseudobridge (a port at the edge of a region) to another port follows a path that is entirely contained within the pseudobridge or MST region.

- Data traffic belonging to different VLANs may follow different paths within the MST regions that are established by MST.

- Loop prevention is achieved by 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.

- A pseudobridge differs from a single SST bridge because the BPDUs that are sent from the pseudobridge's ports have different bridge identifiers. The root identifier and root cost are the same for both bridges.

Common Spanning Tree

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

MST Instances

This release supports up to 16 instances; each spanning tree instance is identified by an instance ID that ranges from 0 to 15. Instance 0 is mandatory and is always present. Instances 1 through 15 are optional.

MST Configuration

MST configuration has three parts as follows:

- Name—A 32-character string (null padded and null terminated) identifying the MST region.
- Revision number—An unsigned 16-bit number that increments each time that a change is made to the configuration.

Note You must set and update the revision number manually, because the number does not auto-increment each time that you commit the MST configuration.

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- 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. You can 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 one value is different, the MST BPDU is treated as an SST BPDU.

When you modify an MST configuration through either a console or Telnet connection, the session exits without committing those changes and the edit buffer locks. Further configuration is impossible until you discard the existing edit buffer and acquire a new edit buffer by entering the **set spantree mst config rollback force** command.

MST Region

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 that is 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 certain delay. We do not recommend partitioning the network into a large number of regions.

Boundary Ports

A port that connects an MST region to an SST region running RSTP (802.1w), an SST region running STP (802.1D), or another MST region is a boundary port. 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.

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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 the 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 stays constant, but the IST path cost is incremented and the IST remaining hops is decremented at each hop. Enter the **show spantree 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 router) is an edge port. A port that connects to a hub is also an edge port, provided that the hub or any LAN that is connected by it does not have a bridge. These ports start forwarding as soon as the link is up.

MST requires that all ports are configured for each host or router. To establish rapid connectivity after a failure, you need to block the nonedge-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 requires twice the forward delay time to start forwarding again. You must explicitly configure the ports that are connected to the hosts and routers as edge ports while using MST.

> **Note** To configure a port as an edge port, you enable PortFast on that port. See Chapter 8, "Configuring Spanning Tree PortFast, BPDU Guard, BPDU Filter, UplinkFast, BackboneFast, and Loop Guard." When you enter the **show spantree portfast** *mod/port* command, if the designation for a port is displayed as edge, that port is also a PortFast port.

To prevent a misconfiguration, PortFast turns off operationally if the port receives a BPDU. You can display the configured and operational status of PortFast by using the **show spantree mst** *mod/port* command.

Link Type

You can establish rapid connectivity only on point-to-point links. For correct operation of the protocol, you must explicitly configure ports to a host or router. However, cabling in most networks meets this requirement, and you can avoid explicit configuration by treating all full-duplex links as point-to-point links. Enter the **set spantree mst link-type** command to configure point-to-point links.

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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 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-to-PVST+ Interoperability

These guidelines apply in a topology where you configure MST switches (all in the same region) to interact with PVST+ switches that have VLANs 1–100 set up to span throughout the network:

- Configure the root for all VLANs inside the MST region. The ports that belong to the MST switch at the boundary simulate PVST+ and send PVST+ BPDUs for all the VLANs. This example shows the ports simulating PVST:

```
Console> (enable) show spantree mst 3
Spanning tree mode        MST
Instance                  3
VLANs Mapped:             31-40

Designated Root           00-10-7b-bb-2f-00
Designated Root Priority  8195  (root priority:8192, sys ID ext:3)
Designated Root Cost      0          Remaining Hops 20
Designated Root Port      1/0

Bridge ID MAC ADDR        00-10-7b-bb-2f-00
Bridge ID Priority        8195  (bridge priority:8192, sys ID ext:3)

Port                    State         Role Cost     Prio Type
----------------------- ------------- ---- -------- ------------------------
 6/1                    forwarding    BDRY   10000    30 P2P,
Boundary(PVST)
 6/2                    blocking      BDRY   20000    32 P2P,
Boundary(PVST)
```

  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 reenable 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. Do not designate switches with a slower CPU running PVST+ as a switch running MST.

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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 this case, the topology changes are only propagated in the instance to which the VLAN is mapped. The topology change stays local to the first MST region and the 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.

Understanding How BPDU Skewing Works

BPDU skewing is the difference between when the BPDUs are expected to be received and the time BPDUs are actually received. Skewing occurs when the following occurs:

- Spanning tree timers lapse.
- Expected BPDUs are not received.
- Spanning tree detects topology changes.

The skew causes BPDUs to reflood the network to keep the spanning tree topology database current.

The root switch advertises its presence by sending out BPDUs for the configured Hello time interval. The nonroot switches receive and process one BPDU during each configured time period. A VLAN might not receive the BPDU as scheduled. If the BPDU is not received on a VLAN at the configured time interval, the BPDU is skewed.

Spanning tree uses the Hello Time (see the "Configuring the Hello Time" section on page 7-44) to detect when a connection to the root switch exists through a port and when that connection is lost. This feature applies to both PVST+ and MISTP. In MISTP, the skew detection is on a per-instance basis.

BPDU skewing detects BPDUs that are not processed in a regular time frame on the nonroot switches in the network. If BPDU skewing occurs, a syslog message is displayed. The syslog applies to both PVST+ and MISTP.

The number of syslog messages that are generated may impact the convergence of the network and the CPU utilization of the switch. New syslog messages are not generated as individual messages for every VLAN because the higher the number of syslog messages that are reported, the slower the switching process will be. To reduce the impact on the switch, the syslog messages are as follows:

- Generated 50 percent of the maximum age time (see the "Configuring the Maximum Aging Time" section on page 45)
- Rate limited at one for every 60 seconds

Using PVST+

PVST+ is the default spanning tree mode for Catalyst 4500 series switches. The following sections describe how to configure PVST+ on Ethernet VLANs.

Default PVST+ Configuration

Table 7-4 shows the default PVST+ configuration.

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Table 7-4   PVST+ Default Configuration

Feature	Default Value
VLAN 1	All ports assigned to VLAN 1
Enable state	PVST+ enabled for all VLANs
MAC address reduction	Disabled
Bridge priority	32,768
Bridge ID priority	32,769 (bridge priority plus system ID extension of VLAN 1)
Port priority	32
Port cost	• Gigabit Ethernet: 4 • Fast Ethernet: 10 • FDDI/CDDI: 10 • Ethernet: 100
Default spantree port cost mode	Short (802.1D)
Port VLAN priority	Same as port priority but configurable on a per-VLAN basis in PVST+
Port VLAN cost	Same as port cost but configurable on a per-VLAN basis in PVST+
Maximum aging time	20 sec
Hello time	2 sec
Forward delay time	15 sec

Setting the PVST+ Bridge ID Priority

The bridge ID priority is the priority of a VLAN when the switch is in PVST+ mode.

When the switch is in PVST+ mode without MAC address reduction enabled, you can enter a bridge priority value between 0–65,535. The VLAN bridge ID priority becomes that value.

When the switch is in PVST+ mode with MAC address reduction enabled, you can enter one of 16 bridge priority values: 0, 4096, 8192, 12,288, 16,384, 20,480, 24,576, 28,672, 32,768, 36,864, 40,960, 45,056, 49,152, 53,248, 57,344, or 61,440.

The switch creates the bridge ID priority by combining the VLAN bridge priority with the system ID extension (the ID of the VLAN).

To set the spanning tree bridge priority for a VLAN, perform this task in privileged mode:

	Task	Command
Step 1	Set the bridge ID priority for a VLAN.	**set spantree priority** *bridge_ID_priority* [*vlan*]
Step 2	Verify the bridge ID priority.	**show spantree** [*vlan*] [**active**]

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This example shows how to set the PVST+ bridge ID when MAC address reduction is not enabled
(default):

```
Console> (enable) set spantree priority 30000 1
Spantree 1 bridge priority set to 30000.
Console> (enable) show spantree 1
VLAN 1
Spanning tree mode        PVST+
Spanning tree type        ieee
Spanning tree enabled

Designated Root           00-60-70-4c-70-00
Designated Root Priority  16384
Designated Root Cost      19
Designated Root Port      2/3
Root Max Age   14 sec   Hello Time 2  sec   Forward Delay 10 sec

Bridge ID MAC ADDR        00-d0-00-4c-18-00
Bridge ID Priority        30000
Bridge Max Age 20 sec   Hello Time 2  sec   Forward Delay 15 sec

Port                    Vlan Port-State    Cost      Prio Portfast Channel_id
----------------------- ---- ------------ --------- ---- -------- ----------
 1/1                    1    not-connected        4   32 disabled 0
 1/2                    1    not-connected        4   32 disabled 0
 2/1                    1    not-connected      100   32 disabled 0
 2/2                    1    not-connected      100   32 disabled 0
```

This example shows how to set the PVST+ bridge ID priority when MAC reduction is enabled:

```
Console> (enable) set spantree priority 32768 1
Spantree 1 bridge ID priority set to 32769
(bridge priority: 32768 + sys ID extension: 1)
Console> (enable) show spantree 1/1 1
VLAN 1
Spanning tree mode        PVST+
Spanning tree type        ieee
Spanning tree enabled

Designated Root           00-60-70-4c-70-00
Designated Root Priority  16384
Designated Root Cost      19
Designated Root Port      2/3
Root Max Age   14 sec   Hello Time 2  sec   Forward Delay 10 sec

Bridge ID MAC ADDR        00-d0-00-4c-18-00
Bridge ID Priority        32769  (bridge priority: 32768, sys ID ext: 1)
Bridge Max Age 20 sec   Hello Time 2  sec   Forward Delay 15 sec

Port                    Vlan Port-State    Cost      Prio Portfast Channel_id
----------------------- ---- ------------ --------- ---- -------- ----------
 1/1                    1    not-connected        4   32 disabled 0
 1/2                    1    not-connected        4   32 disabled 0
 2/1                    1    not-connected      100   32 disabled 0
 2/2                    1    not-connected      100   32 disabled 0
```

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Configuring the PVST+ Port Cost

You can configure the port cost of switch ports. Ports with lower port costs are more likely to be chosen to forward frames. Assign lower numbers to ports that are attached to faster media (such as full duplex), and higher numbers to ports that are attached to slower media.The possible range of *cost* is from 1–65535. The default differs for different media. Typically, the path cost is 1000 ÷ LAN speed in megabits per second.

To configure the port cost for a port, perform this task in privileged mode:

	Task	Command
Step 1	Configure the port cost for a switch port.	**set spantree portcost** {*mod/port*} *cost*
Step 2	Verify the port cost setting.	**show spantree** *mod*/*port*

This example shows how to configure the port VLAN priority on a port and verify the configuration:

```
Console> (enable) set spantree portcost 2/3 12
Spantree port 2/3 path cost set to 12.
Console> (enable) show spantree 2/3
VLAN 1
   .
   .
Port                    Vlan Port-State    Cost      Prio Portfast Channel_id
----------------------- ---- ------------- --------- ---- ------- ----------
 1/1                    1    not-connected         4  32 disabled 0
 1/2                    1    not-connected         4  32 disabled 0
 2/1                    1    not-connected       100  32 disabled 0
 2/2                    1    not-connected       100  32 disabled 0
 2/3                    1    forwarding           12  32 disabled 0
 2/4                    1    not-connected       100  32 disabled
```

Configuring PVST+ Port Priority

You can configure the port priority of switch ports in PVST+ mode. The port with the lowest priority value forwards frames for all VLANs. The possible port priority value is from 0–63. The default is 32. If all ports have the same priority value, the port with the lowest port number forwards frames.

To configure the port priority for a port, perform this task in privileged mode:

	Task	Command
Step 1	Configure the port priority for a switch port.	**set spantree portpri** *mod_num/port_num priority*
Step 2	Verify the port priority setting.	**show spantree** *mod*/*port*

This example shows how to configure the port priority for a port:

```
Console> (enable) set spantree portpri 2/3 16
Bridge port  2/3 port priority set to 16.
Console> (enable) show spantree 2/3
VLAN 1
   .
   .
   .
```

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```
Port                     Vlan Port-State    Cost      Prio Portfast Channel_id
------------------------ ---- ------------- --------- ---- -------- ----------
  1/1                      1   not-connected         4   32 disabled 0
  1/2                      1   not-connected         4   32 disabled 0
  2/1                      1   not-connected       100   32 disabled 0
  2/2                      1   not-connected       100   32 disabled 0
  2/3                      1   forwarding           19   16 disabled 0
  2/4                      1   not-connected       100   32 disabled 0
```

Configuring the PVST+ Default Port Cost Mode

If any switch in your network is using a port speed of 10 Gb or over and the network is using PVST+ spanning tree mode, all switches in the network must have the same path cost defaults. You can enter the **set spantree defaultcostmode** command to force all VLANs that are associated with all the ports to have the same path cost default set.

There are two default port cost modes available–short and long.

- The short mode has these parameters:
    - Portcost.
    - Portvlancost.
    - When you enable UplinkFast, the actual cost is incremented by 3000.

- The long mode has these parameters:
    - Portcost.
    - Portvlancost.
    - When you enable UplinkFast, the actual cost is incremented by 10,000,000.
    - EtherChannel computes the cost of a bundle using the formula, AVERAGE_COST/NUM_PORT.

The default port cost mode in PVST+ is short. For port speeds of 10 Gb and greater, you must set the default port cost mode to long.

To change the default port cost mode, perform this task in privileged mode:

Task	Command
Configure the default port cost mode.	**set spantree defaultcostmode** {**short**	**long**}

This example shows how to configure the default port cost mode:

```
Console> (enable) set spantree defaultcostmode long
Portcost and portvlancost set to use long format default values.
Console> (enable)
```

Configuring the PVST+ Port VLAN Cost

You can configure the port cost for a port on a per-VLAN basis. Ports with a lower port VLAN cost are more likely to be chosen to forward frames. You should assign lower numbers to ports that are attached to faster media (such as full duplex) and higher numbers to ports that are attached to slower media. The default cost differs for different media.

You can set a cost value from 1–65535.

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To configure the port VLAN cost for a port, perform this task in privileged mode:

Task	Command
Configure the port VLAN cost for a VLAN on a switch port.	**set spantree portvlancost** {*mod/port*} [**cost** *cost*] [*vlan_list*]

This example shows how to configure the port VLAN cost on a port:

```
Console> (enable) set spantree portvlancost 2/3 cost 20000 1-5
Port 2/3 VLANs 6-11,13-1005,1025-4094 have path cost 12.
Port 2/3 VLANs 1-5,12 have path cost 20000.
This parameter applies to trunking ports only.
Console> (enable
```

Configuring the PVST+ Port VLAN Priority

When the switch is in PVST+ mode, you can set the port priority for a trunking port in a VLAN. The port with the lowest priority value for a specific VLAN forwards frames for that VLAN. The possible port VLAN priority range is from 0–63. The default is 32. If all ports have the same priority value for a particular VLAN, the port with the lowest port number forwards frames for that VLAN.

The port VLAN priority value must be lower than the port priority value.

To configure the port VLAN priority for a port, perform this task in privileged mode:

	Task	Command
Step 1	Configure the port VLAN priority for a VLAN on a switch port.	**set spantree portvlanpri** *mod_num/port_num priority* [*vlans*]
Step 2	Verify the port VLAN priority.	**show config all**

This example shows how to configure the port VLAN priority on a port:

```
Console> (enable) set spantree portvlanpri 2/3 16 6
Port 2/3 vlans 6 using portpri 16.
Port 2/3 vlans 1-5,7-800,802-1004,1006-4094 using portpri 32.
Port 2/3 vlans 801,1005 using portpri 4.
This parameter applies to trunking ports only.
Console> (enable) show config all
  .
  .
  .
set spantree portcost    2/12,2/15  19
set spantree portcost    2/1-2,2/4-11,2/13-14,2/16-48  100
set spantree portcost    2/3  12
set spantree portpri     2/1-48  32
set spantree portvlanpri 2/1  0
set spantree portvlanpri 2/2  0
  .
  .
  .
set spantree portvlanpri 2/48 0
set spantree portvlancost 2/1  cost 99
set spantree portvlancost 2/2  cost 99
set spantree portvlancost 2/3  cost 20000 1-5,12
```

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Disabling the PVST+ Mode on a VLAN

When the switch is in PVST+ mode, you can disable spanning tree on individual VLANs or all VLANs. When you disable spanning tree on a VLAN, the switch does not participate in spanning tree and any BPDUs that are received in that VLAN are flooded on all ports.

⚠ **Caution**   Do not disable spanning tree on a VLAN unless all switches and bridges in the VLAN have spanning tree disabled. You cannot disable spanning tree on some switches or bridges in a VLAN and leave it enabled on other switches or bridges in the VLAN. Doing so can have unexpected results because switches and bridges with spanning tree enabled will have incomplete information regarding the physical topology of the network.

⚠ **Caution**   We do not recommend disabling spanning tree, even in a topology that is free of physical loops. Spanning tree serves as a safeguard against misconfigurations and cabling errors. Do not disable spanning tree in a VLAN without ensuring that there are no physical loops present in the VLAN.

To disable PVST+ mode, perform this task in privileged mode:

Task	Command
Disable PVST+ mode on a VLAN.	**set spantree disable** *vlans* [**all**]

This example shows how to disable PVST+ on a VLAN:

```
Console> (enable) set spantree disable 4
Spantree 4 disabled.
Console> (enable)
```

Using Rapid PVST+

To configure Rapid PVST+, you need to also configure PVST+ on your switch. You can configure PVST+ either before or after you enable Rapid PVST+.

To configure Rapid PVST+, perform this task in privileged mode:

	Task	Command
Step 1	Enable Rapid PVST+.	**set spantree mode rapid-pvst+**
Step 2	Set the link type to point-to-point mode for the port.	**set spantree link-type** *mod/port* **point-to-point**
Step 3	If any port on the switch is connected to a port on a PVST+ switch, check for any legacy bridges on the port.	**clear spantree detected-protocols** *mod/port*
Step 4	Verify the Rapid PVST+ configuration.	**show spantree** *vlan*

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This example shows how to configure Rapid PVST+:

```
Console> (enable) set spantree mode rapid-pvst+
Spantree mode set to RAPID-PVST+.
Console> (enable) set spantree link-type 3/1 point-to-point
Link type set to point-to-point on port 3/1.
Console> (enable) clear spantree detected-protocols 3/1
Spanning tree protocol detection forced on port 3/1
Console> (enable)
```

This example show how to verify the Rapid PVST+ configuration for VLAN 1. The first line in the output displays the spanning tree mode:

```
Console> show spantree 1
Spanning tree mode        RAPID-PVST+
Spanning tree type        ieee
Spanning tree enabled.
.
.
.
Port          State       Role    Cost    Prio   Type
------------  ----------- ------- -----   ----   -----------------
6/1           forwarding  ROOT    20000   16     Shared, PEER(STP)

Console>
```

This example shows how to verify the link type, edge port, and guard type for port 3/6:

```
Console> show spantree 3/6
Port 3/6
Edge Port:      No, (Configured) Default
Port Guard:     Default
Link Type:      P2P(Configured) Auto

Port    VLAN    State       Role    Cost     Prio   Type
------  -----   ----------  ------  -------- ----   -----
3/6     1       listening   DESG    20000    32     P2P
3/6     2       listening   DESG    20000    32     P2P
3/6     3       listening   DESG    20000    32     P2P
3/6     4       listening   DESG    20000    32     P2P
3/6     5       listening   DESG    20000    32     P2P
3/6     6       listening   DESG    20000    32     P2P
3/6     7       listening   DESG    20000    32     P2P
3/6     8       listening   DESG    20000    32     P2P
3/6     9       listening   DESG    20000    32     P2P
3/6     10      listening   DESG    20000    32     P2P
3/6     11      listening   DESG    20000    32     P2P
3/6     12      listening   DESG    20000    32     P2P
3/6     13      listening   DESG    20000    32     P2P
3/6     14      listening   DESG    20000    32     P2P
3/6     15      listening   DESG    20000    32     P2P
3/6     16      listening   DESG    20000    32     P2P
3/6     17      listening   DESG    20000    32     P2P
3/6     18      listening   DESG    20000    32     P2P
3/6     19      listening   DESG    20000    32     P2P

Console>
```

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Using MISTP-PVST+ or MISTP

The default spanning tree mode on the Catalyst 4500 series switches is PVST+ mode. If you want to use MISTP mode in your network, we recommend that you carefully follow the procedures that are described in the following sections in order to avoid loss of connectivity in your network.

When you change the spanning tree mode from one mode to another, the current mode stops, the information collected at run-time is used to build the port database for the new mode, and the new spanning tree mode restarts the computation of the active topology. Information about the port states is lost; however, all of the configuration parameters are preserved for the previous mode. If you return to the previous mode, the configuration will still be there.

Note We recommend that if you wish to use MISTP mode, you should configure *all* of your Catalyst 4500 series switches to run MISTP.

To use MISTP mode, you first enable an MISTP instance, and then map at least one VLAN to the instance. You must have at least one forwarding port in the VLAN for the MISTP instance to be active.

If you are changing a switch from PVST+ mode to MISTP mode and you have other switches in the network that are using PVST+, you must first enable MISTP-PVST+ mode on each switch on which you intend to use MISTP so that PVST+ BPDUs can flow through the switches while you configure them.

When all switches in the network are configured in MISTP-PVST+, you can then enable MISTP on all of the switches.

Default MISTP Mode Configuration

Table 7-5 shows the default configuration for MISTP and MISTP-PVST+ modes.

Table 7-5   MISTP Mode Default Configuration

Feature	Default Value
Enable state	Disabled until a VLAN is mapped to an MISTP instance
MAC address reduction	Disabled
Bridge priority	32,768
Bridge ID priority	32,769 (bridge priority plus the system ID extension of MISTP instance 1)
Port priority	32 (global)
Port cost	• Gigabit Ethernet: 4 • Fast Ethernet: 10 • FDDI/CDDI: 10 • Ethernet: 100
Default port cost mode	Short (802.1D)
Port VLAN priority	Same as port priority but configurable per VLAN in PVST+
Port VLAN cost	Same as port cost but configurable per VLAN in PVST+
Maximum aging time	20 sec

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Table 7-5   MISTP Mode Default Configuration (continued)

Feature	Default Value
Hello time	2 sec
Forward delay time	15 sec

Setting the MISTP-PVST+ Mode or MISTP Mode

If you enable MISTP in a PVST+ network, you must be very careful to avoid bringing down the network. This section explains how to enable MISTP or MISTP-PVST+ on your network.

⚠️ **Caution**   If you have more than 4500 VLAN ports that are configured on your switch, your network could crash if you change from MISTP to either PVST+ or MISTP-PVST+ mode. To avoid losing connectivity, reduce the number of configured VLAN ports on your switch to no more than 4500.

⚠️ **Caution**   If you are working from a Telnet connection to your switch, the first time that you enable MISTP-PVST+ or MISTP mode, you must do so from the switch console. Do not use a Telnet connection through the data port or you will lose the connection to the switch. Once you map a VLAN to an MISTP instance, you can Telnet to the switch.

To change from PVST+ to MISTP-PVST+ or MISTP, perform this task in privileged mode:

Task	Command
Set a spanning tree mode.	**set spantree mode** {**mistp**	**pvst+**	**mistp-pvst+**}

This example shows how to set a switch to MISTP-PVST+ mode:

```
Console> (enable) set spantree mode mistp-pvst+
PVST+ database cleaned up.
Spantree mode set to MISTP-PVST+.
Warning!! There are no VLANs mapped to any MISTP instance.
Console> (enable)
```

You can display VLAN-to-MISTP instance mapping information that is propagated from the root switch at runtime. This display is available only in the MISTP or MISTP-PVST+ mode. When you are in PVST+ mode, use the optional keyword **config**, to display the list of mappings that are configured on the local switch.

✎ **Note**   MAC addresses are not displayed when you specify the keyword **config**.

To display spanning tree mapping, perform this task in privileged mode:

	Task	Command
Step 1	Set spanning tree mode to MISTP.	**set spantree mode mistp**
Step 2	Show spanning tree mapping.	**show spantree mapping** [**config**]

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This example shows how to display the spanning tree VLAN instance mapping in MISTP mode:

```
Console> (enable) set spantree mode mistp
PVST+ database cleaned up.
Spantree mode set to MISTP.
Console> (enable) show spantree mapping
Inst Root Mac         Vlans
---- ---------------- -------------------------
1    00-50-3e-78-70-00 1
2    00-50-3e-78-70-00 -
3    00-50-3e-78-70-00 -
4    00-50-3e-78-70-00 -
5    00-50-3e-78-70-00 -
6    00-50-3e-78-70-00 -
7    00-50-3e-78-70-00 -
8    00-50-3e-78-70-00 -
9    00-50-3e-78-70-00 -
10   00-50-3e-78-70-00 -
11   00-50-3e-78-70-00 -
12   00-50-3e-78-70-00 -
13   00-50-3e-78-70-00 -
14   00-50-3e-78-70-00 -
15   00-50-3e-78-70-00 -
16   00-50-3e-78-70-00 -
```

Configuring the MISTP Bridge ID Priority

You can set the bridge ID priority for an MISTP instance when the switch is in MISTP or MISTP-PVST+ mode.

The switch combines the bridge priority value with the system ID extension (the ID of the MISTP instance) to create the bridge ID priority. You can set 16 possible bridge priority values: 0, 4096, 8192, 12,288, 16,384, 20,480, 24,576, 28,672, 32,768, 36,864, 40,960, 45,056, 49,152, 53,248, 57,344, and 61,440.

To configure the bridge ID priority for an MISTP instance, perform this task in privileged mode:

	Task	Command
Step 1	Configure the bridge ID priority for an MISTP instance.	**set spantree priority** *bridge_ID_priority* [**mistp-instance** *instance*]
Step 2	Verify the bridge ID priority.	**show spantree mistp-instance** *instance* [*mod/port*] **active**

The example shows how to configure the bridge ID priority for an MISTP instance:

```
Console> (enable) set spantree priority 32768 mistp-instance 1
Spantree 1 bridge ID priority set to 32769
(bridge priority: 32768 + sys ID extension: 1)
Console> (enable) show spantree mistp-instance 1
Instance 1
Spanning tree mode        MISTP
Spanning tree type        ieee
Spanning tree instance enabled

Designated Root           00-05-31-40-64-00
Designated Root Priority  32769  (root priority:32768, sys ID ext:1)
Designated Root Cost      20000
Designated Root Port      1/1
VLANs mapped:             1,74
```

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

         Bridge ID MAC ADDR          00-d0-02-27-9c-00
         Bridge ID Priority          32769  (bridge priority:32768, sys ID ext:1)
         VLANs mapped:               1,74
         Bridge Max Age 20 sec   Hello Time 2  sec   Forward Delay 15 sec

         Port                    Inst Port-State    Cost      Prio Portfast Channel_id
         ----------------------- ---- ------------- --------- ---- -------- ----------
          1/1                     1    forwarding       20000   32 disabled 0
          3/1                     1    forwarding      200000   32 disabled 0
          3/25                    1    forwarding      200000   32 disabled 0
          3/26                    1    forwarding      200000   32 disabled 0
          3/27                    1    forwarding      200000   32 disabled 0
          3/28                    1    forwarding      200000   32 disabled 0
          3/29                    1    forwarding      200000   32 disabled 0
          3/30                    1    forwarding      200000   32 disabled 0
          7/1-4                   1    blocking          5000   32 disabled 833
          7/5                     1    forwarding       20000   32 disabled 0
          7/6                     1    forwarding       20000   32 disabled 0
          8/37                    1    blocking        200000   32 disabled 0
          8/38                    1    blocking        200000   32 disabled 0
         15/1                     1    forwarding       20000   32 enabled  0
         16/1                     1    forwarding       20000   32 enabled  0
         Console> (enable)
```

Configuring the MISTP Port Cost

You can configure the port cost of switch ports. When forwarding frames, the switch is more likely to use ports with lower port costs. Assign lower numbers to ports that are attached to faster media (such as full duplex) and higher numbers to ports that are attached to slower media.The possible range is from 1–65,535. The default differs for different media. Path cost is typically equal to 1000 ÷ LAN speed in megabits per second.

To configure the port cost for a port, perform this task in privileged mode:

	Task	Command
Step 1	Configure the port cost for a switch port.	**set spantree portcost** *mod_num/port_num cost*
Step 2	Verify the port cost setting.	**show spantree mistp-instance** *instance* [*mod_num/port_num*] **active**

This example shows how to configure the port cost on an MISTP instance and verify the configuration:

```
Console> (enable) set spantree portcost 1/1 20000
Spantree port 1/1 path cost set to 20000.
Console> (enable) show spantree mistp-instance 1 active
Instance 1
Spanning tree mode        MISTP
Spanning tree type        ieee
Spanning tree instance enabled

Designated Root           00-05-31-40-64-00
Designated Root Priority  32769  (root priority:32768, sys ID ext:1)
Designated Root Cost      20000
Designated Root Port      1/1
VLANs mapped:             1,74
Root Max Age   20 sec   Hello Time 2  sec   Forward Delay 15 sec

Bridge ID MAC ADDR        00-d0-02-27-9c-00
```

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```
Bridge ID Priority        32769  (bridge priority:32768, sys ID ext:1)
VLANs mapped:             1,74
Bridge Max Age 20 sec   Hello Time 2  sec    Forward Delay 15 sec

Port                    Inst Port-State    Cost      Prio Portfast Channel_id
----------------------- ---- ------------- --------- ---- -------- ----------
 1/1                     1    forwarding      20000   32 disabled 0
 3/1                     1    forwarding     200000   32 disabled 0
 3/25                    1    forwarding     200000   32 disabled 0
 3/26                    1    forwarding     200000   32 disabled 0
 3/27                    1    forwarding     200000   32 disabled 0
 3/28                    1    forwarding     200000   32 disabled 0
 3/29                    1    forwarding     200000   32 disabled 0
 3/30                    1    forwarding     200000   32 disabled 0
 7/1-4                   1    blocking         5000   32 disabled 833
 7/5                     1    forwarding      20000   32 disabled 0
 7/6                     1    forwarding      20000   32 disabled 0
 8/37                    1    blocking       200000   32 disabled 0
 8/38                    1    blocking       200000   32 disabled 0
 15/1                    1    forwarding      20000   32 enabled  0
 16/1                    1    forwarding      20000   32 enabled  0
Console> (enable)
```

Configuring the MISTP Port Priority

You can configure the port priority of switch ports. The port with the lowest priority value forwards frames for all VLANs. The possible port priority value is from 0–63; the default is 32. If all ports have the same priority value, the port with the lowest port number forwards frames.

To configure the port priority for a port, perform this task in privileged mode:

	Task	Command
Step 1	Configure the port priority for a switch port.	**set spantree portpri** *mod_num/port_num priority* [*instance*]
Step 2	Verify the port priority setting.	**show spantree mistp-instance** *instance* [*mod_num/port_num*] **active**

This example shows how to configure the port priority and verify the configuration:

```
Console> (enable) set spantree portpri 1/1 32
Bridge port 1/1 port priority set to 32.
Console> (enable) show spantree mistp-instance 1
Instance 1
Spanning tree mode         MISTP
Spanning tree type         ieee
Spanning tree instance enabled

Designated Root            00-05-31-40-64-00
Designated Root Priority   32769  (root priority:32768, sys ID ext:1)
Designated Root Cost       20000
Designated Root Port       1/1
VLANs mapped:              1,74
Root Max Age  20 sec   Hello Time 2  sec    Forward Delay 15 sec

Bridge ID MAC ADDR         00-d0-02-27-9c-00
Bridge ID Priority         32769  (bridge priority:32768, sys ID ext:1)
VLANs mapped:              1,74
Bridge Max Age 20 sec   Hello Time 2  sec    Forward Delay 15 sec
```

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```
Port                   Inst Port-State     Cost      Prio Portfast Channel_id
---------------------- ---- ------------- --------- ---- -------- ----------
 1/1                    1   forwarding      20000    32 disabled 0
 3/1                    1   forwarding     200000    32 disabled 0
 3/25                   1   forwarding     200000    32 disabled 0
 3/26                   1   forwarding     200000    32 disabled 0
 3/27                   1   forwarding     200000    32 disabled 0
 3/28                   1   forwarding     200000    32 disabled 0
 3/29                   1   forwarding     200000    32 disabled 0
 3/30                   1   forwarding     200000    32 disabled 0
 7/1-4                  1   blocking         5000    32 disabled 833
 7/5                    1   forwarding      20000    32 disabled 0
 7/6                    1   forwarding      20000    32 disabled 0
 8/37                   1   blocking       200000    32 disabled 0
 8/38                   1   blocking       200000    32 disabled 0
15/1                    1   forwarding      20000    32 enabled  0
16/1                    1   forwarding      20000    32 enabled  0
Console> (enable)
```

Configuring the MISTP Port Instance Cost

You can configure the port instance cost for an instance of MISTP or MISTP-PVST+. Ports with a lower instance cost are more likely to be chosen to forward frames. You should assign lower numbers to ports that are attached to faster media (such as full duplex) and higher numbers to ports that are attached to slower media. The default cost differs for different media. The possible value for port instance cost is from 1–268435456.

To configure the port instance cost for a port, perform this task in privileged mode:

Task	Command
Configure the port instance cost on a switch port.	**set spantree portinstancecost** {*mod/port*} [**cost** *cost*] [*instances*]

This example shows how to configure the MISTP port instance cost on a port:

```
Console> (enable) set spantree portinstancecost 1/1 cost 110110 2
Port 1/1 instances 1,3-16 have path cost 20000.
Port 1/1 instances 2 have path cost 110110.
This parameter applies to trunking ports only.
Console> (enable)
```

Configuring the MISTP Port Instance Priority

You can set the port priority for an instance of MISTP. The port with the lowest priority value for a specific MISTP instance forwards frames for that instance. The possible port instance range is from 0–63. If all ports have the same priority value for an MISTP instance, the port with the lowest port number forwards frames for that instance.

To configure the port instance priority on an MISTP instance, perform this task in privileged mode:

Task	Command
Configure the port instance priority on an MISTP instance.	**set spantree portinstancepri** {*mod/port*} *priority* [*instances*]

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This example shows how to configure the port instance priority on an MISTP instance and verify the configuration:

```
Console> (enable) set spantree portinstancepri 1/1 16 2
Port 1/1 MISTP Instances 2 using portpri 16.
Port 1/1 mistp-instance 1,3-16 using portpri 32.
Console> (enable)
```

Enabling an MISTP Instance

You can enable up to 16 MISTP instances. Each MISTP instance defines a unique spanning tree topology. MISTP instance 1, the default instance, is enabled by default; however, you must map a VLAN to it in order for it to be active. You can enable a single MISTP instance, a range of instances, or all instances at once using the **all** keyword.

> **Note**   The software does not display the status of an MISTP instance until it has a VLAN with an active port mapped to it.

To enable an MISTP instance, perform this task in privileged mode:

	Task	Command
Step 1	Enable an MISTP instance.	**set spantree enable mistp-instance** *instance* [**all**]
Step 2	Verify that the instance is enabled.	**show spantree mistp-instance** [*instance*] [**active**] *mod/port*

> **Note**   Enter the **active** keyword to display active ports only.

This example shows how to enable an MISTP instance:

```
Console> (enable) set spantree enable mistp-instance 2
Spantree 2 enabled.

Console> (enable) show spantree mistp-instance 2
Instance 2
Spanning tree mode          MISTP
Spanning tree type          ieee
Spanning tree instance enabled
   .
   .
   .
```

Mapping VLANs to an MISTP Instance

When you are using MISTP-PVST+ or MISTP on a switch, you must map at least one VLAN to an MISTP instance in order for MISTP-PVST+ or MISTP to be active.

> **Note**   See Chapter 10, "Configuring VLANs" for details on using and configuring VLANs.

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- You can only map Ethernet VLANs to MISTP instances.

- At least one VLAN in the instance must have an active port in order for MISTP-PVST+ or MISTP to be active.

- You can map as many Ethernet VLANs as you wish to an MISTP instance.

- You cannot map a VLAN to more than one MISTP instance.

To map a VLAN to an MISTP instance, perform this task in privileged mode:

	Task	Command
Step 1	Map a VLAN to an MISTP instance.	**set vlan** *vlan* **mistp-instance** *instance*
Step 2	Verify that the VLAN is mapped.	**show spantree mistp-instance** [*instance*] [**active**] *mod/port*

This example shows how to map a VLAN to an MISTP instance 1 and verify the mapping:

```
Console> (enable) set vlan 6 mistp-instance 1
Vlan 6 configuration successful
Console> (enable) show spantree mist-instance 1
Instance 1
Spanning tree mode        MISTP-PVST+
Spanning tree type        ieee
Spanning tree instance enabled

Designated Root           00-d0-00-4c-18-00
Designated Root Priority  49153  (root priority: 49152, sys ID ext: 1)
Designated Root Cost      0
Designated Root Port      none
VLANs mapped:             6
Root Max Age  20 sec   Hello Time 2  sec   Forward Delay 15 sec

Bridge ID MAC ADDR        00-d0-00-4c-18-00
Bridge ID Priority        49153  (bridge priority: 49152, sys ID ext: 1)
VLANs mapped:             6
Bridge Max Age 20 sec   Hello Time 2  sec   Forward Delay 15 sec

Port                   Inst Port-State    Cost     Prio Portfast Channel_id
---------------------- ---- ------------- --------- ---- -------- ----------
 2/12                   1    forwarding    22222222  40 disabled 0
```

Determining an MISTP Instance—VLAN Mapping Conflicts

A VLAN can only be mapped to one MISTP instance. If you attempt to map a VLAN to more than one instance, all of its ports are set to blocking mode. You can use the **show spantree conflicts** command to determine to which MISTP instances you have attempted to map the VLAN.

This command prints a list of the MISTP instances that are associated with the VLAN, the MAC addresses of the root switches that are sending the BPDUs containing the VLAN mapping information, and the timers that are associated with the mapping of a VLAN to an MISTP instance. When only one entry is printed or when all the entries are associated to the same instance, the VLAN is mapped to that instance. If two or more entries in the list are associated with different MISTP instances, the VLAN is in conflict.

To clear up the conflict, you must manually remove the incorrect mapping(s) from the root switch. The remaining entry on the list becomes the official mapping.

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To determine VLAN mapping conflicts, perform this task in privileged mode:

Task	Command
Determine VLAN mapping conflicts.	**show spantree conflicts** *vlan*

This example shows that there is an attempt to map VLAN 2 to MISTP instance 1 and to MISTP instance 3 on two different switches as seen from a third switch in the topology:

```
Console> (enable) show spantree conflicts 2
Inst MAC              Delay     Time left
---- ---------------- --------- ---------
1   00-30-a3-4a-0c-00  inactive       20
3   00-30-f1-e5-00-01  inactive       10
```

The Delay timer shows the time in seconds remaining before the VLAN will join the instance. The field displays *inactive* if the VLAN is already mapped to an instance (the timer has expired), or the VLAN is in conflict between instances.

The Time Left timer shows the time in seconds left before the entry will expire and be removed from the table. The timer is restarted every time an incoming BPDU confirms the mapping. Entries pertaining to the root switch show *inactive* on the root switch itself.

The following examples are with VTP version 3 enabled. The root switch is also the primary server for the nonroot switch. The root switch is not the primary server for the switch in conflict, because that switch has been partitioned.

This example is from the root switch:

```
Console> (enable) show spantree conflicts 1
No conflicts for vlan 1.
Inst MAC              Delay     Time left
---- ---------------- --------- ---------
  1  00-05-31-40-64-00  inactive  inactive

Console> (enable)
```

This example is from the nonroot switch:

```
Console> (enable) show spantree conflicts 3
No conflicts for vlan 3.
Inst MAC              Delay     Time left
---- ---------------- --------- ---------
  3  00-05-31-40-64-00  inactive       19

Console> (enable)
```

This example is from the switch in conflict (note that the switch is inactive):

```
Console> (enable) show spantree conflicts 6
Inst MAC              Delay     Time left
---- ---------------- --------- ---------
  6  00-05-31-40-64-00  inactive       18
  5  00-09-7b-62-b0-80  inactive  inactive

Console> (enable)
```

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Unmapping VLANs from an MISTP Instance

The keyword **none** is used to unmap the specified VLANs from the MISTP instances to which they are currently mapped. When you unmap a VLAN from an MISTP instance, the resulting state of all the ports of the VLAN (if the VLAN exists) is *blocking*.

To unmap a VLAN or all VLANs from an MISTP instance, perform this task in privileged mode:

Task	Command
Unmap a VLAN from an MISTP instance.	**set vlan** *vlan* **mistp-instance none**

This example shows how to unmap a VLAN from an MISTP instance:

```
Console> (enable) set vlan 6 mistp none
Vlan 6 configuration successful
```

Disabling MISTP-PVST+ or MISTP

When the switch is in MISTP mode, you disable spanning tree on an instance, not for the whole switch.

When you disable spanning tree on an MISTP instance, the instance still exists on the switch, all of the VLANs mapped to it have all of their ports forwarding, and the instance BPDUs are flooded.

To disable an MISTP instance, perform this task in privileged mode:

Task	Command
Disable an MISTP instance.	**set spantree disable mistp-instance** *instance* [**all**]

This example shows how to disable an MISTP instance:

```
Console> (enable) set spantree disable mistp-instance 2
MI-STP instance 2 disabled.
```

Configuring a Root Switch

This section explains how to configure a primary root switch and a secondary root switch, and how you can prevent a switch from becoming a root switch by using root guard.

Configuring a Primary Root Switch

You can set a root switch on a VLAN when the switch is in PVST+ mode or on an MISTP instance when the switch is in MISTP mode. Enter the **set spantree root** command to lower the bridge priority (the value that is associated with the switch) below the default (32,768); the switch can then become the root switch.

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When you specify a switch as the primary root, the default bridge priority is modified so that it becomes the root for the specified VLANs. Set the bridge priority to 8192. If this setting does not result in the switch becoming a root, modify the bridge priority to be 1 less or the same as the bridge priority of the current root switch. Because different VLANs could potentially have different root switches, the bridge VLAN-priority chosen makes this switch the root for all the VLANs that are specified. If reducing the bridge priority as low as 1 still does not make the switch the root switch, the system displays a message.

⚠ **Caution**   Enter the **set spantree root** command on backbone switches or distribution switches only, not on access switches.

To configure a switch as the primary root switch, perform this task in privileged mode:

Task	Command
Configure a switch as the primary root switch.	set spantree root [*vlans*] [dia *network_diameter*] [hello *hello_time*]

This example shows how to configure the primary root switch for VLANs 1–10:

```
Console> (enable) set spantree root 1-10 dia 4
VLANs 1-10 bridge priority set to 8192
VLANs 1-10 bridge max aging time set to 14 seconds.
VLANs 1-10 bridge hello time set to 2 seconds.
VLANs 1-10 bridge forward delay set to 9 seconds.
Switch is now the root switch for active VLANs 1-6.
Console> (enable)
```

To configure a switch as the primary root switch for an instance, perform this task in privileged mode:

Task	Command
Configure a switch as the primary root switch for an instance.	set spantree root mistp-instance *instance* [dia *network_diameter*] [hello *hello_time*]

This example shows how to configure the primary root for an instance:

```
Console> (enable) set spantree root mistp-instance 2-4 dia 4
Instances 2-4 bridge priority set to 8192
VLInstances 2-4 bridge max aging time set to 14 seconds.
Instances 2-4 bridge hello time set to 2 seconds.
Instances 2-4 bridge forward delay set to 9 seconds.
Switch is now the root switch for active Instances 1-6.
Console> (enable)
```

Configuring a Secondary Root Switch

You can set a secondary root switch on a VLAN when the switch is in PVST+ mode or on an MISTP instance when the switch is in MISTP mode.

The **set spantree root secondary** command reduces the bridge priority to 16,384, making it the probable candidate to become the root switch if the primary root switch fails. You can run this command on more than one switch to create multiple backup switches in case the primary root switch fails.

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

Task	Command
Configure a switch as the secondary root switch.	**set spantree root** [**secondary**] *vlans* [**dia** *network_diameter*] [**hello** *hello_time*]

This example shows how to configure the secondary root switch for VLANs 22 and 24:

```
Console> (enable) set spantree root secondary 22,24 dia 5 hello 1
VLANs 22,24 bridge priority set to 16384.
VLANs 22,24 bridge max aging time set to 10 seconds.
VLANs 22,24 bridge hello time set to 1 second.
VLANs 22,24 bridge forward delay set to 7 seconds.
Console> (enable)
```

To configure a switch as the secondary root switch for an instance, perform this task in privileged mode:

Task	Command
Configure a switch as the secondary root switch for an instance.	**set spantree root** [**secondary**] **mistp-instance** *instance* [**dia** *network_diameter*] [**hello** *hello_time*]

This example shows how to set the secondary root for an instance:

```
Console> (enable) set spantree root secondary mistp-instance 2-4 dia 4
Instances 2-4 bridge priority set to 8192
VLInstances 2-4 bridge max aging time set to 14 seconds.
Instances 2-4 bridge hello time set to 2 seconds.
Instances 2-4 bridge forward delay set to 9 seconds.
Switch is now the root switch for active Instances 1-6.
Console> (enable)
```

Configuring a Root Switch to Improve Convergence

You can configure the root switch to speed up STP convergence time by reducing the value of the Hello Time, Forward Delay Timer, and Maximum Age Timer parameters. For more information, see the "Configuring Spanning Tree Timers" section on page 7-44.

Note Reducing the timer parameters is possible only if your network has LAN links of 10 Mbps or faster. In a network with links of 10 Mbps or faster, the network diameter can reach the maximum value of 7. With WAN connections, you cannot reduce the parameters.

When a link failure occurs in a bridged network, network reconfiguration is not immediate. Reconfiguring the default parameters (that are specified by IEEE 802.1D) for the Hello Time, Forward Delay Timer, and Maximum Age Timer requires a 50-second delay. This reconfiguration delay depends on the network diameter, which is the maximum number of bridges between any two end stations.

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To speed up convergence, use nondefault parameters values that are permitted by 802.1D. The nondefault parameters for a reconvergence of 14 seconds are as follows:

Parameter	Time
Network Diameter (dia)	2 hops
Hello Time	2 sec
Forward Delay Timer	4 sec
Maximum Age Timer	6 sec

You can set these parameters on the Catalyst 4500 series switches without modifying the switches.

Note You can set switch ports for improved convergence in PortFast mode. This setting affects only the transition from disable (link down) to enable (link up), moving the port immediately to the forwarding state. If a port in PortFast mode begins blocking, then it goes through listening and learning before reaching the forwarding state.

To configure the spanning tree bridge to improve convergence, perform this task in privileged mode:

	Task	Command
Step 1	Configure the Hello time for a VLAN or MISTP instance.	**set spantree hello** *interval* [*vlan*] **mistp-instance** [*instances*]
Step 2	Verify the configuration.	**show spantree** [*vlan* | **mistp-instance** *instances*]
Step 3	Configure the forward delay time for a VLAN or MISTP instance.	**set spantree fwddelay** *delay* [*vlan*] **mistp-instance** [*instances*]
Step 4	Verify the configuration.	**show spantree** [*mod/port*] **mistp-instance** [*instances*] [**active**]
Step 5	Configure the maximum aging time for a VLAN or MISTP instance.	**set spantree maxage** *agingtime* [*vlans*] **mistp-instance** *instances*
Step 6	Verify the configuration.	**show spantree** [*mod/port*] **mistp-instance** [*instances*] [**active**]

This example shows how to configure the spanning tree Hello Time, Forward Delay Timer, and Maximum Age Timer to 2, 4, and 6 seconds:

```
Console> (enable) set spantree hello 2 100
Spantree 100 hello time set to 7 seconds.
Console> (enable)
Console> (enable) set spantree fwddelay 4 100
Spantree 100 forward delay set to 21 seconds.
Console> (enable)
Console> (enable) set spantree maxage 6 100
Spantree 100 max aging time set to 36 seconds.
Console> (enable)
```

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```
Console> (enable) set spantree root 1-10 dia 4
VLANs 1-10 bridge priority set to 8192
VLANs 1-10 bridge max aging time set to 14 seconds.
VLANs 1-10 bridge hello time set to 2 seconds.
VLANs 1-10 bridge forward delay set to 9 seconds.
Switch is now the root switch for active VLANs 1-6.
Console> (enable)
```

Using Root Guard—Preventing Switches from Becoming Root

You may want to prevent switches from becoming the root switch. The root guard feature forces a port to become a designated port so that no switch on the other end of the link can become a root switch.

When you enable root guard on a per-port basis, it is automatically applied to all of the active VLANs to which that port belongs. When you disable root guard, it is disabled for the specified port(s). If a port goes into the root-inconsistent state, it automatically goes into the listening state.

To prevent switches from becoming root, perform this task in privileged mode:

	Task	Command
Step 1	Enable root guard on a port.	**set spantree guard** {**root**	**none**} *mod/port*
Step 2	Verify that root guard is enabled.	**show spantree guard** {*mod/port*	*vlan*} {**mistp-instance** *instance*	*mod/port*}

Displaying Spanning Tree BPDU Statistics

Enter the **show spantree statistics bpdu** command to display the total number of spanning tree BPDUs (transmitted, received, processed, and dropped). The command also provides the rate of the BPDUs in seconds. The BPDU counters are cleared using the **clear spantree statistics bpdu** command or when the system is booted.

To display spanning tree BPDU statistics, perform this task in normal mode (clear the statistics from privileged mode):

	Task	Command
Step 1	Display spanning tree BPDU statistics.	**show spantree statistics bpdu**
Step 2	Clear the BPDU statistics.	**clear spantree statistics bpdu**

This example shows how to display spanning tree BPDU statistics:

```
Console> show spantree statistics bpdu
              Transmitted      Received      Processed      Dropped
            -------------- -------------- -------------- --------------

Total            52943073       52016589       52016422            167

Rate(/sec)            989            971            971              0
```

This example shows how to clear spanning tree BPDU statistics:

```
Console> (enable) clear spantree statistics bpdu
Spanning tree BPDU statistics cleared on the switch.
Console> (enable)
```

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Configuring Spanning Tree Timers

Spanning tree timers affect the spanning tree performance. You can configure the spanning tree timers for a VLAN in PVST+ or an MISTP instance in MISTP mode. If you do not specify a VLAN when the switch is in PVST+ mode, VLAN 1 is assumed. If you do not specify an MISTP instance when the switch is in MISTP mode, MISTP instance 1 is assumed.

⚠

Caution   Exercise care using these commands. For most situations, we recommend that you use the **set spantree root** and **set spantree root secondary** commands to modify the spanning tree performance parameters.

Table 7-6 describes the switch variables that affect spanning tree performance.

Table 7-6   Switch Variable Descriptions

Variable	Description	Default
Hello Time	Determines how often the switch broadcasts its Hello message to other switches.	20 sec
Maximum Age Timer	Measures the age of the received protocol information that is recorded for a port and ensures that this information is discarded when its age limit exceeds the value of the maximum age parameter that is recorded by the switch. The timeout value is the maximum age parameter of the switches.	2 sec
Forward Delay Timer	Monitors the time that is spent by a port in the learning and listening states. The timeout value is the forward delay parameter of the switches.	15 sec

Configuring the Hello Time

Enter the **set spantree hello** command to change the Hello time for a VLAN or for an MISTP instance. The possible range for *interval* is from 1–10 seconds.

To configure the spanning tree bridge Hello time for a VLAN or an MISTP instance, perform this task in privileged mode:

	Task	Command
Step 1	Configure the Hello time for a VLAN or MISTP instance.	**set spantree hello** *interval* [*vlan*] **mistp-instance** [*instances*]
Step 2	Verify the configuration.	**show spantree** [*vlan* | **mistp-instance** *instances*]

This example shows how to configure the spanning tree Hello time for VLAN 100 to 7 seconds:

```
Console> (enable) set spantree hello 7 100
Spantree 100 hello time set to 7 seconds.
Console> (enable)
```

This example shows how to set the spantree Hello time for an instance to 3 seconds:

```
Console> (enable) set spantree hello 3 mistp-instance 1
Spantree 1 hello time set to 3 seconds.
Console> (enable)
```

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Configuring the Forward Delay Time

Enter the **set spantree fwddelay** command to configure the spanning tree forward delay time for a VLAN. The possible range for *delay* is from 4–30 seconds.

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

	Task	Command
Step 1	Configure the forward delay time for a VLAN or MISTP instance.	**set spantree fwddelay** *delay* [*vlan*] **mistp-instance** [*instances*]
Step 2	Verify the configuration.	**show spantree** [*mod/port*] **mistp-instance** [*instances*] [**active**]

This example shows how to configure the spanning tree forward delay time for VLAN 100 to 21 seconds:

```
Console> (enable) set spantree fwddelay 21 100
Spantree 100 forward delay set to 21 seconds.
Console> (enable)
```

This example shows how to set the bridge forward delay for an instance to 16 seconds:

```
Console> (enable) set spantree fwddelay 16 mistp-instance 1
Instance 1 forward delay set to 16 seconds.
Console> (enable)
```

Configuring the Maximum Aging Time

Enter the **set spantree maxage** command to change the spanning tree maximum aging time for a VLAN or an instance. The possible range for *agingtime* is from 6–40 seconds.

To configure the spanning tree maximum aging time for a VLAN or an instance, perform this task in privileged mode:

	Task	Command
Step 1	Configure the maximum aging time for a VLAN or MISTP instance.	**set spantree maxage** *agingtime* [*vlans*] **mistp-instance** *instances*
Step 2	Verify the configuration.	**show spantree** [*mod/port*] **mistp-instance** [*instances*] [**active**]

This example shows how to configure the spanning tree maximum aging time for VLAN 100 to 36 seconds:

```
Console> (enable) set spantree maxage 36 100
Spantree 100 max aging time set to 36 seconds.
Console> (enable)
```

This example shows how to set the maximum aging time for an instance to 25 seconds:

```
Console> (enable) set spantree maxage 25 mistp-instance 1
Instance 1 max aging time set to 25 seconds.
Console> (enable)
```

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Configuring MST

The following sections describe how to configure MST:

Enabling MST

To enable and configure MST on the switch, perform this task in privileged mode:

	Task	Command
Step 1	Begin in PVST+ mode.	**set spantree mode mst** [**mistp** | **pvst+** | **mistp-pvst+** | **mst**]
Step 2	Display the STP ports.	**show spantree active**
Step 3	Configure the MST region.	**set spantree mst config** {[**name** *name*] | [**revision** *number*] [**commit** | **rollback** | **force**]}
Step 4	Verify your configuration.	**show spantree mst config**
Step 5	Map VLANs to the MST instance.	**set spantree mst** *instance* **vlan** *vlan*
Step 6	Commit the new region mapping.	**set spantree mst config commit**
Step 7	Enable MST.	**set spantree mode mst** [**mistp** | **pvst+** | **mistp-pvst+** | **mst**]
Step 8	Verify your MST configuration.	**show spantree mst config**
Step 9	Verify your MST instance configuration.	**show spantree mst** *instance*
Step 10	Verify your MST module and port configuration.	**show spantree mst** *mod/port*

These examples show how to enable MST:

```
Console> (enable)
Console> (enable) set spantree mode pvst
Spantree mode set to PVST+.
Console> (enable) show spantree active
VLAN 1
Spanning tree mode        PVST+
Spanning tree type        ieee
Spanning tree enabled

Designated Root           00-50-3e-66-d0-00
Designated Root Priority  24576
Designated Root Cost      104
Designated Root Port      6/1
Root Max Age   20 sec   Hello Time 2  sec   Forward Delay 15 sec

Bridge ID MAC ADDR        00-10-7b-bb-2f-00
Bridge ID Priority        32768
Bridge Max Age 20 sec   Hello Time 2  sec   Forward Delay 15 sec

Port                    Vlan Port-State    Cost      Prio Portfast
Channel_id
----------------------- ---- ------------- --------- ---- --------
----------
 6/1                     1    forwarding         4   32 disabled 0
 6/2                     1    blocking           4   32 disabled 0
Console> (enable)
```

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```
Console> (enable) set spantree mst config name cisco revision 1
Edit Buffer modified. Use 'set spantree mst config commit' to apply the
changes.
Console> (enable) show spantree mst config
Current (NVRAM) MST Region Configuration:
Configuration Name:                               Revision:0
Instance VLANs
-------- ------------------------------------------------------------------
IST      1-4094
  1      -
  2      -
  3      -
  4      -
  5      -
  6      -
  7      -
  8      -
  9      -
 10      -
 11      -
 12      -
 13      -
 14      -
 15      -
============================================================================
NEW MST Region Configuration (Not committed yet)
Configuration Name:cisco                          Revision:1
Instance VLANs
-------- ------------------------------------------------------------------
IST      1-4094
  1      -
  2      -
  3      -
  4      -
  5      -
  6      -
  7      -
  8      -
  9      -
 10      -
 11      -
 12      -
 13      -
 14      -
 15      -
============================================================================
Edit buffer is locked by:Console (pid 142)
Console> (enable)
Console> (enable) set spantree mst 1 vlan 2-10
Edit Buffer modified. Use 'set spantree mst config commit' to apply the
changes.
Console> (enable) set spantree mst 1 vlan 2-20
Edit Buffer modified. Use 'set spantree mst config commit' to apply the
changes.
Console> (enable) set spantree mst 2 vlan 21-30
Edit Buffer modified. Use 'set spantree mst config commit' to apply the
changes.
Console> (enable) set spantree mst 3 vlan 31-40
Edit Buffer modified. Use 'set spantree mst config commit' to apply the
changes.
Console> (enable) set spantree mst 4 vlan 41-50
Edit Buffer modified. Use 'set spantree mst config commit' to apply the
changes.
Console> (enable)
```

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```
Console> (enable) show spantree mst config
Current (NVRAM) MST Region Configuration:
Configuration Name:                              Revision:0
Instance VLANs
-------- ------------------------------------------------------------------
IST     1-4094
  1     -
  2     -
  3     -
  4     -
  5     -
  6     -
  7     -
  8     -
  9     -
 10     -
 11     -
 12     -
 13     -
 14     -
 15     -
==========================================================================
NEW MST Region Configuration (Not committed yet)
Configuration Name:cisco                         Revision:1
Instance VLANs
-------- ------------------------------------------------------------------
IST     1,51-4094
  1     2-20
  2     21-30
  3     31-40
  4     41-50
  5     -
  6     -
  7     -
  8     -
  9     -
 10     -
 11     -
 12     -
 13     -
 14     -
 15     -
==========================================================================
Edit buffer is locked by:Console (pid 142)
Console> (enable)
Console> (enable) set spantree mst config commit
Console> (enable)
Console> (enable) show spantree mst config
Current (NVRAM) MST Region Configuration:
Configuration Name:cisco                         Revision:1
Instance VLANs
-------- ------------------------------------------------------------------
IST     1,51-4094
  1     2-20
  2     21-30
  3     31-40
  4     41-50
  5     -
  6     -
  7     -
  8     -
  9     -
 10     -
 11     -
```

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```
   12     -
   13     -
   14     -
   15     -
========================================================================
Console> (enable)
Console> (enable) set spantree mode mst
PVST+ database cleaned up.
Spantree mode set to MST.
Console> (enable)
Console> (enable)
Console> (enable) show spantree mst 0
Spanning tree mode        MST
Instance                  0
VLANs Mapped:             1,51-4094

Designated Root           00-50-3e-66-d0-00
Designated Root Priority  24576 (root priority:24576, sys ID ext:0)

Designated Root Cost      20100
Designated Root Port      6/1
Root Max Age  20 sec   Hello Time 2  sec   Forward Delay 15 sec

IST Master ID MAC ADDR    00-10-7b-bb-2f-00
IST Master ID Priority    32768
IST Master Path Cost      0           Remaining Hops 20

Bridge ID MAC ADDR        00-10-7b-bb-2f-00
Bridge ID Priority        32768 (bridge priority:32768, sys ID ext:
0)
Bridge Max Age 20 sec   Hello Time 2  sec   Forward Delay 15 sec   Max
Hops 20

Port                   State         Role Cost     Prio Type
---------------------- ------------- ---- -------- ----
-------------------
 6/1                   forwarding    ROOT   20000   32 P2P,
Boundary(PVST)
 6/2                   blocking      ALTR   20000   32 P2P,
Boundary(PVST)
Console> (enable) show spantree mst 1
Spanning tree mode        MST
Instance                  1
VLANs Mapped:             2-20

Designated Root           00-10-7b-bb-2f-00
Designated Root Priority  32769 (root priority:32768, sys ID ext:1)

Designated Root Cost      0           Remaining Hops 20
Designated Root Port      1/0

Bridge ID MAC ADDR        00-10-7b-bb-2f-00
Bridge ID Priority        32769 (bridge priority:32768, sys ID ext:
1)

Port                   State         Role Cost     Prio Type
---------------------- ------------- ---- -------- ----
-------------------
 6/1                   forwarding    BDRY   20000   32 P2P,
Boundary(PVST)
 6/2                   blocking      BDRY   20000   32 P2P,
Boundary(PVST)
Console> (enable)
Console> (enable)
```

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```
Console> (enable) show spantree mst 6/1
Edge Port:      No,  (Configured) Default
Link Type:      P2P,  (Configured) Auto
Port Guard:   Default
Boundary:     Yes (PVST)

Inst State          Role Cost       Prio VLANs
---- ------------- ---- --------- ----
-----------------------------------
   0 forwarding    ROOT    20000   32 1
   1 forwarding    BDRY    20000   32 2-20
   2 forwarding    BDRY    20000   32 21-30
   3 forwarding    BDRY    20000   32 31-40
   4 forwarding    BDRY    20000   32 41-50
Console> (enable)
Console> (enable)
Console> (enable) show spantree mst config
Current (NVRAM) MST Region Configuration:
Configuration Name:cisco                          Revision:1
Instance VLANs
-------- ---------------------------------------------------------------
IST    1,51-4094
  1    2-20
  2    21-30
  3    31-40
  4    41-50
  5    -
  6    -
  7    -
  8    -
  9    -
 10    -
 11    -
 12    -
 13    -
 14    -
 15    -
=====================================================================
Console> (enable)
```

Configuring the MST Bridge ID Priority

You can set the bridge ID priority for an MST instance when the switch is in MST mode. The switch combines the bridge priority value with the system ID extension (the ID of the MST instance) to create the bridge ID priority. You can set 16 possible bridge priority values: 0, 4096, 8192, 12,288, 16,384, 20,480, 24,576, 28,672, 32,768, 36,864, 40,960, 45,056, 49,152, 53,248, 57,344, and 61,440.

To configure the bridge ID priority for an MST instance, perform this task in privileged mode:

	Task	Command
Step 1	Configure the bridge ID priority for an MST instance.	**set spantree priority** *bridge_priority* **mst** [*instance*]
Step 2	Verify the bridge ID priority.	**show spantree mst** [*instance*	*mod/port*]

The example shows how to configure the bridge ID priority for an MST instance:

```
Console> (enable) set spantree priority 8192 mst 3
MST Spantree 3 bridge priority set to 8192.
Console> (enable)
```

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```
Console> (enable) show spantree mst 3
Spanning tree mode        MST
Instance                  3
VLANs Mapped:             31-40

Designated Root           00-10-7b-bb-2f-00
Designated Root Priority  8195  (root priority:8192, sys ID ext:3)
Designated Root Cost      0          Remaining Hops 20
Designated Root Port      1/0

Bridge ID MAC ADDR        00-10-7b-bb-2f-00
Bridge ID Priority        8195  (bridge priority:8192, sys ID ext:3)

Port                    State         Role Cost     Prio Type
----------------------- ------------- ---- -------- ----
--------------------
 6/1                    forwarding    BDRY    20000   32 P2P,
Boundary(PVST)
 6/2                    blocking      BDRY    20000   32 P2P,
Boundary(PVST)
```

Configuring the MST Port Cost

You can configure the port cost of switch ports.The switch uses ports with lower port costs to forward frames. Assign lower numbers to ports that are attached to faster media (such as full duplex) and higher numbers to ports that are attached to slower media. The possible range is from 1–65,535. The default differs for different media. The path cost is typically 1000 ÷ LAN speed in megabits per second.

To configure the port cost for a port, perform this task in privileged mode:

	Task	Command
Step 1	Configure the MST port cost for a switch port.	**set spantree portcost** *mod/port cost* [**mst**]
Step 2	Verify the port cost setting.	**show spantree mst** [*instance*	*mod/port*]

This example shows how to configure the port cost on an MST instance and verify the configuration:

```
Console> (enable) set spantree portcost 6/1 10000 mst
Spantree port 6/1 path cost set to 10000.
Console> (enable)
Console> (enable) show spantree mst 6/1
Edge Port:     No,  (Configured) Default
Link Type:     P2P, (Configured) Auto
Port Guard:  Default
Boundary:    Yes (PVST)

Inst State         Role Cost     Prio VLANs
---- ------------- ---- --------- ----
-----------------------------------
   0 forwarding    ROOT    10000   32 1
   1 forwarding    BDRY    10000   32 2-20
   2 forwarding    BDRY    10000   32 21-30
   3 forwarding    BDRY    10000   32 31-40
   4 forwarding    BDRY    10000   32 41-50
Console> (enable)
```

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Configuring the MST Port Priority

You can configure the port priority of ports. The port with the lowest priority value forwards frames for all VLANs. The possible port priority value is from 0–63; the default is 32. If all ports have the same priority value, the port with the lowest port number forwards frames.

To configure the port priority for a port, perform this task in privileged mode:

	Task	Command
Step 1	Configure the MST port priority for a port.	**set spantree portpri** *mod/port priority* [**mst**]
Step 2	Verify the port priority setting.	**show spantree mst** [*instance* | *mod/port*]

This example shows how to configure the port priority and verify the configuration:

```
Console> (enable) set spantree portpri 6/1 30 mst
Bridge port  6/1 port priority set to 30.
Console> (enable)
Console> (enable) show spantree mst 6/1
Edge Port:       No,  (Configured) Default
Link Type:       P2P, (Configured) Auto
Port Guard:   Default
Boundary:     Yes (PVST)

Inst State          Role Cost      Prio VLANs
---- ------------- ---- --------- ----
-----------------------------------
   0 forwarding    ROOT    10000   30 1
   1 forwarding    BDRY    10000   30 2-20
   2 forwarding    BDRY    10000   30 21-30
   3 forwarding    BDRY    10000   30 31-40
   4 forwarding    BDRY    10000   30 41-50
Console> (enable)
```

Configuring the MST Port Instance Cost

You can configure the port instance cost for an instance of MST. Ports with a lower instance cost are more likely to be chosen to forward frames. You should assign lower numbers to ports that are attached to faster media (such as full duplex) and higher numbers to ports that are attached to slower media. The default cost differs for different media. The possible value for port instance cost is from 1–268,435,456.

To configure the port instance cost for a port, perform this task in privileged mode:

	Task	Command
Step 1	Configure the MST port instance cost on a port.	**set spantree portinstancecost** *mod/port* [**cost** *cost*] **mst** [*instances*]
Step 2	Verify the path cost for the instances on a port.	**show spantree portinstancecost** *mod/port*

This example shows how to configure the MST port instance cost on a port:

```
Console> (enable) set spantree portinstancecost 6/1 cost 5000 mst 4
Port 6/1 MST Instances 0-3,5-15 have path cost 10000.
Port 6/1 MST Instances 4 have path cost 5000.
Console> (enable)
```

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```
Console> (enable) show spantree mst 4
Spanning tree mode        MST
Instance                  4
VLANs Mapped:             41-50

Designated Root           00-10-7b-bb-2f-00
Designated Root Priority  32772  (root priority:32768, sys ID ext:4)

Designated Root Cost      0          Remaining Hops 20
Designated Root Port      1/0

Bridge ID MAC ADDR        00-10-7b-bb-2f-00
Bridge ID Priority        32772  (bridge priority:32768, sys ID ext:
4)

Port                      State         Role Cost     Prio Type
----------------------    ------------- ---- -------- -----------------
 6/1                      forwarding    BDRY    5000   30 P2P,
Boundary(PVST)
 6/2                      blocking      BDRY   20000   32 P2P,
Boundary(PVST)
Console> (enable)
```

Configuring the MST Port Instance Priority

You can set a port priority for an instance of MST. The port with the lowest priority for a specific MST instance forwards frames for that instance. The port instance range is from 0–63. If all ports have the same priority for an MST instance, the port with the lowest port number forwards frames for that instance.

To configure the port instance priority on an MST instance, perform this task in privileged mode:

	Task	Command
Step 1	Configure the port instance priority on an MST instance.	**set spantree portinstancepri** *mod/port priority* **mst** [*instance*]
Step 2	Verify the port instance priority setting.	**show spantree mst** [*instance* | *mod/port*]

This example shows how to configure the port instance priority on an MST instance and verify the configuration:

```
Console> (enable) set spantree portinstancepri 6/1 20 mst 2
Port 6/1 MST Instances 2 using portpri 20.
Port 6/1 MST Instances 0-1,3-15 using portpri 30.
Console> (enable)
Console> (enable)
Console> (enable) show spantree mst 2
Spanning tree mode        MST
Instance                  2
VLANs Mapped:             21-30

Designated Root           00-10-7b-bb-2f-00
Designated Root Priority  32770  (root priority:32768, sys ID ext:2)

Designated Root Cost      0          Remaining Hops 20
Designated Root Port      1/0
```

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```
Bridge ID MAC ADDR          00-10-7b-bb-2f-00
Bridge ID Priority          32770  (bridge priority:32768, sys ID ext:
2)

Port                    State         Role Cost     Prio Type
----------------------- ------------- ---- -------- -----------------------
 6/1                    forwarding    BDRY  10000   20 P2P,
Boundary(PVST)
 6/2                    blocking      BDRY  20000   32 P2P,
Boundary(PVST)
Console> (enable)
```

Mapping and Unmapping VLANs to an MST Instance

Note See Chapter 10, "Configuring VLANs" for details on using VLANs.

By default, all VLANS are mapped to IST (instance 0). For an MST instance (MSTI) 1 through 15 to be active, you must map at least one VLAN to that MSTI. IST will always be active whether VLANs are mapped to IST or not. There are no VLAN mapping conflicts because of separate regions in MST.

Follow these guidelines for mapping and unmapping VLANS to an MST instance:

- You can only map Ethernet VLANs to MST instances.
- At least one VLAN in the instance must have an active port in order for MST to be active.
- You can map as many Ethernet VLANs as you wish to an MST instance.
- You cannot map a VLAN to more than one MST instance.
- The Hello Time, Maximum Age timer, and Forward Delay timer set for mode and all spanning trees are used globally by MST.

To map a VLAN to an MST instance, perform this task in privileged mode:

	Task	Command
Step 1	Map a VLAN to an MST instance.	**set spantree mst** *instance* **vlan** *vlan*
Step 2	Make the new region mapping effective.	**set spantree mst config commit**
Step 3	Verify that the VLAN is mapped.	**show spantree mst** [*instance*] [**active**] *mod/port*

This example shows how to map a VLAN to MST instance 1 and verify the mapping:

```
Console> (enable) show spantree mst config
Current (NVRAM) MST Region Configuration:
Configuration Name:cisco                              Revision:1
Instance VLANs
-------- -------------------------------------------------------------
IST     1,51-4094
  1     2-20
  2     21-30
  3     31-40
  4     41-50
  5     -
  6     -
  7     -
  8     -
  9     -
```

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```
  10     -
  11     -
  12     -
  13     -
  14     -
  15     -
  =======================================================================
  Console> (enable)
  Console> (enable) set spantree mst 14 vlan 900-999
  Edit Buffer modified. Use 'set spantree mst config commit' to apply the
  changes.
  Console> (enable) show spantree mst config
  Current (NVRAM) MST Region Configuration:
  Configuration Name:cisco                        Revision:1
  Instance VLANs
  -------- --------------------------------------------------------------
  IST     1,51-4094
    1     2-20
    2     21-30
    3     31-40
    4     41-50
    5     -
    6     -
    7     -
    8     -
    9     -
  10     -
  11     -
  12     -
  13     -
  14     -
  15     -
  =======================================================================
  NEW MST Region Configuration (Not committed yet)
  Configuration Name:cisco                        Revision:2
  Instance VLANs
  -------- --------------------------------------------------------------
  IST     1,51-899,1000-4094
    1     2-20
    2     21-30
    3     31-40
    4     41-50
    5     -
    6     -
    7     -
    8     -
    9     -
  10     -
  11     -
  12     -
  13     -
  14     900-999
  15     -
  =======================================================================
  Edit buffer is locked by:Console (pid 142)
  Console> (enable)
  Console> (enable) clear spantree mst 14 vlan 900-998
  Edit Buffer modified. Use 'set spantree mst config commit' to apply the
  changes.
  Console> (enable)
```

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```
Console> (enable) show spantree mst config
Current (NVRAM) MST Region Configuration:
Configuration Name:cisco                          Revision:1
Instance VLANs
-------- ----------------------------------------------------------------
IST     1,51-4094
  1     2-20
  2     21-30
  3     31-40
  4     41-50
  5     -
  6     -
  7     -
  8     -
  9     -
 10     -
 11     -
 12     -
 13     -
 14     -
 15     -
========================================================================
NEW MST Region Configuration (Not committed yet)
Configuration Name:cisco                          Revision:2
Instance VLANs
-------- ----------------------------------------------------------------
IST     1,51-998,1000-4094
  1     2-20
  2     21-30
  3     31-40
  4     41-50
  5     -
  6     -
  7     -
  8     -
  9     -
 10     -
 11     -
 12     -
 13     -
 14     999
 15     -
========================================================================
Edit buffer is locked by:Console (pid 142)
Console> (enable)
Console> (enable) set spantree mst config commit
Console> (enable)
Console> (enable) show spantree mst config
Current (NVRAM) MST Region Configuration:
Configuration Name:cisco                          Revision:2
Instance VLANs
-------- ----------------------------------------------------------------
IST     1,51-998,1000-4094
  1     2-20
  2     21-30
  3     31-40
  4     41-50
  5     -
  6     -
  7     -
  8     -
  9     -
 10     -
 11     -
```

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```
   12      -
   13      -
   14      999
   15      -
=======================================================================
Console> (enable)
Console> (enable) show spantree mst 3
Spanning tree mode         MST
Instance                   3
VLANs Mapped:              31-40

Designated Root            00-10-7b-bb-2f-00
Designated Root Priority   8195  (root priority:8192, sys ID ext:3)
Designated Root Cost       0          Remaining Hops 20
Designated Root Port       1/0

Bridge ID MAC ADDR         00-10-7b-bb-2f-00
Bridge ID Priority         8195  (bridge priority:8192, sys ID ext:3)

Port                    State        Role Cost     Prio Type
----------------------- ------------ ---- -------- ----
-------------------
 6/1                    forwarding   BDRY   10000   30 P2P,
Boundary(PVST)
 6/2                    blocking     BDRY   20000   32 P2P,
Boundary(PVST)
Console> (enable)
```

Configuring Spanning Tree BPDU Skewing

Commands that support the spanning tree BPDU skewing feature perform these functions:

- Allow you to enable or disable BPDU skewing. The default is disabled.

- Modify the **show spantree summary** output to show if the skew detection is enabled and for which VLANs or PVST+ or MISTP instances the skew was detected.

- Provide a display of the VLAN or PVST+ or MISTP instance and the port that is affected by the skew and include this information:

    - The duration (in absolute time) of the last skew

    - The duration (in absolute time) of the worst skew

    - The date and time of the worst duration

To change how spanning tree performs BPDU skewing statistics gathering, enter the **set spantree bpdu-skewing** command. The **bpdu-skewing** command is disabled by default.

To configure the BPDU skewing statistics gathering for a VLAN, perform this task in privileged mode:

	Task	Command
Step 1	Configure BPDU skewing.	**set spantree bpdu-skewing** [**enable**	**disable**]
Step 2	Verify the configuration.	**show spantree bpdu-skewing** *vlan* [*mod/port*]
		show spantree bpdu-skewing mistp-instance [*instance*] [*mod/port*]

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This example shows how to configure BPDU skewing and view the skewing statistics:

```
Console> (debug-eng) set spantree bpdu-skewing
Usage:set spantree bpdu-skewing <enable|disable>
Console> (debug-eng)
Console> (debug-eng)
Console> (debug-eng) set spantree bpdu-skewing enable
Spantree bpdu-skewing enabled on this switch.
Console> (debug-eng)
Console> (enable)

Console> (enable) show spantree bpdu-skewing 1
Bpdu skewing statistics for vlan 1
Port    Last Skew ms   Worst Skew ms     Worst Skew Time
------  -------------  -------------  ------------------------
8/2             5869          108370  Tue Nov 21 2000, 06:25:59
8/4             4050          113198  Tue Nov 21 2000, 06:26:04
8/6           113363          113363  Tue Nov 21 2000, 06:26:05
8/8             4111          113441  Tue Nov 21 2000, 06:26:05
8/10          113522          113522  Tue Nov 21 2000, 06:26:05
8/12            4111          113600  Tue Nov 21 2000, 06:26:05
8/14          113678          113678  Tue Nov 21 2000, 06:26:05
8/16            4111          113755  Tue Nov 21 2000, 06:26:05
8/18          113833          113833  Tue Nov 21 2000, 06:26:05
8/20            4111          113913  Tue Nov 21 2000, 06:26:05
8/22          113917          113917  Tue Nov 21 2000, 06:26:05
8/24            4110          113922  Tue Nov 21 2000, 06:26:05
8/26          113926          113926  Tue Nov 21 2000, 06:26:05
8/28            4111          113931  Tue Nov 21 2000, 06:26:05
Console> (enable)
```

This example shows how to configure BPDU skewing for VLAN 1 on module 8, port 4 and view the skewing statistics:

```
Console> (enable) show spantree bpdu-skewing 1 8/4
Bpdu skewing statistics for vlan 1
Port    Last Skew ms   Worst Skew ms     Worst Skew Time
------  -------------  -------------  ------------------------
8/4             5869          108370  Tue Nov 21 2000, 06:25:59
```

You will receive a similar output when MISTP is running.

The **show spantree summary** command shows if BPDU skew detection is enabled and also lists the VLANs or instances that are affected in the skew. This example shows the output of the **show spantree summary** command:

```
Console> (enable) show spantree summary
Root switch for vlans: 1
BPDU skewing detection enabled for the bridge
BPDU skewed for vlans: 1
Portfast bpdu-guard disabled for bridge.
Portfast bpdu-filter disabled for bridge.
Uplinkfast disabled for bridge.
Backbonefast disabled for bridge.

Summary of connected spanning tree ports by vlan

VLAN  Blocking Listening Learning Forwarding STP Active
----- -------- --------- -------- ---------- ----------
    1        6         4        2          0         12
```

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```
          Blocking Listening Learning Forwarding STP Active
----- -------- --------- -------- ---------- ----------
Total     6         4        2        0          12
Console> (enable)
```

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