



Configuring PVST+ and RPVST+

This chapter describes how to configure the Spanning Tree Protocol (STP) on port-based VLANs on the Cisco router. The router can use the per-VLAN spanning-tree plus (PVST+) protocol based on the IEEE 802.1D standard and Cisco proprietary extensions, or the rapid per-VLAN spanning-tree plus (rapid-PVST+) protocol based on the IEEE 802.1w standard.

For information about the Multiple Spanning Tree Protocol (MSTP) and how to map multiple VLANs to the same spanning-tree instance, see the Multiple Spanning Tree Protocol chapter.



Note For complete syntax and usage information for the commands used in this chapter, see the command reference for this release.



Note This feature is only applicable for Cisco NCS 4201 and NCS 4202.

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STP Overview

STP is a Layer 2 link management protocol that provides path redundancy while preventing loops in the network. For a Layer 2 Ethernet network to function properly, only one active path can exist between any two stations. Multiple active paths among end stations cause loops in the network. If a loop exists in the network, end stations might receive duplicate messages. Switches might also learn end-station MAC addresses on multiple Layer 2 interfaces. These conditions result in an unstable network. Spanning-tree operation is transparent to end stations, which cannot detect whether they are connected to a single LAN segment or a switched LAN of multiple segments.

The STP uses a spanning-tree algorithm to select one switch of a redundantly connected network as the root of the spanning tree. The algorithm calculates the best loop-free path through a switched Layer 2 network by assigning a role to each port based on the role of the port in the active topology:

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

The switch that has *all* of its ports as the designated role or the backup role is the root switch. The switch that has at least *one* of its ports in the designated role is called the designated switch.

Spanning tree forces redundant data paths into a standby (blocked) state. If a network segment in the spanning tree fails and a redundant path exists, the spanning-tree algorithm recalculates the spanning-tree topology and activates the standby path. Switches send and receive spanning-tree frames, called bridge protocol data units (BPDUs), at regular intervals. The switches do not forward these frames but use them to construct a loop-free path. BPDUs contain information about the sending switch and its ports, including switch and MAC addresses, switch priority, port priority, and path cost. Spanning tree uses this information to elect the root switch and root port for the switched network and the root port and designated port for each switched segment.

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

Spanning-Tree Topology and BPDUs

The stable, active spanning-tree topology of a switched network is controlled by these elements:

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

When the switches in a network are powered up, each functions as the root switch. Each switch sends a configuration BPDU through all of its ports only through the STP-enabled ports. The BPDUs communicate and compute the spanning-tree topology. Each configuration BPDU contains this information:

- The unique bridge ID of the switch that the sending switch identifies as the root switch

- The spanning-tree path cost to the root
- The bridge ID of the sending switch
- Message age
- The identifier of the sending interface
- Values for the hello, forward delay, and max-age protocol timers

When a switch receives a configuration BPDU that contains *superior* information (lower bridge ID, lower path cost, and so forth), it stores the information for that port. If this BPDU is received on the root port of the switch, the switch also forwards it with an updated message to all attached LANs for which it is the designated switch.

If a switch receives a configuration BPDU that contains *inferior* information to that currently stored for that port, it discards the BPDU. If the switch is a designated switch for the LAN from which the inferior BPDU was received, it sends that LAN a BPDU containing the up-to-date information stored for that port. In this way, inferior information is discarded, and superior information is propagated on the network.

A BPDU exchange results in these actions:

- One switch in the network is elected as the root switch (the logical center of the spanning-tree topology in a switched network).

For each VLAN, the switch with the highest switch priority (the lowest numerical priority value) is elected as the root switch. If all switches are configured with the default priority (32768), the switch with the lowest MAC address in the VLAN becomes the root switch. The switch priority value occupies the most significant bits of the bridge ID, as shown in tables Switch Priority Value and Extended System ID and Spanning-Tree Timer.

- A root port is selected for each switch (except the root switch). This port provides the best path (lowest cost) when the switch forwards packets to the root switch.
- The shortest distance to the root switch is calculated for each switch based on the path cost.
- A designated switch for each LAN segment is selected. The designated switch incurs the lowest path cost when forwarding packets from that LAN to the root switch. The port through which the designated switch is attached to the LAN is called the designated port.

All paths that are not needed to reach the root switch from anywhere in the switched network are placed in the spanning-tree blocking mode.

Bridge ID, Switch Priority, and Extended System ID

The IEEE 802.1D standard requires that each switch has a unique bridge identifier (bridge ID), which controls the selection of the root switch. Because each VLAN is considered as a different *logical bridge* with PVST+ and rapid PVST+, the same switch must have as many different bridge IDs as VLANs configured on it. Each VLAN on the switch has a unique 8-byte bridge ID. The two most-significant bytes are used for the switch priority, and the remaining six bytes are derived from the switch MAC address.

The switch supports the IEEE 802.1t spanning-tree extensions, and some of the bits previously used for the switch priority are now used as the VLAN identifier. The result is that fewer MAC addresses are reserved for the switch, and a larger range of VLAN IDs can be supported, all while maintaining the uniqueness of the bridge ID. As shown in table Switch Priority Value and Extended System ID, the two bytes previously used for the switch priority are reallocated into a 4-bit priority value and a 12-bit extended system ID value equal to the VLAN ID.

Table 1: Switch Priority Value and Extended System ID

Switch Priority Value				Extended System ID (Set Equal to the VLAN ID)											
Bit 16	Bit 15	Bit 14	Bit 13	Bit 12	Bit 11	Bit 10	Bit 9	Bit 8	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1
32768	16384	8192	4096	2048	1024	512	256	128	64	32	16	8	4	2	1

Spanning tree uses the extended system ID, the switch priority, and the allocated spanning-tree MAC address to make the bridge ID unique for each VLAN.

Support for the extended system ID affects how you manually configure the root switch, the secondary root switch, and the switch priority of a VLAN. For example, when you change the switch priority value, you change the probability that the switch will be elected as the root switch. Configuring a higher value decreases the probability; a lower value increases the probability. For more information, see the [Configuring the Root Switch](#) section, the [Configuring a Secondary Root Switch](#) section, and the [Configuring the Switch Priority of a VLAN](#) section.

Spanning-Tree Interface States

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

Each Layer 2 interface on a switch using spanning tree exists in one of these states:

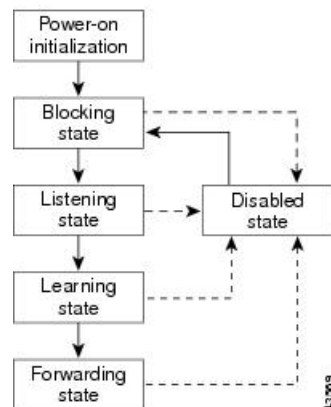
- Blocking—The interface does not participate in frame forwarding.
- Listening—The first transitional state after the blocking state when the spanning tree determines that the interface should participate in frame forwarding.
- Learning—The interface prepares to participate in frame forwarding.
- Forwarding—The interface forwards frames.
- Disabled—The interface is not participating in spanning tree because of a shutdown port, no link on the port, or no spanning-tree instance running on the port.

A port participating in spanning tree moves through these states:

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

The figure below shows how an interface moves through the states.

Figure 1: Spanning-Tree Interface States



Spanning tree is not enabled by default. Once the spanning tree mode is selected, each VLAN on ports goes through the blocking state and the transitional states of listening and learning. Spanning tree stabilizes each interface at the forwarding or blocking state.

When the spanning-tree algorithm places a Layer 2 spanning-tree interface in the forwarding state, this process occurs:

1. The interface is in the listening state while spanning tree waits for protocol information to transition the interface to the blocking state.
2. While spanning tree waits the forward-delay timer to expire, it moves the interface to the learning state and resets the forward-delay timer.
3. In the learning state, the interface continues to block frame forwarding as the switch learns end-station location information for the forwarding database.
4. When the forward-delay timer expires, spanning tree moves the interface to the forwarding state, where both learning and frame forwarding are enabled.

Blocking State

A Layer 2 interface in the blocking state does not participate in frame forwarding. After initialization, a BPDU is sent to each switch interface, or to each switch STP port. A switch initially functions as the root until it exchanges BPDUs with other switches. This exchange establishes which switch in the network is the root or root switch. If there is only one switch in the network, no exchange occurs, the forward-delay timer expires, and the interface moves to the listening state. An interface participating in spanning tree always enters the blocking state after switch initialization.

An interface in the blocking state performs these functions:

- Discards frames received on the interface
- Discards frames switched from another interface for forwarding
- Does not learn addresses
- Receives BPDUs

Listening State

The listening state is the first state a Layer 2 interface enters after the blocking state. The interface enters this state when the spanning tree decides that the interface should participate in frame forwarding.

An interface in the listening state performs these functions:

- Discards frames received on the interface
- Discards frames switched from another interface for forwarding
- Does not learn addresses
- Receives BPDUs

Learning State

A Layer 2 interface in the learning state prepares to participate in frame forwarding. The interface enters the learning state from the listening state.

An interface in the learning state performs these functions:

- Discards frames received on the interface
- Discards frames switched from another interface for forwarding
- Learns addresses
- Receives BPDUs

Forwarding State

A Layer 2 interface in the forwarding state forwards frames. The interface enters the forwarding state from the learning state.

An interface in the forwarding state performs these functions:

- Receives and forwards frames received on the interface
- Forwards frames switched from another interface
- Learns addresses
- Receives BPDUs

Disabled State

A Layer 2 interface in the disabled state does not participate in frame forwarding or in the spanning tree. An interface in the disabled state is non operational.

A disabled interface performs these functions:

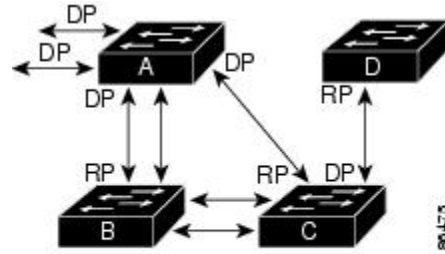
- Discards frames received on the interface
- Discards frames switched from another interface for forwarding
- Does not learn addresses
- Does not receive BPDUs

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

If all switches in a network are enabled with default spanning-tree settings, the switch with the lowest MAC address becomes the root switch. In the figure below, Switch A is elected as the root switch because the switch priority of all the switches is set to the default (32768) and Switch A has the lowest MAC address. However, because of traffic patterns, number of forwarding interfaces, or link types, Switch A might not be the ideal root switch. By increasing the priority (lowering the numerical value) of the ideal switch so that it

becomes the root switch, you force a spanning-tree recalculation to form a new topology with the ideal switch as the root.

Figure 2: Spanning-Tree Topology



RP = Root Port
 DP = Designated Port

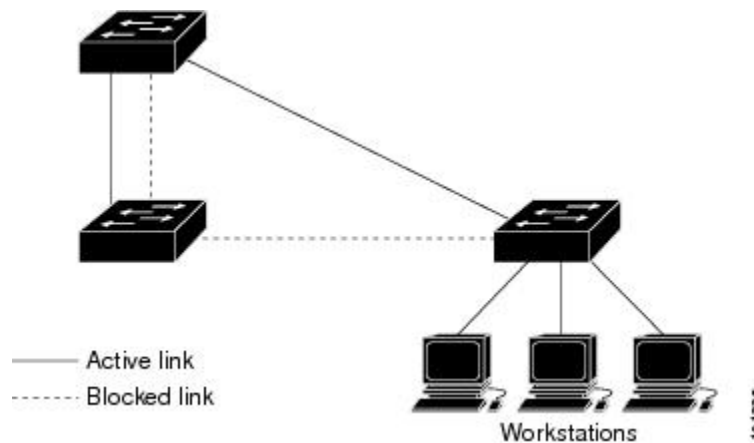
When the spanning-tree topology is calculated based on default parameters, the path between source and destination end stations in a switched network might not be ideal. For instance, connecting higher-speed links to an interface that has a higher number than the root port can cause a root-port change.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

For example, assume that one port on Switch B is a Gigabit Ethernet link and that another port on Switch B (a 10/100 link) is the root port. Network traffic might be more efficient over the Gigabit Ethernet link. By changing the spanning-tree port priority on the Gigabit Ethernet port to a higher priority (lower numerical value) than the root port, the Gigabit Ethernet port becomes the new root port.

Spanning Tree and Redundant Connectivity

You can create a redundant backbone with spanning tree by connecting two switch interfaces that are participating in spanning tree to another device or to two different devices, as shown in the figure below. Spanning tree automatically disables one interface but enables it if the other one fails. If one link is high-speed and the other is low-speed, the low-speed link is always disabled. If the speeds are the same, the port priority and port ID are added together, and spanning tree disables the link with the lowest value.

Figure 3: Spanning Tree and Redundant Connectivity



You can also create redundant links between switches by using EtherChannel groups.

Spanning-Tree Modes and Protocols

The following spanning-tree modes and protocols are supported:

- **PVST+**—This spanning-tree mode is based on the IEEE 802.1D standard and Cisco proprietary extensions. The PVST+ runs on each VLAN on the switch up to the maximum supported, ensuring that each has a loop-free path through the network.

The PVST+ provides Layer 2 load balancing for the VLAN on which it runs. You can create different logical topologies by using the VLANs on your network to ensure that all of your links are used but that no one link is oversubscribed. Each instance of PVST+ on a VLAN has a single root switch. This root switch propagates the spanning-tree information associated with that VLAN to all other switches in the network. Because each switch has the same information about the network, this process ensures that the network topology is maintained.

- **Rapid PVST+**—This spanning-tree mode is the same as PVST+ except that it uses a rapid convergence based on the IEEE 802.1w standard. Rapid PVST+ is compatible with PVST+. To provide rapid convergence, the rapid PVST+ immediately deletes dynamically learned MAC address entries on a per-port basis upon receiving a topology change. By contrast, PVST+ uses a short aging time for dynamically learned MAC address entries.

The rapid PVST+ uses the same configuration as PVST+ (except where noted), and the switch needs only minimal extra configuration. The benefit of rapid PVST+ is that you can migrate a large PVST+ install base to rapid PVST+ without having to learn the complexities of the MSTP configuration and without having to re-provision your network. In rapid-PVST+ mode, each VLAN runs its own spanning-tree instance up to the maximum supported.

- **MSTP**—This spanning-tree mode is based on the IEEE 802.1s standard. You can map multiple VLANs to the same spanning-tree instance, which reduces the number of spanning-tree instances required to support a large number of VLANs. The MSTP runs on top of the RSTP (based on IEEE 802.1w), which provides for rapid convergence of the spanning tree by eliminating the forward delay and by quickly transitioning root ports and designated ports to the forwarding state. You cannot run MSTP without RSTP.

The most common initial deployment of MSTP is in the backbone and distribution layers of a Layer 2 switched network. For more information, see [Multiple Spanning Tree Protocol](#) chapter.

For information about the number of supported spanning-tree instances, see [Restrictions for PVST+ and RPVST+, on page 8](#).

Restrictions for PVST+ and RPVST+

- In PVST+ or rapid-PVST+ mode, the switch supports up to 128 spanning-tree instances.
- You must configure **l2protocol peer stp** command under all the EFP where you prefer to run STP.

The **l2protocol peer stp** influences how STP BPDUs are treated in ingress direction [drop or process], however it has no effect on STP BPDU in egress direction. The ASR 920 router always transmits STP BPDUs in the egress direction.

- Port fast trunk works only if you configure it under interface mode and not under global mode.
- ROOT guard works only if you configure it under interface mode and not under global mode.

Spanning-Tree Interoperability and Backward Compatibility

The table below lists the interoperability and compatibility among the supported spanning-tree modes in a network.

Table 2: PVST+, MSTP, and Rapid-PVST+ Interoperability

	PVST+	MSTP	Rapid PVST+
PVST+	Yes	Yes (with restrictions)	Yes (reverts to PVST+)
MSTP	Yes (with restrictions)	Yes	Yes (reverts to PVST+)
Rapid PVST+	Yes (reverts to PVST+)	Yes (with restrictions)	Yes

In a mixed MSTP and PVST+ network, the common spanning-tree (CST) root must be inside the MST backbone, and a PVST+ switch cannot connect to multiple MST regions.

When a network contains switches running rapid PVST+ and switches running PVST+, we recommend that the rapid-PVST+ switches and PVST+ switches be configured for different spanning-tree instances. In the rapid-PVST+ spanning-tree instances, the root switch must be a rapid-PVST+ switch. In the PVST+ instances, the root switch must be a PVST+ switch. The PVST+ switches should be at the edge of the network.

Default Spanning-Tree Configuration

The table below shows the default spanning-tree configuration.

Table 3: Default Spanning-Tree Configuration

Feature	Default Setting
Enable state	Enabled on ports in VLAN 1.
Spanning-tree mode	Disabled.
Switch priority	32768.
Spanning-tree port priority (configurable on a per-interface basis)	128.
Spanning-tree port cost (configurable on a per-interface basis)	1000 Mbps: 4. 100 Mbps: 19. 10 Mbps: 100.
Spanning-tree VLAN port priority (configurable on a per-VLAN basis)	128.
Spanning-tree VLAN port cost (configurable on a per-VLAN basis)	1000 Mbps: 4. 100 Mbps: 19. 10 Mbps: 100.

Feature	Default Setting
Spanning-tree timers	Hello time: 2 seconds. Forward-delay time: 15 seconds. Maximum-aging time: 20 seconds.

Configuring PVST+ and RPVST+

The switch supports three spanning-tree modes: MSTP, PVST+, rapid PVST+.



Note By default, spanning-tree is disabled.

Use the following procedure to configure spanning-tree mode:

SUMMARY STEPS

1. **configure terminal**
2. **spanning-tree mode {pvst | rapid-pvst}**
3. **spanning-tree vlan *vlan-range***
4. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	configure terminal	Enter global configuration mode.
Step 2	spanning-tree mode {pvst rapid-pvst}	Configure a spanning-tree mode on STP ports on the switch. <ul style="list-style-type: none"> • Select pvst to enable PVST+. • Select rapid-pvst to enable rapid PVST+.
Step 3	spanning-tree vlan <i>vlan-range</i>	Configures STP on the range of VLAN specified.
Step 4	end	Return to privileged EXEC mode.

Configuring STP Peer Under EFP/TEFP

Beginning in privileged EXEC mode, follow these steps to configure the L2 protocol peer under EFP/TEFP. This procedure is optional.

SUMMARY STEPS

1. **configure terminal**
2. **interface TenGigabitEthernetslot/subslot/port**

3. **no ip address**
4. **service instance trunk *trunk id* ethernet**
5. **encapsulation dot1q *vlan-id***
6. **rewrite ingress tag pop 1 symmetric**
7. **l2protocol peer stp**
8. **bridge-domain from encapsulation**
9. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	configure terminal Example: router#configure terminal	Enter global configuration mode.
Step 2	interface TenGigabitEthernet$\textit{slot/subslot/port}$ Example: router(config)#interface TenGigabitEthernet0/0/27	Specifies the Gigabit Ethernet interface to configure. $\textit{slot/subslot/port}$ —Specify the location of the interface.
Step 3	no ip address Example: router(config-if)#no ip address	Disables the IP address on the interface.
Step 4	service instance trunk <i>trunk id</i> ethernet Example: router(config-if)#service instance trunk 1 ethernet	Configures an Ethernet service instance on an interface and enters Ethernet service configuration mode.
Step 5	encapsulation dot1q <i>vlan-id</i> Example: router(config-if-srv)#encapsulation dot1q 1-100	Defines the matching criteria to map 802.1Q frames ingress on an interface to the appropriate service instance.
Step 6	rewrite ingress tag pop 1 symmetric Example: router(config-if-serve)#rewrite ingress tag pop 1 symmetric	Specifies the encapsulation adjustment to be performed on a frame that is entering a service instance.
Step 7	l2protocol peer stp Example: router(config-if-srv)#l2protocol peer stp	Configures STP to peer with a neighbor on a port that has an EFP service instance.
Step 8	bridge-domain from encapsulation Example: router(config-if-srv)#bridge-domain from encapsulation	Configures support for EFPs on the interface.
Step 9	end Example: router(config-ip)# end	Returns to privileged EXEC mode.



Note You must configure **l2protocol peer stp** command under all the EFP where you prefer to run STP.

Disabling Spanning Tree

Disable spanning tree only if you are sure there are no loops in the network topology.



Caution When spanning tree is disabled and loops are present in the topology, excessive traffic and indefinite packet duplication can drastically reduce network performance.

Beginning in privileged EXEC mode, follow these steps to disable spanning-tree on a per-VLAN basis. This procedure is optional.

SUMMARY STEPS

1. **configure terminal**
2. **no spanning-tree vlan *vlan-id***
3. **end**
4. **show spanning-tree vlan *vlan-id***

DETAILED STEPS

	Command or Action	Purpose
Step 1	configure terminal	Enter global configuration mode.
Step 2	no spanning-tree vlan <i>vlan-id</i>	For <i>vlan-id</i> , the range is 1 to 4094.
Step 3	end	Return to privileged EXEC mode.
Step 4	show spanning-tree vlan <i>vlan-id</i>	Verify your entries.

To re-enable spanning-tree, use the **spanning-tree vlan *vlan-id*** global configuration command.

Verifying PVST/RPVST Settings

Use the below commands to verify PVST and RPVST settings:

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

```
VLAN0010
Spanning tree enabled protocol ieee
Root ID    Priority    32778
Address    a89d.21ed.bbbd
Cost       6
Port       18 (GigabitEthernet0/0/11)
Hello Time 2 sec Max Age 20 sec Forward Delay 15 sec
```

```

Bridge ID Priority    32778 (priority 32768 sys-id-ext 10)
Address    b0aa.7754.553d
Hello Time 2 sec Max Age 20 sec Forward Delay 15 sec
Aging Time 0 sec

Interface      Role Sts Cost      Prio.Nbr Type
-----
Gi0/0/7       Altn BLK 4        128.14 P2p
Gi0/0/11      Root FWD 4        128.18 P2p

```

```
router#show spanning-tree interface gigabitEthernet 0/0/7 detail
```

```

Port 14 (GigabitEthernet0/0/7) of VLAN0001 is alternate blocking
Port path cost 4, Port priority 128, Port Identifier 128.14.
Designated root has priority 32769, address a89d.21ed.bbbd
Designated bridge has priority 32769, address b0aa.7737.9dbd
Designated port id is 128.14, designated path cost 4
Timers: message age 4, forward delay 0, hold 0
Number of transitions to forwarding state: 1
Link type is point-to-point by default
BPDU: sent 91, received 8394

```

```
router#show spanning-tree summary
```

```

Switch is in pvst mode
Root bridge for: none
EtherChannel misconfig guard is enabled
Extended system ID          is enabled
Portfast Default            is disabled
PortFast BPDU Guard Default is disabled
Portfast BPDU Filter Default is disabled
Loopguard Default          is disabled
UplinkFast                  is disabled
BackboneFast                is disabled
Configured Pathcost method used is short

```

Name	Blocking	Listening	Learning	Forwarding	STP Active
VLAN0001	1	0	0	1	2
VLAN0002	1	0	0	1	2
VLAN0003	1	0	0	1	2
VLAN0004	1	0	0	1	2
VLAN0005	1	0	0	1	2
VLAN0006	1	0	0	1	2

Configuring the Root Switch

The switch maintains a separate spanning-tree instance for each active VLAN configured on it. A bridge ID, consisting of the switch priority and the switch MAC address, is associated with each instance. For each VLAN, the switch with the lowest bridge ID becomes the root switch for that VLAN.

To configure a switch to become the root for the specified VLAN, use the **spanning-tree vlan *vlan-id* root** global configuration command to modify the switch priority from the default value (32768) to a significantly lower value. When you enter this command, the software checks the switch priority of the root switches for each VLAN. Because of the extended system ID support, the switch sets its own priority for the specified VLAN to 24576 if this value will cause this switch to become the root for the specified VLAN.

If any root switch for the specified VLAN has a switch priority lower than 24576, the switch sets its own priority for the specified VLAN to 4096 less than the lowest switch priority. (4096 is the value of the least-significant bit of a 4-bit switch priority value as shown in Table 14-1 on page 14-4 .)



Note The **spanning-tree vlan *vlan-id* root** global configuration command fails if the value necessary to be the root switch is less than 1.

If your network consists of switches that both do and do not support the extended system ID, it is unlikely that the switch with the extended system ID support will become the root switch. The extended system ID increases the switch priority value every time the VLAN number is greater than the priority of the connected switches running older software.



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

Use the **diameter** keyword to specify the Layer 2 network diameter (that is, the maximum number of switch hops between any two end stations in the Layer 2 network). When you specify the network diameter, the switch automatically sets an optimal hello time, forward-delay time, and maximum-age time for a network of that diameter, which can significantly reduce the convergence time. You can use the **hello** keyword to override the automatically calculated hello time.



Note After configuring the switch as the root switch, we recommend that you avoid manually configuring the hello time, forward-delay time, and maximum-age time through the **spanning-tree vlan *vlan-id* hello-time**, **spanning-tree vlan *vlan-id* forward-time**, and the **spanning-tree vlan *vlan-id* max-age** global configuration commands.

Beginning in privileged EXEC mode, follow these steps to configure a switch to become the root for the specified VLAN. This procedure is optional.

SUMMARY STEPS

1. **configure terminal**
2. **spanning-tree vlan *vlan-id* root primary [diameter *net-diameter* [hello-time *seconds*]]**
3. **end**
4. **show spanning-tree detail**
5. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	configure terminal	Enter global configuration mode.
Step 2	spanning-tree vlan <i>vlan-id</i> root primary [diameter <i>net-diameter</i> [hello-time <i>seconds</i>]]	Configure a switch to become the root for the specified VLAN.

	Command or Action	Purpose
		<ul style="list-style-type: none"> For <i>vlan-id</i>, you can specify a single VLAN identified by VLAN ID number, a range of VLANs separated by a hyphen, or a series of VLANs separated by a comma. The range is 1 to 4094. (Optional) For diameter <i>net-diameter</i>, specify the maximum number of switches between any two end stations. The range is 2 to 7. (Optional) For hello-time <i>seconds</i>, specify the interval in seconds between the generation of configuration messages by the root switch. The range is 1 to 10; the default is 2.
Step 3	end	Return to privileged EXEC mode.
Step 4	show spanning-tree detail	Verify your entries.
Step 5	copy running-config startup-config	(Optional) Save your entries in the configuration file.

To return to the default setting, use the **no spanning-tree vlan *vlan-id* root** global configuration command.

Configuring a Secondary Root Switch

When you configure a switch as the secondary root, the switch priority is modified from the default value (32768) to 28672. The switch is then likely to become the root switch for the specified VLAN if the primary root switch fails. This is assuming that the other network switches use the default switch priority of 32768 and therefore are unlikely to become the root switch.

You can execute this command on more than one switch to configure multiple backup root switches. Use the same network diameter and hello-time values that you used when you configured the primary root switch with the **spanning-tree vlan *vlan-id* root primary** global configuration command.

Beginning in privileged EXEC mode, follow these steps to configure a switch to become the secondary root for the specified VLAN. This procedure is optional.

SUMMARY STEPS

1. **configure terminal**
2. **spanning-tree vlan *vlan-id* root secondary [diameter *net-diameter* [hello-time *seconds*]]**
3. **end**
4. **show spanning-tree detail**
5. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	configure terminal	Enter global configuration mode.

	Command or Action	Purpose
Step 2	<code>spanning-tree vlan <i>vlan-id</i> root secondary [diameter <i>net-diameter</i> [hello-time <i>seconds</i>]]</code>	<p>Configure a switch to become the secondary root for the specified VLAN.</p> <ul style="list-style-type: none"> For <i>vlan-id</i>, you can specify a single VLAN identified by VLAN ID number, a range of VLANs separated by a hyphen, or a series of VLANs separated by a comma. The range is 1 to 4094. (Optional) For diameter <i>net-diameter</i>, specify the maximum number of switches between any two end stations. The range is 2 to 7. (Optional) For hello-time <i>seconds</i>, specify the interval in seconds between the generation of configuration messages by the root switch. The range is 1 to 10; the default is 2. <p>Use the same network diameter and hello-time values that you used when configuring the primary root switch. See Configuring the Root Switch.</p>
Step 3	<code>end</code>	Return to privileged EXEC mode.
Step 4	<code>show spanning-tree detail</code>	Verify your entries.
Step 5	<code>copy running-config startup-config</code>	(Optional) Save your entries in the configuration file.

To return to the default setting, use the `no spanning-tree vlan vlan-id root` global configuration command.

Configuring Port Priority

If a loop occurs, spanning tree uses the port priority when selecting a spanning-tree port to put into the forwarding state. You can assign higher priority values (lower numerical values) to ports that you want selected first and lower priority values (higher numerical values) to ones that you want selected last. If all spanning-tree ports have the same priority value, spanning tree puts the port with the lowest interface number in the forwarding state and blocks the other interfaces.

Beginning in privileged EXEC mode, follow these steps to configure the port priority of a spanning-tree port. This procedure is optional.

SUMMARY STEPS

1. `configure terminal`
2. `interface interface-id`
3. `spanning-tree port-priority priority`
4. `end`
5. Do one of the following:
 - `show spanning-tree interface interface-id`
 - `show spanning-tree vlan vlan-id`
6. `copy running-config startup-config`

DETAILED STEPS

	Command or Action	Purpose
Step 1	<code>configure terminal</code>	Enter global configuration mode.
Step 2	<code>interface interface-id</code>	Specify an interface to configure, and enter interface configuration mode. Note If the interface is a VLAN, only ports with spanning tree enabled in the VLAN will run spanning tree. If the interface is a port channel, all members of the port channel must have spanning tree enabled.
Step 3	<code>spanning-tree port-priority priority</code>	Configure the port priority for the spanning-tree port. For <i>priority</i> , the range is 0 to 240, in increments of 16; the default is 128. Valid values are 0, 16, 32, 48, 64, 80, 96, 112, 128, 144, 160, 176, 192, 208, 224, and 240. All other values are rejected. The lower the number, the higher the priority.
Step 4	<code>end</code>	Return to privileged EXEC mode.
Step 5	Do one of the following: <ul style="list-style-type: none">• <code>show spanning-tree interface interface-id</code>• <code>show spanning-tree vlan vlan-id</code>	Verify your entries.
Step 6	<code>copy running-config startup-config</code>	(Optional) Save your entries in the configuration file.



Note The `show spanning-tree interface interface-id` privileged EXEC command displays information only if the port is in a link-up operative state. Otherwise, you can use the `show running-config interface` privileged EXEC command to confirm the configuration.

To return to the default spanning-tree setting, use the `no spanning-tree [vlan vlan-id] port-priority` interface configuration command.

Configuring Path Cost

The spanning-tree path cost default value is derived from the media speed of an interface (port running spanning tree or port channel of multiple ports running spanning tree). If a loop occurs, spanning tree uses cost when selecting an interface to put in the forwarding state. You can assign lower cost values to interfaces that you want selected first and higher cost values that you want selected last. If all NNIs (or port channels) have the same cost value, spanning tree puts the interface with the lowest interface number in the forwarding state and blocks the other interfaces.

Beginning in privileged EXEC mode, follow these steps to configure the cost of an interface. This procedure is optional.

SUMMARY STEPS

1. **configure terminal**
2. **interface** *interface-id*
3. **spanning-tree cost** *cost*
4. **end**
5. Do one of the following:
 - **show spanning-tree interface** *interface-id*
 - **show spanning-tree vlan** *vlan-id*
6. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	configure terminal	Enter global configuration mode.
Step 2	interface <i>interface-id</i>	Specify an interface to configure, and enter interface configuration mode. Valid interfaces include physical interfaces and port-channel logical interfaces (port-channel <i>port-channel-number</i>).
Step 3	spanning-tree cost <i>cost</i>	Configure the cost for an interface. If a loop occurs, spanning tree uses the path cost when selecting an interface to place into the forwarding state. A lower path cost represents higher-speed transmission. For <i>cost</i> , the range is 1 to 200000000; the default value is derived from the media speed of the interface.
Step 4	end	Return to privileged EXEC mode.
Step 5	Do one of the following: <ul style="list-style-type: none"> • show spanning-tree interface <i>interface-id</i> • show spanning-tree vlan <i>vlan-id</i> 	Verify your entries.
Step 6	copy running-config startup-config	(Optional) Save your entries in the configuration file.



Note The **show spanning-tree interface** *interface-id* privileged EXEC command displays information only for ports that are in a link-up operative state. Otherwise, you can use the **show running-config** privileged EXEC command to confirm the configuration.

To return to the default setting, use the **no spanning-tree [vlan *vlan-id*] cost** interface configuration command.

Configuring the Switch Priority of a VLAN

You can configure the switch priority and make it more likely that the switch will be chosen as the root switch.



Note Exercise care when using this command. For most situations, we recommend that you use the **spanning-tree vlan *vlan-id* root primary** and the **spanning-tree vlan *vlan-id* root secondary** global configuration commands to modify the switch priority.

Beginning in privileged EXEC mode, follow these steps to configure the switch priority of a VLAN. This procedure is optional.

SUMMARY STEPS

1. **configure terminal**
2. **spanning-tree vlan *vlan-id* priority *priority***
3. **end**
4. **show spanning-tree vlan *vlan-id***
5. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	configure terminal	Enter global configuration mode.
Step 2	spanning-tree vlan <i>vlan-id</i> priority <i>priority</i>	Configure the switch priority of a VLAN. <ul style="list-style-type: none"> • For <i>vlan-id</i>, you can specify a single VLAN identified by VLAN ID number, a range of VLANs separated by a hyphen, or a series of VLANs separated by a comma. The range is 1 to 4094. • For <i>priority</i>, the range is 0 to 61440 in increments of 4096; the default is 32768. The lower the number, the more likely the switch will be chosen as the root switch. Valid priority values are 4096, 8192, 12288, 16384, 20480, 24576, 28672, 32768, 36864, 40960, 45056, 49152, 53248, 57344, and 61440. All other values are rejected.
Step 3	end	Return to privileged EXEC mode.
Step 4	show spanning-tree vlan <i>vlan-id</i>	Verify your entries.
Step 5	copy running-config startup-config	(Optional) Save your entries in the configuration file.

To return to the default setting, use the **no spanning-tree vlan *vlan-id* priority** global configuration command.

Configuring Spanning-Tree Timers

Table 4: Spanning-Tree Timers

Variable	Description
Hello timer	Controls how often the switch broadcasts hello messages to other switches.
Forward-delay timer	Controls how long each of the listening and learning states last before the STP port begins forwarding.
Maximum-age timer	Controls the amount of time the switch stores protocol information received on an STP port.

Configuring the Hello Time

You can configure the interval between the generation of configuration messages by the root switch by changing the hello time.



Note Exercise care when using this command. For most situations, we recommend that you use the **spanning-tree vlan *vlan-id* root primary** and the **spanning-tree vlan *vlan-id* root secondary** global configuration commands to modify the hello time.

Beginning in privileged EXEC mode, follow these steps to configure the hello time of a VLAN. This procedure is optional.

SUMMARY STEPS

1. **configure terminal**
2. **spanning-tree vlan *vlan-id* hello-time *seconds***
3. **end**
4. **show spanning-tree vlan *vlan-id***
5. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	configure terminal	Enter global configuration mode.
Step 2	spanning-tree vlan <i>vlan-id</i> hello-time <i>seconds</i>	Configure the hello time of a VLAN. The hello time is the interval between the generation of configuration messages by the root switch. These messages mean that the switch is alive. <ul style="list-style-type: none"> • For <i>vlan-id</i>, you can specify a single VLAN identified by VLAN ID number, a range of VLANs separated

	Command or Action	Purpose
		by a hyphen, or a series of VLANs separated by a comma. The range is 1 to 4094. • For <i>seconds</i> , the range is 1 to 10; the default is 2.
Step 3	end	Return to privileged EXEC mode.
Step 4	show spanning-tree vlan <i>vlan-id</i>	Verify your entries.
Step 5	copy running-config startup-config	(Optional) Save your entries in the configuration file.

To return to the default setting, use the **no spanning-tree vlan *vlan-id* hello-time** global configuration command.

Configuring the Forwarding-Delay Time for a VLAN

Beginning in privileged EXEC mode, follow these steps to configure the forwarding-delay time for a VLAN. This procedure is optional.

SUMMARY STEPS

1. **configure terminal**
2. **spanning-tree vlan *vlan-id* forward-time *seconds***
3. **end**
4. **show spanning-tree vlan *vlan-id***
5. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	configure terminal	Enter global configuration mode.
Step 2	spanning-tree vlan <i>vlan-id</i> forward-time <i>seconds</i>	Configure the forward time of a VLAN. The forward delay is the number of seconds a spanning-tree port waits before changing from its spanning-tree learning and listening states to the forwarding state. • For <i>vlan-id</i> , you can specify a single VLAN identified by VLAN ID number, a range of VLANs separated by a hyphen, or a series of VLANs separated by a comma. The range is 1 to 4094. • For <i>seconds</i> , the range is 4 to 30; the default is 15.
Step 3	end	Return to privileged EXEC mode.
Step 4	show spanning-tree vlan <i>vlan-id</i>	Verify your entries.
Step 5	copy running-config startup-config	(Optional) Save your entries in the configuration file.

To return to the default setting, use the **no spanning-tree vlan *vlan-id* forward-time** global configuration command.

Configuring the Maximum-Aging Time for a VLAN

Beginning in privileged EXEC mode, follow these steps to configure the maximum-aging time for a VLAN. This procedure is optional.

SUMMARY STEPS

1. **configure terminal**
2. **spanning-tree vlan *vlan-id* max-age *seconds***
3. **end**
4. **show spanning-tree vlan *vlan-id***
5. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	configure terminal	Enter global configuration mode.
Step 2	spanning-tree vlan <i>vlan-id</i> max-age <i>seconds</i>	Configure the maximum-aging time of a VLAN. The maximum-aging time is the number of seconds a switch waits without receiving spanning-tree configuration messages before attempting a reconfiguration. <ul style="list-style-type: none"> • For <i>vlan-id</i>, you can specify a single VLAN identified by VLAN ID number, a range of VLANs separated by a hyphen, or a series of VLANs separated by a comma. The range is 1 to 4094. • For <i>seconds</i>, the range is 6 to 40; the default is 20.
Step 3	end	Return to privileged EXEC mode.
Step 4	show spanning-tree vlan <i>vlan-id</i>	Verify your entries.
Step 5	copy running-config startup-config	(Optional) Save your entries in the configuration file.

To return to the default setting, use the **no spanning-tree vlan *vlan-id* max-age** global configuration command.

Displaying the Spanning-Tree Status

To display the spanning-tree status, use one or more of the privileged EXEC commands in the table below:

Table 5: Commands for Displaying Spanning-Tree Status

Command	Purpose
show spanning-tree active	Displays spanning-tree information only on active spanning-tree interfaces.

Command	Purpose
show spanning-tree detail	Displays a detailed summary of interface information.
show spanning-tree interface <i>interface-id</i>	Displays spanning-tree information for the specified spanning-tree interface.
show spanning-tree summary totals	Displays a summary of interface states or displays the total lines of the STP state section.

You can clear spanning-tree counters by using the **clear spanning-tree [interface *interface-id*]** privileged EXEC command.

For information about other keywords for the **show spanning-tree** privileged EXEC command, see the command reference for this release.

