



Your Short Cut to Knowledge

The following is an excerpt from a Short Cut published by one of the Pearson Education imprints.

Short Cuts are short, concise, PDF documents designed specifically for busy technical professionals like you.

We've provided this excerpt to help you review the product before you purchase. Please note, the hyperlinks contained within this excerpt have been deactivated.

**Tap into learning—NOW!**

Visit [www.informit.com/shortcuts](http://www.informit.com/shortcuts) for a complete list of Short Cuts.



**SAMS**

**Cisco Press**

**IBM  
Press™**

**que®**

# Bridging and LAN Switching

## Spanning Tree Protocol

### 802.1D

802.1D Spanning Tree Protocol (STP) is a Layer 2 loop-prevention mechanism. It is an IEEE standards-based protocol. Over the years, Cisco has enhanced this protocol with new features to make much-needed improvements. This chapter discusses those improvements and new IEEE versions of the protocol that dramatically improve the technology. Layer 2 loops are terrible because of no Time To Live (TTL) value in frame. Loops can cause broadcast storms, MAC table corruption, and multiple-frame copies.

#### STP process

The bridge ID is a critical element for the creation of the spanning-tree, loop-free topology. The bridge ID consists of a 2-byte bridge priority and a 6-byte MAC address. The default priority is 32,768. Newer switch operating systems feature a third component for the bridge ID: the extended system ID. This value is just the VLAN ID. Use of the three-part bridge ID allows each VLAN to have a unique bridge ID

while still using the same MAC address and priority value. Previously, multiple MAC addresses were needed for each VLAN to ensure uniqueness.

Path cost is the measure of distance from one bridge to another. Links are assigned a cost value by STP. This cost value is based on bandwidth. Higher-bandwidth links receive a lower-cost value, and STP deems a lower-cost path as preferred to a higher-cost path.

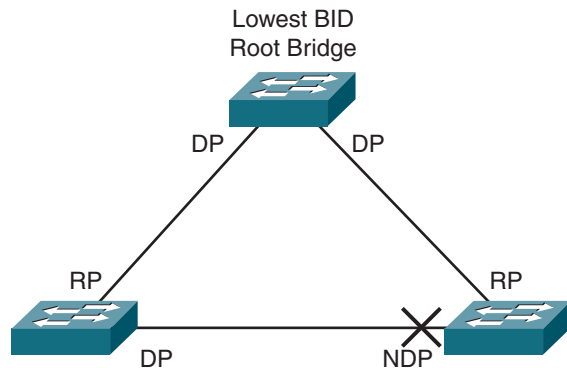
Initially with STP operations, a root bridge must be selected. This root bridge will have all of its ports in the forwarding state (designated ports) and will be the central reference point for the creation of a loop-free Layer 2 topology. For the “election” of this device, configuration bridge protocol data units (BPDU) are sent between switches for each port. Switches use a four-step process to save a copy of the “best” BPDU seen on every port. When a port receives a better BPDU, it stops sending them. If the BPDUs stop arriving for 20 seconds (the default), the port begins sending them again. The process for selecting the best BPDU is as follows:

1. Lowest root bridge ID (RID)
2. Lowest path cost to root bridge
3. Lowest sender BID
4. Lowest port ID (for example, Fa0/10 versus Fa0/20)

After the root bridge for the network has been determined, this reference point can be used to create the loop-free topology. This initial creation of the loop-free topology takes place in three steps:

- Step 1.** Elect a root bridge. The lowest BID wins.
- Step 2.** Elect root ports. Every nonroot bridge selects one root port.
- Step 3.** Elect designated ports. Each segment has one designated port (the bridge with the designated port is the designated bridge for that segment); all active ports on the root bridge are designated (unless you connect two ports to each other).

When convergence occurs, BPDUs radiate out from the root bridge over loop-free paths. Figure 2-1 shows an example of STP in action.



**FIGURE 2-1** Spanning-tree topology

Ports have a port state under 802.1D STP. Ports begin life on the switch as disabled and gradually transition to a forwarding state as long as STP deems it is safe to do so. The possible states are listed here along

with the timers that control the transition times. Note that the states are carefully ordered here to demonstrate the order of transition:

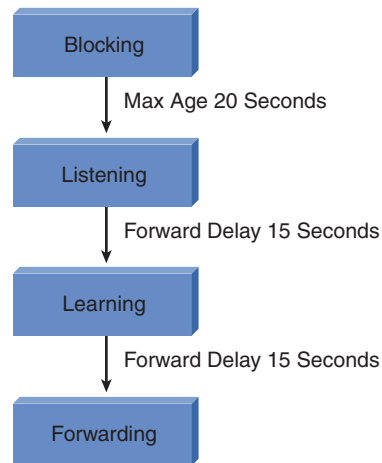
1. Disabled—Administratively down
2. Blocking—BPDUs received only (20 sec)
3. Listening—BPDUs sent and received (15 sec)
4. Learning—Bridging table is built (15 sec)
5. Forwarding—Sending/receiving data

STP timers are used in the process to control convergence:

- **Hello**—2 sec (time between each configuration BPDU)
- **Forward Delay**—15 sec (controls durations of listening/learning states)
- **Max Age**—20 sec (controls the duration of the blocking state)

Default convergence time is 30 to 50 seconds. Timer modification is possible from the root bridge. See Figure 2-2.

Although the timers can be manipulated, Cisco does not recommend this. Instead, there are Cisco mechanisms that can be used to improve convergence times without direct manipulation of the timers by the administrator. Convergence time is a recognized issue with STP and the exact reason for IEEE's creation of new versions of the protocol.



**FIGURE 2-2** 802.1D timers

## Topology changes

STP uses a Topology Change Notification (TCN) BPDU to alert the root bridge that a topology change to the spanning tree might need to occur. The Type field of the BPDU signifies the TCN BPDU: 0x80. TCN BPDUs improve convergence time when failures in the network occur—primarily because they help in a rapid updating of the MAC address tables.

The TCN process of 802.1D is as follows:

1. A bridge sends a TCN BPDU in two cases:
  - a. It takes a port into forwarding, and it has at least one designated port (DP).

b. A port goes from Forwarding/Learning to Blocking.

TCNs are sent out the root port of nonroot devices; they are sent each hello interval until they are acknowledged by the upstream device.

2. Upstream bridges process TCN on DPs.
3. The upstream switch sets the Topology Change Acknowledgement (TCA) field of the next configuration BPDU received and sends this downstream. This causes the downstream switch to stop sending TCN BPDUs.
4. The upstream switch then sends the TCN further upstream.
5. This continues until the root bridge receives the TCN.
6. The root bridge then sets the TCA and Topology Change flags in the next configuration BPDU sent out downstream.
7. The root bridge sets the TC flag in all BPDUs sent for Forward Delay + Max Age. This instructs all switches to age MAC table address entries faster.

## Root bridge placement

You should set the root bridge location in your network using the appropriate Cisco IOS command.

**NOTE**

The CCIE written exam focuses on the Cisco IOS-based command set. As a result, no CatOS commands are shown in any of the Quick Reference Sheets.

You should also select a secondary root in the event the primary root fails.

**spanning-tree vlan *vlan\_ID* priority *priority\_value*** allows you to modify the priority value and directly manipulate the root election. For example, **spanning-tree vlan 100 priority 4096** sets the priority to 4096 for VLAN 100 on the local switch. If all switches are at the default priority value of 32,768, the bridge becomes the root. You can use the priority value of 8192 in this case on another switch to elect it as the secondary root bridge.

The command **spanning-tree vlan *vlan\_ID* root primary** is actually a macro command that examines the priority of the existing root and sets the priority on the local switch to be 1 less. If the default is used on the root, the priority is set to 8192. To create a secondary root, you can use the following command:

**spanning-tree vlan *vlan\_ID* root secondary**

This command sets the priority value to 16,384.

Remember, in a Cisco environment, by default all spanning-tree mechanisms occur on a VLAN-by-VLAN basis. This is called Per-VLAN Spanning Tree (PVST+).

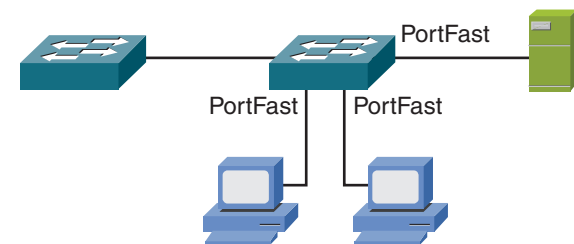
## Fast STP convergence with Cisco-proprietary enhancements to 802.1D

### PortFast

PortFast, shown in Figure 2-3, is a Cisco-proprietary enhancement to the 802.1D STP implementation. You apply the command to specific ports, and that application has two effects:

- Ports coming up are put directly into the forwarding STP mode.
- The switch does not generate a TCN when a port configured for PortFast is going up or down—for example, when a workstation power-cycles.

Therefore, consider enabling PortFast on ports that are connected to end-user workstations. Caution must be used with PortFast ports to ensure that hubs, switches, bridges, or any other device that could cause a loop are not connected to these ports.



**FIGURE 2-3** PortFast

## UplinkFast

Configure UplinkFast on wiring closet switches. It detects a directly connected failure and allows a new root port to come up almost immediately.

When you are configuring UplinkFast, the local switch has a priority set to 49,152, and it adds 3000 to the cost of all links. Finally, a mechanism is included that causes the manipulation of MAC address tables for other bridges.

## BackboneFast

Configure BackboneFast on all switches. It speeds convergence when the failure occurs and is indirectly located, such as in the core of the backbone. It reduces convergence from about 50 seconds to about 30 seconds.

## 802.1w Rapid Spanning Tree Protocol

Rapid Spanning Tree Protocol (RSTP or IEEE 802.1w) improves on 802.1D. The protocol incorporates many new features to speed convergence, including incorporation of the ideas presented by Cisco in its enhancements to 802.1D. Although there are many, many improvements with the new technology, the configuration remains almost identical—and the two technologies can coexist. Full benefits are not realized until all systems are running RSTP, however.

RSTP requires full-duplex, point-to-point connections between adjacent switches to achieve fast convergence.

RSTP defines edge ports as those not participating in STP. Edge ports can be statically configured or will be recognized by the PortFast configuration command.

## RSTP port states

RSTP port states are simplified from 802.1D and consist of the following:

- Discarding
- Learning
- Forwarding

Also, the port states are no longer tied directly to port roles. For example, a DP could be Discarding, even though it is destined to transition to the Forwarding state.

## RSTP port roles

- **Root port**—This port role exists in 802.1D, too, and is the “best” path back to the root bridge; it must exist on all nonroot bridges.
- **Designated port**—This port role exists in 802.1D, too, and there must be a DP on all segments in the topology. By default, all ports on the root bridge are DPs.
- **Alternative port**—This port role is new to 802.1w. This port is a quickly converging backup port to the current DP on a segment.
- **Backup port**—This port role is new to 802.1w. This port is a quickly converging backup to the root port for a system.