Chapter 3: STP

Scaling Networks

Cisco | Networking Academy®
Mind Wide Open™

Chapter 3- Sections & Objectives

- 3.1 Spanning Tree Concepts

  Examine the purpose of STP and how the spanning tree algorithm is used create a loop-free topology.

- 3.2 Varieties of Spanning Tree Protocols

  Examine the varieties of Spanning Tree protocols including PVST+ and Rapid PVST+.

- 3.3 Spanning Tree Configuration

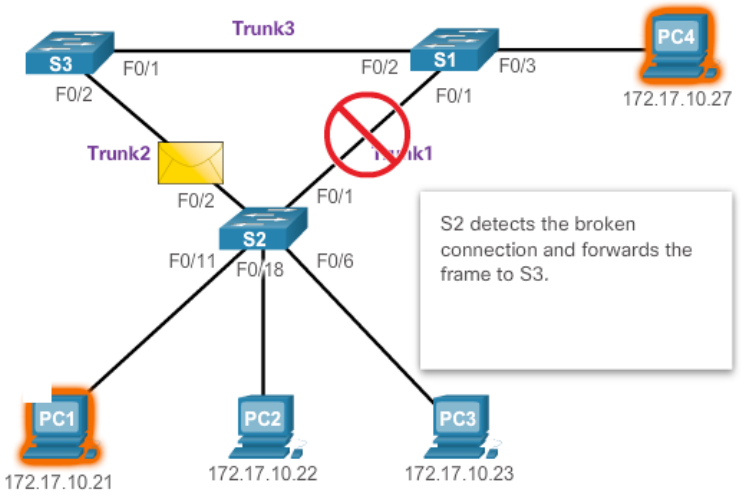
  Configure PVST+ and Rapid PVST+ to improve network performance.

3.1 Spanning Tree Concepts

Cisco | Networking Academy®
Mind Wide Open™

Spanning Tree Concepts
Purpose of Spanning Tree

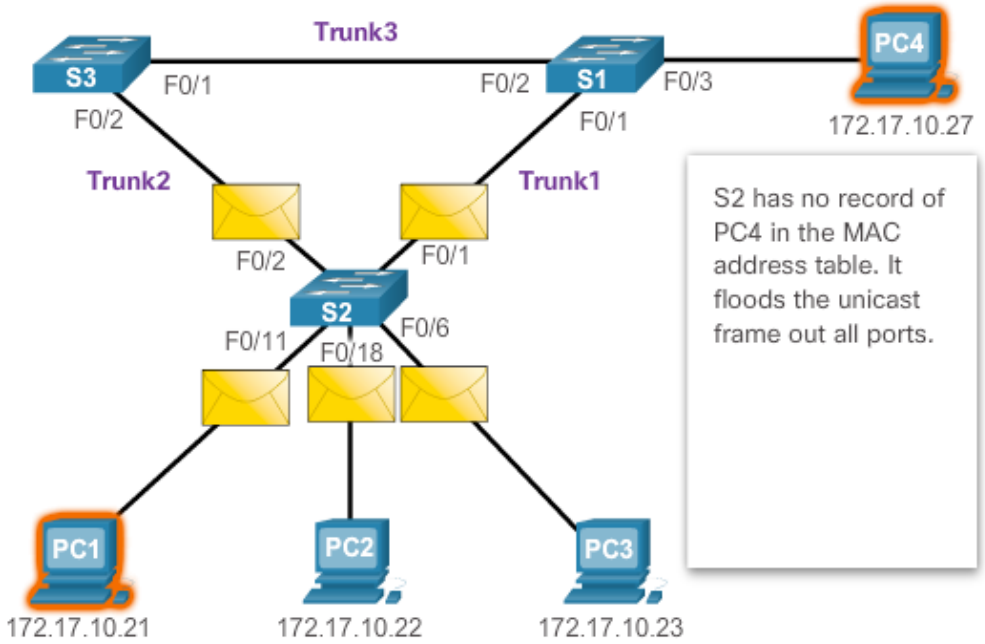
- Redundancy at OSI Layers 1 and 2
- When multiple paths exist between two devices on a network, and there is no spanning tree implementation on the switches, a Layer 2 loop occurs.



  - Issues with Layer 1 Redundancy: MAC Database Instability
  - Ethernet has no mechanism enabled to block continued propagation of these frames on a switched network that continue to propagate between switches. (Not like packet TTL – time to live)
  - Issues with Layer 1 Redundancy: Broadcast Storms
    - A broadcast storm occurs when there are so many broadcast frames caught in a Layer 2 loop that all available bandwidth is consumed. Usually network stops/restarts.

Spanning Tree Concepts
Purpose of Spanning Tree

- Issues with Layer 1 Redundancy: Duplicate Unicast Frames
  - An unknown unicast frame is when the switch does not have the destination MAC address in its MAC address table and must forward the frame out all ports, except the ingress port.
  - Unknown unicast frames sent onto a looped network can result in duplicate frames arriving at the destination device.



Spanning Tree Concepts
STP Operation

- Spanning Tree Algorithm: Introduction
- STP ensures that there is only one logical path between all destinations on the network by intentionally blocking redundant paths that could cause a loop.
- Spanning Tree Algorithm: Port Roles
- Root ports - Ports closest to the root bridge.
- Designated ports - Non-root ports permitted to forward traffic.
- Alternate and backup ports - Blocking state to prevent loops.
- Disabled ports - A disabled port is a switch port that is shut down.
- Spanning Tree Algorithm: Root Bridge (root switch)
- The root bridge serves as a reference point for all STP calculations.
- The switch with the lowest BID (Bridge ID) will become the root bridge

Spanning Tree Concepts
STP Operation

- Spanning Tree Algorithm: considers Root Path Cost
- Default port costs are defined by the speed at which the port operates

Link Speed	Cost (Revised IEEE Specification)
10 Gb/s	2
1 Gb/s	4
100 Mb/s	19
10 Mb/s	100

- Internal root path cost is determined by summing up the individual port costs along the path from the switch to the root bridge.
- Use the spanning-tree cost value interface configuration command on both ends of a link to apply a custom cost.
- Use the show spanning-tree command to verify the port and internal root path cost to the root bridge.

Spanning Tree Concepts
STP Operation

- Port Role Decisions for RSTP (faster implementation of STP)
- Root bridge automatically configures all of its switch ports in the designated role.
- Designated ports are configured for all LAN segments.
- Designated and Alternate Ports
- The switch with the **lower cost path to the root bridge** (root path cost) **will have its port selected as the designated port.**
- The alternate port will not send or receive traffic on that segment.

Spanning Tree Concepts
STP Operation

- 802.1D BPDU Frame Format
- The spanning tree algorithm depends on the exchange of BPDUs.
- The BPDU frame information is included in the Data portion of an Ethernet frame and identifies the following fields:

Field Number	Bytes	Field
1-4	2	Protocol ID
	1	Version
	1	Message Type
	1	Flags
5-8	8	Root ID
	4	Root Path Cost
	8	Bridge ID
	2	Port ID
9-12	2	Message Age
	2	Max Age
	2	Hello Time
	2	Forward Delay

Spanning Tree Concepts
STP Operation

- 802.1D BPDU Propagation and Process
- By default, BPDU frames are sent every two seconds.
- Each switch maintains local information about its own BID, the root ID, and the root path cost in its own database.
- Extended System ID
- The bridge ID (BID) is used to determine the root bridge on a network. The BID field of a BPDU frame contains three separate fields:
- Bridge priority – Default 32768
- Extended system ID - Identifies the VLAN participating in STP
- MAC address - When the bridge priorities are equal, the MAC address is the deciding factor as to which switch is going to become the root bridge (the MAC with the lowest value)

3.2 Varieties of Spanning Tree Protocols

Cisco | Networking Academy®
Mind Wide Open™

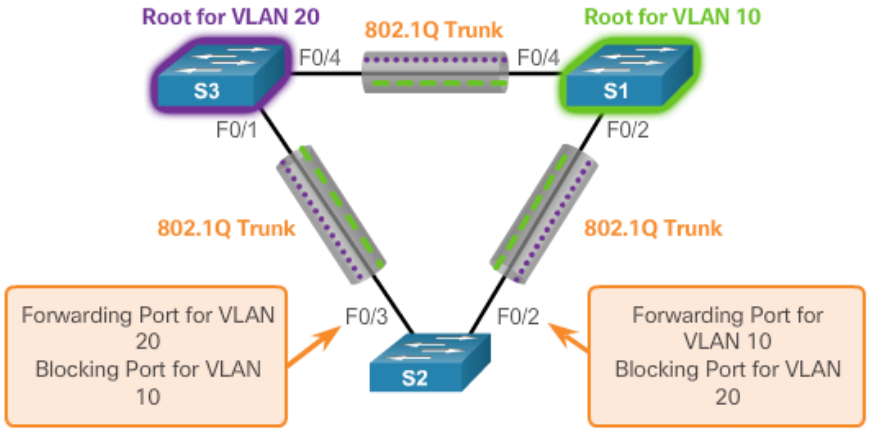
Varieties of Spanning Tree Protocols Overview

- Types of Spanning Tree Protocols
- Several varieties of spanning tree protocols have emerged since the original IEEE 802.1D.
- Characteristics of the Spanning Tree Protocols

Protocol	Standard	Resources Needed	Convergence	Tree Calculation
STP	802.1D	Low	Slow	All VLANs
PVST+	Cisco	High	Slow	Per VLAN
RSTP	802.1w	Medium	Fast	All VLANs
Rapid PVST+	Cisco	Very high	Fast	Per VLAN
MSTP	802.1s, Cisco	Medium or high	Fast	Per Instance

Varieties of Spanning Tree Protocols
PVST+

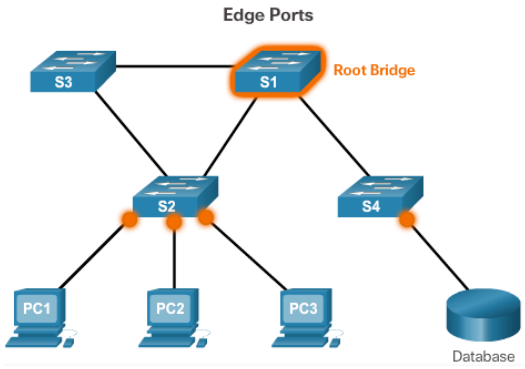
- Overview of PVST+
- Cisco developed PVST+ to run an independent instance of the Cisco implementation of IEEE 802.1D for each VLAN in the network.
- Port States and PVST+ Operation
- STP and PVST+ use five port states consisting of Blocking, Listening, Learning, Forwarding, and Disabled.
- Extended System ID and PVST
  - Extended system ID ensures switches have unique BIDs for each VLAN.
  - To manipulate the root-bridge election, assign a lower priority to the desired root bridge switch for the VLAN(s).



Varieties of Spanning Tree Protocols
Rapid PVST+

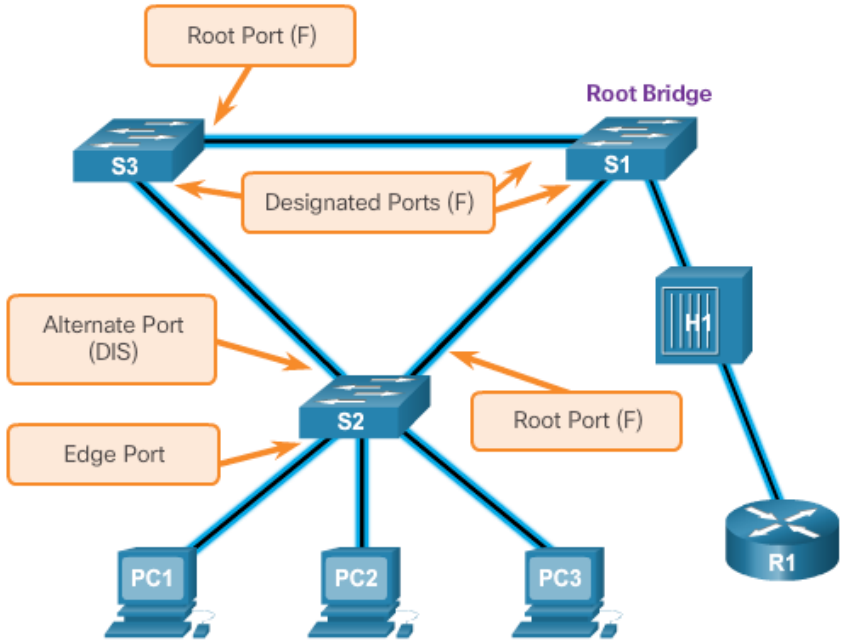
- Overview of Rapid PVST+
  - Rapid PVST+ is the Cisco implementation of per-VLAN RSTP.
  - RSTP can achieve much faster convergence.
  - RSTP BPDU
    - RSTP uses type 2, version 2 BPDUs and populates the flag byte in a slightly different manner than in the original 802.1D.

- Edge Ports
  - RSTP edge port is a switch port that is never intended to be connected to another switch.
  - It immediately transitions to the forwarding state when enabled.



Varieties of Spanning Tree Protocols
Rapid PVST+

- Link Types
- Point-to-Point - A port operating in full-duplex mode typically connects a switch to a switch and is a candidate for a rapid transition to a forwarding state.
- Shared - A port operating in half-duplex mode connects a switch to a legacy hub that attach
  - RSTP must determine the port role:
  - Root ports and Alternate (backup) ports do not use the link-type parameter in most cases.
  - Designated ports make the most use of the link-type parameter and transition to the forwarding state if the link-type parameter is set to point-to-point.

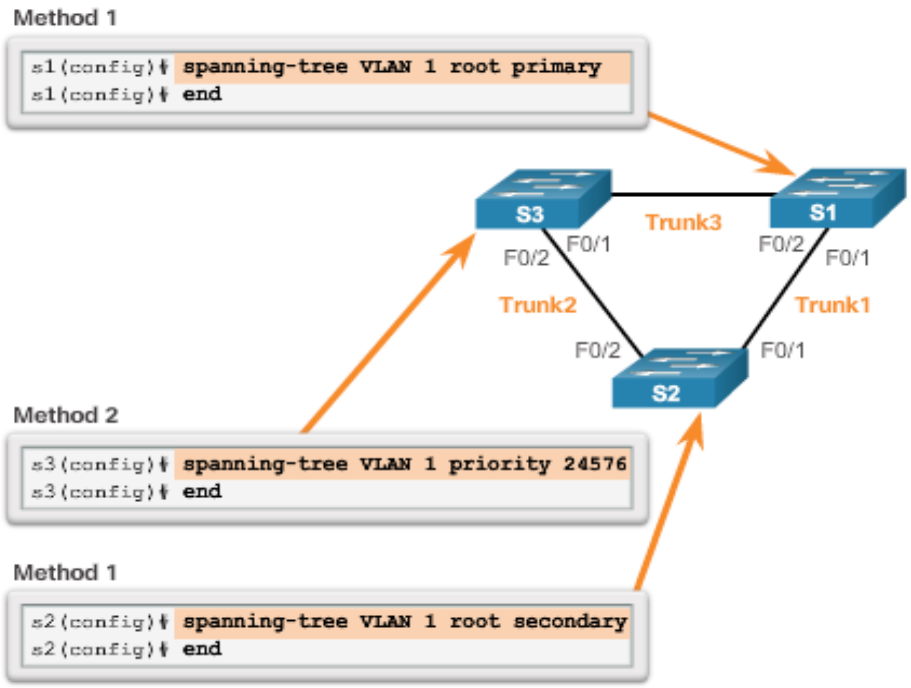


3.3 Spanning Tree Configuration

Cisco | Networking Academy®
Mind Wide Open™

Spanning Tree Configuration
PVST+ Configuration

- Catalyst 2960 Default Configuration
- Default spanning tree mode is PVST+ (Per VLAN Spanning Tree)
- Configuring and Verifying the Bridge ID
  - **Method 1:**
  - **Use the spanning-tree vlan vlan-id root primary global config command.**
  - **Method 2: (most common)**
  - **Use the spanning-tree vlan vlan-id priority value global config command.**
  - **Use the show spanning-tree command to verify the bridge priority of a switch.**



Spanning Tree Configuration
PVST+ Configuration

- PortFast and BPDU Guard (
- PortFast immediately transitions an access port from blocking to forwarding state while BPDU guard puts an access port in an errdisabled (error-disabled) state if it receives a BPDU.
- Use the spanning-tree portfast interface configuration mode command to enable PortFast on a switch port.
- Use the spanning-tree bpduguard enable interface configuration mode command to enable BPDU guard on a Layer 2 access port.

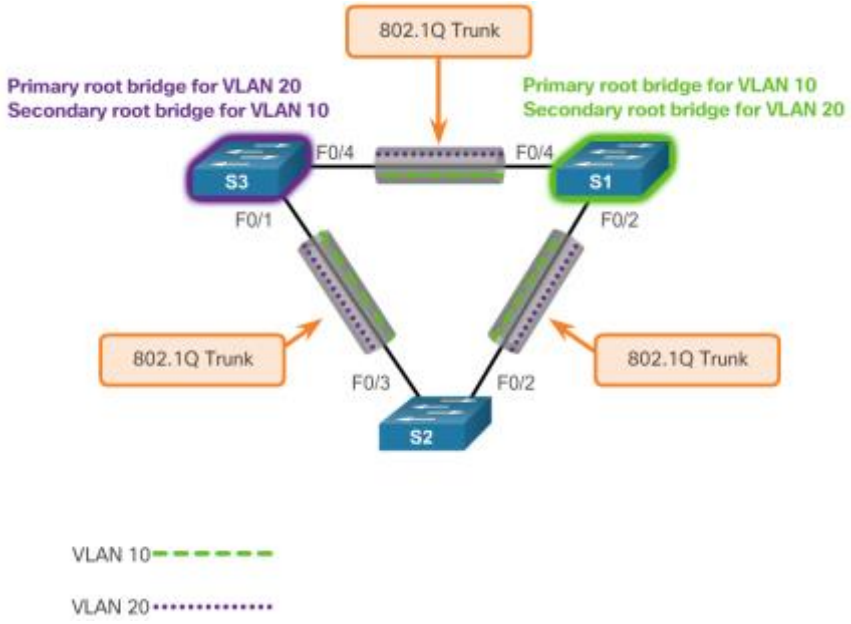
```
S2(config)# interface FastEthernet 0/11
S2(config-if)# spanning-tree portfast
%Warning: portfast should only be enabled on ports connected to
a single host. Connecting hubs, concentrators, switches,
bridges, etc... to this interface  when portfast is enabled,
can cause temporary bridging loops.
 Use with CAUTION

%Portfast has been configured on FastEthernet0/11 but will only
 have effect when the interface is in a non-trunking mode.
S2(config-if)# spanning-tree bpduguard enable
S2(config-if)# end
```

Spanning Tree Configuration
PVST+ Configuration

- PVST+ Load Balancing
- The strategy is to configure two or more root bridges for different sets of VLANs and make use of redundant links.

```
S3(config)# spanning-tree vlan 20 root primary
S3(config)# spanning-tree vlan 10 root secondary
S3(config)#
```

```
S1(config)# spanning-tree vlan 10 root primary
S1(config)# spanning-tree vlan 20 root secondary
S1(config)#
```



Spanning Tree Configuration
Rapid PVST+ Configuration

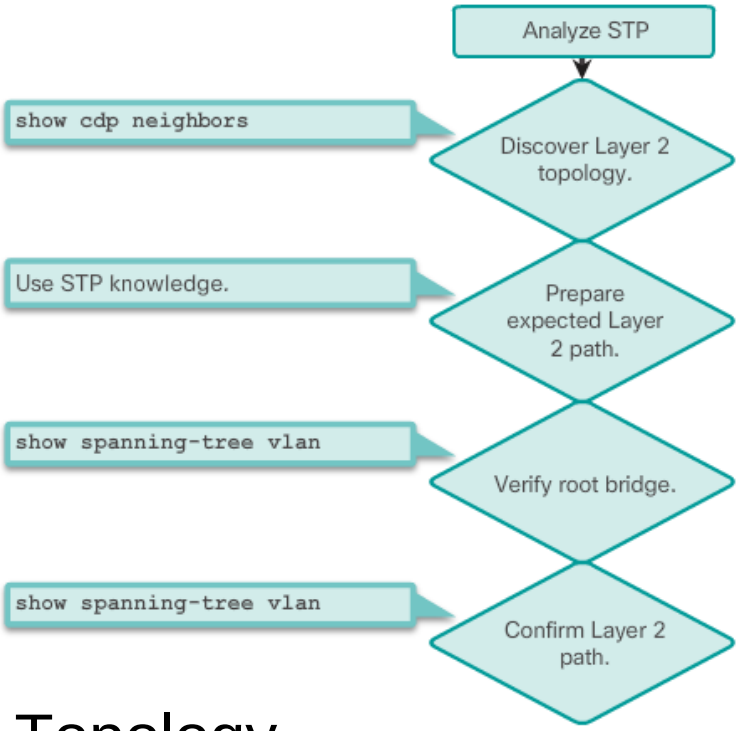
- Spanning Tree Mode
  - Rapid PVST+ is the Cisco implementation of RSTP.
    - PVST+ supports RSTP on a per-VLAN basis.

```
S1# configure terminal
S1(config)# spanning-tree mode rapid-pvst
S1(config)# interface f0/2
S1(config-if)# spanning-tree link-type point-to-point
S1(config-if)# end
S1# clear spanning-tree detected-protocols
```

```
S1# show spanning-tree vlan 10

VLAN0010
  Spanning tree enabled protocol rstp
  Root ID     Priority    4106
              Address     0019.aa9e.b000
              This bridge is the root
              Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec
```

Spanning Tree Configuration
STP Configuration Issues

- Analyzing the STP Topology
  - Use show cdp neighbors to discover topology
  - Use STP knowledge to determine the root switch
  - Use show spanning-tree vlan to verify which switch is the root and port status (forwarding or blocking).



- Expected Topology versus Actual Topology
  - Troubleshooting consists of comparing the actual state of the network against the expected state of the network and spotting the differences.

Spanning Tree Configuration
Switch Stacking Concepts

- Switch Stacking Concepts
  - A switch stack can consist of up to nine Catalyst 3750 switches connected through their StackWise ports.
  - One of the switches controls the operation of the stack and is called the stack master.
- The switch is managed as a single switch, through a single IP address, including passwords, VLANs, and interfaces.
- Spanning Tree and Switch Stacks
  - Another benefit to switch stacking is the ability to add more access ports to a single STP instance without increasing the STP diameter.
  - The IEEE recommends a maximum diameter of seven switches for the default STP timers.

3.3 Chapter Summary

Cisco | Networking Academy®
Mind Wide Open™

Chapter Summary
Summary

- Problems that can result from a redundant Layer 2 network include broadcast storms, MAC database instability, and duplicate unicast frames. STP is a Layer 2 protocol that ensures that there is only one logical path between all destinations on the network by intentionally blocking redundant paths that could cause a loop.
- STP sends BPDU frames for communication between switches. One switch is elected as the root bridge for each instance of spanning tree. An administrator can control this election by changing the bridge priority. Root bridges can be configured to enable spanning tree load balancing by VLAN or by a group of VLANs, depending on the spanning tree protocol used. STP then assigns a port role to each participating port using a path cost. The root path cost is equal to the sum of all the port costs along the path to the root bridge. A port cost is automatically assigned to each port; however, it can also be manually configured. Paths with the lowest cost become preferred, and all other redundant paths are blocked.
- PVST+ is the default configuration of IEEE 802.1D on Cisco switches. It runs one instance of STP for each VLAN. A newer, faster-converging spanning tree protocol, RSTP, can be implemented on Cisco switches on a per-VLAN basis in the form of Rapid PVST+. Multiple Spanning Tree (MST) is the Cisco implementation of Multiple Spanning Tree Protocol (MSTP), where one instance of spanning tree runs for a defined group of VLANs. Features such as PortFast and BPDU guard ensure that hosts in the switched environment are provided immediate access to the network without interfering with spanning tree operation.
- Switch stacking allows connection of up to nine Catalyst 3750 switches to be configured and presented to the network as a single entity. STP views the switch stack as a single switch. This additional benefit helps ensure the IEEE recommended maximum diameter of seven switches.