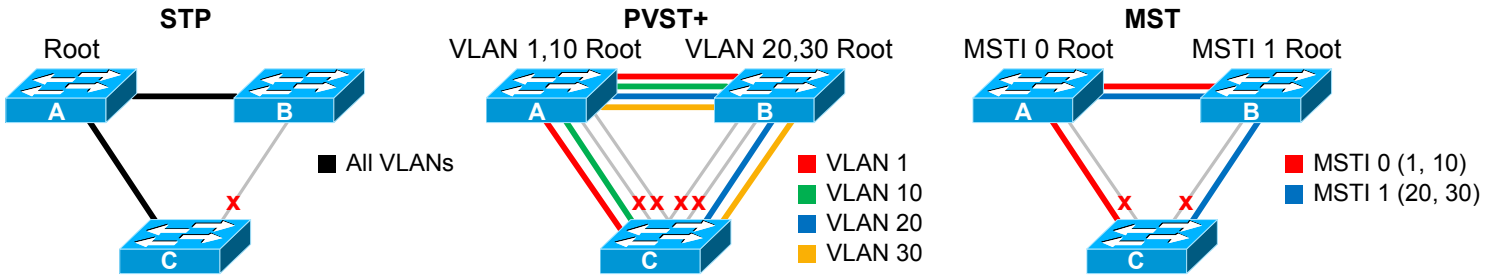


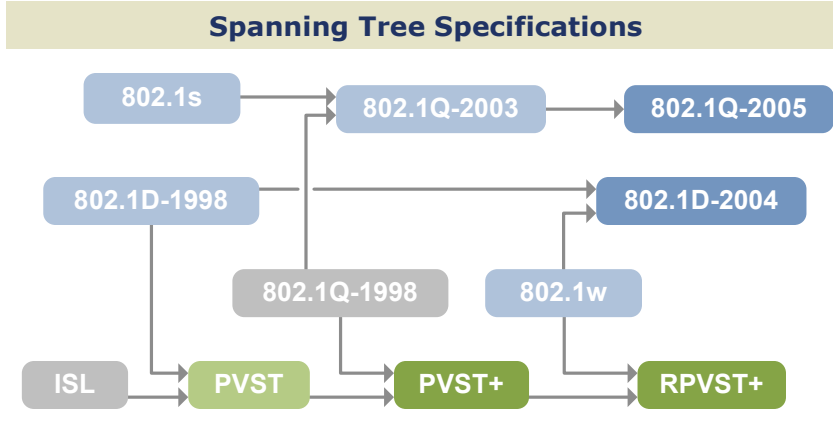
Spanning Tree Protocols

	Legacy STP	PVST	PVST+	RSTP	RPVST+	MST
Algorithm	Legacy ST	Legacy ST	Legacy ST	Rapid ST	Rapid ST	Rapid ST
Defined By	802.1D-1998	Cisco	Cisco	802.1w, 802.1D-2004	Cisco	802.1s, 802.1Q-2003
Instances	1	Per VLAN	Per VLAN	1	Per VLAN	Configurable
Trunking	N/A	ISL	802.1Q, ISL	N/A	802.1Q, ISL	802.1Q, ISL

Spanning Tree Instance Comparison



BPDU Format	
Field	Bits
Protocol ID	16
Version	8
BPDU Type	8
Flags	8
Root ID	64
Root Path Cost	32
Bridge ID	64
Port ID	16
Message Age	16
Max Age	16
Hello Time	16
Forward Delay	16



Link Costs	
Bandwidth	Cost
4 Mbps	250
10 Mbps	100
16 Mbps	62
45 Mbps	39
100 Mbps	19
155 Mbps	14
622 Mbps	6
1 Gbps	4
10 Gbps	2
20+ Gbps	1

IEEE	Specification
IEEE 802.1D-1998	· Deprecated legacy STP standard
IEEE 802.1w	· Introduced RSTP
IEEE 802.1D-2004	· Replaced legacy STP with RSTP
IEEE 802.1s	· Introduced MST
IEEE 802.1Q-2003	· Added MST to 802.1Q
IEEE 802.1Q-2005	· Most recent 802.1Q revision
Cisco PVST	· Per-VLAN implementation of legacy STP
Cisco PVST+	· Added 802.1Q trunking to PVST
Cisco RPVST+	· Per-VLAN implementation of RSTP

Default Timers	
Hello	2s
Forward Delay	15s
Max Age	20s

Port States	
Legacy ST	Rapid ST
Disabled	Discarding
Blocking	Listening
Listening	Learning
Learning	Forwarding
Forwarding	Forwarding

Spanning Tree Operation

- Determine root bridge**
The bridge advertising the lowest bridge ID becomes the root bridge
- Select root port**
Each bridge selects its primary port facing the root
- Select designated ports**
One designated port is selected per segment
- Block ports with loops**
All non-root and non-designated ports are blocked

Port Roles	
Legacy ST	Rapid ST
Root	Root
Designated	Designated
Blocking	Alternate Backup

PVST+ and RPVST+ Configuration

```
spanning-tree mode {pvst | rapid-pvst}

! Bridge priority
spanning-tree vlan 1-4094 priority 32768

! Timers, in seconds
spanning-tree vlan 1-4094 hello-time 2
spanning-tree vlan 1-4094 forward-time 15
spanning-tree vlan 1-4094 max-age 20

! PVST+ Enhancements
spanning-tree backbonefast
spanning-tree uplinkfast

! Interface attributes
interface FastEthernet0/1
  spanning-tree [vlan 1-4094] port-priority 128
  spanning-tree [vlan 1-4094] cost 19

! Manual link type specification
spanning-tree link-type {point-to-point | shared}

! Enables PortFast if running PVST+, or
! designates an edge port under RPVST+
spanning-tree portfast

! Spanning tree protection
spanning-tree guard {loop | root | none}

! Per-interface toggling
spanning-tree bpduguard enable
spanning-tree bpdufilter enable
```

MST Configuration

```
spanning-tree mode mst

! MST Configuration
spanning-tree mst configuration
  name MyTree
  revision 1

! Map VLANs to instances
instance 1 vlan 20, 30
instance 2 vlan 40, 50

! Bridge priority (per instance)
spanning-tree mst 1 priority 32768

! Timers, in seconds
spanning-tree mst hello-time 2
spanning-tree mst forward-time 15
spanning-tree mst max-age 20

! Maximum hops for BPDUs
spanning-tree mst max-hops 20

! Interface attributes
interface FastEthernet0/1
  spanning-tree mst 1 port-priority 128
  spanning-tree mst 1 cost 19
```

Bridge ID Format

4	12	48
Pri	Sys ID Ext	MAC Address

Priority

4-bit bridge priority (configurable from 0 to 61440 in increments of 4096)

System ID Extension

12-bit value taken from VLAN number (IEEE 802.1t)

MAC Address

48-bit unique identifier

Path Selection

- 1 Bridge with lowest root ID becomes the root
- 2 Prefer the neighbor with the lowest cost to root
- 3 Prefer the neighbor with the lowest bridge ID
- 4 Prefer the lowest sender port ID

Optional PVST+ Enhancements

PortFast

Enables immediate transition into the forwarding state (designates edge ports under MST)

UplinkFast

Enables switches to maintain backup paths to root

BackboneFast

Enables immediate expiration of the Max Age timer in the event of an indirect link failure

Spanning Tree Protection

Root Guard

Prevents a port from becoming the root port

BPDU Guard

Error-disables a port if a BPDU is received

Loop Guard

Prevents a blocked port from transitioning to listening after the Max Age timer has expired

BPDU Filter

Blocks BPDUs on an interface (disables STP)

RSTP Link Types

Point-to-Point

Connects to exactly one other bridge (full duplex)

Shared

Potentially connects to multiple bridges (half duplex)

Edge

Connects to a single host; designated by PortFast

Troubleshooting

```
show spanning-tree [summary | detail | root]
show spanning-tree [interface | vlan]
show spanning-tree mst [...]
```