Spanning Tree and Rapid Spanning Tree Protocol

Cisco Guide for Beginners

This is a generic cheat sheet and not for a specific use case.

What is Spanning Tree Protocol (STP)?

Spanning Tree Protocol (STP) is a network protocol that prevents loops in Layer 2 switched networks. When you have multiple paths between switches (for redundancy), STP automatically blocks some paths to prevent broadcast storms and ensure there's only one active path between any two network points.

Why Do We Need STP?

The Problem: Layer 2 Loops

- Switches flood unknown traffic out all ports
- In a loop, traffic circulates endlessly
- Causes broadcast storms and network crashes
- MAC address tables become unstable

The Solution: STP

- Automatically detects loops
- Blocks redundant paths
- Maintains network redundancy
- Activates backup paths when primary fails

How STP Works

STP Process Overview

1. **Elect Root Bridge** - One switch becomes the central reference point
2. **Calculate Path Costs** - Determine best path to root bridge
3. **Select Root Ports** - Choose best port on each switch toward root
4. **Select Designated Ports** - Choose forwarding port for each network segment
5. **Block Redundant Ports** - Put remaining ports in blocking state

STP Port States

State	Duration	Description	Forwards Data	Learns MAC
Disabled	N/A	Port administratively down	No	No
Blocking	20 seconds	Receives BPDUs only	No	No
Listening	15 seconds	Processes BPDUs, no data	No	No
Learning	15 seconds	Builds MAC table	No	Yes
Forwarding	N/A	Normal operation	Yes	Yes

Total Convergence Time: 50 seconds (20 + 15 + 15)

STP Components

Bridge ID

Structure: Priority (2 bytes) + MAC Address (6 bytes)

Default Priority: 32768 (can be modified in increments of 4096)

Example: 32768.0012.3456.789A

Root Bridge Election

- Switch with **lowest Bridge ID** becomes Root Bridge
- **Priority compared first**, then MAC address
- Root Bridge is reference point for all path calculations

Port Costs

Default costs based on interface bandwidth:

Interface Speed	STP Cost	RSTP Cost
10 Mbps	100	2,000,000
100 Mbps	19	200,000
1 Gbps	4	20,000
10 Gbps	2	2,000

BPDU (Bridge Protocol Data Unit)

Configuration BPDU contains:

- Root Bridge ID
- Sender's Bridge ID
- Root Path Cost
- Port ID

- Message Age, Max Age, Hello Time

Default Timers:

- **Hello Time:** 2 seconds
- **Forward Delay:** 15 seconds
- **Max Age:** 20 seconds

STP Port Types

Root Port

- **One per switch** (except Root Bridge)
- Port with **lowest cost path** to Root Bridge
- Always in **Forwarding** state

Designated Port

- **One per network segment**
- Port that **forwards traffic** for that segment
- Located on switch **closest to Root Bridge**

Blocked Port

- **Redundant ports** blocked to prevent loops
- Receives BPDUs but doesn't forward data
- **Backup path** activated if primary fails

Rapid Spanning Tree Protocol (RSTP)

What is RSTP?

IEEE 802.1w - Enhanced version of STP providing:

- **Faster convergence** (seconds instead of 50 seconds)
- **Backward compatibility** with classic STP
- **Improved port roles** and states
- **Better handling** of topology changes

RSTP Improvements

- **Proposal/Agreement mechanism** for fast convergence
- **Edge ports** for end devices (immediate forwarding)

- **Point-to-point** link detection
- **Alternative and backup port roles**

RSTP Port States

RSTP Port States (Simplified)

RSTP State	STP Equivalent	Description
Discarding	Blocking/Listening	Not forwarding, learning, or relaying
Learning	Learning	Building MAC table, not forwarding
Forwarding	Forwarding	Normal operation

No more Listening state in RSTP

RSTP Port Roles

Root Port

- Same as STP
- Best path to Root Bridge

Designated Port

- Same as STP
- Forwards traffic for network segment

Alternative Port

- **Backup path to Root Bridge**
- Different switch than current Root Port
- Quickly becomes Root Port if needed

Backup Port

- **Backup Designated Port**
- Same switch, different port
- Less common in modern networks

Edge Port

- **Connected to end devices**
- Immediately transitions to Forwarding
- Equivalent to PortFast in Cisco

RSTP Convergence

Fast Convergence Mechanisms

Proposal/Agreement

1. **New switch connects** to network
2. **Sends Proposal** on all ports
3. **Designated switch responds** with Agreement
4. **Immediate transition** to Forwarding (no timers)

Edge Port Recognition

- **Automatically detects** end device connections
- **Immediate Forwarding** state
- **No BPDU exchange** expected

Point-to-Point Links

- **Full-duplex links** between switches
- **Enables fast convergence** mechanisms
- **Auto-detected** or manually configured

Cisco STP Variants

Per-VLAN Spanning Tree (PVST+)

- **Cisco proprietary**
- **Separate STP instance** per VLAN
- Allows **per-VLAN root bridges**
- **Load balancing** across VLANs possible

Rapid Per-VLAN Spanning Tree (RPVST+)

- **Cisco implementation** of RSTP
- **Per-VLAN rapid convergence**
- **Default on modern Cisco switches**
- **Backward compatible** with PVST+

Multiple Spanning Tree (MST)

- **IEEE 802.1s standard**

- **Maps multiple VLANs** to single instance
- **Reduces BPDU overhead**
- **Complex configuration**

Basic Cisco STP Configuration

View STP Status

```
Switch# show spanning-tree
Switch# show spanning-tree brief
Switch# show spanning-tree vlan 1
```

Configure Root Bridge

```
Switch(config)# spanning-tree vlan 1 root primary
Switch(config)# spanning-tree vlan 1 root secondary
```

Manual Priority Configuration

```
Switch(config)# spanning-tree vlan 1 priority 4096
```

Configure Port Cost

```
Switch(config)# interface gigabit0/1
Switch(config-if)# spanning-tree cost 10
```

Enable PortFast (Edge Port)

```
Switch(config)# interface gigabit0/1
Switch(config-if)# spanning-tree portfast
```

Global PortFast for Access Ports

```
Switch(config)# spanning-tree portfast default
```

Enable RSTP (Rapid Spanning Tree)

```
Switch(config)# spanning-tree mode rapid-pvst
```

Verify RSTP is Enabled

```
Switch# show spanning-tree summary
Switch# show spanning-tree mode
```

STP vs RSTP Comparison

Feature	STP (802.1D)	RSTP (802.1w)
Convergence Time	30-50 seconds	1-6 seconds
Port States	5 states	3 states
Port Roles	3 roles	5 roles
Topology Change	Slow	Fast
Backward Compatibility	N/A	Yes
BPDU Format	Original	Enhanced

Common STP Issues and Solutions

Root Bridge Placement

Problem: Root Bridge in wrong location **Solution:**

- Manually configure root bridge in network core
- Use `spanning-tree vlan X root primary`

Convergence Time

Problem: Slow convergence with STP **Solution:**

- Upgrade to RSTP/RPVST+
- Configure PortFast on access ports
- Use UplinkFast/BackboneFast (legacy)

Topology Changes

Problem: Frequent topology change notifications **Solution:**

- Identify source of changes
- Configure PortFast on access ports
- Check for duplex mismatches

Loop Prevention

Problem: Temporary loops during convergence **Solution:**

- Ensure proper STP configuration

- Use BPDU Guard on access ports
- Implement Root Guard on uplinks

STP Best Practices

Design Recommendations

- **Place Root Bridge** in network core/distribution layer
- **Configure backup Root Bridge** for redundancy
- **Use consistent VLAN-to-instance mapping**
- **Document STP topology** and port roles

Port Configuration

- **Enable PortFast** on all access ports
- **Configure BPDU Guard** on access ports
- **Use Root Guard** on distribution uplinks
- **Set appropriate port costs** if needed

Monitoring and Maintenance

- **Regular topology verification** with show commands
- **Monitor for unexpected Root Bridge changes**
- **Check for blocked ports** and verify redundancy
- **Update documentation** after network changes

Verification Commands

Basic STP Information

```
Switch# show spanning-tree summary
Switch# show spanning-tree root
Switch# show spanning-tree bridge
```

Port-Specific Information

```
Switch# show spanning-tree interface gigabit0/1
Switch# show spanning-tree interface gigabit0/1 detail
```

Troubleshooting Commands

```
Switch# show spanning-tree inconsistentports
Switch# show spanning-tree blockedports
Switch# debug spanning-tree events
```

Quick Reference

STP Port States Progression

```
Disabled → Blocking → Listening → Learning → Forwarding
```

RSTP Port States Progression

```
Discarding → Learning → Forwarding
```

Default STP Timers

- **Hello Time:** 2 seconds
- **Forward Delay:** 15 seconds
- **Max Age:** 20 seconds

Root Bridge Selection

1. **Lowest Priority** (default 32768)
2. **Lowest MAC Address** (if priority ties)

Port Role Selection

1. **Lowest Root Path Cost**
2. **Lowest Sender Bridge ID**
3. **Lowest Sender Port ID**

Remember: STP prevents loops but RSTP does it faster! Always configure the Root Bridge manually in the network core and use PortFast on access ports to improve convergence times.
