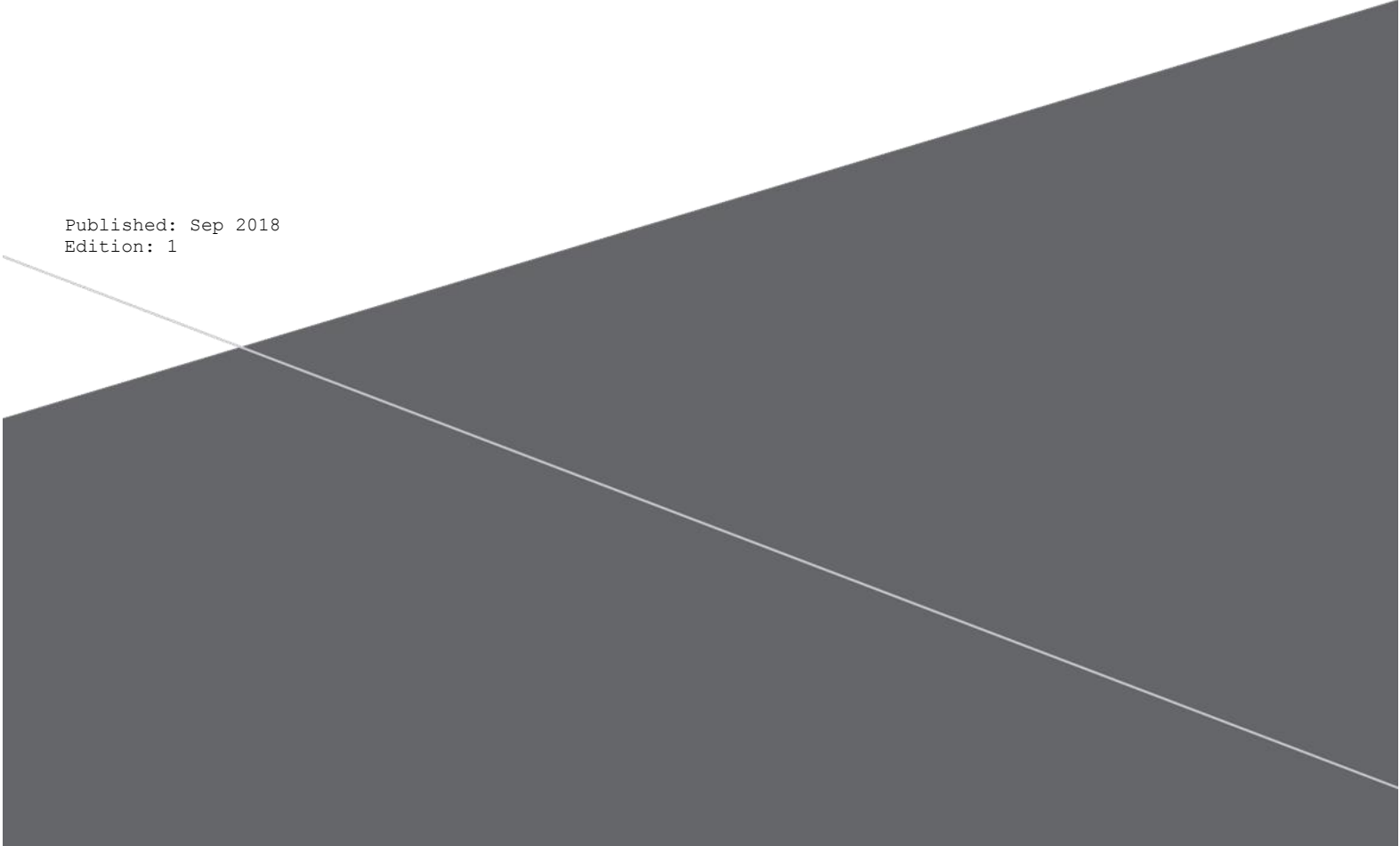


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# Spanning Tree Feature & Interop Guide

Aruba OS & Cisco IOS

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A large, dark gray, abstract geometric shape that resembles a stylized 'A' or a series of overlapping planes, positioned in the lower half of the page. A thin white line runs diagonally across the page, intersecting the gray shape.

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# Spanning Tree Feature and Interop Guide for Aruba OS and Cisco IOS Switches

## Introduction

This document provides instruction on how to configure and validate **Interoperability** between Cisco Switch

## Spanning Tree

These are the various Spanning tree implementations STP, MSTP, RSTP, RapidPVST+. STP and RSTP are IEEE compliant, RapidPVST+ is cisco proprietary and MSTP is advanced improved version of STP. MSTP provides better utilization of alternate paths by enabling the use of alternate spanning-trees of different VLANs or group of VLANs.

Aruba OS switches operates default in MSTP mode [802.1s].

## Spanning tree compatibility modes

Use this CLI to set the spanning tree compatibility mode.

```
spanning-tree force-version [ stp-compatible | rstp-operation | mstp-operation ]
```

This command forces the switch to emulate behavior of earlier versions of spanning tree protocol, or return to MSTP behavior. The command is useful in test or debug applications, and removes the need to reconfigure the switch for temporary changes in spanning tree operation.

### stp-compatible

The switch applies 802.1D STP operation on all ports.

### rstp-operation

The switch applies 802.1w operation on all ports except those ports where it detects a system using 802.1D Spanning Tree. RSTP is Rapid Spanning Tree Protocol.

### mstp-operation

The switch applies 802.1s MSTP operation on all ports where compatibility with 802.1D or 802.1w spanning tree protocols is not required. [Default - Enabled]

### spanning-tree legacy-mode

"spanning-tree legacy-mode" forces spanning tree to operate in legacy (802.1D) mode

## Spanning tree variables

### Hello Time

This is the command to change hello-time globally. Default: 2 seconds.

```
spanning-tree hello-time 1..10
```

To override this global setting on a per-port basis with this command:

```
spanningtree <port-list> hello-time [global | 1 - 10]
```

Default Per-Port setting: Use Global.

### Max Age

Maximum age time for received STP information before it is discarded. Default: 20 seconds

```
spanning-tree maximum age
```

### Switch Priority

The switch with the lowest Bridge Identifier is elected as the root

```
spanning-tree priority <priority-multiplier>
```

Specify a priority multiplier value of 0 - 15, the actual priority assigned to the switch is: (priority-multiplier) x 4096

### Path Cost

If you want to affect how local switch elects the root port, change the cost on the links. The higher cost is the less preferred

```
spanning-tree <port-list> path-cost [auto | 1..200000000]
```

### Port Priority

If you want to affect how downstream switch elects its root port change the priority. This is only local significant between the two directly connected switches. Highest priority is less preferred. Priority multiplier of 0 - 15, the actual priority assigned to the switch is: (priority-multiplier) x 16

```
spanning-tree <port-list> priority <priority-multiplier>
```

### Max Hops

Maximum number of hops before the MSTP BPDU is discarded [default: 20]

```
spanning-tree max-hops
```

### Admin-edge-port or PortFast

During spanning tree establishment, ports with admin-edge-port (Cisco PortFast) enabled transition immediately to the forwarding state. [Default: Disabled]

```
spanning-tree <port-list> admin-edge-port
```

### Auto-edge-port or PortFast

The port looks for BPDUs for the first 3 seconds. If there are none, the port is classified as an edge port [Default: Enabled]

```
spanning-tree <port-list> auto-edge-port
```

### Root Guard

The superior BPDUs received on a port enabled as root-guard are ignored. [Default: Disabled]

```
spanning-tree <port-list> root-guard
```

### Loop Guard

STP Loop Guard causes the non-designated port to go into the STP loop inconsistent state instead of the forwarding state. In the loop-inconsistent state, the port prevents data traffic and BPDU transmission through the link, therefore avoiding the loop creation.

```
spanning-tree <port-list> loop-guard
```

### BPDU Protection

BPDU protection would be applied to edge ports connected to end user devices that do not run STP. If STP BPDU packets are received on a protected port, the feature will disable that port and alert the network manager via an SNMP trap

```
spanning-tree <port-list> bpdu-protection
```

### TCN Guard

When enabled for a port, the port stops propagating received topology change notifications to other ports [Default: Disabled]

```
spanning-tree port-list tcn-guard
```

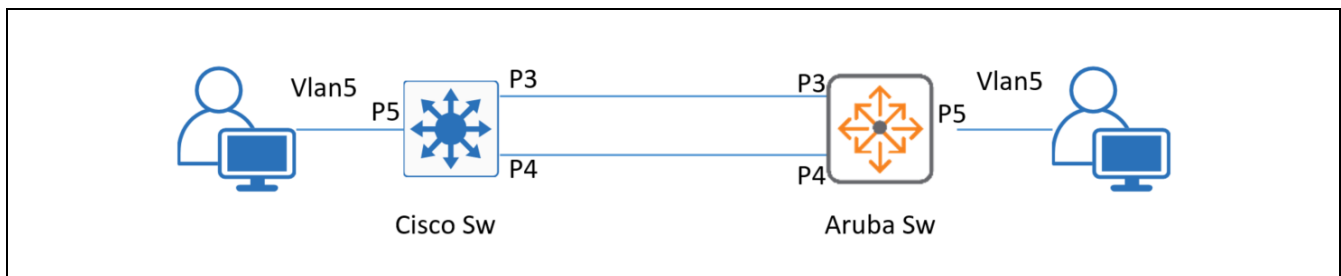
## MSTP

The shown topology below, is simplified version to create a loop between two switches. the topology can be complicated with multiple direct or indirect loops. To interop between Aruba Switch and other vendor switches, enable force mstp version as shown in CLI.

```
spanning-tree force-version mstp-operation
```

With this, the switch applies 802.1s MSTP operation on all ports where compatibility with 802.1D or 802.1w spanning tree protocols is not required. [Default : enabled]

## Topology



## Configurations

### CiscoSW1#show running-config

```
CiscoSW01(config)#spanning-tree mode mst
CiscoSW01(config)#spanning-tree vlan 1 priority 32768
```

### ArubaSW#show running-config

```
ArubaSW(config)#spanning-tree enable
ArubaSW(config)# spanning-tree force-version mstp-operation
ArubaSW(config)# spanning-tree vlan 1 priority 1
```

## Verifications

### ArubaSW# show spanning-tree

Multiple Spanning Tree (MST) Information

ArubaSW(config)# sh spanning-tree

Multiple Spanning Tree (MST) Information

```
STP Enabled      : Yes
Force Version    : MSTP-operation
IST Mapped VLANs : 1-4094
Switch MAC Address : 1c98ec-9e4d00
Switch Priority   : 4096
Max Age          : 20
Max Hops         : 20
Forward Delay     : 15
```

```
Topology Change Count : 16
Time Since Last Change : 62 mins
```

```
CST Root MAC Address : 1c98ec-9e4d00
CST Root Priority     : 4096
CST Root Path Cost    : 0
CST Root Port        : This switch is root
```

```
IST Regional Root MAC Address : 1c98ec-9e4d00
IST Regional Root Priority     : 4096
IST Regional Root Path Cost    : 0
IST Remaining Hops             : 20
```

```

Root Guard Ports      :
Loop Guard Ports      :
TCN Guard Ports       :
BPDU Protected Ports  :
BPDU Filtered Ports   :
PVST Protected Ports  :
PVST Filtered Ports   :

Root Inconsistent Ports :
Loop Inconsistent Ports :

```

Port	Type	Cost	Priority	State	Designated Bridge	Hello Time	PtP	Edge
3	10GbE-T	20000	128	Forwarding	1c98ec-9e4d00	2	Yes	No
4	10GbE-T	20000	128	Forwarding	1c98ec-9e4d00	2	Yes	

### CiscoSW01-C3850#show spanning-tree

```

MST0
Spanning tree enabled protocol mstp
Root ID    Priority    32768
           Address    1c98.ec9e.4d00
           Cost       20000
           Port       3 (GigabitEthernet1/0/3)
           Hello Time 2 sec  Max Age 20 sec  Forward Delay 15 sec

Bridge ID  Priority    32768 (priority 32768 sys-id-ext 0)
           Address    20bb.c0a3.4c80
           Hello Time 2 sec  Max Age 20 sec  Forward Delay 15 sec

Interface          Role Sts Cost      Prio.Nbr Type
-----
Gi1/0/3            Root FWD 20000    128.3    P2p Bound(RSTP)
Gi1/0/4            Altn BLK 20000    128.4    P2p Bound(RSTP)

```

## RSTP

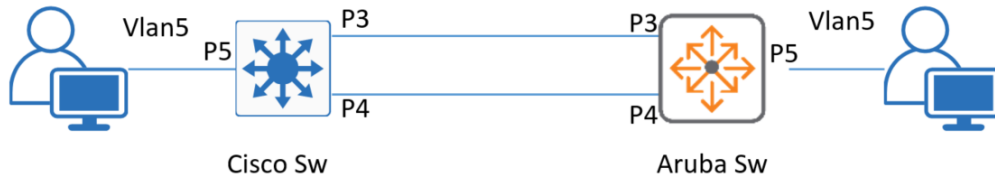
Rapid Spanning Tree Protocol (**RSTP**) as 802.1w. **RSTP** can achieve much faster convergence in a properly configured network in few hundred milliseconds.

```
spanning-tree force-version rstp-operation
```

With this CLI, the switch applies 802.1w operation on all ports except those ports where it detects a system using 802.1D Spanning Tree.

## Topology





## Configurations

### CiscoSW1#show running-config

```
CiscoSW01(config)#spanning-tree mode rapid-pvst
CiscoSW01(config)#spanning-tree vlan 1 priority 32768
```

### ArubaSW#show running-config

```
ArubaSW(config)#spanning-tree enable
ArubaSW(config)#spanning-tree force-version rstp-operation
ArubaSW(config)# spanning-tree vlan 1 priority 8
```

## Verifications

### ArubaSW# show spanning-tree

Multiple Spanning Tree (MST) Information

```
STP Enabled      : Yes
Force Version    : RSTP-operation
IST Mapped VLANs : 1-4094
Switch MAC Address : 1c98ec-9e4d00
Switch Priority   : 32768
Max Age          : 20
Max Hops         : 20
Forward Delay    : 15
```

```
Topology Change Count : 5
Time Since Last Change : 5 mins
```

```
CST Root MAC Address : 1c98ec-9e4d00
CST Root Priority     : 32768
CST Root Path Cost    : 0
CST Root Port        : This switch is root
```

```
IST Regional Root MAC Address : 1c98ec-9e4d00
IST Regional Root Priority     : 32768
IST Regional Root Path Cost    : 0
IST Remaining Hops             : 20
```

```
Root Guard Ports :
```

```

Loop Guard Ports      :
TCN Guard Ports      :
BPDU Protected Ports :
BPDU Filtered Ports  :
PVST Protected Ports :
PVST Filtered Ports  :

```

```

Root Inconsistent Ports :
Loop Inconsistent Ports :

```

Port	Type	Cost	Priority	State	Designated Bridge	Hello Time	PtP	Edge
3	10GbE-T	20000	128	Forwarding	1c98ec-9e4d00	2	Yes	No
4	10GbE-T	20000	128	Forwarding	1c98ec-9e4d00	2	Yes	No

**CiscoSW01-C3850#show spanning-tree**

VLAN0001

```

Spanning tree enabled protocol rstp
Root ID    Priority    32768
           Address    1c98.ec9e.4d00
           Cost        4
           Port        3 (GigabitEthernet1/0/3)
           Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec

```

```

Bridge ID  Priority    32769 (priority 32768 sys-id-ext 1)
           Address    20bb.c0a3.4c80
           Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec
           Aging Time   300 sec

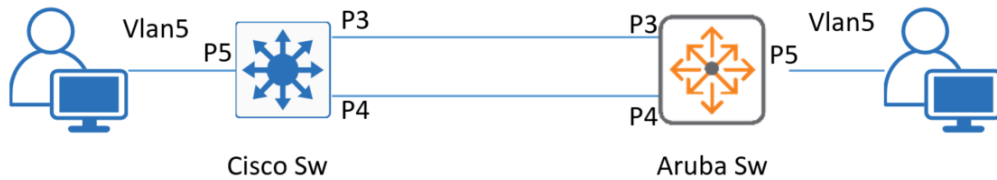
```

Interface	Role	Sts	Cost	Prio.Nbr	Type
Gil1/0/3	Root	FWD	4	128.3	P2p
Gil1/0/4	Altn	BLK	4	128.4	P2p

## Root Bridge election

STP root bridge gets elected based on bridge ID. The bridge ID consists of configurable bridge priority and MAC address of bridge. The bridge with the lowest bridge priority is consist as the root bridge. If the bridge priorities are equal or not configured then the bridge with the lowest MAC is considered the root bridge.

## Topology



## Configurations

**CiscoSW1#show running-config**

```
CiscoSW01(config)#spanning-tree mode rapid-pvst
CiscoSW01(config)#spanning-tree vlan 1 priority 32768
```

**ArubaSW#show running-config**

```
ArubaSW(config)#spanning-tree enable
ArubaSW(config)#spanning-tree force-version rstp-operation
ArubaSW(config)# spanning-tree vlan 1 priority 1
```

## Verifications

**Here is the output after the above Change**

**ArubaSW# show spanning-tree**

```
sh spanning-tree

Multiple Spanning Tree (MST) Information

STP Enabled      : Yes
Force Version    : RSTP-operation
IST Mapped VLANs : 1-4094
Switch MAC Address : 1c98ec-9e4d00
Switch Priority    : 4096
Max Age          : 20
Max Hops          : 20
Forward Delay     : 15

Topology Change Count : 54
Time Since Last Change : 2 mins

CST Root MAC Address : 1c98ec-9e4d00
CST Root Priority      : 4096
CST Root Path Cost    : 0
CST Root Port         : This switch is root
```

```

IST Regional Root MAC Address : 1c98ec-9e4d00
IST Regional Root Priority     : 4096
IST Regional Root Path Cost    : 0
IST Remaining Hops             : 20

```

```

Root Guard Ports      :
Loop Guard Ports      :
TCN Guard Ports       :
BPDU Protected Ports  :
BPDU Filtered Ports   :
PVST Protected Ports  :
PVST Filtered Ports   :

```

```

Root Inconsistent Ports :
Loop Inconsistent Ports :

```

Port	Type	Cost	Priority	State	Designated Bridge	Hello Time	PtP	Edge
3	10GbE-T	20000	128	Forwarding	1c98ec-9e4d00	2	Yes	No
4	10GbE-T	20000	128	Forwarding	1c98ec-9e4d00	2	Yes	No

#### CiscoSW01-C3850#show spanning-tree

```
show spanning-tree
```

```
VLAN0001
```

```
Spanning tree enabled protocol rstp
```

```

Root ID      Priority    4096
             Address     1c98.ec9e.4d00
             Cost         4
             Port         3 (GigabitEthernet1/0/3)
             Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec

```

```

Bridge ID    Priority    32769 (priority 32768 sys-id-ext 1)
             Address     20bb.c0a3.4c80
             Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec
             Aging Time   300 sec

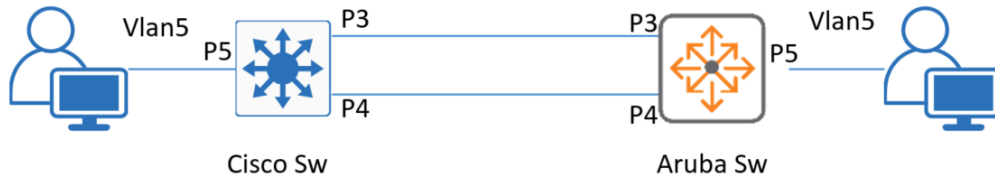
```

Interface	Role	Sts	Cost	Prio.Nbr	Type
Gi1/0/3	Root	FWD	4	128.3	P2p
Gi1/0/4	Altn	BLK	4	128.4	P2p

## Path selection with Path Cost

Local switch elects the root port based on the total path cost to the root, change the cost on the local link when the cost is a tie. The higher cost is the less preferred.

## Topology



## Configurations

```
CiscoSW1#show running-config
```

```
#no changes were made
```

```
ArubaSW#show running-config
```

```
spanning-tree 3 path-cost 30000
```

## Verifications

```
Before configuration change
```

```
ArubaSW1# show spanning-tree
```

```
sh spanning-tree
```

```
Multiple Spanning Tree (MST) Information
```

```
STP Enabled      : Yes
Force Version    : RSTP-operation
IST Mapped VLANs : 1-4094
Switch MAC Address : 1c98ec-9e4d00
Switch Priority   : 32768
Max Age          : 20
Max Hops         : 20
Forward Delay     : 15
```

```
Topology Change Count : 7
Time Since Last Change : 43 secs
```

```
CST Root MAC Address : 20bbc0-a34c80
CST Root Priority     : 4097
CST Root Path Cost    : 20000
CST Root Port        : 3
```

```
IST Regional Root MAC Address : 1c98ec-9e4d00
IST Regional Root Priority     : 32768
IST Regional Root Path Cost    : 0
IST Remaining Hops             : 20
```

```

Root Guard Ports      :
Loop Guard Ports      :
TCN Guard Ports       :
BPDU Protected Ports  :
BPDU Filtered Ports   :
PVST Protected Ports  :
PVST Filtered Ports   :

```

```

Root Inconsistent Ports :
Loop Inconsistent Ports :

```

Port	Type	Cost	Priority	State	Designated Bridge	Hello Time	PtP	Edge
3	10GbE-T	20000	128	Forwarding	20bbc0-a34c80	2	Yes	No
4	10GbE-T	20000	128	Blocking	20bbc0-a34c80	2	Yes	No

### After configuration change

20000 is the default cost, changing the cost of port 3 to 30000, will force the port 4 as root port.

### ArubaSW1# show spanning-tree

```
sh spanning-tree
```

#### Multiple Spanning Tree (MST) Information

```

STP Enabled      : Yes
Force Version    : RSTP-operation
IST Mapped VLANs : 1-4094
Switch MAC Address : 1c98ec-9e4d00
Switch Priority   : 32768
Max Age          : 20
Max Hops         : 20
Forward Delay     : 15

```

```

Topology Change Count : 9
Time Since Last Change : 2 secs

```

```

CST Root MAC Address : 20bbc0-a34c80
CST Root Priority     : 4097
CST Root Path Cost    : 20000
CST Root Port         : 4

```

```

IST Regional Root MAC Address : 1c98ec-9e4d00
IST Regional Root Priority     : 32768
IST Regional Root Path Cost    : 0
IST Remaining Hops             : 20

```

```

Root Guard Ports      :
Loop Guard Ports      :
TCN Guard Ports       :
BPDU Protected Ports  :

```

```
BPDU Filtered Ports :
PVST Protected Ports :
PVST Filtered Ports :
```

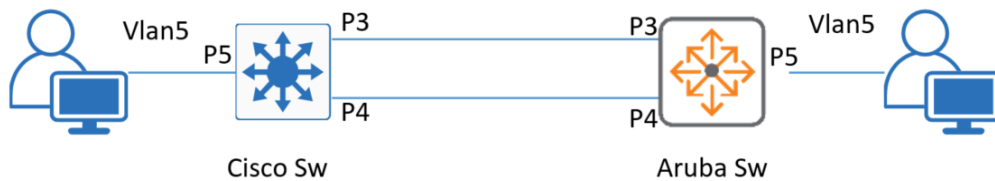
```
Root Inconsistent Ports :
Loop Inconsistent Ports :
```

Port	Type	Cost	Priority	State	Designated Bridge	Hello Time	PtP	Edge
3	10GbE-T	30000	128	Blocking	20bbc0-a34c80	2	Yes	No
4	10GbE-T	20000	128	Forwarding	20bbc0-a34c80	2	Yes	No

## Path selection with port priority

If path cost in tie, STP path selection is determined by port priority of the switch. This happens when two switches compete for root bridge. Change the port priority to affect how downstream (other) switch elects its root port. This is only local significant between the two directly connected switches. Highest priority is less preferred.

### Topology



### Configurations

```
CiscoSW1#show running-config
```

```
int gig 1/0/4
spanning-tree vlan 1 port-priority 0
```

```
ArubaSW#show running-config
```

```
# no config change
```

### Verifications

### Before configuration change

#### ArubaSW1# show spanning-tree

##### Multiple Spanning Tree (MST) Information

STP Enabled : Yes  
Force Version : RSTP-operation  
IST Mapped VLANs : 1-4094  
Switch MAC Address : 1c98ec-9e4d00  
Switch Priority : 32768  
Max Age : 20  
Max Hops : 20  
Forward Delay : 15

Topology Change Count : 17  
Time Since Last Change : 13 secs

CST Root MAC Address : 20bbc0-a34c80  
CST Root Priority : 4097  
CST Root Path Cost : 20000  
CST Root Port : 3

IST Regional Root MAC Address : 1c98ec-9e4d00  
IST Regional Root Priority : 32768  
IST Regional Root Path Cost : 0  
IST Remaining Hops : 20

Root Guard Ports :  
Loop Guard Ports :  
TCN Guard Ports :  
BPDU Protected Ports :  
BPDU Filtered Ports :  
PVST Protected Ports :  
PVST Filtered Ports :

Root Inconsistent Ports :  
Loop Inconsistent Ports :

Port	Type	Cost	Priority	State	Designated Bridge	Hello Time	PtP	Edge
3	10GbE-T	20000	128	Forwarding	20bbc0-a34c80	2	Yes	No
4	10GbE-T	20000	128	Blocking	20bbc0-a34c80	2	Yes	No

### After configuration change

128 is the default priority, changing the port-priority of port 4 to 0 on Cisco Switch, which will force the port 4 as root port on Aruba Switch.

#### ArubaSW1# show spanning-tree

##### Multiple Spanning Tree (MST) Information

STP Enabled : Yes  
Force Version : MSTP-operation



IST Mapped VLANs : 1-4094  
 Switch MAC Address : 1c98ec-9e4d00  
 Switch Priority : 32768  
 Max Age : 20  
 Max Hops : 20  
 Forward Delay : 15

Topology Change Count : 6  
 Time Since Last Change : 5 secs

CST Root MAC Address : 20bbc0-a34c80  
 CST Root Priority : 1  
 CST Root Path Cost : 20000  
 CST Root Port : 4

IST Regional Root MAC Address : 1c98ec-9e4d00  
 IST Regional Root Priority : 32768  
 IST Regional Root Path Cost : 0  
 IST Remaining Hops : 20

Root Guard Ports :  
 Loop Guard Ports :  
 TCN Guard Ports :  
 BPDU Protected Ports :  
 BPDU Filtered Ports :  
 PVST Protected Ports :  
 PVST Filtered Ports :

Root Inconsistent Ports :  
 Loop Inconsistent Ports :

Port	Type	Cost	Prio	State	Designated	Hello	PtP	Edge
			rity		Bridge	Time		
3	10GbE-T	20000	128	Blocking	20bbc0-a34c80	2	Yes	No
4	10GbE-T	20000	128	Forwarding	20bbc0-a34c80	2	Yes	No

### CiscoSW01#show spanning-tree

VLAN0001

Spanning tree enabled protocol rstp

Root ID      Priority      1  
              Address      20bb.c0a3.4c80  
              This bridge is the root  
              Hello Time    2 sec    Max Age 20 sec    Forward Delay 15 sec

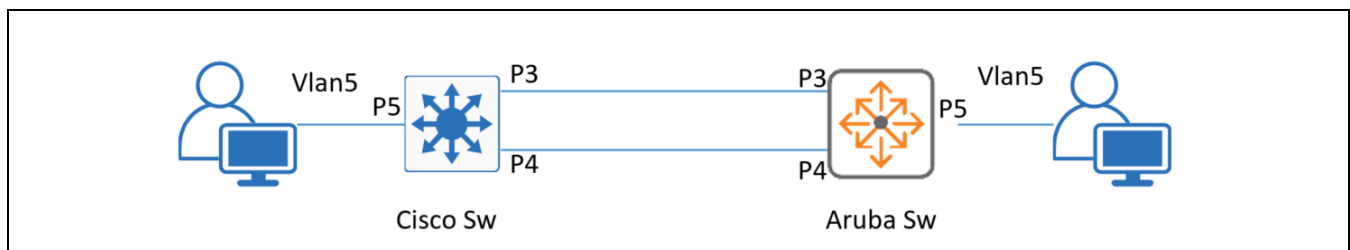
Bridge ID    Priority      1      (priority 0 sys-id-ext 1)  
              Address      20bb.c0a3.4c80  
              Hello Time    2 sec    Max Age 20 sec    Forward Delay 15 sec  
              Aging Time    300 sec

Interface	Role	Sts	Cost	Prio.Nbr	Type
Gi1/0/3	Desg	FWD	4	128.3	P2p
Gi1/0/4	Desg	FWD	4	0.4	P2p

## Tuning STP convergence timers

STP convergence timers once configured on root bridge gets communicated to other switches. It includes max-age and hello-time. The hello time is the time between each bridge protocol data unit (BPDU) that is sent on a port. This time is equal to 2 seconds (sec) by default, but you can tune the time to be between 1 and 10 sec. The max age timer controls the maximum length of time that passes before a bridge port saves its configuration BPDU information.

## Topology



## Configurations

### CiscoSW1#show running-config

```
spanning-tree vlan 1 hello-time 9
spanning-tree vlan 1 max-age 12
spanning-tree vlan 1 forward-time 10
```

### ArubaSW#show running-config

```
#no config changes
```

## Verifications

### Before configuration change

#### Cisco Switch

```
#sh spanning-tree
```

```
VLAN0001
```

```
Spanning tree enabled protocol rstp
```

```
Root ID    Priority    1
           Address    20bb.c0a3.4c80
           This bridge is the root
```

```
Hello Time 2 sec Max Age 20 sec Forward Delay 15 sec
```

```
Bridge ID  Priority    1      (priority 0 sys-id-ext 1)
```

```
Address    20bb.c0a3.4c80
Hello Time 2 sec Max Age 20 sec Forward Delay 15 sec
```

```
Aging Time 300 sec
```

ArubaSW1# show spanning-tree

sh spanning-tree

Multiple Spanning Tree (MST) Information

STP Enabled : Yes  
Force Version : MSTP-operation  
IST Mapped VLANs : 1-4094  
Switch MAC Address : 1c98ec-9e4d00  
Switch Priority : 32768  
Max Age : 20  
Max Hops : 20  
Forward Delay : 15

Topology Change Count : 6  
Time Since Last Change : 17 mins

CST Root MAC Address : 20bbc0-a34c80  
CST Root Priority : 1  
CST Root Path Cost : 20000  
CST Root Port : 4

IST Regional Root MAC Address : 1c98ec-9e4d00  
IST Regional Root Priority : 32768  
IST Regional Root Path Cost : 0  
IST Remaining Hops : 20

Root Guard Ports :  
Loop Guard Ports :  
TCN Guard Ports :  
BPDU Protected Ports :  
BPDU Filtered Ports :  
PVST Protected Ports :  
PVST Filtered Ports :

Root Inconsistent Ports :  
Loop Inconsistent Ports :

Port	Type	Cost	Priority	State	Designated Bridge	Hello Time	PtP	Edge
3	10GbE-T	20000	128	Blocking	20bbc0-a34c80	2	Yes	No
4	10GbE-T	20000	128	Forwarding	20bbc0-a34c80	2	Yes	No

After configuration change

ArubaSW1# show spanning-tree

sh spanning-tree

Multiple Spanning Tree (MST) Information

STP Enabled : Yes  
Force Version : MSTP-operation

```

IST Mapped VLANs : 1-4094
Switch MAC Address : 1c98ec-9e4d00
Switch Priority : 32768
Max Age : 12
Max Hops : 20
Forward Delay : 10

```

```

Topology Change Count : 6
Time Since Last Change : 22 mins

```

```

CST Root MAC Address : 20bbc0-a34c80
CST Root Priority : 1
CST Root Path Cost : 20000
CST Root Port : 4

```

```

IST Regional Root MAC Address : 1c98ec-9e4d00
IST Regional Root Priority : 32768
IST Regional Root Path Cost : 0
IST Remaining Hops : 20

```

```

Root Guard Ports :
Loop Guard Ports :
TCN Guard Ports :
BPDU Protected Ports :
BPDU Filtered Ports :
PVST Protected Ports :
PVST Filtered Ports :

```

```

Root Inconsistent Ports :
Loop Inconsistent Ports :

```

Port	Type	Cost	Priority	State	Designated Bridge	Hello Time	PtP	Edge
3	10GbE-T	20000	128	Blocking	20bbc0-a34c80	9	Yes	No
4	10GbE-T	20000	128	Forwarding	20bbc0-a34c80	9	Yes	No

#### Cisco Switch# show spanning-tree

```

VLAN0001
Spanning tree enabled protocol rstp
Root ID    Priority    1
           Address    20bb.c0a3.4c80
           This bridge is the root
           Hello Time  9 sec Max Age 12 sec Forward Delay 10 sec

Bridge ID  Priority    1           (priority 0 sys-id-ext 1)
           Address    20bb.c0a3.4c80
           Hello Time  9 sec Max Age 12 sec Forward Delay 10 sec

```

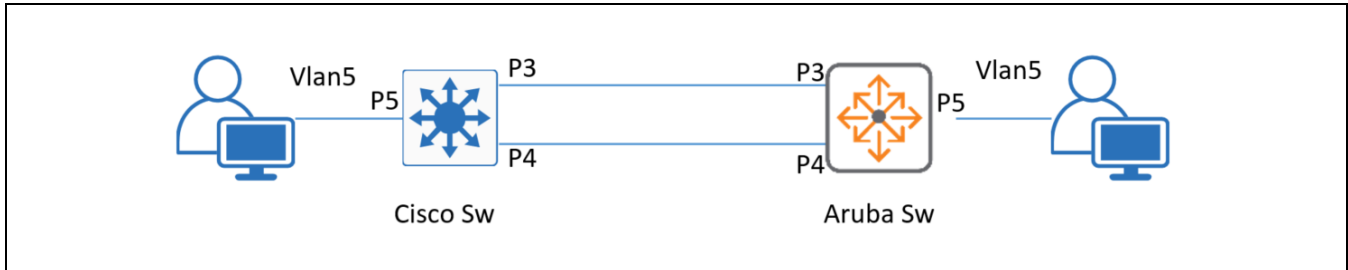
## BPDU Protection

BPDU protection would be applied to edge ports connected to end user devices that do not run STP. If STP BPDU packets are received on a protected port, the feature will disable that port and alert the network manager via an SNMP trap

```
spanning-tree <port-list> bpd protection
```

In below topology, BPDU protection mostly used on Port5 where the end devices are connected

### Topology



### Configurations

Just for demonstration, BPDU protection is configured on Port-4 which is connected to other switch, as expected, this is going to cause problems, and the ports went error-disabled state.

```
CiscoSW1#show running-config
```

```
#NO CONFIG CHANGE
```

```
ArubaSW1#show running-config
```

```
ArubaSW1(config)# spanning-tree enable
```

```
ArubaSW1(config)# spanning-tree 3-4 bpd protection
```

### Verifications

```
Before configuration change
```

```
ArubaSW1# show spanning-tree
```

```
sh spanning-tree
```

```
Multiple Spanning Tree (MST) Information
```

```
STP Enabled : Yes
```

```
Force Version : RSTP-operation
```

```
IST Mapped VLANs : 1-4094
```

```
Switch MAC Address : 1c98ec-9e4d00
```

```
Switch Priority : 4096
```

```
Max Age : 20
```

```
Max Hops : 20
```

```
Forward Delay : 15
```

```
Topology Change Count : 21
```

Time Since Last Change : 1 secs

CST Root MAC Address : 1c98ec-9e4d00  
CST Root Priority : 4096  
CST Root Path Cost : 0  
CST Root Port : This switch is root

IST Regional Root MAC Address : 1c98ec-9e4d00  
IST Regional Root Priority : 4096  
IST Regional Root Path Cost : 0  
IST Remaining Hops : 20

Root Guard Ports :  
Loop Guard Ports :  
TCN Guard Ports :  
BPDU Protected Ports :  
BPDU Filtered Ports :  
PVST Protected Ports :  
PVST Filtered Ports :

Root Inconsistent Ports :  
Loop Inconsistent Ports :

Port	Type	Cost	Prio rity	State	Designated Bridge	Hello Time	PtP	Edge
3	10GbE-T	20000	160	Forwarding	1c98ec-9e4d00	2	Yes	No
4	10GbE-T	20000	160	Forwarding	1c98ec-9e4d00	2	Yes	No

CiscoSW1# show spanning-tree  
sh spanning-tree

VLAN0001

Spanning tree enabled protocol rstp

Root ID    Priority    4096  
          Address    1c98.ec9e.4d00  
          Cost        4  
          Port        3 (GigabitEthernet1/0/3)  
          Hello Time   2 sec    Max Age 20 sec    Forward Delay 15 sec

Bridge ID   Priority    32769 (priority 32768 sys-id-ext 1)  
          Address    20bb.c0a3.4c80  
          Hello Time   2 sec    Max Age 20 sec    Forward Delay 15 sec  
          Aging Time   300 sec

Interface	Role	Sts	Cost	Prio.Nbr	Type
Gi1/0/3	Root	FWD	4	128.3	P2p
Gi1/0/4	Altn	BLK	4	16.4	P2p

**After configuration change on Cisco switch**

CiscoSW01(config)#int range gig 1/0/3-4

```
CiscoSW0 (config-if-range) #shutdown
```

```
CiscoSW01 (config-if-range) #no shutdown
```

After disabling and enabling the port on cisco switch, a new bpdu comes from Cisco switch to Aruba switch. As Aruba switch is configured with bpdu guard, it goes in bpdu error state as shown below

```
ArubaSW1# show spanning-tree
```

```
ArubaSW# sh spanning-tree
```

```
Multiple Spanning Tree (MST) Information
```

```
STP Enabled      : Yes
Force Version    : RSTP-operation
IST Mapped VLANs : 1-4094
Switch MAC Address : 1c98ec-9e4d00
Switch Priority   : 4096
Max Age          : 20
Max Hops         : 20
Forward Delay     : 15
```

```
Topology Change Count : 22
Time Since Last Change : 66 secs
```

```
CST Root MAC Address : 1c98ec-9e4d00
CST Root Priority     : 4096
CST Root Path Cost    : 0
CST Root Port        : This switch is root
```

```
IST Regional Root MAC Address : 1c98ec-9e4d00
IST Regional Root Priority     : 4096
IST Regional Root Path Cost    : 0
IST Remaining Hops             : 20
```

```
Root Guard Ports      :
Loop Guard Ports       :
TCN Guard Ports        :
BPDU Protected Ports  : 3-4
BPDU Filtered Ports    :
PVST Protected Ports   : 3-4
PVST Filtered Ports    :
```

```
Root Inconsistent Ports :
Loop Inconsistent Ports  :
```

Port	Type	Cost	Prio	State	Designated	Hello	Time	PtP	Edge
-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
3	10GbE-T	20000	160	BpduError		2	Yes	No	
4	10GbE-T	20000	160	BpduError		2	Yes	No	

```
After configuration change on cisco switch
```

```
*Sep 2 15:51:45.275: %LINEPROTO-5-UPDOWN: Line protocol on Interface GigabitEthernet1/0/3, changed state to down
```

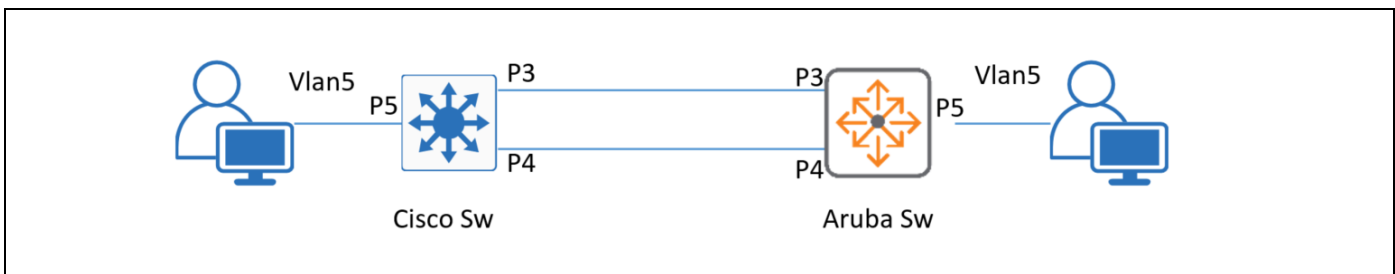
```
*Sep  2 15:51:45.286: %LINEPROTO-5-UPDOWN: Line protocol on Interface GigabitEthernet1/0/4, changed state to down
*Sep  2 15:51:47.316: %LINK-3-UPDOWN: Interface GigabitEthernet1/0/3, changed state to down
*Sep  2 15:51:47.321: %LINK-3-UPDOWN: Interface GigabitEthernet1/0/4, changed state to down
```

## BPDU Filter

The BPDU filter feature allows control of spanning tree participation on a per-port basis. It can be used to exclude specific ports from becoming part of spanning tree operations. A port with the BPDU filter enabled will ignore incoming BPDU packets and stay locked in the spanning tree forwarding state. All other ports will maintain their role.

In below topology, BPDU filter mostly used on Port-5 where the end devices are connected

## Topology



## Configurations

Just to demonstrate, we are configuring the BPDU filter on Port-4 which is connected to other switch, as expected, this is going to cause problems.

```
CiscoSW1#show running-config
```

```
ArubaSW#show running-config
```

```
ArubaSW1(config)# spanning-tree 4 bpdu-filter
```

## Verifications

```
Before configuration change
```

```
ArubaSW1# show spanning-tree
```

```
show spanning-tree
Multiple Spanning Tree (MST) Information
  STP Enabled      : Yes
  Force Version    : RSTP-operation
  IST Mapped VLANs : 1-4094
```



Switch MAC Address : 1c98ec-9e4d00  
 Switch Priority : 4096  
 Max Age : 20  
 Max Hops : 20  
 Forward Delay : 15

Topology Change Count : 21  
 Time Since Last Change : 1 secs

CST Root MAC Address : 1c98ec-9e4d00  
 CST Root Priority : 4096  
 CST Root Path Cost : 0  
 CST Root Port : This switch is root

IST Regional Root MAC Address : 1c98ec-9e4d00  
 IST Regional Root Priority : 4096  
 IST Regional Root Path Cost : 0  
 IST Remaining Hops : 20

Root Guard Ports :  
 Loop Guard Ports :  
 TCN Guard Ports :  
 BPDU Protected Ports :  
 BPDU Filtered Ports :  
 PVST Protected Ports :  
 PVST Filtered Ports :

Root Inconsistent Ports :  
 Loop Inconsistent Ports :

Port	Type	Cost	Prio	State	Designated Bridge	Hello Time	PtP	Edge
3	10GbE-T	20000	160	Forwarding	1c98ec-9e4d00	2	Yes	No
4	10GbE-T	20000	160	Forwarding	1c98ec-9e4d00	2	Yes	No

### CiscoSW1# show spanning-tree

#### VLAN0001

Spanning tree enabled protocol rstp  
 Root ID Priority 4096  
 Address 1c98.ec9e.4d00  
 Cost 4  
 Port 3 (GigabitEthernet1/0/3)  
 Hello Time 2 sec Max Age 20 sec Forward Delay 15 sec

Bridge ID Priority 32769 (priority 32768 sys-id-ext 1)  
 Address 20bb.c0a3.4c80  
 Hello Time 2 sec Max Age 20 sec Forward Delay 15 sec  
 Aging Time 300 sec

Interface	Role	Sts	Cost	Prio.Nbr	Type
Gi1/0/3	Root	FWD	4	128.3	P2p
Gi1/0/4	Altn	BLK	4	16.4	P2p

After configuration change

ArubaSW config)# spanning-tree 4 bpdu-filter

ArubaSW# show spanning-tree

Multiple Spanning Tree (MST) Information

STP Enabled : Yes  
Force Version : RSTP-operation  
IST Mapped VLANs : 1-4094  
Switch MAC Address : 1c98ec-9e4d00  
Switch Priority : 4096  
Max Age : 20  
Max Hops : 20  
Forward Delay : 15

Topology Change Count : 27  
Time Since Last Change : 2 mins

CST Root MAC Address : 1c98ec-9e4d00  
CST Root Priority : 4096  
CST Root Path Cost : 0  
CST Root Port : This switch is root

IST Regional Root MAC Address : 1c98ec-9e4d00  
IST Regional Root Priority : 4096  
IST Regional Root Path Cost : 0  
IST Remaining Hops : 20

Root Guard Ports :  
Loop Guard Ports :  
TCN Guard Ports :  
BPDU Protected Ports :  
BPDU Filtered Ports : 4  
PVST Protected Ports :  
PVST Filtered Ports :

Root Inconsistent Ports :  
Loop Inconsistent Ports :

Port	Type	Cost	Prio	State	Designated	Hello	PtP	Edge
			rity		Bridge	Time		
3	10GbE-T	20000	160	Forwarding	1c98ec-9e4d00	2	Yes	No
4	10GbE-T	20000	160	Forwarding	1c98ec-9e4d00	2	Yes	No

After configuration change on cisco switch

CiscoSW01-C3850#sh spanning-tree

VLAN0001

Spanning tree enabled protocol rstp  
Root ID Priority 4096  
Address 1c98.ec9e.4d00

```

Cost          4
Port          3 (GigabitEthernet1/0/3)
Hello Time    2 sec  Max Age 20 sec  Forward Delay 15 sec

Bridge ID     Priority 32769 (priority 32768 sys-id-ext 1)
Address       20bb.c0a3.4c80
Hello Time    2 sec  Max Age 20 sec  Forward Delay 15 sec
Aging Time    300 sec

Interface      Role Sts Cost      Prio.Nbr Type
-----
Gi1/0/3       Root FWD 4        128.3    P2p
Gi1/0/4       Desg FWD 4        128.4    P2p

```

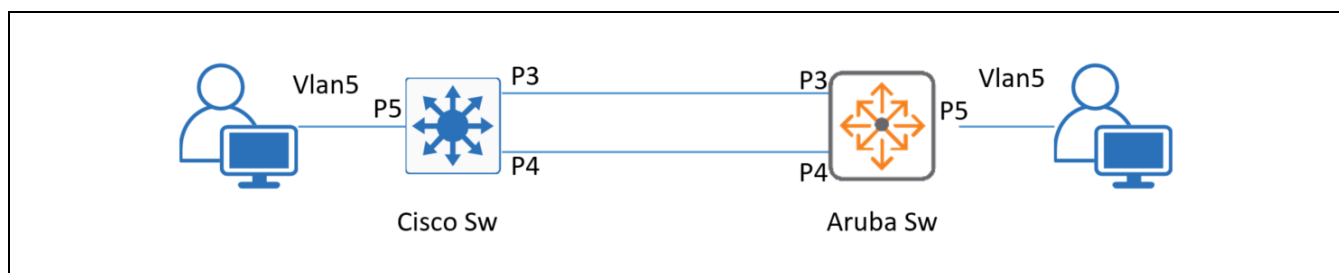
As shown, on Cisco and Aruba both port 3 & 4, are in forwarding mode, which causes loops.

## ROOT Guard

Root guard feature provides a way to place the root bridge placement in the network. In terms of design, this feature is used to avoid rogue devices to act as a man-in-the-middle attack. It is enabled on the designated ports of root switch, so that if those ports listen to the superior BPDU then put that port in inconsistent state.

In below topology, Root Guard mostly used on Port-5 where the end devices are connected and as shown below Aruba Switch is elected as root, and root guard is configured on port 3,4 to retain the role as root. If Cisco switch or any other switches on these interface trying to take root role, the interface will be auto disabled.

## Topology



## Configurations

```
ArubaSW#show running-config
```

```
Aruba(config)#spanning-tree 3-4 root-guard
```

```
CiscoSW1#show running-config
```

```
Cisco(config)#spanning-tree vlan 1 priority 0
```

## Verifications

```
ArubaSW1# show spanning-tree
```

```
ArubaSW# sh spanning-tree
```

Multiple Spanning Tree (MST) Information

STP Enabled : Yes  
Force Version : RSTP-operation  
IST Mapped VLANs : 1-4094  
Switch MAC Address : 1c98ec-9e4d00  
Switch Priority : 4096  
Max Age : 20  
Max Hops : 20  
Forward Delay : 15

Topology Change Count : 30  
Time Since Last Change : 4 mins

CST Root MAC Address : 1c98ec-9e4d00  
CST Root Priority : 4096  
CST Root Path Cost : 0  
CST Root Port : This switch is root

IST Regional Root MAC Address : 1c98ec-9e4d00  
IST Regional Root Priority : 4096  
IST Regional Root Path Cost : 0  
IST Remaining Hops : 20

Root Guard Ports : 3-4

Loop Guard Ports :  
TCN Guard Ports :  
BPDU Protected Ports :  
BPDU Filtered Ports :  
PVST Protected Ports :  
PVST Filtered Ports :

Root Inconsistent Ports :  
Loop Inconsistent Ports :

Port	Type	Cost	Priority	State	Designated Bridge	Hello Time	PtP	Edge
3	10GbE-T	20000	160	Forwarding	1c98ec-9e4d00	2	Yes	No
4	10GbE-T	20000	160	Forwarding	1c98ec-9e4d00	2	Yes	No

```
CiscoSW1# show spanning-tree
```

VLAN0001

Spanning tree enabled protocol rstp

Root ID      Priority      4096  
             Address      1c98.ec9e.4d00  
             Cost          4  
             Port          3 (GigabitEthernet1/0/3)  
             Hello Time    2 sec    Max Age 20 sec    Forward Delay 15 sec

Bridge ID    Priority      32769 (priority 32768 sys-id-ext 1)  
             Address      20bb.c0a3.4c80  
             Hello Time    2 sec    Max Age 20 sec    Forward Delay 15 sec  
             Aging Time    300 sec

Interface	Role	Sts	Cost	Prio.Nbr	Type
-----	----	---	-----	-----	-----
Gi1/0/3	Root	FWD	4	128.3	P2p
Gi1/0/4	Altn	BLK	4	128.4	P2p

#### After configuration change on Aruba and Cisco Switch

Aruba(config)#spanning-tree 3-4 root-guard

Cisco(config)#spanning-tree vlan 1 priority 0

Just for demonstration, Cisco Switch stp priority changed to 0 for vlan-1, which will force Cisco Switch become root. As Root-guard is enabled on port 3-4 of Aruba Switch, when Cisco Switch trying send superior BPDU, these interfaces will be errored.

#### ArubaSW1# show spanning-tree

sh spanning-tree

Multiple Spanning Tree (MST) Information

STP Enabled    : Yes  
Force Version : RSTP-operation  
IST Mapped VLANs : 1-4094  
Switch MAC Address : 1c98ec-9e4d00  
Switch Priority    : 61440  
Max Age    : 20  
Max Hops   : 20  
Forward Delay : 15

Topology Change Count : 15  
Time Since Last Change : 6 mins

CST Root MAC Address : 1c98ec-9e4d00  
CST Root Priority    : 61440  
CST Root Path Cost   : 0  
CST Root Port        : This switch is root

IST Regional Root MAC Address : 1c98ec-9e4d00

```
IST Regional Root Priority      : 61440
IST Regional Root Path Cost    : 0
IST Remaining Hops              : 20
```

```
Root Guard Ports : 3-4
```

```
Loop Guard Ports :
TCN Guard Ports :
BPDU Protected Ports :
BPDU Filtered Ports :
PVST Protected Ports :
PVST Filtered Ports :
```

```
Root Inconsistent Ports : 3-4
```

```
Loop Inconsistent Ports :
```

Port	Type	Cost	Priority	State	Designated Bridge	Hello Time	PtP	Edge
3	10GbE-T	20000	128	Inconsistent	20bbc0-a34c80	2	Yes	No
4	10GbE-T	20000	128	Inconsistent	20bbc0-a34c80	2	Yes	No

## Loop Guard

The loop guard feature makes additional checks for avoiding STP loops.

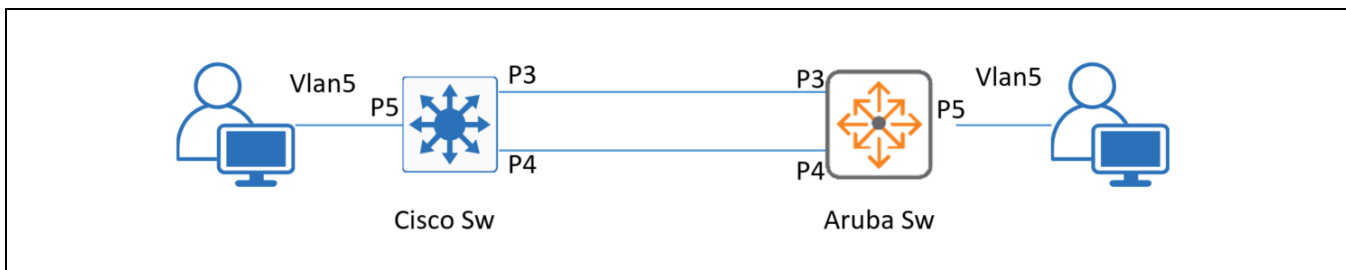
STP Loop Guard causes the non-designated port to go into the STP loop inconsistent state instead of the forwarding state. In the loop-inconsistent state, the port prevents data traffic and BPDU transmission through the link, therefore avoiding the loop creation.

```
spanning-tree <port-list> loop-guard
```

To demonstrate this feature,

1. Enabled BPDU filter on Aruba Switch port-3 to form a spanning tree loop as port-3 will be in forwarding state
2. By enabling loop-guard, helped to recover the topology from loop.

## Topology



## Configurations

```
CiscoSW1#show running-config
```

```
Cisco(config)#int range gigabitEthernet 1/0/3-4  
Cisco(config)#spanning-tree loopguard default
```

```
ArubaSW#show running-config
```

```
Aruba(config)#spanning-tree 3 loop-guard  
Aruba(config)#spanning-tree 4 loop-guard
```

## Verifications

Injecting the problem by filtering BPDU, farms a loop.

```
ArubaSW1 (config)# spanning-tree 3 bpdu-filter
```

After applying the loop-guard, the port-moved to inconsistent state to avoid the loop.

```
ArubaSW1#sh spanning-tree
```

Multiple Spanning Tree (MST) Information

```
STP Enabled      : Yes  
Force Version    : RSTP-operation  
IST Mapped VLANs : 1-4094  
Switch MAC Address : 1c98ec-9e4d00  
Switch Priority    : 61440  
Max Age          : 20  
Max Hops          : 20  
Forward Delay     : 15
```

```
Topology Change Count : 7  
Time Since Last Change : 93 secs
```

```
CST Root MAC Address : 20bbc0-a34c80  
CST Root Priority      : 32769  
CST Root Path Cost     : 20000  
CST Root Port          : 4
```

```
IST Regional Root MAC Address : 1c98ec-9e4d00  
IST Regional Root Priority      : 61440  
IST Regional Root Path Cost     : 0  
IST Remaining Hops              : 20
```

```
Root Guard Ports      :  
Loop Guard Ports      : 3-4  
TCN Guard Ports       :  
BPDU Protected Ports  :  
BPDU Filtered Ports   : 3  
PVST Protected Ports  :  
PVST Filtered Ports   :
```

Root Inconsistent Ports :  
Loop Inconsistent Ports : 3

Port	Type	Cost	Prio rity	State	Designated Bridge	Hello Time	PtP	Edge
-----	-----	+ -----	-----	-----	+ -----	-----	---	-----
3	10GbE-T	20000	128	Inconsistent	20bbc0-a34c80	2	Yes	No
4	10GbE-T	20000	128	Forwarding	20bbc0-a34c80	2	Yes	No