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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:
```
spanning-tree <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 to 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

<table>
<thead>
<tr>
<th></th>
<th>Prio</th>
<th>Designated</th>
<th>Hello</th>
</tr>
</thead>
<tbody>
<tr>
<td>Port</td>
<td>Type</td>
<td>Cost</td>
<td>rity State</td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>---</td>
<td>--------</td>
</tr>
<tr>
<td>3</td>
<td>10GbE-T</td>
<td>20000</td>
<td>128</td>
</tr>
<tr>
<td>4</td>
<td>10GbE-T</td>
<td>20000</td>
<td>128</td>
</tr>
</tbody>
</table>

```
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 :
<table>
<thead>
<tr>
<th>Port</th>
<th>Type</th>
<th>Cost</th>
<th>Priority</th>
<th>Role Sts</th>
<th>Cost</th>
<th>Prio.Nbr</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>10GbE-T</td>
<td>20000</td>
<td>128</td>
<td>Forwarding</td>
<td>128.3</td>
<td>P2p</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>10GbE-T</td>
<td>20000</td>
<td>128</td>
<td>Forwarding</td>
<td>128.4</td>
<td>P2p</td>
<td></td>
</tr>
</tbody>
</table>

**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

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:

<table>
<thead>
<tr>
<th>Port</th>
<th>Type</th>
<th>Cost</th>
<th>Priority</th>
<th>State</th>
<th>Designated</th>
<th>Bridge ID</th>
<th>Hello Time</th>
<th>Max Age</th>
<th>Forward Delay</th>
<th>Forward Delay</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>10GbE-T</td>
<td>20000</td>
<td>128</td>
<td>Forwarding</td>
<td>1c98ec-9e4d00</td>
<td>2</td>
<td>Yes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>10GbE-T</td>
<td>20000</td>
<td>128</td>
<td>Forwarding</td>
<td>1c98ec-9e4d00</td>
<td>2</td>
<td>No</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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
After configuration change

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

```
sh spanning-tree
```

Multiple Spanning Tree (MST) Information

<table>
<thead>
<tr>
<th>STP Enabled</th>
<th>Force Version</th>
<th>IST Mapped VLANs</th>
<th>Switch MAC Address</th>
<th>Switch Priority</th>
<th>Max Age</th>
<th>Max Hops</th>
<th>Forward Delay</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>RSTP-operation</td>
<td>1-4094</td>
<td>1c98ec-9e4d00</td>
<td>32768</td>
<td>20</td>
<td>20</td>
<td>15</td>
</tr>
</tbody>
</table>

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

Root Inconsistent Ports :
Loop Inconsistent Ports :

<table>
<thead>
<tr>
<th>Port</th>
<th>Type</th>
<th>Cost</th>
<th>Prio</th>
<th>Designated State</th>
<th>Bridge</th>
<th>Hello Time PtP Edge</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>10GbE-T</td>
<td>30000</td>
<td>128</td>
<td>Blocking</td>
<td>20bbc0-a34c80</td>
<td>2</td>
</tr>
<tr>
<td>4</td>
<td>10GbE-T</td>
<td>20000</td>
<td>128</td>
<td>Forwarding</td>
<td>20bbc0-a34c80</td>
<td>2</td>
</tr>
</tbody>
</table>

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

![Topology Diagram]

Configurations

**CiscoSW1#show running-config**

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

**ArubaSW#show running-config**

```bash
# 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 :

<table>
<thead>
<tr>
<th>Port</th>
<th>Type</th>
<th>Cost</th>
<th>Priority</th>
<th>State</th>
<th>Designated Bridge</th>
<th>Hello Time PtP Edge</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>10GbE-T</td>
<td>20000</td>
<td>128</td>
<td>Forwarding</td>
<td>20bbc0-a34c80</td>
<td>2 Yes No</td>
</tr>
<tr>
<td>4</td>
<td>10GbE-T</td>
<td>20000</td>
<td>128</td>
<td>Blocking</td>
<td>20bbc0-a34c80</td>
<td>2 Yes No</td>
</tr>
</tbody>
</table>

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 :

<table>
<thead>
<tr>
<th>Port</th>
<th>Type</th>
<th>Cost</th>
<th>Prio</th>
<th>Designated</th>
<th>Hello</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>10GbE-T</td>
<td>20000</td>
<td>128</td>
<td>Blocking</td>
<td>20bbc0-a34c80</td>
</tr>
<tr>
<td>4</td>
<td>10GbE-T</td>
<td>20000</td>
<td>128</td>
<td>Forwarding</td>
<td>20bbc0-a34c80</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Interface</th>
<th>Role</th>
<th>Sts</th>
<th>Cost</th>
<th>Prio</th>
<th>Nbr</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gi1/0/3</td>
<td>Desg FWD 4</td>
<td>128.3</td>
<td>P2p</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gi1/0/4</td>
<td>Desg FWD 4</td>
<td>128</td>
<td>P2p</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
**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**

![Topology Diagram]

**Configurations**

```bash
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**

```bash
#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
```
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
Topo Loop Guard Ports:
Root Guard Ports:
TCN Guard Ports:
BPDU Protected Ports:
BPDU Filtered Ports:
PVST Protected Ports:
PVST Filtered Ports:
VLANs:
<table>
<thead>
<tr>
<th>Port</th>
<th>Prio</th>
<th>Designated</th>
<th>Hello</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>10Gbe-T</td>
<td>20000</td>
<td>128 Blocking</td>
</tr>
<tr>
<td>4</td>
<td>10Gbe-T</td>
<td>20000</td>
<td>128 Forwarding</td>
</tr>
</tbody>
</table>

After configuration change

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:

<table>
<thead>
<tr>
<th>Port</th>
<th>Type</th>
<th>Cost</th>
<th>Priority</th>
<th>State</th>
<th>Bridge ID</th>
<th>Hello Time</th>
<th>Max Age</th>
<th>Forward Delay</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>10GbE-T</td>
<td>20000</td>
<td>128</td>
<td>Blocking</td>
<td>20bbc0-a34c80</td>
<td>9</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>4</td>
<td>10GbE-T</td>
<td>20000</td>
<td>128</td>
<td>Forwarding</td>
<td>20bbc0-a34c80</td>
<td>9</td>
<td>Yes</td>
<td>No</td>
</tr>
</tbody>
</table>

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> bpdu-protection
```

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

**Topology**

![Topology Diagram]

**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
```

```
ArubaSW#show running-config
ArubaSW1(config)# spanning-tree enable
ArubaSW1(config)# spanning-tree 3-4 bpdu-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 VL ANs : 1-4094
Switch MAC Address : 1c98ec-9e4d00
Switch Priority : 4096
Max Age : 20
Max Hops : 20
Forward Delay : 15
Topology Change Count : 21
```
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

<table>
<thead>
<tr>
<th>Interface</th>
<th>Role</th>
<th>Sts</th>
<th>Cost</th>
<th>Prio.Nbr</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>GigabitEthernet1/0/3</td>
<td>Root</td>
<td>FWD</td>
<td>4</td>
<td>128.3</td>
<td>P2p</td>
</tr>
<tr>
<td>GigabitEthernet1/0/4</td>
<td>Altn</td>
<td>BLK</td>
<td>4</td>
<td>16.4</td>
<td>P2p</td>
</tr>
</tbody>
</table>

**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

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 :

<table>
<thead>
<tr>
<th>Port</th>
<th>Type</th>
<th>Prio</th>
<th>Designated</th>
<th>Hello</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>10GbE-T</td>
<td>20000</td>
<td>bpduError</td>
<td>2 Yes No</td>
</tr>
<tr>
<td>4</td>
<td>10GbE-T</td>
<td>20000</td>
<td>bpduError</td>
<td>2 Yes No</td>
</tr>
</tbody>
</table>

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
**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**

![Topology Diagram]

**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 :

<table>
<thead>
<tr>
<th>Prio</th>
<th>Designated</th>
<th>Hello</th>
</tr>
</thead>
<tbody>
<tr>
<td>Port</td>
<td>Type</td>
<td>Cost</td>
</tr>
</tbody>
</table>
+------|------------|-------|
3 10GbE-T | 20000 | 160 | Forwarding |
4 10GbE-T | 20000 | 160 | Forwarding |

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 on Aruba switch
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 :

<table>
<thead>
<tr>
<th>Port</th>
<th>Type</th>
<th>Cost</th>
<th>Priority</th>
<th>Designated</th>
<th>Hello</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>10GbE-T</td>
<td>20000</td>
<td>160</td>
<td>Forwarding</td>
<td>1c98ec-9e4d00</td>
</tr>
<tr>
<td>4</td>
<td>10GbE-T</td>
<td>20000</td>
<td>160</td>
<td>Forwarding</td>
<td>1c98ec-9e4d00</td>
</tr>
</tbody>
</table>

After configuration change on Cisco switch
CiscoSW01-C3850# 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

<table>
<thead>
<tr>
<th>Interface</th>
<th>Role</th>
<th>Sts</th>
<th>Cost</th>
<th>Prio.Nbr</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gi1/0/3</td>
<td>Root FWD</td>
<td>P2p</td>
<td>128.3</td>
<td>P2p</td>
<td></td>
</tr>
<tr>
<td>Gi1/0/4</td>
<td>Desg FWD</td>
<td>P2p</td>
<td>128.4</td>
<td>P2p</td>
<td></td>
</tr>
</tbody>
</table>

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**

![Topology Diagram](image)

**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 :

<table>
<thead>
<tr>
<th>Port</th>
<th>Type</th>
<th>Prio</th>
<th>Cost</th>
<th>Designated State</th>
<th>Bridge MAC</th>
<th>Hello Time</th>
<th>PTP</th>
<th>Edge</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>10GbE-T</td>
<td>10</td>
<td>20000</td>
<td>Forwarding</td>
<td>1c98ec-9e4d00</td>
<td>2</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>4</td>
<td>10GbE-T</td>
<td>10</td>
<td>20000</td>
<td>Forwarding</td>
<td>1c98ec-9e4d00</td>
<td>2</td>
<td>Yes</td>
<td>No</td>
</tr>
</tbody>
</table>

CiscoSW1# show spanning-tree
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

<table>
<thead>
<tr>
<th>Interface</th>
<th>Role</th>
<th>Sts</th>
<th>Cost</th>
<th>Prio.Nbr</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gi1/0/3</td>
<td>Root</td>
<td>FWD 4</td>
<td>128</td>
<td>3</td>
<td>P2p</td>
</tr>
<tr>
<td>Gi1/0/4</td>
<td>Altn</td>
<td>BLK 4</td>
<td>128</td>
<td>4</td>
<td>P2p</td>
</tr>
</tbody>
</table>

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

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

Cisco(config)#spanning-tree vlan 1 priority 3

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
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 farm 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
```

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**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

<table>
<thead>
<tr>
<th>Port</th>
<th>Type</th>
<th>Cost</th>
<th>Prio</th>
<th>Designated State</th>
<th>Bridge</th>
<th>Hello</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>10GbE-T</td>
<td>20000</td>
<td>128</td>
<td>Inconsistent</td>
<td>20bbc0-a34c80</td>
<td>2 Yes No</td>
</tr>
<tr>
<td>4</td>
<td>10GbE-T</td>
<td>20000</td>
<td>128</td>
<td>Forwarding</td>
<td>20bbc0-a34c80</td>
<td>2 Yes No</td>
</tr>
</tbody>
</table>