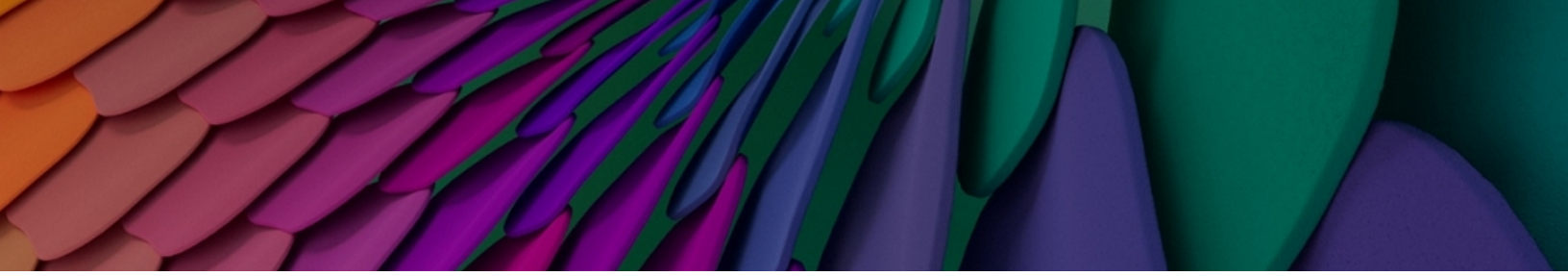

# AOS-CX 10.14 Layer-2 Bridging Guide

## 4100i, 6000, 6100, 6200 Switch Series

aruba
a Hewlett Packard Enterprise company

Published: May 2024
Edition: 1

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# Chapter 1
# About this document

This document describes features of the AOS-CX network operating system. It is intended for administrators responsible for installing, configuring, and managing Aruba switches on a network.

## Applicable products

This document applies to the following products:

- HPE Aruba Networking 4100i Switch Series (JL817A, JL818A)
- HPE Aruba Networking 6000 Switch Series (R8N85A, R8N86A, R8N87A, R8N88A, R8N89A, R9Y03A)
- HPE Aruba Networking 6100 Switch Series (JL675A, JL676A, JL677A, JL678A, JL679A)
- HPE Aruba Networking 6200 Switch Series (JL724A, JL725A, JL726A, JL727A, JL728A, R8Q67A, R8Q68A, R8Q69A, R8Q70A, R8Q71A, R8V08A, R8V09A, R8V10A, R8V11A, R8V12A, R8Q72A, JL724B, JL725B, JL726B, JL727B, JL728B, S0M81A, S0M82A, S0M83A, S0M84A, S0M85A, S0M86A, S0M87A, S0M88A, S0M89A, S0M90A, S0G13A, S0G14A, S0G15A, S0G16A, S0G17A)

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## Command syntax notation conventions

| Convention | Usage |
|---|---|
| `example-text` | Identifies commands and their options and operands, code examples, filenames, pathnames, and output displayed in a command window. Items that appear like the example text in the previous column are to be entered exactly as shown and are required unless enclosed in brackets (**[ ]**). |
| **example-text** | In code and screen examples, indicates text entered by a user. |
| Any of the following:<br>■ *`<example-text>`*<br>■ `<example-text>`<br>■ *`example-text`*<br>■ *example-text* | Identifies a placeholder—such as a parameter or a variable—that you must substitute with an actual value in a command or in code:<br>■ For output formats where italic text cannot be displayed, variables are enclosed in angle brackets (**< >**). Substitute the text—including the enclosing angle brackets—with an actual value.<br>■ For output formats where italic text can be displayed, variables might or might not be enclosed in angle brackets. Substitute the text including the enclosing angle brackets, if any, with an actual value. |

| Convention | Usage |
|---|---|
| `\|` | Vertical bar. A logical **OR** that separates multiple items from which you can choose only one.<br>Any spaces that are on either side of the vertical bar are included for readability and are not a required part of the command syntax. |
| `{ }` | Braces. Indicates that at least one of the enclosed items is required. |
| `[ ]` | Brackets. Indicates that the enclosed item or items are optional. |
| ... or<br>. . . | Ellipsis:<br>■ In code and screen examples, a vertical or horizontal ellipsis indicates an omission of information.<br>■ In syntax using brackets and braces, an ellipsis indicates items that can be repeated. When an item followed by ellipses is enclosed in brackets, zero or more items can be specified. |

# About the examples

Examples in this document are representative and might not match your particular switch or environment.

The slot and port numbers in this document are for illustration only and might be unavailable on your switch.

### Understanding the CLI prompts

When illustrating the prompts in the command line interface (CLI), this document uses the generic term **switch**, instead of the host name of the switch. For example:

```
switch>
```

The CLI prompt indicates the current command context. For example:

```
switch>
```

Indicates the operator command context.

```
switch#
```

Indicates the manager command context.

**switch(*CONTEXT-NAME*)#**

Indicates the configuration context for a feature. For example:

```
switch(config-if)#
```

Identifies the **interface** context.

### Variable information in CLI prompts

In certain configuration contexts, the prompt may include variable information. For example, when in the VLAN configuration context, a VLAN number appears in the prompt:

```
switch(config-vlan-100)#
```

When referring to this context, this document uses the syntax:

```
switch(config-vlan-<VLAN-ID>)#
```

Where <*VLAN-ID*> is a variable representing the VLAN number.

# Identifying switch ports and interfaces

Physical ports on the switch and their corresponding logical software interfaces are identified using the format:
*member/slot/port*

### On the 4100i Switch Series

- *member*: Always 1. VSF is not supported on this switch.
- *slot*: Always 1. This is not a modular switch, so there are no slots.
- *port*: Physical number of a port on the switch.

For example, the logical interface **1/1/4** in software is associated with physical port 4 on the switch.

### On the 6000 and 6100 Switch Series

- *member*: Always 1. VSF is not supported on this switch.
- *slot*: Always 1. This is not a modular switch, so there are no slots.
- *port*: Physical number of a port on the switch.

For example, the logical interface **1/1/4** in software is associated with physical port 4 on the switch.

### On the 6200 Switch Series

- *member*: Member number of the switch in a Virtual Switching Framework (VSF) stack. Range: 1 to 8. The primary switch is always member 1. If the switch is not a member of a VSF stack, then member is 1.
- *slot*: Always 1. This is not a modular switch, so there are no slots.
- *port*: Physical number of a port on the switch.

For example, the logical interface **1/1/4** in software is associated with physical port 4 in slot 1 on member 1.

# Chapter 2
# Introduction

Switches use network bridging to facilitate the interconnection of local area networks (LANs) so that traffic can be exchanged between devices. Bridging occurs at layer 2 of the OSI model.

When creating network bridges on HPE switches, network administrators can configure MAC addressing, VLANs, and various loop prevention protocols.

Devices on a network are identified by their MAC address. The switch maintains a MAC address table where it stores information about the other Ethernet interfaces to which a switch is connected. The table enables the switch to send outgoing data (Ethernet frames) on the specific port required to reach its destination, instead of broadcasting the data on all ports (flooding).

VLANs are primarily used to provide network segmentation at layer 2. VLANs enable the grouping of users by logical function instead of physical location. Layer 2 VLANs can be associated with a single physical port, or multiple aggregated ports (referred to as LAG, short form for Link Aggregation). Link Aggregation enables a logical grouping of individual interfaces to function as a single, higher-speed link, providing dramatically increased bandwidth. This mechanism provides network resiliency when individual link failures occur. Aruba switches include advanced network resiliency through MCLAG (Multi Chassis Link Aggregation) which offers network resiliency on individual device failure as well. MCLAG is not supported in the 6000 and 6100 Switch Series.

When multiple individual links are connected to one another, there is a possibility that multiple paths (loops) will exist between devices. Loops reduce network operational efficiency. AOS-CX provides several features to detect and avoid loops, including:

- MSTP: Multiple-Instance spanning tree protocol (MSTP) ensures that only one active path exists between any two nodes in a spanning tree instance. A spanning tree instance comprises a unique set of VLANs, and belongs to a specific spanning tree region. A region can comprise multiple spanning tree instances (each with a different set of VLANs), and allows one active path among regions in a network.
- RPVST+: Rapid Per VLAN Spanning Tree+ (RPVST+) is an updated implementation of STP (Spanning Tree Protocol). It enables the creation of a separate spanning tree for each VLAN on a switch, and ensures that only one active, loop-free path exists between any two nodes on a given VLAN.
- Loop Protection: In cases where spanning tree protocols cannot be used to prevent loops at the edge of the network, loop protection may provide a suitable alternative. Loop protection can find loops in untagged layer 2 links, as well as on tagged VLANs.

AOS-CX also supports the MVRP (Multiple VLAN Registration Protocol), a registration protocol defined by IEEE, which propagates VLAN information dynamically across devices. It also enables devices to learn and automatically synchronize VLAN configuration information, reducing the configuration workload.

Additionally, AOS-CX supports the Unidirectional Link Detection (UDLD) protocol. UDLD monitors the link between two network devices, and if the link fails, blocks the ports on both ends of the link. UDLD is useful for detecting failures in fiber links and trunks.

# Chapter 3
# MAC address table

The MAC address table is where the switch stores information about the other Ethernet interfaces to which it is connected on a network. The table enables the switch to send outgoing data (Ethernet frames) on the specific port required to reach its destination, instead of broadcasting the data on all ports (flooding).

The MAC address table can contain two types of entries:

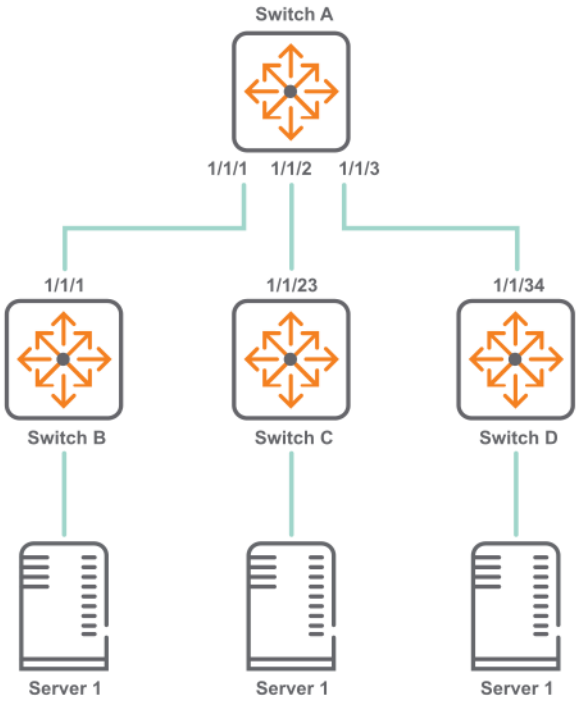
- Static: Static entries are manually added to the table by a switch administrator. Static entries have higher priority than dynamic entries. Static entries remain active until they are removed by the switch administrator.
- Dynamic: Dynamic entries are automatically added to the table through a process called MAC learning, in which the switch retrieves the source MAC address (and VLAN ID, if present) of each Ethernet frame received on a port. If the retrieved address does not exist in the table, it is added. Dynamic entries remain in the table for a predetermined amount of time (defined with the command `mac-address-table age-time`), after which they are automatically deleted.

Dynamic MAC address learning does not distinguish between illegitimate and legitimate frames, which can invite security hazards. When Host A is connected to port A, a MAC address entry will be learned for the MAC address of Host A (for example, MAC A). When an illegal user sends frames with MAC A as the source MAC address to port B, the device performs the following operations:

1. Learns a new MAC address entry with port B as the outgoing interface and overwrites the old entry for MAC A.
2. Forwards frames destined for MAC A out of port B to the illegal user.

As a result, the illegal user obtains the data of Host A. To improve the security for Host A, manually configure a static entry to bind Host A to port A. Then, the frames destined for Host A are always sent out of port A. Other hosts using the forged MAC address of Host A cannot obtain the frames destined for Host A.

For example, in the following topology, switch A learns the MAC addresses of ports on switch B, C, and D. This way, traffic between any two switches is not broadcast to the other switches. For example, if server 1 sends traffic to server 3, it does not get broadcast onto the link to switch C, only on the link to switch D.




# MAC address table commands

## clear mac-address

```
clear mac-address {interface <INTERFACE> | port <PORT-NUM> [vlan <VLAN-ID>] | vlan <VLAN-ID> [port <PORT-NUM>] | <MAC-ADDR> [vlan <VLAN-ID>] [force]| <mac-address mac-move [address <mac-address> vlan <vlan>] | [vlan <VLAN> <VLAN-ID>]}
```

### Description

Clears the dynamic learned MAC addresses on the specified interface, combination of interface and VLAN, port, VLAN, combination of port and VLAN, MAC address, or combination of MAC address and VLAN. The command does not clear any port-security learned MAC addresses.

Port-security MAC addresses are cleared when the port on which the MAC addresses were learned are shut down or the port-access-security feature is disabled on the port or the switch.

| Parameter | Description |
|---|---|
| *<INTERFACE>* | Specifies the list of interfaces, for example, **1/1/1** or **1/1/1-1/1/3** or **lag1** or **vxlan1**. |
| *<PORT-NUM>* | Specifies a physical port on the switch. Format: **member/slot/port**. |
| *<VLAN-ID>* | Specifies the number of a VLAN. |
| *<MAC-ADDR>* | Specifies the MAC address. |
| <mac-address mac-move> | Clears the MAC move count and move history for a specified list or range of VLANs, or for a specific MAC address and VLANs. |

| Parameter | Description |
|---|---|
| | When the MAC address and VLANs are not mentioned, the statistics for all MAC addresses are cleared. |
| `force` | Clears the specified MAC address even if the MAC address is internally programmed by MAC management. |

### Examples

Clearing the learned MAC addresses on a port:

```
switch# clear mac-address port 1/1/1
```

Clearing the learned MAC addresses on a combination of a VLAN and a port:

```
switch# clear mac-address port 1/1/1 vlan 20
```

```
switch# clear mac-address vlan 2 port 1/1/3
```

Clearing the learned MAC addresses on a combination of a VLAN and an interface or a list of interfaces:

```
switch# clear mac-address interface 1/1/1 vlan 10
```

```
switch# clear mac-address vlan 1 interface 1/1/1-1/1/3
```

Clearing the specified MAC addresses entry on the VLAN:

```
switch# clear mac-address 14:FA:01:F1:8B:8F vlan 1
```

Clearing the specified MAC addresses entry by force:

```
switch# clear mac-address 14:FA:01:F1:8B:8F force
```

Clearing the learned MAC move addresses on a port:

```
switch# clear mac-address mac-move
```

Clearing the learned MAC move addresses on a combination of a VLAN and an interface or a list of interfaces:

```
switch# clear mac-address mac-move address 00:00:00:00:00:01 vlan 10
```

Clearing the MAC move addresses entries on the VLAN:

```
switch# clear mac-address mac-move vlan 10-20
```

### Command History

| Release | Modification |
|---|---|
| 10.13 | The **mac-address mac-move** parameter was introduced. |
| 10.09 | Added parameters for interface and MAC address. |
| 10.07 or earlier | -- |

### Command Information

| Platforms | Command context | Authority |
|---|---|---|
| All platforms | Manager (#) | Administrators or local user group members with execution rights for this command. |

## clear mac-address-table

```
clear mac-address-table
   address <mac-address>
   vlan <1-4094>
```

### Description

This command is used to clear the MAC move count and move history for a single MAC address or VLAN, or for a range of VLANs. If no specific MAC address or VLAN is specified, this command clears statistics for all MAC addresses.

| Parameter | Description |
|---|---|
| `address` | (Optional) Clear information for a specific MAC address. |
| *`vlan <1-4094>`* | (Optional) Clear move information for specific VLAN. |

### Examples

Clearing MAC move statistics for all MAC addresses.

```
switch# clear mac-address mac-move
```

Clearing MAC move statistics for MAC addresses in a range of VLANs.

```
switch# clear mac-address mac-move vlan 10-20
```

Clearing MAC move addresses from a specific MAC address and VLAN:

```
switch# clear mac-address mac-move address 00:00:00:00:00:01 vlan 10
```

### Command History

| Release | Modification |
|---|---|
| 10.13 or earlier | Command introduced. |

### Command Information

| Platforms | Command context | Authority |
|---|---|---|
| All platforms | Operator (>) or Manager (#) | Operators or Administrators or local user group members with execution rights for this command. Operators can execute this command from the operator context (>) only. |

## clear mac address mac move

```
clear mac-address mac-move [address <mac-address> vlan <vlan>] | [vlan <VLAN>]
```

### Description

Clears the MAC move count and move history for a specified list or range of VLANs, or for a specific MAC and VLAN.
When MAC and VLAN are not mentioned, it clears statistics for all MACs.

| Parameter | Description |
|---|---|
| *<address>* | Clears information for a specific MAC address. |
| *<vlan>* | Clears mac-move entries on VLANs. |

### Examples

Clearing the learned MAC move addresses on a port:

```
switch# clear mac-address mac-move
```

Clearing the learned MAC move addresses on a combination of a VLAN and an interface or a list of interfaces:

```
switch# clear mac-address mac-move address 00:00:00:00:00:01 vlan 10
```

Clearing the MAC move addresses entries on the VLAN:

```
switch# clear mac-address mac-move vlan 10-20
```

### Command History

| Release | Modification |
|---|---|
| 10.13 | Command introduced |

### Command Information

| Platforms | Command context | Authority |
|---|---|---|
| All platforms | Manager (#) | Administrators or local user group members with execution rights for this command. |

## mac-address-table age-time

```
mac-address-table age-time <SECONDS>
no mac-address-table age-time [<SECONDS>]
```

### Description

Sets the maximum amount of time a MAC address remains in the MAC address table. When this time expires, the MAC address is removed.

The **no** form of this command resets the MAC aging timer to the default value (300 seconds).

| Parameter | Description |
|---|---|
| `age-time <SECONDS>` | Specifies the MAC address aging time in seconds. Range: 60 to 3600. Default: 300. |

### Example

```
switch(config)# mac-address-table age-time 120
```

### Command History

| Release | Modification |
|---|---|
| 10.07 or earlier | -- |

### Command Information

| Platforms | Command context | Authority |
|---|---|---|
| All platforms | `config` | Administrators or local user group members with execution rights for this command. |

## show mac-address-table

```
show mac-address-table
```

### Description

Shows MAC address table information.

### Examples

Showing output when table entries exist:

```
switch# show mac-address-table
MAC age-time             : 300 seconds
Number of MAC addresses : 5

MAC Address          VLAN     Type       Port
-----------------------------------------------------
00:00:00:00:00:05    1        dynamic    1/1/2
00:00:00:00:00:06    2        dynamic    1/1/1
```

Showing output that includes information about an IPv6 VXLAN:

```
3C-T-6300-27# show mac-address-table
MAC age-time             : 300 seconds
Number of MAC addresses : 2
MAC Address          VLAN     Type                      Port
-------------------------------------------------------------------
00:50:56:8d:44:13    1001     dynamic                   1/1/2
00:50:56:8d:45:63    1002     evpn                      vxlan1(1920:1680:1:1::2)
```

Showing output when there are no MAC table entries:

```
switch# show mac-address-table
No MAC entries found.
```

### Command History

| Release | Modification |
|---|---|
| 10.07 or earlier | -- |

### Command Information

| Platforms | Command context | Authority |
|---|---|---|
| All platforms | Operator (>) or Manager (#) | Operators or Administrators or local user group members with execution rights for this command. Operators can execute this command from the operator context (>) only. |

## show mac-address-table address

`show mac-address-table address <MAC-ADDR>`

### Description

Shows MAC address table information for a specific MAC address.

| Parameter | Description |
|---|---|
| *<MAC-ADDR>* | Specifies the MAC address. |

### Example

```
switch# show mac-address-table address 00:00:00:00:00:01
MAC age-time            : 300 seconds
Number of MAC addresses : 2

MAC Address          VLAN     Type       Port
-------------------------------------------------
00:00:00:00:00:01    2        dynamic    1/1/1
00:00:00:00:00:01    1        dynamic    1/1/1
```

### Command History

| Release | Modification |
|---|---|
| 10.07 or earlier | -- |

### Command Information

| Platforms | Command context | Authority |
|---|---|---|
| All platforms | Operator (>) or Manager (#) | Operators or Administrators or local user group members with execution rights for this command. Operators can execute this command from the operator context (>) only. |

## show mac-address-table count

```
show mac-address-table count
     [dynamic | port <PORT-NUM> | vlan <VLAN-ID>]
```

### Description

Displays the number of MAC addresses.

| Parameter | Description |
|---|---|
| `dynamic` | Show the count of dynamically learned MAC addresses. |
| *<PORT-NUM>* | Specifies a physical port on the switch. Format: **member/slot/port**. |
| `vlan` *<VLAN-ID>* | Specifies the number of a VLAN. |

### Examples

Showing the number of MAC addresses:

```
switch# show mac-address-table count
Number of MAC addresses : 8
```

Showing the number of dynamically learned MAC addresses:

```
switch# show mac-address-table count dynamic
Number of MAC addresses : 8
```

Showing the number of MAC addresses per physical port on the switch:

```
switch# show mac-address-table count port 1/1/1
Number of MAC addresses : 2
```

Showing the number of MAC addresses per VLAN:

```
switch# show mac-address-table count vlan 100
Number of MAC addresses : 5
```

### Command History

| Release | Modification |
|---|---|
| 10.07 or earlier | -- |

### Command Information

| Platforms | Command context | Authority |
|---|---|---|
| All platforms | Operator (>) or Manager (#) | Operators or Administrators or local user group members with execution rights for this command. Operators can execute this command from the operator context (>) only. |

## show mac-address-table dynamic

`show mac-address-table dynamic [port <PORT-NUM> | vlan <VLAN-ID>]`

### Description

Shows MAC address table information about dynamically learned MAC addresses.

| Parameter | Description |
|---|---|
| *<PORT-NUM>* | Specifies a physical port on the switch. Format: **member/slot/port**. |
| *<VLAN-ID>* | Specifies the number of a VLAN. |

### Examples

Showing all dynamic MAC address table entries:

```
switch# show mac-address-table dynamic
MAC age-time             : 300 seconds
Number of MAC addresses : 2

MAC Address          VLAN     Type       Port
-------------------------------------------------
00:00:00:00:00:05    1        dynamic    1/1/2
00:00:00:00:00:06    2        dynamic    1/1/1
```

Showing dynamic MAC address table entries for VLAN 1:

```
switch# show mac-address-table dynamic vlan 1
MAC age-time             : 300 seconds
Number of MAC addresses : 1

MAC Address          VLAN     Type       Port
-------------------------------------------------
00:00:00:00:00:05    1        dynamic    1/1/2
```

Showing dynamic MAC address table entries for port **1/1/1**:

```
switch# show mac-address-table dynamic port 1/1/1
MAC age-time             : 300 seconds
Number of MAC addresses : 1

MAC Address          VLAN     Type       Port
-------------------------------------------------
00:00:00:00:00:06    2        dynamic    1/1/1
```

### Command History

| Release | Modification |
|---|---|
| 10.07 or earlier | -- |

### Command Information

| Platforms | Command context | Authority |
|---|---|---|
| All platforms | Operator (>) or Manager (#) | Operators or Administrators or local user group members with execution rights for this command. Operators can execute this command from the operator context (>) only. |

## show mac-address-table interface

`show mac-address-table interface <INTERFACE>`

### Description

Shows the MAC address table entries for the specified interface.

| Parameter | Description |
|---|---|
| *<INTERFACE>* | Specifies an interface or a list of interfaces on the switch. |

### Examples

Showing the MAC address table entries for interface **1/1/1**:

```
switch# show mac-address-table interface 1/1/1
MAC age-time             : 300 seconds
Number of MAC addresses : 1

MAC Address          VLAN     Type       Interface
```

```
------------------------------------------------
00:00:00:00:00:01    2        dynamic    1/1/1
```

### Command History

| Release | Modification |
|---|---|
| 10.09 | Command introduced |

### Command Information

| Platforms | Command context | Authority |
|---|---|---|
| All platforms | Operator (>) or Manager (#) | Operators or Administrators or local user group members with execution rights for this command. Operators can execute this command from the operator context (>) only. |

## show mac-address-table lockout

```
show mac-address-table lockout
```

### Description

Shows MAC lockout table information.

### Examples

```
switch# show mac-address-table lockout
Number of MAC lockout addresses :

2MAC Address          Type
-----------------------------------------
00:00:00:00:01:10    static
00:00:00:00:10:03    static
```

### Command History

| Release | Modification |
|---|---|
| 10.07 or earlier | -- |

### Command Information

| Platforms | Command context | Authority |
|---|---|---|
| All platforms | Operator (>) or Manager (#) | Operators or Administrators or local user group members with execution rights for this command. Operators can execute this command from the operator context (>) only. |

## show mac address table mac move

```
show mac-address-table mac-move [address <mac-address> vlan <vlan>] | [vlan <vlan>]
```

## Description

Displays the MAC entries in the MAC address table that have moved at least once.

The output can be filtered based on a specific VLAN or specific MAC address and VLAN.

| Parameter | Description |
|---|---|
| *<address>* | Displays information for a specific MAC address. |
| *<vlan>* | Displays information for specific VLANs. |

## Examples

Displaying the moved MAC addresses:

```
switch# show mac-address-table mac-move
Number of MAC addresses : 2

MAC Address        VLAN   Current Port    Previous Port   Move Count   Last Move
-------------------------------------------------------------------------------
-------------
00:00:00:00:00:bb  10     1/1/28          1/1/27          2            Fri Sep 15
19:11:52 2023
00:00:00:00:00:aa  10     1/1/27          1/1/28          2            Fri Sep 15
19:11:51 2023

switch# show mac-address-table mac-move address 00:00:00:00:00:aa vlan 10
Number of MAC Move addresses : 1

MAC Address        VLAN   Current Port    Previous Port   Move Count   Last Move
-------------------------------------------------------------------------------
------------
00:00:00:00:00:aa  10     1/1/27          1/1/28          2            Fri Sep 15
19:11:51 2023


switch# show mac-address-table mac-move vlan 10
Number of MAC Move addresses : 2

MAC Address        VLAN   Current Port    Previous Port   Move Count   Last Move
-------------------------------------------------------------------------------
------------
00:00:00:00:00:bb  10     1/1/28          1/1/27          2            Fri Sep 15
19:11:52 2023
00:00:00:00:00:aa  10     1/1/27          1/1/28          2            Fri Sep 15
19:11:51 2023
```

In case of MACs learnt on VXLAN tunnels or "port-access port-security" enabled ports, move scenario is handled by EVPN/port-access feature respectively and it performs the move by deleting the MAC from old port and installing it on new port. Thus, the MAC move data will be removed for the deleted MAC addresses.

## Command History

| Release | Modification |
|---|---|
| 10.13 | Command introduced |

### Command Information

| Platforms | Command context | Authority |
|---|---|---|
| All platforms | Manager (#) | Administrators or local user group members with execution rights for this command. |

## show mac-address-table mac-move

```
show mac-address-table mac-move
   address <mac-address>
   vlan <1-4094>
```

### Description

This command displays the MAC entries in the MAC address table that have moved at least one time. The output of this command can be filtered to display information for a specific VLAN or for a specific MAC address and VLAN.

Users will not be able to view mac-move count for clients that are transitioning between mac-auth enabled ports; however, users will be able to view the mac-move count when clients are transitioning from a mac-auth enabled port to a non-authenticated port.

| Parameter | Description |
|---|---|
| `address` | (Optional) Show move information for a specific MAC address. |
| *`vlan <1-4094>`* | (Optional) Show move information for specific VLAN. |

### Examples

Showing the total number of MAC move addresses:

```
switch# show mac-address-table mac-move
Number of MAC Move addresses : 2

MAC Address        VLAN   Current Port    Previous Port   Move Count   Last Move
-------------------------------------------------------------------------------
------------
00:00:00:00:00:bb  10     1/1/28          1/1/27          2            Fri Sep 15
19:11:52 2023
00:00:00:00:00:aa  10     1/1/27          1/1/28          2            Fri Sep 15
19:11:51 2023
```

Showing the number MAC move addresses on a specific VLAN:

```
switch# show mac-address-table mac-move vlan 10
Number of MAC Move addresses : 2
```

```
MAC Address        VLAN   Current Port    Previous Port   Move Count   Last Move
-------------------------------------------------------------------------------
------------
00:00:00:00:00:bb  10     1/1/28          1/1/27          2            Fri Sep 15
19:11:52 2023
00:00:00:00:00:aa  10     1/1/27          1/1/28          2            Fri Sep 15
19:11:51 2023
```

Showing the number MAC move addresses on a specific MAC address and VLAN:

```
switch# show mac-address-table mac-move address 00:00:00:00:00:aa vlan 10
Number of MAC Move addresses : 1

MAC Address        VLAN   Current Port    Previous Port   Move Count   Last Move
-------------------------------------------------------------------------------
------------
00:00:00:00:00:aa  10     1/1/27          1/1/28          2            Fri Sep 15
19:11:51 2023
```

### Command History

| Release | Modification |
|---|---|
| 10.13 or earlier | Command introduced. |

### Command Information

| Platforms | Command context | Authority |
|---|---|---|
| All platforms | Operator (>) or Manager (#) | Operators or Administrators or local user group members with execution rights for this command. Operators can execute this command from the operator context (>) only. |

## show mac-address-table port

`show mac-address-table port <PORT-NUM>`

### Description

Shows the MAC address table entries for the specified port.

| Parameter | Description |
|---|---|
| *<PORT-NUM>* | Specifies a physical port on the switch. Format: **member/slot/port**. |

### Examples

Showing the MAC address table entries for port **1/1/1**:

```
switch# show mac-address-table port 1/1/1
MAC age-time                : 300 seconds
```

```
Number of MAC addresses : 1

MAC Address          VLAN     Type       Port
-------------------------------------------------
00:00:00:00:00:01    2        dynamic    1/1/1
```

### Command History

| Release | Modification |
|---|---|
| 10.07 or earlier | -- |

### Command Information

| Platforms | Command context | Authority |
|---|---|---|
| All platforms | Operator (>) or Manager (#) | Operators or Administrators or local user group members with execution rights for this command. Operators can execute this command from the operator context (>) only. |

## show mac-address-table static

```
show mac-address-table static
```

### Description

Shows all statically configured MAC addresses.

### Examples

```
switch# show mac-address-table static
Number of MAC addresses : 2

MAC Address          VLAN     Port
-------------------------------------
00:00:00:00:10:02    1        1/1/1
00:00:00:00:10:03    1        1/1/1
```

### Command History

| Release | Modification |
|---|---|
| 10.07 or earlier | -- |

### Command Information

| Platforms | Command context | Authority |
|---|---|---|
| All platforms | Operator (>) or Manager (#) | Operators or Administrators or local user group members with execution rights for this command. Operators can execute this command from the operator context (>) only. |

## show mac-address-table vlan

```
show mac-address-table vlan <VLAN-ID>
```

### Description

Shows MAC addresses learned by or configured on the specified VLAN.

| Parameter | Description |
|---|---|
| `vlan <VLAN-ID>` | Specifies the VLAN ID. |

### Examples

```
switch# show mac-address-table vlan 1
MAC age-time             : 300 seconds
Number of MAC addresses : 1

MAC Address          VLAN     Type       Port
-------------------------------------------------
00:00:00:00:00:01    1        dynamic    1/1/1
```

### Command History

| Release | Modification |
|---|---|
| 10.07 or earlier | -- |

### Command Information

| Platforms | Command context | Authority |
|---|---|---|
| All platforms | Operator (>) or Manager (#) | Operators or Administrators or local user group members with execution rights for this command. Operators can execute this command from the operator context (>) only. |

## static-mac

```
static-mac
   <MAC-ADDR>
   vlan <VLAN-ID> port
   <PORT-NUM>
   workload
   no...
```

### Description

Adds a static MAC address to the MAC address table and associates it with a port or existing VLAN. Static MAC addresses can only be assigned to layer 2 (non-routed) interfaces. Static MAC addresses are not affected by the MAC address aging time.

The **no** form of this command deletes a static MAC address.

| Parameter | Description |
|---|---|
| *<MAC-ADDR>* | Specifies a MAC address (**xx:xx:xx:xx:xx:xx**), where **x** is a |

| Parameter | Description |
|---|---|
| | hexadecimal number from 0 to F. |
| `vlan <VLAN-ID>` | Specifies number of an existing VLAN. |
| `port <PORT-NUM>` | Specifies a physical port on the switch. Format: **member/slot/port**. |

## Examples

```
switch(config)# static-mac 00:00:00:00:00:01 vlan 1 port 1/1/1
switch(config)# no static-mac 00:00:00:00:00:01 vlan 1 port 1/1/1

switch(config)# static-mac 00:00:00:00:00:01 vlan 1 port 1/1/2
1/1/2 is not an L2 port

switch(config)# static-mac 00:00:00:00:00:01 vlan 2 port 1/1/1
VLAN 2 not found
```

## Command History

| Release | Modification |
|---|---|
| 10.07 or earlier | -- |

## Command Information

| Platforms | Command context | Authority |
|---|---|---|
| All platforms | `config` | Administrators or local user group members with execution rights for this command. |

VLANs are primarily used to provide network segmentation at layer 2. VLANs enable the grouping of users by logical function instead of physical location. They make managing bandwidth usage within networks possible by:

- Allowing grouping of high-bandwidth users on low-traffic segments
- Organizing users from different LAN segments according to their need for common resources and individual protocols
- Improving traffic control at the edge of networks by separating traffic of different protocol types.
- Enhancing network security by creating subnets to control in-band access to specific network resources

VLANs are generally assigned on an organizational basis rather than on a physical basis. For example, a network administrator could assign all workstations and servers used by a particular workgroup to the same VLAN, regardless of their physical locations.

Hosts in the same VLAN can directly communicate with one another. A router or a Layer 3 switch is required for hosts in different VLANs to communicate with one another.

VLANs help reduce bandwidth waste, improve LAN security, and enable network administrators to address issues such as scalability and network management.

### Maximum VLANs allowed

| Aruba Switch Series | Maximum VLANs Allowed |
|---|---|
| 6000 | 512 |
| 6100 | 512 |
| 4100i | 512 |
| 6200 | 2048 |

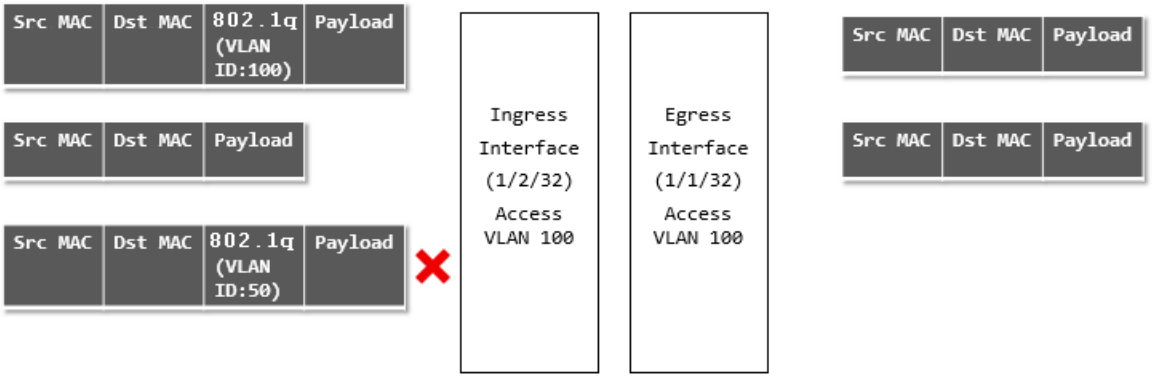
# VLAN interfaces

## Access interface

An access interface carries traffic for a single VLAN ID. Access interfaces are generally used to connect end devices that do not support VLANs to the network. The devices connected to an access interface are not aware of the VLAN. Access interface can carry traffic on only one VLAN, either tagged or untagged.

### Example

This example shows ingress and egress traffic behavior for an access interface.




- An ingress tagged frame with VLAN ID of 100 arrives on interface 1/2/32. The switch accepts this frame and sends it to its target address on interface 1/1/32, where it egresses untagged.
- An ingress untagged frame arrives on interface 1/2/32. The switch accepts this frame and sends it to its target address on interface 1/1/32, where it egresses untagged.
- An ingress tagged frame with VLAN ID of 50 arrives on interface 1/2/32. The switch drops this frame as VLAN ID 50 is not configured on the interface.

## Trunk interface

A trunk interface can carry traffic for one or more VLAN IDs. In most cases, a trunk interface is used to transport data to other switches or routers.

A trunk interface has two important settings:

- Native VLAN: This is the VLAN to which incoming untagged traffic is assigned. Only one VLAN can be assigned as the native VLAN. By default, VLAN 1 is assigned as the native VLAN for all trunk interfaces.
- Allowed VLANs: This is the list of VLANs that can be transported by the trunk. If the native VLAN is not included in the allowed list, all untagged frames that ingress on the trunk interface are dropped.

### Example 1: Native untagged VLAN

This example shows ingress and egress traffic behavior when a trunk interface has a native untagged VLAN.

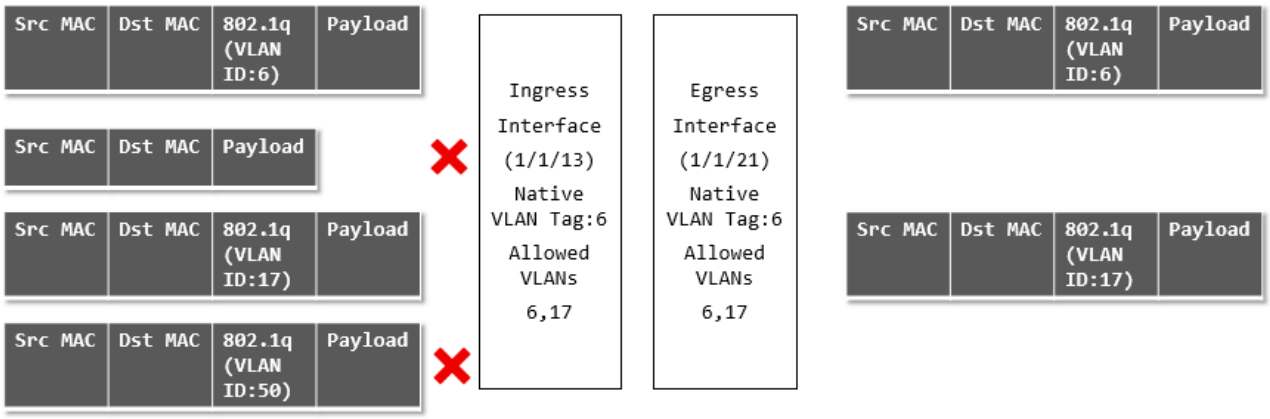

- An ingress tagged frame with VLAN ID of 25 arrives on interface 1/1/1. The switch accepts this frame and sends it to its target address on interface 1/1/2, where it egresses with a VLAN ID of 25 untagged

since port 1/1/2 is configured with a native VLAN ID of 25.

- An ingress untagged frame arrives on interface 1/1/1. The switch accepts this frame and sends it to its target address on interface 1/1/2, where it egresses with a VLAN ID of 25 untagged since port 1/1/2 is configured with a native VLAN ID of 25.
- An ingress tagged frame with VLAN ID of 4 arrives on interface 1/1/1. The switch accepts this frame and sends it to its target address on interface 1/1/2, where it egresses with a VLAN ID of 4 tagged since port 1/1/2 is configured to allow traffic with a VLAN ID of 4.
- An ingress tagged frame with VLAN ID of 50 arrives on interface 1/1/1. The switch drops this frame as VLAN ID 50 is not in the allowed list for interface 1/1/1.

### Example 2: Native tagged VLAN

This example shows ingress and egress traffic behavior when a trunk interface has a native tagged VLAN.




- An ingress tagged frame with VLAN ID of 6 arrives on interface 1/1/13. The switch accepts this frame and sends it to its target address on interface 1/1/21, where it egresses with a VLAN ID of 6 tagged since port 1/1/2 is configured with a native VLAN ID of 6.
- An ingress untagged frame arrives on interface 1/1/13. The switch drops this frame since the interface is configured as native tagged (all untagged frames a dropped in such a configuration).
- An ingress tagged frame with VLAN ID of 17 arrives on interface 1/1/13. The switch accepts this frame and sends it to its target address on interface 1/1/21, where it egresses with a VLAN ID of 17 tagged since port 1/1/2 is configured to allow traffic with a VLAN ID of 17.
- An ingress tagged frame with VLAN ID of 50 arrives on interface 1/1/13. The switch drops this frame as VLAN ID 50 is not in the allowed list for interface 1/1/13.

## Traffic handling summary

| VLAN configuration | Ingress traffic | Egress traffic |
|---|---|---|
| Access interface with:<br>VLAN ID = X | 1. Untagged<br>2. Tagged with VLAN ID = X<br>3. Tagged with any other VLAN ID | 1. Untagged on VLAN X<br>2. Untagged on VLAN X<br>3. Dropped at ingress port itself |
| Trunk interface with:<br>▪ Untagged Native VLAN ID = | 1. Untagged<br>2. Tagged with VLAN ID = X | 1. Untagged on VLAN X<br>2. Untagged on VLAN X |

| VLAN configuration | Ingress traffic | Egress traffic |
|---|---|---|
| X<br>▪ Allowed VLAN IDs = X, Y, Z | 3. Tagged with VLAN ID = Y<br>4. Tagged with VLAN ID = Z<br>5. Tagged with any other VLAN ID | 3. Tagged on VLAN Y<br>4. Tagged on VLAN Z<br>5. Dropped at ingress port itself |
| Trunk interface with:<br>▪ Untagged Native VLAN ID = X<br>▪ Allowed VLAN IDs = ALL | 1. Untagged<br>2. Tagged with VLAN ID = X<br>3. Tagged with a VLAN ID defined on the switch<br>4. Tagged with a VLAN ID not defined on the switch | 1. Untagged on VLAN X<br>2. Untagged on VLAN X<br>3. Tagged on the matching VLAN<br>4. Dropped at ingress port itself |
| Trunk interface with:<br>▪ Tagged Native VLAN ID = X<br>▪ Allowed VLAN IDs = X, Y, Z | 1. Untagged<br>2. Tagged with VLAN ID = X<br>3. Tagged with VLAN ID = Y<br>4. Tagged with VLAN ID = Z<br>5. Tagged with any other VLAN ID | 1. Dropped at ingress port itself<br>2. Tagged on VLAN X<br>3. Tagged on VLAN Y<br>4. Tagged on VLAN Z<br>5. Dropped at ingress port itself |
| Trunk interface with:<br>▪ Tagged Native VLAN ID = X<br>▪ Allowed VLAN IDs = ALL | 1. Untagged<br>2. Tagged with VLAN ID = X<br>3. Tagged with a VLAN ID defined on the switch<br>4. Tagged with a VLAN ID not defined on the switch | 1. Dropped at ingress port itself<br>2. Tagged on VLAN X<br>3. Tagged on the matching VLAN<br>4. Dropped at ingress port itself |
| Trunk interface with:<br>▪ Untagged Native VLAN ID = A<br>▪ Allowed VLAN IDs = X, Y, Z | 1. Untagged<br>2. Tagged with VLAN ID = X<br>3. Tagged with VLAN ID = Y<br>4. Tagged with VLAN ID = Z<br>5. Tagged with any other VLAN ID | 1. Dropped at ingress port itself<br>2. Tagged on VLAN X<br>3. Tagged on VLAN Y<br>4. Tagged on VLAN Z<br>5. Dropped at ingress port itself |

## Comparing VLAN commands on PVOS, Comware, and AOS-CX

The following examples compare the commands needed to implement typical VLAN configurations on different HPE products.

| AOS-CX | PVOS | Comware |
|---|---|---|
| `interface 1/1/1`<br>`vlan trunk native 1`<br>`vlan trunk allowed 10,30,50`<br>A native VLAN must be defined on the switch. By default, this is VLAN 1. Since only VLANs 10, 30, and 50 are allowed on the trunk, all untagged traffic is dropped. | `interface A1`<br>`  tagged vlan 10,30,50`<br>`  no untagged vlan 1` | `Interface G1/0/1`<br>`  port link type trunk`<br>`  port trunk permit vlan 10,30,50`<br>`  port trunk pvid vlan 1`<br>PVID 1 is the default setting. |

| AOS-CX | PVOS | Comware |
|---|---|---|
| `interface 1/1/1`<br>`vlan trunk native 10`<br>`vlan trunk allowed 10,30,50`<br>Same as scenario 1, but allows untagged traffic on VLAN 10 as well. | Not directly supported in PVOS. Scenario 1 is a workaround if there is no need to support untagged traffic. | Not directly supported in Comware. A possible workaround is:<br>`interface g1/0/1`<br>`  port link-mode bridge`<br>`  port link-type hybrid`<br>`  port hybrid protocol-vlan vlan 10`<br>`  port hybrid vlan 10 tagged`<br>`  port hybrid vlan 30 tagged`<br>`  port hybrid vlan 50 tagged` |

| AOS-CX | PVOS | Comware |
|---|---|---|
| `interface 1/1/1`<br>`vlan trunk native 5`<br>`vlan trunk allowed 5, 10,30,50`<br>VLAN 5 must be allowed on the trunk so that untagged traffic is not dropped. | `interface A1`<br>`  untagged vlan 5`<br>`  tagged vlan 10,30,50` | `interface G1/0/1`<br>`  Port link-mode bridge`<br>`  port link-type trunk`<br>`  port trunk pvid vlan 5`<br>`  port trunk permit vlan 5,10,30,50`<br>`link-mode` is only needed on later Comware 7 devices. 5930 is port link-mode route by default. 5900 is bridge by default. |

| AOS-CX | PVOS | Comware |
|---|---|---|
| `interface 1/1/1`<br>`vlan access 5` | `interface A1`<br>`  untagged vlan 5` | `interface G1/0/0`<br>`  port link-mode bridge`<br>`  port access vlan 5` |

## Protocol-mapped VLANs

Not supported on the Aruba 6000, 6100 and 4100i Switch Series.

Protocol-mapped VLANs process traffic based on the specified protocol. An access port can be a part of multiple VLANs with only one VLAN being port-based and others being protocol-mapped VLANS.

- When protocol-mapped VLANs are configured, untagged packets that are ingressing are checked for the protocol type and switched according to the protocol-mapped VLAN configuration for that protocol on the interface.
- If there are no protocol-mapped VLANs configured, all untagged packets are switched as part of the port-based VLAN that is configured. Packets egressing on an access port have no 802.1Q header. Any packet with an 802.1Q header with a non-zero VLAN ID that ingresses on an access port is dropped, except when the VLAN specified in its 802.1Q header matches the VLAN configured on the access port.

## MAC-based VLANs

This feature is supported only in port security enabled platforms.

A port can be a part of multiple VLANs to handle untagged traffic, with only one VLAN being port-based and others being MAC based VLANs, specified by the authentication server.

The source VLAN is determined in the following order of priority:

- Tagged packets (highest priority)
- Mac-based VLANs (port can be untagged to multiple VLANs)
- Protocol VLANs PVID register (port untagged to one VLAN for traffic type)
- Port-membership VLAN (lowest priority)

If protocol VLANs and VLANs from port-access/MBV are configured on a port at the same time, port-access/MBV VLANs take precedence. Protocol based VLANs do not take effect and are ignored.

## VLAN translation

VLAN translation is not supported on the Aruba 4100i, 6000, and 6100 Switch Series.

VLAN translation is used to configure a set of VLAN translation rules on an interface. Once these rules are applied, VLAN-IDs in the incoming and outgoing packets of that interface are mapped to the appropriate VLAN-IDs from the translation rules. This configuration can be used in cases where the VLAN identifiers on the frames need to be modified at the interface.

VLAN translation allows you to configure bidirectional VLAN identifier translation. This allows you to use unique VLAN identifiers internally and maintain legacy VLAN identifiers on logical interfaces. When this configuration is applied on an interface, the ingress traffic for that interface is translated from VLAN1-ID to VLAN2-ID, and the egress traffic for that interface is translated from VLAN2-ID to VLAN1-ID.

For multi-tenancy, VLAN translation is not required on ISL port, so best practices is to configure VLAN translation rules on access ports only.

On the Aruba 6200 Switch Series, If VLAN translations is configured, the trunk allowed list for the VLANs is not honored. Only VLANs that are present as translation VLANs in VT rules, and the native VLAN of the port are respected. Packets that ingress the port with VLANs other than those configured for VLAN translation, are dropped.

If a switch is configured with a VT rule, then traffic must ingress to the device interface with the VLAN with the VT rule. If the traffic ingresses to the device interface with any other VLAN, traffic may be dropped.

### Maximum VLAN translation rules supported

| Aruba Switch Series | Maximum VLAN Translation Rules Supported |
|---|---|
| 6200 | 2000 |

## Assigning a VLAN to an interface

To use a VLAN, it must be assigned to an interface on the switch. VLANs can only be assigned to non-routed (Layer 2) interfaces. All interfaces are non-routed (Layer 2) by default when created. Use `routing` and `no routing` commands to move ports between Layer 3 and Layer 2 interfaces; this makes the port an access port in VLAN 1 by default.

### Assigning a VLAN ID to an access interface

### Prerequisites

At least one defined VLAN.

### Procedure

1. Switch to configuration context with the command `config`.
2. Switch to the interface that you want to define as an access interface with the command `interface`.
3. Configure the access interface and assign a VLAN ID with the command `vlan access`.

### Examples

This example configures interface **1/1/2** as an access interface with VLAN ID set to **20**.

The port must be an L2 port; it can be configured as an L2 port using the command `no routing`.

```
switch# config
switch(config)# vlan 20
switch(config-vlan-20)# exit
switch(config)# interface 1/1/2
switch(config-if)# vlan access 20
```

This example a range of interfaces (**1/1/4-1/1/9**) as an access interface with VLAN ID set to **20**.

```
switch# config
switch(config)# vlan 20
switch(config-vlan-20)# exit
switch(config)#interface 1/1/4-1/1/9
switch(config)# int 1/1/4-1/1/9
switch(config-if-<1/1/4-1/1/9>)# vlan access 20
```

This example configures LAG **1** as an access interface with VLAN ID set to **30**.

```
switch# config
switch(config)# vlan 30
switch(config-vlan-30)# exit
switch(config)# interface lag 1
switch(config-lag-if)# no shutdown
switch(config-lag-if)# vlan access 30
```

## Assigning a VLAN ID to a trunk interface

### Prerequisites

At least one defined VLAN.

### Procedure

1. Switch to configuration context with the command `config`.
2. Switch to the interface that you want to define as a trunk interface with the command `interface`.
3. Configure the trunk interface and assign a VLAN ID with the command `vlan trunk allowed`.

### Examples

This example configures interface **1/1/2** as a trunk interface allowing traffic with VLAN ID set to **20**.

```
switch# config
switch(config)# vlan 20
switch(config-vlan-20)# exit
switch(config)# interface 1/1/2
switch(config-if)# vlan trunk allowed 20
```

This example configures a range of interfaces (**1/1/4-1/1/9**) as a trunk interface with VLAN ID set to **20**.

```
switch# config
switch(config)# vlan 20
switch(config-vlan-20)# exit
switch(config)#interface 1/1/4-1/1/9
switch(config)# int 1/1/4-1/1/9
switch(config-if-<1/1/4-1/1/9>)# vlan trunk allowed 20
```

This example configures interface **1/1/2** as a trunk interface allowing traffic with VLAN IDs **2**, **3**, and **4**.

```
switch# config
switch(config)# vlan 2,3,4
switch(config)# interface 1/1/2
switch(config-if)# vlan trunk allowed 2,3,4
```

This example configures interface **1/1/2** as a trunk interface allowing traffic with VLAN IDs **2** to 8.

```
switch# config
switch(config)# vlan 2-8
switch(config)# interface 1/1/2
switch(config-if)# vlan trunk allowed 2-8
```

This example configures interface **1/1/2** as a trunk interface allowing traffic with VLAN IDs **2 to 8** and **10**.

```
switch# config
switch(config)# vlan 2-8,10
switch(config)# interface 1/1/2
switch(config-if)# vlan trunk allowed 2-8,10
```

This example configures interface **1/1/2** as a trunk interface allowing traffic on all configured VLAN IDs (20-100).

```
switch# config
switch(config)# vlan 20-100
switch(config)# interface 1/1/2
switch(config-if)# vlan trunk allowed all
```

With trunk configuration, when native membership is not specified, the port automatically becomes a native member of VLAN 1.

## Assigning a native VLAN ID to a trunk interface

### Prerequisites

At least one defined VLAN.

### Procedure

1. Switch to configuration context with the command `config`.
2. Switch to the trunk interface to which you want to assign the native VLAN ID with the command `interface`.
3. Assign the native VLAN ID with the command `vlan trunk native`. If tagging is required for the native VLAN, use the command `vlan trunk native tag`.
4. Allow traffic tagged with the native VLAN ID to be transported by the trunk using the command `vlan trunk allowed`.

### Example

This example assigns native VLAN ID **20** to trunk interface **1/1/2**.

```
switch# config
switch(config)# vlan 20
switch(config-vlan-20)# exit
switch(config)# interface 1/1/2
switch(config-if)# vlan trunk native 20
```

This example assigns native VLAN ID **40** to trunk interface **1/1/5**, enables tagging, and allows traffic with VLAN ID 40 to be transported by the trunk.

```
switch# config
switch(config)# vlan 40
switch(config-vlan-40)# exit
switch(config)# interface 1/1/5
switch(config-if)# vlan trunk native 40 tag
switch(config-if)# vlan trunk allow 40
```

# VLAN numbering

VLANs are numbered in the range 1 to 4094. However, a maximum of 2048 (6200 Switch Series) or 512 (6000, 6100 Switch Series) VLANs are supported.

By default, VLAN 1 (the default VLAN) is associated with all interfaces on the switch. VLAN 1 cannot be removed from the switch.

# Configuring VLANs

## Creating and enabling a VLAN

### Procedure

1. Switch to the configuration context with the command `config`.
2. Create a new VLAN with the command `vlan`.

### Example

This example creates **VLAN 10**. The VLAN is enabled by default.

```
switch# config
switch(config)# vlan 10
switch(config-vlan-10)#
```

## Disabling a VLAN

### Procedure

1. Switch to configuration context with the command `config`.
2. Switch to configuration context for the VLAN you want to disable with the command `vlan`.
3. Disable the VLAN with the command `shutdown`.

### Example

This example disables **VLAN 10**.

```
switch(config)# config
switch(config)# vlan 10
switch(config-vlan-10)# shutdown
```

## Viewing VLAN configuration information

### Prerequisites

At least one defined VLAN.

### Procedure

1. View a summary of VLAN configuration information with the command `show vlan summary`.
2. View VLAN configuration settings with the command `show vlan`.
3. View VLANs configured for a specific layer 2 interface with the command `show vlan port`.
4. View the commands used to configure VLAN settings with the command `show running-config interface`.

### Example

This example displays a summary of all VLANs.

```
switch# show vlan summary
Number of existing VLANs   : 2
Number of static VLANs     : 2
Number of dynamic VLANs    : 0
Number of port-access VLANs: 0
```

This example displays configuration information for all defined VLANs.

```
switch# show vlan
--------------------------------------------------------------------------------
-
VLAN  Name             Status  Reason          Type      Interfaces
```

```
--------------------------------------------------------------------------------
-
1     DEFAULT_VLAN_1     up      ok              static    1/1/3-1/1/4
2     UserVLAN1          up      ok              static    1/1/1,1/1/3,1/1/5
3     UserVLAN2          up      ok              static    1/1/2-1/1/3,1/1/5-1/1/6
5     UserVLAN3          up      ok              static    1/1/3
10    TestNetwork        up      ok              static    1/1/3,1/1/5
11    VLAN11             up      ok              static    1/1/3
12    VLAN12             up      ok              static    1/1/3,1/1/6,lag1-lag2
13    VLAN13             up      ok              static    1/1/3,1/1/6
14    VLAN14             up      ok              static    1/1/3,1/1/6
20    ManagementVLAN     down    admin_down      static    1/1/3,1/1/10
```

This example displays configuration information for **VLAN 2**.

```
switch# show vlan 2
--------------------------------------------------------------------------------
-
VLAN  Name                      Status  Reason          Type      Interfaces
--------------------------------------------------------------------------------
-
2     UserVLAN1                 up      ok              static    1/1/1,1/1/3,1/1/5
```

This example displays the VLANs configured on interface **1/1/3**.

```
switch# show vlan port 1/1/3
--------------------------------------------------------------------------------
VLAN  Name                            Mode            Mapping
--------------------------------------------------------------------------------
1     DEFAULT_VLAN_1                  native-untagged port
2     UserVLAN1                       trunk           port
3     UserVLAN2                       trunk           port
5     UserVLAN3                       trunk           port
10    TestNetwork                     trunk           port
11    VLAN11                          trunk           port
12    VLAN12                          trunk           port
13    VLAN13                          trunk           port
14    VLAN14                          trunk           port
20    ManagementVLAN                  trunk           port
30    VLAN30                          trunk           port
40    VLAN40                          trunk           port
50    VLAN50                          trunk           port
100   VLAN100                         trunk           port
200   VLAN200                         trunk           port
```

This example displays VLAN configuration commands for interface **1/1/16**.

```
switch#  show running-config interface 1/1/16
interface 1/1/16
   no routing
   vlan trunk native 108
   vlan trunk allowed all
   exit
```

This example displays VLAN configuration commands for a range of VLANs: **20-30**.

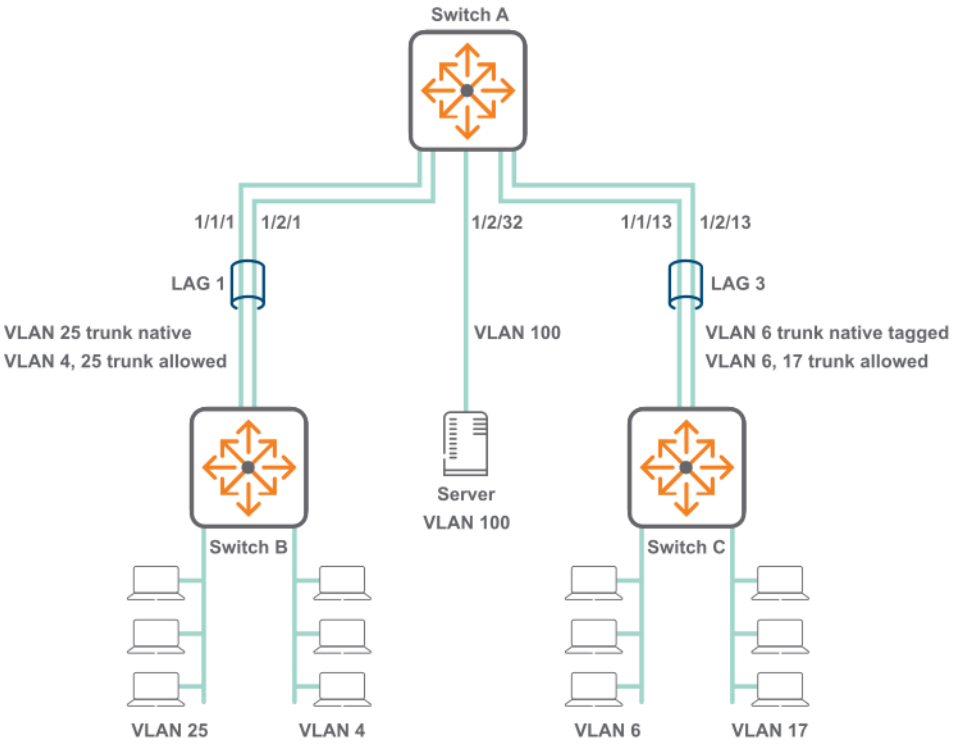
```
Switch(config)# vlan 20-30
Switch(config-vlan-<20-30>)# show vlan

--------------------------------------------------------------------------------
VLAN  Name            Status  Reason                  Type        Interfaces
--------------------------------------------------------------------------------
1     DEFAULT_VLAN_1  down    no_member_forwarding    default     1/3/1-1/3/28,1/5/1-1/5/12,
                                                                  1/6/1-1/6/12
10    VLAN10          down    no_member_port          static
20    VLAN20          down    no_member_port          static
21    VLAN21          down    no_member_port          static
22    VLAN22          down    no_member_port          static
23    VLAN23          down    no_member_port          static
24    VLAN24          down    no_member_port          static
25    VLAN25          down    no_member_port          static
26    VLAN26          down    no_member_port          static
27    VLAN27          down    no_member_port          static
28    VLAN28          down    no_member_port          static
29    VLAN29          down    no_member_port          static
30    VLAN30          down    no_member_port          static
6405(config-vlan-<20-30>)#
```

This example displays VLAN configuration commands for VLANs **15,20,25**.

```
Switch(config)# vlan 15,20,25
Switch(config-vlan-<15,20,25>)# show vlan

--------------------------------------------------------------------------------------------------
--------
VLAN  Name                Status  Reason                  Type        Interfaces

--------------------------------------------------------------------------------------------------
--------
1     DEFAULT_VLAN_1      down    no_member_forwarding    default     1/3/1-1/3/28,1/5/1-
1/5/12,
                                                                                  1/6/1-
1/6/12
15    VLAN15              down    no_member_port          static
20    VLAN20              down    no_member_port          static
25    VLAN25              down    no_member_port          static
switch(config-vlan-<15,20,25>)#
```

# VLAN scenario

This scenario shows how to assign VLAN IDs to access and trunk interfaces for the following deployment:




In this scenario, VLANs are used to isolate the traffic from different devices.

- VLAN 25 carries tagged and untagged traffic from computers connected to switch B.
- VLAN 4 carries tagged traffic from computers connected to switch B.
- VLAN 6 carries tagged and untagged traffic from computers connected to switch C.
- VLAN 17 carries tagged traffic from computers connected to switch C.
- VLAN 100 carries tagged/untagged traffic from the server and only untagged traffic to the server.

### Procedure

1. Execute the following commands on switch A and B.
   a. Create VLANs 4 and 25.

```
switch# config
switch(config)# vlan 4,25
```

   b. Define LAG **1** and assign the VLANs to it.

```
switch(config)# interface lag 1
switch(config-lag-if)# no shutdown
switch(config-lag-if)# vlan trunk native 25
switch(config-lag-if)# vlan trunk allowed 4,25
```

   c. Add ports **1/1/1** and **1/2/1** to LAG **1**.

```
switch(config-lag-if)# interface 1/1/1
switch(config-if)# no shutdown
```

```
switch(config-if)# lag 1
switch(config-if)# interface 1/2/1
switch(config-if)# no shutdown
switch(config-if)# lag 1
```

2. Execute the following commands on switch A and C.
   a. Create VLANs 6 and 17.

```
switch# config
switch(config)# vlan 6,17
```

   b. Define LAG 3 and assign the VLANs to it.

```
switch(config)# interface lag 3
switch(config-lag-if)# no shutdown
switch(config-lag-if)# vlan trunk native 6 tag
switch(config-lag-if)# vlan trunk allowed 6,17
```

   c. Add ports **1/1/13** and **1/2/13** to LAG 3.

```
switch(config-lag-if)# interface 1/1/13
switch(config-if)# no shutdown
switch(config-if)# lag 3
switch(config-if)# interface 1/2/13
switch(config-if)# no shutdown
switch(config-if)# no routing
switch(config-if)# lag 3
```

3. Execute the following commands on switch A to configure the connection to the server. Configure interface **1/2/13** as an access interface with VLAN ID set to 100.

```
switch# config
switch (config)# vlan 100
switch(config-vlan-100)# interface 1/2/32
switch(config-if)# no shutdown
switch(config-if)# vlan access 100
switch(config-if)# exit
```

4. Verify VLAN configuration by running the command `show vlan`. For example:

```
switch# show vlan
-------------------------------------------------------------------------------
VLAN  Name              Status  Reason                Type      Interfaces
-------------------------------------------------------------------------------
1     DEFAULT_VLAN_1    down    no_member_port        default
4     VLAN4             up      ok                    static    lag1
6     VLAN6             up      ok                    static    lag3
17    VLAN17            up      ok                    static    lag3
25    VLAN25            up      ok                    static    lag1
100   VLAN100           up      ok                    static    1/2/32
```

5. Verify that the connection to the DHCP server is sending/receiving data with the command `show interface`. Check that the **Rx** and **Tx** fields are incrementing. For example:

```
switch# show interface 1/2/32
Interface 1/2/32 is up
 Admin state is up
 Description:
 Hardware: Ethernet, MAC Address: 70:72:cf:3a:8a:0b
 MTU 1500
 Type SFP+LR
 qos trust none
 Speed 10000 Mb/s
 Auto-Negotiation is off
 Input flow-control is off, output flow-control is off
 VLAN Mode: access
 Access VLAN: 100

 Rx
            20 input packets              1280 bytes
            0 input error                0 dropped
            0 CRC/FCS
 Tx
            9 output packets             1054 bytes
            0 input error                0 dropped
            0 collision
```

```
switch# show interface 1/1/15
Interface 1/1/15 is up
 Admin state is up
 Link state: up for 1 hour (since Wed Dec 09 04:18:47 UTC 2020)
 Link transitions: 3
Description:
 Hardware: Ethernet, MAC Address: 88:3a:30:47:02:31
 MTU 1500
 Type SFP+SR
 qos trust cos
 Speed 10000 Mb/s
 Auto-Negotiation is off
 Flow-control: off
 Error-control: off
 VLAN Mode: access
 Access VLAN: 100

 Rx
            251 total packets            28975 total bytes
             100 unicast packets
             151 multicast packets
             0 broadcast packets
            0 errors                     0 dropped
            0 CRC/FCS                    0 pause
 Tx
            2486 output packets          319958 total bytes
             100 unicast packets
             2314 multicast packets
             72 broadcast packets
            0 errors                     0 dropped
            0 collision                  0 pause
```

6. Verify LAG interface configuration with the command `show interface`. Check the fields admin state, MAC address, Aggregated-interfaces, VLAN Mode, Native VLAN, Allowed VLAN, Rx count, and Tx count. For example:

```
switch# show interface lag1
Aggregate-name lag1
 Description :
 Admin state           : up
 MAC Address           : 94:f1:28:21:63:00
 Aggregated-interfaces : 1/1/1 1/2/1
 Aggregation-key       : 1
 Speed                 : 1000 Mb/s
 L3 Counters: Rx Disabled, Tx Disabled
 qos trust none
 VLAN Mode: native-untagged
 Native VLAN: 25
 Allowed VLAN List: 4,25
 Rx
            10 input packets             1280 bytes
            0 input error                0 dropped
            0 CRC/FCS
 Tx
            8 output packets             980 bytes
            0 input error                0 dropped
            0 collision
```

```
switch# show interface lag1
Aggregate-name lag1
 Description :
 Admin state           : up
 MAC Address           : f8:60:f0:ca:50:60
 Aggregated-interfaces : 1/1/1 1/1/2
 Aggregation-key       : 1
 Speed                 : 1000 Mb/s
 qos trust cos
 VLAN Mode: native-untagged
 Native VLAN: 25
 Allowed VLAN List: 4,25
 Rx
            11 input packets             913 total bytes
             0 unicast packets
             0 multicast packets
             11 broadcast packets
            0 errors                     0 dropped
            0 CRC/FCS                    0 pause
 Tx
            999 output packets           124533 total bytes
             0 unicast packets
             999 multicast packets
             0 broadcast packets
            0 errors                     0 dropped
            0 collision                  0 pause
```

```
switch# show interface lag3
Aggregate-name lag3
 Description :
 Admin state           : up
```

```
 MAC Address           : 94:f1:28:21:63:00
 Aggregated-interfaces : 1/1/13 1/2/13
 Aggregation-key       : 3
 Speed 1000 Mb/s
 L3 Counters: Rx Disabled, Tx Disabled
 qos trust none
 VLAN Mode: native-tagged
 Native VLAN: 6
 Allowed VLAN List: 6,17
 Rx
            19 input packets              1280 bytes
            0 input error                0 dropped
            0 CRC/FCS
Tx
            15 output packets             1000 bytes
            0 input error                0 dropped
0      Collision
```

a. To check just the LAG interface statistics, you can use the `show interface lag 1 statistics` command:

The following output has been truncated for display purposes and appears differently on the switch.

```
switch(config-if)# sho interface lag1 statistics
-------------------------------------------------
Interface               RX        RX        RX
                        Bytes     Packets   Drops
-------------------------------------------------
1/1/40   - lag1  1663368814276  3249823417      0
lag1             1663368814276  3249823417      0
-------------------------------------------------

Interface                TX         TX           TX
                         Bytes      Packets      Drops
-----------------------------------------------------------
1/1/40   - lag1    2134926620343   4506158466  50555880
lag1               2134926620343   4506158466  50555880
-----------------------------------------------------------

Interface                RX          RX          TX           TX         RX      TX
                         Broadcast   Multicast   Broadcast    Multicast  Pause
Pause
-------------------------------------------------------------------------------------------
-
1/1/40   - lag1             12823       629874   204989954    185789535      0
0
lag1                         12823       629874   204989954    185789535
-------------------------------------------------------------------------------------------
-
```

7. Verify the physical interfaces (1/1/1, 1/2/1, 1/1/13, 1/2/13) with the command `show interface`. Check that the **Rx** and **Tx** fields are incrementing. For example:

```
switch# show interface 1/1/1
Interface 1/1/1 is up
 Admin state is up
 Description:
 Hardware: Ethernet, MAC Address: 94:f1:28:21:73:ff
 MTU 1500
 Type SFP+LR
 qos trust none
 Speed 1000 Mb/s
 Auto-Negotiation is off
 Input flow-control is off, output flow-control is off
 Rx
            6 input packets              620 bytes
            0 input error                0 dropped
            0 CRC/FCS
 Tx
            4 output packets             422 bytes
            0 input error                0 dropped
0      collision
```

8. Verify the lag 1 interface with the command `show running-config`. For example:

```
switch# show running-config interface lag 1
```
```
vlan 1
vlan 2
    name UserVLAN1
vlan 3
    name UserVLAN2
vlan 5
    name UserVLAN3
vlan 10
    name TestNetwork
    voice
    description This is a test only VLAN
vlan 11-14
vlan 20
    name ManagementVLAN
    shutdown
vlan 30,40,50,100,200
trunk-dynamic-vlan-incude
interface lag 1
    no shutdown
    no routing
    vlan access 12
interface lag 2
    no shutdown
    no routing
    vlan access 12
interface 1/1/1
    no shutdown
    no routing
    vlan protocol arp 3
    vlan protocol ipv4 3
    vlan protocol ipv6 5
    vlan access 2
interface 1/1/2
    no shutdown
    no routing
    vlan access 3
```

```
interface 1/1/3
    no shutdown
    no routing
    vlan trunk native 1
    vlan trunk allowed all
interface 1/1/4
    no shutdown
    no routing
    vlan access 1
interface 1/1/5
    no shutdown
    no routing
    vlan trunk native 1
    vlan trunk allowed 2-3,10,20,30,40,50,100
    vlan translate 10 20
    vlan translate 30 40
    vlan translate 50 100
interface 1/1/6
    no shutdown
    no routing
    vlan trunk native 1 tag
    vlan trunk allowed 3,12-14,100,200
    vlan translate 100 200
interface 1/1/10
    no shutdown
    no routing
    vlan access 20
interface 1/1/11
    no shutdown
    lag 1
interface 1/1/12
    no shutdown
    lag 2
```

# UUFB

The Unknown Unicast Flood Block (UUFB) feature controls the flooding of unknown unicast packets. By default, switches flood layer 2 packets to all interfaces within a VLAN if the layer 2 MAC destination address (DA) is not present in the layer 2 forwarding table. In this scenario, UUFB can be used to block unknown unicast flooding on a specific port. UUFB can be typically applied on access ports to prevent flooding of layer 2 packets to other ports within the same VLAN.

UUFB is not supported on 6000 and 6100 Switch Series.

# VLAN commands

## description

`description <DESCRIPTION>`

### Description

Specifies a descriptive for a VLAN.

| Parameter | Description |
|---|---|
| *<DESCRIPTION>* | Specifies a description for the VLAN. |

### Examples

Assigning a description to VLAN **20**:

```
switch(config)# vlan 20
switch(config-vlan-20)# description primary
```

### Command History

| Release | Modification |
|---|---|
| 10.07 or earlier | -- |

### Command Information

| Platforms | Command context | Authority |
|---|---|---|
| All platforms | `config-vlan-`*<VLAN-ID>* | Administrators or local user group members with execution rights for this command. |

## vlan name

`name` *<VLAN-NAME>*

### Description

Associates a name with a VLAN.

| Parameter | Description |
|---|---|
| *<VLAN-NAME>* | Specifies a name for a VLAN. Length: 1 to 32 alphanumeric characters, including underscore (_) and hyphen (-). |

### Usage

- Each named VLAN must have a unique name; there cannot be duplicate names for VLANs.
- By default, VLANs are created with the default name: VLAN *<VLAN-ID>*

### Examples

Assigning the name **backup** to VLAN **20**:

```
switch(config)# vlan 20
switch(config-vlan-20)# name backup
```

### Command History

| Release | Modification |
|---|---|
| 10.07 or earlier | -- |

### Command Information

| Platforms | Command context | Authority |
|---|---|---|
| All platforms | `config-vlan-<VLAN-ID>` | Administrators or local user group members with execution rights for this command. |

## show capacities-status vlan-count

```
show capacities-status vlan-count
```

### Description

Shows the number of VLANs present on the switch and the maximum number of VLANs allowed on the switch.

### Example

Showing switch VLAN capacity status:

```
show capswitch# show capacities-status vlan-count
System Capacities: Filter VLAN count
Capacities Name                                                Value    Maximum
-------------------------------------------------------------------------------
Maximum number of VLANs currently configured                    1        xxxx
```

### Command History

| Release | Modification |
|---|---|
| 10.07 or earlier | -- |

### Command Information

| Platforms | Command context | Authority |
|---|---|---|
| All platforms | Manager (#) | Administrators or local user group members with execution rights for this command. |

## show capacities svi-count

```
show capacities svi-count
```

### Description

Shows the maximum number of SVIs supported by the switch.

### Examples

Showing 6200 switch series SVI capacity:

```
switch# show capacities svi-count
System Capacities: Filter SVI count
Capacities Name                                                    Value
-------------------------------------------------------------------------
Maximum number of SVIs supported in the system                     256
```

Showing 4100i, 6000, and 6100 switch series SVI capacity:

```
switch# show capacities svi-count
System Capacities: Filter SVI count
Capacities Name                                                    Value
-------------------------------------------------------------------------
Maximum number of SVIs supported in the system                     16
```

### Command History

| Release | Modification |
|---|---|
| 10.11 | SVI capacity increased to 256 on the 6200 switch series. |
| 10.07 or earlier | -- |

### Command Information

| Platforms | Command context | Authority |
|---|---|---|
| All platforms | Manager (#) | Administrators or local user group members with execution rights for this command. |

## show capacities vlan-count

```
show capacities vlan-count
```

### Description

Shows the maximum number of VLANs allowed on the switch.

### Example

Showing switch VLAN capacity:

```
show capswitch# show capacities vlan-count
System Capacities: Filter VLAN count
Capacities Name                                                    Value
-------------------------------------------------------------------------
Maximum number of VLANs supported in the system                     4094
```

### Command History

| Release | Modification |
|---|---|
| 10.07 or earlier | -- |

### Command Information

| Platforms | Command context | Authority |
|---|---|---|
| All platforms | Manager (#) | Administrators or local user group members with execution rights for this command. |

## show capacities-status vlan-translation

```
show capacities-status vlan-translation
```

### Description

Shows the number of VLAN translation rules present on the switch and the maximum number of VLAN translation rules allowed on the switch. The maximum number of VLAN translation rules allowed are 2000.

### Example

Showing switch VLAN translation rules capacity:

```
switch(config-vlan-100)# show capacities vlan-translation
System Capacities: Filter VLAN Translation
Capacities Name                                                    Value
-------------------------------------------------------------------------
Maximum number of VLAN Translation rules supported                  2000
switch(config-vlan-100)#
switch(config-vlan-100)#
switch(config-vlan-100)#
switch(config-vlan-100)#
switch(config-vlan-100)# show capacities-st vlan-translation

System Capacities Status: Filter VLAN Translation
Capacities Status Name                                  Value Maximum
-------------------------------------------------------------------------
Number of VLAN Translation rules currently configured       1  2000
```

### Command History

| Release | Modification |
|---|---|
| 10.07 or earlier | -- |

### Command Information

| Platforms | Command context | Authority |
|---|---|---|
| 6200 | Manager (#) | Administrators or local user group members with execution rights for this command. |

## show system internal-vlan-range

```
show system internal-vlan-range
```

### Description

Shows the VLAN range reserved for internal use.

### Examples

Showing reserved VLANs:

*(for 6200 Series switches)*

```
switch(config)# show system internal-vlan-range
Internal VLAN range:           0-0
```

### Command History

| Release | Modification |
|---|---|
| 10.08 | The 6200 Switch Series introduces support for this command. |
| 10.07 or earlier | -- |

### Command Information

| Platforms | Command context | Authority |
|---|---|---|
| 6200 | Manager (#) | Administrators or local user group members with execution rights for this command. |

## show vlan

```
show vlan [<VLAN-ID>]
```

### Description

Displays configuration information for all VLANs or a specific VLAN.

| Parameter | Description |
|---|---|
| *<VLAN-ID>* | Specifies a VLAN ID. |

### Examples

Displaying configuration information for VLAN **2**:

```
switch# show vlan 2
-------------------------------------------------------------------------------
VLAN  Name                      Status  Reason          Type      Interfaces
-------------------------------------------------------------------------------
2     UserVLAN1                 up      ok              static    1/1/1,1/1/3,1/1/5
```

Displaying configuration information for all defined VLANs:

```
switch# show vlan
-------------------------------------------------------------------------------
VLAN  Name                  Status  Reason        Type      Interfaces
-------------------------------------------------------------------------------
-
1     DEFAULT_VLAN_1        up      ok            static    1/1/3-1/1/4
2     UserVLAN1             up      ok            static    1/1/1,1/1/3,1/1/5
3     UserVLAN2             up      ok            static    1/1/2-1/1/3,1/1/5-1/1/6
```

```
5     UserVLAN3            up      ok            static    1/1/3
10    TestNetwork          up      ok            static    1/1/3,1/1/5
11    VLAN11               up      ok            static    1/1/3
12    VLAN12               up      ok            static    1/1/3,1/1/6,lag1-lag2
13    VLAN13               up      ok            static    1/1/3,1/1/6
14    VLAN14               up      ok            static    1/1/3,1/1/6
20    ManagementVLAN       down    admin_down    static    1/1/3,1/1/10
```

Displaying configuration information for auto-vlan:

```
switch# show vlan
--------------------------------------------------------------------------------
VLAN  Name         Status  Reason        Type        Interfaces
--------------------------------------------------------------------------------
--------------------------------
23    VLAN23       up       ok        port-access    1/1/1
```

### Command History

| Release | Modification |
|---|---|
| 10.07 or earlier | -- |

### Command Information

| Platforms | Command context | Authority |
|---|---|---|
| All platforms | Manager (#) | Operators or Administrators or local user group members with execution rights for this command. Operators can execute this command from the operator context (>) only. |

## show vlan port

`show vlan port <INTERFACE-ID>`

### Description

Displays the VLANs configured for a specific layer 2 interface.

| Parameter | Description |
|---|---|
| *<INTERFACE-ID>* | Specifies an interface ID. Format: **member/slot/port**. |

### Examples

Displaying the VLANs configured on interface **1/1/1**:

```
switch# show vlan port 1/1/1
--------------------------------------------------------------------------------
VLAN  Name                            Mode            Mapping
--------------------------------------------------------------------------------
2     UserVLAN1                       access          port
```

```
3     UserVLAN2                       access          arp,ipv4
5     UserVLAN5                       access          ipv6
```

Displaying RADIUS server provided VLAN 2,3,5 as extended access VLANs (MBV):

```
switch# show vlan port 1/1/1
---------------------------------------------------------------------------
VLAN  Name                            Mode            Mapping
---------------------------------------------------------------------------
2     UserVLAN1                       access          mbv, port
3     UserVLAN2                       access          mbv
5     UserVLAN5                       access          mbv

Overriden VLAN list: 2-3,5
```

Displaying RADIUS server provided VLAN 50 as access VLAN and mode as access:

```
switch# show vlan port 1/1/1
---------------------------------------------------------------------------
VLAN  Name                            Mode            Mapping
---------------------------------------------------------------------------
50    VLAN50                          access          port-access

Overridden VLAN list: 2-3,5
```

Displaying RADIUS server provided VLAN 50 as access VLAN and mode as access, and 2,3 as extended access VLANs (MBV):

```
switch# show vlan port 1/1/1
---------------------------------------------------------------------------
VLAN  Name                            Mode            Mapping
---------------------------------------------------------------------------
2     UserVLAN1                       access          mbv
3     UserVLAN2                       access          mbv
50    VLAN50                          access          port-access

Overridden VLAN list: 2-3,5
```

Displaying RADIUS server provided mode as native-untagged, 11-14 as trunk VLANs, VLAN 11 as an access VLAN and VLAN 2, 3 as extended access VLANs (MBV):

```
switch# show vlan port 1/1/1
---------------------------------------------------------------------------
VLAN  Name                            Mode            Mapping
---------------------------------------------------------------------------
2     UserVLAN1                       access          mbv
3     UserVLAN2                       access          mbv
11    VLAN11                          native-untagged port-access
12    VLAN12                          trunk           port-access
13    VLAN13                          trunk           port-access
14    VLAN14                          trunk           port-access

Overridden VLAN list: 2-3,5
```

Displaying RADIUS server provided mode as native-tagged, 11-14 as trunk VLANs, VLAN 11 as an access VLAN and VLAN 2, 3 as extended access VLANs (MBV):

```
switch# show vlan port 1/1/1
--------------------------------------------------------------------------------
VLAN  Name                            Mode            Mapping
--------------------------------------------------------------------------------
2     UserVLAN1                       native-untagged mbv, port
3     UserVLAN2                       access          mbv
11    VLAN11                          trunk           port-access
12    VLAN12                          trunk           port-access
13    VLAN13                          trunk           port-access
14    VLAN14                          trunk           port-access

Overridden VLAN list: 3,5
```

Displaying RADIUS server provided mode as native-tagged, 3, 11-14 as trunk VLANs, VLAN 11 as an access VLAN and VLAN 2, 3 as extended access VLANs (MBV):

```
switch# show vlan port 1/1/1
--------------------------------------------------------------------------------
VLAN  Name                            Mode            Mapping
--------------------------------------------------------------------------------
2     UserVLAN1                       native-untagged mbv, port
3     UserVLAN2                       native-untagged port-access, mbv
11    VLAN11                          trunk           port-access
12    VLAN12                          trunk           port-access
13    VLAN13                          trunk           port-access
14    VLAN14                          trunk           port-access

Overridden VLAN list: 3,5
```

Displaying RADIUS server provided mode as native-tagged, 2, 11-14 as trunk VLANs, VLAN 11 as an access VLAN:

```
switch# show vlan port 1/1/1
--------------------------------------------------------------------------------
VLAN  Name                            Mode            Mapping
--------------------------------------------------------------------------------
2     UserVLAN1                       trunk           port-access
11    VLAN11                          native-tagged   port-access
12    VLAN12                          trunk           port-access
13    VLAN13                          trunk           port-access
14    VLAN14                          trunk           port-access

Overridden VLAN list: 2-3,5
```

Displaying the VLANs configured on interface **1/1/3**:

```
switch# show vlan port 1/1/3
--------------------------------------------------------------------------------
VLAN  Name                            Mode            Mapping
--------------------------------------------------------------------------------
1     DEFAULT_VLAN_1                  native-untagged port
2     UserVLAN1                       trunk           port
3     UserVLAN2                       trunk           port
```

```
5     UserVLAN3                      trunk           port
10    TestNetwork                    trunk           port
11    VLAN11                         trunk           port
12    VLAN12                         trunk           port
13    VLAN13                         trunk           port
14    VLAN14                         trunk           port
20    ManagementVLAN                 trunk           port
30    VLAN30                         trunk           port
40    VLAN40                         trunk           port
50    VLAN50                         trunk           port
100   VLAN100                        trunk           port
200   VLAN200                        trunk           port
```

Displaying RADIUS server provided VLANs 2,11-14 as trunk VLANs, VLAN 2 as an access VLAN, and mode as native-untagged:

```
switch# show vlan port 1/1/3
--------------------------------------------------------------------------------
VLAN  Name                           Mode            Mapping
--------------------------------------------------------------------------------
2     UserVLAN1                      native-untagged port-access
11    VLAN11                         trunk           port-access
12    VLAN12                         trunk           port-access
13    VLAN13                         trunk           port-access
14    VLAN14                         trunk           port-access

Overridden VLAN list: 1-3,5,10-14,20,30,40,50,100,200
```

### Command History

| Release | Modification |
|---|---|
| 10.07 or earlier | -- |

### Command Information

| Platforms | Command context | Authority |
|---|---|---|
| All platforms | Manager (#) | Operators or Administrators or local user group members with execution rights for this command. Operators can execute this command from the operator context (>) only. |

## show vlan summary

```
show vlan summary
```

### Description

Displays a summary of the VLAN configuration on the switch.

### Examples

Displaying a summary of the VLAN configuration on the switch:

```
switch# show vlan summary
Number of existing VLANs: 11
Number of static VLANs:   11
Number of dynamic VLANs:  0
Number of port-access VLANs: 1
```

### Command History

| Release | Modification |
|---|---|
| 10.07 or earlier | -- |

### Command Information

| Platforms | Command context | Authority |
|---|---|---|
| All platforms | Manager (#) | Operators or Administrators or local user group members with execution rights for this command. Operators can execute this command from the operator context (>) only. |

## show vlan voice

```
show vlan voice
```

### Description

Displays the voice VLAN list showing the VLAN ID, name, operational state of the VLAN, and the interfaces associated with the VLAN.

### Example

Displaying the voice VLANs list :

```
switch# show vlan voice
------------------------------------------------------------------------------
------------
VLAN  Name                            Status               Type      Interfaces
------------------------------------------------------------------------------
------------
10    TestNetwork                     up                   static
1/1/3,1/1/5
```

Displaying the information when voice VLANs are not configured:

```
switch# show vlan voice
Voice VLAN not configured
```

### Command History

| Release | Modification |
|---|---|
| 10.07 or earlier | -- |

### Command Information

| Platforms | Command context | Authority |
|---|---|---|
| All platforms | Manager (#) | Operators or Administrators or local user group members with execution rights for this command. Operators can execute this command from the operator context (>) only. |

## shutdown

```
shutdown
no shutdown
```

### Description

Disables a VLAN. (By default, a VLAN is automatically enabled when it is created with the **vlan** command.)

The **no** form of this command enables a VLAN.

### Examples

Enabling VLAN 20:

```
switch(config)# vlan 20
switch(config-vlan-20)# no shutdown
```

Disabling VLAN 20:

```
switch(config)# vlan 20
switch(config-vlan-20)# shutdown
```

### Command History

| Release | Modification |
|---|---|
| 10.07 or earlier | -- |

### Command Information

| Platforms | Command context | Authority |
|---|---|---|
| All platforms | config-vlan-*<VLAN-ID>* | Administrators or local user group members with execution rights for this command. |

## system internal-vlan-range

```
system internal-vlan-range {<VLAND-ID>-<VLAN-ID>} [confirm]
no system internal-vlan-range {<VLAND-ID>-<VLAN-ID>} [confirm]
```

### Description

Configures the VLAN range reserved for internal use for route-only ports and LAGs. The internal VLAN range cannot include any VLANs that are already in use.

If the number of internal VLANs is less than the number of route-only ports and LAGs, some ports will be blocked and unable to be used. When the internal VLAN range is modified, traffic on route-only ports and LAGs is briefly interrupted while they are moved to the new range.

The **no**' form of this command sets the range to the default range:

- 6200 Switch series: 0 to 0

| Parameter | Description |
|---|---|
| *<VLAND-ID>-<VLAN-ID>* | Specifies the starting and ending VLAN number for the range. The reserved range must be between 2 and 4094 and cannot exceed 256 VLANs. |
| `confirm` | Automatically acknowledge warning and skip confirmation prompt. |

### Examples

Setting a new internal VLAN range:

```
switch(config)# system internal-vlan-range 3041-3094
This will briefly interrupt traffic.

Continue (y/n)?
```

Setting a new internal VLAN range, skipping the prompt:

```
switch(config)# system internal-vlan-range 3041-3094 confirm
```

Removing all internal VLANs:

```
switch(config)# no system internal-vlan-range
```

### Command History

| Release | Modification |
|---|---|
| 10.08 | The 6200 Switch Series introduces support for this command. |
| 10.07 or earlier | -- |

### Command Information

| Platforms | Command context | Authority |
|---|---|---|
| 6200 | `config` | Administrators or local user group members with execution rights for this command. |

## system vlan-client-presence-detect

```
system vlan-client-presence-detect
no system vlan-client-presence-detect
```

### Description

Enables VNI mapped VLANs when detecting the presence of a client. When enabled, VNI mapped VLANs are *up* only if there are authenticated clients on the VLAN, or if the VLAN has statically configured ports and those ports are *up*. When not enabled, VNI mapped VLANs are always *up*.

The **no** form of this command disables detection of clients on VNI mapped VLANs.

### Examples

Enabling detection of clients:

```
switch(config)# system vlan-client-presence-detect
```

Disabling detection of clients:

```
switch(config)# no system vlan-client-presence-detect
```

### Command History

| Release | Modification |
|---|---|
| 10.07 or earlier | -- |

### Command Information

| Platforms | Command context | Authority |
|---|---|---|
| 4100i<br>6000<br>6100<br>6200 | `config` | Administrators or local user group members with execution rights for this command. |

## system private-vlan share-hw-resource

```
system private-vlan share-hw-resource
no system private-vlan share-hw-resource
```

### Description

Enables hardware resource sharing for private VLAN (PVLAN) secondary ports and enables you to configure additional secondary ports beyond the capacity limit.

There are no parameters for this command.

The **no** form of this command turns off the hardware resource sharing mode for PVLAN.

### Examples

Configure PVLAN default mode :

```
switch(config)# system private-vlan share-hw-resource
```

Unconfigure PVLAN default mode:

```
switch(config)# no system private-vlan share-hw-resource
```

### Command History

| Release | Modification |
|---|---|
| 10.14 | Command introduced. |

### Command Information

| Platforms | Command context | Authority |
|---|---|---|
| 6200 | `config-if`<br>`config-pa-role` | Administrators or local user group members with execution rights for this command. |

## trunk-dynamic-vlan-include

```
trunk-dynamic-vlan-include
no trunk-dynamic-vlan-include
```

### Description

Indicates if dynamically learned VLANs from MVRP and port-access should be included or excluded on ports configured with **vlan trunk allowed all**. By default, dynamic VLANs are not included in the trunk allowed list. This command is used at the system-level.

The **no** form of this command disables the inclusion of dynamic VLANs in the VLANs table. This is the default.

### Examples

Including the dynamic VLANs in the VLAN table:

```
switch(config)# trunk-dynamic-vlan-include
```

Disabling the inclusion of dynamic VLANs in the VLAN table (default):

```
switch(config)# no trunk-dynamic-vlan-include
```

### Command History

| Release | Modification |
|---|---|
| 10.08 | Command introduced |

### Command Information

| Platforms | Command context | Authority |
|---|---|---|
| All platforms | `config` | Administrators or local user group members with execution rights for this command. |

# uufb

```
uufb
no uufb
```

### Description

Enables the Unknown Unicast Flood Block (UUFB) feature on a physical interface. When this feature is enabled on a physical interface, unknown unicast packets are blocked from egressing the physical interface. This feature is disabled by default.

UUFB can be enabled only on the physical interface.

UUFB cannot be enabled on:

- Routed interface
- LAGs
- VSX inter-switch link
- Interface used as an ISL

### Examples

Enabling UUFB on an L2 access port:

```
switch(config)# interface 1/1/1
switch(config-if)# vlan access 1
switch(config-if)# uufb
```

Enable UUFB on an L2 trunk port:

```
switch(config)# interface 1/1/1
switch(config-if)# vlan trunk allowed all
switch(config-if)# uufb
```

Disabling UUFB on an L2 access or trunk port:

```
switch(config-if)# no uufb
```

### Command History

| Release | Modification |
|---|---|
| 10.11 | Command introduced. |

### Command Information

| Platforms | Command context | Authority |
|---|---|---|
| 4100i<br>6200 | config-if | Administrators or local user group members with execution rights for this command. |

# vlan

```
vlan <VLAN-LIST>
no vlan <VLAN-LIST>
```

### Description

Creates a VLAN and changes to the **config-vlan-id** context for the VLAN. By default, the VLAN is enabled. To disable a VLAN, use the **shutdown** command.

If the specified VLAN exists, this command changes to the **config-vlan-id** context for the VLAN. If a range of VLANs is specified, the context does not change.

VLANs used for internal purposes using the command **system internal vlan range** cannot be used for any other (L2) purposes.

The **no** form of this command removes a VLAN. VLAN 1 is the default VLAN and cannot be deleted.

| Parameter | Description |
|---|---|
| *<VLAN-LIST>* | Specifies a single ID, or a series of IDs separated by commas (2, 3, 4), dashes (2-4), or both (2-4,6). Range: 1 to 4094. A maximum of 2048 (6200 Switch Series)512 (6000, 6100 Switch Series) VLANs are supported. |

### Examples

Creating VLAN **20**:

```
switch(config)# vlan 20
switch(config-vlan-20)#
```

Removing VLAN **20**:

```
switch(config)# no vlan 20
```

Creating VLANs **2** to **8** and **10**:

```
switch(config)# vlan 2-8,10
```

Removing VLANs **2** to **8** and **10**:

```
switch(config)# no vlan 2-8,10
```

Creating a VLAN which is already configured as an internal VLAN:

```
switch(config)# vlan 3001
Ignoring the operation on internal VLAN(s) 3001.
```

Deleting an unconfigured VLAN which is already configured as internal VLAN:

```
switch(config)# no vlan 300
```

```
Ignoring the operation for non-configured VLAN(s) 300.
```

### Command History

| Release | Modification |
|---|---|
| 10.07 or earlier | -- |

### Command Information

| Platforms | Command context | Authority |
|---|---|---|
| All platforms | `config` | Administrators or local user group members with execution rights for this command. |

## vlan access

```
vlan access <VLAN-ID>
no vlan access [<VLAN-ID>]
```

### Description

Creates an access interface and assigns an VLAN ID to it. Only one VLAN ID can be assigned to each access interface.

VLANs can only be assigned to non-routed (Layer 2) interfaces. All interfaces are non-routed (Layer 2) by default when created. Use **routing** and **no routing** commands to move ports between Layer 3 and Layer 2 interfaces.

The **no** form of this command removes an access VLAN from the interface in the current context and sets it to the default VLAN ID of 1.

### Command context

| Parameter | Description |
|---|---|
| *<VLAN-ID>* | Specifies a single ID, or a series of IDs separated by commas (2, 3, 4), dashes (2-4), or both (2-4,6). Range: 1 to 4094. A maximum of 2048 (6200 Switch Series) 512 (6000, 6100 Switch Series) VLANs are supported. |

### Examples

Configuring interface **1/1/2** as an access interface with VLAN ID set to **20**:

```
switch(config)# interface 1/1/2
switch(config-if)# vlan access 20
```

Removing VLAN ID **20** from interface **1/1/2**:

```
switch(config)# interface 1/1/2
switch(config-if)# no vlan access 20
```

or:

```
switch(config)# interface 1/1/2
switch(config-if)# no vlan access
```

### Command History

| Release | Modification |
|---|---|
| 10.07 or earlier | -- |

### Command Information

| Platforms | Command context | Authority |
|---|---|---|
| All platforms | config-if | Administrators or local user group members with execution rights for this command. |

## vlan protocol

```
vlan protocol <PROTOCOL_NAME> <VLAN-ID>
no vlan protocol <PROTOCOL_NAME> <VLAN-ID>
```

### Description

Adds protocol mapping to a VLAN on an interface.

The **no** form of this command removes protocol mapping from the VLAN on an interface.

| Parameter | Description |
|---|---|
| *<VLAN-ID>* | Specifies a VLAN ID. Range: 2 to 4094. |
| *<PROTOCOL_NAME>* | Specifies the protocol that the VLAN is bound to for a given interface. Options are: **appletalk**, **arp**, **ip**, **ipv6**, **ipx**, **netbui**, and **sna**. |

### Usage

- This command is only applicable to access ports.
- Protocol VLAN should be different from access VLANs.
- VLAN should be configured on the switch.
- Routing must be disabled on the interface.
- Interface must be a physical or LAG interface.
- The same protocol-mapped VLAN is recommended for ARP and IPv4 protocols to avoid IPv4 traffic loss.

### Examples

Assigning a protocol mapping to a VLAN on an interface:

```
switch(config)# interface 1/1/2
switch(config-if)# vlan protocol ip 10
```

Assigning a protocol mapping to a VLAN on a LAG interface:

```
switch(config)# interface lag 2
switch(config-lag-if)# vlan protocol ipv6 10
```

Removing a protocol mapping from a VLAN on an interface:

```
switch(config)# interface 1/1/2
switch(config-if)# no vlan protocol ipv6 10
```

Removing a protocol mapping from a VLAN on a LAG interface:

```
switch(config)# interface lag 2
switch(config-lag-if)# no vlan protocol ipv6 10
```

### Command History

| Release | Modification |
|---|---|
| 10.14 | Replaced the **ipv4** parameter with the **ip** parameter. The **ipv4** parameter is deprecated. |
| 10.07 or earlier | -- |

### Command Information

| Platforms | Command context | Authority |
|---|---|---|
| 6200 | `config-if`<br>`config-lag-if` | Administrators or local user group members with execution rights for this command. |

## vlan translate

```
vlan translate <VLAN-1> <VLAN-2>
no vlan translate <VLAN-1> <VLAN-2>
```

### Description

Defines a bidirectional VLAN translation rule that maps an original VLAN ID (VLAN-1) to a translated internal VLAN ID (VLAN-2) on a LAG or layer 2 interface. Applies to both incoming and outgoing traffic.

On the Aruba 6200 Switch Series: Traffic for translated VLANs and native VLAN is allowed, and VLANs which are part of the VLAN trunk allowed list are blocked.

The **no** form of this command removes an existing VLAN translation rule on the current interface.

VLAN translation and MVRP cannot be enabled on the same interface.

A port with a VLAN translation configuration allows traffic only for the translated VLAN and the native VLAN; if it is a member of more VLANS, it does not allow traffic for them.

A translated VLAN must be present on the switch before the rule is created; the original VLAN need not be present.

| Parameter | Description |
|---|---|
| *<VLAN-1>* | |
| *<VLAN-2>* | |

### Usage

- This configuration can be applied only on layer 2 trunk ports.
- Routing must be disabled on the interface.
- Interface must be a layer 2 physical or LAG interface.
- This configuration is supported only on 24 ports.
- Maximum unique VLAN translation rules supported on the Aruba 6200 Switch Series—2000
- For a given port, VLAN translation cannot be applied if there are any Private-VLAN (PVLAN) configuration(s) on the switch (applies to Aruba 6200 Switch Series). VLAN translation and PVLANs are mutually exclusive features.

### Examples

Translates origin VLAN **200** to translated VLAN **20** on interface **1/1/2**.

```
switch# config
switch(config)# vlan 20
switch(config-vlan-20)# exit
switch(config)# interface 1/1/2
switch(config-if)# no routing
switch(config-if)# vlan trunk allowed 20
switch(config-if)# vlan translate 200 20
```

Translates origin VLANs **100** and **300** to translated VLANs **10** and **20** on interface **1/1/2**.

```
switch# config
switch(config)# vlan 10,30
switch(config-vlan-20)# exit
switch(config)# interface 1/1/2
switch(config-if)# no routing
switch(config-if)# vlan trunk allowed 10,30
switch(config-if)# vlan translate 100 10
switch(config-if)# vlan translate 300 30
```

Though VLAN translation is not supported on Native VLAN configurations, a translation rule will be created to ensure VLAN translation works when the native VLAN is updated. These rules appear in the output of the **show running-config** command, though they are not operational.

```
(config)# interface 1/1/4
switch (config-if)# vlan translate 10 2
Warning: Operation not allowed on native VLAN 1
switch(config-if)# show runing-config current-context
interface 1/1/1
no shutdown
no routing
```

```
vlan trunk native 1
vlan trunk allowed all
vlan translate 1 2 <<< non-functional translation rules
```

### Command History

| Release | Modification |
|---|---|
| 10.07 or earlier | -- |

### Command Information

| Platforms | Command context | Authority |
|---|---|---|
| 6200 | `config-if` | Administrators or local user group members with execution rights for this command. |

## vlan trunk allowed

```
vlan trunk allowed [<VLAN-LIST> | all]
no vlan trunk allowed [<VLAN-LIST>]
```

### Description

Assigns a VLAN ID to an trunk interface. Multiple VLAN IDs can be assigned to a trunk interface. These VLAN IDs define which VLAN traffic is allowed across the trunk interface.

VLANs can only be assigned to non-routed (Layer 2) interfaces. All interfaces are non-routed (Layer 2) by default when created. Use **routing** and **no routing** commands to move ports between Layer 3 and Layer 2 interfaces.

The **no** form of this command removes one or more VLAN IDs from a trunk interface. When the last VLAN is removed from a trunk interface, the interface continues to operate in trunk mode, and will trunk all the VLANs currently defined on the switch, and any new VLANs defined in the future. To disable the trunk interface, use the command shutdown.

| Parameter | Description |
|---|---|
| *<VLAN-LIST>* | Specifies a single ID, or a series of IDs separated by commas (2, 3, 4), dashes (2-4), or both (2-4,6). Range: 1 to 4094. |
| `all` | Configures the trunk interface to allow all the VLANs currently configured on the switch and any new VLANs that are configured in the future. |

### Examples

Assigning VLANs **2**, **3**, and **4** to trunk interface **1/1/2**:

```
switch(config)# interface 1/1/2
switch(config-if)# vlan trunk allowed 2,3,4
```

Assigning VLAN IDs **2** to **8** to trunk interface **1/1/2**:

```
switch(config)# interface 1/1/2
switch(config-if)# vlan trunk allowed 2-8
```

Assigning VLAN IDs **2** to **8** and 10 to trunk interface **1/1/2**:

```
switch(config)# interface 1/1/2
switch(config-if)# vlan trunk allowed 2-8,10
```

Removing VLAN IDs **2**, **3**, and **4** from trunk interface **1/1/2**:

```
switch(config)# interface 1/1/2
switch(config-if)# no vlan trunk allowed 2,3,4
```

Removing all VLANs assigned to trunk interface **1/1/2**:

```
switch(config)# interface 1/1/2
switch(config-if)# no vlan trunk allowed 2
```

### Command History

| Release | Modification |
|---|---|
| 10.07 or earlier | -- |

### Command Information

| Platforms | Command context | Authority |
|---|---|---|
| All platforms | `config-if` | Administrators or local user group members with execution rights for this command. |

## vlan trunk native

```
vlan trunk native <VLAN-ID>
no vlan trunk native [<VLAN-ID>]
```

### Description

Assigns a native VLAN ID to a trunk interface. By default, VLAN ID 1 is assigned as the native VLAN ID for all trunk interfaces. VLANs can only be assigned to a non-routed (layer 2) interface or LAG interface. Only one VLAN ID can be assigned as the native VLAN.

When a native VLAN is defined, the switch automatically executes the **vlan trunk allowed all** command to ensure that the default VLAN is allowed on the trunk. To only allow specific VLANs on the trunk, issue the **vlan trunk allowed** command specifying only specific VLANs.

The **no** form of this command removes a native VLAN from a trunk interface and assigns VLAN ID 1 as its native VLAN.

| Parameter | Description |
|---|---|
| *<VLAN-ID>* | Specifies a VLAN ID. Range: 1 to 4094. |

### Examples

Assigning native VLAN ID **20** to trunk interface **1/1/2**:

```
switch(config)# interface 1/1/2
switch(config-if)# vlan trunk native 20
```

Removing native VLAN **20** from trunk interface **1/1/2** and returning to the default VLAN 1 as the native VLAN.

```
switch(config)# interface 1/1/2
switch(config-if)# no vlan trunk native 20
```

or:

```
switch(config)# interface 1/1/2
switch(config-if)# no vlan trunk native
```

Assigning native VLAN ID **20** to trunk interface **1/1/2** and then removing it from the list of allowed VLANs. (Only allow VLAN 10 on the trunk.)

```
switch(config)# interface 1/1/2
switch(config-if)# vlan trunk native 20
switch(config-if)# vlan trunk allowed 10
```

### Command History

| Release | Modification |
|---|---|
| 10.07 or earlier | -- |

### Command Information

| Platforms | Command context | Authority |
|---|---|---|
| All platforms | `config-if` | Administrators or local user group members with execution rights for this command. |

## vlan trunk native tag

`vlan trunk native <VLAN-ID> tag`
`no vlan trunk native <VLAN-ID> tag`

### Description

Enables tagging on a native VLAN. Only incoming packets that are tagged with the matching VLAN ID are accepted. Incoming packets that are untagged are dropped except for BPDUs. Egress packets are tagged.

The **no** form of this command removes tagging on a native VLAN.

| Parameter | Description |
|---|---|
| *<VLAN-ID>* | Specifies the number of a VLAN. Range: 1 to 4094. |

### Examples

Enabling tagging on native VLAN **20** on trunk interface **1/1/2**:

```
switch(config)# interface 1/1/2
switch(config-if)# vlan trunk native 20
switch(config-if)# vlan trunk native 20 tag
```

Removing tagging on native VLAN **20** assigned to trunk interface **1/1/2**:

```
switch(config)# interface 1/1/2
switch(config-if)# no vlan trunk native 20 tag
```

Enabling tagging on native VLAN **20** assigned to LAG trunk interface **2**:

```
switch(config)# interface lag 2
switch(config-lag-if)# vlan trunk native 20
switch(config-lag-if)# vlan trunk native 20 tag
```

### Command History

| Release | Modification |
|---|---|
| 10.07 or earlier | -- |

### Command Information

| Platforms | Command context | Authority |
|---|---|---|
| All platforms | `config-if` | Administrators or local user group members with execution rights for this command. |

## voice

```
voice
no voice
```

### Description

Configures a VLAN as a voice VLAN.

The **no** form of this command removes voice configuration from a VLAN.

### Examples

Configuring VLAN 10 as a voice VLAN:

```
switch(config)# vlan 10
switch(config-vlan-10)# voice
```

Removing voice from VLAN 10:

```
switch(config-vlan-10)# no voice
```

## Command History

| Release | Modification |
|---|---|
| 10.07 or earlier | -- |

## Command Information

| Platforms | Command context | Authority |
|---|---|---|
| All platforms | `config-vlan-<VLAN-ID>` | Administrators or local user group members with execution rights for this command. |

# Chapter 5
# QinQ

QinQ is supported only on 6200 Switch Series.

The QinQ is a technology that stacks multiple 802.1Q VLAN tags into a single frame, within the provider-network that is transparent to the users. QinQ is an essential capability for implementing Metro Ethernet Network (MAN) topologies.

IEEE 802.1Q specification has a VLAN limit of 4096. This creates an issue within a service-provider network, that receives frames of various VLANs ranges utilized by different users. The VLAN used by the user in a service-provider network might overlap, and traffic through the infrastructure can be mixed. Assigning a unique range of VLAN IDs to every user limits the configurations and might easily exceed the VLAN limit of 4096.

IEEE 802.1ad supplier bridge specification addresses the issue by allowing the use of a unique VLAN (called a Service VLAN ID, or S-VID) to each user. Customer VLAN IDs (C-VIDs) are preserved and traffic from different users is carried over to unique service VLAN that segregates each user traffic within the service-provider network. The segregation is achieved by adding a secondary VLAN tag (Service VLAN tag or S-tag with an ether-type of 0x88a8) on the existing C-VLAN tag (otherwise known as double-tagging) once a frame enters the service supplier network. This is also called as stacked VLAN tags or QinQ. In theory, it increases the VLAN ID space by a factor of 4096 providing for up to 16M VLAN IDs instead of the 4K supported by 802.1Q compliant bridges. The S-tag is removed when exiting the service-provider network restoring the original frame. The primary advantage for a service-provider is a reduced number of VLANs that require to be supported within the provider-network for the same number of users.

The following table contains terminology and its behavior:

| Terminology | Behavior |
|---|---|
| CVLAN | Customer VLAN is the regular IEEE 802.1Q VLAN used by the user within their network. |
| SVLAN | Service VLAN is the secondary VLAN tag inserted on existing CVLAN tag, used by a service-provider to switch user traffic across provider core and edge networks. |
| PN port | Provider-Network port is a trunk port facing provider network, that transmits and receives service tag frames for multiple users. |
| CN port | Customer-Network port is an access port facing user network, that carries CVLANs traffic entering the port with QinQ tunnel using SVLAN. |

## QinQ feature interactions

### MSTP

CN and PN ports will not participate in Multiple Spanning Tree Protocol (MSTP). MSTPs Bridge Protocol Data Units (BPDUs) are treated as data packets and QinQ tunneled.

### VSX

It is mandatory to configure VSX-ISL link as trunk member of only SVLANs. VSX-ISL link will act as QinQ PN port on both VSX primary and secondary. MCLAG interface can be configured either as a QinQ PN port or a CN port. Existing commands `vsx-sync` under `vlan` context, `vsx-sync vlans` under `interface` context and `mclag-interfaces` under global `vsx-sync` context will sync with QinQ specific configurations from VSX primary to secondary.

### Loop-Protect

- SVLAN cannot be a Loop-Protect (LP) VLAN.
- QinQ ports cannot be configured with LP.
- CN and PN ports will not participate in LP.
- LP packets are treated as data packets and QinQ tunneled.

## Configuring and displaying QinQ

The following is the sample configuration for enabling QinQ:

```
switch(config)# vlan 10
switch(config-vlan-10)# svlan
switch(config-vlan-10)# interface 1/1/1
switch(config-if)# vlan access 10
switch(config-if)# interface 1/1/2
switch(config-if)# vlan trunk allowed 10
```

Showing the configured QinQ information:

```
switch# show qinq
QinQ Configuration Information

Encapsulation Ethertype: 0x88A8

SVLAN List: 10

-------------------------------------------------------
Port       Type                        VLAN Membership
-------------------------------------------------------
1/1/1      customer-network (access)  10
1/1/2      provider-network (trunk)   10
```

Showing detail information of all QinQ ports.

```
switch# show qinq detail


Interface: 1/1/1

              QinQ port-type        : customer-network

              QinQ transparent vlan : 20,30,40-50
```

```
              QinQ Service vlan     : 100

Interface: 1/1/2

              QinQ port-type        : customer-network

              QinQ transparent vlan : None

              QinQ Service vlan     : 100

                                    : 200 (selective customer vlans: 1000-
2000,3001,3003)

                                    : 300 (selective customer vlans: 2001-3000)

Interface: 1/1/3
          QinQ port-type        : customer-network

              QinQ transparent vlan : None

              QinQ Service vlan     : 100


Interface: 1/1/3
              QinQ port-type        : provider-network

          QinQ transparent vlan : 20,30,40-50

              QinQ Service vlan     : 100,200,300

Interface: 1/1/4
              QinQ port-type        : provider-network

              QinQ transparent vlan : None

              QinQ Service vlan     : 100,200,300
```

# QinQ limitations

The following features are not supported for QinQ:

- Service tag ethertype except 0x88A8.
- Provider Bridge Multiple Spanning Tree Protocol (PB-MSTP).
- MACsec on CN and PN ports.
- Selective or transparent QinQ.
- Layer 2 Protocol Tunneling (L2PT).

The following features are incompatible with QinQ and cannot be enabled together:

These features are CLI restricted against QinQ. However, the mutual exclusion for security features such as MAC-auth, MACsec, Dot1x, and LMA is achieved through the PSPO. PSPO will block traffic on the offending ports, until the configuration is corrected.

- RPVST
- MVRP

- ERPS
- SmartLink
- VLAN Translation
- PVLAN
- VxLAN
- L3 Features
- Security and Security Applications
- Multicast
- IGMP Snooping
- IP enablement on SVLAN

QinQ tunneling requires additional 4 bytes in packet payload to add S-tag and provider bridge EtherType on provider-network ports. Therefore, it is recommended to configure interface MTU to accommodate the same on provider-network ports.

# QinQ commands

## debug vlan qinq

```
debug vlan qinq severity
```

### Description

Enables the VLAN debug logs to trace the QinQ changes and filtering with minimum log severity.

### Examples

Enabling the debug logs for QinQ

```
switch# debug vlan qinq
severity        Minimum log severity to filter debug logs
<cr>
switch# debug vlan qinq severity
```

### Command History

| Release | Modification |
|---|---|
| 10.10 | Command introduced |

### Command Information

| Platforms | Command context | Authority |
|---|---|---|
| 6200 | Operator (>) or Manager (#) | Operators or Administrators or local user group members with execution rights for this command. Operators can execute this command from the operator context (>) only. |

## diag-dump l2vlan basic

```
diag-dump l2vlan basic
```

### Description

Collects the debug information in the case of any issue in the QinQ daemon. Diagnostic for QinQ is part of VLAN daemon.

### Examples

Configuring diagnostic dump for QinQ

```
switch# diag-dump l2vlan basic
```

### Command History

| Release | Modification |
|---|---|
| 10.10 | Command introduced |

### Command Information

| Platforms | Command context | Authority |
|---|---|---|
| 6200 | Operator (>) or Manager (#) | Operators or Administrators or local user group members with execution rights for this command. Operators can execute this command from the operator context (>) only. |

## show qinq

```
show qinq
```

### Description

Shows the configuration details of QinQ.

### Examples

Showing the QinQ configuration

```
switch# show qinq
QinQ Configuration Information

Encapsulation Ethertype: 0x88A8

SVLAN List: 100-103

-------------------------------------------------------
Port       Type                        VLAN Membership
-------------------------------------------------------
1/1/1      customer-network (access)   100
1/1/3      provider-network (trunk)    100-103
1/1/5      customer-network (access)   101
1/1/7      customer-network (access)   102
1/1/9      customer-network (access)   103
```

### Command History

| Release | Modification |
|---|---|
| 10.10 | Command introduced |

### Command Information

| Platforms | Command context | Authority |
|---|---|---|
| 6200 | Operator (>) or Manager (#) | Operators or Administrators or local user group members with execution rights for this command. Operators can execute this command from the operator context (>) only. |

## show running-config qinq

```
show running-config qinq
```

### Description

Shows all the QinQ configurations in the switch.

### Examples

Showing the QinQ running configuration

```
switch# show running-config qinq
Current configuration:
...
vlan 300
    svlan

```
```

### Command History

| Release | Modification |
|---|---|
| 10.10 | Command introduced |

### Command Information

| Platforms | Command context | Authority |
|---|---|---|
| 6200 | Operator (>) or Manager (#) | Operators or Administrators or local user group members with execution rights for this command. Operators can execute this command from the operator context (>) only. |

## show tech qinq

```
show tech qinq
```

### Description

Shows the tech support for QinQ feature.

### Examples
```

Showing the tech support for QinQ feature

```
switch# show tech qinq
=====================================================
Show Tech executed on Thu Mar 17 03:07:03 2022
=====================================================
=====================================================
[Begin] Feature qinq
=====================================================

*********************************
Command : show running-config qinq
*********************************
vlan 300
    svlan

*********************************
Command : show qinq
*********************************

switch# show qinq

QinQ Configuration Information

Encapsulation Ethertype: 0x88A8

SVLAN List: 100-103
-----------------------------------------------------
Port       Type                        VLAN Membership
-----------------------------------------------------
1/1/1      customer-network (access)  100
1/1/3      provider-network (trunk)   100-103
1/1/5      customer-network (access)  101
1/1/7      customer-network (access)  102
1/1/9      customer-network (access)  103
=====================================================
[End] Feature qinq
=====================================================

=====================================================
Show Tech commands executed successfully
```

### Command History

| Release | Modification |
|---|---|
| 10.10 | Command introduced |

### Command Information

| Platforms | Command context | Authority |
|---|---|---|
| 6200 | Operator (>) or Manager (#) | Operators or Administrators or local user group members with execution rights for this command. Operators can execute this command from the operator context (>) only. |

## svlan

```
svlan
no svlan
```

## Description

Configures a VLAN as a service VLAN. A port will implicitly become customer-network port, when it is an access member (untagged) of SVLAN. A port will implicitly become provider-network port, when it is a trunk member (tagged) of SVLAN.

The **no** form of this command removes the service VLAN configuration.

A QinQ CN or PN port, which was a member of the SVLAN, will become normal VLAN port after removing service VLAN configuration from VLAN.

## Usage

- VLAN 1 cannot be configured as an SVLAN.
- An L2 port can be a member of either service VLANs or normal VLANs but cannot be used on both the VLANs.
- An L2 port with **vlan trunk allowed all** will not include service VLANs.
- Native VLAN configuration will be non-operational on PN port.

## Examples

Configuring VLAN 300 and enabling service VLAN mode

```
switch(config)# vlan 300
switch(config-vlan-300)# svlan
```

Removing the service VLAN mode configuration from VLAN 300

```
switch(config)# vlan 100
switch(config-vlan-100)# no svlan
```

## Command History

| Release | Modification |
|---|---|
| 10.10 | Command introduced |

## Command Information

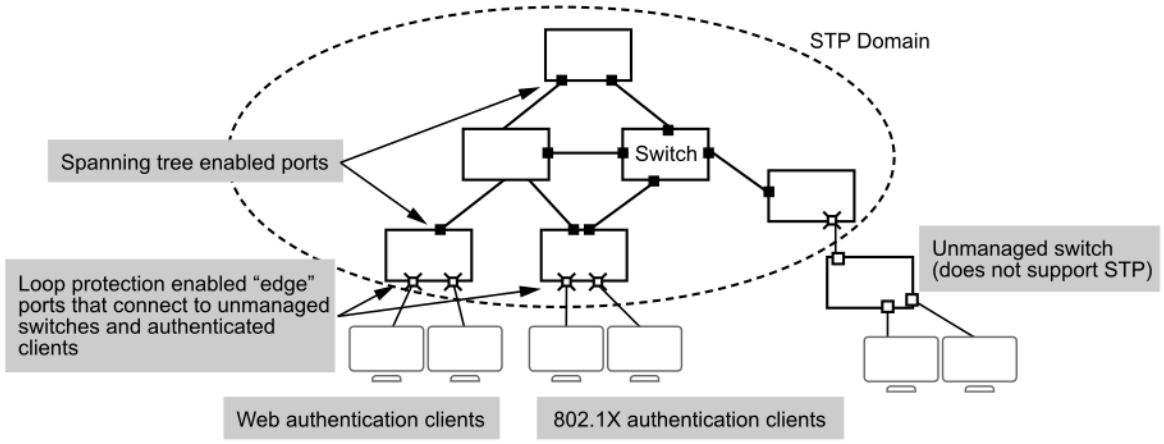
| Platforms | Command context | Authority |
|---|---|---|
| 6200 | `config-vlan-<VLAN-ID>` | Administrators or local user group members with execution rights for this command. |

# Chapter 6
# Loop protection

In cases where spanning tree protocols cannot be used to prevent loops at the edge of the network, loop protection may provide a suitable alternative. Loop protection can find loops in untagged layer 2 links, as well as on tagged VLANs, and VXLAN networks.

The cases where loop protection might be chosen ahead of spanning tree to detect and prevent loops are:

- On ports with client authentication: When spanning tree is enabled on a switch that uses 802.1X, web authentication, or MAC authentication, loops may go undetected. For example, spanning tree packets that are looped back to an edge port will not be processed because they have a different broadcast/multicast MAC address from the client-authenticated MAC address. To ensure that client-authenticated edge ports get blocked when loops occur, you should enable loop protection on those ports.
- On ports connected to unmanaged devices: Spanning tree cannot detect the formation of loops where there is an unmanaged device on the network that does not process spanning tree packets and simply drops them. Loop protection has no such limitation, and can be used to prevent loops on unmanaged switches.




Loop protection finds loops by sending loop protection packets on each port, LAG, VLAN, or VXLAN on which loop protection is enabled. If a loop protection packet is received by the same switch that sent it, it indicates a loop exists and one of the following actions is taken:

- Discovery of the loop is logged but port states are not changed.
- The sending port is disabled.
- The sending and receiving ports are both disabled.

Loop protection on VXLAN interfaces is supported only on AOS-CX 6200,6300,6400,8360,8325,8400,9300,8100,10000 switch series.

Loop protect action is not supported on VXLAN interfaces and the default action for a VXLAN interface is rx-disable. Hence, the receiving L2 port is always disabled.

# Interaction with other protocols

- When loop protection is enabled before STP, and if there is an L2 loop, then the loop will be detected and the port will be disabled.
- When STP is enabled before loop protection, and if there is a L2 loop, then the port will be moved to the **blocked** state by STP. When a port is blocked, the loop protection packet will not reach the sending switch, and the loop will not be detected by loop protection. When multiple instances of STP are configured and different spanning trees are formed for different instances, the PSPO state will be **forwarding**. In this case, loop- protection will consider those ports as normal forwarding ports and will override the STP states.
- STP is mutually exclusive with loop protection. If STP and loop protection are both enabled on the same VLAN, STP takes precedence. This means that loop protection does not take any action on a port blocked by STP.
- MVRP and the loop protection interoperate with each other. However, dynamic VLANs cannot be tagged to a port through user configuration. Therefore, it is not possible to configure a dynamic VLAN as a loop protection enabled VLAN.
- If MCLAG has marked a port as transmit disable (`mclag_pdu_tx_disable` is set to true), then loop-protect will not transmit packets on the port. Similarly, if the `loop_detect_source` column is set to `mclag` then loop protection will not re-enable the port when the re-enable timer expires on that port.
- If the port-access security feature or any other feature blocks the port in PSPO, then loop protection will not detect the loop.

# Configuring loop protection

### Procedure

1. Enable loop protection on each layer 2 interface (port, LAG, VLAN, or VXLAN) for which loop protection is needed, with the commands `loop-protect` and `loop-protect vlan`.
2. Define the action to be taken when a loop is detected with the command `loop-protect action`. The default action is `tx-disable`, which means that the port that transmitted the loop detection packet is disabled. When this action is enabled, environments with N loops must have loop protection configured on at least N-1 ports to ensure a loop free topology.

When the default action (`tx-disable`) is used, it is optional to enable loop protect in all interfaces. By enabling loop protect in a single interface, the loop is detected and the default action is executed. So when the packet from a loop protect-enabled port is received back on an interface where loop protect is not enabled, the loop protect receiver action corresponding to the receiving interface is executed. Please note that all the L2 ports will have a default receiver action of `tx-disable` even when loop protect is not enabled.

Loop protect action is not supported on VXLAN interfaces and the default action for a VXLAN interface is rx-disable .

3. If required, change the interval at which loop protection messages are sent with the command `loop-protect transmit-interval`.
4. If required, change the length of time the switch waits before re-enabling an interface with the command `loop-protect re-enable-timer`.
5. Review loop protection configuration settings with the command `show loop-protect`.

### Example

This example creates the following configuration:

- Enables loop protection on data port **1/1/1** and sets the loop detection action to disable the transmit port.
- Enables loop protection on LAG **25** and sets the loop detection action to disable both transmit and receive ports.
- Enables loop protection on VLANs **100-125** and **200**.
- Enables loop protection on VXLAN 1
- Sets the re-enable timer to **10** seconds.
- Sets the transmit-interval to **30** seconds.

```
switch(config)# interface 1/1/1
switch(config-if)# loop-protect
switch(config-if)# loop-protect action tx-disable
switch(config-if)# exit
switch(config)# interface lag 25
switch(config-lag-if)# loop-protect
switch(config-if)# loop-protect action tx-rx-disable
switch(config-if)# loop-protect vlan 100-125,200
switch(config-if)# exit
switch(config)# loop-protect re-enable-timer 30
switch(config)# exit
switch(config)# interface vxlan 1
switch(config-vxlan-if)# loop protect
switch(config-vxlan-if)# loop protect vlan 2-100
switch(config)# exit
switch#  show loop-protect
Status and Counters - Loop Protection Information
Transmit Interval             : 30 (sec)
Port Re-enable Timer          : 10 (sec)
Interface 1/1/1
  Loop-protect enabled        : Yes
  Loop-Protect enabled VLANs  :
  Action on loop detection    : TX disable
  Loop detected count         : 0
  Loop detected               : No
```

```
  Interface status            : up
Interface lag 25
  Loop-protect enabled        : Yes
  Loop-Protect enabled VLANs  : 100-125,200
  Action on loop detection    : TX-RX disable
  Loop detected count         : 0
  Loop detected               : No
  Interface status            : up

 Interface vxlan1
   Loop-protect enabled        : Yes
   Loop-Protect enabled VLANs  : 2-100
   Action on loop detection    : RX disable
   Loop detected count         : 0
   Loop detected               : No
   Interface status            : up
```

# Loop protect commands

## loop-protect

```
loop-protect
no loop-protect
```

### Description

Enables loop protection on a layer 2 interface, VXLAN interface, or LAG. Loop protection packets are sent/received on the LAG and not the interface which are members of the LAG. Loop protection only works on layer 2 interfaces. If a layer 2 interface is changed to a layer 3 interface, all loop protection configuration settings are lost for that interface.

If loop protection is enabled on a VXLAN interface, the local VTEP will generate loop protect packets on the VXLAN tunnel. Remote VTEP will hardware forward the same loop protect packet. If a local VTEP receives its own packet on any L2 interface, it will be detected as a loop and will bring down the L2 interface on which the loop protect control packet was received.

The **no** form of this command disables loop protection on a layer 2 interface, VXLAN interface, or LAG.

Loop protection on VXLAN interfaces is supported only on AOS-CX 6200,6300,6400,8360,8325,8400,9300,8100,10000 switch series.

### Examples

Enabling loop protection on interface **1/1/1**:

```
switch# config
switch(config)# interface 1/1/1
switch(config-if)# loop-protect
```

Enabling loop protection on LAG **25**:

```
switch# config
switch(config)# interface lag 25
switch(config-lag-if)# loop-protect
```

Enabling loop protection on VXLAN interface:

```
switch# config
switch(config)# interface vxlan 1
switch(config-vxlan-if)# loop-protect
```

### Command History

| Release | Modification |
|---|---|
| 10.12 | Loop protection supported on VXLAN interfaces. |
| 10.07 or earlier | -- |

### Command Information

| Platforms | Command context | Authority |
|---|---|---|
| All platforms | `config-if`<br>`config-lag-if`<br>`config-vxlan-if` | Administrators or local user group members with execution rights for this command. |

## loop-protect action

```
loop-protect action {do-not-disable | tx-disable | tx-rx-disable}
no loop-protect action {do-not-disable | tx-disable | tx-rx-disable}
```

### Description

Sets the action to be taken when a loop protection packet is received on a port.

If an action is configured after a loop is detected, then the new action only takes effect after the re-enable timer expires. To have the action take effect immediately, disable and then re-enable loop protect.

The **no** form of this command resets the action to the default (**tx-disable**).

This command is not supported on a VXLAN interface and the default action for a VXLAN interface is rx-disable .

| Parameter | Description |
|---|---|
| `do-not-disable` | No ports are disabled. On every transmit interval, the loop will be detected and the detection will be reported via an SNMP trap and an event log message. |
| `tx-disable` | The port that transmitted the loop detection packet is disabled. When this setting is enabled, environments with N loops, must have loop protection be configured on at least N-1 ports to have a loop free topology. Default. |
| `tx-rx-disable` | The ports that transmitted and received the loop detection packet are disabled. |

### Example

```
switch(config-if)# loop-protect action do-not-disable
switch(config-if)# no loop-protect action do-not-disable
```

### Command History

| Release | Modification |
|---|---|
| 10.07 or earlier | -- |

### Command Information

| Platforms | Command context | Authority |
|---|---|---|
| All platforms | `config-if` | Administrators or local user group members with execution rights for this command. |

## loop-protect re-enable-timer

```
loop-protect re-enable-timer <TIME>
no loop-protect re-enable-timer <TIME>
```

### Description

Configures the time interval after which an interface disabled by loop protection is re-enabled. The loop protection timer is disabled by default.

The **no** form of this command disables the loop protect timer.

| Parameter | Description |
|---|---|
| *<TIME>* | Specify the number of seconds after which a disabled interface is re-enabled. Range: 15 to 604800. |

### Example

```
switch# config
switch(config)# loop-protect re-enable-timer 60
```

### Command History

| Release | Modification |
|---|---|
| 10.07 or earlier | -- |

### Command Information

| Platforms | Command context | Authority |
|---|---|---|
| All platforms | `config` | Administrators or local user group members with execution rights for this command. |

## loop-protect transmit-interval

```
loop-protect transmit-interval <TIME>
no loop-protect transmit-interval [<TIME>]
```

### Description

Configures the time interval between successive loop protect packets sent on an interface.

The **no** form of this command sets the time interval to the default value of 5 seconds.

| Parameter | Description |
|---|---|
| *<TIME>* | Configures the transmit interval in seconds. Range: 5 to 10. Default: 5. |

### Examples

```
switch(config)# loop-protect transmit-interval 10
switch(config)# no loop-protect transmit-interval
```

### Command History

| Release | Modification |
|---|---|
| 10.07 or earlier | -- |

### Command Information

| Platforms | Command context | Authority |
|---|---|---|
| All platforms | config | Administrators or local user group members with execution rights for this command. |

## loop-protect trap loop-detected

```
loop-protect trap loop-detected
no loop-protect trap loop-detected
```

### Description

Enables sending SNMP traps for loop-protect related events.

The **no** form of this command disables sending SNMP traps for loop-protect related events.

### Examples

Enabling the sending of SNMP traps:

```
switch# loop-protect trap loop-detected
```

Disabling the sending of SNMP traps:

```
switch# no loop-protect trap loop-detected
```

### Command History

| Release | Modification |
|---|---|
| 10.07 or earlier | -- |

### Command Information

| Platforms | Command context | Authority |
|---|---|---|
| All platforms | `config` | Administrators or local user group members with execution rights for this command. |

## loop-protect vlan

```
loop-protect vlan <VLAN-LIST>
no loop-protect vlan
```

### Description

Specifies the trunk allowed VLANs on which loop protection packets are sent. By default, loop protection packets are only sent on access VLANs and native VLANs on a port. To send loop protection packets on trunk allowed VLANs, the VLANs must be explicitly added using this command.

When loop protection is enabled on VXLAN interfaces, the switch will start transmitting loop protect packets to each VTEP peer that are part of a VNI.

Loop protection can be configured on a maximum of 2048 VLANs across all interfaces.

Loop protection on VXLAN interfaces can be enabled on a maximum of 5000 (total of number of VTEPs * number of loop protect enabled VLANs). Loop protection will generate a maximum 5000 VXLAN encapsulated packets within the default loop protect time interval of 5 seconds.

Lower-capacity switches are not able to support this theoretical limit, value due to platform limitations regarding L2VNI and VTEP peers. (For example, 6200 Switch series allows up to 32 L2VNI and 16 VTEP peers.)

The **no** form of this command removes loop protection from all VLANs on the interface.

| Parameter | Description |
|---|---|
| *<VLAN-LIST>* | Specifies the number of a single VLAN, or a series of numbers for a range of VLANs, separated by commas (1, 2, 3, 4), dashes (1-4), or both (1-4, 6). |

### Example

```
switch(config-if)# loop-protect vlan 2-6,10,15-20
```

Enabling loop protection on VXLAN interface:

```
switch# config
switch(config)# interface vxlan 1
switch(config-lag-if)# loop-protect vlan 10
```

### Command History

| Release | Modification |
|---|---|
| 10.12 | Loop protection supported on VXLAN interfaces. |
| 10.07 or earlier | -- |

### Command Information

| Platforms | Command context | Authority |
|---|---|---|
| All platforms | `config-if`<br>`config-vxlan-if` | Administrators or local user group members with execution rights for this command. |

## show loop-protect

### Description

`show loop-protect [<INTERFACE-NAME>]`

This command shows the following global configurations.

- Transmit interval.
- Re-enable timer.
- Per-port configurations.
- Loop-protect enable or disable status.
- Loop detection.
- Loop detected count.
- Timestamp of latest loop detection.
- Loop is detected on VLAN.
- Interface status.
- List of configured VLAN's for that port.
- VTEP port information

Specify the interface name on display for the filter. When rebooting the switch or after switchover, The loop-detected count on the loop detected port is reset to zero.

| Parameter | Description |
|---|---|
| *<INTERFACE-NAME>* | Specifies the name of a logical interface on the switch. This can be one of the following:<br>■ An Ethernet interface associated with a physical port. Format: **member/slot/port**.<br>■ A LAG (link aggregation group). Specify the ID of LAG . For example: **lag100**.<br>■ A VXLAN interface. Specify the VXLAN ID. For example: **vxlan 1**. |

Loop protection on VXLAN interfaces is supported on AOS-CX 6200, 6300, 6400, 8360, 8325, 8400, 9300, 8100, 10000 switch series.

## Examples

```
switch# show loop-protect

Transmit Interval (sec)            : 5
Port Re-enable Timer (sec)         : Disabled
Loop Detected Trap                 : Enabled

Interface 1/1/1
  Loop-protect enabled         : Yes
  Loop-Protect enabled VLANs   :
  Action on loop detection     : TX disable
  Loop detected count          : 0
  Loop detected                : No
  Interface status             : up

Interface 1/1/2
  Loop-protect enabled         : Yes
  Loop-Protect enabled VLANs   :
  Action on loop detection     : TX disable
  Loop detected count          : 0
  Loop detected                : No
  Interface status             : up
Interface vxlan 1
 Loop-protect enabled         : Yes
 Loop-Protect enabled VLANs   :
 Action on loop detection     : RX disable
 Loop detected count          : 0
 Loop detected                : No
 Interface status             : up
```

```
switch# show loop-protect 1/1/3

Status and Counters - Loop Protection Information

Transmit Interval (sec)        : 5
Port Re-enable Timer (sec)     : 0
Loop Detected Trap             : Disabled

Interface 1
  Loop-protect enabled         : Yes
  Loop-Protect enabled VLANs   :
  Action on loop detection     : TX disable
  Loop detected count          : 0
  Loop detected                : No
  Interface status             : up
```

```
switch# show loop-protect
Status and Counters - Loop Protection Information


 Transmit Interval              : 5 (sec)
 Port Re-enable Timer           : Disabled
 Loop Detected Trap             : Disabled

 Interface 1/5/48
   Loop-protect enabled         : No
   Action on loop detection     : TX disable
   Loop detected count          : 1
```

```
 Loop detected               : Yes
 Detected on VLAN          : 100
 Detected at               : 2023-03-20T00:01:17
 Interface status            : down
 Tx_port                     : VTEP_100.1.1.2


Interface vxlan1
 Loop-protect enabled        : Yes
 Loop-Protect enabled VLANs  : 100
 Action on loop detection    : RX disable
 Loop detected count         : 0
 Loop detected               : No
 Interface status            : up
```

## Command History

| Release | Modification |
|---|---|
| 10.12 | Loop protection supported on VXLAN interfaces. |
| 10.07 or earlier | -- |

## Command Information

| Platforms | Command context | Authority |
|---|---|---|
| All platforms | Operator (>) or Manager (#) | Operators or Administrators or local user group members with execution rights for this command. Operators can execute this command from the operator context (>) only. |

# Chapter 7
# MVRP

MVRP provides a mechanism to dynamically share VLAN configuration information across layer 2 switches on a network. MVRP eliminates the need to manually configure VLANs on each switch, enabling the network to dynamically maintain VLANs based on the current network configuration. MVRP propagates local VLAN information to other devices, receives VLAN information from other devices, and dynamically updates local VLAN information. When the network topology changes, MVRP propagates and learns VLAN information again according to the new topology.

MVRP is defined in the IEEE 802.1ak standard. It perform the same functions as Generic Attribute Registration Protocol (GARP), while overcoming GARP limitations, such as bandwidth usage and convergence time in networks with a large numbers of VLANs.

MVRP makes use of the Multiple Registration Protocol (MRP). MRP provides the mechanism for switches on the same layer 2 network to transmit attribute values on a per MSTI (Multiple Spanning Tree Instance) basis. (An MSTI is a group or set of VLANs, all of which are part of the same spanning tree.)

Each MRP-enabled interface is called an MRP participant, and each MVRP-enabled interface is called an MVRP participant. When the VLAN configuration on an MVRP participant changes, it sends a Protocol Data Unit (PDU) to notify other MVRP participants to register and deregister the changed VLAN. MRP rapidly propagates the configuration information of an MRP participant throughout the layer 2 network.

MRP registers and deregisters VLAN attributes as follows:

- When an interface receives a declaration for a VLAN, the interface registers the VLAN and joins the VLAN.
- When an interface receives a withdrawal for a VLAN, the interface deregisters the VLAN and leaves the VLAN.

MVRP only applies to trunk interfaces.

## MVRP functionality and limitations

### MIB support

The MVRP feature supports objects in the following standard MIBs:

- IEEE8021-Q-BRIDGE-MIB (Version 200810150000Z)
- IEEE8021-BRIDGE-MIB (Version 200810150000Z)

It also supports MVRP objects in the HPE proprietary MIB:

HPE-MVRP-MIB (`hpeMvrp.mib`)

### MVRP limitations

- MVRP is only supported on L2 trunk ports.
- MVRP and VLAN translation cannot be enabled on the same interface.
- MVRP will propagate only the first 1024 (6200 Switch Series) or 256 (6000, 6100 Switch Series) VLANs. This number includes existing static VLANs locally. For example, if a peer device already has 100 (6200

Switch Series) or 20 (6000, 6100 Switch Series) static VLANs, then it can only learn 924 (6200 Switch Series) or 236 (6000, 6100 Switch Series) VLANs.

- MVRP and PVST cannot be enabled at the same time.
- For security purposes, MVRP is disabled by default. MVRP packets are blocked on MVRP disabled ports, but can be enabled on ports that are security enabled.
- MVRP supports 1024 VLANs and 512 logical ports.
- If MVRP is enabled globally, MVRP is automatically enabled on LAG interfaces and cannot be disabled.

# MRP messages

MRP messages include the following types:

- Declaration: Includes Join and New messages.
- Withdrawal: Includes Leave and LeaveAll messages.

## Join message

An MRP participant sends a Join message to request the peer participant to register attributes in the Join message.

When receiving a Join message from the peer participant, an MRP participant performs the following tasks:

- Registers the attributes in the Join message.
- Propagates the Join message to all other participants on the device.

After receiving the Join message, other participants send the Join message to their respective peer participants.

Join messages sent from a local participant to its peer participant include the following types:

- JoinEmpty: Declares an unregistered attribute. For example, when an MRP participant joins an unregistered static VLAN, it sends a JoinEmpty message. VLANs created manually and locally are called static VLANs. VLANs learned through MRP are called dynamic VLANs.
- JoinIn: Declares a registered attribute. A JoinIn message is used in one of the following situations:
  - An MRP participant joins an existing static VLAN and sends a JoinIn message after registering the VLAN.
  - The MRP participant receives a Join message propagated by another participant on the device and sends a JoinIn message after registering the VLAN.

## New message

Similar to a Join message, a New message enables MRP participants to register attributes.

When the MSTP topology changes, an MRP participant sends a New message to the peer participant to declare the topology change.

Upon receiving a New message from the peer participant, an MRP participant performs the following tasks:

- Registers the attributes in the message.
- Propagates the New message to all other participants on the device.

After receiving the New message, other participants send the New message to their respective peer participants.

## Leave message

An MRP participant sends a Leave message to the peer participant when it wants the peer participant to deregister attributes that it has deregistered.

When the peer participant receives the Leave message, it performs the following tasks:

- Deregisters the attribute in the Leave message.
- Propagates the Leave message to all other participants on the device.

After a participant on the device receives the Leave message, it determines whether to send the Leave message to its peer participant depending on the attribute status on the device.

- If the VLAN in the Leave message is a dynamic VLAN not registered by any participants on the device, both of the following events occur:
  - The VLAN is deleted on the device.
  - The participant sends the Leave message to its peer participant.
- If the VLAN in a Leave message is a static VLAN, the participant will not send the Leave message to its peer participant.

## LeaveAll message

Each MRP participant starts its LeaveAll timer when starting up. When the timer expires, the MRP participant sends LeaveAll messages to the peer participant.

Upon sending or receiving a LeaveAll message, the local participant starts the Leave timer. The local participant determines whether to send a Join message depending on its the attribute status. A participant can re-register the attributes in the received Join message before the Leave timer expires.

When the Leave timer expires, a participant deregisters all attributes that have not been re-registered to periodically clear useless attributes in the network.

# Configuring MVRP

### Prerequisites

MVRP must be enabled globally to facilitate dynamic VLAN learning.

### Procedure

1. Enable MVRP globally on all interfaces or only for specific interfaces with the command `mvrp`. (For Dynamic LAGs, MVRP is enabled by default).
2. By default, MVRP supports dynamic registration and deregistration of VLANs on all interfaces. If required, customize the behavior for each interface with the command `mvrp registration`.
3. If required, adjust the MVRP timers from their default values with the command `mvrp timer`. To avoid frequent registrations and deregistrations, use the same MVRP timer values throughout the network.
4. Review your MVRP configuration settings with the commands `show mvrp config`, `show mvrp state`, and `show mvrp statistics`.

### Example

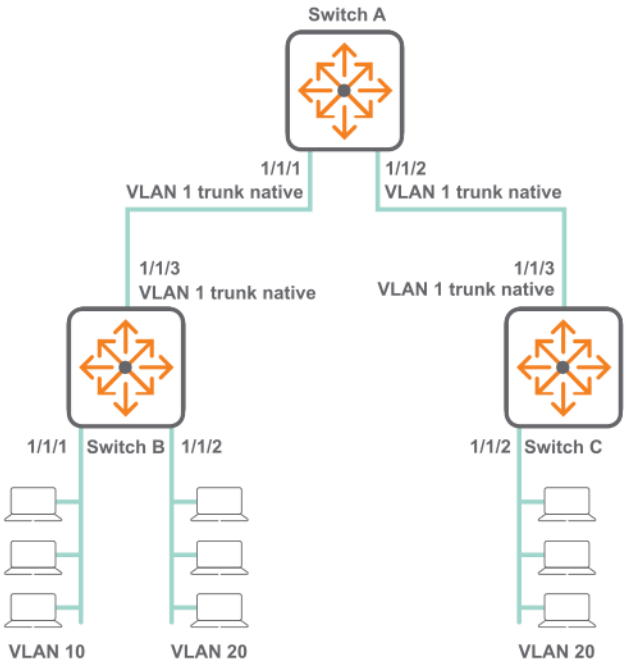
This example creates the following configuration:

- Enables MVRP on all interfaces.
- Sets interface 1/1/1 to ignore VLAN 100.

```
switch(config)# mvrp
switch(config)# interface 1/1/1
switch(config-if)# mvrp registration forbidden 100
switch(config-if)# mvrp
switch(config-if)# quit
switch# show mvrp config
Configuration and Status - MVRP
Global MVRP status : Disabled
Port    Status    Registration Join  Leave  LeaveAll Periodic
                  Type         Timer Timer  Timer    Timer
------- -------- --------      -----  ----- ------   --------
1/1/1   Disabled  Normal         20   300   1000     100
switch# show mvrp state 1/1/1
Configuration and Status - MVRP state for VLAN 1
Port   VLAN Registrar Applicant
            State     State
-----  ---- -------- ---------
1/1/1  1     MT       QA
```

# MVRP scenario 1

This scenario illustrates the configuration of a simple MVRP deployment.




### Procedure

1. On switch A, enable MVRP globally, define VLANs on interface **1/1/1** and **1/1/2**, and enable MVRP on each interface.

```
switch# config
switch(config)# mvrp
switch(config)# interface 1/1/1
switch(config-if)# no shutdown
switch(config-if)# vlan trunk native 1
switch(config-if)# mvrp
switch(config-if)# exit
switch(config)# interface 1/1/2
switch(config-if)# no shutdown
switch(config-if)# vlan trunk native 1
switch(config-if)# mvrp
```

2. On switch B, enable MVRP globally, define VLANs 10 and 20, assign a trunk native VLAN to interface **1/1/3**, and enable MVRP on this interface.

```
switch# config
switch(config)# mvrp
switch(config)# vlan 10
switch(config)# vlan 20
switch(config)# interface 1/1/3
switch(config-if)# no shutdown
switch(config-if)# vlan trunk native 1
switch(config-if)# mvrp
```

3. On switch C, enable MVRP globally, define VLAN 20, assign a trunk native VLAN to interface **1/1/3**, and enable MVRP on this interface.

```
switch# config
switch(config)# mvrp
switch(config)# vlan 20
switch(config)# interface 1/1/3
switch(config-if)# no shutdown
switch(config-if)# vlan trunk native 1
switch(config-if)# mvrp
```

4. Verify VLAN configuration by running the command `show vlan`. It should show that VLAN 10 and 20 are learned by switch A, and VLAN 10 should be learned by switch C. For example:

   On switch A:

```
switch# show vlan
--------------------------------------------------------------------------------
-
VLAN  Name                  Status  Reason             Type      Interfaces
--------------------------------------------------------------------------------
-
1     DEFAULT_VLAN_1        up      ok                 default   1/1/1-
1/1/2
10    VLAN10                up      ok                 dynamic   1/1/2
20    VLAN20                up      ok                 dynamic   1/1/1-
1/1/2
switch#
switch# show mvrp config
Configuration and Status - MVRP
```

```
Global MVRP status : Enabled
Port    Status    Registration Join   Leave    LeaveAll Periodic
                  Type         Timer  Timer    Timer    Timer
------- --------  --------     -----  -------  -------  --------
  1/1/1  Enabled    normal        20      300     1000       100
  1/1/2  Enabled    normal        20      300     1000       100
switch# show mvrp state
Configuration and Status - MVRP state
Port   VLAN Registrar Applicant Forbid
            State     State     Mode
----   ---- --------- --------- ---------
1/1/1  1    IN        QA        No
1/1/1  10   MT        QA        No
1/1/1  20   IN        QA        No
1/1/2  1    IN        QA        No
1/1/2  10   IN        VO        No
1/1/2  20   IN        QA        No
switch# show mvrp statistics
Status and Counters - MVRP
MVRP statistics for port : 1/1/1
-----------------------------
Failed registration   : 0
Last PDU origin       : e0:07:1b:cb:01:ab
Total PDU Transmitted : 313
Total PDU Received    : 377
Frames Discarded      : 0
Message type    Transmitted     Received
--------------- ------------ ------------
New                        0            0
Empty                 179105         2264
In                         0          346
Join Empty               366           62
Join In                  342          692
Leave                      0            0
Leaveall                  43           32

Status and Counters - MVRP
MVRP statistics for port : 1/1/2
-----------------------------
Failed registration   : 0
Last PDU origin       : e0:07:1b:cb:22:54
Total PDU Transmitted : 450
Total PDU Received    : 84
Frames Discarded      : 0
Message type    Transmitted     Received
--------------- ------------ ------------
New                        0            0
Empty                 173629          382
In                       328            0
Join Empty                83           93
Join In                  711           65
Leave                      0            0
Leaveall                  41           33
```

On switch B:

```
switch# show vlan
--------------------------------------------------------------------------------
--
```

```
VLAN  Name                  Status  Reason               Type
Interfaces
------------------------------------------------------------------------------
--
1     DEFAULT_VLAN_1        up      ok                   default   1/1/3
10    VLAN10                up      ok                   static    1/1/3
20    VLAN20                up      ok                   static    1/1/3
SW1-8320#

SW1-8320# show mvrp config
Configuration and Status - MVRP
Global MVRP status : Enabled
Port    Status    Registration Join   Leave    LeaveAll Periodic
                  Type         Timer  Timer    Timer    Timer
------- --------  --------     -----  -------  -------  --------
 1/1/3   Enabled    normal        20      300     1000       100
SW1-8320# show mvrp state
Configuration and Status - MVRP state
Port   VLAN Registrar Applicant Forbid
            State     State     Mode
----   ---- --------- --------- ---------
1/1/3  1    IN        QA        No
1/1/3  10   MT        QA        No
1/1/3  20   IN        QA        No
SW1-8320# show mvrp statistics
Status and Counters - MVRP
MVRP statistics for port : 1/1/3
-----------------------------
Failed registration   : 0
Last PDU origin       : 48:0f:cf:af:f2:fa
Total PDU Transmitted : 77
Total PDU Received    : 303
Frames Discarded      : 0
Message type    Transmitted     Received
--------------- ------------ ------------
New                        0            0
Empty                 115067         1754
In                         0          268
Join Empty               100            1
Join In                   53          581
Leave                      0            0
Leaveall                  28           27
```

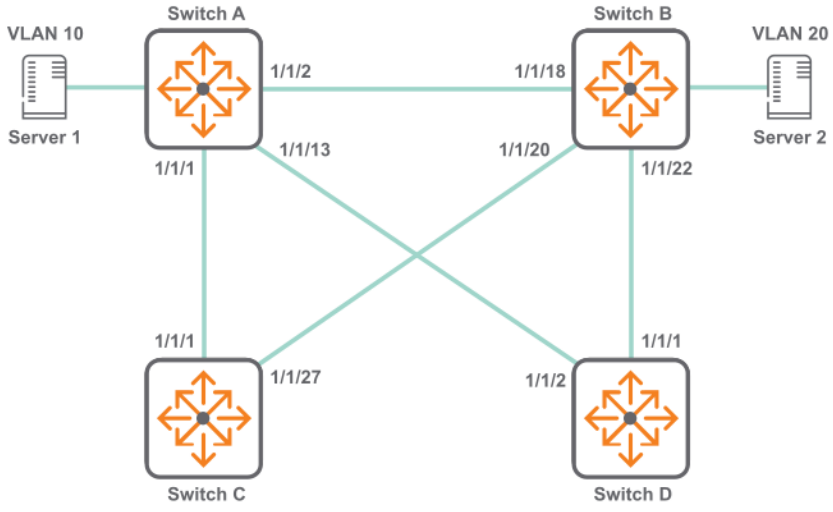
On switch C:

```
switch# show vlan
------------------------------------------------------------------------------
--
VLAN  Name                  Status  Reason               Type
Interfaces
------------------------------------------------------------------------------
--
1     DEFAULT_VLAN_1        up      ok                   default   1/1/3
10    VLAN10                up      ok                   dynamic   1/1/3
20    VLAN20                up      ok                   static    1/1/3
switch#

switch# show mvrp config
Configuration and Status - MVRP
Global MVRP status : Enabled
```

```
Port    Status    Registration Join   Leave    LeaveAll Periodic
                  Type         Timer  Timer    Timer    Timer
------- --------  --------     -----  -------  -------  --------
 1/1/3   Enabled    normal        20      300     1000       100
switch# show mvrp state
Configuration and Status - MVRP state
Port   VLAN Registrar Applicant Forbid
            State     State     Mode
----   ---- --------- --------- ---------
1/1/3   1    IN        QA        No
1/1/3   10   IN        VO        No
1/1/3   20   IN        QA        No
switch#

switch# show mvrp statistics
Status and Counters - MVRP
MVRP statistics for port : 1/1/3
-----------------------------
Failed registration   : 0
Last PDU origin       : 48:0f:cf:af:f2:fb
Total PDU Transmitted : 203
Total PDU Received    : 95
Frames Discarded      : 0
Message type    Transmitted     Received
--------------- ------------ ------------
New                        0            0
Empty                  72915          586
In                       183            0
Join Empty                40          101
Join In                  366          176
Leave                      0            0
Leaveall                  17           16
```

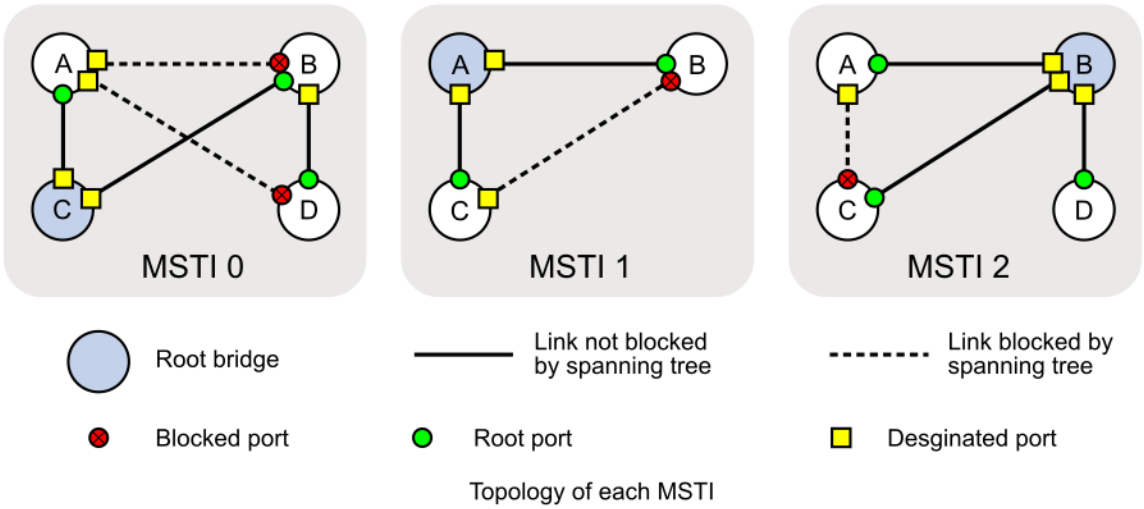
# MVRP scenario 2

This scenario illustrates the configuration of an MVRP deployment with two MSTIs.




Two MSTIs are defined for this scenario:

- VLAN 10 assigned to MSTI 1
- VLAN 20 assigned to MSTI 2
- All other VLANs assigned to the default MSTI 0




Topology of each MSTI

## Procedure

1. On switch A:

```
switch# config
switch(config)# mvrp
switch(config)# vlan 10
switch(config)# spanning-tree
switch(config)# spanning-tree priority 1
switch(config)# spanning-tree config-name sp1
switch(config)# spanning-tree config-revision 1
switch(config)# spanning-tree instance 1 vlan 10
switch(config)# spanning-tree instance 2 vlan 20
switch(config)# interface 1/1/1
switch(config-if)# no shutdown
switch(config-if)# vlan trunk native 1
switch(config-if)# mvrp
switch(config-if)# exit
switch(config)# interface 1/1/2
switch(config-if)# no shutdown
switch(config-if)# vlan trunk native 1
switch(config-if)# mvrp
switch(config-if)# exit
switch(config)# interface 1/1/3
switch(config-if)# no shutdown
switch(config-if)# vlan trunk native 1
switch(config-if)# mvrp
switch(config-if)# exit
switch# show mvrp config
Configuration and Status - MVRP
Global MVRP status : Enabled
Port    Status    Registration Join   Leave    LeaveAll Periodic
                  Type         Timer  Timer    Timer    Timer
------- --------  --------     -----  -------  -------  --------
  1/1/1  Enabled    normal        20      300     1000       100
```

```
  1/1/3  Enabled    normal        20      300     1000       100
  1/1/2  Enabled    normal        20      300     1000       100
switch# show mvrp state
Configuration and Status - MVRP state
Port   VLAN Registrar Applicant Forbid
            State     State     Mode
----   ---- --------- --------- ---------
1/1/1  1    IN        QA        No
1/1/1  20   MT        QA        No
1/1/3  1    IN        QA        No
1/1/3  20   IN        VO        No
1/1/2  1    MT        QA        No
1/1/2  20   MT        QA        No

switch# show spanning-tree mst
#### MST0
Vlans mapped:  1-9,11-19,21-4094
Bridge         Address:48:0f:cf:af:f1:82    priority:4096
Operational    Hello time(in seconds): 2  Forward delay(in seconds):15  Max-
age(in seconds):20  txHoldCount(i6
Configured     Hello time(in seconds): 2  Forward delay(in seconds):15  Max-
age(in seconds):20  txHoldCount(i6
Root           Address:48:0f:cf:af:14:0a  Priority:4096
               Port:1/1/3                 Path cost:0
Regional Root  Address:48:0f:cf:af:14:0a  Priority:4096
               Internal cost:20000        Rem Hops:19

Port           Role           State        Cost       Priority   Type
-------------- -------------- ------------ ---------- ---------- ----------
1/1/1          Designated     Forwarding   20000      128        point_to_
point
1/1/2          Designated     Forwarding   20000      128        point_to_
point
1/1/3          Root           Forwarding   20000      128        point_to_
point


#### MST1
Vlans mapped:  10
Bridge         Address:48:0f:cf:af:f1:82    Priority:32768
Root           Address:48:0f:cf:af:14:0a    Priority:32768
               Port:1/1/3, Cost:20000, Rem Hops:19

Port           Role           State        Cost    Priority   Type
-------------- -------------- ------------ ------- ---------- ----------
1/1/1          Designated     Forwarding   20000   128        point_to_point
1/1/2          Designated     Forwarding   20000   128        point_to_point
1/1/3          Root           Forwarding   20000   128        point_to_point


#### MST2
Vlans mapped:  20
Bridge         Address:48:0f:cf:af:f1:82    Priority:32768
Root           Address:48:0f:cf:af:14:0a    Priority:32768
               Port:1/1/3, Cost:20000, Rem Hops:19

Port           Role           State        Cost    Priority   Type
-------------- -------------- ------------ ------- ---------- ----------
1/1/1          Designated     Forwarding   20000   128        point_to_point
1/1/2          Designated     Forwarding   20000   128        point_to_point
```

```
1/1/3          Root           Forwarding   20000   128        point_to_point
```

2. On switch B:

```
switch# config
switch(config)# mvrp
switch(config)# vlan 20
switch(config)# spanning-tree
switch(config)# spanning-tree priority 1
switch(config)# spanning-tree config-name sp1
switch(config)# spanning-tree config-revision 1
switch(config)# spanning-tree instance 1 vlan 10
switch(config)# spanning-tree instance 2 vlan 20
switch(config)# interface 1/1/18
switch(config-if)# no shutdown
switch(config-if)# vlan trunk native 1
switch(config-if)# vlan trunk allowed all
switch(config-if)# mvrp
switch(config-if)# exit
switch(config)# interface 1/1/20
switch(config-if)# no shutdown
switch(config-if)# vlan trunk native 1
switch(config-if)# vlan trunk allowed all
switch(config-if)# mvrp
switch(config-if)# exit
switch(config)# interface 1/1/22
switch(config-if)# no shutdown
switch(config-if)# vlan trunk native 1
switch(config-if)# vlan trunk allowed all
switch(config-if)# mvrp
switch(config-if)# exit
switch# show mvrp config
Configuration and Status - MVRP
Global MVRP status : Enabled
Port    Status    Registration Join   Leave    LeaveAll Periodic
                  Type         Timer  Timer    Timer    Timer
------- --------  --------     -----  -------  -------  --------
 1/1/18  Enabled    normal        20      300     1000       100
 1/1/20  Enabled    normal        20      300     1000       100
 1/1/22  Enabled    normal        20      300     1000       100
switch# show mvrp state
Configuration and Status - MVRP state
Port   VLAN Registrar Applicant Forbid
            State     State     Mode
----   ---- --------- --------- ---------
1/1/20 1    MT        AA        No
1/1/20 10   MT        AA        No
1/1/20 20   MT        AA        No
1/1/22 1    IN        AP        No
1/1/22 10   IN        VO        No
1/1/22 20   MT        VP        No

switch# show spanning-tree mst
#### MST0
Vlans mapped:  1-9,11-19,21-4094
Bridge         Address:e0:07:1b:cb:22:1c    priority:4096
Operational    Hello time(in seconds): 2  Forward delay(in seconds):15  Max-
age(in seconds):20  txHoldCount(in pp6
Configured     Hello time(in seconds): 2  Forward delay(in seconds):15  Max-
```

```
age(in seconds):20  Max-Hops:20
Root            Address:48:0f:cf:af:14:0a  Priority:4096
                Port:1/1/22                Path cost:0
Regional Root   Address:48:0f:cf:af:14:0a  Priority:4096
                Internal cost:20000        Rem Hops:19

Port            Role           State        Cost       Priority   Type
--------------- -------------- ------------ ---------- ---------- ----------
1/1/18          Alternate      Blocking     20000      128        point_to_
point
1/1/20          Designated     Forwarding   20000      128        point_to_
point
1/1/22          Root           Forwarding   20000      128        point_to_
point


#### MST1
Vlans mapped:  10
Bridge          Address:e0:07:1b:cb:22:1c    Priority:32768
Root            Address:48:0f:cf:af:14:0a    Priority:32768
                Port:1/1/22, Cost:20000, Rem Hops:19

Port            Role           State        Cost    Priority   Type
--------------- -------------- ------------ ------- ---------- ----------
1/1/18          Alternate      Blocking     20000   128        point_to_point
1/1/20          Designated     Forwarding   20000   128        point_to_point
1/1/22          Root           Forwarding   20000   128        point_to_point


#### MST2
Vlans mapped:  20
Bridge          Address:e0:07:1b:cb:22:1c    Priority:32768
Root            Address:48:0f:cf:af:14:0a    Priority:32768
                Port:1/1/22, Cost:20000, Rem Hops:19

Port            Role           State        Cost    Priority   Type
--------------- -------------- ------------ ------- ---------- ----------
1/1/18          Alternate      Blocking     20000   128        point_to_point
1/1/20          Designated     Forwarding   20000   128        point_to_point
1/1/22          Root           Forwarding   20000   128        point_to_point
```

3. On switch C:

```
switch# config
switch(config)# mvrp
switch(config)# vlan 1,20
switch(config)# spanning-tree
switch(config)# spanning-tree priority 1
switch(config)# spanning-tree config-name sp1
switch(config)# spanning-tree config-revision 1
switch(config)# spanning-tree instance 1 vlan 10
switch(config)# spanning-tree instance 2 vlan 20
switch(config)# interface 1/1/25
switch(config-if)# no shutdown
switch(config-if)# vlan trunk native 1
switch(config-if)# vlan trunk allowed all
switch(config-if)# mvrp
switch(config-if)# exit
```

```
switch(config)# interface 1/1/27
switch(config-if)# no shutdown
switch(config-if)# vlan trunk native 1
switch(config-if)# vlan trunk allowed all
switch(config-if)# mvrp
switch(config-if)# exit
switch# show mvrp config
Configuration and Status - MVRP
Global MVRP status : Enabled
Port    Status    Registration Join   Leave    LeaveAll Periodic
                  Type         Timer  Timer    Timer    Timer
------- --------  --------     -----  -------  -------  --------
 1/1/25  Enabled    normal        20      300     1000       100
 1/1/27  Enabled    normal        20      300     1000       100
switch# show mvrp state
Configuration and Status - MVRP state
Port   VLAN Registrar Applicant Forbid
            State     State     Mode
----   ---- --------- --------- ---------
1/1/25 1    IN        QA        No
1/1/25 10   IN        VO        No
1/1/25 20   IN        VO        No

switch# show spanning-tree mst
#### MST0
Vlans mapped:  1-9,11-19,21-4094
Bridge         Address:e0:07:1b:cb:01:7a    priority:4096
Operational    Hello time(in seconds): 2  Forward delay(in seconds):15  Max-
age(in seconds):20  txHoldCount(6
Configured     Hello time(in seconds): 2  Forward delay(in seconds):15  Max-
age(in seconds):20  Max-Hops:20
Root           Address:48:0f:cf:af:14:0a  Priority:4096
               Port:1/1/25                Path cost:0
Regional Root  Address:48:0f:cf:af:14:0a  Priority:4096
               Internal cost:40000        Rem Hops:18

Port           Role           State        Cost       Priority   Type
-------------- -------------- ------------ ---------- ---------- ----------
1/1/25         Root           Forwarding   20000      128        point_to_
point
1/1/27         Alternate      Blocking     20000      128        point_to_
point


#### MST1
Vlans mapped:  10
Bridge         Address:e0:07:1b:cb:01:7a    Priority:32768
Root           Address:48:0f:cf:af:14:0a    Priority:32768
               Port:1/1/25, Cost:40000, Rem Hops:18

Port           Role           State        Cost    Priority   Type
-------------- -------------- ------------ ------- ---------- ----------
1/1/25         Root           Forwarding   20000   128        point_to_point
1/1/27         Alternate      Blocking     20000   128        point_to_point


#### MST2
Vlans mapped:  20
Bridge         Address:e0:07:1b:cb:01:7a    Priority:32768
Root           Address:48:0f:cf:af:14:0a    Priority:32768
               Port:1/1/25, Cost:40000, Rem Hops:18
```

```
Port           Role           State        Cost    Priority   Type
-------------- -------------- ------------ ------- ---------- ----------
1/1/25         Root           Forwarding   20000   128        point_to_point
1/1/27         Alternate      Blocking     20000   128        point_to_point
```

4. On switch D:

```
switch# config
switch(config)# mvrp
switch(config)# vlan 1
switch(config)# spanning-tree
switch(config)# spanning-tree priority 1
switch(config)# spanning-tree config-name sp1
switch(config)# spanning-tree config-revision 1
switch(config)# spanning-tree instance 1 vlan 10
switch(config)# spanning-tree instance 2 vlan 20
switch(config)# interface 1/1/1
switch(config-if)# no shutdown
switch(config-if)# vlan trunk native 1
switch(config-if)# vlan trunk allowed all
switch(config-if)# mvrp
switch(config-if)# exit
switch(config)# interface 1/1/2
switch(config-if)# no shutdown
switch(config-if)# vlan trunk native 1
switch(config-if)# vlan trunk allowed all
switch(config-if)# mvrp
switch(config-if)# exit
switch# show mvrp config
Configuration and Status - MVRP
Global MVRP status : Enabled
Port    Status    Registration Join   Leave    LeaveAll Periodic
                  Type         Timer  Timer    Timer    Timer
------- --------  --------     -----  -------  -------  --------
  1/1/1  Enabled    normal        20      300     1000       100
  1/1/2  Enabled    normal        20      300     1000       100
switch# show mvrp state
Configuration and Status - MVRP state
Port   VLAN Registrar Applicant Forbid
            State     State     Mode
----   ---- --------- --------- ---------
1/1/1  1    IN        QA        No
1/1/1  10   MT        QA        No
1/1/1  20   IN        VO        No
1/1/2  1    IN        AA        No
1/1/2  10   IN        VO        No
1/1/2  20   MT        AA        No

switch# show spanning-tree mst
#### MST0
Vlans mapped:  1-9,11-19,21-4094
Bridge         Address:48:0f:cf:af:14:0a    priority:4096
Root
Regional Root
Operational    Hello time(in seconds): 2  Forward delay(in seconds):15  Max-
age(in seconds):20  txHoldC6
Configured     Hello time(in seconds): 2  Forward delay(in seconds):15  Max-
age(in seconds):20  Max-Hop0
Root           Address:48:0f:cf:af:14:0a  Priority:4096
```

```
               Port:0                      Path cost:0
Regional Root  Address:48:0f:cf:af:14:0a   Priority:4096
               Internal cost:0             Rem Hops:20

Port           Role           State        Cost       Priority   Type
-------------- -------------- ------------ ---------- ---------- ----------
1/1/1          Designated     Forwarding   20000      128        point_to_
point
1/1/2          Designated     Forwarding   20000      128        point_to_
point


#### MST1
Vlans mapped:  10
Bridge         Address:48:0f:cf:af:14:0a    Priority:32768
Root           Address:48:0f:cf:af:14:0a    Priority:32768
               Port:0, Cost:0, Rem Hops:20

Port           Role           State        Cost    Priority   Type
-------------- -------------- ------------ ------- ---------- ----------
1/1/1          Designated     Forwarding   20000   128        point_to_point
1/1/2          Designated     Forwarding   20000   128        point_to_point


#### MST2
Vlans mapped:  20
Bridge         Address:48:0f:cf:af:14:0a    Priority:32768
Root           Address:48:0f:cf:af:14:0a    Priority:32768
               Port:0, Cost:0, Rem Hops:20

Port           Role           State        Cost    Priority   Type
-------------- -------------- ------------ ------- ---------- ----------
1/1/1          Designated     Forwarding   20000   128        point_to_point
1/1/2          Designated     Forwarding   20000   128        point_to_point
```

# MVRP commands

## clear mvrp statistics

`clear mvrp statistics [<PORT-NUM> | <PORT-LIST> | LAG <LAG-NUM>]`

### Description

Resets the MVRP statistic counters globally or for the specified ports or LAG.

| Parameter | Description |
|---|---|
| *<PORT-NUM>* | Specifies a port number. |
| *<PORT-LIST>* | Specifies a list of ports. |
| LAG *<LAG-NUM>* | Specifies a Link Aggregation number. Range: 1 to 128. |

### Examples

```
switch# clear mvrp statistics 1/1/1
```

### Command History

| Release | Modification |
|---|---|
| 10.07 or earlier | -- |

### Command Information

| Platforms | Command context | Authority |
|---|---|---|
| All platforms | Manager (#) | Administrators or local user group members with execution rights for this command. |

## mvrp

```
mvrp
no mvrp
```

### Description

Enables the MVRP feature globally or on a specific interface. By default, MVRP is disabled.

The **no** form of this command disables MVRP.

MVRP and VLAN translation cannot be enabled on the same interface.

### Examples

Enabling MVRP globally:

```
switch(config)# mvrp
```

Enabling MVRP on an interface:

```
switch(config)# interface 1/1/1
switch(config-if)# mvrp
```

### Command History

| Release | Modification |
|---|---|
| 10.07 or earlier | -- |

### Command Information

| Platforms | Command context | Authority |
|---|---|---|
| All platforms | `config`<br>`config-if` | Administrators or local user group members with execution rights for this command. |

## mvrp registration

```
mvrp registration {normal | fixed | forbidden [<VLAN-LIST>]}
no mvrp registration forbidden {<VLAN-LIST>}
```

### Description

Configures the MVRP registrar state which determines how an MVRP participant responds to MRP messages. The default registration mode is normal.

The `no` command removes the specified VLANs from the forbidden list.

| Parameter | Description |
|---|---|
| `normal` | Enables dynamic registration and deregistration of VLANs on the interface, and propagates VLAN information to other switches on the network. Default. |
| `fixed` | Disables dynamic deregistration of VLANs and drops received MVRP frames. The interface does not deregister dynamic VLANs or register new dynamic VLANs. |
| `forbidden` | Disables dynamic registration of VLANs and drops received MVRP frames. The MVRP participant does not register new dynamic VLANs or re-register a deregistered dynamic VLAN. |
| *<VLAN-LIST>* | Disables dynamic registration of VLANs and drops received MVRP frames for specific VLANs only. Normal behavior applies to all other VLANs. Specify the number of a single VLAN, or a series of numbers for a range of VLANs, separated by commas (1, 2, 3, 4), dashes (1-4), or both (1-4,6). |

### Examples

```
switch(config)# switch(config-if)# mvrp registration forbidden 10
```

```
switch(config-if)# mvrp registration fixed
```

```
switch(config-if)# mvrp registration forbidden 1,2,10-20
```

### Command History

| Release | Modification |
|---|---|
| 10.07 or earlier | -- |

### Command Information

| Platforms | Command context | Authority |
|---|---|---|
| All platforms | `config-if` | Administrators or local user group members with execution rights for this command. |

## mvrp timer

```
mvrp timer {join | leave | leaveall | periodic} <TIME>
```

```
no mvrp timer {join | leave | leaveall | periodic}
```

### Description

Sets an MVRP timer.

The **no** form of this command sets the specified timer to its default value.

| Parameter | Description |
|---|---|
| `join <TIME>` | Sets the join timer. You can use the timer to space MVRP join messages. To ensure that join messages are transmitted to other participants, an MRP participant waits for the specified period of the join timer before sending a join message. The Join timer must be less than half of the Leave Timer. Range: 20 to 100 in centiseconds. Default: 20. |
| `leave <TIME>` | Sets the leave timer for the port, specifying the time that the registrar state machine waits in the LV state before transiting to the MT state. The leave timer must be at least twice the join timer and must be less than the leave all timer. Range: 40 - 1000000 centiseconds. Default: 300 centiseconds. |
| `leaveall <TIME>` | Sets the leave all timer for the port, specifying the frequency with which the leave all state machine generates leave alll PDUs. Range: 500 to1000000 centiseconds. Default: 1000. |
| `periodic <TIME>` | Sets the periodic timer for the port, specifying the frequency with which the periodic transmission state machine generates periodic events. The periodic timer is set to 1 second when it is started. Range: 100 to 1000000 centiseconds. Default: 100. |

### Examples

```
switch(config-if)# mvrp timer join 22
```

### Command History

| Release | Modification |
|---|---|
| 10.07 or earlier | -- |

### Command Information

| Platforms | Command context | Authority |
|---|---|---|
| All platforms | `config-if` | Administrators or local user group members with execution rights for this command. |

## show mvrp config

```
show mvrp config [<PORT-NUM> | <PORT-LIST> | LAG <LAG-NUM>]
```

### Description

Displays the MVRP configuration for all L2 ports or optionally for the ports specified.

| Parameter | Description |
|---|---|
| *<PORT-NUM>* | Specifies displaying information for a particular port number. |
| *<PORT-LIST>* | Specifies displaying information for a list of ports. |
| LAG *<LAG-NUM>* | Specifies displaying information by LAG. Range: 1 to 128. |

### Examples

```
switch# show mvrp config
Configuration and Status - MVRP
Global MVRP status : Disabled
Port    Status    Registration Join  Leave  LeaveAll Periodic
                  Type         Timer Timer  Timer    Timer
------- -------- --------      ----- -----  ------   --------
1/1/1    Disabled  Normal         20   300   1000     100
1/1/2    Disabled  Normal         20   300   1000     100
1/1/3    Disabled  Normal         20   300   1000     100
```

### Command History

| Release | Modification |
|---|---|
| 10.07 or earlier | -- |

### Command Information

| Platforms | Command context | Authority |
|---|---|---|
| All platforms | Operator (>) or Manager (#) | Operators or Administrators or local user group members with execution rights for this command. Operators can execute this command from the operator context (>) only. |

## show mvrp state

```
show mvrp state [<VLAN-ID> | <VLAN-ID> <PORT-NUM>]
```

### Description

Displays the MVRP Registrar and Applicant state machine information for all ports on which MVRP is enabled, or for specific ports.

| Parameter | Description |
|---|---|
| *<VLAN-ID>* | |
| *<PORT-NUM>* | Specifies a physical port on the switch. Forrmat: **member/slot/port**. |

### Examples

```
switch# show mvrp state 1
Configuration and Status - MVRP state for VLAN 1
Port   VLAN Registrar Applicant
            State     State
----   ---- -------- ---------
1/1/1  1    MT       QA
```

```
switch# show mvrp state 10 1/1/1
Configuration and Status - MVRP state for VLAN 10
Port   VLAN Registrar Applicant Forbid
            State     State     Mode
----   ---- --------- --------- ---------
1/1/1  10   MT        LO        Yes
switch#
```

### Command History

| Release | Modification |
|---|---|
| 10.07 or earlier | -- |

### Command Information

| Platforms | Command context | Authority |
|---|---|---|
| All platforms | Operator (>) or Manager (#) | Operators or Administrators or local user group members with execution rights for this command. Operators can execute this command from the operator context (>) only. |

## show mvrp statistics

`show mvrp statistics [<PORT-LIST>]`

### Description

Displays MVRP statistics for all ports or on the ports specified in the list.

| Parameter | Description |
|---|---|
| *<PORT-LIST>* | Specifies a list of ports. When specifying a list of ports, the ports for which there are no statistics will be listed in the output. |

### Examples

```
switch# show mvrp statistics
Status and Counters - MVRP
MVRP statistics for port : 1/1/1
---------------------------
Failed registration   : 0
Last PDU origin       : 48:0f:cf:af:b1:76
Total PDU Transmitted : 13127
Total PDU Received    : 327
Frames Discarded      : 0
```

```
Message type    Transmitted     Received
--------------- ------------ ------------
New                       0            0
Empty              50029394         1264
In                        0            4
Join Empty             1425           48
Join In                 563          555
Leave                     0            0
Leaveall              12218           25
```

```
switch# show mvrp statistics  1/1/1

Status and Counters - MVRP
MVRP statistics for port : 1/1/1
----------------------------
Failed registration   : 0
Last PDU origin       : 48:0f:cf:af:b1:76
Total PDU Transmitted : 14874
Total PDU Received    : 327
Frames Discarded      : 0
Message type    Transmitted     Received
--------------- ------------ ------------
New                       0            0
Empty              57181612         1264
In                        0            4
Join Empty             1425           48
Join In                 563          555
Leave                     0            0
Leaveall              13965           25
```

## Command History

| Release | Modification |
|---|---|
| 10.07 or earlier | -- |

## Command Information

| Platforms | Command context | Authority |
|---|---|---|
| All platforms | Operator (>) or Manager (#) | Operators or Administrators or local user group members with execution rights for this command. Operators can execute this command from the operator context (>) only. |

# Chapter 8
# Spanning tree protocols (STP)

## Protocols and feature details

Spanning tree protocols eliminate loops in a physical link-redundant network by selectively blocking redundant links and putting them in a standby state.

Recent versions of STP include the Rapid Per-VLAN Spanning Tree Protocol (RPVST+) and the Multiple Spanning Tree Protocol (MSTP).

## STP

Spanning tree protocol (STP) was developed based on the 802.1d standard of IEEE to eliminate loops at the data link layer in a LAN. Networks often have redundant links as backups in case of failures, but loops are a very serious problem. Devices running STP detect loops in the network by exchanging information with one another. They eliminate loops by selectively blocking certain ports to prune the loop structure into a loop-free tree structure. This avoids proliferation and infinite cycling of packets that would occur in a loop network.

In a narrow sense, STP refers to IEEE 802.1d STP. In a broad sense, STP refers to the IEEE 802.1d STP and various enhanced spanning tree protocols derived from that protocol, such as MSTP and RPVST+.

### Root bridge

A tree network must have a root bridge. The entire network contains only one root bridge, and all the other bridges in the network are called leaf nodes. The root bridge is not permanent and can change when there are changes in the network topology.

Upon initialization of a network, each device generates and periodically sends configuration BPDUs, with itself as the root bridge. After network convergence, only the root bridge generates and periodically sends configuration BPDUs. The other devices only forward the BPDUs.

### Root port

On a non-root bridge, the port which has the least cost to reach the root bridge is the root port.

The root port communicates with the root bridge. Each non-root bridge has only one root port. The root bridge has no root port.

### Designated bridge and designated port

A designated bridge is a bridge on each LAN that provides the minimum root path cost. The designated bridge of a LAN is the only bridge allowed to forward frames to and from the LAN.

The designated bridge:

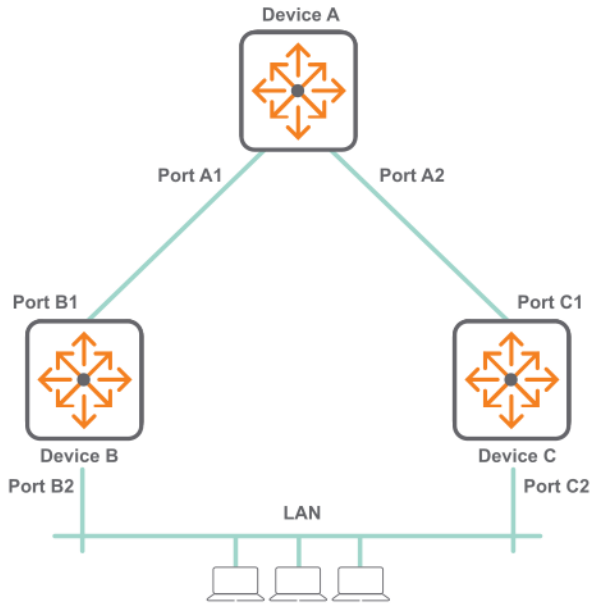
- For a device: Device directly connected with the local device and responsible for forwarding BPDUs to the local device.
- For a LAN: Device responsible for forwarding BPDUs to this LAN segment.

The designated port:

- For a device: Port through which the designated bridge forwards BPDUs to this device.
- For a LAN: Port through which the designated bridge forwards BPDUs to this LAN segment.

In the following topology, Device B and Device C are directly connected to a LAN.

**Figure 1** *Designated bridge and designated port*




If Device A forwards BPDUs to Device B through port A1, the designated bridge and designated port are as follows:

- The designated bridge for Device B is Device A.
- The designated port of Device B is port A1 on Device A.

If Device B forwards BPDUs to the LAN, the designated bridge and designated port are as follows:

- The designated bridge for the LAN is Device B.
- The designated port for the LAN is port B2 on Device B.

## Path cost

Path cost is a reference value used for link selection in STP. To prune the network into a loop-free tree, STP calculates path costs to select the most robust links and block redundant links that are less robust.

## STP timers

The most important timing parameters in STP calculation are forward delay, hello time, and max age.

- Forward delay: Forward delay is the delay time for port state transition. A path failure can cause spanning tree recalculation to adapt the spanning tree structure to the change. However, the resulting new configuration BPDU cannot propagate throughout the network immediately. If the

newly elected root ports and designated ports start to forward data immediately, a temporary loop will likely occur. The newly elected root ports or designated ports require twice the forward delay time before they transit to the forwarding state. This allows the new configuration BPDU to propagate throughout the network.

- Hello time: The device sends hello packets at the hello time interval to the neighboring devices to make sure the paths are fault-free.
- Max age: The device uses the max age to determine whether a stored configuration BPDU has expired and discards it if the max age is exceeded.

## BPDU forwarding mechanism

The configuration BPDUs of STP are forwarded according to these guidelines:

- Upon network initiation, every device regards itself as the root bridge and generates configuration BPDUs with itself as the root. Then it sends the configuration BPDUs at a regular hello interval.
- If the root port received a configuration BPDU superior to the configuration BPDU of the port, the device performs the following tasks:
  - Increases the message age carried in the configuration BPDU.
  - Starts a timer to time the configuration BPDU.
  - Sends this configuration BPDU through the designated port.
- If a designated port receives a configuration BPDU with a lower priority than its configuration BPDU, the port immediately responds with its configuration BPDU.
- If a path fails, the root port on this path no longer receives new configuration BPDUs and the old configuration BPDUs will be discarded due to timeout. The device generates a configuration BPDU with itself as the root and sends the BPDUs and TCN BPDUs. This triggers a new spanning tree calculation process to establish a new path to restore the network connectivity.

However, the newly calculated configuration BPDU cannot be propagated throughout the network immediately. As a result, the old root ports and designated ports that have not detected the topology change continue forwarding data along the old path. If the new root ports and designated ports begin to forward data as soon as they are elected, a temporary loop might occur.

## STP protocol packets

STP uses bridge protocol data units (BPDUs), also known as configuration messages, as its protocol packets. STP-enabled network devices exchange BPDUs to establish a spanning tree.

STP uses the following types of BPDUs:

- Configuration BPDUs: Used by the network devices to calculate a spanning tree and maintain the spanning tree topology.
- Topology change notification (TCN) BPDUs: Use to notify network devices of network topology changes.

Configuration BPDUs contain sufficient information for network devices to complete spanning tree calculation. Important fields in a configuration BPDU include the following:

- Root bridge ID: Priority and MAC address of the root bridge.
- Root path cost: Cost of the path to the root bridge indicated by the root identifier from the transmitting bridge.
- Designated bridge ID: Priority and MAC address of the designated bridge.

- Designated port ID: Priority and global port number of the designated port.
- Message age: Age of the configuration BPDU while it propagates in the network.
- Max age: Maximum age of the configuration BPDU stored on the switch.
- Hello time: Configuration BPDU transmission interval.
- Forward delay: Delay that STP bridges use to transit port state.

## Comparing spanning tree options

Without spanning tree, having more than one active path between a pair of network devices causes loops in the network that can result in duplication of messages, leading to a broadcast storm that can bring down the network.

The 802.1D spanning tree protocol operates without regard to a network's VLAN configuration, and maintains one common spanning tree throughout a bridged network. This protocol maps one loop-free, logical topology onto a given physical topology, resulting in the least optimal link utilization and longest convergence times.

The 802.1s multiple spanning tree protocol (MSTP) uses multiple spanning tree instances with separate forwarding topologies. Each instance is composed of one or more VLANs. This significantly improves network link utilization and the speed of reconvergence after a failure in the network's physical topology. RPVST+ is a proprietary Cisco protocol, whereas MSTP is an open standard protocol based on IEEE 802.1s. So, in multi-vendor environments, MSTP is the preferred option because of interoperability.

In RPVST+, the number of spanning tree instances is equal to the number of VLANs. RPVST+ may become quite resource intensive as a result. The number of spanning tree instances in MSTP can theoretically be the same as the number of VLANs, but in practice, the number of spanning tree instances is limited to a number of physical topologies that is much fewer than the number of VLANs in the network.

RPVST+ is a Cisco-proprietary enhancement to PVST+, which is itself a Cisco-proprietary enhancement to 802.1D STP. PVST+ enables you to create one instance of spanning-tree per VLAN. Similar to PVST+, RPVST+ also enables you to create one spanning-tree instance per VLAN. The difference is network convergence is faster with RPVST+ than PVST+.

With RPVST+, VLAN tagging is applied to the ports in a multi-VLAN network to enable blocking of redundant links in one VLAN, while allowing forwarding over the same links for non-redundant use by another VLAN. Each RPVST+ tree can have a different root switch and therefore can span through different links. Since different VLAN traffic can take different active paths from multiple possible topologies, overall network utilization increases.

## Preparing for spanning tree configuration

Before configuring a spanning tree:

- Determine the spanning tree protocol to be used: RPVST+ or MSTP. RPVST+ is ideal in networks having fewer VLANs. In networks having more VLANs, MSTP is the recommended spanning tree choice due to the increased load on the switch CPU. Even if you have more VLANs, MSTP supports 64 instances, which is more than enough to disperse the load. The switch can distribute the VLANs in use among instances as evenly as feasible, allowing one instance to block redundant links while allowing another instance to forward traffic over the same links for non-redundant use.
- Plan the device roles (the root bridge or leaf node) by adjusting instance priority.

When you configure spanning tree protocols, follow these guidelines:

- If MSTP is enabled on the switch, MSTP takes all MSTI information along with the packet. To advertise a specific VLAN within the network through MSTP, make sure that the VLAN is mapped to an MSTI when you configure the VLAN-to-instance table.
- Configuring instances is not mandatory. It is optional. Simply enable spanning tree (with command `spanning-tree`) and then MSTP works with CIST on all switches (CIST is the common instance for all VLANs in the switch).
- STP is mutually exclusive with loop protection. If STP and loop protection are both enabled on the same VLAN, STP takes precedence. This means that loop protection does not take any action on a port blocked by STP.
- RPVST+ uses IEEE BPDU on the native VLAN and VLAN 1, to converge with MSTP. However RPVST+ uses proprietary PVST MAC address 01:00:0c:cc:cc:cd to converge with other RPVST VLANs. For example, if we enable 'spanning-tree vlan 2' on two switches, these switches converge by exchanging PVST proprietary MAC and not IEEE MAC. In this case, 'spanning-tree vlan 1' sends 1 IEEE MAC to converge with the MSTP network and it also sends 1 PVST MAC to converge with RPVST network.
- One spanning tree variant can be run on the switch at any given time. On a switch running RPVST+, MSTP cannot be enabled. However, any MSTP-specific configuration settings in the startup configuration file will be maintained.
- The following features cannot run concurrently with RPVST+:
  - Multiple VLAN Registration Protocol (MVRP).
  - Filter multicast in RPVST+ mode (The multicast MAC address value cannot be set to the PVST MAC address 01:00:0c:cc:cc:cd.)
- After you enable a spanning tree protocol on a layer 2 aggregate interface, the system performs spanning tree calculation on the layer 2 aggregate interface. It does not perform the spanning tree calculation on the aggregation member ports. The spanning tree protocol enable state and forwarding state of each selected member port is consistent with the state of the corresponding layer 2 aggregate interface.
- Before using AAA and RPVST IOP, you must configure RADIUS-based and MAC-based VLANs statically and also enable RPVST on those VLANs.

## STP cost calculation

### Simplified calculation overview

A tree-shape topology forms once the root bridge, root ports, and designated ports are selected.

1. Upon initialization of a device, each port generates a BPDU with the following contents:
   - The port as the designated port.
   - The device as the root bridge.
   - 0 as the root path cost.
   - The device ID as the designated bridge ID.
2. Initially, each STP-enabled device on the network assumes itself to be the root bridge, with its own device ID as the root bridge ID. By exchanging configuration BPDUs, the devices compare their root bridge IDs to elect the device with the smallest root bridge ID as the root bridge.
3. Root port and designated ports selection on the non-root bridges.
   - A non-root–bridge device regards the port on which it received the optimum configuration BPDU as the root port.
     - Upon receiving a configuration BPDU on a port, the device compares the priority of the received configuration BPDU with that of the configuration BPDU generated by the port. If

the former priority is lower, the device discards the received configuration BPDU and keeps the configuration BPDU the port generated. If the former priority is higher, the device replaces the content of the configuration BPDU generated by the port with the content of the received configuration BPDU.

- The device compares the configuration BPDUs of all the ports and chooses the optimum configuration BPDU.

- Based on the configuration BPDU and the path cost of the root port, the device calculates a designated port configuration BPDU for each of the other ports.
  - The root bridge ID is replaced with that of the configuration BPDU of the root port.
  - The root path cost is replaced with that of the configuration BPDU of the root port plus the path cost of the root port.
  - The designated bridge ID is replaced with the ID of this device.
  - The designated port ID is replaced with the ID of this port.
- The device compares the calculated configuration BPDU with the configuration BPDU on the port whose port role will be determined, and acts depending on the result of the comparison:
  - If the calculated configuration BPDU is superior, the device performs the following tasks:
    - Considers this port as the designated port.
    - Replaces the configuration BPDU on the port with the calculated configuration BPDU.
    - Periodically sends the calculated configuration BPDU.
  - If the configuration BPDU on the port is superior, the device blocks this port without updating its configuration BPDU. The blocked port can receive BPDUs, but cannot send BPDUs or forward data traffic.

When the network topology is stable, only the root port and designated ports forward user traffic. Other ports are all in the blocked state to receive BPDUs but not to forward BPDUs or user traffic.

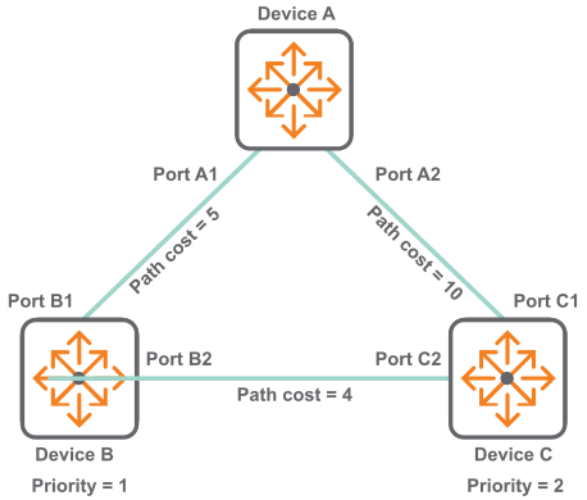
4. The principles of configuration BPDU comparison:
   - The configuration BPDU with the lowest root bridge ID has the highest priority.
   - If configuration BPDUs have the same root bridge ID, their root path costs are compared. For example, the root path cost in a configuration BPDU plus the path cost of a receiving port is S. The configuration BPDU with the smallest S value has the highest priority.
   - If all configuration BPDUs have the same root bridge ID and S value, the following attributes are compared in sequence: Designated bridge IDs, Designated port IDs, and IDs of the receiving ports.

   The configuration BPDU that contains a smaller designated bridge ID, designated port ID, or receiving port ID is selected.

### Calculation example

The following topology is used to illustrate an STP calculation. The priority values of Device A, Device B, and Device C are 0, 1, and 2, respectively. The path costs of links among the three devices are 5, 10, and 4.

**Figure 1** *STP calculation*




Each configuration BPDU contains the following fields: root bridge ID, root path cost, designated bridge ID, and designated port ID.

1. The initial state of the BPDUs on each device is:

| Device | Port name | Configuration BPDU on the port |
|---|---|---|
| Device A | Port A1 | {0, 0, 0, Port A1} |
| | Port A2 | {0, 0, 0, Port A2} |
| Device B | Port B1 | {1, 0, 1, Port B1} |
| | Port B2 | {1, 0, 1, Port B2} |
| Device C | Port C1 | {2, 0, 2, Port C1} |
| | Port C2 | {2, 0, 2, Port C2} |

2. BPDU comparison on each device occurs as follows:

| Device | Comparison process | Configuration BPDU on ports after comparison |
|---|---|---|
| Device A | Port A1 performs the following tasks:<br>1. Receives the configuration BPDU of Port B1 {1, 0, 1, Port B1}.<br>2. Determines that its existing configuration BPDU {0, 0, 0, Port A1} is superior to the received configuration BPDU.<br>3. Discards the received one.<br>Port A2 performs the following tasks:<br>1. Receives the configuration BPDU of Port C1 {2, 0, 2, Port C1}. | ▪ Port A1: {0, 0, 0, Port A1}<br>▪ Port A2: {0, 0, 0, Port A2} |

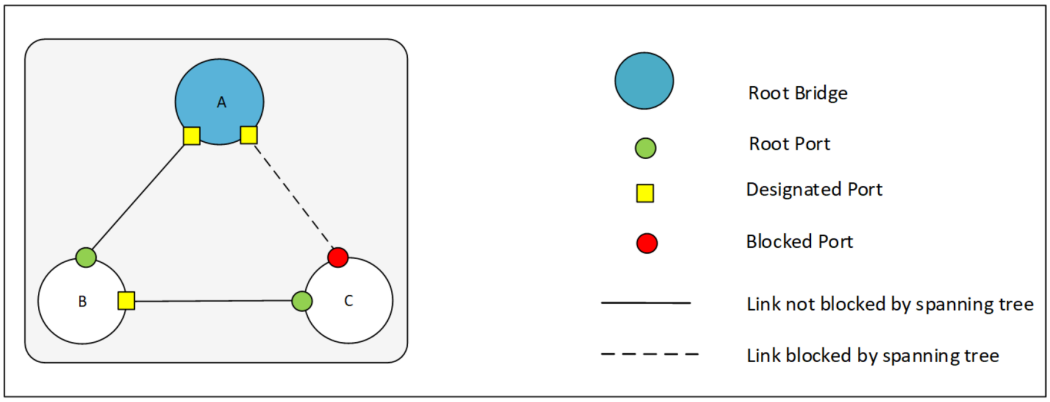
| Device | Comparison process | Configuration BPDU on ports after comparison |
| --- | --- | --- |
| | 2. Determines that its existing configuration BPDU {0, 0, 0, Port A2} is superior to the received configuration BPDU.<br>3. Discards the received one.<br>Device A determines that it is both the root bridge and designated bridge in the configuration BPDUs of all its ports. It considers itself as the root bridge. It does not change the configuration BPDU of any port and starts to periodically send configuration BPDUs. | |
| Device B | Port B1 performs the following tasks:<br>1. Receives the configuration BPDU of Port A1 {0, 0, 0, Port A1}.<br>2. Determines that the received configuration BPDU is superior to its existing configuration BPDU {1, 0, 1, Port B1}.<br>3. Updates its configuration BPDU.<br>Port B2 performs the following tasks:<br>1. Receives the configuration BPDU of Port C2 {2, 0, 2, Port C2}.<br>2. Determines that its existing configuration BPDU {1, 0, 1,Port B2} is superior to the received configuration BPDU.<br>3. Discards the received BPDU. | ■ Port B1: {0, 0, 0, Port A1}<br>■ Port B2: {1, 0, 1, Port B2} |
| | Device B performs the following tasks:<br>1. Compares the configuration BPDUs of all its ports.<br>2. Decides that the configuration BPDU of Port B1 is the optimum.<br>3. Selects Port B1 as the root port with the configuration BPDU unchanged.<br>Based on the configuration BPDU and path cost of the root port, Device B calculates a designated port configuration BPDU for Port B2 {0, 5, 1, Port B2}. Device B compares it with the existing configuration BPDU of Port B2 {1, 0, 1, Port B2}. Device B determines that the calculated one is superior, and determines that Port B2 is the designated port. It replaces the configuration BPDU on Port B2 with the calculated one, and periodically sends the calculated configuration BPDU. | ■ Root port (Port B1): {0, 0, 0, Port A1}<br>■ Designated port (Port B2): {0, 5, 1, Port B2} |
| Device C | Port C1 performs the following tasks:<br>1. Receives the configuration BPDU of Port A2 {0, | ■ Port C1: {0, 0, 0, Port A2}<br>■ Port C2: {1, 0, 1, Port B2} |

| Device | Comparison process | Configuration BPDU on ports after comparison |
|---|---|---|
| | 0, 0, Port A2}.<br>2. Determines that the received configuration BPDU is superior to its existing configuration BPDU {2, 0, 2, Port C1}.<br>3. Updates its configuration BPDU.<br>Port C2 performs the following tasks:<br>1. Receives the original configuration BPDU of Port B2 {1, 0,1, Port B2}.<br>2. Determines that the received configuration BPDU is superior to the existing configuration BPDU {2, 0, 2, Port C2}.<br>3. Updates its configuration BPDU. | |
| | Device C performs the following tasks:<br>1. Compares the configuration BPDUs of all its ports.<br>2. Decides that the configuration BPDU of Port C1 is the optimum.<br>3. Selects Port C1 as the root port with the configuration BPDU unchanged.<br>Based on the configuration BPDU and path cost of the root port, Device C calculates the configuration BPDU of Port C2 {0, 10, 2, Port C2}. Device C compares it with the existing configuration BPDU of Port C2 {1, 0, 1, Port B2}.<br>Device C determines that the calculated configuration BPDU is superior to the existing one, selects Port C2 as the designated port, and replaces the configuration BPDU of Port C2 with the calculated one. | ▪ Root port (Port C1): {0, 0, 0, Port A2}<br>▪ Designated port (Port C2): {0, 10, 2, Port C2} |
| | Port C2 performs the following tasks:<br>1. Receives the configuration BPDU of Port B2 {0, 5, 1, Port B2}.<br>2. Determines that the received configuration BPDU is superior to its existing configuration BPDU {0, 10, 2, Port C2}.<br>3. Updates its configuration BPDU.<br>Port C1 performs the following tasks:<br>1. Receives a periodic configuration BPDU {0, 0, 0, Port A2} from Port A2.<br>2. Determines that it is the same as the existing configuration BPDU.<br>3. Discards the received BPDU. | ▪ Port C1: {0, 0, 0, Port A2}<br>▪ Port C2: {0, 5, 1, Port B2} |

| Device | Comparison process | Configuration BPDU on ports after comparison |
| --- | --- | --- |
| | Device C determines that the root path cost of Port C1 (10) (root path cost of the received configuration BPDU (0) plus path cost of Port C1 (10)) is larger than that of Port C2 (9) (root path cost of the received configuration BPDU (5) plus path cost of Port C2 (4)). Device C determines that the configuration BPDU of Port C2 is the optimum, and selects Port C2 as the root port with the configuration BPDU unchanged.<br>Based on the configuration BPDU and path cost of the root port, Device C performs the following tasks:<br>1. Calculates a designated port configuration BPDU for Port C1 {0, 9, 2, Port C1}.<br>2. Compares it with the existing configuration BPDU of Port C1 {0, 0, 0, Port A2}.<br>3. Determines that the existing configuration BPDU is superior to the calculated one and blocks Port C1 with the configuration BPDU unchanged.<br>Port C1 does not forward data until a new event triggers a spanning tree calculation process: for example, the link between Device B and Device C is down. | ■ Blocked port (Port C1): {0, 0, 0, Port A2}<br>■ Root port (Port C2): {0, 5, 1, Port B2} |

3. After the comparison, a spanning tree with Device A as the root bridge is established as shown:

**Figure 2** *Device A as root bridge*



# STP supported platforms and scale

PTP is supported on all AOS-CX switches.

## Scale

| Platform | RPVST+ VLANs | RPVST+ vPorts | MSTP instances |
|---|---|---|---|
| 4100i | 32 | 512 | 16 |
| 6000 | 32 | 512 | 16 |
| 6100 | 32 | 512 | 16 |
| 6200 | 128 | 2048 | 32 |

# MSTP protocol and feature details

Multiple-Instance spanning tree protocol (MSTP) ensures that only one active path exists between any two nodes in a spanning-tree instance. A spanning-tree instance comprises a unique set of VLANs, and belongs to a specific spanning-tree region. A region can comprise multiple spanning-tree instances (each with a different set of VLANs), and allows one active path among regions in a network.

Without spanning tree, having more than one active path between a pair of nodes causes loops in the network, which can result in duplication of messages, leading to a “broadcast storm” that can bring down the network.

Developed based on IEEE 802.1s, MSTP overcomes the limitations of STP, RSTP, and PVST. In addition to supporting rapid network convergence, it allows data flows of different VLANs to be forwarded along separate paths. This provides a better load sharing mechanism for redundant links.

MSTP provides the following features:

- MSTP divides a switched network into multiple regions, each of which contains multiple spanning trees that are independent of one another.
- MSTP supports mapping VLANs to spanning tree instances by means of a VLAN-to-instance mapping table. MSTP can reduce communication overheads and resource usage by mapping multiple VLANs to one instance.
- MSTP prunes a loop network into a loop-free tree, which avoids proliferation and endless cycling of packets in a loop network. In addition, it supports load balancing of VLAN data by providing multiple redundant paths for data forwarding.
- MSTP is compatible with STP and RSTP, and partially compatible with PVST.
- Configuring instances is not mandatory. MSTP can work with the default instance CIST if spanning-tree is just enabled. All existing VLANs in the switch will be part of CIST.

## MSTP key concepts

MSTP divides an entire Layer 2 network into multiple MST regions, which are connected by a calculated CST. Inside an MST region, multiple spanning trees, called MSTIs, are calculated. Among these MSTIs, MSTI 0 is the internal spanning tree (IST).

**Figure 1** *Network with four MST regions and four switches per region*

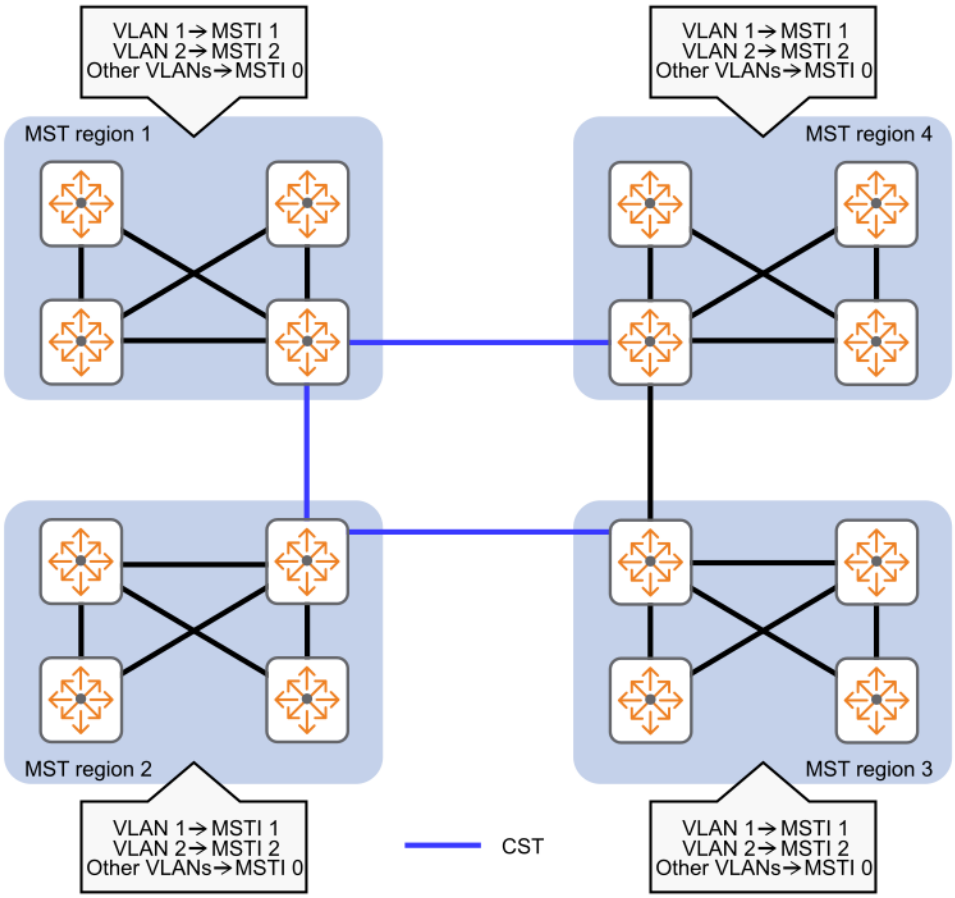
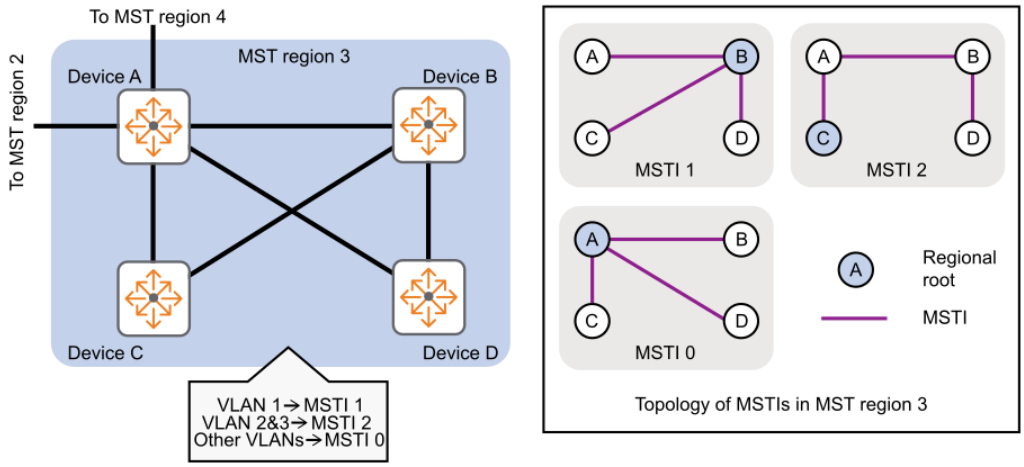



**Figure 2** *MST region 3*



### MST region

A multiple spanning tree region (MST region) consists of multiple devices in a switched network and the network segments between them. All these devices have the following characteristics:

- A spanning tree protocol enabled.
- Same region name.
- Same VLAN-to-instance mapping configuration.
- Same MSTP revision level.
- Physically linked together.

Multiple MST regions can exist in a switched network. You can assign multiple devices to the same MST region.

- The switched network comprises four MST regions, MST region 1 through MST region 4.
- All devices in each MST region have the same MST region configuration.

### MSTI

MSTP can generate multiple independent spanning trees in an MST region, and each spanning tree is mapped to specific VLANs. Each spanning tree is referred to as a multiple spanning tree instance (MSTI). In the figures, MST region 3 comprises three MSTIs, MSTI 1, MSTI 2, and MSTI 0.

MSTI 0

### VLAN-to-instance mapping table

As an attribute of an MST region, the VLAN-to-instance mapping table describes the mapping relationships between VLANs and MSTIs.

In the figures, the VLAN-to-instance mapping table of MST region 3 is as follows:

- VLAN 1 to MSTI 1. (Ports which are not part of any VLAN are by default part of VLAN 1.)
- VLAN 2 and VLAN 3 to MSTI 2.
- Other VLANs to MSTI 0. (VLANs that are not configured as part of any MSTI are by default part of MSTI 0.)

MSTP achieves load balancing by means of the VLAN-to-instance mapping table.

### CST

The common spanning tree (CST) is a single spanning tree that connects all MST regions in a switched network. If you regard each MST region as a device, the CST is a spanning tree calculated by these devices through STP or RSTP. The blue lines in the figures represent the CST.

### IST

An internal spanning tree (IST) is a spanning tree that runs in an MST region. It is also called MSTI 0, a special MSTI to which all VLANs are mapped by default. In the figures, MSTI 0 is the IST in MST region 3.

### CIST

The common and internal spanning tree (CIST) is a single spanning tree that connects all devices in a switched network. It consists of the ISTs in all MST regions and the CST. In the figures, the ISTs (MSTI 0) in all MST regions plus the inter-region CST constitute the CIST of the entire network.

### Regional root

The root bridge of the IST or an MSTI within an MST region is the regional root of the IST or MSTI. Based on the topology, different spanning trees in an MST region might have different regional roots, as shown in MST region 3 in the figures:

- The regional root of MSTI 1 is Device B.
- The regional root of MSTI 2 is Device C.
- The regional root of MSTI 0 (also known as the IST) is Device A.

### Common root bridge

The common root bridge is the root bridge of the CIST. In the figures, the common root bridge is a device in MST region 1.

### Port roles

A port can play different roles in different MSTIs. In the following figure, an MST region comprises Device A, Device B, Device C, and Device D. Port A1 and port A2 of Device A connect to the common root bridge. Port B2 and Port B3 of Device B form a loop. Port C3 and Port C4 of Device C connect to other MST regions. Port D3 of Device D directly connects to a host.

MSTP calculation involves the following port roles:

- Root port: Forwards data for a non-root bridge to the root bridge. The root bridge does not have any root port.
- Designated port: Forwards data to the downstream network segment or device.
- Alternate port: Acts as the backup port for a root port or conductor port. When the root port or conductor port is blocked, the alternate port takes over.
- Backup port: Acts as the backup port of a designated port. When the designated port is invalid, the backup port becomes the new designated port. A loop occurs when two ports of the same spanning tree device are connected, so the device blocks one of the ports. The blocked port acts as the backup.
- Edge port: Does not connect to any network device or network segment, but directly connects to a user host.
- Conductor port: Acts as a port on the shortest path from the local MST region to the common root bridge. The conductor port is not always located on the regional root. It is a root port on the IST or CIST and still a conductor port on the other MSTIs.
- Boundary port: Connects an MST region to another MST region or to an STP/RSTP-running device. In MSTP calculation, a boundary port's role on an MSTI is consistent with its role on the CIST. However, that is not true with conductor ports. A conductor port on MSTIs is a root port on the CIST.

### Port states

In MSTP, a port can be in one of the following states:

- Forwarding: The port receives and sends BPDUs, learns MAC addresses, and forwards user traffic.
- Learning: The port receives and sends BPDUs, learns MAC addresses, but does not forward user traffic. Learning is an intermediate port state.
- Discarding: The port receives and sends BPDUs, but does not learn MAC addresses or forward user traffic.

When in different MSTIs, a port can be in different states.

A port state is not exclusively associated with a port role. The following table lsts the port states that each port role supports. (An X indicates that the port supports this state, while a dash [—] indicates that the port does not support this state.)

| Port state | Port role | | | |
|---|---|---|---|---|
| | Root port/ conductor port | Designated port | Alternate port | Backup port |
| Forwarding | X | X | — | — |
| Learning | X | X | — | — |
| Discarding | X | X | X | X |

### CIST calculation

During the CIST calculation, the following process takes place:

- The device with the highest priority is elected as the root bridge of the CIST.
- MSTP generates an IST within each MST region through calculation.
- MSTP regards each MST region as a single device and generates a CST among these MST regions through calculation.

The CST and ISTs constitute the CIST of the entire network.

### MSTI calculation

Within an MST region, MSTP generates different MSTIs for different VLANs based on the VLAN-to-instance mappings. For each spanning tree, MSTP performs a separate calculation process similar to spanning tree calculation in STP.

In MSTP, a BPDU packet is forwarded along the following paths:

- Within an MST region, the packet is forwarded along the corresponding MSTI.
- Between two MST regions, the packet is forwarded along the CST.

### MSTP on VSX

See the *Virtual Switching Extension (VSX) Guide* for important information when configuring MSTP with VSX.

## MSTP configuration tasks

- Configuring MSTP instances is not mandatory. Instances are required only if you need to reuse the blocked links for some other VLAN path. To enable MSTP, simply configure the same 'configuration-name' across all switches and enable 'spanning-tree' and leave the configuration-revision as default. This is sufficient for MSTP.
- Ensure that the VLAN configuration in your network supports all of the forwarding paths necessary for the desired connectivity. All ports connecting one switch to another within a region and one switch to another between regions should be configured as members of all VLANs configured in the region.

- Configure all ports or trunks connecting one switch to another within a region as members of all VLANs in the region. Otherwise, some VLANs could be blocked from access to the spanning tree root for an instance or for the region.
- Plan individual MST regions based on VLAN groupings. That is, plan on all MSTP switches in a given region supporting the same set of VLANs. Within each region, determine the VLAN membership for each spanning tree instance. (Each instance represents a single forwarding path for all VLANs in that instance.)
- Verify that there is one logical spanning tree path through the following:
  - Any interregional links
  - Any IST (Internal Spanning Tree) or MSTI within a region
  - Any legacy (802.1D or 802.1w) switch or group of switches. (Where multiple paths exist between an MST region and a legacy switch, expect the CST (Common Spanning Tree) to block all but one such path.)
- Determine the root bridge and root port for each MSTI.
- Determine the designated bridge and designated port for each LAN segment.
- Determine which VLANs to assign to each MST instance and use port trunks with 802.1Q VLAN tagging where separate links for separate VLANs would result in a blocked link preventing communication between nodes on the same VLAN.
- Set the admin-edge port type to `admin-edge` for edge ports connected to end nodes.
- Set the admin-edge port type to `admin-network` for ports connected to another switch, a bridge, or a half-duplex repeater.

# MSTP considerations and best practices

- For the best MSTP experience, use at least AOS-CX 10.07.
- Topology Change Notifications (TCN) are an important part of STP. However, reducing unwanted TCNs is important for things such as access ports which can go up and down with end-point attachment and detachment at the network edge. It is recommended to use command **`spanning-tree port-type admin-edge`** to remove unwanted TCNs from end points.
- The use of spanning tree Topology Change Notification (TCN) guard may also be used in certain circumstances using command **`spanning-tree tcn-guard`**.
  - If the access switch is rebooting or the link between access and core switches is flapping, then this will cause TCNs towards the network core. Any TC on any interface on the core will clear all MACs locally and propagate the TC on all other interfaces. This can cause a significant traffic disruption on the network. If the network has a loop-free topology and mac-flush is not really needed on all switches in the network, then it can be feasible to add tcn-guard on access switches facing L2 interfaces. This will avoid mac-flush and TC propagation on the core switch (STP root switch).
  - If a core or aggregation switch in the network keeps getting TC messages due to unpredictable behavior of an access switch, TCN guard can be applied (using command spanning-tree tcn-guard) to the core or aggregation switch on the Layer 2 link facing the access switch.
- Stability in a spanning tree environment is paramount. It is recommended that default timers be used, and any alteration of timers be carried out only under special circumstances and in consultation with experts.
- Avoid automatic placement of root bridges. To enable a deterministic, predictable, and stable network, the placement of Primary and Secondary root bridges should be considered using command command **`spanning-tree vlan <VALUE> priority <VALUE>`**.

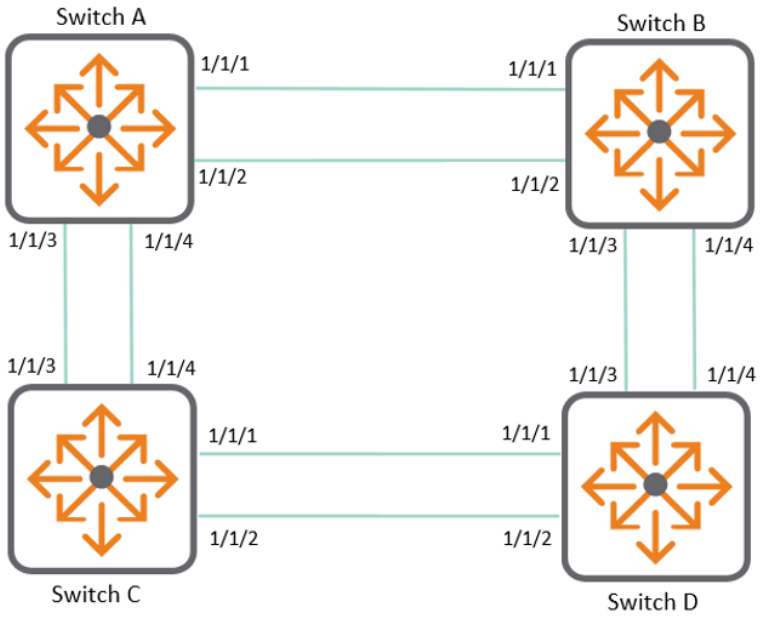
- To further provide stability and deterministic behavior additional security configuration should be considered, such as:
  - **root-guard**: Sets a port to ignore superior BPDUs to prevent it from becoming the root port. This is typically carried out between the core that is required to be the root and access switches to prevent ports that are not expected to originate root information such as server ports and access switch ports.
  - **bpdu-guard**: Disables the specific port if the port receives STP BPDUs. This is done to prevent any inadvertent spanning tree or malicious attack, or switches being connected to the network and causing STP processing. This will be on well-defined ports that are known from your network design on which you never expect BPDUs. For example, user access ports or ports connected to servers in the datacenter where other switches may exist, and technicians can inadvertently patch into.
- With VSX configuration it is advisable that either the VSX pair acts as a STP root switch or that the STP root switch is reachable only through mc-lags. An STP root switch connected to a VSX pair with standalone interfaces (non-mc-lags) is not recommended.

# MSTP use cases

## MSTP use case: Preventing loops

In this use case, all four switches are in same region. VLANs 10, 20, 30, 40, 50, and 60 are defined on all switches, causing a network loop. The physical topology of the network looks like this:

**Figure 1** *Physical topology before loop elimination*



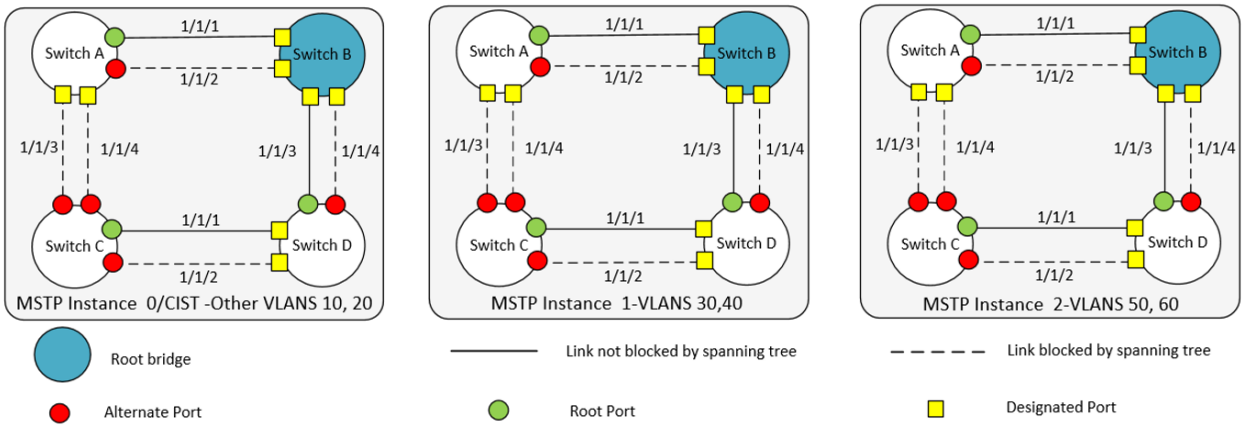

To eliminate the loop, MSTP is enabled on all the switches, with the following configuration:

- Switch B is the root for CIST, MST1, and MST2.
- CIST: VLANs 10, 20
- Instance-1: VLANs 30, 40
- Instance-2: VLANs 50, 60
- All four switches are in the same MSTP region.

To understand how MSTP works in this use case, it is useful to view each instance as a separate logical topology as illustrated in the following figures.

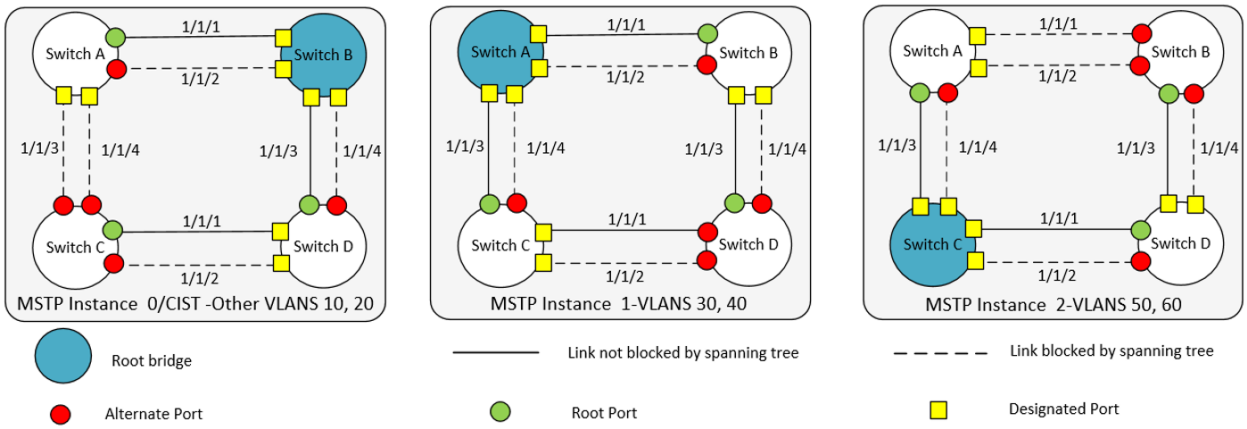
In this initial configuration, loops are avoided by blocking the alternate links for each network segment. All ports designated A (Alternate) are blocked and do not forward traffic. Although this strategy eliminates the loops, it is not the most effective way to configure the MST regions because network resources are not fully used.

**Figure 2** *MSTP loop elimination, initial configuration*




By changing the root for each instance, more effective load sharing can be achieved. With this refined configuration, the links (ports) that were previously unused are now being used by different instances. Also, the network loop is eliminated and load sharing is achieved:

**Figure 3** *MSTP loop elimination, refined configuration*




## Procedure

Configure all switches with the same VLANs, interfaces, and spanning tree instances.

1. Create VLANs 10, 20, 30, 40, 50, and 60 and assign them to interfaces.

```
switch# config
switch(config)# vlan 10,20,30,40,50,60
switch(config)# interface 1/1/1-1/1/4
switch(config-if-<1/1/1-1/1/4>)# no shutdown
switch(config-if-<1/1/1-1/1/4>)# vlan trunk allowed 10,20,30,40,50,60
switch(config-if)# exit
```

2. Configure spanning tree and enable it.

```
switch(config)# spanning-tree config-name reg
switch(config)# spanning-tree config-revision 1
switch(config)# spanning-tree inst 1 vlan 30
switch(config)# spanning-tree inst 1 vlan 40
switch(config)# spanning-tree inst 2 vlan 50
switch(config)# spanning-tree inst 2 vlan 60
switch(config)# spanning-tree
```

3. On switch A, set instance 1 to priority 0.

```
switch-A(config)# spanning-tree inst 1 priority 0
```

4. On switch C, set instance 2 to priority 0.

```
switch-C(config)# spanning-tree inst 2 priority 0
```

5. On switch B set the MSTP default CIST instance priority to 0.

```
switch-B(config)# spanning-tree priority 0
```

## MSTP use case: Deterministic root bridges

Continuing from the previous MSTP use case and as mentioned in *MSTP considerations and best practices*, the placement of root bridges is important in the Layer 2 network domain. Having deterministic Root and Secondary Root bridges is a typically-accepted design that allows you to provide predictability and protection in your network .

The Root and Secondary root are typically placed at the Core of the Layer 2 domain. Figure 1, Deterministic root bridges (physical) shows the physical topology and Figure 2, Deterministic root bridges (logical) shows the logical topology. Switch A and Switch B are the core/center of the Layer 2 domain, and they provide root redundancy for each other.

**Figure 1** *Deterministic root bridges (physical)*

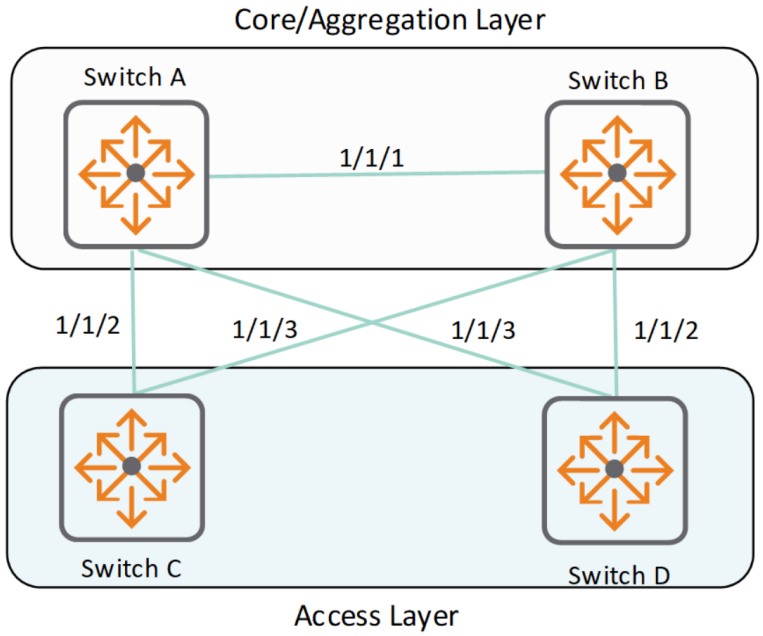
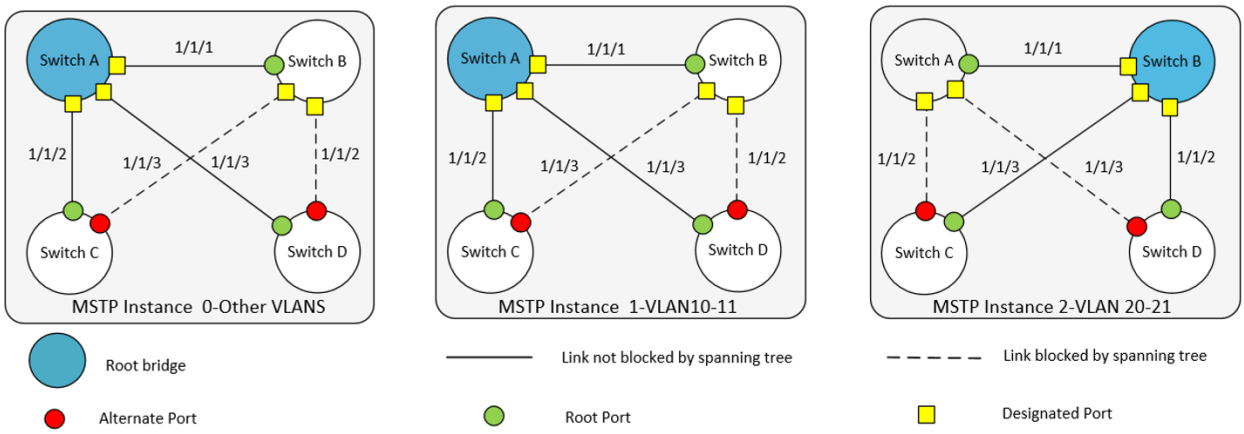



**Figure 2** *Deterministic root bridges (logical)*




In this use case network example there are four VLANs 10, 11, 20 and 21, and the default other VLANs and each group of VLANs has its own independent topology. The root bridges and VLANs are as follows:

- VLAN 10-11 is assigned to MSTP instance 1, Root bridge Switch A, and Secondary Root bridge Switch B.

- VLAN 20-21 is assigned to MSTP instance 2, Root bridge Switch B, and Secondary Root bridge Switch A.
- All other VLANs are assigned to the default MSTP instance 0.

Switches A through D are configured as follows:

In the following switch configuration command sequences, configuration portions (typically default) unrelated to MSTP are represented by an ellipsis" . . . ". Also, descriptive comments, preceded by "<--", are included to the right of some commands.

### Switch A configuration

- Add VLANs 10, 11, 20, 21.
- Configure STP making Switch A the Root for VLANs 10 and 11, instance 1 and the Secondary Root for VLANs 20 and 21 instance 2.
- Trunk all VLANs for interface 1/1/1 to 1/1/3.
- Make Switch A the Root for the CIST

```
config
vlan 10-11,20-21
exit
spanning-tree
spanning-tree config-name sp1
spanning-tree config-revision 1
spanning-tree instance 1 vlan 10-11  <-- Map VLANs to instance
spanning-tree instance 2 vlan 20-21
spanning-tree priority 0             <-- MST 0 Root
spanning-tree instance 1 priority 0  <-- MST 1 Root
spanning-tree instance 2 priority 1  <-- MST 2 Secondary Root
int 1/1/1-1/1/3
vlan trunk 10-11,20-21
vlan trunk native 1
exit
```

### Switch B configuration

- Add VLANs 10, 11, 20, 21.
- Configure STP making Switch B the Root for VLANs 20 and 21, instance 2 and the Secondary Root for VLANs 10 and 11 instance 1.
- Trunk all VLANs for interface 1/1/1 to 1/1/3.

```
SwitchB#
config
vlan 10-11,20-21
exit
spanning-tree
spanning-tree config-name sp1
spanning-tree config-revision 1
spanning-tree instance 1 vlan 10-11
spanning-tree instance 2 vlan 20-21
spanning-tree instance 1 priority 1   <-- MST 1 Secondary Root
spanning-tree instance 2 priority 0   <-- MST 2 Root
int 1/1/1-1/1/3
vlan trunk 10-11,20-21
```

```
vlan trunk native 1
exit
```

## Switch C and D configuration

- Define the VLANS for MSTP and the trunk-required VLANS using the same configuration on both C and D except for the hostname.

```
vlan 10-11,20-21
exit
spanning-tree
spanning-tree config-name sp1
spanning-tree config-revision 1
spanning-tree instance 1 vlan 10-11
spanning-tree instance 2 vlan 20-21
int 1/1/2-1/1/3
int 1/1/2-1/1/3
vlan trunk 10-11,20-21
vlan trunk native 1
exit
```

## Checking the configuration

The applied configurations can be checked as follows:

- Checking MSTP
- Checking that the System ID matches Root for the instance.

### Checking Switch A

Use command **`show spanning-tree mst-config`** to check the general configuration and mappings.

```
SwitchA# show spanning-tree mst-config
MST configuration information
   MST config ID        : sp1
   MST config revision  : 1
   MST config digest    : 098798F08296B22CADC0650E39604C10
   Number of instances  : 2

Instance ID     Member VLANs
--------------- --------------------------------
0               1-9,12-19,22-4094
1               10,11
2               20,21
```

Use command `show spanning-tree summary root` to check root configuration. As seen here, Switch A is Root for instance 0 and 1, identified by the System ID, and Instance 2 Root is another device which is expected to be Switch B based on previous configurations.

Notice the zero Root Port cost indicated in the first two rows of output.

```
SwitchA#show spanning-tree summary root
STP status                    : Enabled
Protocol                      : MSTP
System ID                     : 08:00:09:8a:14:fa
Root bridge for STP Instance : 0,1
```

```
                                                  Root Hello Max Fwd
Instance ID     Priority Root ID                   cost  Time Age Dly    Root Port
--------------- -------- ----------------- --------- ----- --- --- ------------
0                      0 08:00:09:8a:14:fa          0     2  20  15             0
1                      0 08:00:09:8a:14:fa          0     2  20  15             0
2                      0 08:00:09:12:8e:9e      20000     2  20  15         1/1/1
```

### Checking Switch B

Use command `show spanning-tree summary root` to check root configuration. As seen here, Switch B is Root for Instance 2 and identified by System ID which was also shown in the above Switch A command.

Notice the zero Root Port cost indicated in the last output row.

```
SwitchA#show spanning-tree summary root
STP status                    : Enabled
Protocol                      : MSTP
System ID                     : 08:00:09:12:8e:9e
Root bridge for STP Instance : 2

                                                  Root Hello Max Fwd
Instance ID     Priority Root ID                   cost  Time Age Dly    Root Port
--------------- -------- ----------------- --------- ----- --- --- ------------
0                      0 08:00:09:8a:14:fa      20000     2  20  15         1/1/1
1                      0 08:00:09:8a:14:fa      20000     2  20  15         1/1/1
2                      0 08:00:09:12:8e:9e          0     2  20  15
```

### Checking Switches C and D

Although not illustrated, Switches C and D can be checked in a similar manner to the other switches.

## Observe port behavior and state

We can observe the port behavior and state using command `show spanning-tree mst` to examine the behavior of ports and their state. The topology in Figure 2, Deterministic root bridges (logical) for each switch can be observed showing a loop free Layer 2 topology.

### Observing Switch A

Use command `show spanning-tree mst`.

As seen here Switch A for instance 0 and 1, all ports are **`Designated`** and **`Forwarding`**. Instance 2 has Root port 1/1/1 leading to Switch B the Root switch for VLANs 20 and 21, and other ports are **`Designated Forwarding`** leading to Switches C and D respectively.

```
SwitchA# show spanning-tree mst
### Instance MST0
Vlans mapped:  1-9,12-19,22-4094
Bridge         Address:08:00:09:8a:14:fa    priority:0
Root
Regional Root
Operational    Hello time(in seconds): 2  Forward delay(in seconds):15  Max-age(in seconds):20  txHoldCount(in pps): 6
Configured     Hello time(in seconds): 2  Forward delay(in seconds):15  Max-age(in seconds):20  Max-Hops:20
Root           Address:08:00:09:8a:14:fa  Priority:0
               Port:0                     Path cost:0
Regional Root  Address:08:00:09:8a:14:fa  Priority:0
               Internal cost:0            Rem Hops:20
```

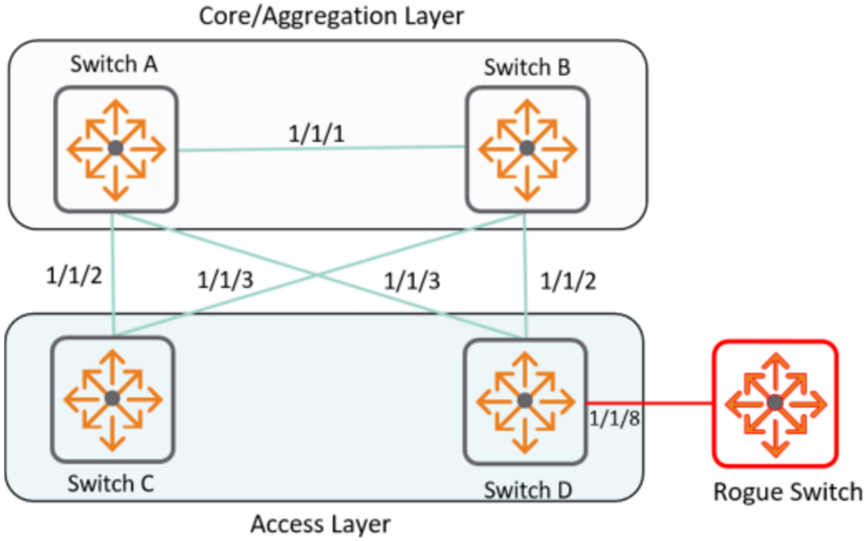
```
Port           Role           State      Cost       Priority   Type            BPDU-Tx    BPDU-Rx    TCN-Tx     TCN-Rx
-------------- -------------- ---------- ---------- ---------- --------------- ---------- ---------- ---------- -----
1/1/1          Designated     Forwarding 20000      128        P2P             32900      28093      10         6
1/1/2          Designated     Forwarding 20000      128        P2P             32902      8          8          4
1/1/3          Designated     Forwarding 20000      128        P2P             32898      5          2          3

Topology change flag          : True
Number of topology changes    : 9
Last topology change occurred : 55669 seconds ago


### Instance MST1
Vlans mapped:  10,11
Bridge         Address:08:00:09:8a:14:fa    Priority:0
Root           Address:08:00:09:8a:14:fa    Priority:0
               Port:0, Cost:0, Rem Hops:20

Port           Role           State      Cost    Priority   Type            BPDU-Tx    BPDU-Rx    TCN-Tx     TCN-Rx
-------------- -------------- ---------- ------- ---------- --------------- ---------- ---------- ---------- --------
1/1/1          Designated     Forwarding 20000   128        P2P             32900      28093      10         6
1/1/2          Designated     Forwarding 20000   128        P2P             32902      8          8          4
1/1/3          Designated     Forwarding 20000   128        P2P             32898      5          2          3

Topology change flag          : True
Number of topology changes    : 9
Last topology change occurred : 55669 seconds ago


### Instance MST2
Vlans mapped:  20,21
Bridge         Address:08:00:09:8a:14:fa    Priority:4096
Root           Address:08:00:09:12:8e:9e    Priority:0
               Port:1/1/1, Cost:20000, Rem Hops:19

Port           Role           State      Cost    Priority   Type            BPDU-Tx    BPDU-Rx    TCN-Tx     TCN-Rx
-------------- -------------- ---------- ------- ---------- --------------- ---------- ---------- ---------- --------
1/1/1          Root           Forwarding 20000   128        P2P             32900      28093      10         6
1/1/2          Designated     Forwarding 20000   128        P2P             32902      8          8          4
1/1/3          Designated     Forwarding 20000   128        P2P             32898      5          2          3

Topology change flag          : True
Number of topology changes    : 7
Last topology change occurred : 55673 seconds ago
```

The same command can be used to observe switches B, C, and D (not shown here).

## MSTP use case: BPDU protection

Various security mechanisms are in place to protect spanning true configurations from interference and rogue devices or unwarranted changes to the network. BPDU protection secures the active topology by preventing spoofed BPDU packets from entering the network. Typically, BPDU protection is applied on edge ports connected to end user devices that do not run STP. If STP BPDU packets are received on a protected port, BPDU guard disables the port and an alert is sent. As shown in Figure 1, Rogue device needing BPDU guard we have a rouge device attempting to connect to Switch D port 1/1/8.

**Figure 1** *Rogue device needing BPDU guard*




BPDU guard is configured on switch D.

```
SwitchD#
config
interface 1/1/8
    no shutdown
    no routing
    vlan access 10
    spanning-tree bpdu-guard
exit
```

Use command `show spanning-tree summary vlan 10` to observe that port 1/1/8 is disabled because BPDU was received on it from the rogue switch.

Notice how port 1/1/8 is disabled due to "Bpdu-Error." A timeout can be configured to re-enable the port.

```
SwitchD# show spanning-tree mst 1

### MST1
Vlans mapped:  10,11
Bridge         Address:08:00:09:ee:11:82    Priority:32768
Root           Address:08:00:09:8a:14:fa    Priority:0
               Port:1/1/2, Cost:40000, Rem Hops:18

Port           Role           State      Cost    Priority   Type            BPDU-Tx    BPDU-Rx    TCN-Tx     TCN-Rx
-------------- -------------- ---------- ------- ---------- --------------- ---------- ---------- ---------- --------
1/1/2          Root           Forwarding 20000   128        P2P             9          210294     0          8
1/1/3          Alternate      Blocking   40001   128        P2P             11         210295     4          4
```

```
1/1/8          Disabled        Bpdu-Error 20000   128        P2P             31         0          0          0

Topology change flag          : True
Number of topology changes    : 7
Last topology change occurred : 350406 seconds ago
```

Use command `show int 1/1/8` to observe the interface state. Notice that port 1/1/8 is down as expected due to BPDU error.

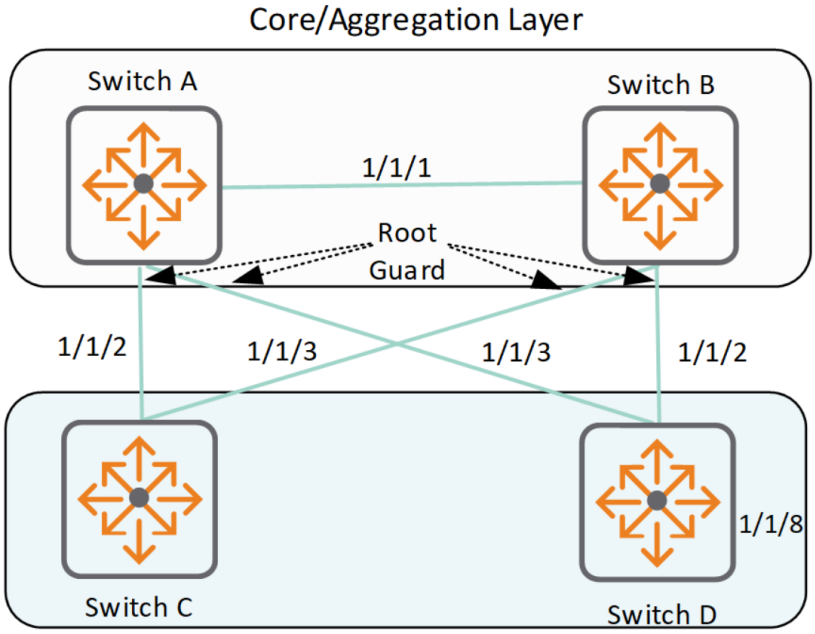
```
SwitchD#show int 1/1/8
Interface 1/1/8 is down
 Admin state is up
 State information:
 Link state: down
 Link transitions: 0
 Description:
 Hardware: Ethernet, MAC Address: 08:00:09:ee:11:c4
 MTU 1500
 Type --
 Full-duplex
 qos trust none
 Speed 1000 Mb/s
 Auto-negotiation is off
 Flow-control: off
 Error-control: off
 MDI mode: none
 VLAN Mode: access
 Access VLAN: 10
```

## MSTP use case: Root protection

Root protection secures the active topology by preventing other switches from declaring their ability to propagate superior BPDUs, containing both better information on the root bridge and path cost to the root bridge which would normally replace the current root bridge selection.

As illustrated in Figure 1, Root protection, by adding root guard on interfaces 1/1/2 and 1/1/3 of both core switches (A and B), these two switches are protected in the core and prevent propagation of superior BPDUs from the access layer.

**Figure 1** *Root protection*




Configuring Switches A and B:

```
SwitchA#
config
interface 1/1/2
   spanning-tree root-guard
exit
interface 1/1/3
   spanning-tree root-guard
exit


SwitchB#
Config
interface 1/1/2
   spanning-tree root-guard
interface 1/1/3
   spanning-tree root-guard
exit
```

To observe the protection behavior, we can (inappropriately) make switch C the root for instance 1 which covers VLAN 10 and 11.

```
SwitchC#
config
```

```
spanning-tree instance 1 priority 0   <-- Make Switch C Root for instance 1
exit
```

Notice how as protection occurs on both Switch A and B, ports show as **`Alternate Root-Inc`** (Alternate Root-Inconsistent). This action maintains Layer 2 stability by protecting the rest of the network from the (inaccurate) information that Switch C is sending "better" BPDUs.

Switch A showing as Root Inconsistent:

```
SwitchA# show spanning-tree mst

### MST0
Vlans mapped:  1-9,12-19,22-4094
Bridge         Address:08:00:09:8a:14:fa    priority:0
Root
Regional Root
Operational    Hello time(in seconds): 2  Forward delay(in seconds):15  Max-age(in seconds):20  txHoldCount(in pps): 6
Configured     Hello time(in seconds): 2  Forward delay(in seconds):15  Max-age(in seconds):20  Max-Hops:20
Root           Address:08:00:09:8a:14:fa  Priority:0
               Port:0                     Path cost:0
Regional Root  Address:08:00:09:8a:14:fa  Priority:0
               Internal cost:0            Rem Hops:20

Port           Role           State      Cost       Priority   Type             BPDU-Tx    BPDU-Rx    TCN-Tx     TCN-Rx
-------------- -------------- ---------- ---------- ---------- ---------------- ---------- ---------- ---------- -----
1/1/1          Designated     Forwarding 20000      128        P2P              217571     217573     11         14
1/1/2          Designated     Forwarding 20000      128        P2P              217566     565        15         8
1/1/3          Designated     Forwarding 20000      128        P2P              217573     27         13         7

Topology change flag          : True
Number of topology changes    : 15
Last topology change occurred : 908 seconds ago


### MST1
Vlans mapped:  10,11
Bridge         Address:08:00:09:8a:14:fa    Priority:0
Root           Address:08:00:09:8a:14:fa    Priority:0
               Port:0, Cost:0, Rem Hops:20

Port           Role           State      Cost    Priority   Type             BPDU-Tx    BPDU-Rx    TCN-Tx     TCN-Rx
-------------- -------------- ---------- ------- ---------- ---------------- ---------- ---------- ---------- --------
1/1/1          Designated     Forwarding 20000   128        P2P              217571     217573     11         14
1/1/2          Alternate      Root-Inc   20000   128        P2P              217566     565        15         8
1/1/3          Designated     Forwarding 20000   128        P2P              217573     27         13         7

Topology change flag          : True
Number of topology changes    : 18
Last topology change occurred : 908 seconds ago


### MST2
Vlans mapped:  20,21
Bridge         Address:08:00:09:8a:14:fa    Priority:4096
Root           Address:08:00:09:12:8e:9e    Priority:0
               Port:1/1/1, Cost:20000, Rem Hops:19

Port           Role           State      Cost    Priority   Type             BPDU-Tx    BPDU-Rx    TCN-Tx     TCN-Rx
-------------- -------------- ---------- ------- ---------- ---------------- ---------- ---------- ---------- --------
1/1/1          Root           Forwarding 20000   128        P2P              217571     217573     11         14
1/1/2          Designated     Forwarding 20000   128        P2P              217566     565        15         8
```

```
1/1/3          Designated     Forwarding 20000   128        P2P             217573     27         13         7

Topology change flag          : True
Number of topology changes    : 13
Last topology change occurred : 911 seconds ago
```

Switch B showing as Root Inconsistent:

```
SwitchB# show spanning-tree mst0

### MST0
Vlans mapped:  1-9,12-19,22-4094
Bridge         Address:08:00:09:12:8e:9e    priority:32768
Operational    Hello time(in seconds): 2  Forward delay(in seconds):15  Max-age(in seconds):20  txHoldCount(in pps): 6
Configured     Hello time(in seconds): 2  Forward delay(in seconds):15  Max-age(in seconds):20  Max-Hops:20
Root           Address:08:00:09:8a:14:fa  Priority:0
               Port:1/1/1                 Path cost:0
Regional Root  Address:08:00:09:8a:14:fa  Priority:0
               Internal cost:20000        Rem Hops:19

Port           Role           State      Cost       Priority   Type            BPDU-Tx    BPDU-Rx    TCN-Tx     TCN-Rx
-------------- -------------- ---------- ---------- ---------- --------------- ---------- ---------- ---------- -----
1/1/1          Root           Forwarding 20000      128        P2P             217900     217897     14         11
1/1/2          Designated     Forwarding 20000      128        P2P             217902     25         13         1
1/1/3          Designated     Forwarding 20000      128        P2P             217900     895        12         2

Topology change flag          : True
Number of topology changes    : 16
Last topology change occurred : 1560 seconds ago


### MST1
Vlans mapped:  10,11
Bridge         Address:08:00:09:12:8e:9e    Priority:4096
Root           Address:08:00:09:8a:14:fa    Priority:0
               Port:1/1/1, Cost:20000, Rem Hops:19

Port           Role           State      Cost    Priority   Type            BPDU-Tx    BPDU-Rx    TCN-Tx     TCN-Rx
-------------- -------------- ---------- ------- ---------- --------------- ---------- ---------- ---------- --------
1/1/1          Root           Forwarding 20000   128        P2P             217900     217897     14         11
1/1/2          Designated     Forwarding 20000   128        P2P             217902     25         13         1
1/1/3          Alternate      Root-Inc   20000   128        P2P             217900     895        12         2

Topology change flag          : True
Number of topology changes    : 19
Last topology change occurred : 1560 seconds ago


#### MST2
Vlans mapped:  20,21
Bridge         Address:08:00:09:12:8e:9e    Priority:0
Root           Address:08:00:09:12:8e:9e    Priority:0
               Port:0, Cost:0, Rem Hops:20

Port           Role           State      Cost    Priority   Type            BPDU-Tx    BPDU-Rx    TCN-Tx     TCN-Rx
-------------- -------------- ---------- ------- ---------- --------------- ---------- ---------- ---------- --------
1/1/1          Designated     Forwarding 20000   128        P2P             217900     217897     14         11
1/1/2          Designated     Forwarding 20000   128        P2P             217902     25         13         1
1/1/3          Designated     Forwarding 20000   128        P2P             217900     895        12         2

Topology change flag          : True
```

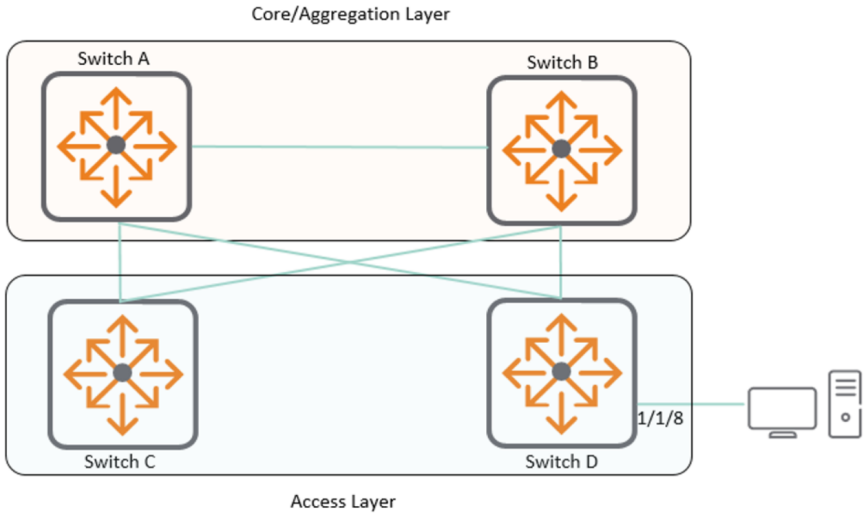
```
Number of topology changes    : 13
Last topology change occurred : 1561 seconds ago
```

Depending on when the `show` command is executed, it may first show the protected port as **`Designated Blocking`** before it shows it as **`Alternate Root-Inc`**.

## MSTP use case: Spanning tree on edge ports

When using spanning tree and taking into consideration the edge of the network ports that provide connectivity to end points, the network should not typically participate in spanning tree. Consider this topology that shows an endpoint connected to port 1/1/8 on Switch D:

**Figure 1** *Spanning tree on edge ports*




End points that connect to ports that do participate in spanning tree (STP) may experience DHCP assignment timeouts or IP address assignment delays plus extended client onboarding time and authentication issues. These problems occur because the port participates in the full STP process. To avoid such issues consider setting the port as a spanning tree administrative edge port by using command **`spanning-tree port-type admin-edge`**. This command removes the port participation from STP interactions when onboarding devices, enabling quicker onboarding.

Edge ports still need to be protected from possible spanning tree attacks. For example BPDU guard can be used. See MSTP use case: BPDU protection.

Before configuring a port as spanning tree administrative edge, the port configuration looks like this:

```
interface 1/1/8
    no shutdown
    vlan access 10
    spanning-tree bpdu-guard
```

The port State is **Forwarding** and the Type is **P2P** (Point to Point) by default.

```
switch# show spanning-tree mst 1

### MST1
Vlans mapped:  10,11
Bridge         Address:38:21:c7:dc:50:60    Priority:32768
Root           Address:88:3a:30:9a:39:00    Priority:0
               Port:1/1/2, Cost:20000, Rem Hops:19

Port           Role           State      Cost    Priority   Type            BPDU-Tx    BPDU-Rx    TCN-Tx     TCN-Rx
-------------- -------------- ---------- ------- ---------- --------------- ---------- ---------- ---------- ----------
1/1/1          Alternate      Blocking   20000   128        P2P             463        467        4          13
1/1/2          Root           Forwarding 20000   128        P2P             466        467        13         0
1/1/3          Disabled       Down       20000   128        P2P             0          0          0          0
1/1/4          Disabled       Down       20000   128        P2P             0          0          0          0
1/1/5          Disabled       Down       20000   128        P2P             0          0          0          0
1/1/6          Disabled       Down       20000   128        P2P             0          0          0          0
1/1/7          Disabled       Down       20000   128        P2P             0          0          0          0
1/1/8          Designated     Forwarding 20000   128        P2P             2          0          0          0
1/1/9          Disabled       Down       20000   128        P2P             0          0          0          0
1/1/10         Disabled       Down       20000   128        P2P             0          0          0          0
1/1/11         Disabled       Down       20000   128        P2P             0          0          0          0
1/1/12         Disabled       Down       20000   128        P2P             0          0          0          0
1/1/13         Disabled       Down       20000   128        P2P             0          0          0          0
1/1/14         Disabled       Down       20000   128        P2P             0          0          0          0
1/1/15         Disabled       Down       20000   128        P2P             0          0          0          0
1/1/16         Disabled       Down       20000   128        P2P             0          0          0          0

Topology change flag          : True
Number of topology changes    : 2
Last topology change occurred : 915 seconds ago
```

Configure the port as admin edge as follows with command **spanning-tree port-type admin-edge**:

```
interface 1/1/8
    no shutdown
    vlan access 10
    spanning-tree bpdu-guard
    spanning-tree port-type admin-edge
    exit
```

Notice how that the port State is now **Forwarding** and the Type is **P2P Edge** meaning that the port will go into the forwarding state and bypass the standard STP listening and learning states.

```
switch# show spanning-tree mst 1


### MST1
Vlans mapped:  10,11
Bridge         Address:38:21:c7:dc:50:60    Priority:32768
Root           Address:88:3a:30:9a:39:00    Priority:0
               Port:1/1/2, Cost:20000, Rem Hops:19

Port           Role           State      Cost    Priority   Type            BPDU-Tx    BPDU-Rx    TCN-Tx     TCN-Rx
-------------- -------------- ---------- ------- ---------- --------------- ---------- ---------- ---------- ----------
1/1/1          Alternate      Blocking   20000   128        P2P             593        597        4          13
1/1/2          Root           Forwarding 20000   128        P2P             596        597        13         0
1/1/3          Disabled       Down       20000   128        P2P             0          0          0          0
```

```
1/1/4          Disabled       Down       20000   128        P2P             0          0          0          0
1/1/5          Disabled       Down       20000   128        P2P             0          0          0          0
1/1/6          Disabled       Down       20000   128        P2P             0          0          0          0
1/1/7          Disabled       Down       20000   128        P2P             0          0          0          0
1/1/8          Designated     Forwarding 20000   128        P2P Edge        132        0          0          0
1/1/9          Disabled       Down       20000   128        P2P             0          0          0          0
1/1/10         Disabled       Down       20000   128        P2P             0          0          0          0
1/1/11         Disabled       Down       20000   128        P2P             0          0          0          0
1/1/12         Disabled       Down       20000   128        P2P             0          0          0          0
1/1/13         Disabled       Down       20000   128        P2P             0          0          0          0
1/1/14         Disabled       Down       20000   128        P2P             0          0          0          0
1/1/15         Disabled       Down       20000   128        P2P             0          0          0          0
1/1/16         Disabled       Down       20000   128        P2P             0          0          0          0

Topology change flag          : True
Number of topology changes    : 2
Last topology change occurred : 1174 seconds ago
```

# MSTP commands

## clear spanning-tree statistics

```
clear spanning-tree statistics
```

### Description

Clears the spanning tree BPDU statistics.

### Example

Clearing the spanning tree BPDU statistics:

```
switch(config)# clear spanning-tree statistics
```

### Command History

| Release | Modification |
|---|---|
| 10.07 or earlier | -- |

### Command Information

| Platforms | Command context | Authority |
|---|---|---|
| All platforms | `config` | Administrators or local user group members with execution rights for this command. |

## show spanning-tree

```
show spanning-tree
```

### Description

Shows priority, address, Hello-time, Max-age, and Forward-delay for bridge and root node.

### Example

Showing spanning tree standard information:

```
switch# show spanning-tree
Spanning tree status      : Enabled Protocol: MSTP

MST0
  Root ID
    Priority      : 32768, Root
    MAC-Address   : 48:0F:CF:AF:04:76
    Hello time(in seconds):2   Max Age(in seconds):20
    Forward Delay(in seconds):15

  Bridge ID
    Priority      : 32768
    MAC-Address   : 48:0F:CF:AF:04:76
    Hello time(in seconds):2   Max Age(in seconds):20
    Forward Delay(in seconds):15
```

```
PORT     ROLE        STATE      COST       PRIORITY  TYPE      BPDU-Tx    BPDU-Rx
  TCN-Tx     TCN-Rx
-------- ----------- ---------- ---------- --------- --------- ---------- --------
-- ---------- ----------
1/1/1    Designated  Forwarding 20000      128       P2P Edge  100        60
  20         10
1/1/2    Designated  Forwarding 20000      128       P2P       100        60
  20         10
1/1/3    Designated  Forwarding 20000      128       Shr       100        60
  20         10
1/1/4    Designated  Forwarding 20000      128       Shr Edge  100        60
  20         10
1/1/5    Alternate   Loop-Inc   20000      128       Shr Edge  100        60
  20         10
1/1/6    Alternate   Root-Inc   20000      128       Shr Edge  100        60
  20         10
1/1/7    Root        Forwarding 2000       128       P2P       100        60
  20         10
1/1/8    Alternate   Blocking   20000      128       P2P       100        60
  20         10
1/1/9    Disabled    Down       20000      128       P2P       100        60
  20         10

Number of topology changes    : 4
Last topology change occurred : 516 seconds ago
```

### Command History

| Release | Modification |
|---|---|
| 10.09 | A new state `Down` is added in the output. |
| 10.07 or earlier | -- |

### Command Information

| Platforms | Command context | Authority |
|---|---|---|
| All platforms | Operator (>) or Manager (#) | Operators or Administrators or local user group members with execution rights for this command. Operators can execute this command from the operator context (>) only. |

## show spanning-tree detail

`show spanning-tree detail`

### Description

Shows spanning tree detail including CIST and corresponding port information.

### Example

Showing spanning tree detailed information:

```
switch# show spanning-tree detail
Spanning tree status      : Enabled Protocol: MSTP
```

```
MST0
  Root ID
    Priority      : 32768, Root
    MAC-Address   : 48:0F:CF:AF:04:76
    Hello time(in seconds):2   Max Age(in seconds):20
    Forward Delay(in seconds):15

  Bridge ID
    Priority      : 32768
    MAC-Address   : 48:0F:CF:AF:04:76
    Hello time(in seconds):2  Max Age(in seconds):20
    Forward Delay(in seconds):15

PORT     ROLE        STATE      COST       PRIORITY  TYPE      BPDU-Tx    BPDU-Rx
  TCN-Tx     TCN-Rx
-------- ----------- ---------- ---------- --------- --------- ---------- --------
-- ---------- ----------
1/1/1    Designated  Forwarding 20000      128       P2P Edge  100        60
  20         10
1/1/2    Designated  Forwarding 20000      128       P2P       100        60
  20         10
1/1/3    Designated  Forwarding 20000      128       Shr       100        60
  20         10
1/1/4    Designated  Forwarding 20000      128       Shr Edge  100        60
  20         10
1/1/5    Alternate   Loop-Inc   20000      128       Shr Edge  100        60
  20         10
1/1/6    Alternate   Root-Inc   20000      128       Shr Edge  100        60
  20         10
1/1/7    Disabled    Down       20000      128       P2P       100        60
  20         10


Topology change flag          : True
Number of topology changes    : 4
Last topology change occurred : 516 seconds ago
Hello expiry                  : 1 second
Forward delay expiry          : 18 seconds

Port 1/1/1
Designated root has priority              : 32768          Address:
48:0F:CF:AF:04:76
Designated bridge has priority            : 32768          Address:
48:0F:CF:AF:04:76
Designated port                           : 1/1/1
Number of transitions to forwarding state : 3
BPDUs sent                                : 347
BPDUs received                            : 9
TCN_Tx: 20, TCN_Rx: 10

Port 1/1/2
Designated root has priority              : 32768          Address:
48:0F:CF:AF:04:76
Designated bridge has priority            : 32768          Address:
48:0F:CF:AF:04:76
Designated port                           : 1/1/2
Number of transitions to forwarding state : 3
BPDUs sent                                : 350
BPDUs received                            : 11
TCN_Tx: 20, TCN_Rx: 10
```

```
Port lag1 ID 321
Designated root has priority              : 32768          Address:
48:0F:CF:AF:04:76
Designated bridge has priority            : 32768          Address:
48:0F:CF:AF:04:76
Designated port id                        : 321
Multi-Chassis role                        : active
Number of transitions to forwarding state : 3
BPDUs sent                                : 340
BPDUs received                            : 5
TCN_Tx: 20, TCN_Rx: 10
```

### Command History

| Release | Modification |
|---|---|
| 10.09 | A new state `Down` is added in the output. |
| 10.07 or earlier | -- |

### Command Information

| Platforms | Command context | Authority |
|---|---|---|
| All platforms | Operator (>) or Manager (#) | Operators or Administrators or local user group members with execution rights for this command. Operators can execute this command from the operator context (>) only. |

## show spanning-tree inconsistent-ports

`show spanning-tree inconsistent-ports [instance <INSTANCE-ID>]`

### Description

Shows ports blocked by STP protection functions such as Root guard, Loop guard, BPDU guard, and RPVST guard in addition to MSTI information.

| Parameter | Description |
|---|---|
| *<INSTANCE-ID>* | Specifies the MSTP instance ID. Range: 0 to 64. |

### Example

Showing spanning tree inconsistent ports:

```
switch# show spanning-tree inconsistent-ports
Instance ID  Blocked Port   Reason
-----------  -------------  ------------
0            1/1/13         BPDU Guard
```

Showing inconsistent port information for instances 1-4:

```
switch# show spanning-tree inconsistent-ports instance 1-4
Instance ID  Blocked Port   Reason
------------ -------------- ------------
1            1/1/3          Root Guard
2            1/1/7          BPDU Guard
3            1/1/9          Loop Guard
4            1/1/37         RPVST Guard
```

### Command History

| Release | Modification |
|---|---|
| 10.07 or earlier | -- |

### Command Information

| Platforms | Command context | Authority |
|---|---|---|
| All platforms | Operator (>) or Manager (#) | Operators or Administrators or local user group members with execution rights for this command. Operators can execute this command from the operator context (>) only. |

## show spanning-tree mst

```
show spanning-tree mst
```

### Description

Shows MSTP configuration and status information for each instance.

### Examples

Showing MSTP configuration and status information:

```
switch# show spanning-tree mst
#### MST0
Vlans mapped   : 2,4-4094
Bridge Address : 48:0F:CF:AF:04:76
Priority       : 32768
Root
Regional Root
Operational    Hello time   : 2 seconds                Forward delay: 15 seconds
               Max-age      : 20 seconds               TxHoldCount  : 6 pps
Configured     Hello time   : 2 seconds                Forward delay: 15 seconds
               Max-age      : 20 seconds               Max-Hops     : 20
Root           Address      : 48:0F:CF:AF:04:76        Priority     : 32768
               Port         : 0                        Path cost    : 0
Regional Root  Address      : 48:0F:CF:AF:04:76        Priority     : 32768
               Internal cost: 0                        Rem Hops     : 20

PORT     ROLE        STATE      COST       PRIORITY  TYPE      BPDU-Tx    BPDU-Rx
  TCN-Tx     TCN-Rx
-------- ----------- ---------- ---------- --------- --------- ---------- --------
-- ---------- ----------
1/1/1    Designated  Forwarding 20000      128       P2P Edge  100        60
  20         10
1/1/2    Designated  Forwarding 20000      128       P2P       100        60
```

```
  20         10
1/1/3    Designated  Forwarding 20000      128       Shr       100        60
  20         10
1/1/4    Designated  Forwarding 20000      128       Shr Edge  100        60
  20         10
1/1/5    Alternate   Loop-Inc   20000      128       Shr Edge  100        60
  20         10
1/1/6    Alternate   Root-Inc   20000      128       Shr Edge  100        60
  20         10
1/1/7    Disabled    Down       20000      128       P2P       100        60
  20         10


Topology change flag          : True
Number of topology changes    : 4
Last topology change occurred : 516 seconds ago

#### MST1
Vlans mapped:  1
Bridge          Address : 48:0F:CF:AF:04:76          Priority: 32768
Root            Address : 48:0F:CF:AF:04:76          Priority: 32768
                Port    : 0                          Cost    : 0
                Rem Hops: 20

PORT     ROLE        STATE      COST       PRIORITY  TYPE      BPDU-Tx    BPDU-Rx
  TCN-Tx     TCN-Rx
-------- ----------- ---------- ---------- --------- --------- ---------- --------
-- ---------- ----------
1/1/1    Designated  Forwarding 20000      128       P2P Edge  100        60
  20         10
1/1/2    Designated  Forwarding 20000      128       P2P       100        60
  20         10
1/1/3    Designated  Forwarding 20000      128       Shr       100        60
  20         10
1/1/4    Designated  Forwarding 20000      128       Shr Edge  100        60
  20         10
1/1/5    Alternate   Loop-Inc   20000      128       Shr Edge  100        60
  20         10
1/1/6    Alternate   Root-Inc   20000      128       Shr Edge  100        60
  20         10
1/1/7    Disabled    Down       20000      128       P2P       100        60
  20         10

Topology change flag          : True
Number of topology changes    : 4
Last topology change occurred : 516 seconds ago

#### MST2
Vlans mapped:  3
Bridge          Address : 48:0F:CF:AF:04:76          Priority: 32768
Root            Address : 48:0F:CF:AF:04:76          Priority: 32768
                Port    : 0                          Cost    : 0
                Rem Hops: 20

PORT     ROLE        STATE      COST       PRIORITY  TYPE      BPDU-Tx    BPDU-Rx
  TCN-Tx     TCN-Rx
-------- ----------- ---------- ---------- --------- --------- ---------- --------
-- ---------- ----------
1/1/1    Designated  Forwarding 20000      128       P2P Edge  100        60
  20         10
1/1/2    Designated  Forwarding 20000      128       P2P       100        60
  20         10
```

```
1/1/3    Designated  Forwarding 20000      128       Shr       100        60
  20         10
1/1/4    Designated  Forwarding 20000      128       Shr Edge  100        60
  20         10
1/1/5    Alternate   Loop-Inc   20000      128       Shr Edge  100        60
  20         10
1/1/6    Alternate   Root-Inc   20000      128       Shr Edge  100        60
  20         10

Topology change flag          : True
Number of topology changes    : 4
Last topology change occurred : 516 seconds ago
```

### Command History

| Release | Modification |
|---|---|
| 10.09 | A new state `Down` is added in the output. |
| 10.07 or earlier | -- |

### Command Information

| Platforms | Command context | Authority |
|---|---|---|
| All platforms | Operator (>) or Manager (#) | Operators or Administrators or local user group members with execution rights for this command. Operators can execute this command from the operator context (>) only. |

## show spanning-tree mst-config

`show spanning-tree mst-config`

### Description

Shows MSTP instance and corresponding VLAN information.

### Examples

Showing configuration information for MST instances and corresponding VLANs:

```
switch# show spanning-tree mst-config
MST configuration information
   MST config ID        : reg
   MST config revision  : 1
   MST config digest    : 2D2BC9A32097B463C48EE1817673FA2D
   Number of instances  : 2

Instance ID     Member VLANs
--------------- ----------------------------------
0               2,4-4094
1               1
2               3
```

### Command History

| Release | Modification |
|---|---|
| 10.07 or earlier | -- |

### Command Information

| Platforms | Command context | Authority |
|---|---|---|
| All platforms | Operator (>) or Manager (#) | Operators or Administrators or local user group members with execution rights for this command. Operators can execute this command from the operator context (>) only. |

## show spanning-tree mst detail

```
show spanning-tree mst detail
```

### Description

Shows detailed information for all MST instances.

### Example

Showing detailed information for all MST instances:

```
switch# show spanning-tree mst detail
#### MST0
Vlans mapped:  2,4-4094
Bridge         Address: 48:0F:CF:AF:04:76          Priority: 32768
Root
Regional Root
Operational    Hello time   : 2 seconds                 Forward delay: 15 seconds
               Max-age      : 20 seconds                TxHoldCount  : 6 pps
Configured     Hello time   : 2 seconds                 Forward delay: 15 seconds
               Max-age      : 20 seconds                Max-Hops     : 20
Root           Address      : 48:0F:CF:AF:04:76         Priority     : 32768
               Port         : 0                         Path cost    : 0
Regional Root  Address      : 48:0F:CF:AF:04:76         Priority     : 32768
               Internal cost: 0                         Rem Hops     : 20

PORT     ROLE        STATE      COST       PRIORITY  TYPE      BPDU-Tx    BPDU-Rx
  TCN-Tx     TCN-Rx
-------- ----------- ---------- ---------- --------- --------- ---------- --------
-- ---------- ----------
1/1/1    Designated  Forwarding 20000      128       P2P Edge  100        60
  20         10
1/1/2    Designated  Forwarding 20000      128       P2P       100        60
  20         10
1/1/3    Designated  Forwarding 20000      128       Shr       100        60
  20         10
1/1/4    Designated  Forwarding 20000      128       Shr Edge  100        60
  20         10
1/1/5    Alternate   Loop-Inc   20000      128       Shr Edge  100        60
  20         10
1/1/6    Alternate   Root-Inc   20000      128       Shr Edge  100        60
  20         10
1/1/7    Disabled    Down       20000      128       P2P       100        60
  20         10

Topology change flag          : True
```

```
Number of topology changes    : 4
Last topology change occurred : 516 seconds ago

Port 1/1/1
Designated root address            : 48:0F:CF:AF:04:76
Designated regional root address   : 48:0F:CF:AF:04:76
Designated bridge address          : 48:0F:CF:AF:04:76
Priority                           : 32768
BPDUs sent                         : 638
BPDUs received                     : 9
Message expiry                     : 1 second
Forward delay expiry               : 18 seconds
Forward transitions                : 3
TCN_Tx: 10, TCN_Rx: 10

Port 1/1/2
Designated root address            : 48:0F:CF:AF:04:76
Designated regional root address   : 48:0F:CF:AF:04:76
Designated bridge address          : 48:0F:CF:AF:04:76
Priority                           : 32768
BPDUs sent                         : 641
BPDUs received                     : 11
Message expiry                     : 1 second
Forward delay expiry               : 18 seconds
Forward transitions                : 3
TCN_Tx: 10, TCN_Rx: 10

#### MST1
Vlans mapped:  1
Bridge         Address : 48:0F:CF:AF:04:76          Priority: 32768
Root           Address : 48:0F:CF:AF:04:76          Priority: 32768
               Port    : 0                          Cost    : 0
               Rem Hops: 20

PORT     ROLE        STATE      COST       PRIORITY  TYPE      BPDU-Tx    BPDU-Rx
  TCN-Tx     TCN-Rx
-------- ----------- ---------- ---------- --------- --------- ---------- --------
-- ---------- ----------
1/1/1    Designated  Forwarding 20000      128       P2P Edge  100        60
  20         10
1/1/2    Designated  Forwarding 20000      128       P2P       100        60
  20         10
1/1/3    Designated  Forwarding 20000      128       Shr       100        60
  20         10
1/1/4    Designated  Forwarding 20000      128       Shr Edge  100        60
  20         10
1/1/5    Alternate   Loop-Inc   20000      128       Shr Edge  100        60
  20         10
1/1/6    Alternate   Root-Inc   20000      128       Shr Edge  100        60
  20         10
1/1/7    Disabled    Down       20000      128       P2P       100        60
  20         10

Topology change flag          : True
Number of topology changes    : 4
Last topology change occurred : 516 seconds ago

Port 1/1/1
Designated root address            : 48:0F:CF:AF:04:76
Designated bridge address          : 48:0F:CF:AF:04:76
Priority                           : 32768
BPDUs sent                         : 638
```

```
BPDUs received                      : 9
Message expiry                      : 1 second
Forward delay expiry                : 18 seconds
Forward transitions                 : 4
TCN_Tx: 10, TCN_Rx: 10

Port 1/1/2
Designated root address             : 48:0F:CF:AF:04:76
Designated bridge address           : 48:0F:CF:AF:04:76
Priority                            : 32768
BPDUs sent                          : 641
BPDUs received                      : 11
Message expiry                      : 1 second
Forward delay expiry                : 18 seconds
Forward transitions                 : 4
TCN_Tx: 10, TCN_Rx: 10


#### MST2
Vlans mapped:  3
Bridge          Address : 48:0F:CF:AF:04:76          Priority: 32768
Root            Address : 48:0F:CF:AF:04:76          Priority: 32768
                Port    : 0                          Cost    : 0
                Rem Hops: 20

PORT     ROLE        STATE      COST       PRIORITY  TYPE      BPDU-Tx    BPDU-Rx
  TCN-Tx     TCN-Rx
-------- ----------- ---------- ---------- --------- --------- ---------- --------
-- ---------- ----------
1/1/1    Designated  Forwarding 20000      128       P2P Edge  100        60
  20         10
1/1/2    Designated  Forwarding 20000      128       P2P       100        60
  20         10
1/1/3    Designated  Forwarding 20000      128       Shr       100        60
  20         10
1/1/4    Designated  Forwarding 20000      128       Shr Edge  100        60
  20         10
1/1/5    Alternate   Loop-Inc   20000      128       Shr Edge  100        60
  20         10
1/1/6    Alternate   Root-Inc   20000      128       Shr Edge  100        60
  20         10
1/1/7    Disabled    Down       20000      128       P2P       100        60
  20         10

Topology change flag          : True
Number of topology changes    : 4
Last topology change occurred : 516 seconds ago

Port 1/1/1
Designated root address             : 48:0F:CF:AF:04:76
Designated bridge address           : 48:0F:CF:AF:04:76
Priority                            : 32768
BPDUs sent                          : 638
BPDUs received                      : 9
Message expiry                      : 1 second
Forward delay expiry                : 18 seconds
Forward transitions                 : 3
TCN_Tx: 10, TCN_Rx: 10

Port 1/1/2
Designated root address             : 48:0F:CF:AF:04:76
Designated bridge address           : 48:0F:CF:AF:04:76
```

```
Priority                          : 32768
BPDUs sent                        : 641
BPDUs received                    : 11
Message expiry                    : 1 second
Forward delay expiry              : 18 seconds
Forward transitions               : 3
TCN_Tx: 10, TCN_Rx: 10
```

### Command History

| Release | Modification |
|---|---|
| 10.09 | A new state **Down** is added in the output. |
| 10.07 or earlier | -- |

### Command Information

| Platforms | Command context | Authority |
|---|---|---|
| All platforms | Operator (>) or Manager (#) | Operators or Administrators or local user group members with execution rights for this command. Operators can execute this command from the operator context (>) only. |

## show spanning-tree mst <INSTANCE-ID>

`show spanning-tree mst <INSTANCE-ID>`

### Description

Displays MSTP configurations for the given instance ID.

| Parameter | Description |
|---|---|
| *<INSTANCE-ID>* | Specifies the MSTP instance number. Range: 0 to 64. |

### Example

```
switch# show spanning-tree mst 1

#### MST1
Vlans mapped:  1
Bridge         Address : 48:0F:CF:AF:04:76          Priority: 32768
Root           Address : 48:0F:CF:AF:04:76          Priority: 32768
               Port    : 0                          Cost    : 0
               Rem Hops: 20

PORT     ROLE        STATE      COST       PRIORITY  TYPE      BPDU-Tx    BPDU-Rx
  TCN-Tx     TCN-Rx
-------- ----------- ---------- ---------- --------- --------- ---------- --------
-- ---------- ----------
1/1/1    Designated  Forwarding 20000      128       P2P Edge  100        60
  20         10
1/1/2    Designated  Forwarding 20000      128       P2P       100        60
  20         10
```

```
1/1/3    Designated  Forwarding 20000      128       Shr       100        60
  20         10
1/1/4    Designated  Forwarding 20000      128       Shr Edge  100        60
  20         10
1/1/5    Alternate   Loop-Inc   20000      128       Shr Edge  100        60
  20         10
1/1/6    Alternate   Root-Inc   20000      128       Shr Edge  100        60
  20         10
1/1/7    Disabled    Down       20000      128       P2P Bound 100        60
  20         10

Topology change flag          : True
Number of topology changes    : 4
Last topology change occurred : 516 seconds ago
```

### Command History

| Release | Modification |
|---|---|
| 10.09 | A new state **Down** is added in the output. |
| 10.07 or earlier | -- |

### Command Information

| Platforms | Command context | Authority |
|---|---|---|
| All platforms | Operator (>) or Manager (#) | Operators or Administrators or local user group members with execution rights for this command. Operators can execute this command from the operator context (>) only. |

## show spanning-tree mst <INSTANCE-ID> detail

`show spanning-tree mst <INSTANCE-ID> detail`

### Description

Displays MSTP configurations for the given instance ID with corresponding port details.

| Parameter | Description |
|---|---|
| *<INSTANCE-ID>* | Specifies the MSTP instance number. Range: 0 to 64. |

### Example

```
switch# show spanning-tree mst 1 detail


#### MST1
Vlans mapped:  1
Bridge         Address : 48:0F:CF:AF:04:76          Priority: 32768
Root           Address : 48:0F:CF:AF:04:76          Priority: 32768
               Port    : 0                          Cost    : 0
               Rem Hops: 20
```

```
PORT     ROLE        STATE      COST       PRIORITY  TYPE      BPDU-Tx    BPDU-Rx
  TCN-Tx     TCN-Rx
-------- ----------- ---------- ---------- --------- --------- ---------- --------
-- ---------- ----------
1/1/1    Designated  Forwarding 20000      128       P2P Edge  100        60
  20         10
1/1/2    Designated  Forwarding 20000      128       P2P       100        60
  20         10
1/1/3    Designated  Forwarding 20000      128       Shr       100        60
  20         10
1/1/4    Designated  Forwarding 20000      128       Shr Edge  100        60
  20         10
1/1/5    Alternate   Loop-Inc   20000      128       Shr Edge  100        60
  20         10
1/1/6    Alternate   Root-Inc   20000      128       Shr Edge  100        60
  20         10
1/1/7    Disabled    Down       20000      128       P2P Bound 100        60
  20         10

Topology change flag          : True
Number of topology changes    : 4
Last topology change occurred : 516 seconds ago

Port 1/1/1
Designated root address            : 48:0F:CF:AF:04:76
Designated bridge address          : 48:0F:CF:AF:04:76
Priority                           : 32768
BPDUs sent                         : 667
BPDUs received                     : 9
Message expiry                     : 0 second
Forward delay expiry               : 18 seconds
Forward transitions                : 4
TCN_Tx: 10, TCN_Rx: 10

Port 1/1/2
Designated root address            : 48:0F:CF:AF:04:76
Designated bridge address          : 48:0F:CF:AF:04:76
Priority                           : 32768
BPDUs sent                         : 670
BPDUs received                     : 11
Message expiry                     : 0 second
Forward delay expiry               : 18 seconds
Forward transitions                : 4
TCN_Tx: 10, TCN_Rx: 10
```

## Command History

| Release | Modification |
|---|---|
| 10.09 | A new state **Down** is added in the output. |
| 10.07 or earlier | -- |

## Command Information

| Platforms | Command context | Authority |
|---|---|---|
| All platforms | Operator (>) or Manager (#) | Operators or Administrators or local user group members with execution rights for this command. Operators can execute this command from the operator context (>) only. |

## show spanning-tree mst interface

`show spanning-tree mst <INSTANCE-ID> interface <IFNAME>`

### Description

Shows MSTP configurations for the given instance ID with corresponding port details.

| Parameter | Description |
|---|---|
| *<INSTANCE-ID>* | Specifies the MSTP instance number. Range: 0 to 64. |
| *<IFNAME>* | Specifies an interface. |

### Examples

Showing MST configuration and port details:

```
switch# show spanning-tree mst 1 interface 1/1/1
Port 1/1/1

Instance       Role           State        Cost       Priority   Vlans mapped
-------------- -------------- ------------ ---------- ---------- ----------
1              Designated     Forwarding   20000      128        1
```

### Command History

| Release | Modification |
|---|---|
| 10.07 or earlier | -- |

### Command Information

| Platforms | Command context | Authority |
|---|---|---|
| All platforms | Operator (>) or Manager (#) | Operators or Administrators or local user group members with execution rights for this command. Operators can execute this command from the operator context (>) only. |

## show spanning-tree summary port

`show spanning-tree summary port`

### Description

Shows spanning tree port summary information.

### Example

Showing summary of spanning tree ports:

```
switch# show spanning-tree summary port

STP status                      : Enabled
Protocol                        : MSTP
```

```
BPDU guard timeout value        : None
BPDU guard enabled interfaces   : 1/1/1-1/1/9,1/1/11,1/1/13,1/1/15,1/1/17,1/1/19,
                                  1/1/21,lag1,lag2
BPDU filter enabled interfaces  : None
Root guard enabled interfaces   : 1/1/3
Loop guard enabled interfaces   : 1/1/2
TCN guard enabled interfaces    : 1/1/1-1/1/3
RPVST filter enabled interfaces : 1/1/37
RPVST guard enabled interfaces  : None

Interface count by state

Instance ID   Blocking Listening Learning Forwarding Down
------------- -------- --------- -------- ---------- ----
0                    2         0        0         15    0
1                    2         0        0         15    0
2                    2         0        0         15    0
------------- -------- --------- -------- ---------- ----
Total = 3            6         0        0         45    0
```

### Command History

| Release | Modification |
|---|---|
| 10.09 | A new state `Down` is added in the output. |
| 10.07 or earlier | -- |

### Command Information

| Platforms | Command context | Authority |
|---|---|---|
| All platforms | Operator (>) or Manager (#) | Operators or Administrators or local user group members with execution rights for this command. Operators can execute this command from the operator context (>) only. |

## show spanning-tree summary root

`show spanning-tree summary root`

### Description

Shows spanning tree root summary information.

### Example

Showing spanning tree root summary:

```
switch# show spanning-tree summary root

STP status                    : Enabled
Protocol                      : MSTP
System ID                     : 70:72:cf:32:50:f5

Root bridge for STP Instance : 0,1,2

                                                Root Hello Max Fwd
```

```
Instance ID     Priority Root ID                cost  Time Age Dly    Root Port
--------------- -------- ----------------- --------- ----- --- --- ------------
0                  32768 70:72:cf:32:50:f5         0     2  20  15          n/a
1                  32768 70:72:cf:32:50:f5         0     2  20  15          n/a
2                  32768 70:72:cf:32:50:f5       200     2  20  15        1/1/1
```

### Command History

| Release | Modification |
|---|---|
| 10.07 or earlier | -- |

### Command Information

| Platforms | Command context | Authority |
|---|---|---|
| All platforms | Operator (>) or Manager (#) | Operators or Administrators or local user group members with execution rights for this command. Operators can execute this command from the operator context (>) only. |

## spanning-tree

```
spanning-tree
no spanning-tree
```

### Description

Enables the spanning tree protocol on the switch.

The **no** form of this command disables the spanning tree protocol on the switch.

### Examples

Enabling spanning tree:

```
switch(config)# spanning-tree
```

Disabling spanning tree:

```
switch(config)# no spanning-tree
```

### Command History

| Release | Modification |
|---|---|
| 10.07 or earlier | -- |

### Command Information

| Platforms | Command context | Authority |
|---|---|---|
| All platforms | `config` | Administrators or local user group members with execution rights for this command. |

## spanning-tree bpdu-filter

```
spanning-tree bpdu-filter
no spanning-tree bpdu-filter
```

### Description

Enables the bpdu filter for the interface.

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, does not transmit BPDU, and stays locked in the spanning tree forwarding state. All other ports maintain their role. Typical uses for this parameter include:

- To have MSTP operations running on selected ports of the switch rather than every port of the switch at a time.
- To prevent the spread of errant BPDU frames.
- To eliminate the need for a topology change when a port's link status changes. For example, ports that connect to servers and workstations can be configured to remain outside of spanning tree operations.
- To protect the network from denial of service attacks that use spoofing BPDUs by dropping incoming BPDU frames. For this scenario, BPDU protection offers a more secure alternative, implementing port shut down and a detection alert when errant BPDU frames are received.

Ports configured with the BPDU filter mode remain active (learning and forward frames). However, spanning tree cannot receive or transmit BPDUs on the port. The port remains in a forwarding state, permitting all broadcast traffic. This can create a network storm if there are any loops (that is, redundant links) using these ports. If you suddenly have a high load, disconnect the link and disable the BPDU filter (using the no command.)

The **no** form of the command sets the bpdu filter status to the default of disabled on the interface.

### Examples

Enabling the bpdu filter on interface 1/1/1:

```
switch(config)# interface 1/1/1
switch(config-if)# spanning-tree bpdu-filter
```

Disabling bpdu filter on interface 1/1/1:

```
switch(config)# interface 1/1/1
switch(config-if)# no spanning-tree bpdu-filter
```

### Command History

| Release | Modification |
|---|---|
| 10.07 or earlier | -- |

### Command Information

| Platforms | Command context | Authority |
|---|---|---|
| All platforms | `config-if` | Administrators or local user group members with execution rights for this command. |

## spanning-tree bpdu-guard

```
spanning-tree bpdu-guard
no spanning-tree bpdu-guard
```

### Description

Enables the BPDU guard on the selected switch interface. When BPDU guard is enabled, interfaces receiving MSTP BPDUs become disabled.

BPDU protection is a security feature designed to protect the active MSTP topology by preventing spoofed BPDU packets from entering the MSTP domain. In a typical implementation, BPDU protection would be applied to edge ports connected to end user devices that do not run MSTP. If MSTP BPDU packets are received on a protected port, this feature disables that port and alerts the network manager using an SNMP trap.

Occasionally a hardware or software failure can cause MSTP to fail, creating forwarding loops that can cause network failures where unidirectional links are used. The non-designated port transitions in a faulty manner because the port is no longer receiving MSTP BPDUs.

The **no** form of the command disables BPDU guard on the selected interface.

### Examples

Enabling the BPDU guard on interface 1/1/1:

```
switch(config)# interface 1/1/1
switch(config-if)# spanning-tree bpdu-guard
```

Disabling BPDU guard on interface 1/1/1:

```
switch(config)# interface 1/1/1
switch(config-if)# no spanning-tree bpdu-guard
```

### Command History

| Release | Modification |
|---|---|
| 10.07 or earlier | -- |

### Command Information

| Platforms | Command context | Authority |
|---|---|---|
| All platforms | config-if | Administrators or local user group members with execution rights for this command. |

## spanning-tree bpdu-guard timeout

```
spanning-tree bpdu-guard timeout <INTERVAL>
no spanning-tree bpdu-guard timeout [<INTERVAL>]
```

### Description

Enables and configures the auto re-enable timeout in seconds for all interfaces with BPDU guard enabled. When an interface is disabled after receiving an unauthorized BPDU it will automatically be re-enabled after the timeout expires. The default is for the interface to stay disabled until manually re-enabled.

The **no** form of the command disables BPDU guard timeout on the interface. This is the default.

| Parameter | Description |
|---|---|
| *<INTERVAL>* | Specifies the re-enable timeout in seconds. Range: 1 to 65535. |

### Example

Enabling the BPDU guard timeout on interface 1/1/1:

```
switch(config)# interface 1/1/1
switch(config-if)# spanning-tree bpdu-guard timeout 10
```

Disabling BPDU guard timeout on interface 1/1/1:

```
switch(config)# interface 1/1/1
switch(config-if)# no spanning-tree bpdu-guard
```

### Command History

| Release | Modification |
|---|---|
| 10.07 or earlier | -- |

### Command Information

| Platforms | Command context | Authority |
|---|---|---|
| All platforms | config | Administrators or local user group members with execution rights for this command. |

## spanning-tree config-name

```
spanning-tree config-name <CONFIG-NAME>
no spanning-tree config-name [<CONFIG-NAME>]
```

### Description

Sets the configuration name for the MST region in which the switch resides.

All switches within an MST region must have identical configuration names. For more than one MSTP switch in the same MST region, the identical region name must be configured on all such switches. If the default configuration name is retained on a switch, it cannot exist in the same MST region with another switch.

The **no** form of this command overwrites the currently configured name with the default name. The default name is a text string using the hexadecimal representation of the system MAC address.

| Parameter | Description |
|---|---|
| *<CONFIG-NAME>* | Specifies the configuration name for the MST region in which the switch resides. Default: text string using the hexadecimal representation of the MAC address of the switch. Range: 1 - 32 nonblank characters (case-sensitive). |

### Examples

Setting the configuration name to MST0:

```
switch(config)# spanning-tree config-name MST0
```

Setting the configuration name to the default value:

```
switch(config)# no spanning-tree config-name
```

### Command History

| Release | Modification |
|---|---|
| 10.07 or earlier | -- |

### Command Information

| Platforms | Command context | Authority |
|---|---|---|
| All platforms | `config` | Administrators or local user group members with execution rights for this command. |

## spanning-tree config-revision

```
spanning-tree config-revision <REVISION-NUMBER>
no spanning-tree config-revision [<REVISION-NUMBER>]
```

### Description

Configures the revision number for the MST region in which the switch resides. All switches within an MST region must have identical revision numbers. Use this setting to differentiate between region configurations. For example, when changing configuration settings within a region where you want to track the configuration versions you use, or when creating a new region from a subset of switches in a current region and you want to maintain the same region name.

The **no** form of this command overwrites the currently configured revision number of the MST region and sets it to the default value of 0.

| Parameter | Description |
|---|---|
| *<REVISION-NUMBER>* | Specifies the revision number for the MST region in which the switch resides.Range: 0 - 65535. Default: 0. |

### Examples

Setting the revision to 40:

```
switch(config)# spanning-tree config-revision 40
```

Setting the revision to the default value:

```
switch(config)# no spanning-tree config-revision
```

### Command History

| Release | Modification |
|---|---|
| 10.07 or earlier | -- |

### Command Information

| Platforms | Command context | Authority |
|---|---|---|
| All platforms | config | Administrators or local user group members with execution rights for this command. |

## spanning-tree cost

```
spanning-tree cost <PORT-COST>
no spanning-tree cost [<PORT-COST>]
```

### Description

Sets individual port cost for MSTI 0.

For a given port, the path cost setting can be different for different MSTIs to which the port may belong.

The switch uses the path cost to determine which ports are the forwarding ports in the MSTI; that is, which links to use for the active topology of the MSTI and which ports to block.

Cost gets calculated based on physical interface link speed. It is not based on cumulative speed of all physical links under a lag. Therefore, the cost will be same for a 1G interface and 2x1G lag interfaces.

The **no** form of the command sets the port cost for MSTI 0 instance to the default value.

| Parameter | Description |
|---|---|
| *<PORT-COST>* | Specifies the cost of the port for MSTI 0. Range: 1-200,000,000. Default is calculated from the port link speed: |

| Parameter | Description |
|---|---|
| | ■ 10 Mbps link speed equals a path cost of 2,000,000.<br>■ 100 Mbps link speed equals a path cost of 200,000.<br>■ 1 Gbps link speed equals a path cost of 20,000.<br>■ 10 Gbps link speed equals a path cost of 2,000.<br>■ 100 Gbps link speed equals a path cost of 200.<br>■ 1 Tbps link speed equals a path cost of 20. |

### Examples

Setting the cost to **2000** on interface **1/1/1**:

```
switch(config)# interface 1/1/1
switch(config-if)# spanning-tree cost 2000
```

Setting the cost to the default on interface **1/1/1**:

```
switch(config)# interface 1/1/1
switch(config-if)# no spanning-tree cost
```

### Command History

| Release | Modification |
|---|---|
| 10.07 or earlier | -- |

### Command Information

| Platforms | Command context | Authority |
|---|---|---|
| All platforms | `config-if` | Administrators or local user group members with execution rights for this command. |

## spanning-tree forward-delay

```
spanning-tree forward-delay <DELAY-IN-SECS>
no spanning-tree forward-delay [<DELAY-IN-SECS>]
```

### Description

Configures the time the switch waits between transitions from listening to learning and from learning to forwarding states.

The **no** form of this command sets forward delay time for the bridge to the default of 15 seconds.

| Parameter | Description |
|---|---|
| *<DELAY-IN-SECS>* | Specifies the forward delay time in seconds. Default: 15 seconds. Range: 4-30. |

### Examples

Setting forward delay to 6 seconds:

```
switch(config)# spanning-tree forward-delay 6
```

Setting forward delay to the default of 15 seconds:

```
switch(config)# no spanning-tree forward-delay
```

### Command History

| Release | Modification |
|---|---|
| 10.07 or earlier | -- |

### Command Information

| Platforms | Command context | Authority |
|---|---|---|
| All platforms | config | Administrators or local user group members with execution rights for this command. |

## spanning-tree hello-time

```
spanning-tree hello-time <HELLO-IN-SECS>
no spanning-tree hello-time [<HELLO-IN-SECS>]
```

### Description

Configures the transmission interval between consecutive Bridge Protocol Data Units (BPDU) that the switch sends as a root bridge. The hello time interval is inserted in outbound BPDUs.

The **no** form of this command sets hello time to the default of 2 seconds.

| Parameter | Description |
|---|---|
| *<HELLO-IN-SECS>* | Specifies the hello time interval in seconds. Default: 2 seconds. Range: 2-10. |

### Examples

Setting the hello time interval to 6 seconds:

```
switch(config)# spanning-tree hello-time 6
```

Setting the hello time interval to the default of 2 seconds:

```
switch(config)# no spanning-tree hello-time
```

### Command History

| Release | Modification |
|---|---|
| 10.07 or earlier | -- |

### Command Information

| Platforms | Command context | Authority |
|---|---|---|
| All platforms | `config` | Administrators or local user group members with execution rights for this command. |

## spanning-tree instance cost

```
spanning-tree instance <INSTANCE-ID> cost <PORT-COST>
no spanning-tree instance <INSTANCE-ID> cost [<PORT-COST>]
```

### Description

Sets the individual port cost for an MSTI. The switch uses the path cost to determine which links to use for the active topology of the MSTI (forwarding ports) and which ports to block. The path cost setting for a port can be different on each MSTI to which the port belongs.

The **no** form of this command sets the port cost for an MSTI to the default value.

| Parameter | Description |
|---|---|
| *<INSTANCE-ID>* | Specifies the MSTI number. Range: 1-64. |
| *<PORT-COST>* | Specifies the cost of the port for the MSTI. Range: 1-200000000. Default value is calculated from the port link speed:<br>■ 10 Mbps link speed equals a path cost of 2000000.<br>■ 100 Mbps link speed equals a path cost of 200000.<br>■ 1 Gbps link speed equals a path cost of 20000. |

### Examples

Setting the port **1/1/1** cost for MSTI **1** to **2000**:

```
switch(config)# interface 1/1/1
switch(config-if)# spanning-tree instance 1 cost 2000
```

Setting the port **1/1/1** cost for MSTI **1** to the default:

```
switch(config)# interface 1/1/1
switch(config-if)# no spanning-tree instance 1 cost
```

### Command History

| Release | Modification |
|---|---|
| 10.07 or earlier | -- |

### Command Information

| Platforms | Command context | Authority |
|---|---|---|
| All platforms | config-if | Administrators or local user group members with execution rights for this command. |

## spanning-tree instance port-priority

```
spanning-tree instance <INSTANCE-ID> port-priority <PRIORITY-MULTIPLIER>
no spanning-tree instance <INSTANCE-ID> port-priority [<PRIORITY-MULTIPLIER>]
```

### Description

Configures the priority as a priority multiplier for the specified ports in the specified MST instance.

For a given port, the priority setting can be different for different MST instances to which the port may belong.

The **no** form of this command sets the port priority to the default value of 8 for the MST instance. The default priority value is derived by multiplying 8 by 16.

| Parameter | Description |
|---|---|
| *<INSTANCE-ID>* | Specifies the MSTP instance number. Range: 1-64. |
| *<PRIORITY-MULTIPLIER>* | Specifies the priority as a multiplier. Default: 8. Range: 0 to 15. The priority range for a port in a given MST instance is 0 to 255. However, this command specifies the priority as a multiplier (0 to 15) of 16. When you specify a priority multiplier of 0 to 15, the actual priority assigned to the switch is: (priority-multiplier) x 16. |

### Examples

Setting the port **1/1/1** priority for instance **1** to **8**:

```
switch(config)# interface 1/1/1
switch(config-if)# spanning-tree instance 1 port-priority 8
```

Setting the port 1/1/1 priority for instance 1 to the default:

```
switch(config)# interface 1/1/1
switch(config-if)# no spanning-tree instance 1 port-priority
```

### Command History

| Release | Modification |
|---|---|
| 10.07 or earlier | -- |

### Command Information

| Platforms | Command context | Authority |
|---|---|---|
| All platforms | config-if | Administrators or local user group members with execution rights for this command. |

## spanning-tree instance priority

```
spanning-tree instance <INSTANCE-ID> priority <PRIORITY-MULTIPLIER>
no spanning-tree instance <INSTANCE-ID> priority [<PRIORITY-MULTIPLIER>]
```

### Description

Sets the switch priority for the specified MST instance.

The **no** form of this command sets the priority for the specified instance to the default of 8.

| Parameter | Description |
|---|---|
| *<INSTANCE-ID>* | Specifies the MSTP instance number. Range: 1 to 64. |
| *<PRIORITY-MULTIPLIER>* | Specifies the priority as a multiplier. Default: 8. Range: 0 to 15. The priority range for an MSTP switch is 0-61440. However, this command specifies the priority as a multiplier (0 - 15) of 4096. That is, when you specify a priority multiplier value of 0 - 15, the actual priority assigned to the switch is: (priority-multiplier) x 4096. For example, with 2 as the priority-multiplier on a given MSTP switch, the switch priority setting is 8,192. |

### Examples

Setting the priority multiplier for instance 1 to 5:

```
switch(config)# spanning-tree instance 1 priority 5
```

Setting the priority multiplier for instance 1 to the default of 8:

```
switch(config)# no spanning-tree instance 1 priority
```

### Command History

| Release | Modification |
|---|---|
| 10.07 or earlier | -- |

### Command Information

| Platforms | Command context | Authority |
|---|---|---|
| All platforms | config | Administrators or local user group members with execution rights for this command. |

## spanning-tree instance vlan

```
spanning-tree instance <INSTANCE-ID> vlan <VLAN-ID>
no spanning-tree instance <INSTANCE-ID> vlan <VLAN-ID>
```

### Description

Creates a new instance with VLANs mapped or maps VLANs to an existing instance.

Each instance must have at least one VLAN mapped to it. When VLANs are mapped to an instance, they are automatically unmapped from the instance they were mapped to before. Any MSTP instance can have all the VLANs configured on the switch.

The **no** form of this command removes the specified VLAN from the MSTP instance.

| Parameter | Description |
|---|---|
| *<INSTANCE-ID>* | Specifies the MSTP instance number. Range: 1 to 64. |
| *<VLAN-ID>* | Specifies a VLAN ID number. |

### Examples

Mapping VLAN 1 to instance 1:

```
switch(config)# spanning-tree instance 1 vlan 1
```

Removing VLAN 1 from instance 1:

```
switch(config)# no spanning-tree instance 1 vlan 1
```

### Command History

| Release | Modification |
|---|---|
| 10.07 or earlier | -- |

### Command Information

| Platforms | Command context | Authority |
|---|---|---|
| All platforms | `config` | Administrators or local user group members with execution rights for this command. |

## spanning-tree link-type

```
spanning-tree link-type {point-to-point|shared}
```

### Description

Specifies the link type of the interface, which is normally derived from the duplex setting of the port. The default setting depends on the duplex mode of the port: full-duplex ports are point-to-point, half-duplex ports are shared.

| Parameter | Description |
|---|---|
| `point-to-point` | Specifies the link type as point-to-point. |
| `shared` | Specifies the link type as shared. |

### Examples

Setting the link type to point-to-point on interface **1/1/1**:

```
switch(config)# interface 1/1/1
switch(config-if)# spanning-tree link-type point-to-point
```

Setting the link type to shared on interface **1/1/1**:

```
switch(config)# interface 1/1/1
switch(config-if)# spanning-tree link-type shared
```

### Command History

| Release | Modification |
|---|---|
| 10.07 or earlier | -- |

### Command Information

| Platforms | Command context | Authority |
|---|---|---|
| All platforms | `config-if` | Administrators or local user group members with execution rights for this command. |

## spanning-tree loop-guard

```
spanning-tree loop-guard
no spanning-tree loop-guard
```

### Description

Enables the loop guard on the interface. STP loop guard is best applied on blocking or forwarding ports.

The **no** form of the command sets the loop guard status to the default of disabled on the interface.

### Usage

Occasionally a hardware or software failure can cause MSTP to fail, creating forwarding loops that can cause network failures where unidirectional links are used. The non-designated port transitions in a faulty manner because the port is no longer receiving MSTP BPDUs.

Loop guard causes the non-designated port to go into the MSTP 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. When BPDUs again are received on the inconsistent port, it resumes normal MSTP operation automatically.

In this example, the transmission from switch 1 port 10 to switch 2 port 20 is blocked due to a hardware failure. Switch 2 port 2 does not receive BPDUs and goes into a forwarding state, creating a loop.

When loop guard is configured for switch 2 port 20, this port goes from a forwarding state to an inconsistent state, and does not forward the traffic through the link, thus avoiding loop creation.

### Examples

Enabling the loop guard on interface **1/1/1**:

```
switch(config)# interface 1/1/1
switch(config-if)# spanning-tree loop-guard
```

Disabling loop guard on interface **1/1/1**:

```
switch(config)# interface 1/1/1
switch(config-if)# no spanning-tree loop-guard
```

### Command History

| Release | Modification |
|---|---|
| 10.07 or earlier | -- |

### Command Information

| Platforms | Command context | Authority |
|---|---|---|
| All platforms | `config-if` | Administrators or local user group members with execution rights for this command. |

## spanning-tree max-age

```
spanning-tree max-age <AGE-IN-SECS>
no spanning-tree max-age [<AGE-IN-SECS>]
```

### Description

Sets the maximum age timer, which specifies the maximum age value that the switch inserts in outbound BPDU packets it sends as a root bridge. Max-age is the interval, specified in the BPDU, that BPDU data remains valid after its reception.

The bridge recomputes the spanning tree topology if it does not receive a new BPDU before max-age expiry.

The **no** form of this command sets the max-age value to the default of 20 seconds.

| Parameter | Description |
|---|---|
| *<AGE-IN-SECS>* | Specifies the max-age in seconds. Range: 6 to 40. Default: 20. |

### Examples

Setting the max-age to 10 seconds:

```
switch(config)# spanning-tree max-age 10
```

Setting the max-age to the default of 20 seconds:

```
switch(config)# no spanning-tree max-age
```

### Command History

| Release | Modification |
|---|---|
| 10.07 or earlier | -- |

### Command Information

| Platforms | Command context | Authority |
|---|---|---|
| All platforms | `config` | Administrators or local user group members with execution rights for this command. |

## spanning-tree max-hops

```
spanning-tree max-hops <HOP-COUNT>
no spanning-tree max-hops [<HOP-COUNT>]
```

### Description

Configures the max hop setting that the switch inserts into BPDUs that it sends out as the root bridge. The max hop setting determines the number of bridges in an MST region that a BPDU can traverse before it is discarded.

The **no** form of this command sets the maximum number of hops to the default of 20.

| Parameter | Description |
|---|---|
| *<HOP-COUNT>* | Specifies the maximum number of hops. Range: 1 to 40. Default: 20. |

### Examples

Setting the hop count to 10:

```
switch(config)# spanning-tree max-hops 10
```

Setting the max-age to the default of 20:

```
switch(config)# no spanning-tree max-hops
```

### Command History

| Release | Modification |
|---|---|
| 10.07 or earlier | -- |

### Command Information

| Platforms | Command context | Authority |
|---|---|---|
| All platforms | `config` | Administrators or local user group members with execution rights for this command. |

# spanning-tree mode

```
spanning-tree mode {mstp|rpvst [auto-vlan-enable [priority <NUMBER>]]}
no spanning-tree mode {mstp|rpvst [auto-vlan-enable [priority <NUMBER>]]}
```

## Description

Sets the spanning tree protocol (STP) mode to either MSTP mode (Multiple-instance Spanning Tree Protocol) or RPVST mode (Rapid Per VLAN Spanning Tree). Enabling the RPVST Auto VLAN feature will run RPVST on all VLANs currently configured on the switch. Default priority of 8 will be assigned to the VLANs being auto created.

The **no** form of this command sets the spanning tree mode to the default **mstp**.

Enabling auto-VLAN can lead to an undeterministic state if auto scaled beyond the max system limit mentioned in the capacity-status.

| Parameter | Description |
|---|---|
| `mstp` | Sets the STP mode to MSTP which applies spanning tree separately for each set of VLANs called an MSTI (multiple spanning tree instance). |
| `rpvst` | Sets the STP mode to RPVST. |
| `auto-vlan-enable` | Selects RPVST auto VLAN mode. |
| `priority <NUMBER>` | Specifies the priorites for all auto created RPVST instances. Configured as a multiple of 4096. Default: 8. |

## Examples

Enabling MSTP mode:

```
switch(config)# spanning-tree mode mstp
```

Disabling MSTP mode:

```
switch(config)# no spanning-tree mode mstp
```

Enabling RPVST mode:

```
switch(config)# spanning-tree mode rpvst
```

Disabling RPVST mode:

```
switch(config)# no spanning-tree mode rpvst
```

Enabling RPVST auto VLAN with a priority of 1:

```
switch(config)# spanning-tree mode rpvst auto-vlan-enable priority 1
```

Disabling RPVST auto VLAN with a priority of 1:

```
switch(config)# no spanning-tree mode rpvst auto-vlan-enable priority 1
```

### Command History

| Release | Modification |
|---|---|
| 10.12.1000 | Auto VLAN enable added. |
| 10.07 or earlier | -- |

### Command Information

| Platforms | Command context | Authority |
|---|---|---|
| All platforms | `config` | Administrators or local user group members with execution rights for this command. |

## spanning-tree port-priority

```
spanning-tree port-priority <PRIORITY-MULTIPLIER>
no spanning-tree port-priority [<PRIORITY-MULTIPLIER>]
```

### Description

Configures the port priority. The priority of a port can be different for each MST instance to which it belongs.

The **no** form of the command sets the port priority for MST instance 0 to the default of 8. The default priority value is derived by multiplying 8 by 8. For LAG interfaces the default is 4.

| Parameter | Description |
|---|---|
| *<PRIORITY-MULTIPLIER>* | Specifies the port priority as a multiplier. Default: 8, except for LAG interfaces where the default is 4. Range: 0 to15.<br>The priority range for a port in a given MSTI is 0 to 255. However, this command specifies the priority as a multiplier (0 to 15) of 16. When you specify a priority multiplier of 0 to15, the actual priority assigned to the switch is: (priority-multiplier) x 16. |

### Examples

Setting the port priority to 8 on interface **1/1/1**:

```
switch(config)# interface 1/1/1
switch(config-if)# spanning-tree port-priority 8
```

Setting the port priority to the default on interface **1/1/1**:

```
switch(config)# interface 1/1/1
switch(config-if)# no spanning-tree port-priority
```

### Command History

| Release | Modification |
|---|---|
| 10.07 or earlier | -- |

### Command Information

| Platforms | Command context | Authority |
|---|---|---|
| All platforms | config-if | Administrators or local user group members with execution rights for this command. |

## spanning-tree port-type

```
spanning-tree port-type {admin-edge|admin-network}
no spanning-tree port-type [admin-edge|admin-network]
```

### Description

Sets the STP port type for the interface.

Port types include: admin-edge and admin-network.

The **no** form of the command sets the port type to the default of admin-network.

| Parameter | Description |
|---|---|
| admin-edge | Specifies the port type as administrative edge. During spanning tree establishment, ports with admin-edge enabled transition immediately to the forwarding state. |
| admin-network | Specifies the port type as administrative network. When this option is selected, the port looks for BPDUs for the first 3 seconds. If there are none, the port is classified as an edge port and immediately starts forwarding packets. If BPDUs are seen on the port, the port is classified as a non-edge port and normal STP operation commences on that port. |

### Examples

Setting the port type to admin-edge on interface **1/1/1**:

```
switch(config)# interface 1/1/1
switch(config-if)# spanning-tree port-type admin-edge
```

Setting the port type to admin-network on interface **1/1/1**:

```
switch(config)# interface 1/1/1
switch(config-if)# spanning-tree port-type admin-network
```

Setting the port type to the default of admin-network on interface 1/1/1:

```
switch(config)# interface 1/1/1
switch(config-if)# no spanning-tree port-type
```

### Command History

| Release | Modification |
|---|---|
| 10.07 or earlier | -- |

### Command Information

| Platforms | Command context | Authority |
|---|---|---|
| All platforms | config-if | Administrators or local user group members with execution rights for this command. |

## spanning-tree priority

```
spanning-tree priority <PRIORITY-MULTIPLIER>
no spanning-tree priority [<PRIORITY-MULTIPLIER>]
```

### Description

Configures the switch (bridge) priority for the designated region in which the switch resides.

The switch compares this priority with the priorities of other switches in the same region to determine the root switch for the region. The lower the priority value, the higher the priority.

The **no** form of this command sets the bridge priority to the default of 8. The default priority value is derived by multiplying 8 by 4096.

| Parameter | Description |
|---|---|
| *<PRIORITY-MULTIPLIER>* | Specifies the priority as a multiplier. Range: 0 to 15. Default: 8. The priority range for an MSTP switch is 0-61440. However, this command specifies the priority as a multiplier (0 to 15) of 4096. That is, when you specify a priority multiplier value of 0 to 15, the actual priority assigned to the switch is: (priority-multiplier) x 4096. For example, with 2 as the priority-multiplier on a given MSTP switch, the switch priority setting is 8,192. |

### Usage

Every switch running an instance of MSTP has a Bridge Identifier, which is a unique identifier that helps distinguish this switch from all others. The switch with the lowest Bridge Identifier is elected as the root for the tree. The Bridge Identifier is composed of a configurable priority component (2 bytes) and the bridge's MAC address (6 bytes). You can change the priority component provides flexibility in determining which switch will be the root for the tree, regardless of its MAC address.

### Examples

Setting the priority multiplier to 12:

```
switch(config)# spanning-tree priority 12
```

Setting the priority multiplier to the default of 8:

```
switch(config)# no spanning-tree priority
```

### Command History

| Release | Modification |
|---|---|
| 10.07 or earlier | -- |

### Command Information

| Platforms | Command context | Authority |
|---|---|---|
| All platforms | config | Administrators or local user group members with execution rights for this command. |

## spanning-tree root-guard

```
spanning-tree root-guard
no spanning-tree root-guard
```

### Description

Enables the root guard on the interface.

When a port is enabled as root-guard, it cannot be selected as the root port even if it receives superior STP BPDUs. The port is assigned an "alternate" port role and enters a blocking state if it receives superior MSTP BPDUs.

A superior BPDU contains both "better" information on the root bridge and path cost to the root bridge, which would normally replace the current root bridge selection.

The **no** form of the command sets the root guard status to the default of disabled on the interface.

### Examples

Enabling the root guard on interface **1/1/1**:

```
switch(config)# interface 1/1/1
switch(config-if)# spanning-tree root-guard
```

Disabling root guard on interface **1/1/1**:

```
switch(config)# interface 1/1/1
switch(config-if)# no spanning-tree root-guard
```

### Command History

| Release | Modification |
|---|---|
| 10.07 or earlier | -- |

### Command Information

| Platforms | Command context | Authority |
|---|---|---|
| All platforms | config-if | Administrators or local user group members with execution rights for this command. |

## spanning-tree rpvst-filter

```
spanning-tree rpvst-filter
no spanning-tree rpvst-filter
```

### Description

Enables the RPVST filter for the interface. This command is only applicable to MSTP mode. It is not applicable to RPVST+ mode.

When the RPVST filter is enabled, the ingressing RPVST proprietary BPDUs are dropped after copying to CPU whereas the standard IEEE RPVST BPDUs are still allowed. This helps in preventing the flooding of RPVST proprietary BPDUs under an MSTP-RPVST interop environment.

If the neighboring switch is running RPVST then this pair of switches will not converge as RPVST BPDUs will not reach them.

If enabling RPVST filter causes a high traffic load, shutdown the port and reconfigure the BPDU filter with the CLI command: **no spanning tree rpvst-filter**.

RPVST filter is disabled by default.

### Example

Enabling the RPVST filter on interface 1/1/1:

```
switch# configure terminal
switch(config)# interface 1/1/1
switch(config-if)# spanning-tree rpvst-filter
```

Disabling RPVST filter on interface 1/1/1:

```
switch# configure terminal
switch(config)# interface 1/1/1
switch(config-if)# no spanning-tree rpvst-filter
```

### Command History

| Release | Modification |
|---|---|
| 10.07 or earlier | -- |

### Command Information

| Platforms | Command context | Authority |
|---|---|---|
| All platforms | config-if | Administrators or local user group members with execution rights for this command. |

# spanning-tree rpvst-guard

```
spanning-tree rpvst-guard
no spanning-tree rpvst-guard
```

### Description

Enables RPVST guard on the switch interface. This command is only applicable to MSTP mode. It is not applicable to RPVST+ mode.

When RPVST guard is enabled on an interface, it will disable that interface if RPVST BPDUs are received on it.

The **no** form of the command sets the RPVST guard status to the default of disabled on the interface.

### Example

Enabling RPVST guard on interface 1/1/1:

```
switch# configure terminal
switch(config)# interface 1/1/1
switch(config-if)# spanning-tree rpvst-guard
```

Disabling RPVST guard on interface 1/1/1:

```
switch# configure terminal
switch(config)# interface 1/1/1
switch(config-if)# no spanning-tree rpvst-guard
```

### Command History

| Release | Modification |
|---|---|
| 10.07 or earlier | -- |

### Command Information

| Platforms | Command context | Authority |
|---|---|---|
| All platforms | config-if | Administrators or local user group members with execution rights for this command. |

# spanning-tree tcn-guard

```
spanning-tree tcn-guard
no spanning-tree tcn-guard
```

### Description

Enables the TCN (Topology Change Notification) guard in the interface. When enabled for a port, the port stops propagating received topology change notifications and topology changes to other ports.

The **no** form of the command sets the TCN guard status to the default of disabled on the interface.

### Examples

Enabling TCN guard on interface **1/1/1**:

```
switch(config)# interface 1/1/1
switch(config-if)# spanning-tree tcn-guard
```

Disabling TCN guard on interface **1/1/1**:

```
switch(config)# interface 1/1/1
switch(config-if)# no spanning-tree tcn-guard
```

### Command History

| Release | Modification |
|---|---|
| 10.07 or earlier | -- |

### Command Information

| Platforms | Command context | Authority |
|---|---|---|
| All platforms | `config-if` | Administrators or local user group members with execution rights for this command. |

## spanning-tree transmit-hold-count

```
spanning-tree transmit-hold-count <COUNT>
no spanning-tree transmit-hold-count [<COUNT>]
```

### Description

Sets the maximum number of BPDUs per second that the switch can send from an interface.

The **no** form of this command sets the transmit-hold-count to the default of 6.

| Parameter | Description |
|---|---|
| *<COUNT>* | Specifies the number of BPDUs that can be sent per second. Range: 1 to 10. Default: 6. |

### Examples

Setting the transmit-hold-count to 5:

```
switch(config)# spanning-tree transmit-hold-count 5
```

Setting the transmit-hold-count to the default of 6:

```
switch(config)# no spanning-tree transmit-hold-count
```

### Command History

| Release | Modification |
|---|---|
| 10.07 or earlier | -- |

### Command Information

| Platforms | Command context | Authority |
|---|---|---|
| All platforms | `config` | Administrators or local user group members with execution rights for this command. |

## spanning-tree trap

```
spanning-tree trap {new-root|topology-change [instance <INSTANCE-ID>] |
       errant-bpdu | root-guard-inconsistency | loop-guard-inconsistency}
no spanning-tree trap {new-root|topology-change [instance <INSTANCE-ID>] |
       errant-bpdu | root-guard-inconsistency | loop-guard-inconsistency}
```

### Description

Enables SNMP traps for new root, topology change event, errant-bpdu received event, root-guard inconsistency, and loop-guard inconsistency notifications. It is disabled by default.

The **no** form of this command disables the notifications for SNMP traps.

| Parameter | Description |
|---|---|
| `new-root` | Enabling SNMP notification when a new root is elected on any MST instance on the switch. |
| `topology-change` | Enabling SNMP notification when a topology change event occurs in the specified MST instance on the switch. |
| *<INSTANCE-ID>* | Specifies the instance ID for the topology change trap. Range: 0 to 64. |
| `errant-bpdu` | Enabling SNMP notification when an errant bpdu is received by any MST instance on the switch. |
| `root-guard-inconsistency` | Enabling SNMP notification when the root-guard finds the port inconsistent for any MST instance on the switch. |
| `loop-guard-inconsistency` | Enabling SNMP notification when the loop-guard finds the port inconsistent for any MST instance on the switch. |

### Examples

Enabling the notifications for the SNMP traps:

```
switch(config)# spanning-tree trap
  new-root                  Enable notifications which are sent when a new root is
elected
  topology-change           Enable notifications which are sent when a topology
change occurs
  errant-bpdu               Enable notifications which are sent when an errant
bpdu is received
  root-guard-inconsistency  Enable notifications which are sent when root guard
```

```
inconsistency occurs
  loop-guard-inconsistency  Enable notifications which are sent when loop guard
inconsistency occurs
switch(config)# spanning-tree trap new-root
  <cr>
switch(config)# spanning-tree trap topology-change
  instance  Enable topology change notification for the specified MST instance id.
switch(config)# spanning-tree trap topology-change instance
  <0-64>  Enable topology change information on the specified instance id.
switch(config)# spanning-tree trap topology-change instance 1
  <cr>
switch(config)# spanning-tree trap errant-bpdu
  <cr>
switch(config)# spanning-tree trap root-guard-inconsistency
  <cr>
switch(config)# spanning-tree trap loop-guard-inconsistency
  <cr>
```

Disabling the notifications for the SNMP traps:

```
switch(config)# no spanning-tree trap
  new-root                  Disable notifications which are sent when a new root
is elected
  topology-change           Disable notifications which are sent when a topology
change occurs
  errant-bpdu               Disable notifications which are sent when an errant
bpdu is received
  root-guard-inconsistency  Disable notifications which are sent when root guard
inconsistency occurs
  loop-guard-inconsistency  Disable notifications which are sent when loop guard
inconsistency occurs
switch(config)# no spanning-tree trap new-root
  <cr>
switch(config)# no spanning-tree trap topology-change
  instance  Disable topology change notification for the specified MST instance
switch(config)# no spanning-tree trap topology-change instance
  <0-64>  Disable topology change information on the specified instance id
switch(config)# no spanning-tree trap topology-change instance 1
  <cr>
switch(config)# no spanning-tree trap errant-bpdu
  <cr>
switch(config)# no spanning-tree trap root-guard-inconsistency
  <cr>
switch(config)# no spanning-tree trap loop-guard-inconsistency
  <cr>
```

## Command History

| Release | Modification |
|---|---|
| 10.07 or earlier | -- |

## Command Information

| Platforms | Command context | Authority |
|---|---|---|
| All platforms | `config` | Administrators or local user group members with execution rights for this command. |

# MSTP debugging and troubleshooting

When there are suspected convergence problems with MSTP with respect to traffic forwarding and convergence time, use the information provided in this section to help solve the problems.

### Check the forwarding path for each instance configured, root elected, and root port for each node.

a. Use command show spanning-tree. Note the green highlights showing the items of interest.

```
show spanning-tree
Spanning tree status    : Enabled Protocol: MSTP

MST0
  Root ID    Priority    : 0
             MAC-Address: 10:10:10:10:10:10
             Hello time(in seconds):2  Max Age(in seconds):20
             Forward Delay(in seconds):15

  Bridge ID  Priority  : 32768
             MAC-Address: 8c:85:c1:5a:67:80
             Hello time(in seconds):2  Max Age(in seconds):20
             Forward Delay(in seconds):15


Port      Role         State      Cost     Priority   Type        BPDU-Tx  BPDU-Rx  TCN-Tx   TCN-
Rx
--------- ------------ ---------- -------- ---------- ----------- -------- -------- -------- -----
---
1/1/12    Designated   Forwarding 20000    128        P2P         9        0        0        0
2/1/1     Designated   Forwarding 20000    128        P2P         9        0        0        0
2/1/12    Designated   Forwarding 20000    128        P2P         9        0        0        0
3/1/11    Designated   Forwarding 200000   128        P2P         9        0        0        0
3/1/12    Root         Forwarding 20000    128        P2P         9        0        0        0
lag1      Root         Forwarding 20000    64         P2P Bound   4        7        2        1

Number of topology changes    : 1
Last topology change occurred : 16 seconds ago
```

### Check whether MSTP is configured with Intra or Intra-region configurations.

a. Modify the configuration as required. To make all nodes use intra-region convergence, confirm that these items are the same.
   a. **MST config ID**
   b. **MST config**
   c. **Instance ID** to **Member VLAN** mapping.

Use command **show spanning-tree mst-config**.

```
show spanning-tree mst-config
MST configuration information
   MST config ID        : reg
   MST config revision  : 1
   MST config digest    : 2D2BC9A32097B463C48EE1817673FA2D
   Number of instances  : 2
```

```
Instance ID     Member VLANs
--------------- ---------------------------------
0               2,4-4094
1               1
2               3
```

### Avoiding VSX-related problems with MSTP

VSX requires that STP configuration be the same on both primary and secondary VSX switches. The STP configurations in the global and mc-lag-interface contexts must be the same across VSX pairs. You can configure identical STP configurations on both the VSX-primary and VSX-secondary or alternatively use the vsx-sync feature to sync all STP related configurations.

Example configuration including the synchronization of MSTP global configuration from VSX-Primary to VSX-secondary using command **`vsx-sync stp-global`**:

```
spanning-tree
spanning-tree mode mstp
spanning-tree vlan 1-100
spanning-tree vlan 1 priority 10
...
vsx
   vsx-sync stp-global
```

Example configuration including the synchronization of mc-lag configuration from VSX-Primary to VSX-secondary using command **`vsx-sync mclag-interfaces`**:

```
interface lag 10 mc-lag
   spanning-tree vlan 150-200 cost 5000
   spanning-tree port-prio 8
   spanning-tree admin-edge
   spanning-tree tcn-guard
...
vsx
    vsx-sync mclag-interfaces
```

# MSTP FAQ

### 1. Are there any specific loop-prevention recommendations for access switches?

If the access switch is prone to receiving excess BPDUs, consider enabling RPVST+ or MSTP.

### 2. What is the default spanning tree protocol (STP) mode?

The default STP mode is MSTP. RPVST+ is also supported. Set the SPT mode with command **`spanning-tree mode`**.

### 3. Can RPVST+ and MSTP switches be interconnected?

Yes. To interconnect typically use the default VLAN 1. This is based on the RFC for interconnection.

### 4. What network-resiliency features are available for physical links?

The Industry-standard feature unidirectional link detection (UDLD on fiber links) is available.

### 5. What is the maximum number of STP hops supported?

The maximum is 40. The default is 20.

### 6. For MST 0 how do I change the priority so I can determine the Root and Secondary Root for the CIST?

Use command **`spanning-tree priority`**. For MST 0, the default priority is 8. To set the priority of other STP instances, use command **`spanning-tree instance priority`**.

### 7. Does MSTP have any per-platform capacity differences?

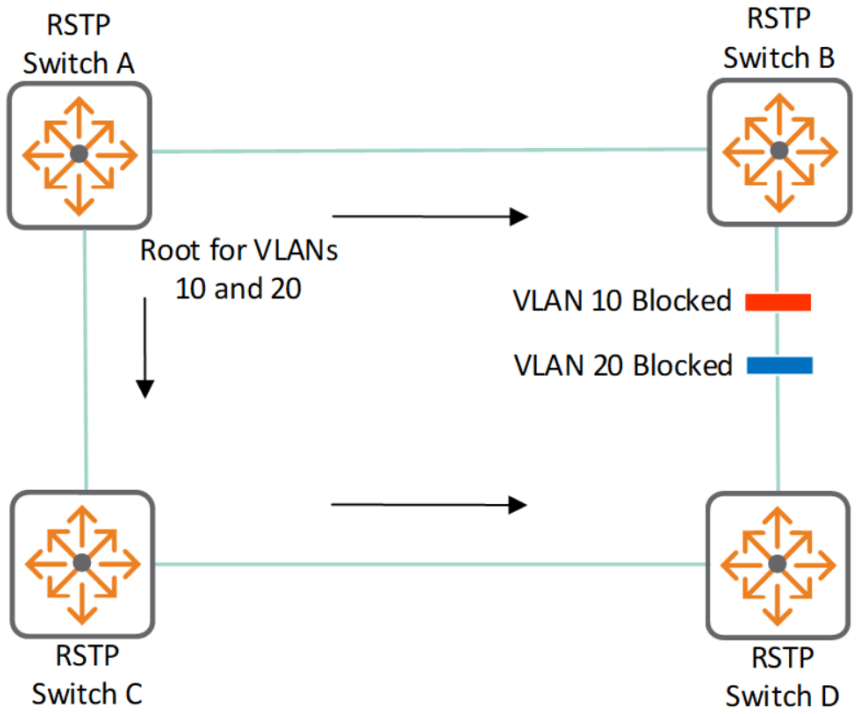
Yes. Refer to the platform-specific number of **MSTP instances** under STP supported platforms and scale.

# RPVST+ protocol and feature details

Rapid Per VLAN Spanning Tree+ (RPVST+) is an updated implementation of STP (Spanning Tree Protocol). It enables the creation of a separate spanning tree for each VLAN on a switch, and ensures that only one active, loop-free path exists between any two nodes on a given VLAN.

Spanning tree protocols are used to prevent loops from occurring when multiple paths exist between the devices on a network. They are also used to provide redundancy, enabling data to use an alternative path when one link to a device fails. For example, in the following topology several paths exist between each switch.

**Figure 1** *RSTP topology with VLANs 10 and 20 blocked*

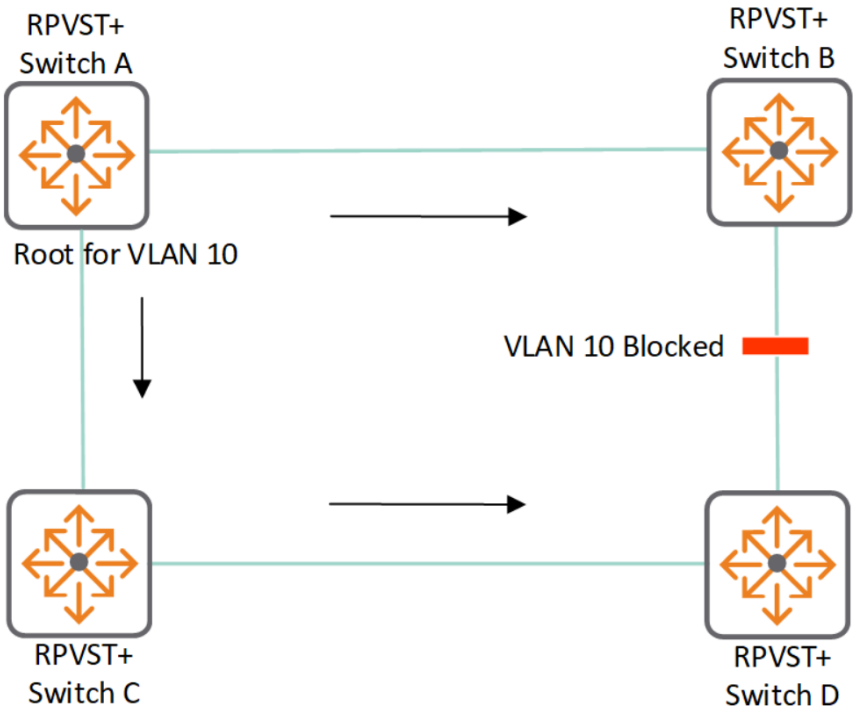



The above topology has four switches running RSTP. Switch “A” is the root switch. To prevent a loop, RSTP blocks the link between switch “B” and switch “D”. There are two VLANs in this network (VLAN 10 and VLAN 20). Since RSTP does not have VLAN intelligence, it forces all VLANs in a layer 2 domain to follow the same spanning tree.

In the following topologies, there will not be any traffic through the link between switch “B” and switch “D” and therefore the link bandwidth is wasted. On the other hand, RPVST+ runs different spanning trees for different VLANs.

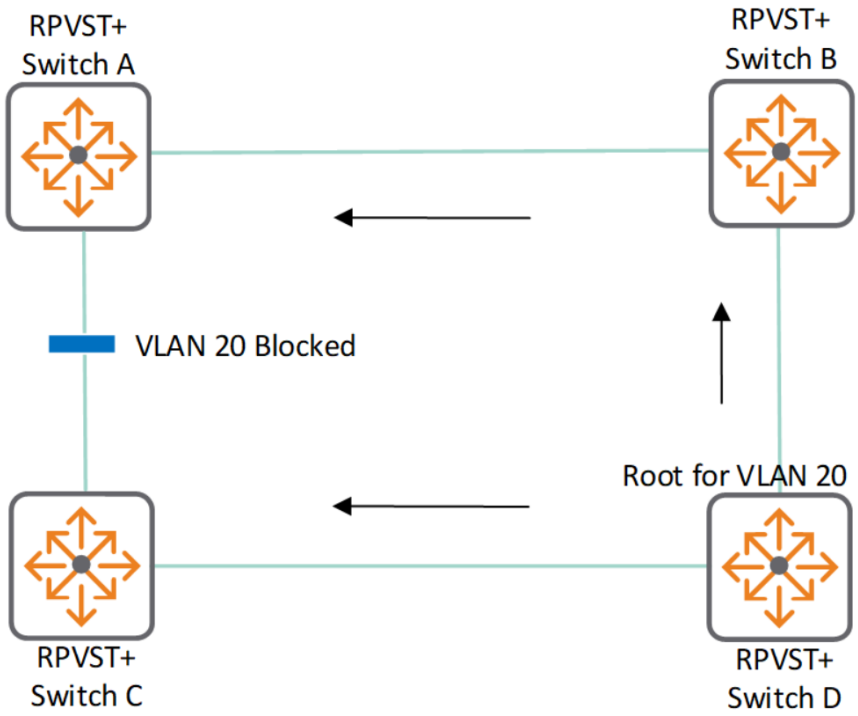
RVPST+ creates a spanning tree for VLAN 10.

**Figure 2** *RPVST+ topology with VLAN 10 blocked*




RVPST+ creates another spanning tree for VLAN 20.

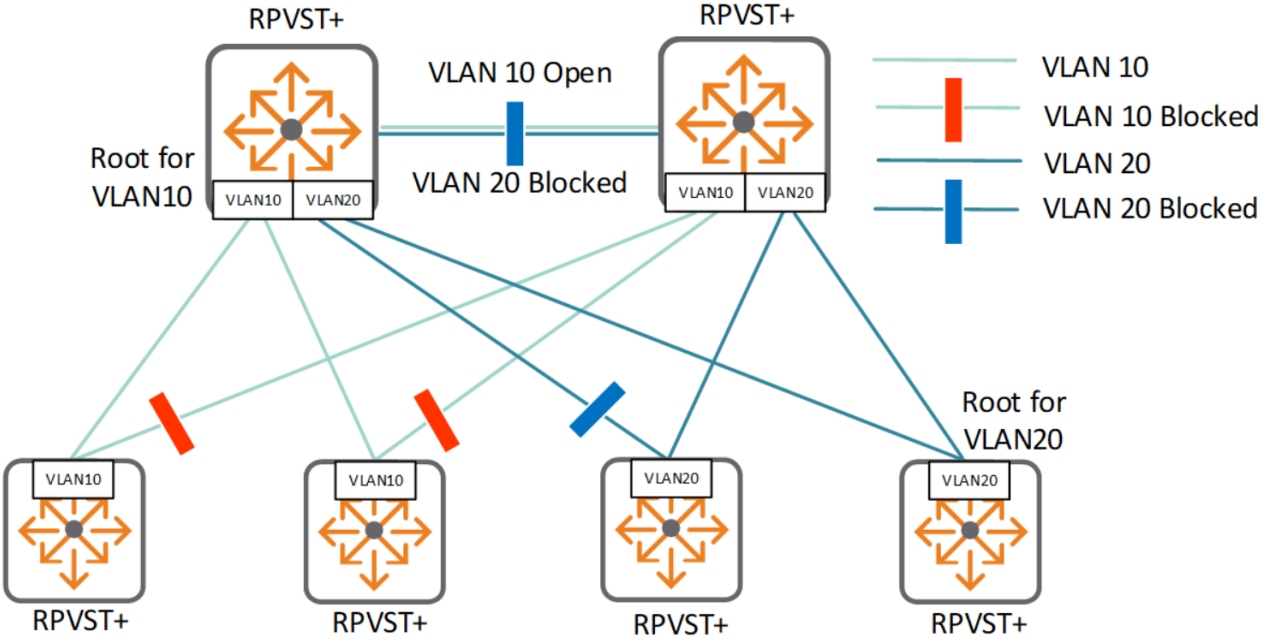
**Figure 3** *RPVST+ topology with VLAN 20 blocked*




The two topologies above are the same as the first topology, but now the switches run RPVST+ and can span different trees for different VLANs. Switch A is the root switch for the VLAN 10 spanning tree and switch D is the root switch for the VLAN 20 spanning tree. The link between switch B and switch D is only blocked for VLAN 10 traffic but VLAN 20 traffic goes through that link. Similarly the link between switch A and switch C is blocked only for VLAN 20 traffic but VLAN 10 traffic goes through that link. Here, traffic passes through all the available links, and network availability and bandwidth utilization increase.

The following topology shows a further example of shared links and redundant path-blocking in a network running RPVST+.

**Figure 4** *RPVST+ topology with shared links and redundant path blocking*




In the factory default configuration, spanning tree operation is enabled on access devices with MSTP operation. For STP, MSTP, and RSTP, configuration with default settings is automatic, and in many cases does not require any adjustments. Configuring spanning tree mode as RPVST+ and then enabling spanning tree, requires that spanning tree VLAN instances be enabled manually for the intended VLANS.

Also, the switch retains its currently configured spanning tree parameter settings when spanning tree is disabled. Thus, if you disable, then later re-enable spanning tree, the parameter settings will be the same as before spanning tree was disabled.

RPVST+ interoperates with devices that run legacy IEEE 802.1D STP and MSTP-IEEE 802.1s.

RPVST+ applies one RSTP tree per-VLAN. Each of these RSTP trees can have a different root switch and span the network through shared or different links.

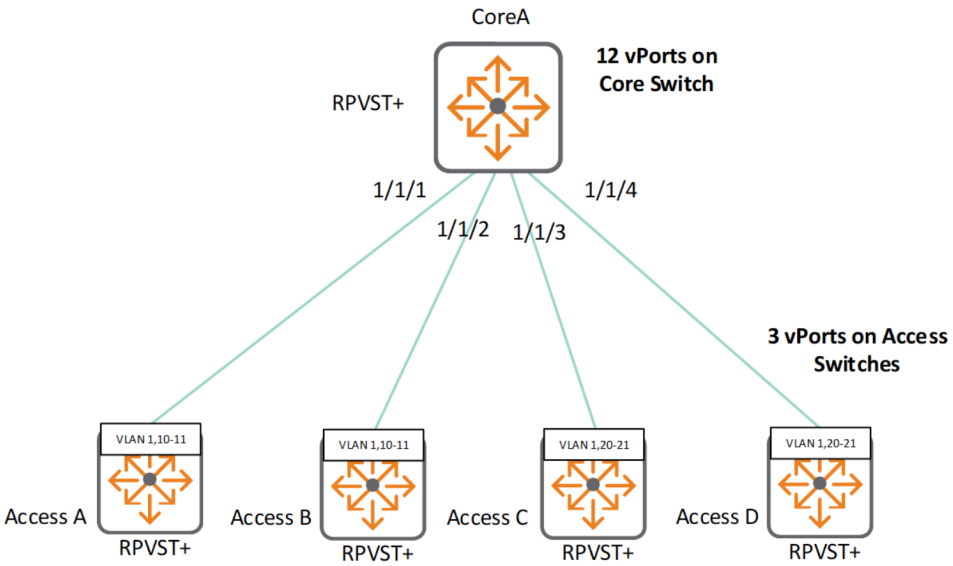
The switch automatically senses port identity and type, and automatically defines spanning tree parameters for each type, and parameters that apply across the switch. Although these parameters can be adjusted, HPE strongly recommends leaving these settings in their default configurations unless the proposed changes have been supplied by an experienced network administrator who has a strong understanding of RPVST+ operation.

## RPVST+ vPorts

When considering vPorts these are defined as active spanning tree VLANs that are declared on an interface. As vPorts increase the load on the CPU and switch resources increase as more BPDUs are processed.

In the following example core switch **CoreA** has four links with three VLANs on each link, for a total of 12 vPorts (4 links x 3 VLANs), allocated on the switch. The four access switches (**Access A** through **Access D**) use three vPorts each.

**Figure 1** *RPVST+ topology with vPorts*




Configuration of switch **CoreA** seen in the above topology:

```
Hostname CoreA
vlan 1,10-11,20-21
spanning-tree mode rpvst
spanning-tree
spanning-tree vlan 1,10,11,20,21
interface 1/1/1
    no shutdown
    no routing
    vlan trunk native 1
    vlan trunk allowed 10-11
interface 1/1/2
    no shutdown
    no routing
    vlan trunk native 1
    vlan trunk allowed 10-11
interface 1/1/3
    no shutdown
    no routing
    vlan trunk native 1
    vlan trunk allowed 20-21
interface 1/1/4
    no shutdown
    no routing
    vlan trunk native 1
    vlan trunk allowed 20-21
```

# RPVST+ configuration tasks

## Procedure

1. Set RPVST+ as the spanning tree mode with the command `spanning-tree mode rpvst`.
2. Enable spanning tree with the command `spanning-tree`.
3. Configure the list of VLANs that are part of the spanning tree with the command `spanning-tree vlan`.
4. Set the priority for each VLAN with the command `spanning-tree vlan port-priority`. If you do not use this, STP will use the default priority,
5. Set the port cost and priority for each VLAN with the commands `spanning-tree vlan cost` and `spanning-tree vlan port-priority`. If you do not do this, STP will internally calculate port cost based on the link speed and set port priority to its default value.
6. For most deployments, the default values for the following settings do not need to be changed. If your deployment requires different settings, change the default values with the indicated commands:

| RPVST+ setting | Default value | Command to change it |
|---|---|---|
| Include VLAN ID in spanning tree packets. | Enabled. | `spanning-tree extend-system-id` |
| Block links when VLAN mismatch is detected. | Disabled. | `spanning-tree ignore-pvid-inconsistency` |
| STP link type. | Point-to-point. | `spanning-tree link-type` |
| Support extended range of paths costs for high-speed links. | Enabled. | `spanning-tree pathcost-type` |
| Propagate topology changes to other ports. | Disabled. | `spanning-tree tcn-guard` |

7. Review RPVST+ configuration settings with the command `show spanning tree`.

## Example

This example creates the following configuration:

- Sets the spanning tree mode to **rpvst**.
- Enables spanning tree.
- Defines spanning tree support for VLANs **2-5**.
- Sets the priority for each VLAN.

```
switch# config
switch(config)# spanning-tree mode rpvst
switch(config)# spanning-tree
switch(config)# spanning-tree vlan 2-5
switch(config)# spanning-tree vlan 2 priority 5
switch(config)# spanning-tree vlan 3 priority 4
```

```
switch(config)# spanning-tree vlan 4 priority 3
switch(config)# spanning-tree vlan 5 priority 2
switch(config)# exit
switch# show spanning-tree

Spanning tree status           : Enabled Protocol: RPVST
Extended System-id             : Enabled
Ignore PVID Inconsistency      : Disabled
Path cost method               : Long
RPVST-MSTP Interconnect VLAN   : 1
RPVST-Configured VLAN          : all
RPVST-Enabled VLAN             : 1
Current Virtual Ports Count    : 28
Maximum Allowed Virtual Ports  : 2048

VLAN1
  Root ID    Priority   : 32768
             MAC-Address: 38:21:c7:5c:df:c0
             Hello time(in seconds):2  Max Age(in seconds):20
             Forward Delay(in seconds):15

VLAN2
  Root ID    Priority   : 20480
             MAC-Address: 70:72:cf:38:21:e5
             This bridge is the root
             Hello time(in seconds):2  Max Age(in seconds):20
             Forward Delay(in seconds):15

  Bridge ID  Priority  : 20480
             MAC-Address: 70:72:cf:38:21:e5
             Hello time(in seconds):2  Max Age(in seconds):20
             Forward Delay(in seconds):15

Port         Role           State        Cost    Priority   Type
------------ -------------- ------------ ------- ---------- ----------
1/1/1        Designated     Forwarding   20000   128        point_to_point

VLAN3
  Root ID    Priority   : 16384
             MAC-Address: 70:72:cf:38:21:e5
             This bridge is the root
             Hello time(in seconds):2  Max Age(in seconds):20
             Forward Delay(in seconds):15

  Bridge ID  Priority  : 16384
             MAC-Address: 70:72:cf:38:21:e5
             Hello time(in seconds):2  Max Age(in seconds):20
             Forward Delay(in seconds):15

Port         Role           State        Cost    Priority   Type
------------ -------------- ------------ ------- ---------- ----------
1/1/1        Designated     Forwarding   20000   128        point_to_point

VLAN4
  Root ID    Priority   : 12288
             MAC-Address: 70:72:cf:38:21:e5
             This bridge is the root
             Hello time(in seconds):2  Max Age(in seconds):20
             Forward Delay(in seconds):15

  Bridge ID  Priority  : 12288
             MAC-Address: 70:72:cf:38:21:e5
```

```
              Hello time(in seconds):2  Max Age(in seconds):20
              Forward Delay(in seconds):15

Port          Role           State        Cost    Priority   Type
------------ -------------- ------------ ------- ---------- ----------
1/1/1         Designated     Forwarding   20000   128        point_to_point

VLAN5
  Root ID     Priority   : 8192
              MAC-Address: 70:72:cf:38:21:e5
              This bridge is the root
              Hello time(in seconds):2  Max Age(in seconds):20
              Forward Delay(in seconds):15

  Bridge ID   Priority  : 8192
              MAC-Address: 70:72:cf:38:21:e5
              Hello time(in seconds):2  Max Age(in seconds):20
              Forward Delay(in seconds):15

Port          Role           State        Cost    Priority   Type
------------ -------------- ------------ ------- ---------- ----------
1/1/1         Designated     Forwarding   20000   128        point_to_point
```

## Viewing RPVST+ information

### Prerequisites

These commands are in the manager context, as indicated by the `switch#` prompt.

### Procedure

To view various aspects of RPVST+ information, use the following commands.

- To view information on spanning-tree mode and the RPVST+ instances, use:
  `show spanning-tree`
- To view information on spanning-tree mode and the RPVST+ instance of a specific VLAN, use:
  `show spanning-tree vlan`
- To view a summary of the spanning-tree configurations related to a port, use:
  `show spanning-tree summary port`
- To view a summary of the spanning-tree configurations, use:
  `show spanning-tree summary root`

# RPVST+ Considerations and best practices

- For the best RPVST+ experience, use at least AOS-CX 10.07.
- A trunk port which is not a member of an interconnect VLAN (default 1) will not support a CPU RX (receive) rule for IEEE BPDUs. In such deployments, if the switch receives any IEEE BPDUs on these ports, the IEEE BPDUs are hardware forwarded and multicast like regular data traffic, which may cause STP convergence issues with other switches in the network. *Therefore, best practices is to configure an ACL rule to drop IEEE BPDUs on these ports*.
- Access ports or trunk ports with only a native VLAN 1 use IEEE BPDUs as a part of the STP process to prevent loops. In such deployments, if the switch receives an RPVST BPDU on these ports, these BPDUs will get hardware forwarded and multicasted like regular data traffic, as a result of

unavailable CPU RX rules, which may cause STP convergence issues within other switches in network. *Therefore, the best practice is to configure an ACL rule to drop RPVST BPDUs on these ports.*

- As the number of VLANs increase in an RPVST+ environment the consumption of switch resources increases and you should therefore consider reducing VLAN sprawl. If VLAN increases are required and can be mapped sensibly, consider using MST
- Do not exceed the available number of VLANs or vPorts supported on your switch
- Check the number of RPVST+ VLANs and vPorts currently in use and the maximum number available using command **`show capacities-status rpvst`** like this:

```
switch# show capacities-status rpvst

System Capacities Status: Filter rpvst
Capacities Status Name                                                    Value Maximum
------------------------------------------------------------------------------------
Number of RPVST VLANs currently configured                                    3    254
Number of RPVST Vports currently configured                                   9   2048
```

- Only select the VLANs required on a specific link for the allowed list based on the requirement on each port. For example for a link using VLANs 10,11,12 and 15 use command **`vlan trunk 10-12,15`**.
- To whatever degree possible, avoid using the catch all command **`vlan trunk allowed all`**.
- Topology Change Notifications (TCN) are an important part of STP. However, reducing unwanted TCNs is important for things such as access ports which can go up and down with end-point attachment and detachment at the network edge. It is recommended to use command **`spanning-tree port-type admin-edge`** to remove unwanted TCNs from end points.
- The use of spanning tree Topology Change Notification (TCN) guard may also be used in certain circumstances using command **`spanning-tree tcn-guard`**.
  - If the access switch is rebooting or the link between access and core switches is flapping, then this will cause TCNs towards the network core. Any TC on any interface on the core will clear all MACs locally and propagate the TC on all other interfaces. This can cause a significant traffic disruption on the network. If the network has a loop-free topology and mac-flush is not really needed on all switches in the network, then it can be feasible to add tcn-guard on access switches facing L2 interfaces. This will avoid mac-flush and TC propagation on the core switch (STP root switch).
  - If a core or aggregation switch in the network keeps getting TC messages due to unpredictable behavior of an access switch, TCN guard can be applied (using command `spanning-tree tcn-guard`) to the core or aggregation switch on the Layer 2 link facing the access switch.
- Stability in a spanning tree environment is paramount. It is recommended that default timers be used, and any alteration of timers be carried out only under special circumstances and in consultation with experts.
- Avoid automatic placement of root bridges. To enable a deterministic, predictable, and stable network, the placement of Primary and Secondary root bridges should be considered using command **`spanning-tree vlan <VALUE> priority <VALUE>`**.
- To further provide stability and deterministic behavior additional security configuration should be considered, such as:
  - **root-guard**: Sets a port to ignore superior BPDUs to prevent it from becoming the root port. This is typically carried out between the core that is required to be the root and access switches to prevent ports that are not expected to originate root information such as server ports and access switch ports.

- **rpvst-guard**: Disables the specific port if the port receives RPVST+ BPDUs. This will be on well-defined ports that are known from your network design on which you never expect RPVST+ BPDUs. For example, user access ports or ports connected to servers in the datacenter where other switches may exist, and technicians can inadvertently patch into.
- **bpdu-guard**: Disables the specific port if the port receives STP BPDUs. This is done to prevent any inadvertent spanning tree or malicious attack, or switches being connected to the network and causing STP processing. This will be on well-defined ports that are known from your network design on which you never expect BPDUs. For example, user access ports or ports connected to servers in the datacenter where other switches may exist, and technicians can inadvertently patch into.

- With VSX configuration it is advisable that either the VSX pair acts as a STP root switch or that the STP root switch is reachable only through mc-lags. An STP root switch connected to a VSX pair with standalone interfaces (non-mc-lags) is not recommended.
- For RPVST auto VLAN, only priority configuration is supported. Other configurations such as forward-delay, hello-time, max-age, cost, port-priority, and topology-change trap are not configurable. These will have default values while running in an RPVST auto VLAN spanning tree instance.

# RPVST+ use cases

## RPVST+ use case: Deterministic root bridges

As mentioned in *RPVST+ Considerations and best practices*, the placement of root bridges is important in the Layer 2 network domain. Having deterministic Root and Secondary Root bridges is a typically-accepted design that allows you to provide predictability and protection in your network .

The Root and Secondary root are typically placed at the Core of the Layer 2 domain. Figure 1, Deterministic root bridges (physical) shows the physical topology and Figure 2, Deterministic root bridges (logical) shows the logical topology. Switch A and Switch B are the core/center of the Layer 2 domain, and they provide root redundancy for each other.

**Figure 1** *Deterministic root bridges (physical)*

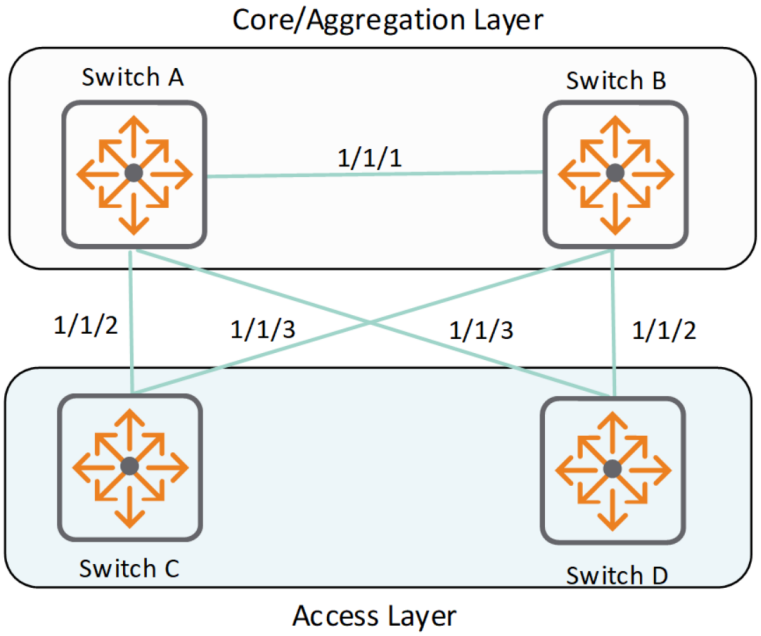
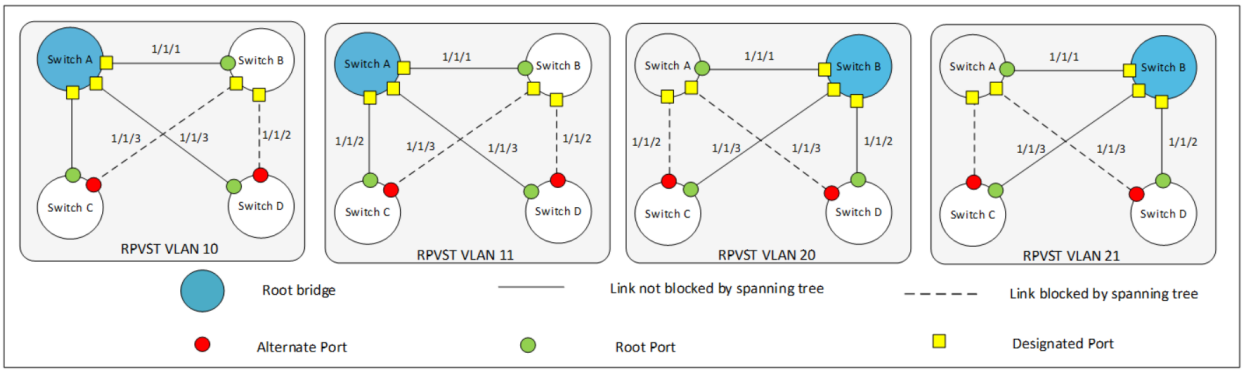


**Figure 2** *Deterministic root bridges (logical)*




In this example network there are four VLANs and each VLAN has its own independent topology. The root bridges and VLANs are as follows:

- VLAN 10 Root bridge Switch A, Secondary Root bridge Switch B
- VLAN 11 Root bridge Switch A, Secondary Root bridge Switch B
- VLAN 20 Root bridge Switch B, Secondary Root bridge Switch A
- VLAN 21 Root bridge Switch B, Secondary Root bridge Switch A

Switches A through D are configured as follows:

In the following switch configuration command sequences, configuration portions (typically default) unrelated to RPVST+ are represented by an ellipsis" . . . ". Also, descriptive comments, preceded by "<---", are included to the right of some commands.

## Switch A configuration

- Add VLANs 10,11,20,21.
- Configure RPVST+ making Switch A the root for VLANs 10 and 11 and the secondary root for VLANs 20, 21.
- Allow the required VLANs for interfaces 1/1/1 to 1/1/3.

```
SwitchA#
...
vlan 10-11,20-21
spanning-tree mode rpvst          <-- Enable RPVST+
spanning-tree
spanning-tree vlan 10-11,20-21    <-- Define VLANs for RPVST+
spanning-tree vlan 10 priority 1  <-- Make Switch A Root Bridge for VLANs
spanning-tree vlan 11 priority 1
spanning-tree vlan 20 priority 2  <-- Make Switch A Secondary Root Bridge for
VLANs
spanning-tree vlan 21 priority 2
...
interface  1/1/1                  <-- Allocate required VLANs to interface
vlan trunk 10-11,20-21
vlan trunk native 1
interface  1/1/2
vlan trunk 10-11,20-21
vlan trunk native 1
```

```
interface  1/1/3
vlan trunk 10-11,20-21
vlan trunk native 1
...
```

### Switch B configuration

- Add VLANs 10,11,20,21.
- Configure RPVST+ making Switch B the root for VLANs 20, 21, and the secondary root for VLANs 10, 11.
- Configure the trunk-required VLANs for interfaces 1/1/1 to 1/1/3.

```
SwitchB#
...
vlan 10-11,20-21
spanning-tree mode rpvst
spanning-tree
spanning-tree vlan 10-11,20-21
spanning-tree vlan 10 priority 2
spanning-tree vlan 11 priority 2
spanning-tree vlan 20 priority 1
spanning-tree vlan 21 priority 1
...
interface  1/1/1
vlan trunk 10-11,20-21
vlan trunk native 1
interface  1/1/2
vlan trunk 10-11,20-21
vlan trunk native 1
interface  1/1/3
vlan trunk 10-11,20-21
vlan trunk native 1
...
```

### Switch C and D configuration

- Define the VLANS for RPVST+ and the trunk-required VLANS using the same configuration on both C and D except for the hostname.

```
vlan 10-11,20-21
exit
spanning-tree mode rpvst
spanning-tree
spanning-tree vlan 10-11,20-21
int 1/1/2-1/1/3
vlan trunk 10-11,20-21
vlan trunk native 1
exit
...
vlan 10-11,20-21
spanning-tree mode rpvst
spanning-tree
spanning-tree vlan 10-11,20-21
...
interface  1/1/2
vlan trunk 10-11,20-21
vlan trunk native 1
```

```
interface  1/1/3
vlan trunk 10-11,20-21
vlan trunk native 1
...
```

## Checking the configuration

The applied configurations can be checked as follows:

- Checking RPVST+
- Checking that the System ID matches Root for the VLAN.

### Checking Switch A

Use command `show spanning-tree summary root`. As seen here, Switch A is Root for VLAN 10 and 11, identified by the System ID, and VLAN 20 and 21 Root is another device which is expected to be Switch B based on previous configurations.

Notice the zero Root Port cost indicated in the first two rows of output.

```
SwitchA#show spanning-tree summary root
STP status             : Enabled
Protocol               : RPVST
System ID              : 08:00:09:8a:14:fa     <-- System ID
Root bridge for VLANs : 10,11     <-- Identify root bridges for VLANs
                                          Root Hello Max Fwd
VLAN     Priority Root ID                 cost  Time Age Dly    Root Port
-------- -------- ----------------- --------- ----- --- --- ------------
VLAN10       4096 08:00:09:8a:14:fa         0     2  20  15             0
VLAN11       4096 08:00:09:8a:14:fa         0     2  20  15             0
VLAN20       4096 08:00:09:12:8e:9e     20000     2  20  15         1/1/1
VLAN21       4096 08:00:09:12:8e:9e     20000     2  20  15         1/1/1
```

### Checking Switch B

As seen here, Switch B is Root for VLAN 20 and 21 identified by the System ID, and VLAN 10 and 11 Root is Switch A identified by the System ID.

```
SwitchA#show spanning-tree summary root
STP status             : Enabled
Protocol               : RPVST
System ID              : 08:00:09:12:8e:9e

Root bridge for VLANs : 20,21

                                          Root Hello Max Fwd
VLAN     Priority Root ID                 cost  Time Age Dly    Root Port
-------- -------- ----------------- --------- ----- --- --- ------------
VLAN10       4096 08:00:09:8a:14:fa     20000     2  20  15         1/1/1
VLAN11       4096 08:00:09:8a:14:fa     20000     2  20  15         1/1/1
VLAN20       4096 08:00:09:12:8e:9e         0     2  20  15             0
VLAN21       4096 08:00:09:12:8e:9e         0     2  20  15             0
```

### Checking Switches C and D

Although not illustrated, Switches C and D can be checked in a similar manner to the other switches.

## Observe port behavior and state

We can observe the port behavior and state using command `show spanning-tree`. The topology in Figure 2, Deterministic root bridges (logical) for each switch can be observed showing a loop free Layer 2 topology. The following command sequences focus on VLAN 10.

### Observing Switch A for VLAN 10

Use command `show spanning-tree`. As seen here, all ports shown on Switch A, the Root Bridge for VLAN 10, are **Designated Forwarding** as expected.

```
SwitchA# show spanning-tree vlan 10

VLAN10
Spanning tree status : Enabled Protocol: RPVST
  Root ID    Priority   : 4096
             MAC-Address: 08:00:09:8a:14:fa
             This bridge is the root
             Hello time(in seconds):2  Max Age(in seconds):20
             Forward Delay(in seconds):15

  Bridge ID  Priority  : 4096
             MAC-Address: 08:00:09:8a:14:fa
             Hello time(in seconds):2  Max Age(in seconds):20
             Forward Delay(in seconds):15

Port         Role           State      Cost           Priority   Type       BPDU-Tx    BPDU-Rx    TCN-Tx     TCN-Rx
------------ -------------- ---------- -------------- ---------- ---------- ---------- ---------- ---------- ---------
1/1/1        Designated     Forwarding 20000          128        P2P        2586       533        10         8
1/1/2        Designated     Forwarding 20000          128        P2P        2679       434        5          7
1/1/3        Designated     Forwarding 20000          128        P2P        3106       5          6          2

Number of topology changes    : 6
Last topology change occurred : 4828 seconds ago
```

### Observing Switch B for VLAN 10

As seen here, the Root Bridge for VLAN 10 is identified by its MAC address “08:00:09:8a:14:fa” which is Switch A. The port connecting to Switch A 1/1/1 is the Root port and **Forwarding** and the other two ports are **Designated Forwarding** leading to Switch C and D respectively. All ports follow the VLAN 10 topology (as seen in *Use case: Deterministic root bridges example network*) as expected.

```
SwitchB# show spanning-tree vlan 10

VLAN10
Spanning tree status : Enabled Protocol: RPVST
  Root ID    Priority   : 4096
             MAC-Address: 08:00:09:8a:14:fa
             Hello time(in seconds):2  Max Age(in seconds):20
             Forward Delay(in seconds):15

  Bridge ID  Priority  : 8192
             MAC-Address: 08:00:09:12:8e:9e
             Hello time(in seconds):2  Max Age(in seconds):20
             Forward Delay(in seconds):15

Port         Role           State      Cost           Priority   Type       BPDU-Tx    BPDU-Rx    TCN-Tx     TCN-Rx
------------ -------------- ---------- -------------- ---------- ---------- ---------- ---------- ---------- ---------
1/1/1        Root           Forwarding 20000          128        P2P        537        2770       8          9
1/1/2        Designated     Forwarding 20000          128        P2P        3298       7          6          2
1/1/3        Designated     Forwarding 20000          128        P2P        3298       9          9          3
```

```
Number of topology changes    : 3
Last topology change occurred : 5247 seconds ago
```

### Observing Switch C for VLAN 10

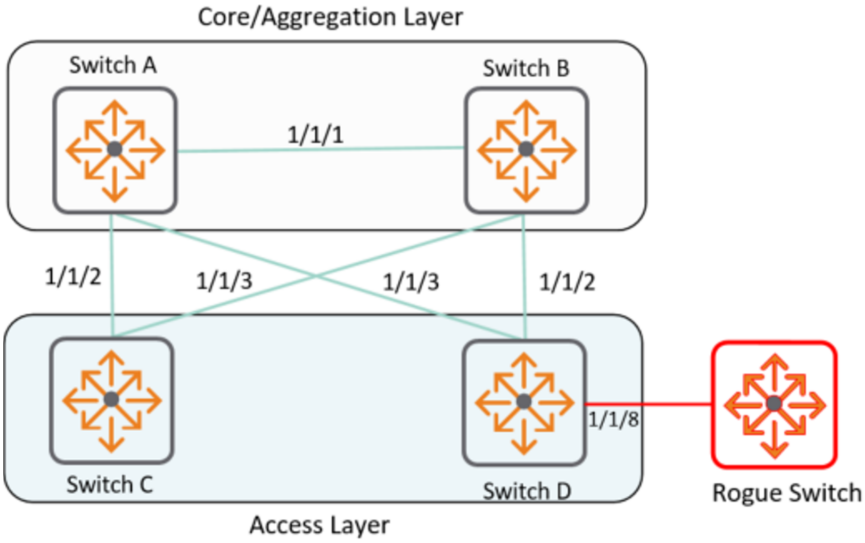
As seen here, the Root Bridge for VLAN 10 is identified by its MAC address “08:00:09:8a:14:fa” which is Switch A. The port connecting to Switch A 1/1/2 is the Root port and **Forwarding**, and the other port 1/1/3 towards Switch B is **Alternate Blocking** preventing a looped topology for VLAN 10. Although not illustrated, Switch D can be observed in a similar manner.

```
SwitchC# show spanning-tree vlan 10

VLAN10
Spanning tree status : Enabled Protocol: RPVST
  Root ID     Priority   : 4096
              MAC-Address: 08:00:09:8a:14:fa
              Hello time(in seconds):2  Max Age(in seconds):20
              Forward Delay(in seconds):15

  Bridge ID   Priority   : 32768
              MAC-Address: 08:00:09:16:7b:7e
              Hello time(in seconds):2  Max Age(in seconds):20
              Forward Delay(in seconds):15

Port         Role           State      Cost           Priority   Type       BPDU-Tx    BPDU-Rx    TCN-Tx     TCN-Rx
------------ -------------- ---------- -------------- ---------- ---------- ---------- ---------- ---------- ---------
1/1/2        Root           Forwarding 20000          128        P2P        438        3553       7          4
1/1/3        Alternate      Blocking   20000          128        P2P        9          3986       3          8

Number of topology changes    : 5
Last topology change occurred : 6811 seconds ago
```

## RPVST+ use case: BPDU protection

Various security mechanisms are in place to protect spanning true configurations from interference and rogue devices or unwarranted changes to the network. BPDU protection secures the active topology by preventing spoofed BPDU packets from entering the network. Typically, BPDU protection is applied on edge ports connected to end user devices that do not run STP. If STP BPDU packets are received on a protected port, BPDU guard disables the port and an alert is sent. As shown in Figure 1, Rogue device needing BPDU guard we have a rouge device attempting to connect to Switch D port 1/1/8.

**Figure 1** *Rogue device needing BPDU guard*




BPDU guard is configured on switch D.

```
SwitchD#
config
interface 1/1/8
    no shutdown
    no routing
    vlan access 10
    spanning-tree bpdu-guard
exit
```

Use command `show spanning-tree summary vlan 10` to observe that port 1/1/8 is disabled because BPDU was received on it from the rogue switch.

Notice how port 1/1/8 is disabled due to "Bpdu-Error." A timeout can be configured to re-enable the port.

```
SwitchD# show spanning-tree vlan 10

VLAN10
Spanning tree status : Enabled Protocol: RPVST
  Root ID    Priority   : 4096
             MAC-Address: 08:00:09:8a:14:fa
             Hello time(in seconds):2  Max Age(in seconds):20
             Forward Delay(in seconds):15

  Bridge ID  Priority  : 32768
             MAC-Address: 08:00:09:ee:11:82
             Hello time(in seconds):2  Max Age(in seconds):20
             Forward Delay(in seconds):15

Port         Role           State      Cost          Priority   Type       BPDU-Tx    BPDU-Rx    TCN-Tx     TCN-Rx
------------ -------------- ---------- ------------- ---------- ---------- ---------- ---------- ---------- ---------
1/1/2        Root           Forwarding 20000         128        P2P        580        1237       400        395
1/1/3        Alternate      Blocking   40001         128        P2P        214        1057       212        303
1/1/8        Disabled       Bpdu-Error 20000         128        P2P        81         0          0          0

Number of topology changes    : 307
Last topology change occurred : 2 seconds ago
```

Use command `show int 1/1/8` to observe the interface state. Notice that port 1/1/8 is down as expected due to BPDU error.

```
SwitchD#show int 1/1/8
Interface 1/1/8 is down
 Admin state is up
 State information:
 Link state: down
 Link transitions: 0
 Description:
 Hardware: Ethernet, MAC Address: 08:00:09:ee:11:c4
 MTU 1500
 Type --
 Full-duplex
 qos trust none
 Speed 1000 Mb/s
 Auto-negotiation is off
 Flow-control: off
 Error-control: off
 MDI mode: none
 VLAN Mode: access
```

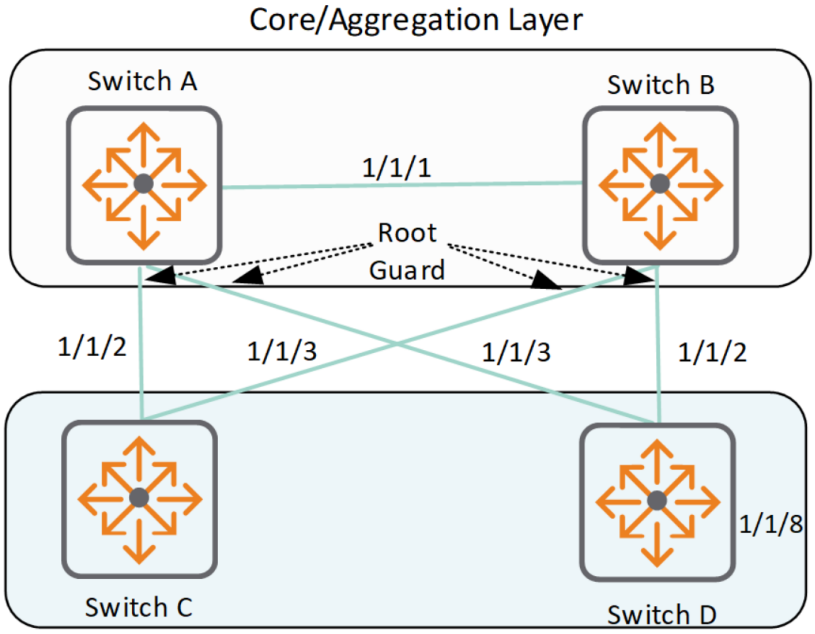
```
Access VLAN: 10
```

## RPVST+ use case: Root protection

Root protection secures the active topology by preventing other switches from declaring their ability to propagate superior BPDUs, containing both better information on the root bridge and path cost to the root bridge which would normally replace the current root bridge selection.

As illustrated in Figure 1, Root protection, by adding root guard on interfaces 1/1/2 and 1/1/3 of both core switches (A and B), these two switches are protected in the core and prevent propagation of superior BPDUs from the access layer.

**Figure 1** *Root protection*




Configuring Switches A and B:

```
SwitchA#
config
interface 1/1/2
   spanning-tree root-guard
exit
interface 1/1/3
   spanning-tree root-guard
exit


SwitchB#
Config
interface 1/1/2
   spanning-tree root-guard
interface 1/1/3
   spanning-tree root-guard
exit
```

To observe the protection behavior, we can (inappropriately) make switch C the root for VLAN 10.

```
SwitchC#
config
```

```
spanning-tree vlan 10 priority 0   <-- Make Switch C Root for VLAN 10
exit
```

Notice how as protection occurs, VLAN 10 on both Switch A and B ports show as **`Alternate Root-Inc`** (Alternate Root-Inconsistent). This action maintains Layer 2 stability by protecting the rest of the network from the (inaccurate) information that Switch C is sending "better" BPDUs.

```
SwitchA# show spanning-tree vlan 10

VLAN10
Spanning tree status : Enabled Protocol: RPVST
  Root ID    Priority   : 4096
             MAC-Address: 08:00:09:8a:14:fa
             This bridge is the root
             Hello time(in seconds):2  Max Age(in seconds):20
             Forward Delay(in seconds):15

  Bridge ID  Priority  : 4096
             MAC-Address: 08:00:09:8a:14:fa
             Hello time(in seconds):2  Max Age(in seconds):20
             Forward Delay(in seconds):15

Port         Role           State      Cost           Priority   Type       BPDU-Tx    BPDU-Rx    TCN-Tx     TCN-Rx
------------ -------------- ---------- -------------- ---------- ---------- ---------- ---------- ---------- ---------
1/1/1        Designated     Forwarding 20000          128        P2P        1606       383        432        159
1/1/2        Alternate      Root-Inc   20000          128        P2P        1571       114        520        92
1/1/3        Designated     Forwarding 20000          128        P2P        1567       172        447        167

Number of topology changes    : 694
Last topology change occurred : 1 seconds ago
```

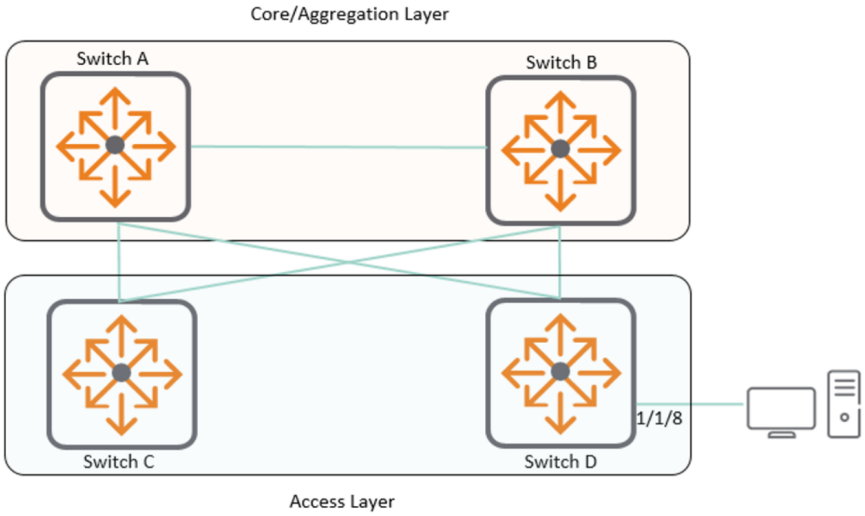
```
SwitchB# show spanning-tree vlan 10

VLAN10
Spanning tree status : Enabled Protocol: RPVST
  Root ID    Priority   : 4096
             MAC-Address: 08:00:09:8a:14:fa
             Hello time(in seconds):2  Max Age(in seconds):20
             Forward Delay(in seconds):15

  Bridge ID  Priority  : 8192
             MAC-Address: 08:00:09:12:8e:9e
             Hello time(in seconds):2  Max Age(in seconds):20
             Forward Delay(in seconds):15

Port         Role           State      Cost           Priority   Type       BPDU-Tx    BPDU-Rx    TCN-Tx     TCN-Rx
------------ -------------- ---------- -------------- ---------- ---------- ---------- ---------- ---------- ---------
1/1/1        Designated     Learning   20000          128        P2P        1127       551        608        125
1/1/2        Root           Forwarding 20000          128        P2P        1865       354        569        187
1/1/3        Alternate      Root-Inc   20000          128        P2P        1717       479        627        88

Number of topology changes    : 763
Last topology change occurred : 2 seconds ago
```

Depending on when the `show` command is executed, it may first show the protected port as **`Designated Blocking`** before it shows it as **`Alternate Root-Inc`**.

## RPVST+ use case: Spanning tree on edge ports

When using spanning tree and taking into consideration the edge of the network ports that provide connectivity to end points, the network should not typically participate in spanning tree. Consider this topology that shows an endpoint connected to port 1/1/8 on Switch D:

**Figure 1** *Spanning tree on edge ports*




End points that connect to ports that do participate in spanning tree (STP) may experience DHCP assignment timeouts or IP address assignment delays plus extended client onboarding time and authentication issues. These problems occur because the port participates in the full STP process. To avoid such issues consider setting the port as a spanning tree administrative edge port by using command **`spanning-tree port-type admin-edge`**. This command removes the port participation from STP interactions when onboarding devices, enabling quicker onboarding.

Edge ports still need to be protected from possible spanning tree attacks. For example BPDU guard can be used. See RPVST+ use case: BPDU protection.

Before configuring a port as spanning tree administrative edge, the port configuration looks like this:

```
interface 1/1/8
    no shutdown
    vlan access 10
    spanning-tree bpdu-guard
```

The port State is **`Forwarding`** and the Type is **`P2P`** (Point to Point) by default.

```
switch# show spanning-tree vlan 10


Port         Role          State      Cost          Priority   Type       BPDU-Tx    BPDU-Rx    TCN-Tx     TCN-Rx
------------ ------------- ---------- ------------- ---------- ---------- ---------- ---------- ---------- --------
1/1/8        Designated    Forwarding 2000000       128        P2P        167        0          0          0
```

Configure the port as admin edge as follows with command **`spanning-tree port-type admin-edge`**:

```
interface 1/1/8
    no shutdown
    vlan access 10
    spanning-tree bpdu-guard
    spanning-tree port-type admin-edge
    exit
```

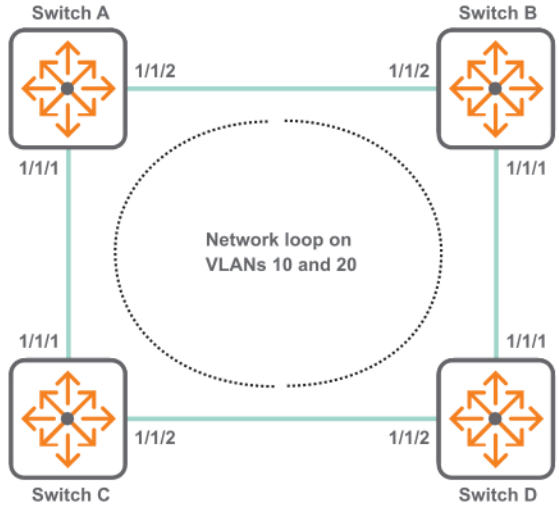
Notice how that the port State is now **`Forwarding`** and the Type is **`P2P Edge`** meaning that the port will go into the forwarding state and bypass the standard STP listening and learning states.

```
switch# show spanning-tree vlan 10show spanning-tree vlan 10

Port         Role           State      Cost           Priority   Type       BPDU-Tx    BPDU-Rx    TCN-Tx     TCN-Rx
------------ -------------- ---------- -------------- ---------- ---------- ---------- ---------- ---------- --------
1/1/8        Designated     Forwarding 2000000        128        P2P  Edge  347        0          0          0

Number of topology changes    : 0
Last topology change occurred : 0 seconds ago
```

## RPVST+ use case: Preventing loops

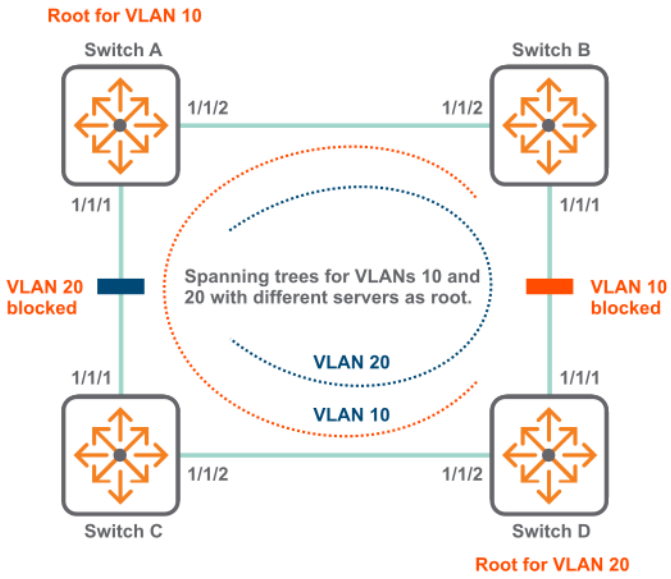
In this scenario, four switches are interconnected. VLANs 10 and 20 are defined on all switches, causing a network loop.

**Figure 1** *Topology with an undesired loop*




To eliminate the loop, RPVST+ is enabled and switch A and B are defined as high-priority for VLAN 10 and 20 respectively. RPVST+ then eliminates the loop by assigning switch A as the root for VLAN 10 and switch B designated as the root for VLAN 20, and blocking access on one of the links.

**Figure 2** *Topology with loop eliminated by RPVST+*




## Procedure

1. Configure switch A.
   a. Create VLANs 1, 10, and 20.
      ```
      switch# config
      switch(config)# vlan 1, 10, 20
      ```
   b. Enable RPVST+ and assign the VLANs 10 and 20 to it. Assign a priority of 5 to VLAN 10. This will force switch A to become the root of the spanning tree for VLAN 10.
      ```
      switch(config)# spanning-tree mode rpvst
      switch(config)# spanning-tree
      switch(config)# spanning-tree vlan 10,20
      switch(config)# spanning-tree vlan 10 priority 5
      ```
   c. Define interfaces **1/1/1** and **1/1/2**.
      ```
      switch(config)# interface 1/1/1
      switch(config-if)# no shutdown
      switch(config-if)# vlan trunk native 1
      switch(config-if)# vlan trunk allowed all
      switch(config-if)# interface 1/1/2
      switch(config-if)# no shutdown
      switch(config-if)# vlan trunk native 1
      switch(config-if)# vlan trunk allowed all
      ```
2. Configure switch B and switch C with the same settings.
   a. Create VLANs 1, 10, and 20.
      ```
      switch# config
      switch(config)# vlan 1, 10, 20
      ```
   b. Enable RPVST+ and assign the VLANs 10 and 20 to it.
      ```
      switch(config)# spanning-tree mode rpvst
      switch(config)# spanning-tree
      switch(config)# spanning-tree vlan 10,20
      ```
   c. Define interfaces **1/1/1** and **1/1/2**.
      ```
      switch(config)# interface 1/1/1
      switch(config-if)# no shutdown
      switch(config-if)# vlan trunk native 1
      switch(config-if)# vlan trunk allowed all
      switch(config-if)# interface 1/1/2
      ```

```
switch(config-if)# no shutdown
switch(config-if)# vlan trunk native 1
switch(config-if)# vlan trunk allowed all
```

3. Configure switch D.
   a. Create VLANs 1, 10, and 20.
   ```
   switch# config
   switch(config)# vlan 1, 10, 20
   ```
   b. Enable RPVST+ and assign the VLANs 10 and 20 to it. Assign a priority of 5 to VLAN 20. This will force switch D to become the root of the spanning tree for VLAN 20.
   ```
   switch(config)# spanning-tree mode rpvst
   switch(config)# spanning-tree
   switch(config)# spanning-tree vlan 10,20
   switch(config)# spanning-tree vlan 20 priority 5
   ```
   c. Define interfaces **1/1/1** and **1/1/2**.
   ```
   switch(config)# interface 1/1/1
   switch(config-if)# no shutdown
   switch(config-if)# vlan trunk native 1
   switch(config-if)# vlan trunk allowed all
   switch(config-if)# interface 1/1/2
   switch(config-if)# no shutdown
   switch(config-if)# vlan trunk native 1
   switch(config-if)# vlan trunk allowed all
   ```

# RPVST+ commands

## clear spanning-tree statistics

```
clear spanning-tree statistics [VLAN-ID]
```

### Description

Clears the spanning tree BPDU statistics, either all statistics or those related to a specified VLAN.

| Parameter | Description |
|---|---|
| VLAN-ID | Specifies the VLAN ID. |

### Example

Clearing all spanning tree BPDU statistics:

```
switch(config)# clear spanning-tree statistics
```

Clearing spanning tree BPDU statistics for a particular VLAN :

```
switch(config)# clear spanning-tree statistics 10
```

### Command History

| Release | Modification |
|---|---|
| 10.07 or earlier | -- |

### Command Information

| Platforms | Command context | Authority |
|---|---|---|
| All platforms | config | Administrators or local user group members with execution rights for this command. |

## show capacities rpvst

```
show capacities rpvst
```

### Description

Shows the capacities of RPVST VLANs configurable on a system and RPVST VPORTs supported in a system.

### Examples

Showing capacities on a 6200 switch:

```
switch# show capacities rpvst
System Capacities : Filter RPVST
```

```
Capacities Name                                                          Value
-------------------------------------------------------------------------------
Maximum number of RPVST VLANs configurable on the system                  128
Maximum number of RPVST VPORTs supported in a system                     2048
```

Showing capacities:

```
switch# show capacities rpvst
System Capacities : Filter RPVST
Capacities Name                                                          Value
-------------------------------------------------------------------------------
Maximum number of RPVST VLANs configurable on the system                   32
Maximum number of RPVST VPORTs supported in a system                      512
```

### Command History

| Release | Modification |
|---|---|
| 10.07 or earlier | -- |

### Command Information

| Platforms | Command context | Authority |
|---|---|---|
| All platforms | Operator (>) or Manager (#) | Operators or Administrators or local user group members with execution rights for this command. Operators can execute this command from the operator context (>) only. |

## show capacities-status rpvst

```
show capacities-status rpvst
```

### Description

Shows the number of RPVST VLANs and RPVST VPORTs currently configured.

### Examples

Showing capacities-status:

```
switch# show capacities-status rpvst
System Capacities Status : Filter RPVST
Capacities Status Name                Value            Maximum
-------------------------------------------------------------------------------
Number of RPVST VLANs configured          3                254
Number of RPVST VPORTs configured         9               2048
```

### Command History

| Release | Modification |
|---|---|
| 10.07 or earlier | -- |

### Command Information

| Platforms | Command context | Authority |
|---|---|---|
| All platforms | Operator (>) or Manager (#) | Operators or Administrators or local user group members with execution rights for this command. Operators can execute this command from the operator context (>) only. |

## show spanning-tree

```
show spanning-tree
```

### Description

Shows the spanning tree mode and information on the RPVST instances.

When Port security is enabled on the port and the client is not-yet authenticated, the security feature keeps the port in the **Down** state. STP also keeps the port in the **Blocking** state and the role as **Disabled** in the **show spanning-tree** command output, whereas in the hardware, the state is maintained as **Learning**. After client authentication is successful, the port state changes to **Forwarding**.

### Examples

Showing spanning tree mode and RPVST instance information:

```
switch# show spanning-tree
Spanning tree status           : Enabled Protocol: RPVST
Extended System-id             : Enabled
Ignore PVID Inconsistency      : Enabled
Path cost method               : Long
RPVST-MSTP Interconnect VLAN   : 1
Current Virtual Ports Count    : 7
Maximum Allowed Virtual Ports  : 2048

VLAN1
  Root ID    Priority   : 32768
             MAC-Address: 70:72:cf:31:c9:23
             This bridge is the root
             Hello time(in seconds):2  Max Age(in seconds):20
             Forward Delay(in seconds):15

  Bridge ID  Priority  : 32768
             MAC-Address: 70:72:cf:31:c9:23
             Hello time(in seconds):2  Max Age(in seconds):20
             Forward Delay(in seconds):15

PORT     ROLE        STATE      COST    PRIORITY  TYPE      BPDU-Tx   BPDU-Rx   TCN-Tx    TCN-Rx
-------- ----------- ---------- ------- --------- --------- --------- --------- --------- -------
1/1/1    Designated  Forwarding 20000   128       P2P Edge  100       60        20        10
1/1/2    Designated  Forwarding 20000   128       P2P       100       60        20        10
1/1/3    Designated  Forwarding 20000   128       Shr       100       60        20        10
1/1/4    Designated  Forwarding 20000   128       Shr Edge  100       60        20        10
1/1/5    Alternate   Loop-Inc   20000   128       Shr Edge  100       60        20        10
1/1/6    Alternate   Root-Inc   20000   128       Shr Edge  100       60        20        10
1/1/7    Disabled    Down       20000   128       P2P       100       60        20        10

Number of topology changes    : 4
Last topology change occurred : 516 seconds ago
```

### Command History

| Release | Modification |
|---|---|
| 10.09 | A new state `Down` is added in the output. |
| 10.07 or earlier | -- |

### Command Information

| Platforms | Command context | Authority |
|---|---|---|
| All platforms | Operator (>) or Manager (#) | Operators or Administrators or local user group members with execution rights for this command. Operators can execute this command from the operator context (>) only. |

## show spanning-tree detail

`show spanning-tree detail`

### Description

Shows the detailed spanning tree mode and information on the RPVST instances.

When Port security is enabled on the port and the client is not-yet authenticated, the security feature keeps the port in the **Down** state. STP also keeps the port in the **Blocking** state and the role as **Disabled** in the **show spanning-tree** command output, whereas in the hardware, the state is maintained as **Learning**. After client authentication is successful, the port state changes to **Forwarding**.

### Examples

Showing spanning tree mode and detailed RPVST instance information:

```
switch# show spanning-tree detail
Spanning tree status           : Enabled Protocol: RPVST AUTO
Extended System-id             : Enabled
Ignore PVID Inconsistency      : Disabled
Path cost method               : Long
RPVST-MSTP Interconnect VLAN   : 1
Current Virtual Ports Count    : 2032
Maximum Allowed Virtual Ports  : 2048
Maximum Allowed RPVST Instances: 254
Configured RPVST Enable Vlans  : 20-30,100
Configured RPVST Disable Vlans : 1-10
Auto RPVST Enable Vlans        : 11-19,31-99,101-264
Vlans with no RPVST Instance due to Max limit reach : 265-300

VLAN1
  Root ID    Priority   : 32768
             MAC-Address: 70:72:cf:31:c9:23
             This bridge is the root
             Hello time(in seconds):2  Max Age(in seconds):20
             Forward Delay(in seconds):15

  Bridge ID  Priority  : 32768
             MAC-Address: 70:72:cf:31:c9:23
             Hello time(in seconds):2  Max Age(in seconds):20
             Forward Delay(in seconds):15
```

```
PORT     ROLE        STATE      COST    PRIORITY  TYPE      BPDU-Tx   BPDU-Rx   TCN-Tx    TCN-Rx
-------- ----------- ---------- ------- --------- --------- --------- --------- --------- -------
1/1/1    Designated  Forwarding 20000   128       P2P Edge  100       60        20        10
1/1/2    Designated  Forwarding 20000   128       P2P       100       60        20        10
1/1/3    Designated  Forwarding 20000   128       Shr       100       60        20        10
1/1/4    Designated  Forwarding 20000   128       Shr Edge  100       60        20        10
1/1/5    Alternate   Loop-Inc   20000   128       Shr Edge  100       60        20        10
1/1/6    Alternate   Root-Inc   20000   128       Shr Edge  100       60        20        10
1/1/7    Disabled    Down       20000   128       P2P       100       60        20        10
lag1     Disabled    Down       20000   128       P2P Bound 100       60        20        10

Topology change flag : False
Number of topology changes : 1
Last topology change occurred : 33293 seconds ago

Port 1/1/1
Designated Root Priority                  : 32768          Address: 48:0F:CF:AF:22:1D
Designated Bridge Priority                : 32768          Address: 48:0F:CF:AF:22:1D
Designated Port                           : 1/1/1
Forwarding-State transitions              : 0
BPDUs sent 1582, received 1506
TCN_Tx: 10, TCN_Rx: 10

Port lag1
Designated Root Priority                  : 32768          Address: 48:0F:CF:AF:22:1D
Designated Bridge Priority                : 32768          Address: 48:0F:CF:AF:22:1D
Designated Port                           : lag1
Forwarding-State transitions              : 0
BPDUs sent 1402, received 1316
TCN_Tx: 10, TCN_Rx: 10
Multi-chassis role                        : active
```

### Command History

| Release | Modification |
|---|---|
| 10.09 | A new state **Down** is added in the output. |
| 10.07 or earlier | -- |

### Command Information

| Platforms | Command context | Authority |
|---|---|---|
| All platforms | Operator (>) or Manager (#) | Operators or Administrators or local user group members with execution rights for this command. Operators can execute this command from the operator context (>) only. |

## show spanning-tree inconsistent-ports

`show spanning-tree inconsistent-ports [vlan <VLAN-ID>]`

### Description

Shows ports blocked by STP protection functions such as Root guard, Loop guard, BPDU guard, and RPVST guard.

| Parameter | Description |
|---|---|
| *<VLAN-ID>* | Specifies a VLAN ID number. |

### Examples

Showing inconsistent port information:

```
switch# show spanning-tree inconsistent-ports
VLAN ID      Blocked Port   Reason
------------ -------------- ------------
1            1/1/1          BPDU Guard
2            1/1/1          BPDU Guard
3            1/1/1          BPDU Guard
4            1/1/1          BPDU Guard
5            1/1/1          BPDU Guard
6            1/1/1          BPDU Guard
7            1/1/1          BPDU Guard
8            1/1/1          BPDU Guard
9            1/1/1          BPDU Guard
10           1/1/1          BPDU Guard
```

Showing inconsistent port information for VLANs 1 to 4:

```
switch# show spanning-tree inconsistent-ports vlan 1-4
VLAN ID      Blocked Port   Reason
------------ -------------- ------------
1            1/1/3          Root Guard
2            1/1/7          BPDU Guard
3            1/1/9          Loop Guard
4            1/1/37         RPVST Guard
```

### Command History

| Release | Modification |
|---|---|
| 10.07 or earlier | -- |

### Command Information

| Platforms | Command context | Authority |
|---|---|---|
| All platforms | Operator (>) or Manager (#) | Operators or Administrators or local user group members with execution rights for this command. Operators can execute this command from the operator context (>) only. |

## show spanning-tree summary port

```
show spanning-tree summary port
```

### Description

Shows a summary of port-related spanning-tree configuration and status.

### Example

Showing a summary of port-related spanning tree information:

```
switch# show spanning-tree summary port

STP status                      : Enabled
Protocol                        : RPVST
BPDU guard timeout value        : None
BPDU guard enabled interfaces   : 1/1/1
BPDU filter enabled interfaces  : None
Root guard enabled interfaces   : 1/1/3
Loop guard enabled interfaces   : 1/1/2
TCN guard enabled interfaces    : 1/1/1-1/1/3

Interface count by state

VLAN                    Blocking Listening Learning Forwarding Down
---------------------- -------- --------- -------- ---------- ----
VLAN1                          0         0        0          1    0
VLAN2                          0         0        0          1    0
---------------------- -------- --------- -------- ---------- ----
Total = 2                      0         0        0          2    0
```

### Command History

| Release | Modification |
|---|---|
| 10.09 | A new state **Down** is added in the output. |
| 10.07 or earlier | -- |

### Command Information

| Platforms | Command context | Authority |
|---|---|---|
| All platforms | Operator (>) or Manager (#) | Operators or Administrators or local user group members with execution rights for this command. Operators can execute this command from the operator context (>) only. |

## show spanning-tree summary root

```
show spanning-tree summary root
```

### Description

Shows the summary of spanning tree root and configurations for all VLANs.

### Example

Showing summary of spanning tree configurations:

```
switch# show spanning-tree summary root

STP status            : Enabled
Protocol              : RPVST
System ID             : f8:60:f0:c9:70:40

Root bridge for VLANs : 1-10
```

```
                                          Root Hello Max Fwd
VLAN     Priority Root ID                 cost  Time Age Dly    Root Port
-------- -------- ----------------- --------- ----- --- --- ------------
VLAN1       32768 f8:60:f0:c9:70:40         0     2  20  15            0
VLAN2       32768 f8:60:f0:c9:70:40         0     2  20  15            0
VLAN3       32768 f8:60:f0:c9:70:40         0     2  20  15            0
VLAN4       32768 f8:60:f0:c9:70:40         0     2  20  15            0
VLAN5       32768 f8:60:f0:c9:70:40         0     2  20  15            0
VLAN6       32768 f8:60:f0:c9:70:40         0     2  20  15            0
VLAN7       32768 f8:60:f0:c9:70:40         0     2  20  15            0
VLAN8       32768 f8:60:f0:c9:70:40         0     2  20  15            0
VLAN9       32768 f8:60:f0:c9:70:40         0     2  20  15            0
VLAN10      32768 f8:60:f0:c9:70:40         0     2  20  15            0
```

### Command History

| Release | Modification |
|---|---|
| 10.07 or earlier | -- |

### Command Information

| Platforms | Command context | Authority |
|---|---|---|
| All platforms | Operator (>) or Manager (#) | Operators or Administrators or local user group members with execution rights for this command. Operators can execute this command from the operator context (>) only. |

## show spanning-tree vlan

`show spanning-tree vlan <VLAN-ID>`

### Description

Displays the spanning tree mode and information on the RPVST instance of the specified VLAN.

| Parameter | Description |
|---|---|
| *<VLAN-ID>* | Specifies the number of a VLAN. |

### Examples

Showing spanning tree mode and RPVST instance information for VLAN 2:

```
switch# show spanning-tree vlan 2
VLAN2
Spanning tree status: Enabled Protocol: RPVST
  Root ID    Priority   : 32768
             MAC-Address: 70:72:cf:76:43:2a
             This bridge is the root
             Hello time(in seconds):2  Max Age(in seconds):20
             Forward Delay(in seconds):15

  Bridge ID  Priority  : 32768
```

```
            MAC-Address: 70:72:cf:76:43:2a
            Hello time(in seconds):2  Max Age(in seconds):20
            Forward Delay(in seconds):15

PORT      ROLE        STATE      COST       PRIORITY  TYPE      BPDU-Tx    BPDU-Rx
  TCN-Tx     TCN-Rx
--------- ----------- ---------- ---------- --------- --------- ---------- --------
-- ---------- ----------
1/1/1     Designated  Forwarding 20000      128       P2P Edge  100        60
  20         10
1/1/2     Designated  Forwarding 20000      128       P2P       100        60
  20         10
1/1/3     Designated  Forwarding 20000      128       Shr       100        60
  20         10
1/1/4     Designated  Forwarding 20000      128       Shr Edge  100        60
  20         10
1/1/5     Alternate   Loop-Inc   20000      128       Shr Edge  100        60
  20         10
1/1/6     Alternate   Root-Inc   20000      128       Shr Edge  100        60
  20         10
1/1/7     Disabled    Down       20000      128       P2P       100        60
  20         10

Number of topology changes    : 4
Last topology change occurred : 516 seconds ago
```

### Command History

| Release | Modification |
|---|---|
| 10.09 | A new state **Down** is added in the output. |
| 10.07 or earlier | -- |

### Command Information

| Platforms | Command context | Authority |
|---|---|---|
| All platforms | Operator (>) or Manager (#) | Operators or Administrators or local user group members with execution rights for this command. Operators can execute this command from the operator context (>) only. |

## show spanning-tree vlan detail

`show spanning-tree vlan <VLAN-ID> detail`

### Description

Displays the spanning tree mode and information on the RPVST instance of the specified VLAN and optionally displays details on the RPVST instance for the VLAN.

| Parameter | Description |
|---|---|
| *<VLAN-ID>* | Specifies the number of a VLAN. |

### Examples

Showing spanning tree mode and detailed RPVST instance information for VLAN 2:

```
switch# show spanning-tree vlan 2 detail
VLAN2
Spanning tree status: Enabled Protocol: RPVST
  Root ID    Priority   : 32768
             MAC-Address: 70:72:cf:76:43:2a
             This bridge is the root
             Hello time(in seconds):2  Max Age(in seconds):20
             Forward Delay(in seconds):15

  Bridge ID  Priority  : 32768
             MAC-Address: 70:72:cf:76:43:2a
             Hello time(in seconds):2  Max Age(in seconds):20
             Forward Delay(in seconds):15

PORT     ROLE        STATE      COST       PRIORITY  TYPE      BPDU-Tx    BPDU-Rx
  TCN-Tx     TCN-Rx
-------- ----------- ---------- ---------- --------- --------- ---------- --------
-- ---------- ----------
1/1/1    Designated  Forwarding 20000      128       P2P Edge  100        60
  20         10
1/1/2    Designated  Forwarding 20000      128       P2P       100        60
  20         10
1/1/3    Designated  Forwarding 20000      128       Shr       100        60
  20         10
1/1/4    Designated  Forwarding 20000      128       Shr Edge  100        60
  20         10
1/1/5    Alternate   Loop-Inc   20000      128       Shr Edge  100        60
  20         10
1/1/6    Alternate   Root-Inc   20000      128       Shr Edge  100        60
  20         10
1/1/7    Disabled    Down       20000      128       P2P       100        60
  20         10

Topology change flag : False
Number of topology changes : 1
Last topology change occurred : 33293 seconds ago

Port 1/1/1
Designated root has priority :32768 Address: 48:0f:cf:af:22:1d
Designated bridge has priority :32768 Address: 48:0f:cf:af:22:1d
Designated port :1
Number of transitions to forwarding state : 0
BPDUs sent 1582, received 1506
TCN_Tx: 10, TCN_Rx: 10
```

## Command History

| Release | Modification |
|---|---|
| 10.09 | A new state **Down** is added in the output. |
| 10.07 or earlier | -- |

## Command Information

| Platforms | Command context | Authority |
|---|---|---|
| All platforms | Operator (>) or Manager (#) | Operators or Administrators or local user group members with execution rights for this command. Operators can execute this command from the operator context (>) only. |

## spanning-tree bpdu-guard timeout

```
spanning-tree bpdu-guard timeout <INTERVAL>
no spanning-tree bpdu-guard timeout [<INTERVAL>]
```

### Description

Enables and configures the auto re-enable timeout in seconds for all interfaces with BPDU guard enabled. When an interface is disabled after receiving an unauthorized BPDU it will automatically be re-enabled after the timeout expires. The default is for the interface to stay disabled until manually re-enabled.

The **no** form of the command disables BPDU guard timeout on the interface. This is the default.

| Parameter | Description |
|---|---|
| *<INTERVAL>* | Specifies the re-enable timeout in seconds. Range: 1 to 65535. |

### Example

Enabling the BPDU guard timeout on interface 1/1/1:

```
switch(config)# interface 1/1/1
switch(config-if)# spanning-tree bpdu-guard timeout 10
```

Disabling BPDU guard timeout on interface 1/1/1:

```
switch(config)# interface 1/1/1
switch(config-if)# no spanning-tree bpdu-guard
```

### Command History

| Release | Modification |
|---|---|
| 10.07 or earlier | -- |

### Command Information

| Platforms | Command context | Authority |
|---|---|---|
| All platforms | `config` | Administrators or local user group members with execution rights for this command. |

## spanning-tree extend-system-id

```
spanning-tree extend-system-id {enable | disable}
no spanning-tree extend-system-id
```

### Description

Configures use of extended system ID. When enabled, the VLAN ID is included in spanning tree packets. When disabled, the VLAN ID is set to NULL in the spanning tree packets.

By default, extended system ID is enabled. If you disable extended system ID, the bridge identifier field in the spanning tree packet is filled with zeros.

The **no** form of this command disables extended system ID.

| Parameter | Description |
|---|---|
| `enable` | Specifies enabling use of extended system ID. |
| `disable` | Specifies disabling use of extended system ID. |

### Examples

Enabling extended system ID:

```
switch# config
switch(config)# spanning-tree extend-system-id enable
```

Disabling extended system ID:

```
switch# config
switch(config)# spanning-tree extend-system-id disable
switch(config)# no spanning-tree extend-system-id
```

### Command History

| Release | Modification |
|---|---|
| 10.07 or earlier | -- |

### Command Information

| Platforms | Command context | Authority |
|---|---|---|
| All platforms | `config` | Administrators or local user group members with execution rights for this command. |

## spanning-tree ignore-pvid-inconsistency

```
spanning-tree ignore-pvid-inconsistency {enable | disable}
no spanning-tree ignore-pvid-inconsistency
```

### Description

Configures port behavior when per-VLAN ID inconsistencies are present. For example, when the ports on both ends of a point-to-point link are untagged members of different VLANs, enabling this option allows RPVST+ to process untagged RPVST+ packets belonging to the peer's untagged VLAN as if they were received on the current device's untagged VLAN. When this option is disabled, RPVST+ blocks the link, causing traffic on the mismatched VLANs to be dropped.

If this option is enabled on multiple switches connected by hubs, there could be more than two VLANs involved in PVID mismatches that will be ignored by RPVST+.

If port VLAN memberships is misconfigured on a switch in the network, then enabling this option prevents RPVST+ from detecting the problem, which may result in packet duplication in the network since RPVST+ would not converge correctly.

This command affects all ports on the switch belonging to VLANs on which RPVST+ is enabled.

By default ignore per-VLAN ID inconsistency is disabled.

The **no** form of this command sets the ignore per-VLAN ID inconsistencies to disabled.

| Parameter | Description |
|---|---|
| `enable` | Specifies ignore per-VLAN ID inconsistencies and allow RPVST to run on mismatched links. |
| `disable` | Disables the ignore per-VLAN ID inconsistencies functionality. |

### Examples

Enabling ignore per-VLAN ID inconsistencies:

```
switch# config
switch(config)# spanning-tree ignore-pvid-inconsistency enable
```

Disabling ignore per-VLAN ID inconsistencies:

```
switch# config
switch(config)# spanning-tree ignore-pvid-inconsistency disable
switch(config)# no spanning-tree ignore-pvid-inconsistency
```

### Command History

| Release | Modification |
|---|---|
| 10.07 or earlier | -- |

### Command Information

| Platforms | Command context | Authority |
|---|---|---|
| All platforms | `config` | Administrators or local user group members with execution rights for this command. |

## spanning-tree link-type

```
spanning-tree link-type {point-to-point | shared}
no spanning-tree link-type
```

### Description

Configures the link type of a port.

The **no** form of this command sets the spanning tree link type to the default value of **point-to-point**.

| Parameter | Description |
|---|---|
| `point-to-point` | Sets the spanning tree link type as point-to-point. Use this for full-duplex ports that provide a point-to-point link to devices such as a switch, bridge, or end-node. Default. |
| `shared` | Sets the spanning tree link type as shared. Use this when the port is connected to a hub. |

### Examples

Setting spanning tree link type to shared:

```
switch(config)# interface 1/1/1
switch(config-if)# spanning-tree link-type shared
```

Setting spanning tree link type to point-to-point for a port:

```
switch(config)# interface 1/1/1
switch(config-if)# no spanning-tree link-type
```

### Command History

| Release | Modification |
|---|---|
| 10.07 or earlier | -- |

### Command Information

| Platforms | Command context | Authority |
|---|---|---|
| All platforms | `config-if` | Administrators or local user group members with execution rights for this command. |

## spanning-tree mode

```
spanning-tree mode {mstp|rpvst [auto-vlan-enable [priority <NUMBER>]]}
no spanning-tree mode {mstp|rpvst [auto-vlan-enable [priority <NUMBER>]]}
```

### Description

Sets the spanning tree protocol (STP) mode to either MSTP mode (Multiple-instance Spanning Tree Protocol) or RPVST mode (Rapid Per VLAN Spanning Tree). Enabling the RPVST Auto VLAN feature will run RPVST on all VLANs currently configured on the switch. Default priority of 8 will be assigned to the VLANs being auto created.

The **no** form of this command sets the spanning tree mode to the default **mstp**.

Enabling auto-VLAN can lead to an undeterministic state if auto scaled beyond the max system limit mentioned in the capacity-status.

| Parameter | Description |
|---|---|
| `mstp` | Sets the STP mode to MSTP which applies spanning tree separately for each set of VLANs called an MSTI (multiple spanning tree instance). |
| `rpvst` | Sets the STP mode to RPVST. |
| `auto-vlan-enable` | Selects RPVST auto VLAN mode. |
| `priority <NUMBER>` | Specifies the priorites for all auto created RPVST instances. Configured as a multiple of 4096. Default: 8. |

## Examples

Enabling MSTP mode:

```
switch(config)# spanning-tree mode mstp
```

Disabling MSTP mode:

```
switch(config)# no spanning-tree mode mstp
```

Enabling RPVST mode:

```
switch(config)# spanning-tree mode rpvst
```

Disabling RPVST mode:

```
switch(config)# no spanning-tree mode rpvst
```

Enabling RPVST auto VLAN with a priority of 1:

```
switch(config)# spanning-tree mode rpvst auto-vlan-enable priority 1
```

Disabling RPVST auto VLAN with a priority of 1:

```
switch(config)# no spanning-tree mode rpvst auto-vlan-enable priority 1
```

## Command History

| Release | Modification |
|---|---|
| 10.12.1000 | Auto VLAN enable added. |
| 10.07 or earlier | -- |

## Command Information

| Platforms | Command context | Authority |
|---|---|---|
| All platforms | `config` | Administrators or local user group members with execution rights for this command. |

## spanning-tree pathcost-type

```
spanning-tree pathcost-type {long | short}
no spanning-tree pathcost-type [long|short]
```

### Description

Configures the spanning tree path cost type. The long mode provides support for the wider range of link speeds required by high-speed interfaces. All switches in the network must use the same path cost type or errors can occur in the spanning tree.

The **no** form of this command sets the spanning tree path cost type to the default **long**.

| Parameter | Description |
|---|---|
| `long` | Specifies the spanning tree path cost type as a 32-bit value, allowing port cost values to be set in the range 1-200,000,000. Default. |
| `short` | Specifies the spanning tree path cost type as a 16-bit value, allowing port cost values to be set in the range 1-65535. |

### Examples

Setting spanning tree path cost type to short:

```
switch# config
switch(config)# spanning-tree pathcost-type short
```

Setting spanning tree path cost type to long:

```
switch# config
switch(config)# spanning-tree pathcost-type long
```

Setting spanning tree path cost to default of long:

```
switch# config
switch(config)# no spanning-tree pathcost-type
```

### Command History

| Release | Modification |
|---|---|
| 10.07 or earlier | -- |

### Command Information

| Platforms | Command context | Authority |
|---|---|---|
| All platforms | `config` | Administrators or local user group members with execution rights for this command. |

## spanning-tree rpvst-mstp interconnect vlan

```
spanning-tree rpvst-mstp-interconnect-vlan <VLAN-ID>
no spanning-tree rpvst-mstp-interconnect-vlan [<VLAN-ID>]
```

### Description

Configures the VLAN that has to be used to interconnect RPVST and MSTP domains. VLAN 1 is used by default.

The **no** form of this command sets the VLAN configuration to the default of 1.

- It is required to create the interconnect VLAN and then configure RPVST spanning tree on it.
- The same interconnect VLAN must be kept on all the switches in the network.
- Adding or deleting the interconnect VLAN triggers a re-convergence in the network.
- Deleting a VLAN that is configured as the interconnect VLAN does not reset the value to the default.

| Parameter | Description |
|---|---|
| *<VLAN-ID>* | Specifies the number of a VLAN. |

### Examples

This example configures VLAN 10 to used to interconnect RPVST and MSTP domains.

```
switch#(config)# spanning-tree rpvst-mstp-interconnect-vlan 10
```

### Command History

| Release | Modification |
|---|---|
| 10.07 or earlier | -- |

### Command Information

| Platforms | Command context | Authority |
|---|---|---|
| All platforms | `config` | Administrators or local user group members with execution rights for this command. |

## spanning-tree tcn-guard

```
spanning-tree tcn-guard
no spanning-tree tcn-guard
```

### Description

Disables propagation of topology change notifications (TCNs) to other STP ports. Use this when you do not want topology changes to be noticed by peer devices. By default, the propagation is enabled.

The **no** form of this command, enables propagation of topology changes which is the default.

### Examples

Enabling `tcn-guard`, which disables propagation of topology changes:

```
switch(config-if)# spanning-tree tcn-guard
```

Disabling `tcn-guard`, which enables propagation of topology changes:

```
switch(config-if)# no spanning-tree tcn-guard
```

### Command History

| Release | Modification |
|---|---|
| 10.07 or earlier | -- |

### Command Information

| Platforms | Command context | Authority |
|---|---|---|
| All platforms | `config-if` | Administrators or local user group members with execution rights for this command. |

## spanning-tree vlan

```
spanning-tree vlan <VLAN-LIST> [{hello-time | foward-delay | max-age | priority} <VALUE>]
no spanning-tree vlan <VLAN-LIST> [hello-time | foward-delay | max-age | priority]
```

### Description

Creates an RPVST instance for the specified VLAN. This command also allows for configuration of RPVST instance-specific time parameters.

The **no** form of this command removes the RPVST instance associated with the specified VLAN, and configures default values for RPVST instance-specific parameters.

| Parameter | Description |
|---|---|
| *<VLAN-LIST>* | Specifies the number of a single VLAN, or a series of numbers for a range of VLANs, separated by commas (1, 2, 3, 4), dashes (1-4), or both (1-4,6). |
| `hello-time` *<VALUE>* | Specifies the hello-time in seconds for the RPVST instance. Range: 2-10 seconds. Default: 2 seconds. |
| `forward-delay` *<VALUE>* | Specifies the forward-delay time in seconds for the RPVST instance. Range: 4-30 seconds. Default: 15 seconds. |
| `max-age` *<VALUE>* | Specifies the maximum age time in seconds for the RPVST instance. Range: 6-40 seconds. Default: 20 seconds. |
| `priority` *<VALUE>* | Specifies the priority for the RPVST instance. Priority value is |

| Parameter | Description |
|---|---|
| | configured as a multiple of 4096. Range: 0-15. Default: 8 which is 32768. |

### Examples

Creating an RPVST instance for a list of VLANs and configuring various time parameters:

```
switch# config
switch(config)# spanning-tree vlan 2-5
switch(config)# spanning-tree vlan 2-5 hello-time 5
switch(config)# spanning-tree vlan 5 max-age 10
switch(config)# spanning-tree vlan 2-5 forward-delay 25
switch(config)# spanning-tree vlan 2-5 priority 5
```

Removing an RPVST instance for a list of VLANs and setting various time parameters to the default:

```
switch# config
switch(config)# no spanning-tree vlan 2-5
switch(config)# no spanning-tree vlan 2-5 hello-time
switch(config)# no spanning-tree vlan 2-5 forward-time
switch(config)# no spanning-tree vlan 2-5 max-age
switch(config)# no spanning-tree vlan 2-5 priority
```

### Command History

| Release | Modification |
|---|---|
| 10.07 or earlier | -- |

### Command Information

| Platforms | Command context | Authority |
|---|---|---|
| All platforms | `config` | Administrators or local user group members with execution rights for this command. |

## spanning-tree vlan cost

```
spanning-tree vlan <VLAN-LIST> cost <PORT-COST>
no spanning-tree vlan <VLAN-LIST> cost
```

### Description

Configures the spanning tree cost for the VLAN. This is the cost to reach the root port.

The **no** form of this command sets the port cost to the default value.

| Parameter | Description |
|---|---|
| *<VLAN-LIST>* | Specifies the number of a single VLAN, or a series of numbers for a range of VLANs, separated by commas (1, 2, 3, 4), dashes (1-4), or both (1-4,6). |

| Parameter | Description |
|---|---|
| *<PORT-COST>* | Specifies the spanning tree cost for the VLAN. Range: 1-200,000,000. Default is calculated from the port link speed:<br>■ 10 Mbps link speed equals a path cost of 2,000,000.<br>■ 100 Mbps link speed equals a path cost of 200,000.<br>■ 1 Gbps link speed equals a path cost of 20,000.<br>■ 2 Gbps link speed equals a path cost of 10,000.<br>■ 10 Gbps link speed equals a path cost of 2,000.<br>■ 100 Gbps link speed equals a path cost of 200.<br>■ 1 Tbps link speed equals a path cost of 20. |

### Examples

Setting port cost:

```
switch(config-if)# spanning-tree vlan 5 cost 100000
```

Setting port cost to the default:

```
switch(config-if)# no spanning-tree vlan 5 cost
```

### Command History

| Release | Modification |
|---|---|
| 10.07 or earlier | -- |

### Command Information

| Platforms | Command context | Authority |
|---|---|---|
| All platforms | `config-if` | Administrators or local user group members with execution rights for this command. |

## spanning-tree vlan port-priority

```
spanning-tree vlan <VLAN-LIST> port-priority <PRIORITY>
no spanning-tree vlan <VLAN-LIST> port-priority
```

### Description

Configures port priority. A port with the lowest priority number has the highest priority for use in forwarding traffic.

The **no** form of this command, sets the port priority to the default of 8.

| Parameter | Description |
|---|---|
| *<VLAN-LIST>* | Specifies the number of a single VLAN, or a series of numbers for a range of VLANs, separated by commas (1, 2, 3, 4), dashes (1-4), or both (1-4,6). |

| Parameter | Description |
|---|---|
| *<PRIORITY>* | Specifies the port priority. The value, configured as a multiple of 16, helps in determining the designated port. The lower a priority value, the higher the priority. Range: 1 to15. Default: 8. |

### Examples

Setting port priority:

```
switch(config-if)# spanning-tree vlan 5 port-priority 10
```

Setting port priority to the default of 8:

```
switch(config-if)# no spanning-tree vlan 5 port-priority
```

### Command History

| Release | Modification |
|---|---|
| 10.07 or earlier | -- |

### Command Information

| Platforms | Command context | Authority |
|---|---|---|
| All platforms | `config-if` | Administrators or local user group members with execution rights for this command. |

## spanning-tree trap

```
spanning-tree trap {new-root | topology-change [vlan <VLAN-ID>] |
   errant-bpdu | root-guard-inconsistency | loop-guard-inconsistency}
no spanning-tree trap {new-root | topology-change [vlan <VLAN-ID>] |
   errant-bpdu | root-guard-inconsistency | loop-guard-inconsistency}
```

### Description

Enables SNMP traps for new root, topology change event, errant-bpdu received event, root-guard inconsistency, and loop-guard inconsistency notifications. It is disabled by default.

The **no** form of this command disables the notifications for SNMP traps.

| Parameter | Description |
|---|---|
| `new-root` | Enables SNMP notification when a new root is elected on any PVST vlan on the switch. |
| `topology-change` | Enables SNMP notification when a topology change event occurred in specified PVST vlan on the switch. |
| *<VLAN-ID>* | Specifies the VLAN ID for the topology change trap. Range: 1 to 4094. |

| Parameter | Description |
|---|---|
| errant-bpdu | Enables SNMP notification when an errant bpdu is received by any PVST vlan on the switch. |
| root-guard-inconsistency | Enables SNMP notification when the root-guard finds the port inconsistent for any PVST vlan on the switch. |
| loop-guard-inconsistency | Enables SNMP notification when the loop-guard finds the port inconsistent for any PVST vlan on the switch. |

## Examples

Enabling the notifications for the SNMP traps:

```
switch(config)# spanning-tree trap
  new-root                  Enable notifications which are sent when a new root is
elected
  topology-change           Enable notifications which are sent when a topology
change occurs
  errant-bpdu               Enable notifications which are sent when an errant
bpdu is received
  root-guard-inconsistency  Enable notifications which are sent when root guard
inconsistency occurs
  loop-guard-inconsistency  Enable notifications which are sent when loop guard
inconsistency occurs
switch(config)# spanning-tree trap new-root
  <cr>
switch(config)# spanning-tree trap topology-change
  vlan  Enable topology change notification for the specified PVST vlan id.
switch(config)# spanning-tree trap topology-change vlan
  <1-4094>  Enable topology change information on the specified vlan id.
switch(config)# spanning-tree trap topology-change vlan 1
  <cr>
switch(config)# spanning-tree trap errant-bpdu
  <cr>
switch(config)# spanning-tree trap root-guard-inconsistency
  <cr>
switch(config)# spanning-tree trap loop-guard-inconsistency
  <cr>
```

Disabling the notifications for the SNMP traps:

```
switch(config)# no spanning-tree trap
  new-root                  Disable notifications which are sent when a new root
is elected
  topology-change           Disable notifications which are sent when a topology
change occurs
  errant-bpdu               Disable notifications which are sent when an errant
bpdu is received
  root-guard-inconsistency  Disable notifications which are sent when root guard
inconsistency occurs
  loop-guard-inconsistency  Disable notifications which are sent when loop guard
inconsistency occurs
switch(config)# no spanning-tree trap new-root
  <cr>
switch(config)# no spanning-tree trap topology-change
  instance  Disable topology change notification for the specified PVST vlan id.
switch(config)# no spanning-tree trap topology-change vlan
```

```
  <1-4094>  Disable topology change information on the specified PVST vlan id.
switch(config)# no spanning-tree trap topology-change vlan 1
  <cr>
switch(config)# no spanning-tree trap errant-bpdu
  <cr>
switch(config)# no spanning-tree trap root-guard-inconsistency
  <cr>
switch(config)# no spanning-tree trap loop-guard-inconsistency
  <cr>
```

## Command History

| Release | Modification |
|---|---|
| 10.07 or earlier | -- |

## Command Information

| Platforms | Command context | Authority |
|---|---|---|
| All platforms | `config` | Administrators or local user group members with execution rights for this command. |

# RPVST+ debugging and troubleshooting

When there are suspected convergence problems with RPVST+, use the information provided in this section to help solve the problems. The main symptoms of a convergence problem are as follows:

### Check L2 port VLAN configurations.

a. If a ports is expected to be a root ports with direct connection but are not selected, check if the port is enabled for that vlan using command **`show vlan`**.
b. For proper convergence, confirm that command **`show spanning-tree vlan`** shows all expected ports of the VLAN.
c. Check the default cost and port-priority set for all configured interfaces (ports) and LAGS. Any custom configurations should be justified and should not be affecting the path selection. For example the undesired use of a 10G forwarding path instead of available redundant 25G or 40G paths.

### Set the RPVST instance priorities

a. Use command `spanning-tree vlan <VLAN-LIST> priority <VALUE>` to set the RPVST instance.

### Eliminate mismatched path cost types across all devices in the network.

Aruba switches use Long path cost by default, other vendor switches might be using short path cost. Set path cost the same on all devices.

a. Set spanning tree cost with command **`spanning-tree vlan cost`**.

### If convergence is slow or improper, check if the vPort limit has been reached, and if so, reduce Vport consumption.

It is recommended to not allow more vPorts to be used than the maximum shown with command **`show capacities rpvst`**.

When excessive vPort consumption occurs (beyond the maximum indicated by the **`show capacities rpvst`** command), convergence may slow or have problems.

Some typical symptoms of slowed or problematic convergence are as follows:

- For any link down, network segment down, or root change, the convergence takes more than 30 seconds, thus impacting traffic for more than 30 seconds.
- Root or designated or alternate port selection could be improper.
- The vPort limit is the maximum the system can process the RPVST PDUs within required time (to allow convergence and process and send BPDUs within limits so that convergence is sustained), hence sometime with less system load or with non-participating STP-ports (such as those connected to end-hosts or other non-STP-devices). But careful evaluation of vPorts need to be done, so that we shall not stress RPVST.

Use command **`show capacities status rpvst`**. Confirm that the number of RPVST vPorts does not equal the maximum. When the number of configured vPorts is close to the maximum, RPVST+ convergence slows.

vPort consumption can be reduced as follows:

a. Check if you have configured unnecessary VLANs as part of a trunk, or if you have accidentally configured **`vlan trunk allowed all`**. Remove unnecessary VLANs from L2 ports, to reduce vPort consumption.
b. Reduce the number of unused L2 ports that are enabled. Although unused L2 ports are not actively participating in convergence, they do consume vPorts.
c. Optimize the number of RPVST+ instances created. If there are VLANs without risk of loops or VLANs local to edge switches, then delete such VLANs or delete the VLAN RPVST+ instances.

Alternatively, consider using MSTP instead of RPVST+. MSTP is not limited by the number of L2 ports and VLANs configured.

# RPVST+ FAQ

### 1. Are there any specific loop-prevention recommendations for access switches?

If the access switch is prone to receiving excess BPDUs, consider enabling RPVST+ or MSTP.

### 2. What is the default spanning tree protocol (STP) mode?

The default STP mode is MSTP. RPVST+ is also supported. Set the SPT mode with command **`spanning-tree mode`**.

### 3. Can RPVST+ and MSTP switches be interconnected?

Yes. To interconnect typically use the default VLAN 1. This is based on the RFC for interconnection.

### 4. What network-resiliency features are available for physical links?

The Industry-standard feature unidirectional link detection (UDLD on fiber links) is available.

### 5. What is the maximum number of STP hops supported?

The maximum is 40. The default is 20.

### 6. When adding RPVST+ VLANs, will new VLANs be added to the STP instance automatically?

No. Each VLAN that is added must be added to the STP instance using command **`spanning-tree vlan`**.

### 7. Does RPVST+ have any per-platform capacity differences?

Yes. Refer to the platform-specific number of **RPVST+ VLANs** and **RPVST+ vPorts** under STP supported platforms and scale.

### 8. Do AOS-CX switches provide Uplink Fast or Backbone Fast for faster convergence?

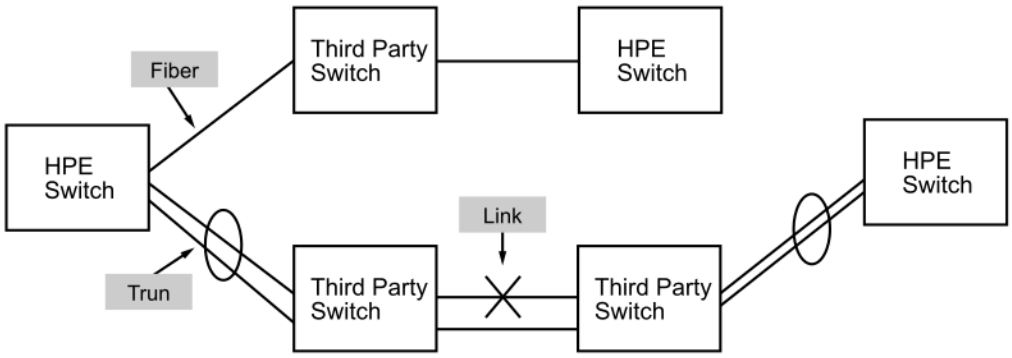
These are proprietary features of other vendors. RPVST+ includes equivalent functionality.

# Chapter 9
# UDLD

The Unidirectional Link Detection (UDLD) protocol enables detection of unidirectional behavior of layer 2 link. For UDLD to work, both connected devices must run the same UDLD protocol on the respective ports.

UDLD monitors the link between two network devices and blocks the ports on both ends of the link if the link fails. UDLD is particularly useful for detecting failures in fiber links and trunks.

In the following example each switch load balances traffic across two ports in a trunk group. Without the UDLD feature, a link failure on a link that is not directly attached to one of the HPE switches remains undetected. As a result, each switch continues to send traffic on the ports connected to the failed link. When UDLD is enabled on the trunk ports on each switch, the switches detect the failed link, block the ports connected to the failed link, and use the remaining ports in the trunk group to forward the traffic.




Similarly, UDLD is effective for monitoring fiber optic links that use two uni-direction fibers to transmit and receive packets. Without UDLD, if a fiber breaks in one direction, a fiber port may assume the link is still good (because the other direction is operating normally) and continue to send traffic on the connected ports. UDLD-enabled ports; however, will prevent traffic from being sent across a bad link by blocking the ports in the event that either the individual transmitter or receiver for that connection fails.

Ports enabled for UDLD exchange health-check packets once every seven seconds (the link-keepalive interval). If a port does not receive a health-check packet from the port at the other end of the link within the keepalive interval, the port waits for four more intervals. If the port still does not receive a health-check packet after waiting for five intervals, the port concludes that the link has failed and blocks the UDLD-enabled port.

When a port is blocked by UDLD, the event is recorded in the switch log and other port blocking protocols, like spanning tree or meshing, will not use the bad link to load balance packets. The port will remain blocked until the link is unplugged, disabled, or fixed. The port can also be unblocked by disabling UDLD on the port.

Port blocking behavior is dependant on the UDLD mode in use. The previous paragraphs describe RFC5171 Aggressive mode. Other modes behave as follows:

- RFC 5171 normal: The port is not blocked but a notification is triggered.
- Aruba OS verify-then-forward: The links are considered blocked until bi-directionality is confirmed. After a link is considered bidirectional, if the retries are met and no packets are received, the link is marked as blocked.
- Aruba OS forward-then-verify: The links start up as unblocked. After a link is considered bidirectional, if the retries are met and no packets are received, the link is marked as blocked.

# Configuring UDLD

### Procedure

1. Enable UDLD on an interface with the command `udld`.
2. For most deployments, the default values for the following settings do not need to be changed. If your deployment requires different settings, change the default values with the indicated command:

| UDLD setting | Default value | Command to change it |
|---|---|---|
| Packet transmission delay interval. | 7000 ms | `udld interval` |
| Operating mode. | Interconnect with HPE PVOS/Brocade/Foundry switches in forward-then-verify mode. | `udld mode` |
| Retry count. | 4 | `udld retries` |

3. Review UDLD configuration settings with the command `show udld`.

### Example

This example creates the following configuration:

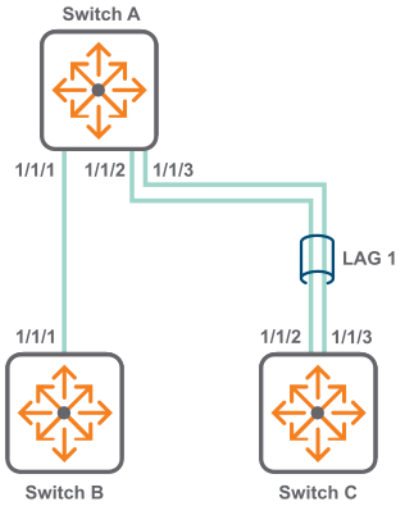
- Enables UDLD on interface **1/1/1**.
- Sets the UDLD mode to **rfc5171 aggressive**.
- Sets the UDLD interval to **1000**.
- Sets the UDLD retries to **3**.

```
switch(config)# interface 1/1/1
switch(config-if)# mode rfc5171 aggressive
switch(config-if)# interval 10000
switch(config-if)# retries 3
switch(config-if)# udld
switch(config-if)# quit
switch(config)# show udld interface 1/1/1
Interface 1/1/1
 Config: enabled
 State: active
 Substate: bidirectional
 Link: unblock
 Version: rfc5171
 Mode: aggressive
```

```
Interval: 10000 milliseconds
Retries: 3
Tx: 0 packets
Rx: 0 packets, 0 discarded packets, 0 dropped packets
Port transitions: 0
```

# UDLD scenario

This scenario describes how to use UDLD on a single physical interface as well as a LAG.




### Procedure

1. On switch A:
   a. Configure the UDLD session between switch A and B.

```
switch# config
switch(config-if)# interface 1/1/1
switch(config-if)# udld
switch(config-if)# exit
switch(config)#
```

   b. Configure the UDLD session between switch A and C.

```
switch(config)# interface 1/1/2
switch(config-if)# no shutdown
switch(config-if)# lag 1
switch(config-if)# udld interval 400udld interval 1000-90000
switch(config-if)# udld mode aruba-os verify-then-forward
switch(config-if)# udld retries 5
switch(config)# exit
switch(config)# interface 1/1/3
switch(config-if)# no shutdown
switch(config-if)# lag 1
switch(config-if)# udld interval 400udld interval 1000-90000
switch(config-if)# udld mode aruba-os verify-then-forward
switch(config-if)# udld retries 5
```

2. On switch B, configure the UDLD session between switch B and A.

```
switch# config
switch(config-if)# interface 1/1/1
switch(config-if)# udld
switch(config-if)# exit
```

3. On switch C, configure the UDLD session between switch C and A.

```
switch# config
switch(config)# interface 1/1/2
switch(config-if)# no shutdown
switch(config-if)# lag 1
switch(config-if)# udld interval 400udld interval 1000-90000
switch(config-if)# udld mode aruba-os verify-then-forward
switch(config-if)# udld retries 5
switch(config)# exit
switch(config)# interface 1/1/3
switch(config-if)# no shutdown
switch(config-if)# lag 1
switch(config-if)# udld interval 400udld interval 1000-90000
switch(config-if)# udld mode aruba-os verify-then-forward
switch(config-if)# udld retries 5
```

4. On switch A, verify UDLD configuration by running the command `show udld`. (A packet must arrive on each switch for it to unblock the interface.)

```
switch# show udld
Abbreviations:
 VTF - Verify then forward    FTV - Forward then verify
 NOR - RFC 5171 normal        AGG - RFC 5171 aggressive

-------------------------------------------------------------------------------
-----------------------------------------------------
Interface  UDLD      UDLD    UDLD           UDLD     Mode Interval
Retries  Tx    Rx    Rx          Rx         Transitions
           Config    State   Substate       Link
    Pkts  Pkts  Pkts disc.  Pkts drop.
-------------------------------------------------------------------------------
-----------------------------------------------------
1/1/1      enabled   active  Bidirectional  unblock  FTV  7000          4
    0     0     0           0          0
1/1/2      enabled   active  Bidirectional  unblock  VTF  400           5
    2     2     0           0          1
1/1/3      enabled   active  Bidirectional  unblock  VTF  400           5
    2     2     0           0          1
```

```
switch# show udld
Abbreviations:
 VTF - Verify then forward    FTV - Forward then verify
 NOR - RFC 5171 normal        AGG - RFC 5171 aggressive

-------------------------------------------------------------------------------
-----------------------------------------------------
Interface  UDLD      UDLD    UDLD           UDLD     Mode Interval
```

```
Retries  Tx    Rx    Rx          Rx         Transitions
           Config    State   Substate       Link
    Pkts  Pkts  Pkts disc.  Pkts drop.
--------------------------------------------------------------------------------
-------------------------------------------------
1/1/1      enabled   active  Bidirectional  unblock  FTV  7000          4
    0     0     0           0          0
1/1/2      enabled   active  Bidirectional  unblock  VTF  1000-90000    5
    2     2     0           0          1
1/1/3      enabled   active  Bidirectional  unblock  VTF  1000-90000    5
    2     2     0           0          1
```

# UDLD commands

## clear udld statistics

`clear udld statistics [interface <INTERFACE-NAME>]`

### Description

Clears UDLD statistics for all interfaces or a specific interface.

### Examples

Clearing all UDLD statistics on all interfaces:

```
switch# clear udld statistics
```

Clearing all UDLD statistics on interface 1/1/1:

```
switch# clear udld statistics interface 1/1/1
```

### Command History

| Release | Modification |
|---|---|
| 10.07 or earlier | -- |

### Command Information

| Platforms | Command context | Authority |
|---|---|---|
| All platforms | Manager (#) | Administrators or local user group members with execution rights for this command. |

## show udld

`show udld [interface <INTERFACE-NAME>]`

### Description

Displays UDLD information for all interfaces or for a specific interface.

| Parameter | Description |
|---|---|
| `interface <INTERFACE-NAME>` | Specifies the name of a logical interface on the switch, which can be:<br>■ An Ethernet interface associated with a physical port. Use the format **member/slot/port** (for example, **1/3/1**).<br>■ UDLD runs only on physical interfaces. LAGs, tunnels, and the like are not supported. However, UDLD can be configured individually on each port of a LAG or trunk group. Configuring UDLD on a trunk group primary port enables UDLD on that port only. |

## Examples

Displaying all UDLD information:

```
switch# show udld

Abbreviations:
 VTF - Verify-then-forward    FTV - Forward-then-verify
 NOR - RFC 5171 normal        AGG - RFC 5171 aggresive

------------------------------------------------------------------------
Interface  UDLD      UDLD      UDLD           UDLD    Mode  Interval
           Config    State     Substate       Link
------------------------------------------------------------------------
1/1/1      Disabled  Inactive  Undetermined   Unblock FTV   8000
1/1/2      Enabled   Active    Bidirectional  Unblock FTV   7000
1/1/3      Enabled   Active    Blocked        Block   FTV   7000
1/1/4      Enabled   Inactive  Uninitialized  Unblock NOR   7000
1/1/5      Enabled   Active    ErrDisabled    Block   AGG   7000
1/1/6      Disabled  Active    Detection      Unblock NOR   7000

-----------------------------------------------------------------
Retries  Tx       Rx       Rx          Rx          Transitions
         Pkts     Pkts     Pkts disc.  Pkts drop.
-----------------------------------------------------------------
4        4        54       123         123         1
7        1234567  1548421  23214       1878981     3
4        3        77871    2157        81878       1
5        50       0        0           0           0
3        150      25       0           2           1
3        6        54       123         23          1
```

Displaying information for interface **1/1/1**:

```
switch# show udld interface 1/1/1

Interface 1/1/1
 Config: Enabled
 State: Active
 Substate: Bidirectional
 Link: Unblock
 Version: Aruba OS
 Mode: Forward then verify
 Interval: 7000 milliseconds
 Retries: 7
 Tx: 1234567 packets
```

```
 Rx: 1548421 packets, 23214 discarded packets, 1878981 dropped packets
 Port transitions: 3
```

Displaying the UDLD enable interfaces information:

```
switch# show udld enabled

Abbreviations:
 VTF - Verify-then-forward    FTV - Forward-then-verify
 NOR - RFC 5171 normal        AGG - RFC 5171 aggresive

-------------------------------------------------------------------------------
-------------------------------------------------
Interface  UDLD      UDLD      UDLD           UDLD     Mode  Interval  Retries  Tx
      Rx       Rx          Rx          Transitions
           Config    State     Substate       Link
Pkts     Pkts     Pkts disc.  Pkts drop.
-------------------------------------------------------------------------------
-------------------------------------------------
2          Enabled   Active    Bidirectional  Unblock  FTV   7000      7
1234567  1548421  23214       1878981     3
3          Enabled   Active    Blocked        Block    FTV   7000      4        3
      77871    2157        81878       1
4          Enabled   Inactive  Uninitialized  Unblock  NOR   7000      5        50
      0        0           0           0
5          Enabled   Active    ErrDisabled    Block    AGG   7000      3
150      25       0           2           1
```

### Command History

| Release | Modification |
|---|---|
| 10.07 or earlier | -- |

### Command Information

| Platforms | Command context | Authority |
|---|---|---|
| All platforms | Operator (>) or Manager (#) | Operators or Administrators or local user group members with execution rights for this command. Operators can execute this command from the operator context (>) only. |

## udld

```
udld [disable]
no udld [disable]
```

### Description

Enables UDLD support on a physical interface. UDLD is disabled by default. UDLD is configured on a per-port basis and must be enabled at both ends of the link.

UDLD runs only on physical interfaces. LAGs, tunnels, and the like are not supported. However, UDLD can be configured individually on each port of a LAG or trunk group. Configuring UDLD on a trunk group's primary port enables UDLD on that port only.

The **no** form of this command disables UDLD support and resets all configuration values to their default settings.

| Parameter | Description |
|---|---|
| *disable* | Disables UDLD on the interface but retains all UDLD configuration settings. |

### Examples

Enabling UDLD on interface **1/1/1**:

```
switch(config)# interface 1/1/1
switch(config-if)# udld
```

Disabling UDLD on interface **1/1/1**:

```
switch(config)# interface 1/1/1
switch(config-if)# no udld
```

### Command History

| Release | Modification |
|---|---|
| 10.07 or earlier | -- |

### Command Information

| Platforms | Command context | Authority |
|---|---|---|
| All platforms | config-if | Administrators or local user group members with execution rights for this command. |

## udld interval

```
udld interval <TIME>
no udld interval [<TIME>]
```

### Description

Sets the packet transmission interval.

The **no** form of this command sets the packet transmission interval to the default value of 7000 ms.

The allowed values vary depending on the operation mode.

The default interval is 7000 ms (7 seconds) for both ArubaOS-Switch and RFC5171 operation modes.

Values must be specified as multiples of 10 ms (7000 ms is allowed but 7005 ms is not a valid setting).

Sessions under 100ms total detection time are susceptible to increasing processing load on the system. It is advisable to experiment with values that provide adequate detection times and system/protocol stability. Aruba recommends additional testing prior to configuring these sessions on a production environment.

However, these settings are recommended for specific deployments only, such as using UDLD for Ethernet Ring Protection Switching (ERPS) link-failure detection (ERPS is not supported on the 6000 or 6100). The minimum detection time appropriate for your environment depends on the specific device family and configuration on which the protocol and system load is running. Aruba recommends additional testing for these configurations. During testing, monitor for unexpected false positive detections (i.e., UDLD records a failure when there was not any) on the interfaces running UDLD. Such false positive failures are an indication that the interval configuration requires tuning and that the system load might not allow such configuration.

When configuring detection times under 100ms for LAG interfaces, consider adding the interface first to the LAG and then enabling UDLD in the interface, to avoid false positive link failure detections. Adding an interface to a LAG causes momentary control plane traffic interruption for up to 100ms, which UDLD detects as a link failure if the detection time is following the control traffic interruption interval.

| Parameter | Description |
|---|---|
| *<TIME>* | Specifies the packet transmission interval. Range: 200 ms to 90000 ms or 1000 ms to 90000 ms for the 6000 and 6100 Switch Series (in increments of 10). |

### Examples

Setting the packet transmission interval to **1000** ms on interface **1/1/1**.

```
switch(config)# interface 1/1/1
switch(config-if)# udld interval 1000
```

Setting the packet transmission interval on interface **1/1/1** to the default value.

```
switch(config)# interface 1/1/1
switch(config-if)# no udld interval
```

Trying to set the packet interval to 1055 ms on interface 1 is rejected because the interval must be specified as a multiple of 10:

```
switch(config)# interface 1
switch(config-if)# udld interval 1055
Invalid interval. The interval value must be between 20ms and 90000ms and should
be
specified as a multiple of 10, for example: 20, 100, 3000 or 90000.
```

Trying to set the packet interval to less than 7000 ms on interface 1 is rejected if using the RFC5171 mode.

```
switch(config)# interface 1
switch(config-if)# udld mode rfc5171 normal
switch(config-if)# udld interval 1000
Invalid interval. The interval must be equal or greater than 7000ms.
```

### Command History

| Release | Modification |
|---|---|
| 10.07 or earlier | -- |

### Command Information

| Platforms | Command context | Authority |
|---|---|---|
| All platforms | `config-if` | Administrators or local user group members with execution rights for this command. |

## udld mode

```
udld mode aruba-os {verify-then-forward | forward-then-verify}
udld mode rfc5171 <RFC5171-MODE>
no udld mode [[aruba-os [verify-then-forward | forward-then-verify]] | [rfc5171
[<RFC5171-MODE>]]]
```

### Description

Sets the operating mode.

The **no** form of this command sets the operating mode to the default value of **aruba-os** and **forward-then-verify**.

| Parameter | Description |
|---|---|
| `aruba-os {verify-then-forward \| forward-then-verify}` | Selects the ArubaOS mode to use. Use this mode when interconnecting with HPE PVOS/Brocade/Foundry switches. |
| `verify-then-forward` | In this mode:<br>■ Interfaces start as unblocked.<br>■ Once an interface is determined to be bidirectional, it is blocked if the retry limit is reached without receiving any UDLD packets.<br>■ Interfaces automatically unblock if a UDLD packet is received.<br>■ On failover, the UDLD state does not change if the (interval * retries) time is around 6 seconds. |
| `forward-then-verify` | In this mode:<br>■ Interfaces start as unblocked.<br>■ Interfaces transition to the unblocked state when receiving UDLD packets.<br>■ Once an interface is determined to be bidirectional, it is blocked if the retry limit is reached without receiving any UDLD packets.<br>■ Interfaces automatically unblock if a UDLD packet is received. |
| `rfc5171 <RFC5171-MODE>` | Selects the RFC5171 mode to use. Use this mode when interconnecting with third-party switches. |
| `normal` | In this mode:<br>■ Interfaces start as unblocked.<br>■ Interfaces do not block when the retry limit is reached without |

| Parameter | Description |
|---|---|
| | receiving any UDLD packets (plus 8 extra packets sent to the peer). Instead, an event is generated.<br>▪ Interfaces automatically unblock if a UDLD packet is received. |
| `aggressive` | In this mode:<br>▪ Interfaces start as unblocked.<br>▪ Once an interface is determined to be bidirectional, an interface will block when the retry limit is reached without receiving any UDLD packets (plus 8 extra packets sent to the peer).<br>▪ Interfaces implement a limited/reduced errDisabled recovery mechanism. When the interface's state goes to errDisabled, a maximum of 3 attempts (5 minutes apart) are triggered to try and bring up the interface in case the remote endpoint is still sending UDLD packets. After these 3 retries, the interface will remain blocked even if UDLD packets are received. The only way to unblock the interface when this occurs is to disable (and optionally re-enable) UDLD on the interface. The retry limit is reset once the interface becomes unblocked. |

## Examples

Setting the operating mode to **aruba-os** and **forward-then-verify** on interface **1/1/1**:

```
switch(config)# interface 1/1/1
switch(config-if)# udld mode aruba-os forward-then-verify
```

Setting the operating mode to **rfc5171** and **aggressive** on interface **1/1/1**:

```
switch(config)# interface 1/1/1
switch(config-if)# udld mode rfc5171 aggressive
```

Setting the operating mode on interface **1/1/1** to the default value:

```
switch(config)# interface 1/1/1
switch(config-if)# no udld mode
```

## Command History

| Release | Modification |
|---|---|
| 10.07 or earlier | -- |

## Command Information

| Platforms | Command context | Authority |
|---|---|---|
| All platforms | `config-if` | Administrators or local user group members with execution rights for this command. |

## udld retries

```
udld retries <COUNT>
no udld retries [<COUNT>]
```

### Description

Sets the UDLD retry count.

The **no** form of this command sets the retry count to the default of 4.

| Parameter | Description |
|---|---|
| *<COUNT>* | Specifies the UDLD retry count. Range: 3 to 10. Default: 4. |

### Examples

Setting the UDLD retry count to **5** on interface **1/1/1**:

```
switch(config)# interface 1/1/1
switch(config-if)# udld retries 5
```

Setting the UDLD retry count on interface **1/1/1** to the default value:

```
switch(config)# interface 1/1/1
switch(config-if)# no udld retries
```

### Command History

| Release | Modification |
|---|---|
| 10.07 or earlier | -- |

### Command Information

| Platforms | Command context | Authority |
|---|---|---|
| All platforms | `config-if` | Administrators or local user group members with execution rights for this command. |

# Chapter 10
# Private VLAN

The private VLAN (PVLAN) feature partitions a VLAN by grouping multiple sets of ports that need layer 2 traffic isolation from one another into independent broadcast sub domains. The VLAN that is being partitioned is referred to as the primary VLAN and the sub domains carved out of this primary VLAN are referred to as secondary VLANs. These secondary VLANs are also regular VLANs, constituted by a subgroup of ports of the original VLAN and identified by a unique VLAN ID. Depending on the level of isolation provided, secondary VLANs can be further classified into isolated and community VLANs. Traffic in the secondary domain will be seen inside the PVLAN domain and when the traffic leaves the PVLAN domain it will go only on the primary VLAN.

| Switch Series | Max primary VLAN instances | Max secondary VLANS under primary |
|---|---|---|
| 4100i | 32 | 8 |
| 6000 | 32 | 8 |
| 6100 | 32 | 8 |
| 6200 | 32 | 24 |
| 6300 | 32 | 24 |
| 6400 | 32 | 24 |
| 8325 | 32 | 24 |
| 8360 | 32 | 24 |
| 10000 | 512 | 24 |

## Terminology

- **Primary VLAN** - Root of the PVLAN domain. There can be multiple secondary VLANs associated with a primary VLAN, which uses the primary VLANs to communicate with hosts outside the PVLAN domain.
- **Secondary VLAN** - Term for both isolated and community VLANs.
- **Isolated VLAN** - A secured VLAN where hosts cannot communicate with each other through L2 switching.
- **Community VLAN** - A VLAN where hosts can communicate with each other through L2 switching. There can be multiple community VLANs associated with a primary VLAN.
- **Promiscuous port** - A port that is a member of the primary VLAN. These ports can send packets to all ports of the primary VLAN and ports of associated isolated and community VLANs. Promiscuous ports are used to communicate outside the PVLAN domain.

- **Secondary port** - A port that is a member of a secondary VLAN. Secondary ports which belong to community VLANs can send packets to all ports of the same community VLAN and to promiscuous ports of its primary VLAN. A port belonging to an isolated VLAN can only send traffic to promiscuous ports of its primary VLAN.
- **Inter-switch-link (ISL)** - A generic term used to describe the extension of a PVLAN domain across multiple switches. This is not to be confused with VSX-ISL. As secondary VLAN traffic traverses the inter-switch-links, all switches in the path use the secondary VLAN information carried in the traffic to ensure that PVLAN traffic forwarding rules are preserved.

Refer to the `show capacities private-vlan` command to find the maximum allowed PVLAN secondary ports on the system.

# Secondary Port Considerations

The secondary ports capacity generally depends on the hardware resources available. Some platforms do not have any restriction.

For platforms where restrictions already exist, the following usage modes are supported:

- Default mode
- Legacy mode

## Secondary Port Limits

| Switch platform | Number of PVLAN secondary ports (physical ports per line card or LAGs) allowed in legacy mode | Number of PVLAN secondary ports (physical ports per line card or LAGs) allowed in default mode |
|---|---|---|
| 4100/6000/6100 | No limit | NA (resource sharing mode is not applicable) |
| 6200/6300 | 24 | No limit |
| 6400/6400v2 | 24 | No limit |
| 6400 with v2-Aggregation-High-Bandwidth, v2-Core-High-Bandwidth, or v2-Leaf-Extended-High-Bandwidth profile configured | 48 | NA (resource sharing mode is not applicable) |
| 8100 | 24 | No limit |
| 8360 | 24 for JL720A/JL720C models. No limit for all other models. | No limit for JL720A/JL720C models. Resource sharing mode is not applicable for other models. |
| 8325/10000 | No limit | NA (resource sharing mode is not applicable) |

# Secondary Ports Usage Modes

## Default Mode

In the default mode, there is no limit on the number of secondary ports on switches which previously had a lower limit. This mode is turned **ON** by default.

Some switches have a limit of 24 secondary ports in the legacy mode. On platforms/LCs with 48 or more ports, there may be situations where more than 24 ports or LAGs might need to be configured as PVLAN secondary ports. The PVLAN default mode enables you to configure additional PVLAN secondary ports.

This mode is only applicable to switches that have a maximum of 24 secondary ports.

In this mode, multiple trunk ports as secondary ports can share the hardware resources in one or both of the following scenarios:

a. Primary VLAN to secondary VLAN mapping is the same.
b. Primary VLAN to secondary VLAN mapping has no overlap or is unique. This is also applicable to LAG ports.

**Example**:

In this example, all the secondary ports **(1/1/1** to **1/1/48**) can work as PVLAN secondary ports and would consume only one hardware resource.

```
vlan 100
    private-vlan primary
vlan 101
    private-vlan isolated primary-vlan 100
vlan 200
    private-vlan primary
vlan 201
    private-vlan community primary-vlan 200
interface 1/1/1-1/1/48
    vlan trunk allowed 101,201
    private-vlan port-type secondary
interface 1/1/49-1/1/50
    vlan trunk allowed 100,200
    private-vlan port-type promiscuous
```

When LAG member ports are spread across multiple line cards (or multiple member switches in a VSF), one hardware resource will be used in each line card (or VSF member) where the LAG has member ports. This resource may be shared with other physical ports or LAG members based on the VLAN membership configuration.

### Default mode limitations

While the default mode would enable most of the deployment scenarios that need more PVLAN ports, there might be some configurations that may result in hardware resources exhaustion. In such cases, the port will be brought down. There will be an associated event log and will be shown in **show private-vlan inconsistency** command output as well.

In the case of a LAG with member ports spread across multiple line cards (or multiple member switches in a VSF), it is possible that hardware resources are exhausted in certain line cards (or VSF member switches) only. In that case, the LAG member port belonging to the specific line card (or VSF member switch) would be brought down with a event log and will be shown in **show private-vlan inconsistency**

command output. The LAG member ports belonging to other line cards (or VSF member switch) will be functional.

If the configuration changes in a way that some of the previously used hardware resource can be made available, then the ports which were brought down due to hardware resource exhaustion can be brought up. The port bring up would be accompanied by an event log. The respective port entry would get removed from with **show private-vlan inconsistency** command output as well.

Examples for the type of configuration changes which can help to bring up the ports are:

- VLAN removal or addition for a port which is down due to hardware resource exhaustion in such a way that they can reuse an existing hardware resource.
- Change in PVLAN port type for other ports to no longer require a secondary port leading to a hardware resource to be free.

## Legacy Mode

In this mode, some platforms have a lower limit for the number of secondary ports.

There may be traffic disruption on PVLAN ports while moving to or from legacy mode during runtime.

It is also important to note the following:

- If a specific switch model or line card model has less ports than the limit mentioned above, then the applicable limit for that switch/line card will be the port count.
- **Limit with VSF:** The number of physical ports allowed to be PVLAN secondary ports from each VSF member switch is as mentioned above. If a LAG is configured as secondary port, one resource from each VSF member is internally reserved for each LAG. In that case, the number of additional physical ports/LAGs allowed as secondary ports is reduced by one on each VSF member.
- **Limit on switches with modular line cards:** The number of physical ports allowed as PVLAN secondary ports from each line card is as mentioned above. If a LAG is configured as a PVLAN secondary port, then one resource from each line card is internally reserved for each LAG. In that case, the number of additional physical ports/LAGs allowed as secondary ports is reduced by one on each line card.
- **Practical limit where limit is mentioned as "No limit":** The practical limit is the physical port count of the switch, including the count of maximum possible split ports.

Examples where each scenario has a limit of 24 PVLAN secondary ports:

- **Pizza box form factor standalone switch:** If two LAGs are already configured as PVLAN secondary ports, the number of physical ports allowed to be additional secondary ports is 22. The number of additional LAGs allowed as secondary ports is 22 if no physical port is configured.
- **VSF:** If two LAGs are already configured as PVLAN secondary ports, the number of physical ports allowed to be additional secondary ports from each VSF member will be 22. The number of additional LAGs allowed as secondary ports is 22 if no physical port is configured.
- **Chassis with modular line cards:** If two LAGS are already configured as PVLAN secondary port, the number of physical ports allowed to be additional secondary ports on each line card will be 22. The number of additional LAGs allowed as secondary ports will be 22 if no physical port is configured.

## PVLAN L2 interoperability

| Feature | Sub-features | Details |
|---|---|---|
| MAC management | Static MAC | MAC learned on primary VLAN will be replicated to secondary VLAN and vice versa. Type field in `show mac-address-table` will append “pv” for replicated MAC entries. |
| | Dynamic MAC | MAC learned on primary VLAN will be replicated to secondary VLAN and vice versa. Type field in `show mac-address-table` will append “pv” for replicated MAC entries. |
| Forwarding | Voice VLAN | Voice VLAN is agnostic with PVLAN. |
| | Static LAG | Similar limitations apply on VLAN membership as other physical port. |
| Loop detection and control | MSTP | All VLANs in a PVLAN domain need to be in same MSTP instance to avoid loops in primary and secondary VLANs. The `show private-vlan inconsistency` command displays VLANs that are disabled by PVLAN in case of misconfiguration. |
| | RPVST | Not supported with PVLAN. |
| | Loop Protect | PVLAN ports and VLANs can be loop protect enabled. |
| Link detection and control | UDLD | PVLAN ports can be UDLD enabled. |
| Device discovery | LLDP | Device detection will work via LLDP on PVLAN ports. |
| | CDP | Device detection will work via CDP on PVLAN ports. |
| | LACP | LACP protocol allowed to run on PVLAN ports. |
| Dynamic configuration | MVRP | Not supported with PVLAN. |
| | Protocol VLANs | Protocol VLANs (such as ARP, IPv4, IPv6, etc.) aren’t supported with PVLAN. |

## PVLAN L3 interoperability

| Feature | Details |
|---|---|
| L3 VLAN Interface | SVIs may only be configured for primary VLANs. The `show private-vlan inconsistency` command displays VLANs that are disabled by PVLAN in case of misconfiguration. |
| Routing protocols | Routing protocol configurations are only applicable to primary VLAN SVIs. |
| Neighbor entries | Neighbors on secondary VLANs are only learned on primary VLANs. |

| Feature | Details |
|---|---|
| ACL/PBR | Configurations are only applicable to primary VLAN SVIs and are applied internally on all associated secondary VLANs. |

If the primary VLAN has an SVI, one SVI will be internally reserved for each secondary VLAN under the primary. These secondary VLAN SVIs are counted when the number of SVIs in the system is considered. The combined total of configured SVIs and secondary VLAN reserved SVIs should not exceed the SVI capacity of the switch.

## PVLAN and security

Private VLAN and port type can be applied on the client port as part of the authorization process during port access authentication (802.1X, MAC authentication, or device profile.)

For more information on PVLAN Security, see the *Port access* chapter in the *Security Guide*.

| Feature | Details |
|---|---|
| MAC-auth | In case of any PVLAN inconsistencies, all authenticated clients on that port would move to unauthorized state. The clients are reauthorized once the inconsistency is removed on that port. |
| 802.1X | |
| LMA/device profile | |
| Port security | PVLAN agnostic. PVLAN and port-type can be configured in port-security enabled ports. |
| Radius VSA | VSA ID: 64 is added as a new authorization parameter for `Aruba-PVLAN-Port-Type`. |
| User role | PVLAN port-type configuration is added as a new parameter for `user role`. VLAN and port-type can be configured via local and downloadable user roles.<br>An example of user role configuration:<br>`port-access role dot1x-role-test`<br>`reauth-period 120`<br>`private-vlan port-type secondary`<br>`vlan access 902` |

## PVLAN and MCAST

| Feature | Sub-features | Details |
|---|---|---|
| IGMP/MLD snooping | Configuration | IGMP/MLD snooping when enabled or disabled on the primary VLAN would be internally enabled or disabled on all secondary VLANs. The configuration is ignored if applied on secondary VLANs. The `show private-vlan inconsistency` command will verify any configuration inconsistencies. The `show ip igmp-snooping` and `show ipv6 mld snooping` commands will show the group joined on the primary VLAN when hosts connected to |

| Feature | Sub-features | Details |
|---|---|---|
| | | secondary VLANs join the group. IGMP/MLD querier is expected on promiscuous or ISL ports. |
| PIM | Neighbor | PIM neighbors will only be detected on primary VLAN, ISL, and regular ports. If a PIM router is seen on a secondary port then a neighbor relationship will not be formed. |
| Multicast stream (bridged/routed) | N/A | A multicast source on primary or secondary VLAN can stream packets to a joined client in the same or different private VLAN domain in accordance with PVLAN traffic semantics. PIM has to be configured on the primary VLAN when the source and client are in different PVLAN domains.<br>The `show ip mroute` command will display a field called *PVLAN incoming interface* which displays the incoming interface for multicast source traffic. The *Incoming interface* field will show the primary VLAN where PIM is enabled. |

## PVLAN and VSF

| Feature | Details |
|---|---|
| VSF | VSF is supported. Switchover and failover are supported. PVLAN secondary and promiscuous ports can be on any member device. |

### VLAN operational state

- If the primary VLAN is set to administratively down, then all its secondary VLAN(s) will be down with the reason *pvlan_primary_down*.
- If a secondary VLAN is set to administratively down, it will be ignored.
- If there is no primary VLAN association for a secondary VLAN, that secondary will be set to down.

# Private VLAN commands

## diag-dump private-vlan basic

```
diag-dump private-vlan basic
```

### Description

Collects the debug information in the case of any issue in the PVLAN feature.

### Command History

| Release | Modification |
|---|---|
| 10.12 | Command introduced for 4100i, 6000, 6100, and 8100 Switch series |

| Release | Modification |
|---|---|
| 10.08 | Command introduced for 6200, 6300, 6400, 8100, 8360 Switch series |

### Command Information

| Platforms | Command context | Authority |
|---|---|---|
| 4100i<br>6000<br>6100<br>6200 | Operator (>) or Manager (#) | Operators or Administrators or local user group members with execution rights for this command. Operators can execute this command from the operator context (>) only. |

## private-vlan

```
private-vlan {primary | isolated | community} primary-vlan <VLAN-ID>
no private-vlan {primary | isolated | community} primary-vlan <VLAN-ID>
```

### Description

Configures a VLAN as either a primary, isolated, or community private VLAN and associates secondary VLANs to a primary VLAN.

The **no** form of this command removes the private VLAN configuration of a VLAN.

| Parameter | Description |
|---|---|
| `primary` | Configures the VLAN as PVLAN type primary.<br><br>**NOTE:** The number of primary VLANs are restricted to 512 instances for the Aruba 10000 Switch Series. All other switches that support PVLAN support up to 32 primary VLAN instances.<br><br>Up to 8 secondary VLANs can be configured under a primary VLAN for the Aruba 4100i, 6000, and 6100 Switch Series.<br><br>Up to 24 secondary VLANs can be configured under a primary VLAN for the Aruba 6200, 6300, 6400, 8325, 8360, and 10000 Switch Series. |
| `isolated` | Configures the VLAN as PVLAN type isolated. |
| `community` | Configures the VLAN as PVLAN type community. |
| *<VLAN-ID>* | Specifies the primary VLAN ID to be associated. Range: 2-4094. |

### Examples

Configuring VLAN 100 as PVLAN type primary

```
switch(config)# vlan 100
switch(config-vlan-100)# private-vlan primary
```

Removing the private VLAN configuration from VLAN 100

```
switch(config)# vlan 100
switch(config-vlan-100)# no private-vlan primary
```

Associating community VLAN 200 with primary VLAN 100

```
switch(config)# vlan 200
switch(config-vlan-200)# private-vlan community primary-vlan 100
```

Removing the association of community VLAN 200 from primary VLAN 100

```
switch(config)# vlan 200
switch(config-vlan-200)# no private-vlan community primary-vlan 100
```

Associating isolated VLAN 300 with primary VLAN 100

```
switch(config)# vlan 300
switch(config-vlan-300)# private-vlan isolated primary-vlan 100
```

Removing the association of isolated VLAN 300 from primary VLAN 100

```
switch(config)# vlan 300
switch(config-vlan-300)# no private-vlan isolated primary-vlan 100
```

### Command History

| Release | Modification |
|---|---|
| 10.12 | Command introduced for 4100i, 6000, 6100, and 8100 Switch series |
| 10.08 | Command introduced for 6200, 6300, 6400, 8100, 8360 Switch series |

### Command Information

| Platforms | Command context | Authority |
|---|---|---|
| 4100i<br>6000<br>6100<br>6200 | config-vlan-*<VLAN-ID>* | Administrators or local user group members with execution rights for this command. |

## private-vlan port-type

```
private-vlan port-type {promiscuous | secondary}
no private-vlan port-type {promiscuous | secondary}
```

### Description

Configures a port as either promiscuous or secondary when in the **interface** context. Configures PVLAN port type for a role when in the **config-pa-role** context. Multiple secondary VLANs associated with the same primary VLAN cannot be tagged under a secondary port.

The **no** form of this command removes the PVLAN port type configuration.

When an interface has been configured as "vlan trunk allowed all" `private-vlan port-type` cannot be configured.

| Parameter | Description |
|---|---|
| `promiscuous` | Configures the port as promiscuous. |
| `secondary` | Configures the port as secondary. |

## Examples

Configuring interface 1/1/1 as promiscuous:

```
switch(config)# interface 1/1/1
switch(config-if)# private-vlan port-type promiscuous
```

Configuring port type as secondary for the port access role:

```
switch(config)# port-access role Role1
switch(config-pa-role)# private-vlan port-type secondary
```

Removing the promiscuous configuration from interface 1/1/1:

```
switch(config)# interface 1/1/1
switch(config-if)# no private-vlan port-type promiscuous
```

Removing port type as secondary for the port access role:

```
switch(config)# port-access role Role1
switch(config-pa-role)# no private-vlan port-type secondary
```

## Command History

| Release | Modification |
|---|---|
| 10.12 | Command introduced for 4100i, 6000, 6100, and 8100 Switch series |
| 10.08 | Command introduced for 6200, 6300, 6400, 8100, 8360 Switch series |

## Command Information

| Platforms | Command context | Authority |
|---|---|---|
| 4100i<br>6000<br>6100<br>6200 | `config-if`<br>`config-pa-role` | Administrators or local user group members with execution rights for this command. |

## show capacities private-vlan

```
show capacities private-vlan
```

### Description

Shows the maximum number of primary and secondary VLANs per domain and secondary ports per LC that can be configured.

### Examples

Showing the private VLAN capacity on a 4100i:

```
switch# show capacities private-vlan
System Capacities: Filter Private-VLAN
Capacities Name
                        Value
-----------------------------------------------------------------
Maximum number of primary VLANs allowed to be created
   for Private-VLAN on the system                              32
Maximum number of secondary VLANs allowed to be created
   for a specific private VLAN                                  8
```

### Command History

| Release | Modification |
|---|---|
| 10.12 | Command introduced for 4100i, 6000, 6100, and 8100 Switch series |
| 10.08 | Command introduced for 6200, 6300, 6400, 8100, 8360 Switch series |

### Command Information

| Platforms | Command context | Authority |
|---|---|---|
| 4100i<br>6000<br>6100<br>6200 | Operator (>) or Manager (#) | Operators or Administrators or local user group members with execution rights for this command. Operators can execute this command from the operator context (>) only. |

## show capacities-status private-vlan

```
show capacities-status private-vlan
```

### Description

Shows the number of primary VLANs currently configured and the maximum capacity of primary VLANs on the switch.

### Examples

Showing the current capacity status of private-VLAN on the switch

```
switch# show capacities-status private-vlan
System Capacities Status: Filter Private-VLAN
Capacities Status Name                                          Value Maximum
---------------------------------------------------------------------------
Number of Private-VLAN domains currently configured                 2      32
```

### Command History

| Release | Modification |
|---|---|
| 10.12 | Command introduced for 4100i, 6000, 6100, and 8100 Switch series |
| 10.08 | Command introduced for 6200, 6300, 6400, 8100, 8360 Switch series |

### Command Information

| Platforms | Command context | Authority |
|---|---|---|
| 4100i<br>6000<br>6100<br>6200 | Operator (>) or Manager (#) | Operators or Administrators or local user group members with execution rights for this command. Operators can execute this command from the operator context (>) only. |

## show private-vlan

```
show private-vlan [type {<VLAN-ID> | primary | isolated | community}]
```

### Description

Shows the private VLAN configuration for all private VLANs or the private VLAN type specified.

| Parameter | Description |
|---|---|
| <VLAN-ID> | Specifies a list of VLANs. Range: 2-4094. |
| primary | Shows primary private VLANs. |
| isolated | Shows isolated private VLANs. |
| community | Shows community private VLANs. |

### Examples

Showing all private VLANs

```
switch# show private-vlan
-------------------------------------------
Primary   Isolated          Community
-------------------------------------------
100       201               -
342       -                 1342,3000-3022
343       -                 1343
344       -                 1344
345       -                 1345
```

Showing private VLANs 100 through 102

```
switch# show private-vlan type 100-102
------------------
VLAN       Type
------------------
100        Primary
101        Isolated
102        Community
```

Showing all primary VLANs

```
switch# show private-vlan type primary
------------------
VLAN       Type
------------------
100        Primary
200        Primary
300        Primary
400        Primary
500        Primary
600        Primary
605        Primary
700        Primary
705        Primary
```

## Command History

| Release | Modification |
|---|---|
| 10.12 | Command introduced for 4100i, 6000, 6100, and 8100 Switch series |
| 10.08 | Command introduced for 6200, 6300, 6400, 8100, 8360 Switch series |

## Command Information

| Platforms | Command context | Authority |
|---|---|---|
| 4100i<br>6000<br>6100<br>6200 | Operator (>) or Manager (#) | Operators or Administrators or local user group members with execution rights for this command. Operators can execute this command from the operator context (>) only. |

# show private-vlan association

`show private-vlan association <VLAN-ID>`

## Description

Shows primary and secondary VLAN associations for all private VLANs or a specified private VLAN.

| Parameter | Description |
|---|---|
| *<VLAN-ID>* | Specifies a list of VLANs. Range: 2-4094. |

## Examples

Showing all private VLAN associations

```
switch# show private-vlan association
--------------------------------------------------
Primary   Isolated   Community
--------------------------------------------------
100       101        102,103
200       201        205,210-214
300       301        -
400       -          405-410,411
500       -          502,504,506-508,510,512,514,
                     516,518
600       601,603,   -
605
700       701,703,   707-709,711,713-715,717-719,
          705        721,723-724
```

Showing private VLAN associations for VLAN 100

```
switch# show private-vlan association 100
--------------------------------------------------
Primary   Isolated   Community
--------------------------------------------------
100       101        102,103
```

## Command History

| Release | Modification |
|---|---|
| 10.12 | Command introduced for 4100i, 6000, 6100, and 8100 Switch series |
| 10.08 | Command introduced for 6200, 6300, 6400, 8100, 8360 Switch series |

## Command Information

| Platforms | Command context | Authority |
|---|---|---|
| 4100i<br>6000 | Operator (>) or Manager (#) | Operators or Administrators or local user group members with execution rights for this command. Operators can execute this |

| Platforms | Command context | Authority |
|---|---|---|
| 6100<br>6200 | | command from the operator context (>) only. |

## show private-vlan inconsistency

```
show private-vlan inconsistency
```

### Description

Shows the list of interfaces and VLANs which are disabled or ignored by private VLAN due to private VLAN configuration and operational inconsistencies.

Possible interface inconsistencies:

- Hardware resource allocation failure
- Interface is a member of multiple secondary VLANs in the same domain
- Interface is a member of both primary and secondary VLAN
- Interface of private vlan port-type promiscuous is not allowed to join secondary VLAN
- Protocol VLANs and private VLANs are mutually exclusive features
- Interface of private vlan port-type secondary is not allowed to join the primary VLAN
- Interface has reached the private-vlan port limit of 24 ports (only applicable for the Aruba 6200 Switch Series)
- Interface is a member of a secondary VLAN which has an SVI configured on it
- Interface **trunk-allowed-all** configuration is not allowed on promiscuous or secondary private-vlan port-type
- VSX ISL configuration is not allowed on private-vlan ports

Possible VLAN inconsistencies:

- Default VLAN is not allowed to join private-vlan domain
- ERPS instances must match for all VLANs in a private-VLAN domain
- VLAN has invalid or no private-vlan primary VLAN association
- MSTP instances must match for all VLANs in a private-VLAN domain
- MVRP and private-VLAN are mutually exclusive features
- VLAN has no primary associated VLAN
- VLAN has reached the private VLAN limit of 32 primary VLANs for the Aruba 4100i, 6000, 6100, 6200, 6300, 6400, 8325, and 8360 Switch Series. (The private VLAN limit is 512 on the Aruba 10000 Switch Series).
- RPVST and private VLAN are mutually exclusive features
- VLAN has reached the private VLAN limit of 24 secondary VLANs on the Aruba 6200, 6300, 6400, 8325, 8360, and 10000 Switch Series or 8 secondary VLANs on the Aruba 4100i, 6000, or 6100 Switch Series.
- Smartlink groups must match for all VLANs in a private-VLAN domain
- VLAN translation and private-VLAN are mutually exclusive features
- VLAN is a secondary VLAN with SVI configured

- Primary VLAN's IGMP snooping configuration is applied
- Primary VLAN's MLD snooping configuration is applied
- Primary VLAN's ND snooping configuration is applied
- Primary VLAN's DHCPV4 snooping configuration is applied
- Primary VLAN's DHCPV6 snooping configuration is applied
- Primary VLAN's CIPT configuration is applied

### Examples

Showing interfaces which have been disabled due to private VLAN inconsistencies. In the example below vlan101, vlan201, and vlan301 are secondary VLANs:

```
switch# show private-vlan inconsistency
------------------------------------------------------------------------
Interface/VLAN   Action    Inconsistency-Reason
------------------------------------------------------------------------
1/1/1            Down      Interface is a member of multiple secondary VLANs
1/2/5            Down      Interface is a member of both primary and secondary
VLAN
vlan20           Down      VLAN has invalid or no private-vlan primary VLAN
association
vlan101          Ignore    Primary VLAN's IGMP snooping config is applied.
vlan201          Ignore    Primary VLAN's ND snooping config is applied.
vlan301          Ignore    Primary VLAN's DHCPV4 snooping config is applied.
```

### Command History

| Release | Modification |
|---|---|
| 10.12 | Command introduced for 4100i, 6000, 6100, and 8100 Switch series |
| 10.08 | Command introduced for 6200, 6300, 6400, 8100, 8360 Switch series |

### Command Information

| Platforms | Command context | Authority |
|---|---|---|
| 4100i<br>6000<br>6100<br>6200 | Operator (>) or Manager (#) | Operators or Administrators or local user group members with execution rights for this command. Operators can execute this command from the operator context (>) only. |

## show private-vlan port-type

```
show private-vlan port-type
```

### Description

Shows all the private VLAN port type configurations.

### Examples

Showing the ports with private-vlan port-type configuration

```
switch# show private-vlan port-type
--------------------------------------------------
Port           Port Type
--------------------------------------------------
1/1/1          promiscuous
1/1/2          secondary
```

### Command History

| Release | Modification |
|---|---|
| 10.12 | Command introduced for 4100i, 6000, 6100, and 8100 Switch series |
| 10.08 | Command introduced for 6200, 6300, 6400, 8100, 8360 Switch series |

### Command Information

| Platforms | Command context | Authority |
|---|---|---|
| 4100i<br>6000<br>6100<br>6200 | Operator (>) or Manager (#) | Operators or Administrators or local user group members with execution rights for this command. Operators can execute this command from the operator context (>) only. |

## show running-configuration private-vlan

```
show running-configuration private-vlan
```

### Description

Shows all private VLAN configurations on the switch.

### Examples

Showing the current private VLAN configuration

```
switch# show running-configuration private-vlan
vlan 300
private-vlan type primary
vlan 100
private-vlan type isolated primary-vlan 300
vlan 200
private-vlan type community primary-vlan 300
interface 1/1/1
vlan trunk allowed 300
private-vlan port-type promiscuous
interface 1/1/2
vlan trunk allowed 100
private-vlan port-type secondary
interface 1/1/3
vlan trunk allowed 200
private-vlan port-type secondary
`````
```

### Command History
```

| Release | Modification |
|---|---|
| 10.12 | Command introduced for 4100i, 6000, 6100, and 8100 Switch series |
| 10.08 | Command introduced for 6200, 6300, 6400, 8100, 8360 Switch series |

### Command Information

| Platforms | Command context | Authority |
|---|---|---|
| 4100i<br>6000<br>6100<br>6200 | Operator (>) or Manager (#) | Operators or Administrators or local user group members with execution rights for this command. Operators can execute this command from the operator context (>) only. |

## show tech private-vlan

```
show tech private-vlan
```

### Description

Shows the output of **show tech** for the private-VLAN feature.

### Example

Showing the output of **show tech** for private-VLAN

```
switch# show tech private-vlan
=====================================================
Show Tech executed on Mon Sep 28 06:05:02 2020
=====================================================
=====================================================
[Begin] Feature private-vlan
=====================================================
*********************************
Command : show running-config private-vlan
*********************************
vlan 100
private-vlan primary
vlan 101
private-vlan isolated primary-vlan 100
vlan 102
private-vlan community primary-vlan 100
vlan 200
private-vlan primary
vlan 201
private-vlan community primary-vlan 200
interface 1/1/1
vlan access 1
private-vlan promiscuous
interface 1/1/2
vlan access 1
private-vlan secondary
*********************************
Command : show private-vlan type
```

```
********************************
--------------------
VLAN      Type
--------------------
100       primary
101       isolated
102       community
200       primary
201       community
********************************
Command : show private-vlan association
********************************
------------------------------------------
Primary   Isolated          Community
------------------------------------------
100       101               102
200       -                 201
********************************
Command : show private-vlan port-type
********************************
----------------------
Port      Port-type
----------------------
1/1/1     promiscuous
1/1/2     secondary
======================================================
[End] Feature private-vlan
======================================================
======================================================
Show Tech commands executed successfully
======================================================
```

## Command History

| Release | Modification |
|---|---|
| 10.12 | Command introduced for 4100i, 6000, 6100, and 8100 Switch series |
| 10.08 | Command introduced for 6200, 6300, 6400, 8100, 8360 Switch series |

## Command Information

| Platforms | Command context | Authority |
|---|---|---|
| 4100i<br>6000<br>6100<br>6200 | Operator (>) or Manager (#) | Operators or Administrators or local user group members with execution rights for this command. Operators can execute this command from the operator context (>) only. |

# Chapter 11
# Support and Other Resources

## Accessing HPE Aruba Networking Support

| | |
|---|---|
| HPE Aruba Networking Support Services | https://www.arubanetworks.com/support-services/ |
| AOS-CX Switch Software Documentation Portal | https://www.arubanetworks.com/techdocs/AOS-CX/help_portal/Content/home.htm |
| HPE Aruba Networking Support Portal | https://networkingsupport.hpe.com/home |
| North America telephone | 1-800-943-4526 (US & Canada Toll-Free Number)<br>+1-408-754-1200 (Primary - Toll Number)<br>+1-650-385-6582 (Backup - Toll Number - Use only when all other numbers are not working) |
| International telephone | https://www.arubanetworks.com/support-services/contact-support/ |

Be sure to collect the following information before contacting Support:

- Technical support registration number (if applicable)
- Product name, model or version, and serial number
- Operating system name and version
- Firmware version
- Error messages
- Product-specific reports and logs
- Add-on products or components
- Third-party products or components

### Other useful sites

Other websites that can be used to find information:

| | |
|---|---|
| Airheads social forums and Knowledge Base | https://community.arubanetworks.com/ |
| HPE Aruba Networking Hardware Documentation and Translations Portal | https://www.arubanetworks.com/techdocs/hardware/DocumentationPortal/Content/home.htm |

| | |
|---|---|
| HPE Aruba Networking software | https://networkingsupport.hpe.com/downloads |
| Software licensing and Feature Packs | https://lms.arubanetworks.com/ |
| End-of-Life information | https://www.arubanetworks.com/support-services/end-of-life/ |
| HPE Aruba Networking Developer Hub | https://developer.arubanetworks.com/ |

# Accessing Updates

You can access updates from the HPE Aruba Networking Support Portal at https://networkingsupport.hpe.com.

Some software products provide a mechanism for accessing software updates through the product interface. Review your product documentation to identify the recommended software update method.

To subscribe to eNewsletters and alerts:

https://networkingsupport.hpe./notifications/subscriptions (requires an active HPE Aruba Networking Support Portal account to manage subscriptions). Security notices are viewable without an HPE Aruba Networking Support Portal account.

# Warranty Information

To view warranty information for your product, go to https://www.arubanetworks.com/support-services/product-warranties/.

# Regulatory Information

To view the regulatory information for your product, view the *Safety and Compliance Information for Server, Storage, Power, Networking, and Rack Products*, available at https://www.hpe.com/support/Safety-Compliance-EnterpriseProducts

### Additional regulatory information

HPE Aruba Networking is committed to providing our customers with information about the chemical substances in our products as needed to comply with legal requirements, environmental data (company programs, product recycling, energy efficiency), and safety information and compliance data, (RoHS and WEEE). For more information, see https://www.arubanetworks.com/company/about-us/environmental-citizenship/.

# Documentation Feedback

HPE Aruba Networking is committed to providing documentation that meets your needs. To help us improve the documentation, send any errors, suggestions, or comments to Documentation Feedback (docsfeedback-switching@hpe.com). When submitting your feedback, include the document title, part number, edition, and publication date located on the front cover of the document. For online help

content, include the product name, product version, help edition, and publication date located on the legal notices page.