# HP 5920 & 5900 Switch Series

OpenFlow

Configuration Guide

# Contents

# Configuring OpenFlow

Software-Defined Networking (SDN) was developed to meet the growing requirements of virtualization technologies and data networks. SDN uses software to separate controlling functions from data forwarding, and provides simple, flexible device operations and high extensibility.

OpenFlow is the communication interface between a controller and network devices to implement SDN. With OpenFlow, you can perform centralized data forwarding management for physical and virtual devices.

## Overview

OpenFlow separates the data forwarding and routing decision functions. It keeps the flow-based forwarding function and employs a separate controller to make routing decisions. A switch communicates with the controller through a secure channel.

**Figure 1 OpenFlow network diagram**
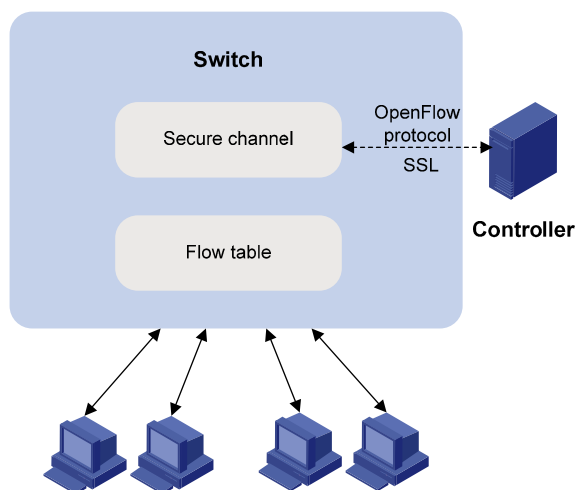


## Basic concepts

### OpenFlow switch

OpenFlow switches are classified into the following types:

- **OpenFlow-only**—Supports only OpenFlow operation.
- **OpenFlow-hybrid**—Supports both OpenFlow operation and traditional Ethernet switching operations. Switches of this series are OpenFlow-hybrid switches.

### OpenFlow port

OpenFlow supports the following types of ports:

- **Physical port**—Corresponds to a hardware interface of a switch, such as an Ethernet interface. A physical port can be either an ingress port or an output port.

1

- **Logical port**—Does not correspond to a hardware interface of a switch and might be defined by non-OpenFlow methods, such as an aggregate interface. A logical port can be either an ingress port or an output port.
- **Reserved port**—Defined by OpenFlow to specify forwarding actions. Reserved ports include the following types:
  - **All**—All OpenFlow ports that can be used to forward a packet.
  - **Controller**—OpenFlow controller.
  - **Table**—Flow table.
  - **In Port**—Packet ingress port.
  - **Any**—Generic port description. The port cannot be used as an ingress port or output port.
  - **Local**—Local CPU.
  - **Normal**—Normal forwarding process.
  - **Flood**—Flooding.

  Except the **Any** type, all reserved ports can be used only as output ports.

## OpenFlow flow table

An OpenFlow switch matches packets against one or more user-defined flow tables. A flow table consists of flow entries, and packets are matched based on the matching precedence of flow entries.

**Figure 2 Components of a flow entry**

| Match Fields | Priority | Counters | Instructions | Timeouts | Cookie |
|---|---|---|---|---|---|

A flow entry contains the following fields:

- **Match fields**—Matching rules of the flow entry. These consist of the ingress port, packet headers, and metadata specified by the previous table.
- **Priority**—Matching precedence of the flow entry. A packet is matched against the table and only the highest priority flow entry that matches the packet is selected.
- **Counters**—Counts of the packets that match the flow entry.
- **Instructions**—To modify the action set or pipeline processing. These include the following types:
  - **Meter**—Directs the packets to the specified meter to limit the rate of the packets.
  - **Apply-Actions**—Applies the specified actions in the action list immediately.
  - **Clear-Actions**—Clears all the actions in the action set immediately.
  - **Write-Actions**—Modifies all the actions in the action set immediately.
  - **Write-Metadata**—Modifies packets between two flow tables if there are multiple flow tables.
  - **Goto-Table**—Indicates the next flow table in the processing line.

  Actions are executed in one of the following ways:
  - **Action Set**—When the instruction set of a flow entry does not contain a **Goto-Table** instruction, pipeline processing stops and the actions in the action set are executed. An action set contains a maximum of one action of each type.
  - **Action List**—The actions in the action list are executed immediately in the order specified by the action list. The effect of those actions is cumulative.
- **Timeouts**—Maximum amount of idle time or hard time for the flow entry.
  - **idle Time**—The flow entry is removed when it has matched no packets during the idle time.

- hard Time—The flow entry is removed when the hard time timeout is exceeded, regardless of whether or not it has matched packets.
- **Cookies**—Flow entry identifier specified by the controller.

Every flow table must support a table-miss flow entry to process table misses. The table-miss flow entry specifies how to process packets unmatched by other flow entries in the flow table. The table-miss flow entry wildcards all match fields (all fields omitted) and has the lowest priority 0. The table-miss flow entry behaves in most ways like any other flow entry.

## OpenFlow pipeline

The OpenFlow pipeline processing defines how packets interact with flow tables contained by a switch.

The flow tables of an OpenFlow switch are sequentially numbered, starting at 0. The packet is first matched against flow entries of first flow table: flow table 0. A flow entry can only direct a packet to a flow table number which is greater than its own flow table number.

When a packet matches a flow entry, the OpenFlow switch updates the action set for the packet and passes the packet to the next flow table. In the last flow table, the OpenFlow switch executes all actions to modify packet contents and specify the output port for packet forwarding. If the instruction set of one of the flow tables contains an action list, the OpenFlow switch executes the actions to modify a copy of the packet immediately in this table.

**Figure 3 OpenFlow forwarding workflow**
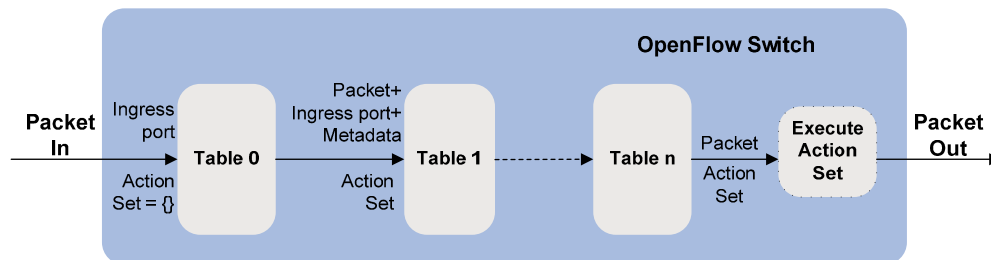


OpenFlow flow tables include the following types:
- **MAC-IP**—Combines the MAC address table and FIB table.

  A MAC-IP flow table provides the following match fields:
  - Destination MAC address
  - VLAN
  - Destination IP address

  A MAC-IP flow table provides the following actions:
  - Modifying the destination MAC address
  - Modifying the source MAC address
  - Modifying the VLAN
  - Specifying the output port
- **Extensibility**—Provides more matching fields and actions than a MAC-IP flow table does.

## Group table

The ability for a flow entry to point to a group enables OpenFlow to represent additional methods of forwarding. A group table consists of group entries.

**Figure 4 Components of a group entry**

| Group Identifier | Group Type | Counters | Action Buckets |
|---|---|---|---|

A group entry contains the following fields:

- **Group Identifier**—A 32 bit unsigned integer uniquely identifying the group.
- **Group Type**—Type of the group.
- **Counters**—Updated when packets are processed by a group.
- **Action Buckets**—An ordered list of action buckets, where each action bucket contains a set of actions to execute and associated parameters.

## Meter table

Meters enable OpenFlow to implement various simple QoS operations, such as rate-limiting. A group table consists of meter entries.

**Figure 5 Components of a meter entry**

| Meter Identifier | Meter Bands | Counters |
|---|---|---|

A meter entry contains the following fields:

- **Meter Identifier**—A 32 bit unsigned integer uniquely identifying the meter.
- **Meter Bands**—Each meter can have one or more meter bands. Each band specifies the rate at which the band applies and the way packets should be processed. If the current rate of packets exceeds the rate of multiple bands, the band with the highest configured rate is used.
- **Counters**—Updated when packets are processed by a meter.

**Figure 6 Components of a meter band**

| Band Type | Rate | Counters | Type Specific arguments |
|---|---|---|---|

A meter band contains:

- **Band Type**—Defines how packets are processed. Packets that exceed the band rate are dropped.
- **Rate**—Used by the meter to select the meter band, defines the lowest rate at which the band can apply.
- **Counters**—Updated when packets are processed by a band.

**Type Specific Arguments**—Some band types have optional arguments.

# OpenFlow instance

You can configure one or more OpenFlow instances on the same device. A controller considers each OpenFlow instance as a separate OpenFlow switch and deploys forwarding instructions to it.

In this chapter, an OpenFlow switch is the same as an OpenFlow instance, unless otherwise specified.

## Associated VLAN

When an OpenFlow instance is associated with VLANs, the flow tables take effect on packets only within these VLANs.

### Activation and reactivation

The controller can deploy flow entries only to OpenFlow instances that are activated.

An activated OpenFlow instance need be reactivated when any of the following parameters are changed:

- Associated VLANs
- Flow tables
- Maximum number of supported flow entries

After reactivation, the OpenFlow instance is disconnected from all controllers and reconnects to them.

### OpenFlow instance port

An OpenFlow switch sends information about the following ports to the controller:

- Physical ports
- Logical ports
- Reserved ports of the local type

These ports belong to the VLANs that are associated with the OpenFlow instance only when all associated VLANs are within the list of the VLANs to which the ports are assigned. However, if the **loosen** mode is used, a port belongs to the OpenFlow instance when VLANs that are associated with the OpenFlow instance overlap with the VLANs to which the port is assigned.

## Protocols and standards

*OpenFlow Switch Specification Version 1.3.1*

# OpenFlow configuration task list

| Tasks at a glance |
| --- |
| (Required.) Configure an OpenFlow instance:<br>1. (Required.) Configuring OpenFlow instances<br>2. (Required.) Configuring an OpenFlow instance:<br>  o (Required.) Associating an OpenFlow instance with VLANs<br>  o (Optional.) Configuring flow table IDs<br>  o (Optional.) Setting the connection mode for an OpenFlow instance to establish connections to controllers<br>  o (Optional.) Configuring the maximum number of flow entries<br>  o (Optional.) Configuring in-band management VLANs<br>  o (Optional.) Disabling MAC address learning in the VLANs associated with an OpenFlow instance<br>  o (Optional.) Configuring the datapath ID for an OpenFlow instance<br>3. (Required.) Activating or reactivating an OpenFlow instance |
| (Required.) Configure controllers for an OpenFlow switch:<br>• (Required.) Configuring controllers and main connections<br>• (Optional.) Setting the connection interruption mode |
| (Optional.) Setting OpenFlow timers |
| (Optional.) Configuring OpenFlow to support dynamic MAC addresses |

# Configuring OpenFlow instances

To use LLDP together with OpenFlow, you must enable LLDP globally on OpenFlow switches. To prevent LLDP from affecting topology discovery of OpenFlow controllers, HP recommends that you disable LLDP on ports of OpenFlow instances. For more information about LLDP, see *Layer 2—LAN Switching Configuration Guide*.

## Creating an OpenFlow instance

| Step | Command | Remarks |
|------|---------|---------|
| 1. Enter system view. | **system-view** | N/A |
| 2. Create an OpenFlow instance and enter OpenFlow instance view. | **openflow instance** *instance-id* | By default, no OpenFlow instance exists. |
| 3. (Optional.) Specify a description for the OpenFlow instance. | **description** *text* | By default, an OpenFlow instance does not have a description. |

## Associating an OpenFlow instance with VLANs

When you associate an OpenFlow instance with VLANs, follow these guidelines:

- Do not associate multiple OpenFlow instances to the same VLAN. Otherwise, VLAN traffic cannot be correctly processed.
- When you activate an OpenFlow instance that is associated with non-existent VLANs, the system automatically creates the VLANs. Do not delete any of these VLANs after the OpenFlow instance is activated.

To associate an OpenFlow instance with VLANs:

| Step | Command | Remarks |
|------|---------|---------|
| 1. Enter system view. | **system-view** | N/A |
| 2. Enter OpenFlow instance view. | **openflow instance** *instance-id* | N/A |
| 3. Associate the OpenFlow instance with VLANs. | **classification vlan** *vlan-id* [ **mask** *vlan-mask* ] [ **loosen** ] | By default, an OpenFlow instance is not associated with any VLAN. |

## Configuring flow table IDs

You can configure one MAC-IP flow table and one extensibility flow table for an OpenFlow instance, and the MAC-IP flow table ID must be smaller than the extensibility flow table ID.

To configure flow table IDs for an OpenFlow instance:

| Step | Command | Remarks |
|------|---------|---------|
| 1. Enter system view. | **system-view** | N/A |

| Step | Command | Remarks |
|------|---------|---------|
| 2. Enter OpenFlow instance view. | **openflow instance** *instance-id* | N/A |
| 3. Configure the flow table ID. | **flow-table** { **extensibility** *table-id* \| **mac-ip** *table-id* }* | By default, OpenFlow supports only one flow table with an ID of 0, which is the extensibility type. |

# Setting the connection mode for an OpenFlow instance to establish connections to controllers

The following connection modes are available for an OpenFlow instance to establish connections to controllers:

- **single**—When the connection mode is **single**, an OpenFlow establishes a connection to only one controller at a time, and the other controllers back up the controller. When the current connection is broken, the OpenFlow instance attempts to connect to the next controller until it successfully establishes a connection.

- **multiple**—When the connection mode is **multiple**, an OpenFlow can establish connections to multiple controllers at a time. When the OpenFlow instance fails to connect to a controller or the connection to a controller is broken, the OpenFlow instance attempts to reconnect to the controller after the reconnection interval expires until it successfully establishes a connection to the controller.

To set the connection mode for an OpenFlow instance to establish connections to controllers:

| Step | Command | Remarks |
|------|---------|---------|
| 1. Enter system view. | **system-view** | N/A |
| 2. Enter OpenFlow instance view. | **openflow instance** *instance-id* | N/A |
| 3. Set the connection mode for the OpenFlow instance to establish connections to controllers. | **controller mode** { **multiple** \| **single** } | By default, the connection mode is **multiple**. |

# Configuring the maximum number of flow entries

To improve OpenFlow availability, extensibility flow table can have a maximum number of flow entries. When entries in a table reaches the maximum number, the OpenFlow instance does not accept new flow entries for that table and sends a deployment failure notification to the controller.

To configure the maximum number of flow entries that each extensibility flow table supports:

| Step | Command | Remarks |
|------|---------|---------|
| 1. Enter system view. | **system-view** | N/A |
| 2. Enter OpenFlow instance view. | **openflow instance** *instance-id* | N/A |
| 3. Configure the maximum number of extensibility flow entries. | **flow-entry max-limit** *limit-value* | By default, an OpenFlow extensibility flow table supports at most 65535 flow entries. |

# Configuring in-band management VLANs

In-band management VLANs of an OpenFlow instance are part of the VLANs associated with the OpenFlow instance. In-band management VLANs are used to establish connections between the OpenFlow instance and controllers in an OpenFlow instance.

When the in-band management VLANs are configured, the data packets within the in-band management VLANs are not forwarded through OpenFlow, and the ports that are assigned to only in-band management VLANs are not OpenFlow ports. Before configuring in-band management VLANs, you must plan the network.

To configure in-band management VLANs:

| Step | Command | Remarks |
|------|---------|---------|
| 1. Enter system view. | **system-view** | N/A |
| 2. Enter OpenFlow instance view. | **openflow instance** *instance-id* | N/A |
| 3. Configure in-band management VLANs. | **in-band management vlan** *vlan-list* | By default, no in-band management VLAN is configured. The in-band management VLANs of an OpenFlow instance must be within the list of the VLANs that are associated with the OpenFlow instance. |

# Disabling MAC address learning in the VLANs associated with an OpenFlow instance

This configuration does not take effect on in-band management VLANs.

To disable MAC address learning in the VLANs associated with an OpenFlow instance:

| Step | Command | Remarks |
|------|---------|---------|
| 1. Enter system view. | **system-view** | N/A |
| 2. Enter OpenFlow instance view. | **openflow instance** *instance-id* | N/A |
| 3. Disable MAC address learning in the VLANs associated with an OpenFlow instance. | **mac-learning forbidden** | By default, MAC address learning is enabled in the VLANs associated with an OpenFlow instance. |

# Configuring the datapath ID for an OpenFlow instance

In an OpenFlow network, each OpenFlow instance is uniquely identified by a datapath ID. By default, the datapath ID of an OpenFlow instance consists of the instance ID and the bridge MAC address. The datapath ID is configurable.

To configure the datapath ID for an OpenFlow instance:

| Step | Command | Remarks |
|------|---------|---------|
| 1. Enter system view. | **system-view** | N/A |
| 2. Enter OpenFlow instance view. | **openflow instance** *instance-id* | N/A |
| 3. Configure the datapath ID for the OpenFlow instance. | **datapath-id** *datapath-id* | By default, the datapath ID of an OpenFlow instance consists of the instance ID and the bridge MAC address. The upper 16 bits are the instance ID and the lower 48 bits are the bridge MAC address. |

## Activating or reactivating an OpenFlow instance

⚠ CAUTION:

Reactivating an OpenFlow instance refreshes the configuration data and interrupts communication with the controllers.

To activate or reactivate an OpenFlow instance:

| Step | Command | Remarks |
|------|---------|---------|
| 1. Enter system view. | **system-view** | N/A |
| 2. Enter OpenFlow instance view. | **openflow instance** *instance-id* | N/A |
| 3. Activate or reactivate the OpenFlow instance. | **active instance** | By default, an OpenFlow instance is not activated. |

# Configuring controllers for an OpenFlow switch

## Configuring controllers and main connections

An OpenFlow switch supports up to 64 controllers. However, the OpenFlow channel between the OpenFlow switch and each controller can have only one main connection, which uses TCP or SSL. The main connection must be reliable and processes control messages to complete tasks such as deploying entries, obtaining data, and sending information.

To specify a controller for an OpenFlow switch and configure the main connection to the controller:

| Step | Command | Remarks |
|------|---------|---------|
| 1. Enter system view. | **system-view** | N/A |
| 2. Enter OpenFlow instance view. | **openflow instance** *instance-id* | N/A |
| 3. Specify a controller and configure the main connection to the controller. | **controller** *id* **address** { **ip** *ip-address* \| **ipv6** *ipv6-address* } [ **port** *port-number* ] [ **ssl** *ssl-policy-name* ][ **vrf** *vrf-name* ] | By default, an OpenFlow instance is not configured with any main connection. |

# Setting the connection interruption mode

An OpenFlow switch is set to either of the following modes when it is disconnected from all controllers:

- **Secure**—In this mode, the OpenFlow switch forwards traffic based on flow tables and does not delete unexpired flow entries.
- **Standalone**—The OpenFlow switch uses the normal forwarding process.

To set the connection interruption mode for an OpenFlow switch:

| Step | Command | Remarks |
|------|---------|---------|
| 1. Enter system view. | **system-view** | N/A |
| 2. Enter OpenFlow instance view. | **openflow instance** *instance-id* | N/A |
| 3. Set the connection interruption mode. | **fail-open mode** { **secure** \| **standalone** } | By default, the **secure** mode is used. |

# Setting OpenFlow timers

An OpenFlow switch supports the following timers:

- **Connection detection interval**—Interval at which the OpenFlow switch sends an Echo Request message to a controller. The OpenFlow switch can send up to three Echo Request messages. If none of the requests received a reply, the OpenFlow switch is disconnected from the controller.
- **Reconnection interval**—Interval for the OpenFlow switch to wait before it attempts to reconnect to a controller.

To set OpenFlow timers for an OpenFlow switch:

| Step | Command | Remarks |
|------|---------|---------|
| 1. Enter system view. | **system-view** | N/A |
| 2. Enter OpenFlow instance view. | **openflow instance** *instance-id* | N/A |
| 3. Set the connection detection interval. | **controller echo-request interval** *interval-value* | The default setting is 5 seconds. If the CPU overhead is high, HP recommends that you set the connection detection interval to a large value. |
| 4. Set the reconnection interval. | **controller connect interval** *interval-value* | The default setting is 60 seconds. |

# Configuring OpenFlow to support dynamic MAC addresses

On an OpenFlow switch that supports MAC-IP flow tables, you can configure OpenFlow to support query and deletion of dynamic MAC addresses in the flow tables.

To configure OpenFlow to support dynamic MAC addresses:

| Step | | Command | Remarks |
|------|--|---------|---------|
| 1. | Enter system view. | **system-view** | N/A |
| 2. | Enter OpenFlow instance view. | **openflow instance** *instance-id* | N/A |
| 3. | Configure OpenFlow to support dynamic MAC addresses. | **mac-ip dynamic-mac aware** | By default, OpenFlow prohibits controllers from querying and deleting dynamic MAC addresses. |

# Displaying and maintaining OpenFlow

Execute **display** commands in any view.

| Task | Command |
|------|---------|
| Display the detailed information for an OpenFlow instance. | **display openflow instance** [ *instance-id* ] |
| Display flow table entries for an OpenFlow instance. | **display openflow instance** *instance-id* **flow-table** [ *table-id* ] |
| Display controller information for an OpenFlow instance. | **display openflow instance** *instance-id* **controller** |
| Display group table information for an OpenFlow instance. | **display openflow instance** *instance-id* **group** [ *group-id* ] |
| Display meter information for an OpenFlow instance. | **display openflow instance** *instance-id* **meter** [ *meter-id* ] |
| Display summary OpenFlow instance information. | **display openflow summary** |

# OpenFlow configuration example

## Network requirements

As shown in Figure 7, perform the following configuration on the switch to enable OpenFlow communication with the controller in specific VLANs:

- Create OpenFlow instance 1, associate VLANs 4092 and 4094 with the OpenFlow instance, and activate the OpenFlow instance.
- Configure the controller's IP address to have the controller manage the OpenFlow switch.

**Figure 7 Network diagram**
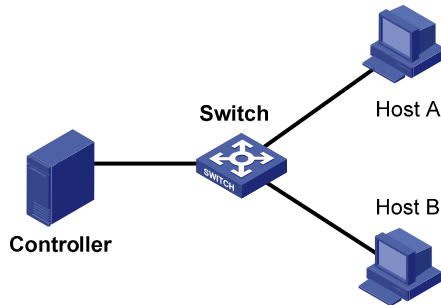


# Configuration procedure

# Create VLANs 4092 and 4094.

```
<Switch> system-view
[Switch] vlan 4092
[Switch-vlan4092] quit
[Switch] vlan 4094
[Switch-vlan4092] quit
```

# Create OpenFlow instance 1 and associate VLANs with it.

```
[Switch] openflow instance 1
[Switch-of-inst-1] classification vlan 4092 mask 4093
```

# Specify a controller for the OpenFlow instance and activate the instance.

```
[Switch-of-inst-1] controller 1 address ip 192.168.49.49
[Switch-of-inst-1] active instance
```

# Verifying the configuration

# Display the detailed information for OpenFlow instance 1.

```
[Switch-of-inst-1] display openflow summary
Instance 1 verbose information:

Configuration information:
 Description   : --
 Active status : active
 Inactive configuration:
  none
 Active configuration:
  Classification VLAN, total VLANs(2)
   4092, 4094
  In-band management VLAN, total VLANs(0)
   empty VLAN
  Connect mode: multiple
  Mac-address learning: Enabled
  Flow table:
   Table ID(type): 0(Extensibility), count: 0
```

```
  Flow-entry max-limit: 65535
  Datapath ID: 0x00010cda415e232e
Port information:
 none
Active channel information:
 Failopen mode: secure
```

# Support and other resources

## Contacting HP

For worldwide technical support information, see the HP support website:

http://www.hp.com/support

Before contacting HP, collect the following information:

- Product model names and numbers
- Technical support registration number (if applicable)
- Product serial numbers
- Error messages
- Operating system type and revision level
- Detailed questions

## Subscription service

HP recommends that you register your product at the Subscriber's Choice for Business website:

http://www.hp.com/go/wwalerts

After registering, you will receive email notification of product enhancements, new driver versions, firmware updates, and other product resources.

# Related information

## Documents

To find related documents, browse to the Manuals page of the HP Business Support Center website:

http://www.hp.com/support/manuals

- For related documentation, navigate to the Networking section, and select a networking category.
- For a complete list of acronyms and their definitions, see *HP FlexNetwork Technology Acronyms.*

## Websites

- HP.com http://www.hp.com
- HP Networking http://www.hp.com/go/networking
- HP manuals http://www.hp.com/support/manuals
- HP download drivers and software http://www.hp.com/support/downloads
- HP software depot http://www.software.hp.com
- HP Education http://www.hp.com/learn

# Conventions

This section describes the conventions used in this documentation set.

## Command conventions

| Convention | Description |
|---|---|
| **Boldface** | **Bold** text represents commands and keywords that you enter literally as shown. |
| *Italic* | *Italic* text represents arguments that you replace with actual values. |
| [ ] | Square brackets enclose syntax choices (keywords or arguments) that are optional. |
| { x \| y \| ... } | Braces enclose a set of required syntax choices separated by vertical bars, from which you select one. |
| [ x \| y \| ... ] | Square brackets enclose a set of optional syntax choices separated by vertical bars, from which you select one or none. |
| { x \| y \| ... } * | Asterisk-marked braces enclose a set of required syntax choices separated by vertical bars, from which you select at least one. |
| [ x \| y \| ... ] * | Asterisk-marked square brackets enclose optional syntax choices separated by vertical bars, from which you select one choice, multiple choices, or none. |
| &<1-n> | The argument or keyword and argument combination before the ampersand (&) sign can be entered 1 to n times. |
| # | A line that starts with a pound (#) sign is comments. |

## GUI conventions

| Convention | Description |
|---|---|
| **Boldface** | Window names, button names, field names, and menu items are in bold text. For example, the **New User** window appears; click **OK**. |
| > | Multi-level menus are separated by angle brackets. For example, **File** > **Create** > **Folder**. |

## Symbols

| Convention | Description |
|---|---|
| ⚠ WARNING | An alert that calls attention to important information that if not understood or followed can result in personal injury. |
| △ CAUTION | An alert that calls attention to important information that if not understood or followed can result in data loss, data corruption, or damage to hardware or software. |
| ⓘ IMPORTANT | An alert that calls attention to essential information. |
| NOTE | An alert that contains additional or supplementary information. |
| ⓣ TIP | An alert that provides helpful information. |

## Network topology icons

| | |
|---|---|
| | Represents a generic network device, such as a router, switch, or firewall. |
| | Represents a routing-capable device, such as a router or Layer 3 switch. |
| | Represents a generic switch, such as a Layer 2 or Layer 3 switch, or a router that supports Layer 2 forwarding and other Layer 2 features. |
| | Represents an access controller, a unified wired-WLAN module, or the switching engine on a unified wired-WLAN switch. |
| | Represents an access point. |
| | Represents a security product, such as a firewall, a UTM, or a load-balancing or security card that is installed in a device. |
| | Represents a security card, such as a firewall card, a load-balancing card, or a NetStream card. |

## Port numbering in examples

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

# Index