HP OpenFlow 1.3 Administrator Guide

Wired Switches K/KA/KB/WB 15.15

Abstract

This document describes the general steps and individual commands for enabling OpenFlow operation on HP Switches.

Applicable Products

HP Switch 2920 series
HP Switch 3500 series
HP Switch 3800 series
HP Switch 5400 series, v1 and v2 modules
HP Switch 5406R series
HP Switch 5412A series
HP Switch 6200 series
HP Switch 6600 series
HP Switch 8200 series, v1 and v2 modules

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Acknowledgments

This product contains OpenFlow protocol support functionality as provided in Open vSwitch code licensed under the Apache Software License v2.0 and available at http://openvswitch.org. The full text of the Apache Software License v2.0 is contained in the *OpenFlow License Information* document available at www.hp.com/Networking/support.

Warranty

For the software end user license agreement and the hardware limited warranty information for HP Networking products, visit www.hp.com/networking/support.

Contents

1 Introduction

This document provides the following:

- General steps for OpenFlow configuration and administration
- OpenFlow command syntax descriptions, including show commands
- OpenFlow troubleshooting commands and debug actions

This document only covers the additional features and commands for administering OpenFlow on certain HP switches that use software version 15.10 or later, as described below:

Release Version	Description
K/KA.15.10	Added OpenFlow 1.0 support for the following switches: • HP 3500, HP 3500 yl • HP 3800 • HP 5400 zl with v1 or v2 modules • HP 6200 yl • HP 6600 • HP 8200 zl with v1 and v2 modules
K/KA.15.11	Added HP QoS Extensions to OpenFlow
K/KA.15.12 and WB.15.12	Added OpenFlow support for the HP 2920
K/KA/WB 15.14	Added OpenFlow v1.3 support

For more information about upgrading software, see the 'Software Management' chapter in the *Management and Configuration Guide* for your HP switch.

Conceptual overview

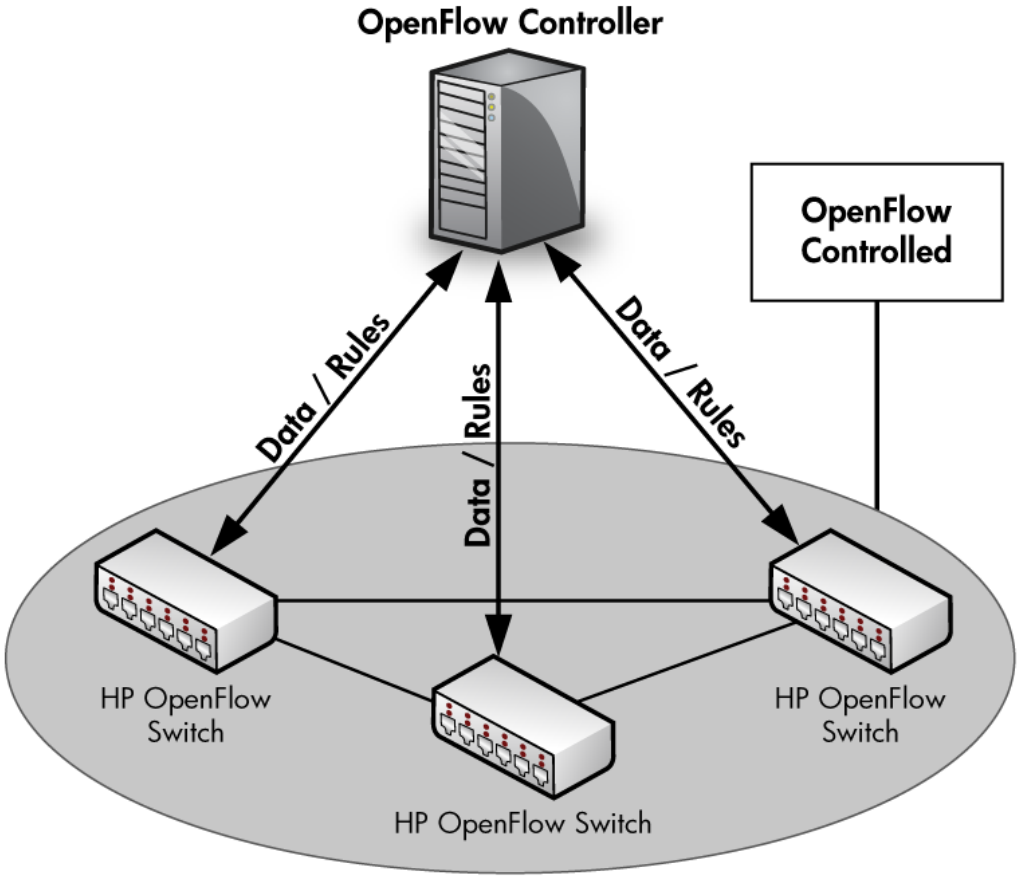
OpenFlow is a programmable open-standard network protocol that uses flexible matching rules to classify and manage network traffic into flows. OpenFlow defines a set of actions that network devices can take to manage these flows. An OpenFlow controller defines and communicates policies to specify traffic behavior on OpenFlow switches. OpenFlow separates the control plane (that decides how traffic must be forwarded) from the data plane (that implements how traffic is forwarded.)

OpenFlow is based on an Ethernet switch with internal flow-tables and a standardized interface to add and remove flow entries via an external controller.

OpenFlow is a software environment that allows for experimentation of networking protocols and traffic flows without interrupting the operation of production network. OpenFlow traffic can be separated from the rest of the traffic on the network per VLAN, so that non-OpenFlow traffic is not impacted by OpenFlow.

OpenFlow implementation on HP Switches separates OpenFlow traffic and non-OpenFlow traffic with OpenFlow instances. Traffic within an OpenFlow instance does not influence or degrade non-OpenFlow traffic. OpenFlow configuration commands are applied per-instance.

Figure 1 OpenFlow switches and controller



HP implementation complies with OpenFlow Switch Specification v1.0.0 (December 31, 2009.) With the K/KA.15.14 and WB.15.14 release, HP switches support OpenFlow Switch Specification v1.3.1 (September 2012). For implementation limitations with respect to the supported specifications, see "Supported RFCs and standards" (page 11).

For more information see the Open Networking Foundation website at https://www.opennetworking.org/.

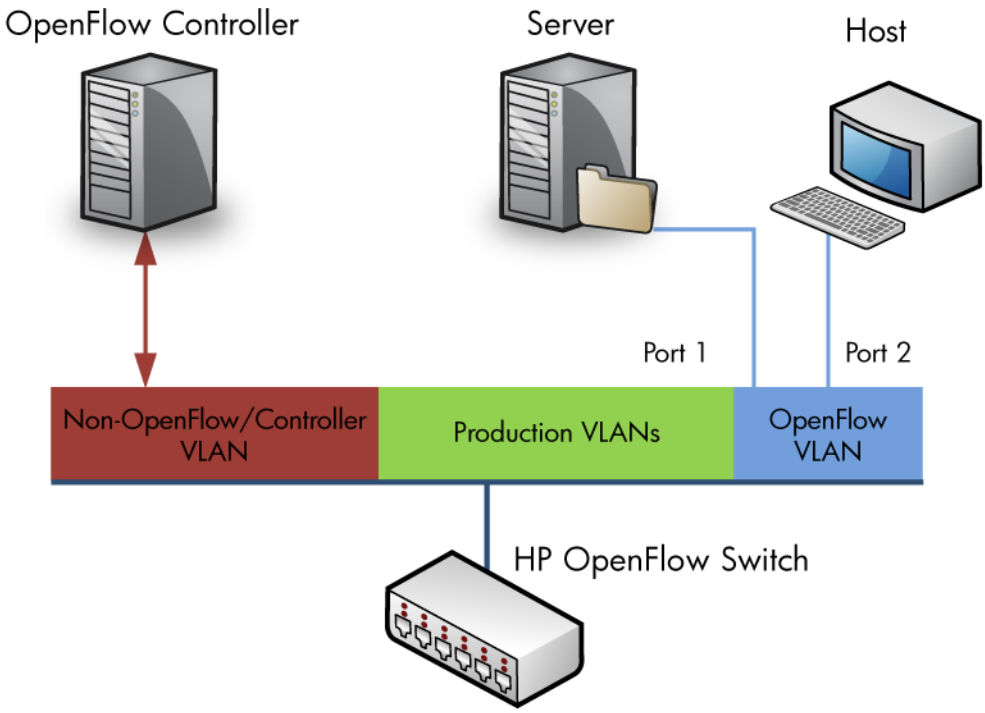
OpenFlow architecture

OpenFlow can be configured to separate non-OpenFlow traffic from OpenFlow traffic. An OpenFlow instance can either be in the Virtualization or Aggregation Mode.

Virtualization mode

Virtualization mode allows production (non-OpenFlow) VLANs and VLANs that belong to OpenFlow instances to be configured on the switch. Each OpenFlow instance is independent and has its own OpenFlow configuration and OpenFlow controller connection. An OpenFlow instance in virtualization mode must have a VLAN associated as a member VLAN.

Figure 2 Virtualization mode



Aggregation mode

In Aggregation mode, all VLANs in the switch are part of an OpenFlow instance. The exception is the management VLAN and a VLAN that communicates to the controller. Similar to a lab environment the OpenFlow controller manages all the switching and routing for the switch.

NOTE: When Aggregation is configured, there is only OpenFlow traffic, no production traffic.

Figure 3 Aggregation mode

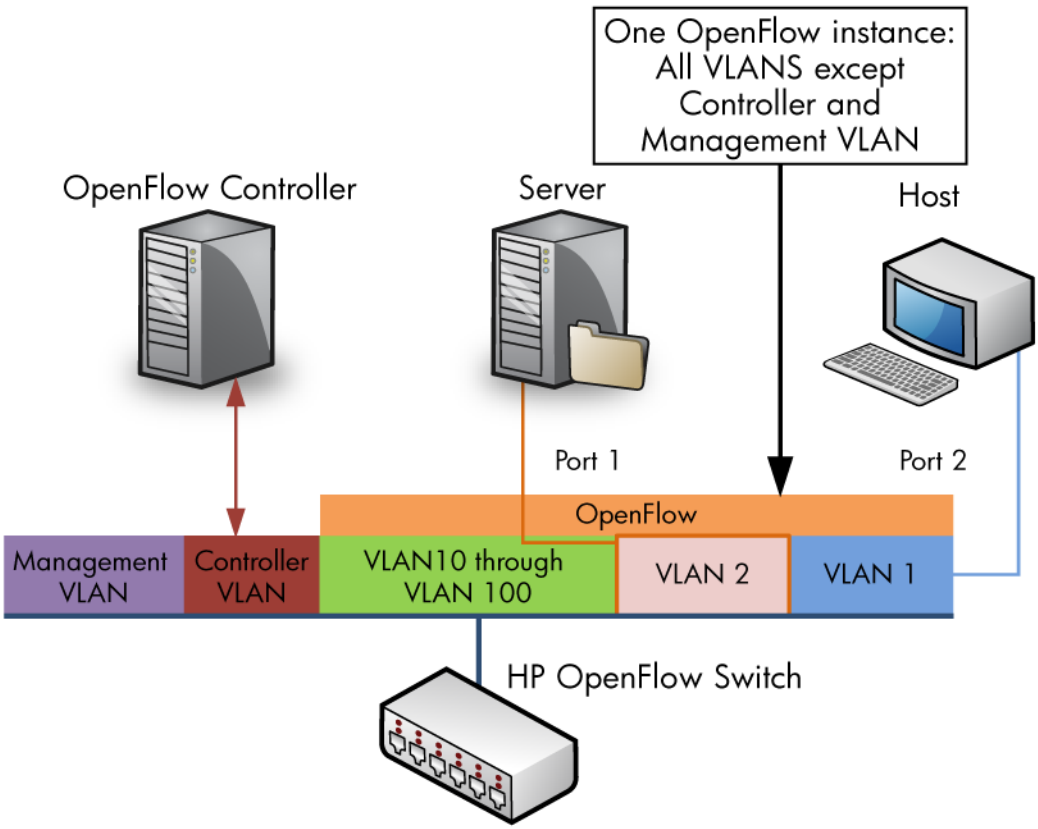
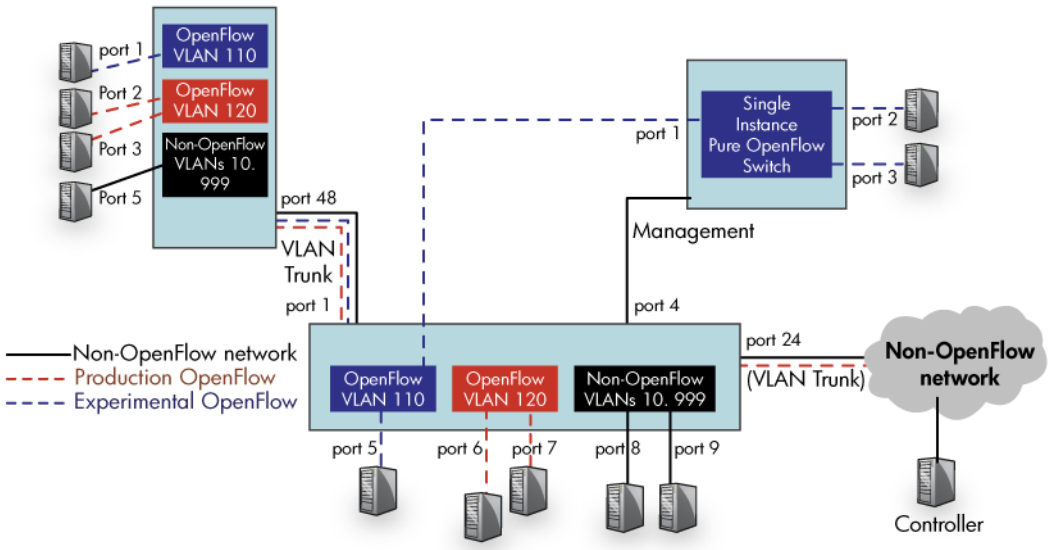


Figure 4 Example network with production non-OpenFlow, production OpenFlow, and experimental OpenFlow



OpenFlow features and benefits

With the addition of OpenFlow Specification 1.3, the following features are supported:

- Multiple Flow tables
  - Pipeline processing
- OpenFlow physical, logical and reserve ports
- Version negotiation
- Group tables
- Auxiliary connections
- OpenFlow Extensible Match (OXM)
- Multiple controllers
- Support for IPv6 flows

OpenFlow switch side configuration enables the user to:

- Enable or disable OpenFlow
- Create OpenFlow instances and configure controller connections
- Display OpenFlow related configuration
- Availability of Config support to retain OpenFlow configuration across a reboot

OpenFlow supports high availability:

- The OpenFlow flow table is preserved across Management Module failover
- The OpenFlow configuration is synced from the AMM to the SMM

OpenFlow includes tools for limiting resources:

- Support for limiting the percentage of policy engine and IP control table resources used by OpenFlow
- Support for rate-limiting the amount of OpenFlow traffic sent to the controller
- Support for rate-limiting the amount of OpenFlow traffic that gets forwarded by the policy engine rules programmed by OpenFlow

OpenFlow modes of operation:

- Support for hardware-only mode such where only flows that can be programmed into hardware are accepted from the controller.
- Support for active mode (default) where new flows are sent to the controller by the switch.
- Support for passive mode where new flows no longer are sent to the controller but are handled normally handled by the switch.

IPv6 and OpenFlow

Directing IPv6 traffic using OpenFlow is supported beginning with OpenFlow Specification 1.3. For more information on configuring IPv6 on switches, see the *IPv6 Configuration Guide* for your switch.

Administrative methods

This document provides the HP CLI commands for configuring and administering HP OpenFlow switches.

OpenFlow controllers include utilities for monitoring, administering, and troubleshooting OpenFlow switches. For example, the OpenvSwitch controller distribution includes the utility `ovs-ofctl`. The utility can show the current state of a switch that supports OpenFlow, including features, configuration and table entries. Other controllers have similar utilities; see the documentation for your controller for the complete command set.

Supported RFCs and standards

HP switches support OpenFlow Switch Specification, version 1.3.1 (September 2012) from the Open Networking Foundation, https://www.opennetworking.org/ with some differences.

Unsupported features:

- OFPP TABLE action.
- Set-Queue action.
- Handling of IP Fragments: OFPC_IP_REASM/OFPC_FRAG_REASM.
  - Push-MPLS, Set MPLS TTL, Decrement MPLS TTL actions
  - Push-PBB action
  - Copy TTL outwards, Copy TTL inwards actions
- Strip VLAN action is supported on both Policy Engine Table and Software Table.
- Some commands for port modification from a controller:
  - OFPPC_PORT_DOWN
  - OFPPC_NO_STP
  - OFPPC_NO_RECV
  - OFPPC_NO_RECV_STP
  - OFPPC_NO_FWD

NOTE: When the above commands are sent from the controller, an error message is returned to the controller:

```
OFPET_PORT_MOD_FAILED.
```

Hardware differences between v1 & v2 Modules affect feature functionality, see "Flow classification on v1 and v2 modules" (page 68) for details.

Interoperability

Table 1 HP Switch features and interoperability with OpenFlow — by effect on feature or application

Effect	Feature
Feature can override OpenFlow [1]	802.1X MAC Auth MAC Lockout MAC Lockdown Port Security Web Auth
Feature can override OpenFlow [2]	ACLs – Port, VLAN, Router, IDM variants IDM
Feature can override OpenFlow [3]	Rate Limiting
Feature can be configured if OpenFlow is used	Management VLAN **NOTE:** Management VLAN feature can be configured but it cannot be part of an OpenFlow instance.

Table 1 HP Switch features and interoperability with OpenFlow — by effect on feature or application *(continued)*

Effect	Feature
	Q-in-Q
	Remote Mirror Endpoint
	Transparent Mode
Feature cannot be configured if OpenFlow is used [4]	Meshing
OpenFlow can override this feature [5]	DHCP Snooping
	DHCPv4 client
	DHCPv4 relay
	DHCPv6 client
	DNS
	Ping
	SNTP
	Telnet client and server
	TFTP
	TimeP
	Traceroute
	UDP broadcast forwarder
OpenFlow can override this feature [5]	BGP
	DHCPv6 relay
	Dynamic ARP Protection
	Dynamic IP Lockdown
	IGMP Proxy
	IGMPv2
	IGMPv3
	MLDv1
	MLDv2
	OSPFv2
	OSPFv3
	PIM-DM
	PIM-SM
	RIP
	Static Multicast Routes
	Static Routes
	Virus Throttling
	VRRP
OpenFlow does not affect this feature	Support existing L2, L3, security, HA, QoS functionalities
OpenFlow does not affect this feature [6]	Distributed Trunking

Table 1 HP Switch features and interoperability with OpenFlow — by effect on feature or application *(continued)*

Effect	Feature
	GVRP LACP Loop Protect sFlow
	UDLD
OpenFlow does not affect this feature [7]	STP loop guard
	BPDU guard
	MSTP RSTP STP PVST

[1] These authentication features still function in an OpenFlow instance and ports of an OpenFlow instance. The security features take a first look at the packet before sending the packets to OpenFlow.

[2] Any ACL entry that sets a drop bit in hardware (TCAM) would always win over the TCAM entry to copy OpenFlow traffic to the controller such that packets on an OpenFlow instance could get dropped in hardware due to an ACL entry and an OpenFlow controller would never be able to see those packets.

[3] Rate Limiting may be applied to limit OpenFlow traffic as well as other traffic. OpenFlow uses a form of rate-limiter to limit the OpenFlow traffic that gets to the CPU and to the controller.

[4] Enabling Meshing can break the distinction between OpenFlow VLANs and non-OpenFlow VLANs.

[5]
- The OpenFlow controller could set up a flow to match a protocol header and an action to drop the matching packets. This could lead to the protocol's packets never making it to the protocol handling code in the software data path causing the protocol to break on the OpenFlow instance.
- The OpenFlow controller could set up a flow to match a protocol header and a NORMAL action in software for the matching packets. In such a case, the protocol's packets are removed by OpenFlow in the software data path but reintroduced after examining the software flow table. Though this action may not break the protocol, it introduces an additional latency before the protocol running on the switch gets the protocol's packets.

[6] Protocol packets are not sent through the OpenFlow software data path.

[7] Port up or down events are sent to the controller to keep the controller aware of available ports on the switch. OpenFlow cannot override STP, RSTP, or MSTP decisions.

Scalability

Table 2 Switch modules scalability

Switch/Modules	K/KA.15.10	K/KA.15.14, WB.15.14
Compatible mode – "allow v1 modules" – A chassis where v1 as well as v2 modules are present may execute in this mode. Non-compatible mode – "no allow v1 modules" – A chassis that only has v2 modules may execute in this mode.		
8200/5400 v1 modules 3500 series 6600 series 6200 series	Total: 64 K	Total: 64 K
	Hardware: TCAM – 1.5K per module	Hardware: Standard match mode TCAM – 1.5 K per module
	Software: Total minus Hardware	Software: Total minus Hardware
8200/5400 v2modules 3800 series 2920 series (Flow numbers will be lower for this series)	Total: 64 K 16 K for 2920	Total: 64 K 16 K for 2920

Table 2 Switch modules scalability *(continued)*

Switch/Modules	K/KA.15.10	K/KA.15.14, WB.15.14
	Hardware: TCAM - 2000 per slot TCAM – 500 per slot for 2920	Hardware: Compatible mode – 1.5 K per slot Non-compatible mode TCAM – 4K per slot
	Software: Total minus Hardware	Software: Total minus Hardware

2 Configuring OpenFlow

Configuration overview

1. Enable OpenFlow
2. Configure OpenFlow instances
3. Configure OpenFlow instance members
4. Set OpenFlow instance mode
5. Set Flow location
6. Configure software and hardware rate limiting
7. Configure listener ports
8. Configure controller IP and port
9. Configure policy engine resources

Entering OpenFlow

Entering OpenFlow context

You can use the `openflow` command options from configuration level by entering the word `openflow`, or from OpenFlow context level by typing the command option.

Syntax

`openflow`
Enters OpenFlow context

Entering OpenFlow instance context

You can use the `instance` *`instance-name`* command from configuration level by beginning the command with `openflow`, or from OpenFlow instance context level by typing the command option.

Syntax

`openflow instance` *`instance-name`*
Enters OpenFlow instance context

`instance-name`
OpenFlow instance name

Preparing for configuration

Plan your network including production and OpenFlow VLANs, OpenFlow instances, OpenFlow controller ports, listening ports, naming and numbering strategy.

Plan the number of VLANs configured for OpenFlow versus non-OpenFlow.

OpenFlow works on an instance only when OpenFlow is enabled on the instance as well as globally on the switch.

NOTE:

A maximum of 128 OpenFlow instances can be configured. (16 on 2920)
A maximum of 2048 VLANs are supported.

Enabling or disabling OpenFlow

Enable or disable OpenFlow globally:

Syntax

```
openflow [ enable | disable ]
[no] openflow enable
```

`enable`

Enables OpenFlow globally.

`disable`

Disables OpenFlow globally.

NOTE: Using `no openflow` without any additional parameters deletes **all** OpenFlow configuration. A warning message to confirm this command appears.

NOTE: OpenFlow instance parameters can only be changed with OpenFlow disabled. Instance parameters cannot be changed when instance is enabled. To enable an instance use the following command.

```
openflow instance <instance name> enable
```

Setting OpenFlow protocol version

Syntax

```
openflow-instance-name # version 1.0|1.3 only
```

Default version:1.0

OpenFlow protocol version supported by the instance.

This command lets you choose which version of OpenFlow the instance will use to negotiate with the controller. The command also allows for supported earlier versions of OpenFlow to be used in negotiation with the controller unless the option `only` is specified.

Default: version 1.0

Configuring OpenFlow instances

Configures an OpenFlow instance.

NOTE:

- Configuration changes are not allowed when instance is enabled. Disable the instance and make instance specific configuration changes.
- For a named instance to be enabled, a listen port or a controller, and a member VLAN has to have been added to the instance.
- To enable an aggregate instance, a listen-port or a controller has to be added to the instance.

For more on Aggregation Mode, see "Aggregation mode" (page 8).

For more on Virtualization Mode, see "Virtualization mode" (page 7).

Syntax

```
openflow instance { instance-name | aggregate }[ enable |
disable ]
[no] openflow instance { instance-name | aggregate }
enable
```

The `no` form of the command deletes **all** OpenFlow configurations for the instance.

`instance-name`

Creates an OpenFlow instance.

Instance names can have a maximum length of 32 case-insensitive alphanumeric characters, numerals, and underscore.

`aggregate`
Creates an OpenFlow instance that includes all VLANs except the management VLAN and the OpenFlow controller VLANs. See "Aggregation mode" (page 8) for details on the use of this parameter.

`enable`
Enables the named OpenFlow instance or aggregate.

`disable`
Disables the named OpenFlow instance or aggregate.

OpenFlow instance mode

OpenFlow can work either in *`active`* or *`passive`* mode.

Active mode
New packets of a flow that the switch is not aware of are sent to the OpenFlow controller.

Passive mode
There is one-way communication from the OpenFlow controller to the switch. Packets that do not match any flow in the flow table on the switch are not sent to the controller. Such packets of new flows are handled normally by the switch.

NOTE: This option is only for an OpenFlow version 1.0 instance.

This command sets operation mode for an OpenFlow instance.

Syntax

```
openflow instance { instance-name | aggregate }
mode { active | passive }
```

`instance` *`instance-name`*
Sets the mode for the named instance.

`aggregate`
Sets the mode for the aggregate instance.

`active`
New flows are redirected to the controller for the instance.

`passive`
New flows are not sent to the controller for the instance.

Default: active

Configure OpenFlow instance members

Configures OpenFlow instance members.

- Only one VLAN can be added as a member of an OpenFlow instance in virtualization mode.
- The same VLAN cannot be added as a member of multiple OpenFlow instances.
- The management VLAN cannot be added to an OpenFlow instance as a member VLAN.
- A Controller VLAN cannot be added to an OpenFlow instance as a member VLAN.

Syntax

```
[no] openflow instance instance-name
member vlan vlan-id
```

instance-name

Add a member to this OpenFlow instance.

`vlan` *vlan-id*

Adds the VLAN to the named OpenFlow instance.

Flow location

This command sets the location of flows for an instance or the aggregate. In hardware-only mode, flows are programmed only in hardware. The flows are located in hardware and software by default.

Syntax

`[no] openflow instance { instance-name | aggregate } flow-location hardware-only`

instance-name

Sets flow location for the named instance.

`aggregate`

Sets flow location for the aggregate instance.

`hardware-only`

Sets the location of flows to hardware only.

Default: Software and hardware.

NOTE: An error is returned to the controller if the flow cannot be added in hardware and the flow-location is set as hardware-only.

Communicating port status to the controller

OpenFlow provides the ability to program flows for ports which are not up yet. The OpenFlow switch communicates port state notification to the controller as part of OFPT_PORT_STATUS message. This allows the controller to pre-provision flows in the switch referring ports that may be down. The post status messages are:

- OFPPS_LIVE – Physical link present
- OFPPS_LINK_DOWN – No physical link present
- OFPPS_BLOCKED – Port is blocked

Example

```
HP-Stack-3800(openflow)# show vlan 3
Status and Counters - VLAN Information - VLAN 3
VLAN ID : 3
Name    : VLAN3
Status  : Port-based
Voice   : No
Jumbo   : No

Port Information  Mode         Unknown VLAN  Status
----------------  --------   ------------   ----------
1/1               Untagged    Learn         Up
1/2               Untagged    Learn         Up
1/4               Untagged    Learn         Down
1/5               Untagged    Learn         Down

openflow@openflow-ubuntu-02:~$ dpctl tcp:20.0.0.1:6633 port-desc
SENDING:
stat_req{type="port-desc", flags="0x0"}
```

```
RECEIVED:
stat_repl {type="port-desc", flags="0x0"

{no="4", hw_addr="08:2e:5f:69:6e:7c", name="1/4", config="0x0"
, state="0x1", curr="0x0", adv="0x0", supp="0x0", peer="0x0",
curr_spd="0kbps", max_spd="0kbps"},

{no="2", hw_addr="08:2e:5f:69:6e:7e", name="1/2", config="0x0",
state="0x4", curr="0x220", adv="0x0", supp="0x22f",
peer="0x0", curr_spd="3567587328kbps", max_spd="3567587328kbps"},

{no="5", hw_addr="08:2e:5f:69:6e:7b", name="1/5", config="0x0",
state="0x1", curr="0x0", adv="0x0", supp="0x0", peer="0x0",
curr_spd="0kbps", max_spd="0kbps"},

{no="local", hw_addr="08:2e:5f:69:6e:65", name="local",
config="0x0", state="0x0", curr="0x0", adv="0x0", supp="0x0",
peer="0x0", curr_spd="0kbps", max_spd="0kbps"},

{no="1", hw_addr="08:2e:5f:69:6e:7f", name="1/1", ="0x0",
state="0x4", curr="0x220", adv="0x0", supp="0x22f", peer="0x0",
curr_spd="3567587328kbps", max_spd="3567587328kbps"}}}
```

Configuring listener ports

Configures an OpenFlow port to listen for incoming connections from an OpenFlow controller.

Syntax

```
[no] openflow instance { instance-name | aggregate }
listen-port [tcp-port] [oobm]
```

instance-name

Sets the `listen-port` for the named instance.

`aggregate`

Sets the `listen-port` for the aggregate instance.

tcp-port

Specify the port to listen on.

Default: Port number 6633

Range: Port number 1024 - 65536

`oobm`

Configure to listen through the out-of-band management (OOBM) port. Only applicable for switches that have a separate OOBM port.

Configuring a controller

A controller is identified by its IP address and a connection port. Each OpenFlow instance can have up to 3 controllers. OpenFlow controllers can be added or deleted using this command.

Syntax

```
openflow controller-id <id> [ip <ip-address>] [port <tcp-port>]
controller-interface { vlan <vlan-id> | oobm }
[no] openflow controller-id <id>
```

id

OpenFlow controller identification number.

The no removes the identified controller, if the controller is not in use by any OpenFlow instances.

Range: 1 – 128

ip-address

OpenFlow controller IP address.

tcp-port

Optional: Specify the port through which to connect to a controller.

Default: port number 6633

Range: 1024 – 65535

controller-interface

The no form of the command with this parameter deletes the OpenFlow controller connection.

vlan-id

Connect to the OpenFlow controller through the identified VLAN.

NOTE: A VLAN that is a member of an OpenFlow instance cannot be added as an OpenFlow controller interface.

oobm

Connect to the OpenFlow controller through the OOBM interface. Only applicable for switches that have a separate out-of-band management (OOBM) port.

Associate OpenFlow instance with OpenFlow controller

Once the OpenFlow controller is set up, each instance must be associated to a controller.

Syntax

[no] openflow instance { *instance-name* | aggregate }
controller-id *controller-ID*

Up to three controllers can be specified per OpenFlow instance.

The [no] removes the identified controllers.

instance-name

Sets controller for the named instance.

aggregate

Sets controller for the aggregate instance.

controller-ID

OpenFlow controller ID to be associated with the instance; up to 3 controllers per instance.

Example 1 Associating an OpenFlow instance with multiple controllers

To associate controllers 1, 5, and 100 to instance “test”, use the following commands:

```
HPswitch(config)# openflow instance test controller-id 1
#openflow instance test controller-id 5
#openflow instance test controller-id 100
```

NOTE: When an OpenFlow controller is associated with an OpenFlow instance it cannot be deleted.

Securing the connection between an OpenFlow instance and the controller

Syntax

[no] `controller-id` *`controller-id secure`*

`secure`

Initiates a TLS connection with the controller (TLS version 1.0 or greater.)

This command:

- Secures the instance controller main connection. This option is available for OpenFlow version1.0 as well as OpenFlow version 1.3.
- Supports CA signed certificates. For CA signed certificates, same ROOT certificate is used to sign both controller and switch certificate.
- Supports mutual authentication.

Example

```
HP-3500yl-48G-PoEP(of-inst-t1)# show openflow instance t1
Configured OF Version    : 1.3
Negotiated OF Version    : 1.3
Instance Name            : t1
Admin. Status            : Enabled
Member List              : VLAN 3
Listen Port              : None
Oper. Status             : Up
Oper. Status Reason      : NA
Datapath ID              : 0003b499ba86bf80
Mode                     : Active
Flow Location            : Hardware and Software
No. of Hw Flows          : 0
No. of Sw Flows          : 0
Hw. Rate Limit           : 0 kbps
Sw. Rate Limit           : 100 pps
Conn. Interrupt Mode     : Fail-Secure
Maximum Backoff Interval : 60 seconds
Probe Interval           : 10 seconds
Hw. Table Miss Count     : NA
No. of Sw Flow Tables    : 1
Egress Only Ports        : None
Table Model              : Policy Engine and Software

Controller Id  Connection Status  Connection State Secure Role
-------------- ----------------- - --------------- - ------ -----
1              Connected         Active            Yes    Equal
```

Configuring auxiliary connections

Syntax

`openflow # auxiliary-connection` *`index`* `port` *`port-number`* `type tcp|udp`

Creates an auxiliary connection with a unique index which is later associated with the instance controller main connection. Auxiliary connection uses the same source IP address and the datapath ID as the main connection. The main connection auxiliary ID is set to zero, while the auxiliary connection ID is set to 1. Only one auxiliary connection is supported per main connection and transport protocol options for auxiliary connections can be either TCP or UDP.

The packets supported on an auxiliary channel are:

- OFPT_HELLO
- OFPT_ERROR
- OFPT_ECHO_REQUEST/ REPLY
- OFPT_FEATURES_REQUEST/REPLY
- OFPT_PACKET_IN
- OFPT_PACKET_OUT

The main use of an auxiliary connection is for transactions related to message of type: OFPT_PACKET_IN/OFPT_PACKET_OUT.

Options

index
: Unique identifier for an auxiliary connection.

port
: Protocol port on which the controller can be reached.

type
: Type of transport protocol to be used: TCP or UDP.

[no]
: Removes the auxiliary connection.

NOTE: Auxiliary connections are terminated when the main connection goes down or is closed by the user or when the OpenFlow instance/openflow is disabled or OpenFlow is globally disabled.

TLS is not supported for Auxiliary connections.

Example

```
HP-Stack-3800(openflow)# auxiliary-connection 1 port 6633 type tcp
HP-Stack-3800(openflow)# inst t1
HP-Stack-3800(of-inst-t1)# controller-id 1 auxiliary-connection 1

HP-E5406zl(config)# shopenflow instance t1
Configured OF Version    : 1.3
Negotiated OF Version    : NA
Instance Name            : t1
Admin. Status            : Enabled
Member List              : VLAN 2
Listen Port              : 6633
Oper. Status             : Down
Oper. Status Reason      : NA
Datapath ID              : 0000002320e877fe
Mode                     : Active
Flow Location            : Hardware and Software
No. of Hw Flows          : 0
No. of Sw Flows          : 0
Hw. Rate Limit           : 0 kbps
Sw. Rate Limit           : 100 pps
Conn. Interrupt Mode     : Fail-Secure
Maximum Backoff Interval : 60 seconds
Probe Interval           : 10 seconds
Hw. Table Miss Count     : NA
No. of Sw Flow Tables    : 1
Egress Only Ports        : None
Table Model              : Single Table
```

```
Controller Id Connection Status Connection State Secure Role
------------- ----------------- ---------------- ------ ------
1             Disconnected      Void             No     Equal

 Auxiliary            Auxiliary               Auxiliary
 Controller Id Conn. index Auxiliary ID Conn. Status Conn. State Type
 ------------- ----------- ------------ ------------ ----------- ----
1              1           1            Disconnected  Void        TCP


#HP-8206zl# show run
openflow
 controller-id 1 ip 20.0.0.2 controller-interface vlan 1
  auxiliary-connection 1 port 6633 type tcp
  instance "t1"
   listen-port
  member vlan2
  controller-id 1 auxiliary-connection 1
  version 1.3
  enable
   exit
 enable
  exit
```

Associating the auxiliary connection index with an OpenFlow instance

Syntax

`(openflow-instance-name)-# auxiliary-connection 1`

Auxiliary connection index to be associated with the main connection

Range: 1–128

`auxiliary connection` *`1`*

Calls out only connection supported per main controller connection.

Configuring number of software flow tables per instance

Syntax

`openflow-instance-name # software-flow-table` *`value`*

Configures the number of software flow tables required for an instance.

Default: 1, Range: 1–4

This is applicable only for an OpenFlow version 1.3 instance.

OpenFlow instance connection interruption mode

Use this to set behavior when an OpenFlow instance on the switch loses connection with the controller.

Syntax

[no] `openflow instance` [*`instance-name`*]
`connection-interruption-mode { fail-secure | fail-standalone }`

`fail-secure`

If the switch loses connection with all controllers, packets and messages intended for controllers are dropped. Flows continue to expire according to their time-outs.

Default: `fail-secure`

`fail-standalone`

If the switch loses connection with all controllers, packets of new flows are handled by the legacy switching and routing functions. Existing flows of this OpenFlow instance are removed.

Setting maximum backoff interval for an instance

You can specify the maximum interval between two consecutive attempts to connect to a controller by an OpenFlow instance. The interval between two consecutive attempts increases exponentially until it reaches the specified value. All subsequent attempts use the specified value.

Syntax

```
openflow instance { instance-name | aggregate }
max-backoff-interval secs
```

`instance-name`

Sets the backoff interval for the named instance.

`aggregate`

Sets the backoff interval for the aggregate instance.

`secs`

Default: 60 secondsRange: 1 — 3600 seconds

Configuring IP Control Table Mode

Includes IP control table in the OpenFlow packet processing pipeline. Default disabled.

Syntax

```
openflow # [no]
ip-control-table-mode
```

Include IP control table in the OpenFlow packet processing pipeline. Default disabled.

Configure OpenFlow controller ports

An OpenFlow controller is configured globally under OpenFlow context and associated with an instance under instance context (see “Entering OpenFlow instance context” (page 15) for more information). OpenFlow controller traffic cannot be “in-band” or transit on a VLAN managed by OpenFlow and must transit on a VLAN not managed by OpenFlow.

OpenFlow controller traffic and OpenFlow traffic can transit on the same port, as long as they use different VLANs.

The VLAN chosen for OpenFlow controller traffic depends entirely on the IP address of the controller, and no specific configuration is needed. Thus the switch must have a proper IP configuration, and the controller address must be part of a subnet that is not on an OpenFlow VLAN.

For information on how to either manually assign an IP address to the switch or set it up to perform DHCP queries, see the ‘Configuring IP Addressing’ chapter in the *Basic Operation Guide* for your HP switch.

Each OpenFlow instance can be controlled by up to three OpenFlow controllers and each generates OpenFlow commands and data flows between an OpenFlow switch and the controller.

Controller roles

Controller Roles is a mechanism which helps controllers synchronize handoff's in a scenario where multiple controllers are connected to the switch. A Controller is assigned one of the following roles:

- Equal
- Master
- Slave

Equal

This is the default role for a controller. The controller has full access to the switch and is equal to other controllers in the same role receiving all of the switch asynchronous messages (such as packet-in, flow-removed.) Controller-to-switch commands are sent and modified within this role.

Slave

A Slave controller only has the right to access to the switch in read-only mode. The controller cannot receive switch asynchronous messages except for Port-status. The controller is denied execution of the controller-to-switch commands: OFPT_PACKET_OUT, OFPT_FLOW_MOD, OFPT_GROUP_MOD, OFPT_PORT_MOD and OFPT_TABLE_MOD.

Master

The controller has full access to the switch. Only one controller can be the Master. When a controller role is changed to Master, the switch will automatically change all other controllers to Slave.

Syntax

To learn about controller roles on the switch CLI:

```
show openflow instance [instance-name]
```

Example

```
HP-3500yl-48G-PoEP(of-inst-t1)# show openflow instance t1
Configured OF Version       : 1.3
Negotiated OF Version       : 1.3
Instance Name               : t1
Admin. Status               : Enabled
Member List                 : VLAN 3
Listen Port                 : None
Oper. Status                : Up
Oper. Status Reason         : NA
Datapath ID                 : 0003b499ba86bf80
Mode                        : Active
Flow Location               : Hardware and Software
No. of Hw Flows             : 0
No. of Sw Flows             : 0
Hw. Rate Limit              : 0 kbps
Sw. Rate Limit              : 100 pps
Conn. Interrupt Mode        : Fail-Secure
Maximum Backoff Interval    : 60 seconds
Probe Interval              : 10 seconds
Hw. Table Miss Count        : NA
No. of Sw Flow Tables       : 1
Egress Only Ports           : None
Table Model                 : Policy Engine and Software

Controller Id Connection Status Connection State  Secure  Role
------------- ----------------- ----------------  ------  ------
1                Connected           Active             No
    Slave
```

```
2                   Connected           Active              No
    Master
```

Controller role change

When a controller's role is changed, the following messages occur:

OFPT_ROLE_REQUEST

Message from controller to change or query its role.

OFPT_ROLE_REPLY

Message sent in response to the OFPT_ROLE_REQUEST, it returns the current Roleof the controller.

OFPT_SET_ASYNC

A controller, through this message can configure what asynchronous message it wants to receive.

OFPT_GET_ASYNC

Controller uses this message to retrieve the asynchronous configuration set using the OFPT_SET_ASYNC message.

NOTE: On failover/connection interruption, once connection is reestablished, each controller connection is set as OFPCR_ROLE_EQUAL, which controller can query and change if required

Port modification

Port modification is used to change the characteristics of a port for an instance on the switch via the controller. The controller sends an OFP_PORT_MOD message to the switch that can change the characteristics of a specific port.

The following command checks the state of the port configuration for all ports of an instance.

Syntax

```
show openflow instance t1 port-statistics
```

Example

```
HP-Stack-3800(of-inst-t1)# show openflowinstance t1 port-statistics
Number of Ports :1
Port 1/1        : Up
Status
Admin. Status     : Enabled        Flood    : Enabled
Receive           : Enabled        Forward  : Enabled
Packet_in         : Disabled
Statistics
  Collisions      : 0
  Rx Packets      : 0            TxPackets : 47
  Rx Bytes        : 0            TxBytes   : 10718
  Rx Dropped      : 0            TxDropped : 0
  Rx Errors       : 0            TxErrors  : 0
   Frame Errors     : 0
   CRC Errors       : 0
   Overrun Errors   : 0
```

Example v1.0

```
Wireshark Capture of a sample Port-Mod message for a 1.0 instance

OpenFlow Protocol
  Header
   Version: 0x01
   Type: Port Mod (CSM) (15)
   Length: 32
   Transaction ID: 4
```

```
  Port Modification
   Port #: 5
    MAC Address: HewlettP_02:2c:bb (84:34:97:02:2c:bb)
Port ConfigFlags
.... .... .... .... .... .... .... ...0 = Port is administratively down: No (0)
.... .... .... .... .... .... .... ..0. = Disable 802.1D spanning tree on port: No (0)
.... .... .... .... .... .... .... .0.. = Drop non-802.1D packets received on port: No (0)
.... .... .... .... .... .... .... 0... = Drop received 802.1D STP packets: No (0)
.... .... .... .... .... .... ...1 .... = Do not include this port when flooding: Yes (1)
.... .... .... .... .... .... ..0. .... = Drop packets forwarded to port: No (0)
.... .... .... .... .... .... .0.. .... = Do not send packet-in msgs for port: No (0)
Port Config Mask
.... .... .... .... .... .... .... ...0 = Port is administratively down: No (0)
.... .... .... .... .... .... .... ..0. = Disable 802.1D spanning tree on port: No (0)
.... .... .... .... .... .... .... .0.. = Drop non-802.1D packets received on port: No (0)
.... .... .... .... .... .... .... 0... = Drop received 802.1D STP packets: No (0)
.... .... .... .... .... .... ...1 .... = Do not include this port when flooding: Yes (1)
.... .... .... .... .... .... ..0. .... = Drop packets forwarded to port: No (0)
.... .... .... .... .... .... .0.. .... = Do not send packet-in msgs for port: No (0)
Port Advertise Flags
.... .... .... .... .... .... .... ...0 = 10 Mb half-duplex rate support: No (0)
.... .... .... .... .... .... .... ..0. = 10 Mb full-duplex rate support: No (0)
.... .... .... .... .... .... .... .0.. = 100 Mb half-duplex rate support: No (0)
.... .... .... .... .... .... .... 0... = 100 Mb full-duplex rate support: No (0)
... .... .... .... .... .... ...0 .... = 1 Gb half-duplex rate support: No (0)
.... .... .... .... .... .... ..0. .... = 1 Gb full-duplex rate support: No (0)
.... .... .... .... .... .... .0.. .... = 10 Gb full-duplex rate support: No (0)
.... .... .... .... .... .... 0... .... = Copper medium support: No (0)
.... .... .... .... .... ...0 .... .... = Fiber medium support: No (0)
.... .... .... .... .... ..0. .... .... = Auto-negotiation support: No (0)
 .... .... .... .... .... .0.. .... .... = Pause support: No (0)
.... .... .... .... .... 0... .... .... = Asymmetric pause support: No (0)
Pad: 0
Pad: 0
Pad: 0
Pad: 0
```

Example v1.3

```
Wireshark Capture of a sample Port-Mod message for a 1.3 instance
OpenFlow Protocol
  Header
   Version: 0x04
   Type: Port Mod (CSM) (16)
    Length: 40
   Transaction ID: 4043243760
   Port Modification
   Port #: 2
   Pad: 0
    Pad: 0
    Pad: 0
    Pad: 0
  MAC Address: HewlettP_02:2c:be (84:34:97:02:2c:be)
    Pad: 0
   Pad: 0
   Port ConfigFlags
.... .... .... .... .... .... .... ...0 = Port is administratively down: No (0)
.... .... .... .... .... .... .... ..0. = Disable 802.1D spanning tree on port: No (0)
.... .... .... .... .... .... .... .0.. = Drop non-802.1D packets received on port: No (0)
.... .... .... .... .... .... .... 0... = Drop received 802.1D STP packets: No (0)
.... .... .... .... .... .... ...0 .... = Do not include this port when flooding: No (0)
.... .... .... .... .... .... ..0. .... = Drop packets forwarded to port: No (0)
.... .... .... .... .... .... .1.. .... = Do not send packet-in msgs for port: Yes (1)
   Port Config Mask
.... .... .... .... .... .... .... ...0 = Port is administratively down: No (0)
.... .... .... .... .... .... .... ..0. = Disable 802.1D spanning tree on port: No (0)
.... .... .... .... .... .... .... .0.. = Drop non-802.1D packets received on port: No (0)
.... .... .... .... .... .... .... 0... = Drop received 802.1D STP packets: No (0)
.... .... .... .... .... .... ...0 .... = Do not include this port when flooding: No (0)
.... .... .... .... .... .... ..0. .... = Drop packets forwarded to port: No (0)
.... .... .... .... .... .... .1.. .... = Do not send packet-in msgs for port: Yes (1)
  Port Advertise Flags
.... .... .... .... .... .... .... ...0 = 10 Mb half-duplex rate support: No (0)
.... .... .... .... .... .... .... ..0. = 10 Mb full-duplex rate support: No (0)
.... .... .... .... .... .... .... .0.. = 100 Mb half-duplex rate support: No (0)
.... .... .... .... .... .... .... 0... = 100 Mb full-duplex rate support: No (0)
.... .... .... .... .... .... ...0 .... = 1 Gb half-duplex rate support: No (0)
.... .... .... .... .... .... ..0. .... = 1 Gb full-duplex rate support: No (0)
.... .... .... .... .... .... .0.. .... = 10 Gb full-duplex rate support: No (0)
.... .... .... .... .... .... 0... .... = Copper medium support: No (0)
.... .... .... .... .... ...0 .... .... = Fiber medium support: No (0)
```

```
.... .... .... .... .... ..0. .... .... = Auto-negotiation support: No (0)
.... .... .... .... .... .0.. .... .... = Pause support: No (0)
.... .... .... .... .... 0... .... .... = Asymmetric pause support: No (0)
   Pad: 0
   Pad: 0
  Pad: 0
  Pad: 0
```

Example

Send a Port-Mod command to the switch using dpctl, a controller utility.

```
root@openflow-ubuntu-10:/home/openflow# dpctltcp:10.20.30.50:6633 port-desc

... {no="6", hw_addr="00:1b:3f:cf:76:fa", name="A6", config="0x0", state="0x1",
curr="0x0", adv="0x0", supp="0x0", peer="0x0", curr_spd="100000000kbps",
max_spd="100000000kbps"} ...

root@openflow-ubuntu-10:/home/openflow# dpctltcp:10.20.30.50:6633 port-mod
port=6,addr=00:1b:3f:cf:76:fa,conf=0x40,mask=0x40

SENDING:
port_mod{port="6", hwaddr="00:1b:3f:cf:76:fa", config="0x00000040",
mask="0x40", adv="0x0"}
OK

root@openflow-ubuntu-10:/home/openflow# dpctltcp:10.20.30.50:6633 port-desc
... {no="6", hw_addr="00:1b:3f:cf:76:fa", name="A6", config="0x40",
state="0x1", curr="0x0", adv="0x0", supp="0x0", peer="0x0",
curr_spd="100000000kbps", max_spd="100000000kbps"} ...
```

Port modification and OpenFlow versions

OFP_PORT_CONFIG, OFPPC_NO_FLOOD and OFPPC_NO_PACKET_IN are supported by an OpenFlow 1.0 instance on the switch.

OFP_NO_FLOOD and OFPPC_NO_PACKET_IN are supported by an OpenFlow v1.3 instance on the switch.

NOTE: If a port is not exclusive to the Openflow Member VLAN, a Port Modification message from the controller will result in an error returned to the controller.

Configuring egress only ports

This CLI command enables or disables support for advertising egress-only ports to the controller. Ports that are members of non-OpenFlow VLANs are egress-only ports. A controller can add a flow with an egress-only port as an output port to allow traffic to be forwarded from an OpenFlow VLAN to a non-OpenFlow VLAN. All instance member ports and egress-only ports are exposed as instance ports to the controller.

Syntax

```
(Openflow) # egress-only-ports
```

egress-only-ports

Enable or disable support for advertising egress-only ports to the controller.

Ports that are members of non-OpenFlow VLANs are egress-only ports. A controller can add a flow with an egress-only port as an output port to enable traffic to be forwarded from an OpenFlow VLAN to a non-OpenFlow VLAN.

NOTE: Egress-only ports cannot be used as an “in-port” in any flow by a controller. If this is attempted an error message will be returned and the flow addition will fail.

Example

```
Openflow # egress-only-ports
Configured OF Version    : 1.0
Negotiated OF Version    : 1.0
Instance Name            : test
Admin. Status            : Enabled
Member List              : VLAN 3
Listen Port              : None
Oper. Status             : Up\
Oper. Status Reason      : NA
DatapathID               : 00032c4138c98500
Mode                     : Active
Flow Location            : Hardware and Software
No. of Hw Flows          : 0
No. of Sw Flows          : 0
Hw. Rate Limit           : 0 kbps
Sw. Rate Limit           : 100 pps
Conn. Interrupt Mode     : Fail-Secure
 Maximum BackoffInterval : 60 seconds
Probe Interval           : 10 seconds
Hw. Table Miss Count     : 0
No. of Sw Flow Tables    : NA
Egress Only Ports        : A1,A3-A24,F1-F22

Table Model: Single Table

Controller id  Connection Status Connection State Secure  Role
-------------- ----------------- ---------------- ------  ------
1              Disconnected      Backoff          No      Equal
```

NOTE: When the Egress-Only Ports option is enabled for OpenFlow on the switch, the Port-Mod message for an egress-only port will result in an error.

Software and hardware rate limiting

You can specify resource limits used by an OpenFlow instance. Each OpenFlow instance has completely independent rate-limiters that can be set separately.

Syntax

```
openflow instance { instance-name | aggregate }
limit { hardware-rate kbps | software-rate pps }
```

instance-name

Set software and hardware rate limiting for the named instance.

aggregate

Set software and hardware rate limiting for the aggregate instance.

kbps

Limit the bandwidth that can be utilized by an OpenFlow instance.

Default: 0 kbpsRange 0 — 10,000,000 kbps

pps

Configure the OpenFlow instance packet rate limit.

Limits the number of packets per second per module that this instance can send to the software path.

Default: 100 ppsRange: 1 — 10,000 pps

NOTE: Increasing the software rate limit increases CPU consumption and may impact system performance.

If the software rate limit is specified beyond 1000 pps, the warning listed below will be displayed:

```
Increasing the software rate limit would increase CPU
consumption and may impact the system performance.
```

Limiting the usage of hardware resources

Syntax

```
OpenFlow # limit policy-engine-usage | ip-ctrl-table-usage
| multiport-filter-usage max-percentage
```

policy-engine-usage

Maximum percentage of policy engine resources used by OpenFlow.

ip-ctrl-table-usage

Maximum percentage of IP control table resources used by OpenFlow.

multiport-filter-usage

Maximum percentage of the multiport-filter resources used by OpenFlow.

You can limit the OpenFlow usage of policy engine resources, ip control table and multiport filters so that other functions that use the same resources are not impacted severely.

The limit can only be set when OpenFlow is disabled globally.

Max-Percent

Specifying 0% allocates no resources for OpenFlow.

By default, the OpenFlow policy engine resource usage is set at 50% to avoid oversubscribing resources and impacting performance. In addition to OpenFlow, the policy engine resource can be used by Access Control Lists, Quality of Service, Identity Driven Management, Virus Throttling, Mirroring, Policy Based Routing, and other features.

NOTE: The maximum percentage is not a guaranteed percentage but a maximum allowed limit.

Using the default 50% resource usage setting, the 8200zl and 5400zl switches with v1 zl modules, and the 3500/3500yl, 6200yl, and 6600 switches can support approximately 1000 OpenFlow rules in hardware while the 8200zl and 5400zl switches with v2 zl modules and the 3800 switches can support up to 2000 OpenFlow rules in hardware.

To increase the number of flows beyond the default 50% setting, use the above OpenFlow limit policy-engine-usage command. If all policy engine resources are in use, OpenFlow rules will no longer be added in hardware and the switch will deny attempts to configure ACLs with the CLI. To determine resource usage on your switch, see "Viewing OpenFlow resources" (page 40) and the appendix titled "Monitoring Resources" in the latest *Management and Configuration Guide* for your switch.

Default: 50%Range: 0 — 100%

NOTE: Resource usage can only be set when OpenFlow is disabled.

Example

```
openflow# limit multiport-filter-usage [1-100]
0-100:  Maximum percentage of Multiport filters used by OpenFlow.

HP-3500yl-24G-PoEP# show openflow multiport-filter-limit
Total Multiport Filters: 2037
                 Filters       Filters        Filters
Features       Allocated    Used            Free
------------ ---------- -----------  -----------
OpenFlow       1024            0                1024
```

Hardware statistics refresh rate

Syntax

`openflow-instance-name [#]hardware statistics|refresh rate policy-engine-table <value>`

Refresh rate for policy engine table statistics.

Default: 0–3600

Backing up your configuration (optional)

Dual management module in E8200 platforms is supported. Flow configuration is synchronized across management modules and flow table preserved during switchover.

See 'Chassis Redundancy' in the *Management and Configuration Guide* for your switch.

Configuring VLANs

For information on configuring and verifying VLANs, see the *Advanced Traffic Management Guide* for your switch.

Configuring and verifying routing

For information on configuring and verifying routing, see the *Multicast and Routing Guide* for your switch.

Configuring physical and logical ports

For information on configuring and verifying ports, see the 'Port Status and Configuration' chapter in the *Management and Configuration Guide* for your switch.

3 Group table

Groups represent sets of actions for flooding as well as more complex forwarding semantics (e.g. multipath, fast reroute, and link aggregation). As a general layer of indirection, groups also enable multiple flow entries to forward to a single identifier (e.g. IP forwarding to a common next hop). This abstraction allows common output actions across flow entries to be changed efficiently.

The group table contains group entries; each group entry contains a list of action buckets with specific semantics dependent on group type. The actions in one or more action buckets are applied to packets sent to the group. There are 4 types of groups:

1. **All**

   All the action buckets in the group should be executed when a packet hits the group table.

2. **Select**

   Execute any one action bucket in the group. The switch implementation uses round-robin to select the action bucket to be executed. Openflow specification defines a weight mechanism to do load sharing. However, this is not supported in the switch implementation. The weight MUST be given as 1. For all the other groups, weight MUST be specified as 0.

3. **Indirect**

   Execute the one defined bucket in this group. This group supports only a single bucket.

4. **Fast failover**

   Execute the first live bucket. The buckets are evaluated for liveness in the order defined by the group.

For the implementation of groups, the following is important to note:

- Group table is supported only in software. Hence, group cannot be referenced directly from a hardware flow entry.
- The number of groups per OpenFlow instance is capped to 32.
- The total number of groups in the switch is capped to 1024.
- Chaining of groups not supported. As a consequence, watch_group is also not supported while doing group additions. Watch_group MUST always be set to OFPG_ANY for all the group types.

4 OpenFlow per-flow rate limiting

OpenFlow supports per-flow rate-limiters for OpenFlow 1.0 as HP vendor extensions.

A rate-limiter controls the rate of packets passing through a switch. Per-flow rate-limiters associate an arbitrary number of flows with a rate-limiter. Using OpenFlow with per flow rate-limiters, any number of flows can be flexibly mapped to a rate-limiter, regardless of their source and destination ports. The use of rate-limiters requires a version of ovs-ofctl which includes HP QoS extension. Rate-limiters are addressed by a limiter_id, an arbitrary 32 bit number. Configuration of rate-limiters is done through a simple message from the OpenFlow controller which can add, modify or remove a rate-limiter. Flows are directed to rate-limiters through an action. Multiple flows can be associated with the same rate-limiter. Statistics can be read from the OpenFlow controller for each rate-limiter.

NOTE: Per-flow rate-limiters are used only if the hardware rate-limiter for the instance is disabled.

QoS extensions

HP QoS extension to the OpenFlow protocol provides support for rate-limiters. A rate-limiter controls the rate of packets passed through it. Per-flow rate-limiters associate an arbitrary number of flows with a rate-limiter. The HP QoS vendor extensions support per-flow rate-limiters with only drop rate flag and not mark rate or other flags.

Maintain limiter in rule

The rule structure maintains the limiter identification and a flag to indicate if the rule has a limiter ID associated with it.

Create a limiter

A per-flow rate-limiter is added/created from the OpenFlow controller using the add-limiter command. Note that this requires the controller to have the HP QoS extensions.

On receiving a vendor request from the OpenFlow controller, the vendor ID is checked for HPX_VENDOR_ID and then passed on to “ofputil_decode_hpx” to be decoded. On receiving a message of type OFPUTIL_HPX_ADD_LIMITER, a new meter is created with the parameters received in the message. The meters are created, updated and deleted by calls to platform independent functions, which in turn call the platform dependent functions.

Get limiter details

The details on the limiters configured can be retrieved by issuing a `dump-limiters` command from the OpenFlow controller. These details can also be checked on the switch using `show openflow <inst_name> limiters`.

Support flow with a limiter

A flow can be associated with a per-flow rate-limiter by giving the limiter ID in actions. For example, assume that a per flow rate-limiter with ID 100 is created with an `add-limiter` command from the OpenFlow controller. From an ovs controller with HP QoS extensions, a flow can be associated with this rate-limiter using the **rate_limit** key word in the actions as indicated below.

```
ovs-ofctl add-flow tcp:192.168.1.2:6633
idle_timeout=0,ip,nw_src=20.20.20.41,
action=output:57,rate_limit:100
```

5 Administering OpenFlow

Additional fields and filters added in OpenFlow version 1.3 increases the available show commands.

Monitoring OpenFlow

OpenFlow can be monitored at several levels and the rate at which the information from the hardware is refreshed can be configured.

Displaying OpenFlow information

Displays the versions of OpenFlow instance with status and flow data.

Syntax

```
show openflow
```

Example

```
HP-Switch# show openflow

OpenFlow              : Disabled
IP Control Table Mode : Enabled

Instance Information
                                 No. of     No. of     OpenFlow
  Instance Name       Status     H/W Flows  S/W Flows  Version
  ------------------- ---------- ---------- ---------  ---------
  titan               Down          0          0       1.0
  marez               Up            0          0       1.3 only
```

Setting OpenFlow statistics refresh rate

Choose the maximum time before hardware statistics are refreshed.

Syntax

`openflow hardware-statistics refresh-rate` *`secs`*

`secs`

The hardware statistics refresh-rate for OpenFlow.

Default: 20 secondsRange: 0— 3600 seconds

NOTE: With value of 0, the hardware is no longer polled to update the statistics.

Viewing OpenFlow information

You can display OpenFlow information for all instances, ports, and flows. The returned information includes the OpenFlow version supported.

Syntax

`show openflow [ resources | controllers | instance` *`instance-name`* `[[ port-statistics ] | flows [` *`flow-filters`* `auxiliary-connections] ] ]`

Show OpenFlow information.

`resources`

Shows OpenFlow resource utilization. See "Viewing OpenFlow resources" (page 40).

`controllers`

Shows controllers configured for OpenFlow. See "Viewing OpenFlow controllers" (page 41)

`instance-name`

Instance information can be obtained for ports or flows.

`port-statistics`

Shows port statistics.

`flows`

`flow-type`

Shows the flow table entries for a particular OpenFlow instance. The various flows displayed using *`flow-type`* are shown in Example 2 "Flow version 1.0" and Example 3 "Flow version 1.3" below.

Example 2 Flow version 1.0

```
(<openflow>)# show openflow instance titan flows
Flow 1 Match
  Incoming Port           : F24                  Ethernet Type     : IP
  Source MAC            : 000000-000000       Destination MAC  : 000000-000000

  VLAN ID                 : 0                    VLAN Priority     : 0
  Source Protocol Address : 255.255.255.255/32
  Target Protocol Address : 128.128.128.128/32
  IP Protocol             : 0x00                 IP ToS Bits       : 0
  Source Port              : 0                    Destination Port : 0
Attributes
  Priority                : 32768                Duration          : 10 secs
  Hard Timeout            : 0 secs               Idle Timeout      : 60 secs
  Byte Count              : 0                    Packet Count      : 0
  Controller ID           : 1                    Cookie            : 0x0
  Flow Location           : Software             Hardware Index    : 1
  Reason Code             : 100
  Reason Description      : Rule is in hardware
Actions
  Modify Destination IP   : 183.23.45.64
  Modify Source IP        : 200.123.23.54
  Output                  : A21
```

Example 3 Flow version 1.3

```
(<openflow>)# show openflow instance titan flows
Flow 1
 Match
  Incoming Port           : 1/17                Ethernet Type     : IP
  Source MAC            : 000000-000000       Destination MAC  : 000000-000000

  VLAN ID                 : 0                   VLAN Priority     : 0
  Source Protocol Address : 255.255.255.255/32
  Target Protocol Address : 128.128.128.128/32
  IP Protocol             : TCP                 IP ToS Bits       : 0
  IP ECN                  : 0                   IP DSCP           : 18
  Source Port              : 0                   Destination Port : 0
 Attributes
  Priority                : 32768               Duration          : 10 secs
  Hard Timeout            : 0 secs              Idle Timeout      : 0 secs
  Byte Count              : 5040                Packet Count      : 28
  Flow Table ID           : 3                   Controller ID     : 1
  Activity Count          : 0xffffffff          Cookie            : 0x0
  Hardware Index          : 1
 Instructions
  Clear Actions
   Write Actions   Pop VLAN
         Push VLAN Decrement TTL
         Output: : 3/24, 4/5, 1/18
         Goto Table ID: 2
Flow 2
 Match
  Incoming Port           : Trk1                Ethernet Type     : IPv6
  Source MAC            : 000000-000000       Destination MAC  : 000000-000000

  VLAN ID                 : 0                   VLAN Priority     : 0
  Source Protocol Address : 255.255.255.255/32
  Target Protocol Address : 128.128.128.128/32
  IPv6 Flow Label         : 0
  IPv6 Ext. Header        : Fragment
  ND Source MAC         : 000000-000000 ND    Destination MAC  : 00000-000000

  ND Target IP            : 0:0:0:0:0:0:0:0
  IP Protocol             : 0x2C
  IP ECN                  : 0                   IP DSCP           : 20
  Source Port              : 0                   Destination Port : 0
 Attributes
  Priority                : 12345               Duration          : 10 secs
  Hard Timeout            : 300 secs            Idle Timeout      : 160 secs
  Byte Count              : 0                   Packet Count      : 0
  Flow Table ID           : 6                   Controller ID     : 1
  Activity Count          : 0xffffffff          Cookie            : 0x0
  Hardware Index          : 1
 Instructions
  Apply Actions
     Modify Destination IP  : 2000::5
     Modify Source IP       : 2000::6
     Modify Source MAC      : 121212-121212
     Modify Destination MAC : 131313-131313
     Modify VLAN ID         : 123
     Modify IP DSCP         : 18
     Modify IP ECN          : 1
     Decrement TTL
     Meter ID                : 112
     Group ID               : 2
  Write Actions
     Decrement TTL
     Goto Table ID          : 4
Flow 3
 Match
  Incoming Port           : 0                   Ethernet Type     : ARP
  Source MAC            : 000000-000000       Destination MAC  : 000000-000000

  VLAN ID                 : 0                   VLAN Priority     : 0
  ARP Opcode              : 1
  ARP Source MAC         : 00A0C9-22B210       ARP Target MAC   : 000000-000000

  Source Protocol Address : 255.255.255.255/32
  Target Protocol Address : 128.128.128.128/32
 Attributes
  Priority                : 32768               Duration          : 10 secs
  Hard Timeout            : 0 secs              Idle Timeout      : 0  secs
  Byte Count              : 12450               Packet Count      : 2323
  Flow Table ID           : 3                   Controller ID     : 3
```

```
  Activity Count          : 0xffffffff          Cookie           : 0x0
  Hardware Index          : 1
Flow 4
 Match
  Source MAC              : 000000-000000       Ethernet Type    : 0x8035
  VLAN ID                : 0                   Destination MAC  : 000000-000000

  ARP Opcode              : 0                   VLAN Priority    : 0
  ARP Source MAC          : 000000-000000
  ARP Target MAC          : 000000-000000
  Source Protocol Address : 0.0.0.0
  Target Protocol Address : 0.0.0.0
  Source IP               : 0.0.0.0
  Destination IP          : 0.0.0.0             ARP Target IP      : 0.0.0.0
  IPv6 Flow Label         : 0
  IPv6 Ext. Header        : None
  ND Source MAC           : 000000-000000
  ND Target IP            : 0:0:0:0:0:0:0:0     ND Destination MAC :
000000-000000
  IP Protocol             : 0x00
  IP ECN                  : 0                   IP DSCP            : 0
  Source Port              : 0                   Destination Port   : 0
 Attributes
  Priority                : 32768               Duration           : 15 secs
  Hard Timeout            : 0 secs              Idle Timeout       : 50 secs
  Byte Count              : 0                   Packet Count       : 0
  Flow Table ID           : 5                   Controller ID      : 5
  Activity Count          : 0xffffffff          Cookie             : 0x0
  Hardware Index          : 1
 Instructions
  Write Actions
     Output   : 2/1
     Output   : Controller
```

Where the various flows that can be shown using the *flow-type* are:

`destination-ip`
: Show flows matching the destination IP address.

`destination-mac`
: Show flows matching the destination MAC address.

`destination-port`
: Show flows matching the destination port.

`ethernet-type`
: Show flows matching the EtherType.

`ip-protocol`
: Show flows matching the IP protocol.

`ip-tos-bits`
: Show flows matching the IP ToS bits.

`source-ip`
: Show flows matching the source IP address.

`source-mac`
: Show flows matching the source MAC address.

`source-port`
: Show flows matching the source port.

`vlan-id`
: Show flows matching the VLAN ID.

`vlan-priority`
: Show flows matching the VLAN priority.

destination-ipv6
: Show flows matching the destination IPv6 address.

flow-table
Show flows that are hit most corresponding to the flow table number.

ingress-port
Show flows matching the ingress port.

source-ipv6
Show flows matching the source IPv6 address.

Viewing OpenFlow instances

You can display OpenFlow information for a specific instance. This includes the memberships of OpenFlow instance, the controllers and listen-port for that instance and other relevant information.

Syntax

```
show openflow instance { instance-name | aggregate }
```

instance-name
Displays the OpenFlow configuration for a specific instance.

Example

```
HP-5406zl(of-inst-test)# show openflow instance test
Configured OF Version    : 1.0
Negotiated OF Version    : 1.0
Instance Name            : test
Admin. Status            : Enabled
Member List              : VLAN 2
Listen Port              : 6633
Oper. Status             : Up
Oper. Status Reason      : NA
Datapath ID              : 00000023209d1bf1
Mode                     : Active
Flow Location            : Hardware and Software
No. of Hw Flows          : 0
No. of Sw Flows          : 0
Hw. Rate Limit           : 0 kbps
Sw. Rate Limit           : 100 pps
Conn. Interrupt Mode      : Fail-Secure
Maximum Backoff Interval : 60 seconds
Probe Interval           : 10 seconds
Hw. Table Miss Count     : 0
No. of Sw Flow Tables    : NA
Egress Only Ports : None

Controller Id Connection Status Connection State Secure Role
------------- ----------------- ---------------- ------ ------
1             Disconnected      Void             No     Equal
```

The `operational status` can be `down` if:

- The member VLAN of the OpenFlow instance does not exist on the switch
- The controller VLAN of the OpenFlow instance does not exist on the switch
- When multiple controllers connect over multiple controller VLANs, the operational status is`Down` when none of the controller VLANs exist on the switch
- The member VLAN is down, for example when all ports on the member VLAN are down

  If controllers are associated with the instance, then the following table appears:

```
Controller-ID  Connection Status  Connection State
-------------  -----------------  ----------------
10             Connected          Active
11             Disconnected       Void
13             Connected          Idle
```

Possible connection states are *Active*, *Idle*, *Backoff*, *Connecting*, or *Void*.

Possible connection status values are *Connected* or *Disconnected*.

Viewing instance aggregate

Display information of an OpenFlow aggregate instance.

Example 4 Show OpenFlow instance aggregate

```
show openflow instance titan
Configured OF Version    : 1.3
Negotiated OF Version    : NA
OpenFlow Version         : 1.3
Instance Name            : titan
Admin. Status            : Disabled
Member List              : VLAN 1
Listen Port              : 6633
Oper. Status             : Down
Oper. Status Reason      : No port in member VLAN
[1]Datapath ID            : 0000002320e52b88
Mode                     : NA
Flow Location            : NA
No. of Hw Flows          : 0
No. of Sw Flows          : 0
Hw. Rate Limit           : 0 kbps
Sw. Rate Limit           : 100 pps
Conn. Interrupt Mode     : Fail-Secure
Maximum Backoff Interval : 60 seconds
Probe Interval           : 45 seconds
Hw. Table  Miss Count     : 100
[2]No. of Sw Flow Tables     : 4
[3]Egress Only Ports        : 1/11, 1/23, 1/24
[4]Table Model              : Single Table  [5]


Controller ID Connection Status Connection State Secure Role[6]
------------- ----------------- ---------------- ------ ------
1             Connected         Active           Yes    Master
2             Disconnected      Void             No     Slave

              Auxiliary               Auxiliary     Auxiliary
Controller ID Conn. index Auxiliary ID Conn. Status  Conn. State    Type [7]
 ------------- ----------- ------------ ------------ -------------- ----
1             1               111      Connected     Active         TCP
2             2               121      NA            Send Hello     UDP
```

Viewing OpenFlow resources

Syntax

```
show openflow resources
```

1. Reason will be N/A when operational status is up.
2. Only for 1.0 instance. NA for 1.3 instance.
3. Only for 1.3 instance. NA for 1.3 instance.
4. “None” if no ports available.
5. “Single Table” for 1.0 instance. For 1.3 instance the values could be “Policy Engine and Software or IP Control With Policy Engine and Software”
6. Will be equal for 1.0 instance.
7. This table appears only for 1.3 instance.

Example 5 Show OpenFlow resources

```
HP Switch(config)# show openflow resources

Resource usage in Policy Enforcement Engine

               |   Rules    |  Rules Used
        Slots  | Available  | ACL | QoS | IDM |  VT | Mirr | PBR |  OF  | Other |
---------------+------------+-----+-----+-----+-----+------+-----+------+-------|
  A            |       3055|    0|    0|    0|    0|     0|    0|     0|      0|
  F            |       3055|    0|    0|    0|    0|     0|    0|     0|      0|

               |   Meters   |  Meters Used
        Slots  | Available  | ACL | QoS | IDM |  VT | Mirr | PBR |  OF  | Other |
---------------+------------+-----+-----+-----+-----+------+-----+------+-------|
  A            |        255|     |    0|    0|     |      |     |     0|      0|
  F            |        255|     |    0|    0|     |      |     |     0|      0|

               |Application|
               |Port Ranges|  Application Port Ranges Used
        Slots  | Available  | ACL | QoS | IDM |  VT | Mirr | PBR |  OF  | Other |
---------------+------------+-----+-----+-----+-----+------+-----+------+-------|
  A            |         14|    0|    0|    0|     |     0|    0|      |      0|
  F            |         14|    0|    0|    0|     |     0|    0|      |      0|

 0 of 8 Policy Engine management resources used.

 Key:
 ACL = Access Control Lists
 QoS = Device & Application Port Priority, QoS Policies, ICMP rate limits
 IDM = Identity Driven Management
 VT  = Virus Throttling blocks
 Mirr = Mirror Policies, Remote Intelligent Mirror endpoints
 PBR = Policy Based Routing Policies
 OF = OpenFlow
 Other = management VLAN, DHCP Snooping, ARP Protection, Jumbo IP-MTU,
         Transparent Mode, RA Guard.

 Resource usage includes resources actually in use, or reserved for future
 use by the listed feature. Internal dedicated-purpose resources, such as
 port bandwidth limits or VLAN QoS priority, are not included.
```

Viewing OpenFlow controllers

Displays OpenFlow controllers configured for use by OpenFlow.

Syntax

```
show openflow controllers
```

Example 6 show OpenFlow controllers

```
HP Switch(config)# show openflow controllers

Controller Information

Controller Id IP Address                Port    Interface
------------------------------- ------ ---------
1              20.0.0.2                  6633    VLAN 6
```

Viewing OpenFlow instance attributes

Viewing flow table information

These commands display per instance flow table information, including both hardware and software flow tables.

NOTE: This option is available only for instances running OpenFlow version 1.3.

Viewing additional flow information

Syntax

```
show openflow instance instance-name flow-table flow-table-id
table-capability
```

Viewing global flow table information

Syntax

```
show openflow flow-table
```

Displays global flow table information.

Example

```
HP-5406zl(of-inst-t1)# show openflow flow-table

Flow Table Information

                                                 Max.       Refresh          Flow
Table Name               Usage     Rate (seconds)    Count
------------------------ --------- --------------  ------
IP Control Table         50%   12              0
Policy Engine Table      50%   20              0

            IP Control Table    Policy Engine Table
Slot ID   Current Usage (%)   Current Usage (%)
-------- -----------------   -------------------
1           0.000000              0.07
6           0.000000              0.07
```

Note: Current usage is percentage of OpenFlow maximum usage

Viewing specific flow table information

Viewing table capability

Syntax

```
show openflow instance [instance-name]flow-table table-id
table-capability
```

Shows OpenFlow table capability information for a specific flow table ID.

Example 7 Show table-capability

```
show openflow instance test flow-table 50 table-capability

OpenFlow IP Control Table

Table Match Capabilites:
   VLAN ID
   Source IPv4, IPv6
   Destination IPv4, IPv6
Table Instructions:
   Goto Table 101
Table-Miss Instructions:
   *Goto Table 102

*Currently configured action for table-miss flow.

show openflow instance test flow-table 101 table-capability

OpenFlow Accelerated Table

Table Match Capabilities:
   Incoming Port                    Ethernet Type: IPv4, IPv6
   VLAN ID                          VLAN Priority
   Source IPv4, IPv6                Destination IPv4, IPv6
   IPv6 Flow Label
   IP Protocol                      IP DSCP
   Source Port                      Destination Port
   ICMPv4 Type                      ICMPv4 Code
Table Instructions:
   Metering
      Band Type
         Drop
         Remark DSCP
   Apply-Actions
      Set-Field
         VLAN ID
         VLAN Priority
         Strip VLAN ID
         Source MAC
         Destination MAC
         IP DSCP
      Output
        Switch Port, Drop, Normal
Table-Miss Instructions:
   Apply-Actions
      Output
        Drop, Normal
   *Goto Table 200

*Currently configured action for table-miss flow.


show openflow instance test flow-table 200 table-capability

OpenFlow Software Table 1

Table Match Capabilites:
   Incoming Logical Port               Incoming Physical Port
   Metadata                            Destination MAC
   Ethernet Type                       Source MAC
   VLAN ID                             VLAN Priority
   IP DSCP                             IP ECN
```

```
   IP Proto
   Source IPv4, IPv6                    Destination IPv4, IPv6

   Source Port                          Destination Port
   IPV6 Flow Label
   Source SCTP Port                     Destination SCTP Port
   ICMPv4 Type                          ICMPv4 Code
   ARP Opcode
   ARP Source IPv4                      ARP Destination IPv4
   ARP Source MAC                       ARP Destination MAC
   ICMPv6 Type                          ICMPv6 Code
   IPv6 ND SLL                          IPv6 ND TLL
   ND IPv6 Target
Table Instructions:
   Apply-Actions
      Set-Field
         VLAN ID                        VLAN Priority
         Strip VLAN
         Source MAC                     Destination MAC
         Set TTL                        Decrement TTL
         IP ECN                         IP DSCP
      Output
         Drop, Normal
   Clear-Actions
   Write-Actions
   Write-Metadata
Table-Miss Instructions:
   Apply-Actions
      Output
         Drop, Normal
   Goto Table-201, *202, 203, 204

*Currently configured action for table-miss flow.
```

Viewing group table information

Syntax

`show openflow instance` *`instance-name`* `| aggregate groups` *`group-id`*

Shows OpenFlow group table information. Groups are supported in software tables. Up to 4 types of groups are supported with 32 groups supported per instance and 1024 groups across all instances. A select group uses the round-robin method for every packet and the number of action buckets capped to 8 per group.

Example Group table information

```
show openflow instance [instance-name] groups
Group ID          : 1
Group Type        : ALL
Reference Count   : 32767
Packet Count      : 0
Byte Count        : 0
Duration          : 10 seconds
Action Buckets    : 1, 2
 Bucket 1
  Packet Count      : 0
  Byte Count        : 0
  Watch port        : Any
  Weight            : 0
  Actions           : output A1
 Bucket 2
```

```
   Actions    :output F2
  Packet Count      : 0
  Byte Count        : 0
  Watch port        : Any
  Weight            : 0
  Action            : Output F23

Group ID : 1
Group Type : SELECT
Reference Count: 0Packet Count: 0
Byte Count: 0
Duration: 10
Action Buckets: 1
 Bucket 1:
  Packet Count: 0
  Byte Count: 0
  Watch Port: Any
  Weight: 1
  Actions: output A

Group ID: 7
Group Type: INDIRECT
Reference Count: 0
Packet Count: 0
Byte Count: 0
Duration: 10
Action Buckets: 1
 Bucket 1
  Packet Count: 0
  Byte Count: 0
  Watch Port: Any
  Weight: 0
  Actions: output A1
Group ID: 32
 Group Type: FAST
  FAIL OVER
Reference Count: 0
Packet Count: 0
Byte Count: 0
Duration: 10
Action Buckets: 1
 Bucket 1
  Packet Count: 0
  Byte Count: 0
  Watch port: A1
  Weight: 0
  Actions: output A1
```

Viewing group information for a specific instance

Displays group information for a specific instance.

Syntax

```
show openflow instance instance-name groups group-ID
```

Example

Viewing meter information for a specific instance

Displays meter information. Meters are instance-specific. Meters are only supported in hardware tables and the maximum number of meters differs between platforms. DSCP remark type band

supported only in extended match mode; however DSCP remark type band meter cannot be attached to flows with a non-IP match.

Syntax

```
show openflow instance instance-name meters
```

```
HP-3800-24SFP-2SFPP# show open inst t3 meters

OpenFlow Instance Meters
Meter ID : 1
Flow Count : 1
Input Packet Count : 0
Duration : 0

          Packet
Band Type Rate          Count
--------- ------------ --------
Drop      150 kbps      0
```

Viewing auxiliary connection information

Only one auxiliary connection is supported per main controller connection.

Syntax

```
show openflow auxiliary-connections
```

Displays auxiliary connection information.

Example 8 Show OpenFlow auxiliary connections

```
show openflow auxiliary-connections

Auxiliary
Conn. Index Type Port
----------- ---- ----
1           TCP  7777
2           UDP  8888
```

Viewing per flow rate limiter information

Syntax

```
show openflow instance <instance-name> limiters
```

Displays per-flow rate limiters information.

Example 9 Show OpenFlow instance information

```
HP-3500yl-24G-PoEP# show openflow instance <INSTANCE-NAME> limiters

OpenFlow Instance Per Flow Rate Limiters
Maximum Limiters  :  256

                                    Rate
Limiter ID   Action     (kbps)           Flow Count
----------   ------     ----------    ----------
112              Drop       128              2
```

Viewing group table information

Viewing multiport-filter-limit

Syntax

`show openflow multiport-filter-limit`

Displays multiport filter information. (Only in OpenFlow version 1.3.)

Example 10 Viewing multiport filter information

```
HP-Switch# show openflow multiport-filter-limit

Total Multiport Filters: 4096

             Filters     Filters     Filters
Features     Allocated   Used        Free
------------ ----------- ----------- -----------
OpenFlow     2048        1500        500
```

Viewing statistics

Viewing port statistics per instance

Syntax

`show openflow instance` *`instance-name`* `port statistics`

Displays port statistics information per instance.

Example 11 Display port statistics for version 1.3

```
HP-Switch# show openflow instance test port-statistics
Number of Ports: 2
Port 47: Up
 Status
  Admin. Status    : Enabled              Flood        : Enabled
  Receive          : Enabled              Forward      : Enabled
  Packet_in        : Enabled
 Statistics
  Collisions       : 0
  Rx Packets       : 0                    Tx Packets   : 68
  Rx Bytes         : 0                    Tx Bytes     : 8066
  Rx Dropped       : 0                    Tx Dropped   : 0
  Rx Errors        : 0                    Tx Errors    : 0
  Frame Errors     : 0
  CRC Errors       : 0
  Overrun Errors   : 0
  Port 48: Down
 Status
  Admin. Status    :                       Flood        :
  Receive          :                       Forward      :
  Packet_in        :
 Statistics
  Collisions       :
   Rx Packets       : 0                   Tx Packets   : 0
     Rx Bytes         : 0                   Tx Bytes     : 0
   Rx Dropped       : 0                   Tx Dropped   : 0
   Rx Errors        : 0                   Tx Errors    : 0
   Frame Errors     : 0
     CRC Errors       : 0
   Overrun Errors   : 0
```

Viewing message statistics for an instance

This command displays statistics for flow, port, group and meter modification message from the controller, the number of modification messages received from the controller and the number of messages rejected.

Syntax

`show openflow instance` *`instance-name`* `| aggregate message-statistics`

Show message statistics information for an instance. This displays the number of OpenFlow modification messages received from the controller and the number of messages rejected by the switch.

Example 12 Show OpenFlow instance message-statistics

```
OpenFlow #: show openflow instance instance-name message statistics
OpenFlow
Message Type    Received Rejected
--------------- -------- --------
OFPT_FLOW_MOD   100      12
OFPT_PORT_MOD   120      22
OFPT_GROUP_MOD  22       2
OFPT_METER_MOD  12       0
```

Viewing OpenFlow instance information

Syntax

`show openflow instance <instance-name> capabilities`

Displays OpenFlow instance capabilities.

Example 13 Show OpenFlow instance information

```
HP-3500yl-24G-PoEP# show openflow instance <INSTANCE-NAME>
capabilities

Policy Engine Match Capability : Extended Match

Switch Capabiilties
--------------------
Flow Statistics
Table Statistics
Port Statistics
Group Statistics
Blank Ports
```

6 Troubleshooting OpenFlow

Diagnostic Tools Overview and Usage

Debug OpenFlow

You can display OpenFlow protocol packets or event description.

NOTE: The `debug openflow packets` option only displays OpenFlow protocol packets exchanged between the switch and the controller.

Syntax

```
HP Switch# debug openflow <errors|events|instance|packets>
```

errors
: Display OpenFlow error messages.

events
: Enable debug messages for all OpenFlow events like addition/deletion/modification, enable/disable etc.

instance
: Specify an OpenFlow instance for instance-specific debug messages.

packets
: Enable debug messages for all OpenFlow packets.

Example 14 Debug logs

Flow deletion

```
mOFCtrlTask: 00020| DBG|Flow deletion:
idle_timeout=60,dl_type=0x0800,in_port=27,dl_vlan=65535,
dl_vlan_pcp=0,dl_src=00:50:56:9f:5f:0a,dl_dst=00:50:56:9f:19:92,
nw_src=1.2.3.6,nw_dst=1.2.3.4,icmp_type=0,icmp_code=0,
actions=output:26
```

Flow addition

```
mOFCtrlTask: 00019| DBG|Flow addition:
idle_timeout=60,dl_type=0x0800,in_port=27,
dl_vlan=65535,dl_vlan_pcp=0,dl_src=00:50:56:9f:5f:0a,
dl_dst=00:50:56:9f:19:92,nw_src=1.2.3.6,nw_dst=1.2.3.4,
icmp_type=0,icmp_code=0,actions=output:26
```

Flow expiry

```
mOFCtrlTask: 00018| DBG|Flow expiry:
idle_timeout=1200,dl_type=0x0800,nw_src=1.2.3.7,
nw_dst=1.2.3.8,actions=mod_nw_src:9.8.7.6
```

Error messages

Interoperability error messages

Enabling OpenFlow

Enabling OpenFlow when Meshing is enabled will result in an error message similar to the following.

```
OpenFlow cannot be enabled when Meshing is configured.
```

Enabling meshing

Enabling meshing when OpenFlow is enabled will result in an error message similar to the following.

```
Meshing cannot be configured when OpenFlow is enabled.
```

Enable OpenFlow with QinQ

Enabling OpenFlow when Q-in-Q is enabled will result in an error message similar to the following.

```
OpenFlow cannot be enabled when Q-in-Q is configured.
```

Enabling QinQ with OpenFlow

Enabling Q-in-Q when OpenFlow is enabled will result in an error message similar to the following.

```
Q-in-Q cannot be configured when OpenFlow is enabled.
```

Enabling transparent mode

Enabling Transparent Mode (TRmode) when OpenFlow is enabled will result in an error message similar to the following.

```
Transparent Mode cannot be enabled when OpenFlow is enabled.
```

Enabling OpenFlow with transparent mode

Enabling OpenFlow when Transparent Mode is enabled will result in an error message similar to the following.

```
OpenFlow cannot be enabled when Transparent Mode is enabled.
```

Enabling remote mirror endpoint

Enabling Remote Mirror Endpoint when OpenFlow is enabled generates an error message similar to the following.

```
Remote Mirror Endpoint cannot be configured when OpenFlow
is enabled.
```

Enabling OpenFlow with remote mirror endpoint

Enabling OpenFlow when Remote Mirror Endpoint is enabled generates an error message similar to the following.

```
OpenFlow cannot be enabled when Remote Mirror Endpoint is
configured.
```

Adding a port

Adding a port to a trunk that is part of an OpenFlow member VLAN generates an error message similar to the following.

```
Trunk in use by an OpenFlow instance may not be modified.
```

Deleting a port

Deleting a port from a trunk that is part of an OpenFlow member VLAN generates an error message similar to the following.

```
Trunk in use by an OpenFlow instance may not be modified.
```

Moving a trunk

When moving a trunk that is part of an OpenFlow member VLAN from one VLAN to another VLAN generates an error message similar to the following.

```
Trunk in use by an OpenFlow instance may not be moved.
```

Tagging/Untagging trunk

Toggling membership of the trunk from tagged to untagged when that trunk is part of an OpenFlow member VLAN generates an error message similar to the following.

```
Trunk in use by an OpenFlow instance may not be modified.
```

Enable LACP

Trying to enable LACP while OpenFlow is enabled generates the following error message.

```
LACP cannot be configured when OpenFlow is enabled.
```

Enable OpenFlow

Trying to enable OpenFlow when LACP is enabled generates the following error message.

```
OpenFlow cannot be configured when LACP is enabled.
```

Show per-flow rate limiters

Trying to show per-flow rate limiters for an instance running OpenFlow version 1.3 generates an error message similar to the following.

```
This command is supported only for an OpenFlow version 1.0
instance.
```

no allow-v1–module

Trying to run the command `[no] allow-v1-module` when OpenFlow is enabled generates an error message similar to the following.

```
V1 modules cannot be disabled when OpenFlow is enabled.
```

allow-v1–module

Trying to run the command `allow-v1-module` when OpenFlow is enabled generates an error message similar to the following.

```
V1 modules cannot be enabled when IP Control Table Mode is
enabled.
```

Non-compatible mode

Trying to enable OpenFlow when a switch is in a non-compatible mode (no allow-v1–module) generates an error message similar to the following.

```
OpenFlow cannot be enabled when V1 modules are disabled.
```

Enable virus throttling

Trying to enable virus throttling when OpenFlow is enabled generates an error message similar to the following.

```
Virus throtting cannot be enabled when OpenFlow is enabled.
```

Enable OpenFlow with virus throttling

Trying to enable OpenFlow when virus throttling is enabled generates an error message similar to the following.

```
OpenFlow cannot be configured when virus throttling is
enabled.
```

Controller error messages

Deleting an unconfigured controller

Attempt to delete a controller that has not been configured will result in an error message similar to the following.

```
HP-8206zl(vlan-3)# no openflow controller-id 2
[controller-id] 2 not found.
```

Configure or modifying an existing controller

Attempting to configure a controller that already exists or modifying the parameters of an existing controller will result in an error message similar to the following.

```
A controller is already configured with this ID.
```

Associated controllers

Attempting to delete existing controllers previously associated with an OpenFlow instance will result in an error message similar to the following.

```
Controller cannot be removed when in use by an OpenFlow
instance.
```

Setting IP Control Table mode

Attempting to set IP Control Table Mode when the switch is in compatible mode will result in an error message similar to the following.

```
IP Control Table Mode cannot be set when V1 module is
enabled.
```

Specifying and invalid flow table

Attempting to specify an invalid flow table ID will result in an error message similar to the following.

```
Invalid flow table number
```

Listen port or controller error

Commands issued from listen port or controllers are not successful.

1. Enable `debug openflow` which will display the switch output helping you to identify whether the error is occuring at the switch or the controller.
2. Enable `debug openflow instance [instance-name]` to further identify the error.
3. Verify the packet capture for the request and reply to isolate whether the error is occuring at the switch or the controller.

   NOTE: This problem occurs if some controllers do not fully conform to the specification and therefore cannot handle replies from the switch. The replies in the packet capture will be visible from the switch but not from the controller.

4. Enable `debug destination session` to further identify the error.

Specifying a port

If you are trying to specify an application port that is out of range will result in an error message similar to the following.

```
Invalid port. Valid range is 1024-65534.
```

Port error messages

Egress-only ports

Trying to enable or disable egress-only ports when OpenFlow is enabled generates an error message similar to the following.

```
Egress only ports can be set only when OpenFlow is disabled.
```

Limiter error messages

Removing limiters

Trying to remove a limiter when none are configured for an instance generates an error message similar to the following.

```
No limiters found for this OpenFlow instance.
```

VLAN error messages

Member to controller VLAN

Specifying a member VLAN as a controller VLAN will result in an error message similar to the following.

```
The specified VLAN is already member of OpenFlow instance
instance-name and hence cannot be added as controller
interface.
```

VLAN in an OpenFlow instance

Specifying a VLAN that is already a part of a different OpenFlow instance will result in an error message similar to the following.

```
The VLAN specified is already a member of another OpenFlow
instance.
```

More than one VLAN

Specifying more than one VLAN per instance will result in an error message similar to the following.

```
Only one VLAN can be configured as a member of an OpenFlow
instance.
```

VLAN range

Specifying a VLAN that is outside the allowed VLAN range will result in an error message similar to the following.

```
Invalid Input : VLAN-ID
```

Management VLAN

When the user tries to add the management VLAN to an OpenFlow instance will result in an error message similar to the following.

```
A management VLAN cannot be a member of an OpenFlow instance.
```

Configure VLAN as management

When the user tries to configure an OpenFlow instance VLAN as management VLAN will result in an error message similar to the following.

```
Management VLAN cannot be configured. VLAN <n> is member of
an OpenFlow instance.
```

Dynamic VLAN

When a dynamic VLAN is added as a member VLAN will result in an error message similar to the following.

```
Dynamic VLAN cannot be added as a member VLAN.
```

Controller interface

Adding a controller interface as member VLAN will result in an error message similar to the following.

```
Controller interface cannot be added as member VLAN.
```

Instance error messages

Enable a named instance

Attempting to enable a named instance without a listen port or controller and a member VLAN will display an error message similar to the following.

```
A controller and a member VLAN must be added to the named
instance before enabling it.
```

Enable an aggregate instance

Attempt to enable an aggregate instance without a listen port or controller will display an error message similar to the following.

```
A listen-port or a controller must be added to the aggregate
instance before enabling it.
```

Maximum number of instances

Configuring an instance when the maximum number of OpenFlow instances is already configured will display an error message similar to the following.

```
Maximum number of OpenFlow instances (128) already
configured.
```

Instance name that exceeds length

Configuring an instance with a name that exceeds the maximum length requirement will display an error message similar to the following.

```
Maximum length of the instance-name is 32 characters.
```

Create an aggregate instance

Trying to create an aggregate instance when a named instance already exists on the switch will display an error message similar to the following.

```
An aggregate instance cannot be created when named instances
exist.
```

Create a named instance

Trying to create a named instance when an aggregate instance is already configured will display an error message similar to the following.

```
Named instances cannot be created when an aggregate instance
exists.
```

Deleting an instance

Trying to delete a nonexistent instance will display an error message similar to the following.

```
Instance not found.
```

Enabling an instance

Attempt to enable an OpenFlow instance without configuring a listen port or a controller will display an error message similar to the following.

```
A listen-port or a controller, and a member VLAN must be
added to the named instance before enabling it.
```

Delete a member

Trying to delete a member which does not belong to the instance will display an error message similar to the following.

VLAN *VLAN-ID* is not a member of this instance.

Modifying backoff interval

Trying to modify the backoff interval when the instance is enabled will display an error message similar to the following.

```
Instance configuration cannot be modified when the instance
is enabled.
```

Instance name

When naming an instance, only alphanumeric characters, numerals and underscores are allowed in the instance name. Failure to following this rule will display an error message similar to the following.

```
Invalid name. Only alphanumeric characters and underscores
are allowed.
```

Errors concerning auxiliary connections

Removing auxiliary connection

Removing an auxiliary connection which is associated displays an error message similar to the following

```
Auxiliary connection is in use by an OpenFlow instance and
cannot be removed.
```

Deleting unconfigured auxiliary connection

Deleting an auxiliary connection that has not been configured displays an error message similar to the following.

```
Auxiliary connection index not found.
```

Associating multiple auxiliary indexes

Associating more than one auxiliary index displays an error message similar to the following.

```
Only one auxiliary connection can be configured per main
controller connection.
```

Associating un-configured auxiliary indexes

Associating an auxiliary index which is not configured displays an error message similar to the following.

```
No auxiliary connection is configured with this index.
```

Checking for the static limit

Checking for the static limit and error out while configuring displays an error message similar to the following.

```
Maximum number of auxiliary connections configured.
```

Associating auxiliary connection

Associating an auxiliary connection to an instance running version 1.0 displays an error message similar to the following.

```
Auxiliary connection can only be associated with instance
running version 1.3 and above.
```

Associating multiple auxiliary connections

Associating more than one auxiliary connection to an instance controller connection displays an error message similar to the following.

```
Only one auxiliary connection can be configured per main
controller connection.
```

Other scenarios

Setting policy engine resource usage when OpenFlow is enabled

When the policy engine resource usage is set while OpenFlow is enabled, will display an error message similar to the following.

```
Resource usage can be set only when OpenFlow is disabled.
```

Securing a connection with no certificate configured

When securing a connection with no certificate configured for OpenFlow, will display an error message similar to the following.

```
Certificate for OpenFlow is not configured.
```

Setting the protocol version with instances enabled

Setting the protocol version when instances are enabled will display a message similar to the following.

```
Instance configuration cannot be modified when the instance
is enabled.
```

Entering the wrong protocol version

Entering the wrong protocol version will display an error message similar to the following.

```
Entering the wrong protocol version will display an error
message similar to the following.
```

Troubleshooting scenarios for instances

Troubleshooting an instance

To troubleshoot instances, check the following.

- To connect a controller there must be ip-connectivity between controller and switch over the controller VLAN.
- The controller must be capable of negotiating to a version equal to or less than the configured or supported version.
- Use the `show openflow` command to check instances

Example

```
HP-Stack-3800(config)# show openflow
OpenFlow                          : Enabled
IP Control Table Mode           : Disabled

Instance Information
        No. of         No. of        OpenFlow
Instance Name            Oper.Status  H/W Flows S/W Flows  Version
----------------- ------------  --------- ---------- ----------
test               Down          0          0          1.0
```

- Use the `show openflow instance [instance-name]` command

Example

```
HP-Stack-3800(config)# show openflow instance test
Configured OF Version     : 1.0
Negotiated OF Version    : 1.0
Instance Name            : test
Admin. Status            : Enabled
Member List              : VLAN 3
Listen Port              : 6677
Oper. Status             : Down
Oper. Status Reason      : NA
```

```
Datapath ID              : 0003082e5f698e25
Mode                     : Active
Flow Location            : Hardware and Software
No. of Hw Flows          : 0
No. of Sw Flows          : 0
Hw. Rate Limit           : 0 kbps
Sw. Rate Limit           : 100 pps
Conn. Interrupt Mode     : Fail-Secure
Maximum Backoff Interval : 60 seconds
Probe Interval           : 10 seconds
Hw. Table Miss Count     : 0
No. of Sw Flow Tables    : NA
Egress Only Ports        : None
Table Model              : Single Table
Controller Id Connection Status Connection State Secure  Role
------------- ----------------- ---------------- ------  ------
1               Disconnected       Backoff            No      Equal
```

Commands issued from listen port or controllers are not successful

When commands issued from the listen port or the controller are not successful, the following commands can be used to isolate and troubleshoot the problem.

Syntax

`show openflow instance [instance-name] flow-table [table#] table-capabilities`

To display the table-capabilities of the instance in OpenFlow 1.3.

Syntax

`show vlan [member-vlan-no]`

To display the port-description.

Syntax

`show openflow instance [instance-name]`

To see egress-only ports.

Syntax

`show openflow instance [instance-name]port-statistics`

To display port statistics.

Syntax

`show openflow instance [instance-name] meters [number]`

To display the meter statistics.

Syntax

`show openflow instance [instance-name]groups`

To display groups.

Connection interruption mode setting

For minimal impact to an underlying network when a switch loses connection to the controller, the recommended setting is `fail-standalone` mode.

Flow modification

Add/Modify/Delete flow

When a request to add, modify or delete a flow mod is rejected by the switch, use the following command.

Syntax

```
show openflow instance [instance-name]message-statistics
```

Example

```
HP-Stack-3800(config-class)# show openflow instance test
message-statistics

OpenFlow
Message Type        Received          Rejected
 ----------------  ---------------  --------
OFPT_FLOW_MOD         0                  0
OFPT_PORT_MOD         0                  0
OFPT_GROUP_MOD        0                  0
OFPT_METER_MOD        0                  0
```

Verifying flows

The flow can be verified at the switch by using the following command.

Syntax

```
show openflow instance [instance-name]flows
```

Enable `debug openflow` at the switch. Run the command and observe the debug output for more specific rejection reasons why the flow is rejected by the switch.

NOTE: Similar troubleshooting techniques can be employed for port-modification, meter-modification and group-modification issues.

Programming flow errors

When programming flows via a controller, error messages may be returned based on implementation restrictions in the OpenFlow switch. Examples relevant to OpenFlow 1.3 include:

- Table 0 restrictions
- Table 0, a read-only table, in the OpenFLow 1.3 multiple pipeline represents the start of the pipeline.

IP control table restrictions

Error conditions for Table 50 may be caused by the following.

- Table-miss rule is read-only.
- Only unicast IP addresses can be used as match parameters in a flow.
- `Only "Goto" instruction is supported by this table.`
- `Flow with invalid VLAN match parameter is not allowed. A VLAN that does not exist on the switch is considered invalid.`

Possible errors returned to the controller:

OFPERR_OFPMFC_EPERM
OFPERR_OFPFMFC_TABLE_FULL

OFPERR_OFPBMC_BAD_FIELD (Bad or unsupported match parameter in the flow)
OFPERR_OFPBAC_BAD_TYPE (Bad or unsupported action in the flow)
OFPERR_OFPBIC_BAD_TABLE_ID
OFPERR_OFPFMFC_UNKNOWN (Any internal system error)

Policy engine table restrictions

Error conditions for Table 100, 101, or 102 may result from the following:

- In Aggregate mode, an Output-Port action is allowed only if the flow has VLAN as a match field or has as a Modify-VLAN action specified.
- Modify VLAN-PCP and P-ToS are the only Set—field actions allowed along with Output:NORMAL action.

OpenFlow v1.0 instance

OpenFlow 1.0 exposes a single table to the controller. The action of the default table-miss rule for such an instance is `"Goto Controller"`.

OpenFlow 1.3 instance

OpenFlow 1.3 instance exposes a multi-table model. For every table, the action of the default table-miss rule is “DROP”. For traffic to traverse the multi-table pipeline, the table-miss rule for every table must be modified appropriately by the controller.

Example

Consider the table model in standard mode comprised of tables 0, 100, 200-201-202-203:

- If a rule is programed into table 200 that permits traffic, then unless the default “table-miss rule” for table 100 is modified, traffic will not pass to table 200.
- If the default table-miss rule of table 100 is modified with the action given as “Gototable 200”, traffic will proceed to table 200. A table-miss rule would have to be programmed similarly for table 200 and so on.

NOTE: A table-miss rule is a flow with priority of 0 and all match fields wild-carded.

Flows go missing after addition

Verify the idle-timeout/hard-timeout of the flow.

- Table 50 supports only 12 seconds as the minimum hardware refresh rate. Flows programmed in this table should have at least an idle-timeout of twice that, or 24 seconds.
- Tables 100/101/102 support a configurable hardware refresh rate. If the “policy-engine-table refresh-interval” is configured for 5 seconds, then minimum idle-timeout supported would be 10 seconds (double the time configured.)

Missing line rate performance after flows are successfully installed

If an instance is running OpenFlow v1.0 and the flow cannot be accommodated in the hardware or a higher priority overlapping rule is present in software or we have reached the policy engine usage limit configured, then . the flow will be housed in the software table. This is verified by the `show openflow instance [instance-name] flows` command.

If the flow is programmed in software, line rate performance will not be seen in packet forwarding.

To know which flows will be accommodated in hardware, see the Flow classification section of this document.

For an OpenFlow1.3 instance, there could be several software tables, 200 to 203.

Troubleshooting scenarios and error messages

How to troubleshoot if instance is not coming up

When an instance is not coming up, use the following commands to troubleshoot the instance status.

1. Run the command `HP-Stack-3800(config)# show openflow`

```
HP-Stack-3800(config)# show openflow
OpenFlow                    : Enabled
IP Control Table Mode       : Disabled
Instance Information
                    No. of       No. of       OpenFlow
Instance Name                          Oper. Status  H/W Flows   S/W Flows   Version
-------------------------------- ------------  ----------  ----------  --------
 test                                  Down     0             0           1.0
```

2. Run the command `HP-Stack-3800(config)# show openflowinstance test`

```
HP-Stack-3800(config)# show openflowinstance test
Configured OF Version     : 1.0
Negotiated OF Version     : 1.0
Instance Name             : test
Admin. Status             : Enabled
Member List               : VLAN 3
Listen Port               : 6677
Oper. Status              : Down
Oper. Status Reason       : NA
Datapath ID               : 0003082e5f698e25
Mode                      : Active
Flow Location             : Hardware and Software
No. of Hw Flows           : 0
No. of Sw Flows           : 0
Hw. Rate Limit            : 0 kbps
Sw. Rate Limit            : 100 pps
Conn. Interrupt Mode      : Fail-Secure
Maximum Backoff Interval  : 60 seconds
Probe Interval            : 10 seconds
Hw. Table Miss Count      : 0
No. of Sw Flow Tables     : NA
Egress Only Ports         : None
Table Model               : Single Table

Controller Id Connection Status Connection State Secure Role
------------- ----------------- ---------------- ------ ------
1               Disconnected        Backoff            No     Equal
```

Reporting problems

If you are unable to solve a problem with OpenFlow, do the following:

1. Read the release notes for OpenFlow to see if the problem is known. If it is, follow the solution offered to solve the problem.
2. Determine whether the product is still under warranty or whether your company purchased support services for the product. Your operations manager can supply you with the necessary information.
3. Access HP Support Center and search the technical knowledge databases to determine if the problem you are experiencing has already been reported. The type of documentation and resources you have access to depend on your level of entitlement.

NOTE: The HP Support Center at HP Support Center offers peer-to-peer support to solve problems and is free to users after registration.

If this is a new problem or if you need additional help, log your problem with the HP Support Center, either on line through the support case manager at HP Support Center, or by calling HP Support. If your warranty has expired or if you do not have a valid support contract for your product, you can still obtain support services for a fee, based on the amount of time and material required to solve your problem.

4. If you are requested to supply any information pertaining to the problem, gather the necessary information and submit it. The following sections describe some of the information that you may be asked to submit.

7 Support and other resources

Contacting HP

Before you contact HP

Be sure to have the following information available before you call contact HP:

- Technical support registration number (if applicable)
- Product serial number
- Product model name and number
- Product identification number
- Applicable error message
- Add-on boards or hardware
- Third-party hardware or software
- Operating system type and revision level

HP contact information

For the name of the nearest HP authorized reseller:

- See the Contact HP worldwide (in English) website at http://welcome.hp.com/country/us/en/wwcontact.html.

For HP technical support:

- In the United States, for contact options see the Contact HP United States website at http://www8.hp.com/us/en/home.html.

  To contact HP by phone:

  - Call 1-800-HP-INVENT (1-800-474-6836.) This service is available 24 hours a day, 7 days a week. For continuous quality improvement, calls may be recorded or monitored.
  - If you have purchased a Care Pack (service upgrade), call 1-800-633-3600. For more information about Care Packs, see the HP website at http://www.hp.com/hps.
  - In other locations, see the Contact HP worldwide (in English) website at http://www8.hp.com/us/en/contact-hp/contact.html.

Subscription service

HP recommends that you register your product at the Subscriber's Choice for Business website at http://www.hp.com/country/us/en/contact_us.html. After registering, you will receive email notification of product enhancements, new driver versions, firmware updates, and other product resources.

Documents

You can find additional switch documents by using the Manuals page of the HP Business Support Center website at http://pro-networking-h17007.external.hp.com/us/en/support/converter/index.aspx.

Additional documentation for your HP Switch may include:

- *Access Security Guide*
- *Advanced Traffic Management Guide*

- *Basic Operation Guide*
- *IPv6 Configuration Guide*
- *Management and Configuration Guide*
- *Multicast and Routing Guide*
- *Event Log Message Reference Guide*
- *Comware CLI Commands in ProVision Software*

Websites

HP product websites are available for additional information.

- HP Switch Networking web site: http://www.hp.com/networking/support
- HP Technical Support website: http://www.hp.com/support

Typographic conventions

This document uses the following typographical conventions:

`%`, `$`, or `#`
: A percent sign represents the C shell system prompt. A dollar sign represents the system prompt for the Bourne, Korn, and POSIX shells. A number sign represents the superuser prompt.

audit(5)
: A manpage. The manpage name is *audit*, and it is located in Section 5.

`Command`
: A command name or qualified command phrase.

`Computer output`
: Text displayed by the computer.

Ctrl+x
: A key sequence. A sequence such as **Ctrl+x** indicates that you must hold down the key labeled **Ctrl** while you press another key or mouse button.

`ENVIRONMENT VARIABLE`
: The name of an environment variable, for example, `PATH`.

ERROR NAME
: The name of an error, usually returned in the `errno` variable.

Key
: The name of a keyboard key. **Return** and **Enter** both refer to the same key.

Term
: The defined use of an important word or phrase.

`User input`
: Commands and other text that you type.

`Variable`
: The name of a placeholder in a command, function, or other syntax display that you replace with an actual value.

[ ]
: The contents are optional in syntax. If the contents are a list separated by `|`, you must choose one of the items.

{ }
The contents are required in syntax. If the contents are a list separated by |, you must choose one of the items.

...
The preceding element can be repeated an arbitrary number of times.

Indicates the continuation of a code example.

|
Separates items in a list of choices.

WARNING
A warning calls attention to important information that if not understood or followed will result in personal injury or nonrecoverable system problems.

CAUTION
A caution calls attention to important information that if not understood or followed will result in data loss, data corruption, or damage to hardware or software.

IMPORTANT
This alert provides essential information to explain a concept or to complete a task

NOTE
A note contains additional information to emphasize or supplement important points of the main text.

Customer self repair

HP products are designed with many Customer Self Repair parts to minimize repair time and allow for greater flexibility in performing defective parts replacement. If during the diagnosis period HP (or HP service providers or service partners) identifies that the repair can be accomplished by the use of a Customer Self Repair part, HP will ship that part directly to you for replacement. There are two categories of Customer Self Repair parts:

- Mandatory—Parts for which Customer Self Repair is mandatory. If you request HP to replace these parts, you will be charged for the travel and labor costs of this service.
- Optional—Parts for which Customer Self Repair is optional. These parts are also designed for customer self repair. If, however, you require that HP replace them for you, there may or may not be additional charges, depending on the type of warranty service designated for your product.

NOTE: Some HP parts are not designed for Customer Self Repair. In order to satisfy the customer warranty, HP requires that an authorized service provider replace the part. These parts are identified as *No* in the Illustrated Parts Catalog.

Based on availability and where geography permits, Customer Self Repair parts will be shipped for next business day delivery. Same day or four-hour delivery may be offered at an additional charge where geography permits. If assistance is required, you can call the HP Technical Support Center and a technician will help you over the telephone. HP specifies in the materials shipped with a replacement Customer Self Repair part whether a defective part must be returned to HP. In cases where it is required to return the defective part to HP, you must ship the defective part back to HP within a defined period of time, normally five (5) business days. The defective part must be returned with the associated documentation in the provided shipping material. Failure to return the defective part may result in HP billing you for the replacement. With a Customer Self Repair, HP will pay all shipping and part return costs and determine the courier/carrier to be used.

For more information about the HP Customer Self Repair program, contact your local service provider. For the North American program, visit the HP website at http://www.hp.com/go/selfrepair.

8 Documentation feedback

HP 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@hp.com.) Include the document title and part number, version number, or the URL when submitting your feedback.

NOTE: There has been a change to the style of the documentation with the newest release. The "Command Table" commonly seen at the beginning of the chapters has been replaced with the ability to search for commands using the index. All commands are now listed in the index within the category "Command syntax".

A Flow classification on v1 and v2 modules

Hardware differences between v1 and v2 Modules affect flow match and capabilities.

For additional information about v1 and v2 Modules, compatibility and inter-operation of v2 zl Modules with v1 zl Modules in a chassis switch, see the latest Release Notes for your switch in the Compatibility Mode section, and the *HP 8200 zl, 5400 zl, 3500, and 6200 yl Switch Series Technical Overview White Paper*, 4AA0-5388ENW.pdf available on the HP Switch Networking web site at http://www.hp.com/networking/support.

Hardware match chart

Figure 5 OpenFlow v1.0 – K.15.10 and K.15.14 for 3500, 6200, 6600, 5400 and 8200 with v1 modules, OpenFlow v1.3 – K.15.14 for 3500, 6200, 6600, 5400 and 8200 with v1 modules

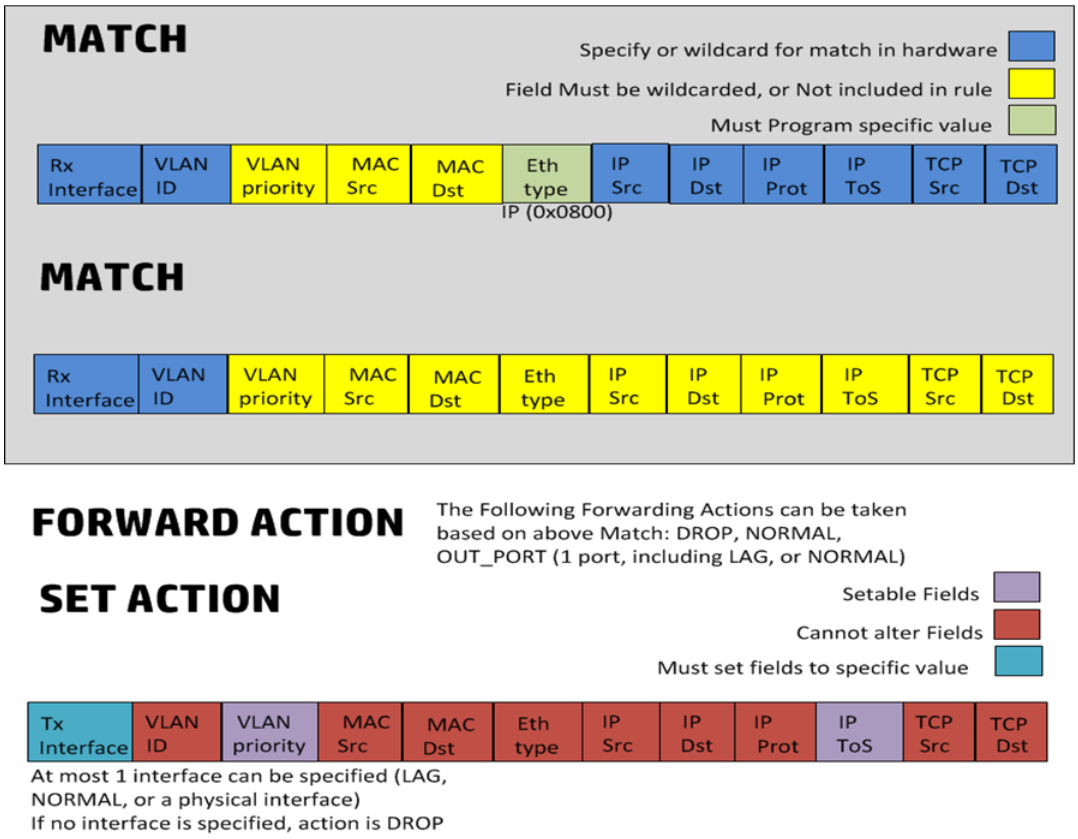


Figure 6 OpenFlow v1.0 – K.15.10 for 5400 and 8200 with v2 modules, KA.15.10 for 3800 and WB.15.12 for 2920

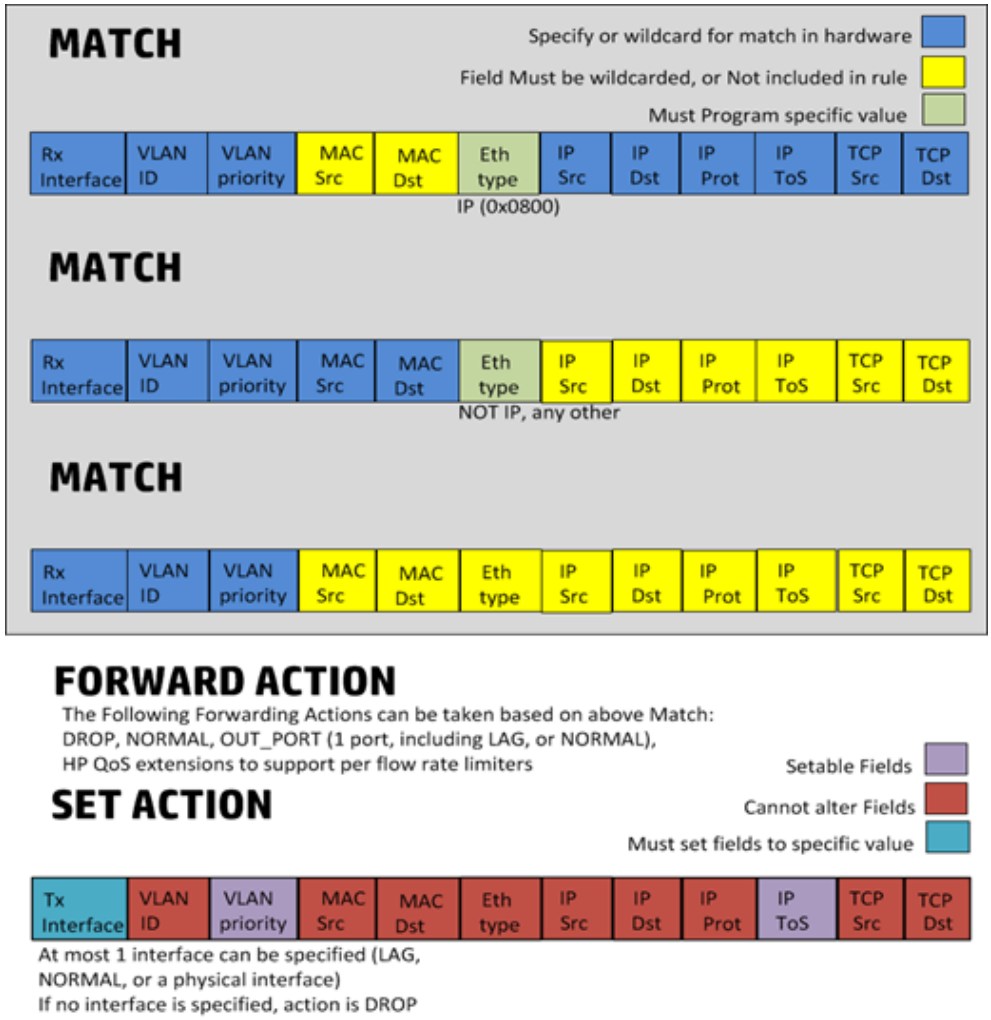
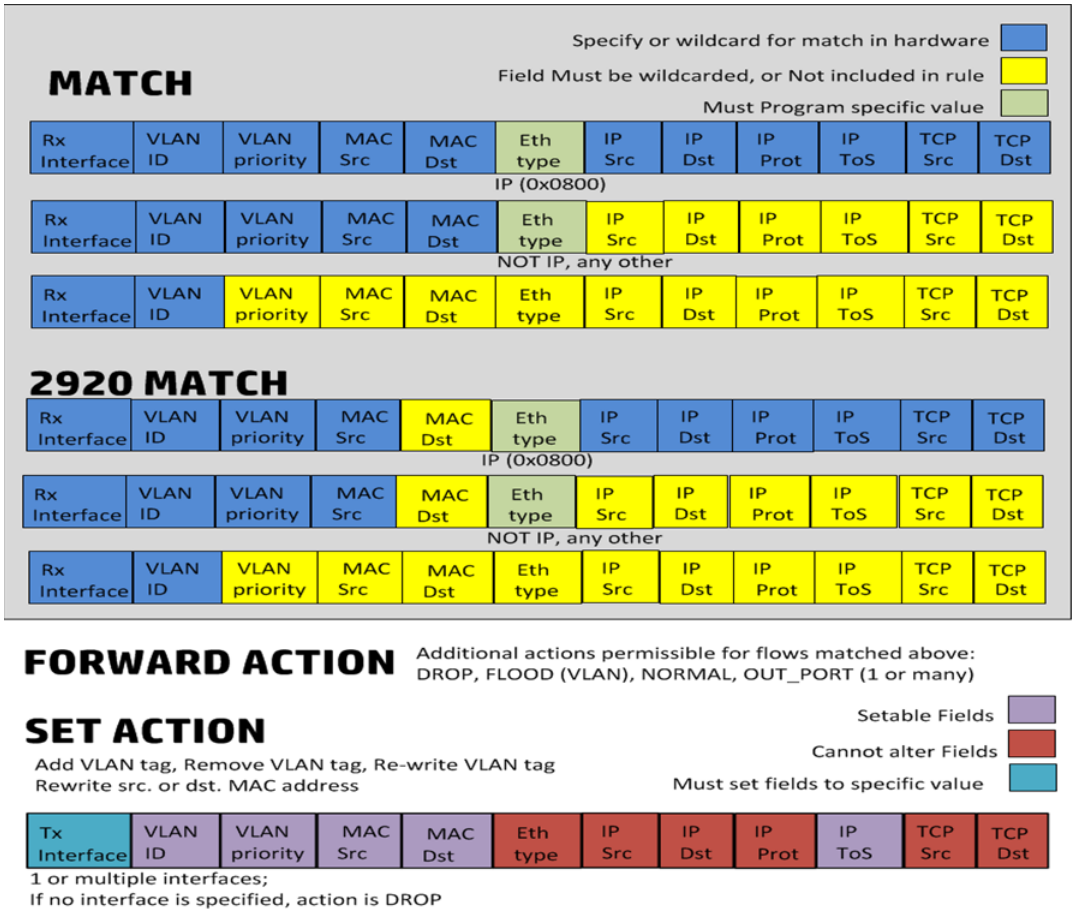


Figure 7 OpenFlow v1.0 and v1.3 – K.15.14 for 3500, 6200, 5400 and 8200 with v2 modules, KA.15.14 for 3800 and WB.15.14 for 2920



OpenFlow 1.3 multi-table model and device modes

Figure 8 Standard mode

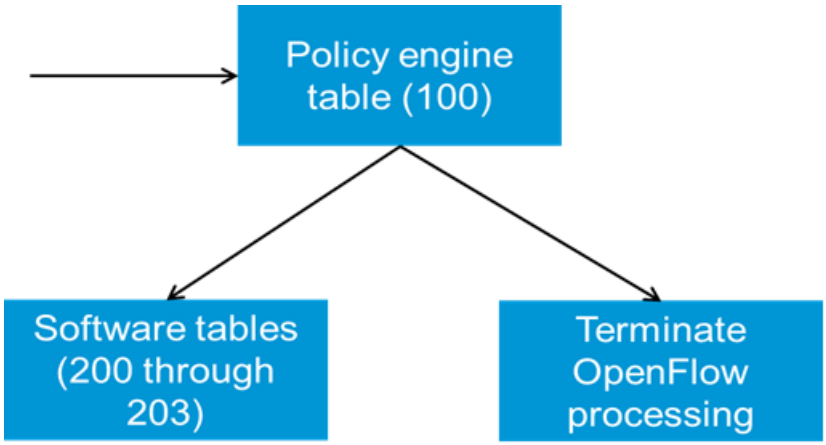


Figure 9 IP control table mode

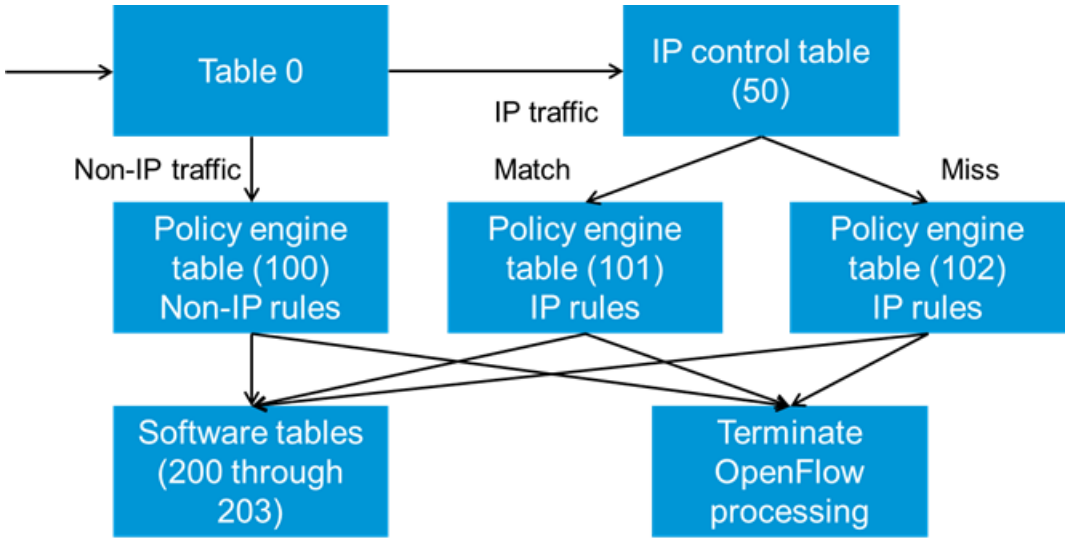


Table 3 Device modes and OpenFlow table model

Openflow Protocol Version	**Switch Mode**	**Table Model**	**Number of tables**	**Matching ability**	**Actions in Hardware (Nov 2013)**
V1.0	Compatible Mode – "allow-v1-modules" (V1 and V2) acts as V1	Single table only	1	Same as 15_10	Same as 15_10
V1.0	Non Compatible Mode – "no allow-v1-modules" (V2 only) act as V2	Single table only	1	Full 12 tuple match in policy engine	Same as 15_10 Plus new actions – rewrite VLAN ID, rewrite MAC address, forward to multiple ports
V1.3	Compatible Mode (V1 and V2) acts as V1	Standard Match	1 policy engine + 1 software	Same as 15_10	Same as 15_10
V1.3	Non-Compatible Mode (V2 only) act as V2	Standard Match	1 policy engine + 1 software	Full 12 tuple match in policy engine	Same as 15_10 Plus new actions - rewrite VLAN ID, rewrite MAC address, forward to multiple ports
V1.3	Non-Compatible Mode (V2 only) act as V2	IP Control Mode	1 IP control table + 3 policy engine tables (IP control table match, IP control table miss, Non-IP)+1 software	{src. VLAN, src. IP, dst. IP} in IP control table + Full 12 tuple match in policy engine	Same as 15_10 Plus new actions in - rewrite VLAN ID, rewrite MAC address, forward to multiple ports

B Implementation notes

This section documents some of the behaviors exhibited during the implementation of OpenFlow. These behaviors were exposed during testing and may include unit, conformance, integration, interoperability, stress and system testing.

A hardware flow with an idle timeout of 10 seconds gets deleted even though packets match the flow within the idle timeout

Problem statement

A hardware rule is programmed with idle timeout as 10 seconds and hard timeout as 0. Packets are pumped at 1000 pps to the switch matching the flow. However, after 10 seconds, the rule gets removed from the switch.

Reason for this behavior

By default the hardware statistics refresh rate (set using `openflow hardware statistics refresh rate` and information available through `show openflow`) is 20 seconds. This means that the packet count statistics get updated only every 20 seconds. So, when the idle timeout is set to less than 20 seconds, when a check is done for flow statistics after 10 seconds, it would not be updated. Hence, the flow would get deleted.

Customer Note

The user has the option of reducing or incriminating the refresh rate. However, the user needs to be aware of its implications. An increase in refresh rate would lead to deletion of flows which has an idle timeout less than the configured refresh rate. A decrease in refresh rate would lead to over-use of CPU (because of polling hardware statistics more frequently.)

Controller flows — flow in hardware and processing software

Flows with an action to send matching traffic to controller are actually installed on hardware. But, the actual traffic forwarding takes place in software as we need to add the required OpenFlow specific headers. Due to this characteristic, the actual forwarding will not take place at the line rate. A sample controller flow would look like:

Example

In this example, any packet that comes on port A1, will be forwarded to the controller after adding required OpenFlow packet headers (as the packet will be sent as a packet_in) to the controller. Since this processing is done on software, we will not be able to send the incoming traffic at line rate.

```
HP-8206zl(openflow)# show openflow instance test flows
Flow 1
  Incoming Port    : A1              Ethernet Type       : 0x0000
  Source MAC       : 000000-000000   Destination MAC      :
000000-000000
  VLAN ID          : 0               VLAN priority       :
  Source IP        : 0.0.0.0         Destination IP      : 0.0.0.0
  IP Protocol        : 0               IP ToS Bits         : 0
  Source Port      : 0               Destination Port    : 0
  Priority         : 2
  Duration         : 1 seconds
  Idle Timeout     : 60 seconds      Hard Timeout        : 0 seconds

  Packet Count     : 1               Byte Count          : 0
  Flow Location    : Hardware
```

```
Actions
  Controller Port
```

DUT matches and processes incoming untagged packets for VLAN id

For certain flows with a match on the VLAN ID, even untagged packets are matched. This happens on untagged ports only. The existing behavior exists because L2 hardware adds the VLAN id and VLAN priority meta-information irrespective of whether the packet came in tagged or untagged. Flows which can be accelerated into hardware are put into hardware whereas flows which cannot be accelerated in hardware are put into software. The observed behavior is observed for hardware flows. For software flows, the match happens for packets which come with a VLAN tag only and with proper VLAN id.

Events that change the Operational Status of the OpenFlow instance

The `Oper. Status` field indicates the operational status of the instance and can be either up or down. The operational status will be down when either the member VLAN of the OpenFlow instance does not exist on the switch or the controller VLAN of the OpenFlow instance does not exist on the switch. In the case when multiple controllers connect over multiple controller VLANs, the operational status will be down when none of the controller VLANs exist on the switch. When the member VLAN is down - all ports on the member VLAN are down.

For example, the `show openflow instance` displays all the OpenFlow instance related information as follows:

```
show openflow instance <test>
```

NOTE: Note that for purposes of this example the instance *<test>* has been created.

```
Instance Name              : Test
Admin. Status              : Enabled
Member List                : VLAN 3
Listen Port                : 6633
Oper. Status               : Down
Datapath ID                : 00030026f1212000
Mode                       : Active
Flow Location              : Hardware and Software
No. of Hw Flows            : 0
No. of Sw Flows            : 0
Hw. Rate Limit             : 0 kbps
Sw. Rate Limit             : 100 pps
Conn. Interrupt Mode       : Fail-Secure
Maximum Backoff Interval : 60 seconds

Controller Id Connection Status Connection State
------------- ----------------- ----------------
2             Disconnected      Backoff
```

OpenFlow's influence on CPU generated packets

In some cases, the CPU generated packets will be effected by the TCAM rules. OpenFlow Specification 1.0.0. does not clearly outline the behavior for CPU generated packets. One example of such a case is when a rule is in place with the `in_port`as a wild-card but has a SRC IP address that matches the IP address configured on the switch.

OpenFlow supports IP address masking

OpenFlow supports IP subnet mask. Controllers can specify the subnet mask associated with an IP address and sent to the OpenFlow switch. The switch accepts the IP address with the subnet mask and associates any packets coming with the subnet mask with the rule.

For example the K.15.10. OpenFlow implementation supports the ability to match on IP address and subnet mask when the OpenFlow controller programs such flows. Consider this example where the ovs-ofctl utility is used to add a flow that matches on a network source address of 1.1.1.1 with

a subnet mask of /24. Note that 10.10.10.1 here is the IP address of the switch which has an OpenFlow listen port open on port 6633.

```
openflow@openflow-ubuntu-08:~$ ovs-ofctl add-flow
tcp:10.10.0.1:6633 ip,nw_src=1.1.1.1/24,actions=output:1
```

To verify that this flow has been installed on the switch, we run the `ovs-ofctl` command and verify the output.

```
openflow@openflow-ubuntu-08:~$ ovs-ofctl dump-flows tcp:10.10.0.1:6633
NXST_FLOW reply (xid=0x4): cookie=0x0, duration=13.535s, table=0,
n_packets=0, n_bytes=0, ip,nw_src=1.1.0.0/24 actions=output:1
```

The `show openflow instance t1 flows` command when executed on the HP switch displays the following:

Example

```
HP-3500yl-48G-PoEP(of-inst-t1)# show openflow instance t1
Configured OF Version    : 1.3
Negotiated OF Version    : 1.3
Instance Name            : t1
Admin. Status            : Enabled
Member List              : VLAN 3
Listen Port              : None
Oper. Status             : Up
Oper. Status Reason      : NA
Datapath ID              : 0003b499ba86bf80
Mode                     : Active
Flow Location            : Hardware and Software
No. of Hw Flows          : 0
No. of Sw Flows          : 0
Hw. Rate Limit           : 0 kbps
Sw. Rate Limit           : 100 pps
Conn. Interrupt Mode     : Fail-Secure
Maximum Backoff Interval : 60 seconds
Probe Interval           : 10 seconds
Hw. Table Miss Count     : NA
No. of Sw Flow Tables    : 1
Egress Only Ports        : None
Table Model              : Policy Engine and Software

Controller Id Connection Status Connection State Secure Role
------------- ----------------- ---------------- ------ ------
1             Connected         Active           Yes    Equal
```

Virtualization mode verses Aggregation mode — VLAN tags in `packet_in` messages

There is a difference in the `packet_in` messages that are sent to the OpenFlow controller by the switch based on the mode that the OpenFlow instance is operating in. In Virtualization mode, no VLAN tags are sent in `packet_in` messages sent to the OpenFlow controller. Even if the packets that came in to the switch on the OpenFlow instance had VLAN tags, they will get removed by the switch in `packet_in` messages sent to the controller. Flows that match on VLAN PCP or modify VLAN PCP are not supported in Virtualization mode. Any tagged packets that are received in Virtualization mode may have their PCP modified to default. VLAN PCP isn't matched because tag is always stripped in Virtualization mode.

In Aggregate mode, VLAN tags are always sent by the switch in `packet_in` messages sent to the OpenFlow controller. Even if the packets that came in to the switch on the OpenFlow instance did not have VLAN tags, they will be added by the switch in `packet_in` messages sent to the controller. The switch adds a VLAN tag either based on the tag that the packet already carried

when it came in to the switch or based on the membership of the port that the packet came in to the switch.

Precedence level in meters

As per the OpenFlow specification 1.3.1, the prec_level given in the ofp_meter_band_dscp_remark indicates by what amount the DSCP value in the packets should be incremented if the packets exceed the band. However, the switch implementation directly replaces the DSCP value in the IP packets with the prec_level when the band exceeds the meter defined by the controller

Support for miss_len field in 'switch configuration' messages

The switch implementation does not honor the miss_len miss_send_len field specified in the packet-in switch configuration messages. This is because, switch doesn't buffer packets. Due to this controller will see the entire packet copied in packet-in message with buffer_id set as OFP_NO_BUFFER.

C Configuring secure connection HP VAN SDN controller

HP Switches running OpenFlow can securely connect to HP VAN SDN controller.

Follow the procedures to accomplish the secure connection.

1. On the HP Switch running OpenFlow, create a **crypto profile**.

   ### Syntax

   ```
   crypto pki ta-profile VanProfile
   ```

2. Copy root certificate to the HP switch using this command:

   ### Syntax

   ```
   copy tftp ta-certificate VanProfile [103.0.11.34] HpRoot.pem
   ```

3. Create an identity profile on the HP switch using this command:

   ### Syntax

   ```
   crypto pki identity-profile VanIdentity subject [common-name]
   ```

4. Make a certificate signing request.

   ### Syntax

   ```
   crypto pki create-csr certificate-name Vancert ta-profile
   VanProfile usage openflow
   ```

5. Copy the CSR request text in step 4 and paste to a file named “switch.csr”
6. Execute the command:

   ### Syntax

   ```
   ./signCSR.pl-in switch.csr-out switch-l 2
   ```

7. Execute the command:

   ### Syntax

   ```
   crypto pki install signed certificate
   ```

8. Copy and paste the contents of switch.pem into the HP switch console.
9. Configure OpenFlow to connect to the VAN SDN controller.

```
openflow
controller id 3 ip 103.0.11.31 port 6634 controller interface
vlan 1 instance "van"
member vlan 100
controller id 3 secure
version 1.3
limit hardware rate 10000000
limit software rate 10000
enable
exit
enable
```

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