Cisco Plug-in for OpenFlow

Prerequisites for Cisco Plug-in for OpenFlow

- A Cisco device and its corresponding operating system that supports the installation of Cisco Plug-in for OpenFlow.

  Note   Refer to the corresponding release notes for information about which operating system release supports the features and necessary infrastructure.

  - Release notes for Cisco Catalyst 4500-X Series Switches

  - Release notes for Cisco Catalyst 4500-E Series Switches

- An open virtual application (OVA) package that is compatible with the device operating system and downloaded from an FTP server connected to the device. The OVA package is available for download in the same location as your system image (.bin) file.

- A controller installed on a connected server.

Table 1: Controller Support

OpenFlow Version	Supported Controllers
OpenFlow 1.0	Extensible Network Controller (XNC) 1.0, POX, Cisco Open SDN Controller, or Ixia controllers .

OpenFlow Version	Supported Controllers
OpenFlow 1.3	Ixia, Cisco Open SDN Controller, or OpenDaylight

- The required disk storage available on the device for installation and deployment of Cisco Plug-in for OpenFlow. The recommended disk space is 360 MB.

- 2048 TCAM entries are available before you enable OpenFlow.

Restrictions for Cisco Plug-in for OpenFlow

- Cisco Plug-in for OpenFlow supports only a subset of OpenFlow 1.3 functions. For more information, see the *Cisco Plug-in for OpenFlow Feature Support* section.

- You cannot configure more than one Cisco Plug-in for OpenFlow logical switch. The logical switch ID has a value of 1.

- OpenFlow hybrid model (ships-in-the-night) is supported. VLANs configured for Cisco Plug-in for OpenFlow logical switch ports should not overlap with regular device interfaces.

- Cisco Plug-in for OpenFlow logical switch ports must not be configured in a mode other than trunk port.

- You cannot configure a bridge domain, Virtual LANs, virtual routing and forwarding (VRF) or port-channel interfaces on a Cisco Plug-in for OpenFlow logical switch. You can only configure physical interfaces.

- You cannot make additional configurations to an interface configured as a port of Cisco Plug-in for OpenFlow Logical Switch without removing the configuration as a port of Cisco Plug-in for OpenFlow Logical Switch.

- High availability is not supported. On switchover, all flows are deleted resulting in traffic loss. When the standby RP becomes active, the flows are relearned from the controller and reprogrammed. Until then, traffic loss is experienced.

- Cisco IOS In-Service Software Upgrade (ISSU) is not supported for Cisco Plug-in for OpenFlow.

- Virtual Switching System (VSS) is not supported for Cisco Plug-in for OpenFlow.

- MIBs and XMLs are not supported.

- You must not add or remove an interface as a port of a Cisco Plug-in for OpenFlow if the Cisco Plug-in for OpenFlow is inactive or not running.

- You cannot configure more than 1000 flows.

- A maximum of 48 ports can be assigned for Openflow operation.

- In general, the maximum sustained flow programming rate from the controller should not exceed 70 (added or deleted) flows per second. For flows that have more than 1 match criteria (more than input port + 1 match), the sustained controller programming rate should not exceed 40 flows per second.

- The maximum burst flow programming rate from the controller should not exceed 1000 flows, spaced by 30-second time intervals. A minimum of 30-second time interval should be maintained between addition or deletion of flows.

• The rate of PACKET_IN messages sent to the controller should be rate-limited to 300 packets per second, using configuration.

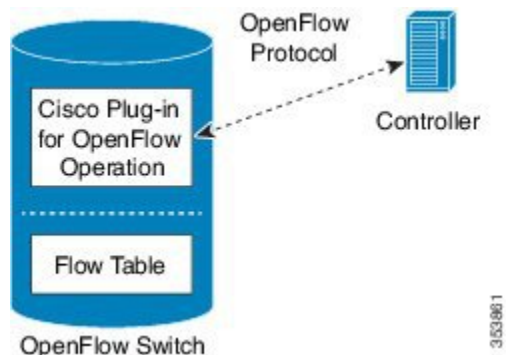# Information About Cisco Plug-In for Open Flow

About OpenFlow

OpenFlow Switch Specification Version 1.0.1 (Wire Protocol 0x01), referred to as OpenFlow 1.0, and OpenFlow Switch Specification Version 1.3.0 (Wire Protocol 0x04), referred to as OpenFlow 1.3, are based on the concept of an Ethernet switch with an internal flow table and standardized interface to allow traffic flows on a device to be added or removed. OpenFlow 1.3 defines the communication channel between Cisco Plug-in for OpenFlow and controllers.

Cisco supports a subset of OpenFlow 1.0 and OpenFlow 1.3 functions. Beginning with the latest, the following Cisco OpenFlow versions are available—Cisco Plug-in for OpenFlow, Version 2.0.2, Cisco Plug-in for OpenFlow, Version 2.0.0.

A controller can be Extensible Network Controller (XNC) 1.0, or any controller compliant with OpenFlow 1.3.

The following figure gives an overview of the OpenFlow network:

Figure 1: OpenFlow Overview

Related concepts include:

Related Topics

Cisco Plug-in for OpenFlow Operation

Cisco Plug-in for OpenFlow creates OpenFlow–based connections to controllers for a Cisco Plug-in for OpenFlow logical switch. The Cisco Plug-in for OpenFlow creates databases for the following:

• A configured logical switch—Contains all the information needed to connect to a controller.

- OpenFlow-enabled interfaces—Contains the list of OpenFlow-enabled interfaces associated with a logical switch.

- Flows—Contains the list of flows on a logical switch and for the interface that is programmed into forwarded traffic.

OpenFlow Controller Operation

OpenFlow controller (referred to as controller) controls the switch and inserts flows with a subset of OpenFlow 1.3 and 1.0 match and action criteria through Cisco Plug-in for OpenFlow logical switch. Cisco Plug-in for OpenFlow rejects all OpenFlow messages with any other action.

Cisco Plug-in for OpenFlow and Virtual Services Container

Cisco Plug-in for OpenFlow runs in an operating–system–level virtual service container on the device. The Cisco Plug-in for OpenFlow virtual service container is delivered in an open virtual application (OVA) file package (.ova). The OVA package is installed and enabled on the device through the CLI.

Cisco Plug-in for OpenFlow Feature Support

The following is a subset of OpenFlow 1.3 and OpenFlow 1.0 functions that are supported by Cisco Plug-in for OpenFlow.

Feature	Notes
The OpenFlow hybrid (ships-in-night) model is supported.	OpenFlow-hybrid models where traffic can flow between Cisco Plug-in for OpenFlow ports and regular interfaces (integrated) are not supported. Both types of ports can transmit and receive packets. **Note** VLANs must be configured such that the VLANs on the Cisco Plug-in for OpenFlow do not overlap with those on the regular device interfaces.
Configuration of physical interfaces as Cisco Plug-in for OpenFlow logical switch ports	Bridge domain, Virtual LANs and Virtual Routing and Forwarding (VRF), and port-channel interfaces are not supported. Only L2 interfaces can be Cisco Plug-in for OpenFlow logical switch ports.

Feature	Notes
Supported OpenFlow message types	• Controller to switch: • Handshake • Switch Configuration • Modify State (Port Modification message is not supported) • Read State • Packet-Out • Barrier • Asynchronous messages: • Packet-In • Flow Removed • Port Status • Error • Symmetric messages: • Hello • Echo Request • Echo Reply • Vendor
Connection to controllers	You can connect up to eight controllers. Connection to the controller through a management interface or a switched virtual interface (SVI) is supported. Connection via TCP and TLS is supported.

Feature	Notes
Multiple actions	If multiple actions are associated with a flow, they are processed in the order specified. The output action should be the last action in the action list. Any action after the output action is not supported, and can cause the flow to fail and return an error to the controller.
	Flows defined on the controller must follow the these guidelines:
	• The flow can have only one output action.
	• Some action combinations which are not supported may be rejected at flow programming time.
	• The flow should not have an output–to–controller action in combination with other rewrite actions.
Supported OpenFlow counters	Per Table—Active entries, packet lookups, and packet matches.
	Per Flow—Received Packets, Duration (seconds), Duration (milliseconds).
	Per Port—Received or transmitted packets, and bytes.
	Per Controller— Flow addition, modification, deletion, error messages, echo requests or replies, barrier requests or replies, connection attempts, successful connections, packet in or packet out.
Default forwarding rule	All packets that cannot be matched to programmed flows are dropped by default. You can configure sending unmatched packets to the controller. You can modify the default action taken on unmatched packets either using the **default-miss** command or by the controller.
Idle timeout	A minimum Idle timeout of 15 seconds is supported for 700 flows and 48 ports.
	The statistics collection interval influences the minimum idle timeout. When the interval is set to 7 seconds, the timeout is a minimum of 15 seconds. 700 flows are supported with the 15-second idle timeout.
	When using an idle timeout of less than 25 seconds, the number of L3 flows should be limited to 700.

Supported Match and Actions and Pipelines

Feature	Notes
Pipelines for Cisco Plug-in for OpenFlow Logical Switch	Pipelines are mandatory for the logical switch. The logical switch supports two tables: an L2 MAC forwarding table and an L3 forwarding table.
L2 MAC forwarding table	Match criteria: • Ingress port • Ethertype • Source MAC address • Destination MAC address • VLAN priority • DOT1q VLAN ID Action Criteria: • Set VLAN priority • Strip VLAN • Set source MAC address (SMAC) • Set destination MAC address (DMAC) • Set VLAN ID • Output to single port • Punt to controller (OpenFlow packet-in message) • Drop • Set queue ID • Go to next table (If **default-miss** is configured) **Note** This action cannot be combined with any other action for a flow in an L2 table.

Feature	Notes
L3 forwarding table	

Feature	Notes
	The following match criteria are supported: • Ethertype (IPv4 only) • Ingress port • IP protocol number • IP Type of Service (DSCP bits) • IPv4 source address • IPv4 destination address • Layer 4 source port • Layer 4 destination port • ICMPv4 type and code • IPv6 source address • IPv6 destination address The following action criteria are supported: • Set IPv4 Type of Service • Set IPv4 source address • Set IPv4 destination address • Set Layer 4 source port • Set Layer 4 destination port • Output to single port • Punt to controller (OpenFlow packet-out message) • Drop • Set queue ID • Drop, or punt, or forward to the output port An L3 flow supports Rewrite for these L2 fields: • **set ethernet source mac** • **set ethernet destination mac** • **set vlan id** • **set vlan priority (cos)** • **pop vlan tag** **Note** • L3 forwarding table match restrictions—For IPV6 match on an L3 table, the only supported matches are input port, IPv6 source, and IPv6

Feature	Notes

	destination address.
	
	• L3 forwarding table action restrictions:
	
	  ◦ All rewrite combinations are supported, except for those that have the following fields as a subset— **source MAC** + **source IP** + **destination IP** .
	
	  ◦ For IPV6 match on an L3 table, the only supported actions are drop or punt to controller and output to a physical port.

Number of flows	You can configure up to 1000 flows.
Configuration of VLANs for each port of the Cisco Plug-in for OpenFlow logical switch	VLAN range is from 1 to 4094.

How to Configure Cisco Plug-In for Open Flow

OpenFlow Workflow

The following figure describes the overall process of installing and activating the Cisco Plug-In for Open Flow.

Figure 2: OpenFlow WorkFlow
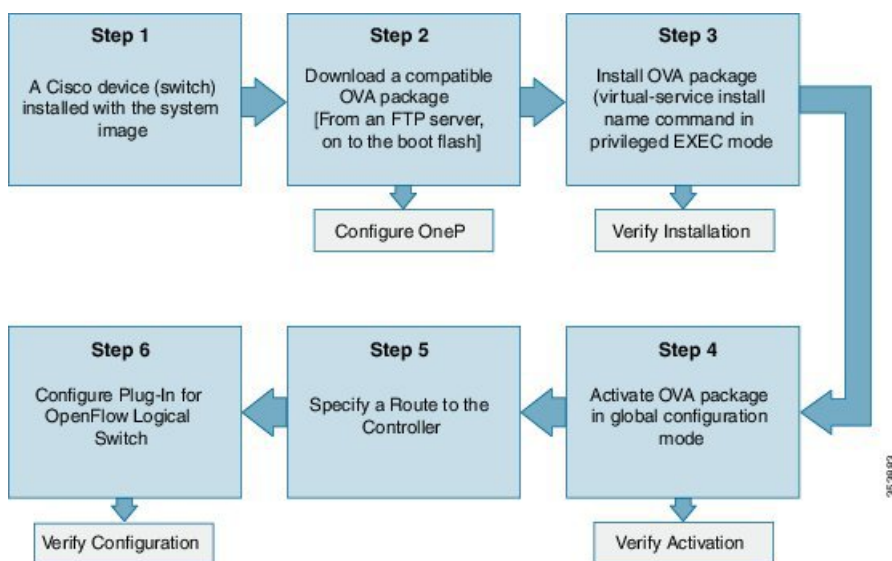
Specifying a Route to a Controller

The following tasks are used to specify a route from the device to a controller. This can be done using a physical interface (Front Panel) or a management interface.

Related Topics

Specifying a Route to a Controller Using a Physical Interface

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface** *type number*
4. **no switchport**
5. **ip address** *ip-address mask*
6. **exit**
7. **ip route 0.0.0.0 0.0.0.0** *next-hop*
8. **exit**
9. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** Switch> **enable**	Enables privileged EXEC mode. Enter your password if prompted.
Step 2	**configure terminal** **Example:** Switch# **configure terminal**	Enters the global configuration mode.
Step 3	**interface** *type number* **Example:** Switch(config)# **interface GigabitEthernet1/0/1**	Enters the physical interface. The interface used here should not be an Cisco Plug-in for OpenFlow ports.

	Command or Action	**Purpose**
Step 4	**no switchport** **Example:** Switch(config-if)# **no switchport**	Configures a specified interface as a Layer 3 interface and deletes any interface configuration specific to Layer 2.
Step 5	**ip address** *ip-address mask* **Example:** Switch(config-if)# **ip-address 10.0.1.4 255.255.255.0**	Configures an IP address for a specified interface.
Step 6	**exit** **Example:** Switch(config-if)# **exit**	Exits interface configuration mode and enters global configuration mode.
Step 7	**ip route 0.0.0.0 0.0.0.0** *next-hop* **Example:** Switch(config)# **ip route 0.0.0.0 0.0.0.0 10.0.1.6**	Configures a default route for packet addresses not listed in the routing table. Packets are directed to a controller.
Step 8	**exit** **Example:** Switch(config)# **exit**	Exits global configuration mode and enters privileged EXEC mode.
Step 9	**copy running-config startup-config** **Example:** Switch# **copy running-config startup-config**	(Optional) Saves your entries in the configuration file.

What to Do Next

Configure interfaces for the Cisco Plug-in for OpenFlow logical switch.

Specifying a Route to a Controller Using a Management Interface

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface** *type number*
4. **ip address** *ip-address mask*
5. **exit**
6. **ip route vrf** *vrf-name* **0.0.0.0 0.0.0.0** *next-hop*
7. **exit**

DETAILED STEPS

	Command or Action	**Purpose**
Step 1	**enable** **Example:** Switch> **enable**	Enables privileged EXEC mode. Enter your password if prompted.
Step 2	**configure terminal** **Example:** Switch# **configure terminal**	Enters the global configuration mode.
Step 3	**interface** *type number* **Example:** Switch(config)# **interface FastEthernet1**	Enters the management interface. The interface used here should not be an Cisco Plug-in for OpenFlow ports.
Step 4	**ip address** *ip-address mask* **Example:** Switch(config-if)# **ip-address 10.0.1.4 255.255.255.0**	Configures an IP address for the specified interface.
Step 5	**exit** **Example:** Switch(config-if)# **exit**	Exits interface configuration mode and enters global configuration mode.
Step 6	**ip route vrf** *vrf-name* **0.0.0.0 0.0.0.0** *next-hop* **Example:** Switch(config)# **ip route vrf mgmtVrf 0.0.0.0 0.0.0.0 10.0.1.6**	Configures an IP address for the specified interface.

	Command or Action	Purpose
Step 7	**exit** **Example:** Switch(config)# **exit**	Exits global configuration mode and enters privileged EXEC mode.

What to Do Next

Configure interfaces for the Cisco Plug-in for OpenFlow logical switch.

Configuring OneP

To enable the internal OneP infrastructure required to support the OpenFlow Plug-in, perform this task

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **onep**
4. **end**
5. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** Switch> **enable**	Enables privileged EXEC mode. Enter your password if prompted.
Step 2	**configure terminal** **Example:** Switch# **configure terminal**	Enters the global configuration mode.
Step 3	**onep** **Example:** Switch(config)# **onep**	Enters OneP configuration mode.

	Command or Action	**Purpose**
Step 4	**end** **Example:** Switch(config-onep)# **end**	Returns to privileged EXEC mode.
Step 5	**copy running-config startup-config** **Example:** Switch# **copy running-config startup-config**	(Optional) Saves your entries in the configuration file.

Configuring a Cisco Plug-in for OpenFlow Logical Switch

To configure a Cisco Plug-in for OpenFlow logical switch and the IP address of a controller, perform this task:

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **openflow**
4. **switch** *logical-switch-id*
5. **pipeline** *pipeline-id*
6. **of-port interface** *interface-name*
7. **protocol-version** *version-info*
8. **controller ipv4** *ip-address* [**port** *tcp-port*][**vrf** *vrf-name*] **security**{ **none** | **tls** }
9. **default-miss** *action-for-unmatched-flows*
10. **datapath-id** *datapath-id*
11. (Optional) **tls trust-point local** *local-trust-point* **remote** *remote-trust-point*
12. (Optional) **logging flow-mod**
13. (Optional) **probe-interval** *probe-interval*
14. (Optional) **rate-limit packet_in** *controllet-packet-rate* **burst** *maximum-packets-to-controller*
15. (Optional) **max-backoff** *backoff-timer*
16. **statistics collection-interval** *interval*
17. **end**
18. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** Switch> **enable**	Enables privileged EXEC mode. Enter your password if prompted.
Step 2	**configure terminal** **Example:** Switch# **configure terminal**	Enters the global configuration mode.
Step 3	**openflow** **Example:** Switch(config)# **openflow**	Enters Cisco Plug-in for OpenFlow mode.
Step 4	**switch** *logical-switch-id* **Example:** Switch(config-ofa-switch)# **switch 1**	Specifies an ID for a logical switch that is used for OpenFlow switching and enters logical switch configuration mode. The only logical switch ID supported is 1.
Step 5	**pipeline** *pipeline-id* **Example:** Switch(config-ofa-switch)# **pipeline 1**	Configures a pipeline . This step is mandatory for a logical switch configuration. The only pipeline ID supported is 1.
Step 6	**of-port interface** *interface-name* **Example:** Switch(config-ofa-switch)# **of-port interface GigabitEthernet5/23** **Example:** Switch(config-ofa-switch)# **of-port interface TenGigabitEthernet5/23**	Configures an Ethernet interface as a port of a Cisco Plug-in for OpenFlow logical switch. Observe these guidelines: • Do not abbreviate the interface type. Ensure that the interface type is spelled out completely and is as shown in the examples. If the keyword is abbreviated, the interface is not configured. • The interface must be designated for the Cisco Plug-in for OpenFlow logical switch only. • The **onep application openflow exclusive** configuration is added to an interface when an interface is configured as a port of Cisco Plug-in for OpenFlow. To add or remove an interface as a port of Cisco Plug-in for OpenFlow, ensure that the Cisco Plug-in for OpenFlow is activated and running to ensure the proper automatic addition and removal of the **onep application openflow exclusive** configuration. To remove an interface as a port of Cisco Plug-in for OpenFlow, use the no form of this command. Repeat this step to configure additional interfaces.

	Command or Action	**Purpose**

Step 7	**protocol-version** *version-info*
	
	Example:
	Switch(config-ofa-switch)#
	protocol-version negotiate
		Configures the protocol version. Supported values are:
		
		    • **1.0**—Configures device to connect to 1.0 controllers only.
		
		    • **1.3**—Configures device to connect to 1.3 controllers only.
		
		    • **negotiate**—Negotiates the protocol version with the controller. Device uses 1.3 for negotiation.
		
		The default value is **negotiate**.

Step 8	**controller ipv4** *ip-address* [**port** *tcp-port*][**vrf** *vrf-name*] **security**{ **none** | **tls** }
	
	Example:
	Controller in default VRF:
	Switch(config-ofa-switch)#
	controller ipv4 10.1.1.2 security none
	
	Controller in management VRF:
	Switch(config-ofa-switch)#
	controller ipv4 10.1.1.2 vrf mgmtVrf security none
		Specifies the IPv4 address, port number used by the controller to connect to the logical switch and the VRF of the controller. Observe these guidelines:
		
		    • Repeat this step if you need to configure additional controllers. You can configure up to eight controllers.
		
		    • If TLS is used in this step, configure TLS trustpoints in the next step.
		
		    • You can use the **clear openflow switch 1 controller all** command to clear controller connections. This command can reset a connection after Transport Layer Security (TLS) certificates and keys are updated. This is not required for TCP connections.
		
		If unspecified, the default VRF is used; Controllers use TCP port 6653 by default.
		
		A connection to a controller is initiated by the logical switch.

Step 9	**default-miss** *action-for-unmatched-flows*
	
	Example:
	Switch(config-ofa-switch)#
	default-miss controller
		Configures the action to be taken for packets that do not match any of the flow defined. Supported values are:
		
		    • **continue-drop**
		
		    • **continue-controller**
		
		    • **drop**
		
		    • **controller**
		
		The default action for both tables or pipeline 1 is **drop**. This can be overridden by this configuration or the controller.

Step 10	**datapath-id** *datapath-id* **Example:** Switch(config-ofa-switch)# **datapath-id 0x222**	Configures a unique datapath ID for the switch. This step is mandatory for a logical switch configuration. Enter a 64-bit hexadecimal value.

	Command or Action	Purpose
Step 11	**tls trust-point local** *local-trust-point* **remote** *remote-trust-point* **Example:** Switch(config-ofa-switch)# **tls trust-point local mylocal remote myremote**	(Optional) Specifies the local and remote TLS trustpoints to be used for the controller connection. For more information about configuring trustpoints, see chapter PKI Trustpool Management in the *Public Key Infrastructure Configuration Guide*.
Step 12	**logging flow-mod** **Example:** Switch(config-ofa-switch)# **logging flow-mod**	(Optional) Enables logging of flow changes, including addition, deletion, and modification of flows. Logging of flow changes is a CPU intensive activity and should not be enabled for a large number of flows. Logging of flow changes is disabled by default. Flow changes are logged in syslog and can be viewed using the **show logging** command.
Step 13	**probe-interval** *probe-interval* **Example:** Switch(config-ofa-switch)# **probe-interval 5**	(Optional) Configures the interval (in seconds) at which the controller is probed. After the configured interval of time passes, if the switch has not received any messages from the controller, the switch sends an echo request (echo_request) to the controller. It should normally receive an echo reply (echo_reply). If no message is seen for the duration of another probe interval, the switch presumes that the controller is down and disconnects the controller connection. The switch tries to reconnect periodically. The default value is 5 seconds; the range is from 5 to 65535 seconds.
Step 14	**rate-limit packet_in** *controllet-packet-rate* **burst** *maximum-packets-to-controller* **Example:** Switch(config-ofa-switch)# **rate-limit packet_in 300 burst 50**	(Optional) Configures the maximum packet rate sent to the controller and the maximum packets burst sent to the controller in a second. The default value is zero, that is, an indefinite packet rate and packet burst is permitted. This rate limit is for Cisco Plug-in for OpenFlow. It is not related to the rate limit of the device (data plane) configured by COPP.
Step 15	**max-backoff** *backoff-timer* **Example:** Switch(config-ofa-switch)# **max-backoff 8**	(Optional) Configures the duration (in seconds) for which the device must wait before attempting to initiate a connection with the controller. The device initially tries to initiate connection frequently, as the number of unsuccessful attempts increases, the device tries less frequently, that is, the waiting period between attempts also increases. The backoff timer configures the maximum period that the device waits in-between each retry. The default value is 8 seconds; the range is from 1 to 65535 seconds.

	Command or Action	**Purpose**

Step 16	**statistics collection-interval** *interval*
	
	Example:
	Switch(config-ofa-switch)#
	statistics collection-interval 10
		Configures the statistics collection interval (in seconds) for all configured flows of Cisco Plug-in for OpenFlow. Observe these guidelines:
		
		   • The default interval value is 41 seconds.
		
		   • The minimum interval is 7 seconds; the maximum is 82 seconds.
		
		   • You can also specify a value of 0, this disables statistics collection.
		
		   • Flows with an idle timeout value less than $2 * interval$ are rejected.
		
		Configured interval value is displayed in the output of the show openflow switch 1 command.

Step 17	**end** **Example:** Switch(config-ofa-switch)# **end**	
Step 18	**copy running-config startup-config** **Example:** Switch# **copy running-config startup-config**	(Optional) Saves your entries in the configuration file.

What to Do Next

Verify Cisco Plug-in for OpenFlow.

Related Topics

Verifying Cisco Plug-in for OpenFlow

SUMMARY STEPS

1. **show openflow copyright**
2. **show openflow switch** *switch-id*
3. **show openflow switch** *switch-id* **controllers** [**stats**]
4. **show openflow switch** *switch* **ports**
5. **show openflow** *switch-id* **flows** [**configured** | **controller** | **default** | **fixed** | **pending** | **pending-del**] [**brief** | **summary**]
6. **show openflow switch** *switch-id* **stats**
7. **show interfaces** *type number* **counter**
8. **show running-config** | **section openflow**
9. **show openflow hardware capabilities**

DETAILED STEPS

Step 1   **show openflow copyright**
Displays copyright information related to Cisco Plug-in for OpenFlow.

Example:
```
Switch# show openflow copyright
openflow-ott-of-c4k-103-3620
Cisco Plug-in for OpenFlow
TAC support: http://www.cisco.com/tac
Copyright (c) 2013-2015 by Cisco Systems, Inc. All rights reserved.
The copyrights to certain works contained in this software are
owned by other third parties and used and distributed under
license. Certain components of this software are licensed under
the GNU General Public License (GPL) version 2.0, the GNU
Lesser General Public License (LGPL) Version 2.1, or or the GNU
Library General Public License (LGPL) Version 2. A copy of each
such license is available at
http://www.opensource.org/licenses/gpl-2.0.php and
http://www.opensource.org/licenses/lgpl-2.1.php and
http://www.gnu.org/licenses/old-licenses/lgpl-2.0.txt
```

Step 2   **show openflow switch** *switch-id*
Displays information related to Cisco Plug-in for OpenFlow logical switch.

Example:
```
Switch# show openflow switch 1
Logical Switch Context
Id: 1
Switch type: Forwarding
Pipeline id: 1
Data plane: secure
Table-Miss default: continue-drop
Configured protocol version: Negotiate
```

```
Config state: no-shutdown
Working state: enabled
Rate limit (packet per second): 300
Burst limit: 50
Max backoff (sec): 8
Probe interval (sec): 5
TLS local trustpoint name: not configured
TLS remote trustpoint name: not configured
Logging flow changes: Disabled
Stats collect interval (sec): 7
Stats collect Max flows: 2000
Stats collect period (sec): 1
Minimum flow idle timeout (sec): 15
OFA Description:
  Manufacturer: Cisco Systems, Inc.
  Hardware: WS-C4507R+E V01
  Software: Cisco IOS Software, IOS-XE Software, Catalyst 4500 L3 Switch Software
 (cat4500e-UNIVERSALK9-M), Version 03.07.03.E3.212 EARLY DEPLOYMENT [DEV IMAGE]
 ENGINEERING NOVA_WEEKLY BUILD, synced to V152_3_2_46_E2
Technical Support: http://www.cisco.com/techsupp
  Serial Num: FOX1447GWNY
  DP Description: ott-of-c4k-102:sw1
OF Features:
  DPID:0000000000000222
  Number of tables:2
  Number of buffers:256
  Capabilities: FLOW_STATS TABLE_STATS PORT_STATS
Controllers:
  5.0.3.3:6102, Protocol: TCP, VRF: default
Interfaces:
  GigabitEthernet5/1
  GigabitEthernet5/2
```

Step 3 **show openflow switch** *switch-id* **controllers** [**stats**]

Displays information related to the connection status between an Cisco Plug-in for OpenFlow logical switch and connected controllers.

Example:

Here the switch is not connected to the controller

```
Switch# show openflow switch 1 controllers stats
Logical Switch Id: 1
Total Controllers: 1
  Controller: 1
    address                         :  tcp:5.0.3.3:6102
    connection attempts             :  9
    successful connection attempts  :  0
    flow adds                       :  0
    flow mods                       :  0
    flow deletes                    :  0
    flow removals                   :  0
    flow errors                     :  0
    flow unencodable errors         :  0
    total errors                    :  0
    echo requests                   :  rx: 0, tx: 0
    echo reply                      :  rx: 0, tx: 0
    flow stats                      :  rx: 0, tx: 0
    barrier                         :  rx: 0, tx: 0
    packet-in/packet-out            :  rx: 0, tx: 0
```

```
Switch# show openflow switch 1 controllers
Logical Switch Id: 1
Total Controllers: 1
  Controller: 1
    5.0.3.3:6102
    Protocol: tcp
    VRF: default
    Connected: No
    Role: Master
    Negotiated Protocol Version: disconnected
    Last Alive Ping: N/A
    last_error:Connection refused
    state:BACKOFF
    sec_since_disconnect:7
```

Example:

Here the switch is connected to the controller.

```
Switch# show openflow switch 1 controllers
openflow-ott-of-c4k-102-3890
Logical Switch Id: 1
Total Controllers: 1
  Controller: 1
    5.0.3.3:6102
    Protocol: tcp
    VRF: default
    Connected: Yes
    Role: Master
    Negotiated Protocol Version: OpenFlow 1.0
    Last Alive Ping: 03/30/2015 16:19:02
    last_error:Connection refused
    state:ACTIVE
    sec_since_connect:143
    sec_since_disconnect:151
```

```
Switch# show openflow switch 1 controllers stats
openflow-ott-of-c4k-102-3890
Logical Switch Id: 1
Total Controllers: 1
  Controller: 1
    address                       : tcp:5.0.3.3:6102
    connection attempts           : 110313
    successful connection attempts : 3
    flow adds                     : 0
    flow mods                     : 0
    flow deletes                  : 0
    flow removals                 : 0
    flow errors                   : 0
    flow unencodable errors       : 0
    total errors                  : 0
    echo requests                 : rx: 0, tx: 49628
    echo reply                    : rx: 49627, tx: 0
    flow stats                    : rx: 0, tx: 0
    barrier                       : rx: 3, tx: 3
    packet-in/packet-out          : rx: 1, tx: 257093
```

Step 4 **show openflow switch** *switch* **ports**

Displays the mapping between physical device interfaces and ports of an Cisco Plug-in for OpenFlow logical switch.

Example:
```
Switch# show openflow switch 1 ports
Logical Switch Id: 1
Port  Interface Name    Config-State    Link-State      Features
5097  Gi1/24            PORT_UP         LINK_DOWN       1GB-FD
```

Step 5   **show openflow** *switch-id* **flows** [**configured** | **controller** | **default** | **fixed** | **pending** | **pending-del**] [**brief** | **summary**]
Displays flows defined for the device by controllers.

Example:
This example shows how to add a flow, which sends packet with src=1.1.1.0/24 to 'Gi5/1'.
```
Switch# show openflow switch 1 flows
openflow-ott-of-c4k-102-3890
Logical Switch Id: 1
Total flows: 3

Flow: 1
  Match:            any
  Actions:          goto_table:1
  Priority:         0
  Table:            0
  Cookie:           0x0
  Duration:         1341.41s
  Number of packets: 0
  Number of bytes:   0

Flow: 2
  Match:            ip,nw_src=1.1.1.0/24
  Actions:          output:5100
  Priority:         32768
  Table:            1
  Cookie:           0x465f30352e3031
  Duration:         9.173s
  Number of packets: 0
  Number of bytes:   0

Flow: 3
  Match:            any
  Actions:          drop
  Priority:         0
  Table:            1
  Cookie:           0x0
  Duration:         1341.437s
  Number of packets: 0
  Number of bytes:   0
```

Example:
```
Switch# show openflow switch 1 flows configured
Logical Switch Id: 1
Total flows: 2

Flow: 1
  Match:            any
  Actions:          goto_table:1
  Priority:         0
  Table:            0
  Cookie:           0x0
```

```
   Duration:           1374.617s
   Number of packets: 0
   Number of bytes:    0

Flow: 2
   Match:              any
   Actions:            drop
   Priority:           0
   Table:              1
   Cookie:             0x0
   Duration:           1374.644s
   Number of packets: 0
   Number of bytes:    0
```

Example:
```
Switch# show openflow switch 1 flows controller
Logical Switch Id: 1
Total flows: 1

Flow: 1
   Match:              ip,nw_src=1.1.1.0/24
   Actions:            output:5100
   Priority:           32768
   Table:              1
   Cookie:             0x465f30352e3031
   Duration:           92.122s
   Number of packets: 0
   Number of bytes:    0
```

Step 6   **show openflow switch** *switch-id* **stats**

Displays send and receive statistics for each port defined for a Cisco Plug-in for OpenFlow logical switch.

Example:
```
Switch# show openflow switch 1 stats
openflow-ott-of-c4k-102-415
Logical Switch Id: 1

Total ports: 4
   Port 5100: rx pkts=0, bytes=0, drop=0, errs=0,
           tx pkts=0, bytes=0, drop=0, errs=0,
   Port 5098: rx pkts=0, bytes=0, drop=0, errs=0,
           tx pkts=0, bytes=0, drop=0, errs=0,
   Port 5097: rx pkts=0, bytes=0, drop=0, errs=0,
           tx pkts=0, bytes=0, drop=0, errs=0,
   Port 5099: rx pkts=0, bytes=0, drop=0, errs=0,
           tx pkts=0, bytes=0, drop=0, errs=0,
Total tables: 2
   Table 0: L2 Table
   Wildcards = 0x00000
   Max entries =  10000
   Active entries = 1
   Number of lookups = 0
   Number of matches = 0
   Table 1: L3 Table
   Wildcards = 0x00000
   Max entries =  10000
   Active entries = 1
```

```
         Number of lookups = 0
         Number of matches = 0
```

Step 7   **show interfaces** *type number* **counter**
Displays send and receive statistics for the specified port defined for an Cisco Plug-in for OpenFlow logical switch.

Example:
```
Switch# show interfaces GigabitEthernet 5/32 counters detail
Port                        InBytes        InUcastPkts        InMcastPkts
InBcastPkts
Gi5/32                           0                  0                  0
       0

Port                       OutBytes       OutUcastPkts       OutMcastPkts
OutBcastPkts
Gi5/32                           0                  0                  0
       0

Port                     InPkts 64        OutPkts 64      InPkts 65-127       OutPkts
65-127
Gi5/32                           0                  0                  0
       0

Port             InPkts 128-255   OutPkts 128-255    InPkts 256-511       OutPkts
256-511
Gi5/32                           0                  0                  0
       0

Port             InPkts 512-1023  OutPkts 512-1023
Gi5/32                           0                  0

Port            InPkts 1024-1518 OutPkts 1024-1518 InPkts 1519-1548 OutPkts
1519-1548
Gi5/32                           0                  0                  0
       0

Port            InPkts 1549-9216 OutPkts 1549-9216
Gi5/32                           0                  0

Port            Tx-Bytes-Queue-1  Tx-Bytes-Queue-2 Tx-Bytes-Queue-3
Tx-Bytes-Queue-4
Gi5/32                           0                  0                  0
       0

Port            Tx-Bytes-Queue-5  Tx-Bytes-Queue-6 Tx-Bytes-Queue-7
Tx-Bytes-Queue-8
Gi5/32                           0                  0                  0
       0

Port            Tx-Drops-Queue-1  Tx-Drops-Queue-2 Tx-Drops-Queue-3
Tx-Drops-Queue-4
Gi5/32                           0                  0                  0
       0

Port            Tx-Drops-Queue-5  Tx-Drops-Queue-6 Tx-Drops-Queue-7
Tx-Drops-Queue-8
Gi5/32                           0                  0                  0
       0
```

```
Port              Dbl-Drops-Queue-1 Dbl-Drops-Queue-2 Dbl-Drops-Queue-3
Dbl-Drops-Queue-4
Gi5/32                            0                 0                 0
       0

Port              Dbl-Drops-Queue-5 Dbl-Drops-Queue-6 Dbl-Drops-Queue-7
Dbl-Drops-Queue-8
Gi5/32                            0                 0                 0
       0

Port              Rx-No-Pkt-Buff     RxPauseFrames     TxPauseFrames
PauseFramesDrop
Gi5/32                            0                 0                 0
     0

Port              UnsupOpcodePause
Gi5/32                           0
```

Step 8   **show running-config | section openflow**
Displays configurations made for Cisco Plug-in for OpenFlow.

Example:
```
Switch# show running-config | section openflow
onep application openflow exclusive
 onep application openflow exclusive
 onep application openflow exclusive
 onep application openflow exclusive
 onep application openflow exclusive
 onep application openflow exclusive
openflow
  switch 1
   pipeline 1
   of-port interface GigabitEthernet5/1
   of-port interface GigabitEthernet5/2
   of-port interface GigabitEthernet5/3
   of-port interface GigabitEthernet5/4
   controller ipv4 5.0.3.3 port 6102 security none
   default-miss drop
   probe-interval 5
   statistics collection-interval 7
   rate-limit packet_in 300 burst 50
   datapath-id 0x2222
```

Step 9   **show openflow hardware capabilities**
Displays Cisco Plug-in for OpenFlow configurations.

Example:
```
Switch# show openflow hardware capabilities
Max Flow Batch Size: 250

  Statistics Max Polling Rate (flows/sec): 500

  Max Interfaces: 1000

  Aggregated Statistics: NO

  Pipeline ID: 1
```

```
Pipeline Max Flows: 2000

Pipeline Default Statistics Collect Interval: 7

Flow table ID: 0

Max Flow Batch Size: 250
Max Flows: 1000
Bind Subintfs: FALSE
Primary Table: TRUE
Table Programmable: TRUE
Miss Programmable: TRUE
Number of goto tables: 1
goto table id:        1
Stats collection period (sec): 2000

Match Capabilities              Match Types
------------------              -----------
ethernet mac destination        optional
ethernet mac source             optional
ethernet type                   optional
VLAN ID                         optional
VLAN priority code point        optional
in port (virtual or physical)   optional

Actions                   Count Limit          Order
specified interface             1              100
controller                      1              100
divert a copy of pkt to application 1          100

set eth source mac              1              10
set eth destination mac         1              10
set vlan id                     1              10
set vlan priority (cos)         1              10
set qos group                   1              10

pop vlan tag                    1              10

drop packet                     1              100


Miss actions              Count Limit              Order
controller                      1              100
perform another lookup in the specified table     1              200

drop packet                     1              100



Flow table ID: 1

Max Flow Batch Size: 250
Max Flows: 1000
Bind Subintfs: FALSE
Primary Table: FALSE
Table Programmable: TRUE
Miss Programmable: TRUE
Number of goto tables: 0
goto table id:
```

```
Stats collection period (sec): 2000

Match Capabilities              Match Types
------------------              -----------
ethernet type                   mandatory
IP DSCP                         optional
IP protocol                     optional
IPv4 source address             lengthmask
IPv4 destination address        lengthmask
ipv6 source addresss            lengthmask
ipv6 destination address        lengthmask
source port                     optional
destination port                optional
icmpv4 type                     optional
icmpv4 code                     optional
in port (virtual or physical)   optional

Actions                   Count Limit           Order
specified interface            1                100
controller                     1                100
divert a copy of pkt to application 1           100

set eth source mac             1                 10
set eth destination mac        1                 10
set vlan id                    1                 10
set vlan priority (cos)        1                 10
set IPv4 source address        1                 10
set IPv4 destination address   1                 10
set IP tos byte                1                 10
set IP dscp                    1                 10
set TCP source port            1                 10
set TCP destination port       1                 10
set UDP source port            1                 10
set UDP destination port       1                 10
set qos group                  1                 10

pop vlan tag                   1                 10

drop packet                    1                100


Miss actions              Count Limit               Order
controller                     1                100

drop packet                    1                100
```

Related Topics

Collecting Troubleshooting Information

Configuration Examples for Cisco Plug-In for OpenFlow

Example: Configuring Control Plane Policing for Packets Sent to a Controller

```
Switch> enable
Switch# configure terminal
Switch(config)# setup
          ---- Basic System Configuration Dialog ----

This setup utility will guide you through the basic configuration of
the system. Setup configures only enough connectivity for management
of the system.

*Note: setup is mainly used for configuring the system initially,
when no configuration is present. So setup always assumes system
defaults and not the current system configuration values.

Press Enter at anytime to skip a dialog. Use ctrl-c at anytime
to skip the remaining dialogs.

Would you like to enter the basic configuration dialog (yes/no): yes


  Create another login account (yes/no) [n]:

  Configure read-only SNMP community string (yes/no) [n]:

  Configure read-write SNMP community string (yes/no) [n]:

  Enter the switch name : QI32

  Continue with Out-of-band (mgmt0) management configuration? (yes/no)
[y]: n

  Configure the default gateway? (yes/no) [y]: n

  Enable the telnet service? (yes/no) [n]: y

  Enable the ssh service? (yes/no) [y]: n

  Configure the ntp server? (yes/no) [n]:

  Configure default interface layer (L3/L2) [L2]:

  Configure default switchport interface state (shut/noshut) [noshut]:
  Configure CoPP System Policy Profile ( default / l2 / l3 ) [default]:

The following configuration will be applied:
  switchname QI32
  telnet server enable
  no ssh server enable
  system default switchport
  no system default switchport shutdown
  policy-map type control-plane copp-system-policy ( default )

Would you like to edit the configuration? (yes/no) [n]:

Use this configuration and save it? (yes/no) [y]:

[#######################################] 100%
Copy complete, now saving to disk (please wait)...
```

```
Switch# configure terminal
Switch(config)# policy-map type control-plane copp-system-policy
Switch(config-pmap)# class copp-s-dpss
Switch(config-pmap-c)# police pps 1000
Switch(config-pmap-c)# end
Switch# show run copp
```

Example: Specifying a Route to a Controller Using a Physical Interface

```
Switch> enable
Switch# configure terminal
Switch(config)# interface GigabitEthernet1/1
Switch(config-if)# no switchport
Switch(config-if)# ip address 10.0.1.4 255.255.255.255
Switch(config-if)# exit
Switch(config)# ip route 0.0.0.0 0.0.0.0 10.0.1.6
Switch# copy running-config startup-config
Switch(config)# exit
```

Example: Specifying a Route to a Controller Using a Management Interface

```
Device> enable
Switch# configure terminal
Switch(config)# interface FastEthernet1
Switch(config-if)# no switchport
Switch(config-if)# ip address 10.0.1.4 255.255.255.0
Switch(config-if)# exit
Switch(config)# ip route vrf mgmtVrf 0.0.0.0 0.0.0.0 10.0.1.6
Switch# copy running-config startup-config
Switch(config)# exit
```

Example: Cisco Plug-In for OpenFlow Logical Switch Configuration (Default VRF)

```
Switch> enable

Switch# configure terminal
Switch(config)# onep
Switch(config-onep)# exit

Switch(config)# openflow
Switch(config-ofa)# switch 1
! Specifies the pipeline that enables the IP Forwarding Table.

Switch(config-ofa-switch)# pipeline 1
Switch(config-ofa-switch)# logging flow-mod
Switch(config-ofa-switch)# tls trust-point local local-trustpoint-name remote
remote-trustpoint-name
Switch(config-ofa-switch)# max-backoff 5
Switch(config-ofa-switch)# probe-interval 5
Switch(config-ofa-switch)# rate-limit packet-in 300 burst 50
Switch(config-ofa-switch)# controller ipv4 10.0.1.6 security none
Switch(config-ofa-switch)# datapath-id 0x222
! Adding an interface to the Cisco Plug-In for OpenFlow logical switch.

Switch(config-ofa-switch)# of-port interface GigabitEthernet5/23
Switch(config-ofa-switch)# end
Switch# copy running-config startup-config
```

Example: Configuring a Cisco Plug-In for OpenFlow Logical Switch (Management VRF)

```
Switch> enable
Switch# configure terminal
Switch(config)# onep
Switch(config-onep)# exit
Switch(config)# openflow
```

```
Switch(config-ofa)# switch 1

Switch(config-ofa-switch)# pipeline 1
! Specifying a controller that is part of a VRF.

Switch(config-ofa-switch)# controller ipv4 10.0.1.6 vrf mgmtVrf security none
! Adding an interface to the Cisco Plug-In for OpenFlow logical switch.

Switch(config-ofa-switch)# of-port interface GigabitEthernet5/23
Switch(config-ofa-switch)# end
Switch# copy running-config startup-config
```

Additional Information for Cisco Plug-In for OpenFlow

Related Documents

Related Topic	Document Title
Cisco commands	Cisco IOS Master Command List, All Releases

Standards and RFCs

Standard/RFC	Title
OpenFlow 1.3	*OpenFlow Switch Specification Version 1.3.0 (Wire Protocol 0x04).*
OpenFlow 1.0	*OpenFlow Switch Specification Version 1.0.1 (Wire Protocol 0x01).*

Technical Assistance

Description	Link
The Cisco Support and Documentation website provides online resources to download documentation and tools. Use these resources to troubleshoot and resolve technical issues with Cisco products and technologies. Access to most tools on the Cisco Support and Documentation website requires a Cisco.com user ID and password.	http://www.cisco.com/cisco/web/support/index.html