Dell OpenFlow Deployment and User Guide 3.0
Dell Software-Defined Networking (SDN)

Notes, Cautions, and Warnings

NOTE: A NOTE indicates important information that helps you make better use of your computer.

CAUTION: A CAUTION indicates either potential damage to hardware or loss of data and tells you how to avoid the problem.

WARNING: A WARNING indicates a potential for property damage, personal injury, or death.

Contents

Introduction

OpenFlow (OF) 1.0 [STD-1] is supported on the S4810, S4820T, S6000, Z9000, and MXL switches.

Overview

In a software-defined network (SDN), an external controller cluster manages the network and the resources on each switch. OpenFlow is a protocol used for communication between the controller and the switch.

In the example topology below, the controller uses the OpenFlow protocol to communicate with two S4810 switches.
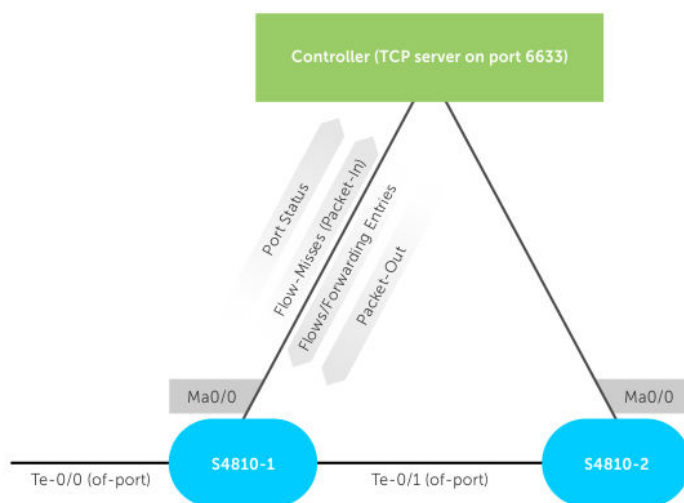
Figure 1. OpenFlow Topology

OpenFlow offloads all switching and routing protocol state machines to the controller. A simplified and efficient software layer on the switch programs the forwarding tables.

Dell currently supports OpenFlow version 1.0. For information about exceptions, refer to Exceptions.

OpenFlow 1.0 Support

OpenFlow (OF) 1.0 [STD-1] is supported on the S4810, S4820T, S6000, Z9000, and MXL switches. OpenFlow (OF) 1.3 [STD-1] is supported on the S4810, S4820T, S5000, S6000, Z9000, Z9500, and MXL switches.

NOTE: When of-instance is enabled with version 1.3, the OpenFlow 1.0 functionality is also supported.

Match Parameters and Supported Values

Using OpenFlow, you can transmit the switch's ports and forwarding tables to the controller, allowing the controller to configure forwarding entries on the switch. OpenFlow also allows the controller to insert control packets through the switch and to redirect any missed flow packets from the switch to the controller.

The flows in OpenFlow allow the switch to match based on the following parameters and values:

Table 1. Match Parameters and Supported Values

Match Parameter	Supported Values
Ingress port	NA
Ethernet source address	MAC address (nn:nn:nn:nn:nn:nn format)
Ethernet destination address	MAC address (nn:nn:nn:nn:nn:nn format)
Inner Ethertype	All supported IEEE values
External VLAN ID	0 to 4094
External VLAN priority	0 to 7
IP source address	IP address (x:x:x:x::x format then the prefix length in the /x format)
IP destination address	IP address (x:x:x:x::x format then the prefix length in the /x format)
IP protocol type	• session initiation protocol (SIP) • dynamic IP (DIP) • type of service (TOS)protocol
Type of service (ToS)	0 to 255
Transport source port (`transport sport`)	0 to 65535
Transport destination port (`transport dport`)	0 to 65535
ICMP type	0 to 255
ICMP code	0 to 255

The software forwards the match results out of one or more network ports, with the option to modify the packet headers.

Supported Flow Actions

The following flow actions are supported:

- `OFPAT_FLOOD` or `OFPAT_ALL`: Floods packets to all ports and VLANs on the OF interface.
- `OFPAT_CONTROLLER`: Sends all `NO_MATCH` or `ACTION` packets to the controller specified by the packet's VLAN tag.
- `OFPAT_out_port`: Displays a list of ports that can receive traffic.
- `OFPAT_DROP`: Drops all packets that match the specified criteria.
- `MODIFY FIELD — Set VLAN ID`: Assigns a VLAN ID (0 to 4094).
- `MODIFY FIELD — Set VLAN priority`: Assigns a priority to a VLAN (0 to 7).
- `MODIFY FIELD — Modify Ethernet source MAC address`: Changes the Ethernet source MAC address to the specified value.
- `MODIFY FIELD — Modify Ethernet destination MAC address`: Changes the Ethernet destination MAC address to the specified value.
- `MODIFY FIELD — Modify IPv4 ToS bits`: Changes the IPv4 ToS in the packet header to the specified value.
- `OFPAT_ENQUEUE`: Send the specified flow to the queue.

NOTE: If there is a conflict between actions, the action with the higher priority takes precedence.

Unsupported OpenFlow Messages

The following OpenFlow messages are not supported. Some unsupported messages generate `OFPT_ERROR`, which is an error message sent to the controller.

Table 2. Unsupported OpenFlow Messages

Message	System Response
`OFPT_SET_CONFIG`	This message is ignored by the switch.
`OFPT_QUEUE_GET_CONFIG_REQUEST`	`OFPT_ERROR` generates in response.
`OFPT_PORT_MOD`	`OFPT_ERROR` generates in response.
Emergency Flows (`OFPFF_EMERG`)	`OFPT_ERROR` generates in response.
Queue Statistics (`OFPST_QUEUE`)	`OFPT_ERROR` generates in response.

For supported `flow-match` and `flow action` parameters for each flow type, refer to [Flow Types](#).

The following is a list of actions that are not supported for any flow types. All of the following commands generate an `OFPT_ERROR` message.

- `OFPAT_SET_NW_SRC (set src-ip)`
- `OFPAT_SET_NW_DST (set dst-ip)`
- `OFPAT_SET_TP_SRC (set tcp/udp src-port)`
- `OFPAT_SET_TP_DST (set tcp/udp dst-port)`
- `OFPAT_OUTPUT to OFPP_IN_PORT`
- `OFPAT_OUTPUT to OFPP_TABLE`

- `OFPAT_OUTPUT to OFPP_NORMAL`
- `OFPAT_OUTPUT to OFPP_LOCAL`
- `FORWARD — Normal`
- `FORWARD — LOCAL`
- `FORWARD — Inport`
- `MODIFY FIELD — Strip VLAN header`
- `MODIFY FIELD — Modify IPv4 source address`
- `MODIFY FIELD — Modify IPv4 destination address`
- `MODIFY FIELD — Modify transport source port`
- `MODIFY FIELD — Modify transport destination port`
- `MAX_BYTES_TO_SEND`

Limitations

- `OFPAT_OUTPUT to OFPP_FLOOD` and `OFPP_ALL` are supported on the S4810, S4820T, S6000, and MXL switches. Support for these commands on the Z9000 was introduced in version 9.4(0.0).
- Multiple output ports are supported on S4810, S4820T, and MXL switches. Multiple output ports are not supported on the Z9000 platform.
- The set/modify actions must precede the output ports actions. If you specify multiple output ports, the switch cannot transmit different copies.
- You cannot specify individual output ports for `ALL` or `FLOOD` actions.

OpenFlow 1.3 Support

OpenFlow (OF) 1.3 [STD-1] is supported on the S4810, S4820T, S5000, S6000, Z9000, Z9500, and MXL switches.

Dell Networking OS supports OpenFlow 1.3 message types. Although OpenFlow 1.3 is enabled, the OpenFlow 1.0 functionality is also supported. Additionally, the group flow and multipart message types features are supported. The multipart message types features replaces the statistics feature in OpenFlow 1.0 version.

Match Parameters and Supported Values

Using OpenFlow, you can transmit the switch's ports and forwarding tables to the controller, allowing the controller to configure forwarding entries on the switch. OpenFlow also allows the controller to insert control packets through the switch and to redirect any missed flow packets from the switch to the controller.

The flows in OpenFlow allow the switch to match based on the following parameters and values:

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External VLAN ID	0 to 4094
External VLAN priority	0 to 7
IP source address	IP address (x:x:x:x::x format then the prefix length in the /x format)
IP destination address	IP address (x:x:x:x::x format then the prefix length in the /x format)
IP protocol type	• session initiation protocol (SIP) • dynamic IP (DIP) • type of service (TOS)protocol
Type of service (ToS)	0 to 255
Transport source port (`transport sport`)	0 to 65535
Transport destination port (`transport dport`)	0 to 65535
ICMP type	0 to 255
ICMP code	0 to 255

The software forwards the match results out of one or more network ports, with the option to modify the packet headers.

Supported Flow Actions

The following flow actions are supported:

- `OFPAT_FLOOD` or `OFPAT_ALL`: Floods packets to all ports and VLANs on the OF interface.
- `OFPAT_CONTROLLER`: Sends all `NO_MATCH` or `ACTION` packets to the controller specified by the packet's VLAN tag.
- `OFPAT_out_port`: Displays a list of ports that can receive traffic.
- `OFPAT_DROP`: Drops all packets that match the specified criteria.
- `OFPXMT12_OFB_ETH_TYPE` — `Ethernet frame type`
- `OFPXMT12_OFB_VLAN_PCP` — `VLAN priority`
- `MODIFY FIELD` — `Set VLAN ID`: Assigns a VLAN ID (0 to 4094).
- `MODIFY FIELD` – `Strip Vlan ID`: Strips VLAN ID from the packet.
- `MODIFY FIELD` — `Set VLAN priority`: Assigns a priority to a VLAN (0 to 7).
- `MODIFY FIELD` — `Modify Ethernet source MAC address`: Changes the Ethernet source MAC address to the specified value.
- `MODIFY FIELD` — `Modify Ethernet destination MAC address`: Changes the Ethernet destination MAC address to the specified value.
- `MODIFY FIELD` — `Modify IPv4 ToS bits`: Changes the IPv4 ToS in the packet header to the specified value.
- `OFPAT_ENQUEUE`: Send the specified flow to the queue.

NOTE: If there is a conflict between actions, the action with the higher priority takes precedence.

Unsupported OpenFlow Messages

The following OpenFlow messages are not supported. Some unsupported messages generate
`OFPT_ERROR`, which is an error message sent to the controller.

Table 4. Unsupported OpenFlow Messages

Message	System Response
`OFPT_SET_CONFIG`	This message is ignored by the switch.
`OFPT_QUEUE_GET_CONFIG_REQUEST`	`OFPT_ERROR` generates in response.
Emergency Flows (`OFPFF_EMERG`)	`OFPT_ERROR` generates in response.
Queue Statistics (`OFPST_QUEUE`)	`OFPT_ERROR` generates in response.

For supported `flow-match` and `flow action` parameters for each flow type, refer to [Flow Types](#).

The following is a list of actions that are not supported for any flow types. All of the following commands
generate an `OFPT_ERROR` message.

- `OFPAT_SET_NW_SRC (set src-ip)`
- `OFPAT_SET_NW_DST (set dst-ip)`
- `OFPAT_SET_TP_SRC (set tcp/udp src-port)`
- `OFPAT_SET_TP_DST (set tcp/udp dst-port)`
- `OFPAT_OUTPUT to OFPP_IN_PORT`
- `OFPAT_OUTPUT to OFPP_TABLE`
- `OFPAT_OUTPUT to OFPP_NORMAL`
- `OFPAT_OUTPUT to OFPP_LOCAL`
- `FORWARD — Normal`
- `FORWARD — LOCAL`
- `FORWARD — Inport`
- `MODIFY FIELD — Strip VLAN header`
- `MODIFY FIELD — Modify IPv4 source address`
- `MODIFY FIELD — Modify IPv4 destination address`
- `MODIFY FIELD — Modify transport source port`
- `MODIFY FIELD — Modify transport destination port`
- `MAX_BYTES_TO_SENDLimitations`

Limitations

- `OFPAT_OUTPUT to OFPP_FLOOD` and `OFPP_ALL` are supported on the S4810, S4820T, S6000, and MXL switches. Support for these commands on the Z9000 was introduced in version 9.4(0.0).
- Multiple output ports are supported on S4810, S4820T,Z9000, and MXL switches.
- The set/modify actions must precede the output ports actions. If you specify multiple output ports, the switch cannot transmit different copies.
- You cannot specify individual output ports for `ALL` or `FLOOD` actions.

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Configuring ACL CAM Carving on the S4810, S4820T, S6000, S5000, and MXL switch

Dell Networking switches can operate in Hybrid mode, which enables OpenFlow and legacy functionality on the same switch. By default, access control list content addressable memory (ACL CAM) space is not allocated for OpenFlow. To enable OpenFlow, reserve CAM space for OpenFlow using the following commands. The amount of CAM space that you allocate for OpenFlow determines the number of available ACL entries. For more information on CAM, refer to the *Content Addressable Memory (CAM)* chapter in the *FTOS Configuration Guide*.

✎ NOTE: The commands to allocate CAM space for OpenFlow on the S4810, S4820T, S6000, S5000, and MXL switches differ from the commands used for the Z9000 and Z9500.

1. Enter a value for `cam-acl`.

   Select one of the following values for `cam-acl`:

   • 0 (default): No space is allocated for OpenFlow. Change this value to four or eight to enable OpenFlow.

   • 4: Allocates space for up to 242 flow entries (20 entries are reserved for internal purposes from the 256 available flows, leaving 242 entries for use by OpenFlow). For S6000, entering a 4 allocates space for up to 498 flow entries (14 entries are reserved for internal purposes from the 512 available flows, leaving 498 entries for use by OpenFlow).

   • 8: Allocates space for up to 498 flow entries (14 entries are reserved for internal purposes from the 512 available flows, leaving 498 entries for use by OpenFlow). For S6000, entering an 8 allocates space for up to 998 flow entries (14 entries are reserved for internal purposes from the 1012 available flows, leaving 998 entries for use by OpenFlow).

   The following sample S4810 configuration reserves 512 entries for OpenFlow:

   ```
   Dell(conf)#cam-acl l2acl 3 ipv4acl 2 ipv6acl 0 ipv4qos 2 l2qos 2 l2pt 0
   ipmacacl 0 vman-qos 0 ecfmacl 0 openflow 8 fcoeacl 0 iscsioptacl 0
   ```

2. Enter a value for `cam-acl-vlan`.

   Select one of the following values for `cam-acl-vlan`:

   • 0 (default): No space is allocated for OpenFlow. Change this value to 1 to enable OpenFlow.

   • 1: Enables OpenFlow.

   The following sample configuration shows a value of 1 for `cam-acl-vlan`:

   ```
   Dell(conf)#cam-acl-vlan vlanopenflow 1 vlaniscsi 1
   ```

3. Reboot the switch after changing the `cam-acl` and `cam-vlan-acl` values. If you do not reboot the switch, the configuration changes do not take effect.

NOTE:

To upgrade any configuration changes that have changed the NVRAM content if you enable BMP 3.0, use the `reload conditional nvram-cfg-change` command to perform a reload on the chassis.

Configuring ACL CAM Carving on Z9000 and Z9500

Dell Networking switches can operate in Hybrid mode, which enables OpenFlow and legacy functionality on the same switch. By default, access control list content addressable memory (ACL CAM) space is not allocated for OpenFlow. To enable OpenFlow, reserve CAM space for OpenFlow using the following commands. The amount of CAM space that you allocate for OpenFlow determines the number of available ACL entries. For more information on CAM, refer to the *Content Addressable Memory (CAM)* chapter in the *FTOS Configuration Guide*.

> **NOTE:** The commands to allocate CAM space for OpenFlow on the Z9000 and Z9500 differ from the commands used for the S4810, S4820T, S6000, S5000, and MXL switches.

1. Enter a value for `cam-acl`.

   Select one of the following values for `cam-acl`:

   - 0 (default): No space is allocated for OpenFlow. Change this value to four or eight to enable OpenFlow.

   - 4: Allocates space for up to 242 flow entries (14 entries are reserved for internal purposes from the 256 available flows, leaving 242 entries for use by OpenFlow).

   - 8: Allocates space for up to 498 flow entries (14 entries are reserved for internal purposes from the 512 available flows, leaving 498 entries for use by OpenFlow).

   The following sample Z9000 and Z9500 configuration reserves 512 entries for OpenFlow:

   ```
   Dell(conf)# cam-acl l2acl 2 ipv4acl 2 ipv6acl 0 ipv4qos 4 l2qos 1 l2pt 0
   ipmacacl 0 vman-qos 0 ecfmacl 0 openflow 8
   ```

   > **NOTE:** For Z9000 and Z9500, the `cam-acl-vlan` value is set to 1 (enabled) by default; no additional configuration is required.

2. Reboot the switch after changing the `cam-acl` values. If you do not reboot the switch, the configuration changes do not take effect.

   > **NOTE:**
   > To upgrade any configuration changes that have changed the NVRAM content, if you enable BMP 3.0, use the `reload conditional nvram-cfg-change` command to perform a reload on the chassis .

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Flow Types

Dell Networking switches support three types of flows:

- ACL
- L2
- L3

The following sections describe the mandatory match fields, optional match fields, mandatory actions, and optional actions for each flow type.

ACL Flows

Parameter Type	Parameters
Mandatory match fields	None; any of the match parameters can be wildcards.
Optional match fields	All 12 match fields defined in OpenFlow (OF) 1.0 are supported.
Mandatory actions	None.
Optional actions	`set_vlan_id` `set_vlan_pcp` `strip_vlan` `set_dl_src` (set src-mac) `set_dl_dst` (set dst-mac) `set_nw_tos` - output to one or more switch ports

> **NOTE:** For output action limitations, refer to [OpenFlow 1.0 Support](#).

L3 Flows

Parameter Type	Parameters
Mandatory match fields	- You must specify `dl_dst` (dst-mac) as the switch's port mac. - You must specify `dl_type` (ether-type) as 0x800.
Optional match fields	`nw_dst` (dst-ip)

Parameter Type	Parameters
	• All fields other than the ones listed in "Mandatory match fields" and "Optional match fields" must be wildcards.
Mandatory actions	• You must specify `set_dl_src` (set src-mac) as the port mac (local mac) for the swtich. • `set_dl_dst` (set dst-mac) • Single `OFPAT_OUTPUT` action to a switch port.
Optional actions	OFPAT_SET_VLAN is optional for OpenFlow (OF) ports and mandatory for OF virtual local area networks (VLANs).

L2 Flows

Parameter Type	Parameters
Mandatory match fields	• `dl_vlan` (input vlan id) • `dl_dst` (dst-mac)
Optional match fields	All fields other than `dl_vlan` and `dl_dst` must be wildcards.
Mandatory actions	Single `OFPAT_OUTPUT` action to a switch port.
Optional actions	None.

Max Limits

This section defines the maximum number of permitted flow types. The number of available flow types varies depending on the type of flow.

• You can provision up to 8 OF instances on each switch.
• The number of flows supported on each switch depends on the flow type.
• OF flow types can be combined — for example, the following flow combination is supported: 256 ACL flows, 48,000 L2 flows, and 6,000 L3 flows.

Flow Type	Max Limit
ACL	256 or 512 (depending on ACL content addressable memory [CAM] carving) NOTE: This value is platform specific. It differs from one platform to another.
L2/MAC	48,000
L3/Route	6,000

Group Flows

Parameter Types	Parameters
Mandatory Match Fields	None.
Optional Match Fields	None.
Action Types	• ALL
Mandatory Actions	• output_port

> **NOTE:** Multiple actions in a single bucket is not supported. This feature is available only when of-instance version is set to 1.3.

Optional Actions	None.

The following example shows the Group Flow details:

```
Instance: 2, Table: acl, Flow: 5, Cookie: 0xc80a3c5800000000
Priority: 22016, Internal Priority: 22016
Up Time: 2d 20:34:54, Hard Timeout: 0 seconds
Idle Timeout: 0 seconds, Internal Idle Timeout: 0 seconds
Packets: 0, Bytes: 0
Match Parameters:
  Valid Match: InPort,Etype,DMAC
  In Port    : Te 0/13              EType     : arp
  SMAC       : *
  DMAC       : 01:00:00:00:00:00 / 01:00:00:00:00:00
  VLAN id    : *                    VLAN PCP  : *
  IP TOS     : *                    IP proto  : *
  Src IP     : *                    Dest IP   : *
  Src Port   : *                    Dest Port : *
Actions:
  Output: Group:0x0x10000001 Type:All
Buckets:
  controller
  Te 0/13
  Po 112
```

5

Configuring OpenFlow Instances

This section describes how to enable and configure OpenFlow instances on a switch.

- You can use up to 8 OpenFlow instances on a switch. The OpenFlow (OF) ID range is from 1 to 8.
- You must allocate CAM blocks for use by OpenFlow before configuring any OpenFlow instances. For more information, refer to Configuring ACL CAM Carving on the S4810, S4820T, S6000, and MXL switch for S4810, S4820T, S6000, and MXL switches or Configuring ACL CAM Carving on Z9000 for the Z9000 platform.
- Only transmission control protocol (TCP) connections are supported on Dell Networking switches. Transport layer security (TLS) connections are not supported.
- You can configure only one controller IP and one TCP port for each OF instance.
- The connection is established when you enable the OF instance using the `no shut` command.
- You cannot modify the OF instance while it is enabled. To make configuration changes, use the `shutdown` command to disable the OF instance, as shown below.

```
Dell#show running-config openflow of-instance
!
openflow of-instance 1
 controller 1 10.11.205.184  tcp
 shutdown
Dell#
```

- The `show openflow of-instance` command displays details on the instance, as shown below:

```
Dell#show openflow of-instance 1

Instance       : 2
Admin State    : Up
OF Version     : V1-3
Interface Type : Vlan
DP Id          : 00:02:74:86:7a:ff:6f:e4
Forwarding Tbls : acl, mac, route
Flow map       :l2, l3
EchoReq interval: 15 seconds
Connect interval: 15 seconds
Number of Flows : 21 (acl:21)
Packets (acl)  : 575600
Bytes (acl)    : 36838400
Fail mode      : secure
Flow misses    : copy-to-controller
Controller 1   : TCP, 10.11.54.186/6633, rcv/sndbuf 1000/1000, connected
(equal) high-priority
Controller 2   : -
 Port List     :

 Vlan List     :
                 Vl 200
 Vlan Mbr list :
                 Fo 1/16 (209), Fo 1/20 (213), Fo 2/0 (385)
```

If you do not specify a default VLAN for packet routing, the software assigns the first available VLAN as the default VLAN when you create the first OF instance. To specify a default VLAN, use the openflow vlan command.

1. Create or modify an OF instance.
   CONFIGURATION mode

   ```
   openflow of-instance of-id
   ```

2. If this is a new OF instance, continue to step 3. To change an existing OF instance, disable it first.

   NOTE: All new OF instances are disabled by default. For existing OF instances, you must disable the OpenFlow instance before you can configure it.

   OPENFLOW INSTANCE mode

   ```
   shutdown
   ```

3. Add a physical interface or VLAN to an OpenFlow instance.
   INTERFACE mode

   ```
   of-instance of-id
   ```

   NOTE: For more information, refer to OpenFlow Interfaces

4. Specify the interface type for the OF instance.
   OPENFLOW INSTANCE mode

   ```
   interface-type {any|port|vlan}
   ```

   NOTE: Dell Networking does not recommend selecting `any` for the `interface-type` unless both OF ports and OF VLANs are required in a single instance. If you select `any` for the `interface-type`, the number of available ACL flows is reduced by half (128 of 256 entries or 256 of 512 entries).

   NOTE: Dell Networking does not recommend configuring global spanning-tree protocol (STP) instances on ports using both legacy virtual local area networks (VLANs) and OF VLANs.

5. Specify the OF controller configuration used by OF to establish a connection.
   OPENFLOW INSTANCE mode

   ```
   controller {controller-id}{ip-address}[portport-number]tcp
   ```

6. (OPTIONAL) Configure the high-priority value for the OF - controller.
   OPENFLOW INSTANCE mode

   ```
   controller {controller-id} {ip-address} tcp high-priority
   ```

7. (OPTIONAL) Configure the timed interval (in seconds) that the OF instance waits after attempting to establish a connection with the OF controller.
   OPENFLOW INSTANCE mode

   ```
   connect retry-interval interval
   ```

8. (OPTIONAL) Configure the controller to be a High Priority controller.
   OPENFLOW INSTANCE mode

   ```
   controller {controller-id} {ip-address} {tcp} [high-priority]
   ```

9. (OPTIONAL) Specify if flows installed by the controller should be interpreted by the switch for placement in L2 or L3 tables.
   OPENFLOW INSTANCE mode

   ```
   flow-map {l2|l3} enable
   ```
10. (OPTIONAL) Advertise all forwarding tables (ACL, L2, and L3) to the controller.
   OPENFLOW INSTANCE mode

   ```
   multiple-fwd-table enable
   ```
11. Enable the OF instance.
   OPENFLOW INSTANCE mode

   ```
   no shutdown
   ```

6

Forwarding Features

Flow Failover

This feature provides failover support if a controller is unavailable. If the connection to a controller is lost, installed flows are retained and used for forwarding traffic until they are updated. This feature is enabled by default but you can disable failover on individual instances by using the use the `no fail-mode secure` command. If you disable failover, all flows to the unavailable controller are dropped. For more information, refer to the [fail-mode secure](#) command.

Flow Misses

By default, flows that do not reach their intended destination (flow misses), are copied to the controller. To disable this feature on an OF instance, configure the controller to drop flow misses instead of copying them to the controller by using the `flow-misses drop` command. For more information, refer to the [flow-misses drop](#) command.

Default VLAN

In the previous version of OpenFlow, some packet types, such as untagged ARP broadcasts, received on an OF port could not be forwarded from a physical port and could only be copied to the controller. To resolve this issue, assign a default VLAN to the OF ports using the `openflow vlan` command. If you do not assign a VLAN, the software selects one when you create the first OF instance. The default VLAN applies to all OF instances and can only be configured if you have not configured any OF instances. For more information, refer to the [openflow vlan](#) command.

Source Suppression

Source suppression prevents received packets from being transmitted from the ingress port. Source suppression is enabled by default and is applied to all instances on the switch. If you disable source suppression, received packets can be transmitted from the ingress port.

> **NOTE:** If you disable source suppression, the following conditions apply:
>
> - Dell Networking does not recommend enabling legacy features.
> - You cannot enable [Hybrid mode](#).
> - If you install flows using `OFPP_FLOOD` or `OFPP_ALL`, traffic loops may occur. If you disable source suppression, Dell Networking recommends that you do not install flows using these parameters.

For more information, refer to the [src-suppression](#) command.

VLAN Tag Removal

This feature allows an interface processor (IFP) action to remove the outer VLAN tag from a packet before sending it out of the egress port. OpenFlow VLAN egress ports are now supported and flows with the `strip-vlan` action and an OF VLAN member port as the egress port are accepted.

NOTE: This feature is supported for OF egress ports only.

Egress QoS

The controller can provide basic egress quality of service (QoS) policies for packets and assign a priority based on match parameters specified by the controller.

To enable QoS, use one flow to determine the egress port for the packet (for example, an L3 flow) and another flow such as an ACL flow to determine the egress port for all packets matching the specified parameters. Using the `Set Enqueue` action, the controller specifies the egress queue for received packets matching the specified parameters. You can configure queues and queue rates on individual ports or for all physical ports in the OF instance.

There are four data queues available, from Q0 to Q3. The minimum rate of a queue is calculated using the default weights associated with the queue. If you use legacy CLIs, there is no change in the rate. The following table displays the default weight assigned to each queue:

Queue Number	Default Weight	Percentage of port line rate
Q0	1	6.67%
Q1	2	13.33%
Q2	4	26.67%
Q3	8	53.33%

After the controller identifies the queues and their rates, it can install flows using the `Set Enqueue` command. For example, to send all packets with the source IP address 1.1.1.1 from Queue 0, regardless of the egress port, the controller creates the following flow:

- Match parameters = Source IP 1.1.1.1
- Action = `Set Enqueue`
- Queue = 0

Caveats

- Ingress and egress QoS legacy commands are not supported.
- Queues and queue rates are based on default values. You must disable the instance before configuring queue and queue rates.

OpenFlow Interfaces

This section describes how you can apply OpenFlow to specific interfaces.

- You can use the S4810, S4820T, S6000, S5000, Z9000, Z9500, or MXL switch as a Hybrid switch, allowing both OpenFlow (OF) and legacy functionality simultaneously.
- By default, all ports are available for legacy functionality.
- To enable OpenFlow, associate a port or virtual local area network (VLAN) to an OF instance. You can only do this when the OF instance is disabled.
- OpenFlow is supported with link aggregation groups (LAGs); for example, you can configure port channel interfaces as OF ports or as members of OF VLANs.

OF Ports

The following configuration example associates two ports (Te 0/7 and Te 0/31) to of-instance 1:

```
Dell(conf)#interface tengigabitethernet 0/7
Dell(conf-if-te-0/7)#of-instance 1
Dell(conf-if-te-0/7)#interface tengigabitethernet 0/31
Dell(conf-if-te-0/31)#of-instance 1
Dell(conf-if-te-0/31)#
```

To see the list of ports associated with an OF instance, use the `show openflow of-instance` command. The number displayed in parentheses is the port ID sent to the controller (for example, Te 0/7 is sent to the controller as of-port 8, as shown below).

```
Dell#show openflow of-instance 1

Instance        : 2
Admin State     : Up
OF Version      : V1-3
Interface Type  : Vlan
DP Id           : 00:02:74:86:7a:ff:6f:e4
Forwarding Tbls : acl, mac, route
Flow map        :l2, l3
EchoReq interval: 15 seconds
Connect interval: 15 seconds
Number of Flows : 21 (acl:21)
Packets (acl)   : 575600
Bytes (acl)     : 36838400
Fail mode       : secure
Flow misses     : copy-to-controller
Controller 1    : TCP, 10.11.54.186/6633, rcv/sndbuf 1000/1000, connected
(equal) high-priority
Controller 2    : -
 Port List      :

 Vlan List      :
                  Vl 200
 Vlan Mbr list  :
                  Fo 1/16 (209), Fo 1/20 (213), Fo 2/0 (385)
```

OF VLANs

Instead of assigning an entire port to an OF instance, you can assign a VLAN to an OF instance when you create the VLAN. You can only create OF VLANs when the associated instance is disabled using the `shutdown` command. Configure OF VLAN members in the same way as you would configure a legacy VLAN.

NOTE: You cannot assign the default VLAN as an OF VLAN.

There is an `interface-type` parameter in each instance. By default, this parameter is set to `port`, indicating that the instance is used for OF ports. To use an OF instance in an OF VLAN, change this parameter to `vlan`, as shown in the example below:

```
Dell(conf)#openflow of-instance 1
Dell(conf-of-instance-1)#interface-type vlan
Dell(conf-of-instance-1)#
```

To use both OF ports and OF VLANs, set the interface type to `any`.

NOTE: Dell Networking does not recommend using the interface type `any` unless both OF ports and OF VLANs are required in a single instance. If you use the `any` interface type, the number of ACL flows available to the controller is reduced by half (for example, to 128 of 256 available entries or to 256 of 512 available entries).

The following configuration example associates VLAN 100 (with tagged members Te 0/0 and Te 0/1) to of-instance 1:

```
Dell(conf)#interface vlan 100 of-instance 1
Dell(conf-if-vl-100)#tagged tengigabitethernet 0/0
Dell(conf-if-vl-100)#tagged tengigabitethernet 0/1
Dell(conf-if-vl-100)#no shutdown
Dell(conf-if-vl-100)#
```

To display the OF VLANs and OF VLAN members associated with the OF instance, use the `show openflow of-instance` command , as shown below:

```
Dell#show openflow of-instance 1

Instance        : 1
Admin State     : Up
OF Version      : V1-3
Interface Type  : Vlan
DP Id           : 00:01:74:86:7a:ff:6f:e4
Forwarding Tbls : acl
Flow map        :
EchoReq interval: 15 seconds
Connect interval: 15 seconds
Number of Flows : 21 (acl:21)
Packets (acl)   : 575600
Bytes (acl)     : 36838400
Fail mode       : secure
Flow misses     : copy-to-controller
Controller 1    : TCP, 10.11.54.186/6633, rcv/sndbuf 1000/1000, connected
(equal) high-priority
Controller 2    : -
 Port List      :

 Vlan List      :
                  Vl 50
```

```
Vlan Mbr list  :
              Fo 1/16 (209), Fo 1/20 (213), Fo 2/0 (385)
```

Flow Setup

This chapter describes the configuration options required to set up flows.

Sample Topology

In the following sample topology, two OF instances are shown. `of-instance 1` has an interface type of `port` and demonstrates ACL and L3 flows. `of-instance 2` has an interface type of `vlan` and demonstrates ACL, L2, and L3 flows. L2 flows are supported on OF VLANs only.
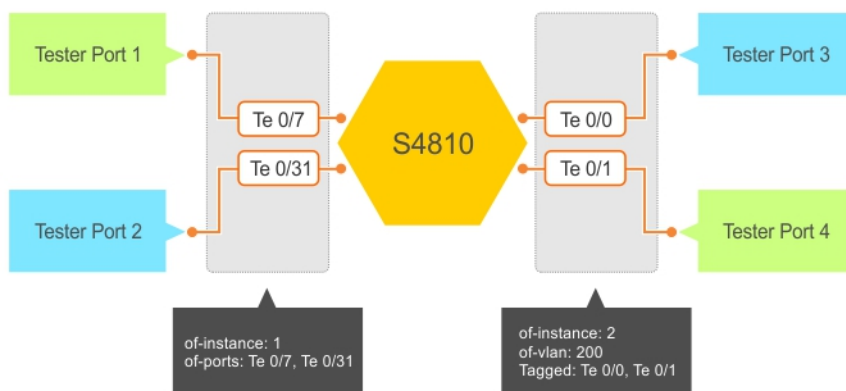
Figure 2. OpenFlow Sample Topology

To display the following information, use the `show running-config openflow of-instance 1` command :

📝 **NOTE:** To display information, you must have an active connection to the OF controller.

```
Dell# show running-config openflow of-instance 1
!
openflow of-instance 1
 controller 1 10.11.205.184  tcp
 flow-map l3 enable
 multiple-fwd-table enable
 no shutdown
Dell#show openflow of-instance 1

Instance        : 1
Admin State     : Up
OF Version      : V1-3
Interface Type  : Vlan
DP Id           : 00:01:74:86:7a:ff:6f:e4
Forwarding Tbls : acl, mac, route
Flow map        :
EchoReq interval: 15 seconds
```

```
Connect interval: 15 seconds
Number of Flows : 21 (acl:21)
Packets (acl)  : 575600
Bytes (acl)    : 36838400
Fail mode      : secure
Flow misses    : copy-to-controller
Controller 1   : TCP, 10.11.54.186/6633, rcv/sndbuf 1000/1000, connected
(equal) high-priority
Controller 2   : -
 Port List     :

 Vlan List     :
                Vl 50
 Vlan Mbr list :
                Fo 1/16 (209), Fo 1/20 (213), Fo 2/0 (385)
```

To display information for the second OF instance, use the `show running-config openflow of-instance 2` command:

```
Dell# show running-config openflow of-instance 2
!
openflow of-instance 2
 controller 1 10.11.205.184  tcp
 flow-map l2 enable
 flow-map l3 enable
 interface-type vlan
 multiple-fwd-table enable
 no shutdown
Dell#show openflow of-instance 2

Instance       : 2
Admin State    : Up
OF Version     : V1-3
Interface Type : Vlan
DP Id          : 00:02:74:86:7a:ff:6f:e4
Forwarding Tbls : acl, mac, route
Flow map       :l2, l3
EchoReq interval: 15 seconds
Connect interval: 15 seconds
Number of Flows : 21 (acl:21)
Packets (acl)  : 575600
Bytes (acl)    : 36838400
Fail mode      : secure
Flow misses    : copy-to-controller
Controller 1   : TCP, 10.11.54.186/6633, rcv/sndbuf 1000/1000, connected
(equal) high-priority
Controller 2   : -
 Port List     :

 Vlan List     :
                Vl 200
 Vlan Mbr list :
                Fo 1/16 (209), Fo 1/20 (213), Fo 2/0 (385)
```

ACL Flows

By default, all flows are treated as ACL flows. No additional configuration is required to set up ACL flows. You can view per-flow and aggregate statistics for ACL flows using the `show openflow of-instance` and `show openflow flows of-instance` commands.

To clear these statistics, use the `clear openflow statistics of-instance` command. The following sample ACL flow was configured using a controller. It matches by `dmac`, `ether-type`, `ip-protocol`, and `tcp-dst-port`, then sets the VLAN ID to 111 and forwards the packet from Te 0/31.

```
Dell#show openflow flows of-instance 1
Instance: 1, Table: acl, Flow: 18, Cookie: 0xc8054d1800000000
Priority: 24600, Internal Priority: 24600
Up Time: 0d 00:01:25, Hard Timeout: 0 seconds
Idle Timeout: 0 seconds, Internal Idle Timeout: 0 seconds
Packets: 0, Bytes: 0
Match Parameters:
  Valid Match: DMAC,Vid
  In Port    : *                      EType     : *
  SMAC       : *
  DMAC       : 02:00:00:58:72:93 / ff:03:ff:ff:ff:ff
  VLAN id    : 4094                   VLAN PCP  : *
  IP TOS     : *                      IP proto  : *
  Src IP     : *                      Dest IP   : *
  Src Port   : *                      Dest Port : *
 Actions:
  Set VLAN id: 50
  Set DMAC: 10:00:00:00:00:01
  Output: Fo 1/16


Dell#show openflow of-instance 1

Instance        : 1
Admin State     : Up
OF Version      : V1-3
Interface Type  : Vlan
DP Id           : 00:01:74:86:7a:ff:6f:e4
Forwarding Tbls : acl, mac, route
Flow map        :
EchoReq interval: 15 seconds
Connect interval: 15 seconds
Number of Flows : 21 (acl:21)
Packets (acl)   : 575600
Bytes (acl)     : 36838400
Fail mode       : secure
Flow misses     : copy-to-controller
Controller 1    : TCP, 10.11.54.186/6633, rcv/sndbuf 1000/1000, connected
(equal) high-priority
Controller 2    : -
 Port List      :

 Vlan List      :
                  Vl 50
 Vlan Mbr list  :
                  Fo 1/16 (209), Fo 1/20 (213), Fo 2/0 (385)
```

For complete ACL flow formats, refer to [Flow Types](#) .

L3 Flows

To use L3 flows, enable the `multiple-fwd-table` and `flow-map l3` commands, as shown in the following example. If you do not enable either of these commands, L3 flows are added to the ACL table.

```
Dell#show running-config openflow of-instance 1
!
openflow of-instance 1
 controller 1 10.11.205.184  tcp
 flow-map l3 enable
```

```
 multiple-fwd-table enable
 no shutdown
```

The entry for `dst-mac` in the match field and `set-src-mac` in the action set must use the switch's port MAC address. All ports on a Dell Networking switch are associated with the same MAC address, which you can view using the `show interface` command.

```
Dell#show interfaces tengigabitethernet 0/0
TenGigabitEthernet 0/0 is up, line protocol is up
Hardware is DellForce10Eth, address is 00:01:e8:8b:1a:32
    Current address is 00:01:e8:8b:1a:32
...
```

You can configure L3 flows on OF ports as well as on OF VLANs. You must specify the `set-vlan-id` option in the action set for OF VLANs. As shown in the following example, the L3 flow `of-instance 1` transmits packets from OF port Te 0/31:

```
Dell#show openflow flows of-instance 1

Instance: 1, Table: route, Flow: 2, Cookie: 0xfffffffffa17177b0
Priority: 32768, Internal Priority: 0
Up Time: 0d 00:00:13, Hard Timeout: 0 seconds
Idle Timeout: 0 seconds, Internal Idle Timeout: 0 seconds
Packets: -, Bytes: -
Match Parameters:
  Valid Match: Etype,DMAC,DIP
  In Port    : *                   EType     : ip
  SMAC       : *                   DMAC      : 00:01:e8:8b:1a:32
  VLAN id    : *                   VLAN PCP  : *
  IP TOS     : *                   IP proto  : *
  Src IP     : *                   Dest IP   : 1.1.1.0/24
  Src Port   : *                   Dest Port : *
 Actions:
  Set SMAC: 00:01:e8:8b:1a:32
  Set DMAC: 00:00:00:00:00:11
  Output: Te 0/31
```

The following example shows the sample L3 flow `of-instance 2` transmitting packets from the OF VLAN port Te 0/1:

```
Dell#show openflow flows of-instance 2

Instance: 2, Table: route, Flow: 3, Cookie: 0xfffffffffa4cb6a2e
Priority: 32768, Internal Priority: 0
Up Time: 0d 00:00:11, Hard Timeout: 0 seconds
Idle Timeout: 0 seconds, Internal Idle Timeout: 0 seconds
Packets: -, Bytes: -
Match Parameters:
  Valid Match: Etype,DMAC,DIP
  In Port    : *                   EType     : ip
  SMAC       : *                   DMAC      : 00:01:e8:8b:1a:32
  VLAN id    : *                   VLAN PCP  : *
  IP TOS     : *                   IP proto  : *
  Src IP     : *                   Dest IP   : 2.2.2.2/32
  Src Port   : *                   Dest Port : *
 Actions:
  Set VLAN id: 200
  Set SMAC: 00:01:e8:8b:1a:32
  Set DMAC: 00:00:00:00:00:22
  Output: Te 0/1
```

For complete L3 flow formats, refer to [Flow Types](#) .

L2 Flows

L2 flows are only supported on OF VLANs. In the following example, `of-instance 2` is used to demonstrate an L2 flow. To use the L2 flow table, enable the `multiple-fwd-table` and `flow-map l2` commands, as shown in the following example. If you do not enable either command, L2 flows are added to the ACL table.

```
Dell#show running-config openflow of-instance 2
!
openflow of-instance 2
 controller 1 10.11.205.184  tcp
 flow-map l2 enable
 flow-map l3 enable
 interface-type vlan
 multiple-fwd-table enable
 no shutdown
```

The following example demonstrates a sample flow `of-vlan 200`:

```
Dell#show openflow flows of-instance 2

Instance: 2, Table: mac, Flow: 4, Cookie: 0xffffffffac2dbbf2
Priority: 32768, Internal Priority: 0
Up Time: 0d 00:00:09, Hard Timeout: 0 seconds
Idle Timeout: 0 seconds, Internal Idle Timeout: 0 seconds
Packets: -, Bytes: -
Match Parameters:
  Valid Match: DMAC,Vid
  In Port    : *                    EType     : *
  SMAC       : *                    DMAC      : 00:22:22:22:22:22
  VLAN id    : 200                  VLAN PCP  : *
  IP TOS     : *                    IP proto  : *
  Src IP     : *                    Dest IP   : *
  Src Port   : *                    Dest Port : *
 Actions:
  Output: Te 0/1
```

For complete L2 flow formats, refer to [Flow Types](#) .

Packet Trace

Enable OpenFlow protocol packet tracing by using the `debug openflow packets packet-type {packets} of-instance {of-id}` command. For more information, refer to [debug openflow packets](#).

10

Exceptions

This section describes the constraints of OpenFlow.

- Dell Networking switches can operate as Hybrid switches (switches running OpenFlow and legacy functions simultaneously). You cannot enable Legacy functionality (switching and routing) on OF ports or OF virtual local area networks (VLANs), as these interfaces are controlled by an OpenFlow controller and are not available.
- Stacking of OpenFlow switches is not supported for the S4810, S4820T, S6000, or MXL switches. If you configure stacking but disabled it in preparation for future stacking, the stack unit number must be zero to enable OpenFlow on S4810, S4820T, S6000, or MXL switches.
- For OF ports and OF VLANs, the VLAN IDs used for OpenFlow must be unique; the VLAN IDs can be used for legacy functionality on the same switch.
- Dell Networking does not recommend using global spanning tree protocol (STP) instances on ports with both legacy VLANs and OF VLANs.
- Transport layer security (TLS) connections are not supported.
- Because controllers typically run their own version of link layer discovery protocol (LLDP), disable legacy LLDP on OF ports.
- To avoid session timeout issues if you change the system clock, you must disable and re-enable all existing OF instances.
- Emergency flows are not supported.
- Packet buffering is not supported.
- Data center bridging (DCB) and Internet small computer system interface (iSCSI) are not supported on OpenFlow interfaces.
- The following packet types can only be copied to the controller and cannot be forwarded from a physical switch port:

    - STP BDPU
    - LLDP
    - GVRP
    - ARP Replies
    - 802.1x frames
    - untagged broadcast packets received on an OF port

ACL Flow Exceptions

- Flooding (action "output=all" or "output=flood") is supported on S4810, S4820T, S6000, and MXL switches. Support for this command on the Z9000 was introduced in version 9.4(0.0).
- By default, ACL flows override flows installed in the L2 or L3 tables.
- Address resolution protocol (ARP) opcode, sender IP, and target IP matching are not supported.

L3 Flow Exceptions

- Non-zero integers for the idle timeout are not supported and are ignored for L3 flows. L3 flows are not aged out.
- For L3 flows, flow priority is not applicable. Instead, the destination IP (dst-ip) network mask length is used to prioritize the flow, with longer mask lengths having priority over shorter mask lengths. For example, an L3 flow with a dst-ip network mask length of 32 has priority over a flow with a dst-ip network mask length of 31.
- Time-to-live (TTL) is decremented for traffic forwarded using L3 flows.

L2 Flow Exceptions

- If you specify a non-zero idle timeout value for an L2 flow and there is no activity or traffic, the flow is aged out according to the MAC address table aging time configured on the switch. If the idle timeout value is zero, the flow is not aged.
- Flow priority is ignored for L2 flows.
- L2 flows are supported on OF VLANs only.

11

OpenFlow Commands

Use the following commands for software-defined networking (SDN) OpenFlow.

- connect retry-interval
- controller
- debug openflow packets
- fail-mode secure
- flow-map
- flow-misses drop
- interface-type
- interface vlan
- multiple-fwd-table
- of-instance (Interface)
- of-instance (Configuration)
- of-version
- openflow vlan
- show openflow
- show openflow flows
- shutdown
- src-suppression

SDN Command Modes

To navigate and launch various CLI modes, use the following commands.

CONFIGURATION Mode

In EXEC Privilege mode, use the `configure` command to enter CONFIGURATION mode and configure routing protocols and access interfaces.

To enter CONFIGURATION mode:

1. Verify that you are logged in to EXEC Privilege mode.
2. Enter the `configure` command. The prompt changes to include (conf).

From this mode, you can enter INTERFACE mode by using the `interface` command.

EXEC Mode

When you initially log in to the switch, by default, you are logged in to EXEC mode. This mode allows you to view settings and enter EXEC Privilege mode, which is used to configure the device.

When you are in EXEC mode, the > prompt is displayed following the host name prompt, which is "Dell" by default. You can change the host name prompt using the `hostname` command.

> **NOTE:** Each mode prompt is preceded by the host name.

INTERFACE Mode

Use INTERFACE mode to configure interfaces or IP services on those interfaces. An interface can be physical (for example, a Gigabit Ethernet port) or virtual (for example, the Null interface).

To enter INTERFACE mode:

1. Verify that you are logged in to CONFIGURATION mode.
2. Enter the `interface` command and then enter an interface type and interface number that is available on the switch.

The prompt changes to include the designated interface and slot/port number.

OPENFLOW INSTANCE Mode

To enable and configure OpenFlow instances, use OPENFLOW INSTANCE mode. For more information, refer to [SDN Commands](#).

To enter OPENFLOW INSTANCE mode:

1. Verify that you are logged in to CONFIGURATION mode.
2. Enter the `openflow of-instance` command then the OpenFlow ID number of the instance you want to create or configure. The prompt changes to include (conf-of-instance *of-id*).

You can return to the CONFIGURATION mode by entering the `exit` command.

connect retry-interval

Configure the timed interval (in seconds) that the OpenFlow (OF) instance waits after requesting a connection with the OpenFlow controller.

Syntax	`connect retry-interval` *interval*
	To disable this configuration, use the `no connect retry-interval` *interval*`command.
Parameter	

interval	Enter the number of seconds the OF instance waits after attempting to establish a connection with OF controller. The range is from 10 to 60.

Defaults	15(seconds)
Command Modes	OPENFLOW INSTANCE

Command History		
	Version	**Description**
	9.7(0.0)	Introduced on the S5000, S6000-ON, and Z9500.
	9.3(0.0)	Introduced on the S6000.

Version	Description
9.2(0.0)	Introduced on the S4820T and MXL.
9.1(0.0)	Introduced on the Z9000 and S4810.

Usage Information	After the interval time lapses, the OpenFlow instance reattempts to establish a connection to the OpenFlow controller.
Related Commands	openflow of-instance — Creates or modifies an OpenFlow instance.

controller

Specify the OpenFlow controller configuration that the OpenFlow instance uses to establish a connection.

Syntax	`controller {controller-id}{ip-address}[`**`port`** `port-number]tcp {high-priority	rcvbuf	sndbuf}`
	To remove the OpenFlow configuration for the controller, use the `no` `controller {controller-id}{ip-address}[`**`port`** `port-number]tcp {high-priority	rcvbuf	sndbuf}`command.

Parameter

controller-id	Enter the controller number. Enter `1` to assign the controller a primary role or enter `2` to assign the controller a backup role.
ip-address	Enter the IP address of the controller.
port *port-number*	Enter the keyword `port` followed by the port number to use for the connection. The range is from 1 to 65535.
high-priority	Enter the keyword `high-priority` to configure the controller as higher priority.
rcvbuf	Enter the keyword `rcvbuf` to specify the socket receive buffer size. The default value is 2000.
sndbuf	Enter the keyword `rcvbuf` to specify the socket receive buffer size. The default value is 2000.

Defaults	The default port number for the TCP connection is 6633.
Command Modes	OPENFLOW INSTANCE

Command History

Version	Description
9.7(0.0)	Introduced on the S5000, S6000-ON, and Z9500.
9.7(0.0)	Added the high-priority, rcvbuf, sndbuf parameters.
9.3(0.0)	Introduced on the S6000.
9.2(0.0)	Introduced on the S4820T and MXL.

Version	Description
9.1(0.0)	Introduced on the Z9000 and S4810.

Usage Information	Only TCP connection is supported.
Related Commands	openflow of-instance — Creates or modifies an OpenFlow instance.

debug openflow packets

Enable debugging for OpenFlow packets.

Syntax	`debug openflow packets packet-type {`*`packet-type`*`} of-instance {`*`of-id`*`}`
Parameter	

{packet-type *packet-type*}	Enter the keywords `packet-type` followed by one of the following packet types:
`all`	Enable debugging for all packets.
`barrier-reply`	Enable debugging for barrier-reply packets.
`barrier-request`	Enable debugging for barrier-request packets.
`echo-reply`	Enable debugging for echo-reply packets.
`echo-request`	Enable debugging for echo-request packets.
`error`	Enable debugging for error packets.
`features-reply`	Enable debugging for features-reply packets.
`features-request`	Enable debugging for features-request packets.
`flow-mod`	Enable debugging for flow-mod packets.
`flow-removed`	Enable debugging for flow-removed packets.
`get-async-request`	Enable debugging for get-async-request packets (V1.3).
`get-async-reply`	Enable debugging for get-async-reply packets (V1.3).
`get-config-reply`	Enable debugging for get-config-reply packets.

get-config-request	Enable debugging for get-config-request packets.
group-mod	Enable debugging for group-mod packets (V1.3).
hello	Enable debugging for hello packets.
meter-mod-request	Enable debugging for meter-mod packets (V1.3).
multipart-request	Enable debugging for multipart-request packets (V1.3).
multipart-reply	Enable debugging for multipart-reply packets (V1.3).
packet-in	Enable debugging for packet-in packets.
packet-out	Enable debugging for packet-out packets.
port-mod	Enable debugging for port-mod packets.
port-status	Enable debugging for port-status packets.
queue-get-config-reply	Enable debugging for queue-get-config-reply packets.
queue-get-config-request	Enable debugging for queue-get-config-request packets.
role-request	Enable debugging for role-request packets (V1.3).
role-reply	Enable debugging for role-reply packets (V1.3).
set-async-request	Enable debugging for set-async-request packets (V1.3).
set-config	Enable debugging for set-config packets.
stats-reply	Enable debugging for stats-reply packets.
stats-request	Enable debugging for stats-request packets.
table-mod	Enable debugging for table-mod packets (V1.3).
vendor	Enable debugging for vendor packets.

	of-instance {*of-id*}	Enter the keywords `of-instance` followed by the OF instance ID. The range is 1 to 8.

Defaults None

Command Modes EXEC

Command History

Version	Description
9.7(0.0)	Introduced on the S5000, S6000-ON, and Z9500. Packet instances corresponding to Version 1.3 are included.
9.3(0.0)	Introduced on the S6000.
9.2(0.0)	Introduced on the S4820T and MXL.
9.1(0.0)	Introduced on the Z9000 and S4810.

Usage Information To enable debugging for all packets, use the `debug openflow packets packet-type all` command.

echo-request interval

Configure the echo request interval.

Syntax `echo-request interval` *interval*

To remove the echo-request interval, use the `no echo-request interval` *interval* command.

Parameter

interval	Enter the time interval in seconds. The range is from 10 to 20.

Defaults The default is 15.

Command Modes OPENFLOW INSTANCE

Command History

Version	Description
9.7(0.0)	Introduced on the S-Series and Z-Series.

Related Commands openflow of-instance — Creates or modifies an OpenFlow instance.

fail-mode secure

Enable flow failover to prevent flow loss if a controller is unavailable.

Syntax `fail-mode secure`

To disable flow failover, use the `no fail-mode secure` command on the specific OF instance.

Command Modes	OPENFLOW INSTANCE	

Command History	**Version**	**Description**
	9.7(0.0)	Introduced on the S5000, S6000-ON, and Z9500.
	9.3(0.0)	Introduced on the S6000.
	9.2(0.2)	Introduced on the S4820T and MXL.
	9.2(0.2)	Introduced on the Z9000 and S4810.

Usage Information	This feature provides failover support if a controller is unavailable. If the connection to a controller is lost, installed flows are retained and used for forwarding traffic until they are updated. This feature is enabled by default but you can disable failover on individual instances. If you disable failover, all flows to the unavailable controller are dropped.

flow-map

Specify if flows installed by the controller should be interpreted by the switch for placement in L2 or L3 tables.

Syntax	`flow-map {l2|l3} enable`
	To disable flow interpretations, use the `no flow-map {l2|l3} enable`command.

Parameter	l2	Enter l2 to interpret Layer 2 flows.
	l3	Enter l3 to interpret Layer 3 flows.

Defaults	None (not enabled)

Command Modes	OPENFLOW INSTANCE

Command History	**Version**	**Description**
	9.7(0.0)	Introduced on the S5000, S6000-ON, Z9500.
	9.3(0.0)	Introduced on the S6000.
	9.2(0.0)	Introduced on the S4820T and MXL.
	9.1(0.0)	Introduced on the Z9000 and S4810.

Usage Information	L2 flow-mapping is not supported on OpenFlow instances with an interface-type of `port`.

Related Commands	openflow of-instance — Creates or modifies an OpenFlow instance.

flow-misses drop

Prevents flow misses (flows that do not reach their intended destination) from being copied to the controller.

Syntax	`flow-misses drop`
	To copy flow misses to the controller, use the `no flow-misses drop` on the specific OF instance.

Defaults	none

Command Modes	OPENFLOW INSTANCE

Command History

Version	Description
9.7(0.0)	Introduced on the S5000, S6000-ON, and Z9500.
9.3(0.0)	Introduced on the S6000.
9.2(0.2)	Introduced on the S4820T and MXL.
9.2(0.2)	Introduced on the Z9000 and S4810.

Usage Information	By default, flow misses are copied to the controller. To disable this feature on an OF instance, configure the controller to drop flow misses instead of copying them to the controller by using the flow-misses drop command.

Related Commands	shutdown — Enables or disables the OpenFlow instance.
	show openflow — Displays general information about OpenFlow instances.
	controller — Specifies the OpenFlow controller configuration that the OpenFlow instance uses to establish a connection.

interface-type

Specify the type of interface (port, VLAN, or any) for the OpenFlow instance.

Syntax	`interface-type {any|port|vlan}`
	To remove the flow-miss behavior, use the `no interface-type {any|port|vlan}` command.

Defaults	`port`

Parameter

any	Enter the keyword `any` to enable configuration of physical interfaces, LAGs, and VLANs on the selected OF instance.
port	Default. Enter the keyword `port` to enable configuration of LAGs or physical interfaces on the selected OF instance.
vlan	Enter the keyword `vlan` to enable configuration of VLANs on the selected OF instance.

> ![NOTE icon] **NOTE:** You must associate the OF instance with the VLAN when you create the VLAN.

Command Modes	OPENFLOW INSTANCE

Command History

Version	Description
9.7(0.0)	Introduced on the S5000, S6000-ON, and Z9500.
9.3(0.0)	Introduced on the S6000.
9.2(0.0)	Introduced on the S4820T and MXL.
9.1(0.0)	Introduced on the Z9000 and S4810.

Example (VLAN interface type)

```
Dell(conf)#openflow of-instance 1
Dell(conf-of-instance-1)#interface-type vlan
Dell(conf-of-instance-1)#
```

Usage Information

Dell Networking does not recommend selecting `any` for the `interface-type` unless both OF ports and OF VLANs are required in a single instance. If you select `any` is selected for the `interface-type`, the number of available ACL flows is reduced by half.

Disable legacy LLDP on of-ports to avoid conflicts with the controller's version of LLDP.

Dell Networking does not recommend configuring global STP instances on ports using both legacy VLANs and OF VLANs.

Related Commands

openflow of-instance — Creates or modifies an OpenFlow instance.

interface vlan

Creates a VLAN and associates it with an OpenFlow instance.

Syntax	`interface vlan vlan-id of-instance of-id`

Parameters

vlan-id	Enter the keyword `vlan` then the VLAN ID to specify a VLAN. The range is from 1 to 4096.
of-id	Enter the keyword `of-instance` then the OF ID to specify an OF instance. The range is from 1 to 8.

Command Modes	CONFIGURATION

Command History

Version	Description
9.7(0.0)	Introduced on the S5000, S6000-ON, and Z9500.

Version	Description
9.3(0.0)	Introduced on the S6000.
9.2(0.2)	Introduced on the S4820T and MXL.
9.2(0.2)	Introduced on the Z9000 and S4810.

Usage Information

- You cannot configure an IP address as an OF VLAN.
- You cannot add an existing VLAN to an OpenFlow instance.
- You cannot enable STP if you have configured an OF VLAN.
- You cannot assign the default VLAN as an OF VLAN.

Related Commands

openflow of-instance — Creates or modifies an OpenFlow instance.

multiple-fwd-table enable

Advertise all forwarding tables (ACL, L2, and L3) to the controller.

Syntax

```
multiple-fwd-table enable
```

To disable advertisement of forwarding table, use the `no multiple-fwd-table enable`command.

Defaults

Disabled

Command Modes

OPENFLOW INSTANCE

Command History

Version	Description
9.7(0.0)	Introduced on the S5000, S6000-ON, and Z9500.
9.3(0.0)	Introduced on the S6000.
9.2(0.0)	Introduced on the S4820T and MXL.
9.1(0.0)	Introduced on the Z9000 and S4810.

Usage Information

This is a vendor-specific CLI.

Related Commands

openflow of-instance — Creates or modifies an OpenFlow instance.

of-instance (Interface)

Add a physical interface or LAG to an OpenFlow instance. After you assign an interface to an OF instance, you cannot apply L2 or L3 protocols to that instance.

Syntax

```
of-instance of-id
```

Parameter		
	of-id	Enter the OpenFlow instance ID. The range is from 1 to 8.

Command Modes	INTERFACE MODE

Command History

Version	Description
9.7(0.0)	Introduced on the S5000, S6000-ON, and Z9500.
9.3(0.0)	Introduced on the S6000.
9.2(0.0)	Introduced on the S4820T and MXL.
9.1(0.0)	Introduced on the Z9000 and S4810.

Example

In the following example, the ports Te 1/7 and Te 1/31 are associated with of-instance 1:

```
Dell(conf)#interface gigabitethernet 1/7
Dell(conf-if-gi-1/7)#of-instance 1
Dell(conf-if-gi-1/7)#interface gigabitethernet 1/31
Dell(conf-if-gi-1/31)#of-instance 1
Dell(conf-if-gi-1/31)#
```

Usage Information

To enable OpenFlow, associate a port or a VLAN to an OF instance. Associate ports and VLANs when you create the OF instance and it is disabled using the `shutdown` command.

Before applying the interface, the software checks to ensure that none of the following apply:

- L2 or L3 more
- LACP is configured
- Included in a LAG
- Included in another OF instance
- Not a destination port for a port monitoring session

If any of the above apply, the interface is not applied to the OF instance.

LAGs or port-channel interfaces are supported as OF ports or OF VLAN members on OpenFlow.

By default, all ports are available for legacy functionality.

The following features are not supported on physical interfaces associated with an OpenFlow instance:

- Dot1x
- Ethernet
- GVRP
- IPv4
- IPv6

- MAC
- MTU
- Port-channel protocols
- Spanning-tree protocols
- Switchport

The following features are not supported on LAGs associated with an OpenFlow instance:

- Ethernet
- GVRP
- IPv4
- IPv6
- MAC
- MTU
- Spanning-tree protocols
- Switchport

Related Commands	openflow of-instance — Creates or modifies an OpenFlow instance.

of-instance (Configuration)

Create an OF instance or modify an existing OF instance.

Syntax	`openflow of-instance of-id`

Parameters	*of-id*	Enter the number of the OF instance. The range is from 1 to 8.

If you are creating a new OF instance, enter the number you want to assign to the OF instance.

If you are modifying an existing OF instance, enter the number of the instance you want to change.

> **NOTE:** Disable the OF instance before making any configuration changes.

Defaults	none
Command Modes	CONFIGURATION

Command History

Version	Description
9.7(0.0)	Introduced on the S5000, S6000-ON, and Z9500.
9.3(0.0)	Introduced on the S6000.
9.2(0.0)	Introduced on the S4820T and MXL.

Version	Description
9.1(0.0)	Introduced on the Z9000 and S4810.

Usage Information

- Stacking for S4810 and virtual link trunking (VLT) are not supported on OF instances. High availability (HA) is supported only with AFC.
- To enable OpenFlow on the S4810, the stack unit number must be zero.
- When you configure the OF instance, the interface type is assigned automatically, based on the configured interface type:

  - **Port:** No configuration (default) or configured for physical ports and port channels only
  - **VLAN:** Configured for VLANs only
  - **Any:** Configured for physical ports, LAG, and VLANs

- You can create up to 8 OF instances.
- To modify the OF instance, disable the OF instance first using the `shutdown` command.
- To establish a connection with the controller, enable the OF instance using the `no shutdown` command.
- You can configure one controller IP and one TCP port for each OF instance.
- The number of supported flows depends on the flow type. The following table provides the number of supported flows for each flow type:

Flow Type	Maximum Number of Available Flows
ACL	256 or 512 (depending on ACL CAM carving)
L2	48,000
L3	6,000

- To avoid session timeout issues if you change the time or date on the system clock, you must disable and re-enable all existing OpenFlow instances.

Related Commands

shutdown — Enables or disables the OpenFlow instance.

show openflow — Displays general information about OpenFlow instances.

controller — Specifies the OpenFlow controller configuration that the OpenFlow instance uses to establish a connection.

of-version

Specify the of-version of OpenFlow instances.

Syntax

```
of-version {1.0 | 1.3}
```

Parameter

1.0	Enter the keyword `1.0` to specify the OF instance version as 1.0.
1.3	Enter the keyword `1.3` to specify the OF instance version as 1.3.

Defaults	The default port number for the TCP connection is 6633.
Command Modes	OPENFLOW INSTANCE
Command History	**Version 9.7(0.0)** Introduced on the S-Series and Z-Series.
Related Commands	openflow of-instance — Creates or modifies an OpenFlow instance.

openflow vlan

Assign a default VLAN ID to an OpenFlow port to copy certain packet types received on an OF port to the controller and forward them out of a physical switch port.

Syntax	openflow vlan *vlan-id*
Parameters	**vlan-id** Enter the VLAN ID. The range is from 1 to 4094.
Defaults	none
Command Modes	OPENFLOW INSTANCE

Command History

Version	Description
9.7(0.0)	Introduced on the S5000, S6000-ON, and Z9500.
9.3(0.0)	Introduced on the S6000.
9.2(0.2)	Introduced on the S4820T and MXL.
9.2(0.2)	Introduced on the Z9000 and S4810.

Usage Information

In the previous version of SDN, when some packet types, such as untagged ARP broadcasts, received on an OF port could not be forwarded from a physical port and could only copied to the controller. To resolve this issue, assign a default VLAN to the OF ports. If you do not assign a VLAN, the software selects one when you create the first OF instance. The default VLAN applies to all OF instances and can only be configured if you have not configured any OF instances.

Example

```
Dell(conf)#openflow vlan 2000
Dell(conf)#exit
Dell#show openflow

Manufacturer       : Dell
Hardware Desc      : OpenFlow switch HW ver. 1.0
Software Desc      : OpenFlow switch SW ver. 1.0 and 1.3
Capabilities       : port,table,flow,queue
Actions            : output,enqueue,strip-vlan,set-vlan,set-
pcp,set-smac,
                      set-dmac,set-tos
Default VLAN       : 2000 (configured), 2000 (used)
```

Related Commands	shutdown — Enables or disables the OpenFlow instance.
	show openflow — Displays general information about OpenFlow instances.
	controller — Specifies the OpenFlow controller configuration that the OpenFlow instance uses to establish a connection.

show openflow

Display general information about OpenFlow instances.

Syntax	`show openflow [of-instance[`*of-id*`]]`

Parameter		
	of-instance *of-id*	(OPTIONAL)
		Enter the keywords `of-instance` to display information such as administrative state, interface-type, and operational state for all OpenFlow instances.
		(OPTIONAL) Enter the keywords `of-instance` followed by the OF instance ID to display details for the specified OF instance. The range is from 1 to 8.

Defaults	None

Command Modes	EXEC

Command History	Version	Description
	9.7(0.0)	Introduced on the S5000, S6000-ON, and Z9500.
	9.3(0.0)	Introduced on the S6000.
	9.2(0.0)	Introduced on the S4820T and MXL.
	9.1(0.0)	Introduced on the Z9000 and S4810.

Example

```
Dell#show openflow of-instance 1

Instance        : 2
Admin State     : Up
OF Version      : V1-3
Interface Type  : Vlan
DP Id           : 00:02:74:86:7a:ff:6f:e4
Forwarding Tbls : acl, mac, route
Flow map        :l2, l3
EchoReq interval: 15 seconds
Connect interval: 15 seconds
Number of Flows : 21 (acl:21)
Packets (acl)   : 575600
Bytes (acl)     : 36838400
Fail mode       : secure
Flow misses     : copy-to-controller
Controller 1    : TCP, 10.11.54.186/6633, rcv/sndbuf
1000/1000, connected (equal) high-priority
Controller 2    : -
```

```
                            Port List      :

                            Vlan List      :
                                            Vl 200
                            Vlan Mbr list  :
                                            Fo 1/16 (209), Fo 1/20 (213), Fo 2/0 (385)
```

Usage Information	To display general information such as version, capabilities, and supported actions, use the show openflow command.
Related Commands	openflow of-instance — Creates or modifies an OpenFlow instance.

show openflow flows

Display detailed information about OpenFlow instances.

Syntax	show openflow flows[of-instance{*of-id*}][table{*acl*|*mac*|*route*|*vlan*}flow-id{*flow-id*}]

Parameter

of-instance *of-id*	Enter the keywords of-instance followed by the OF instance ID to display details of all flows installed for the specified OF instance. The range is from 1 to 8.
table *acl* | *mac* | *route* | *vlan* **flow-id** *flow-id*	Enter the keyword table followed by the table type and the keywords flow-id followed by the flow ID to display details for the specified flow:

acl	Display ACL table information.
mac	Display MAC table information.
route	Display routing table information.
vlan	Display VLAN table information.

Defaults	None
Command Modes	EXEC

Command History

Version	Description
9.7(0.0)	Introduced on the S5000, S6000-ON, and Z9500.
9.3(0.0)	Introduced on the S6000.
9.2(0.0)	Introduced on the S4820T and MXL.
9.1(0.0)	Introduced on the Z9000 and S4810.

Related Commands	show openflow — Displays general information about OpenFlow instances.

shutdown (OpenFlow Instance)

Enable or disable the OpenFlow instance.

Syntax	`[no] shutdown`
Defaults	Disabled (`shutdown`)
Command Modes	OPENFLOW INSTANCE

Command History

Version	Description
9.7(0.0)	Introduced on the S5000, S6000-ON, and Z9500.
9.3(0.0)	Introduced on the S6000.
9.2(0.0)	Introduced on the S4820T and MXL.
9.1(0.0)	Introduced on the Z9000 and S4810.

Usage Information

To enable the OpenFlow instance, use the `no shutdown` command. When you use the `no shutdown` command, the OpenFlow instance sends a request to the OpenFlow controller to establish a connection.

To disable an OpenFlow instance, use the `shutdown` command. Use the `shutdown` command before making any configuration changes to the OpenFlow instance.

All OpenFlow instances are disabled by default.

Related Commands

openflow of-instance — Creates or modifies an OpenFlow instance.
controller — Configures the controller used by OpenFlow.

src-suppression

Prevents received packets from being sent out of the ingress port.

Syntax	`src-suppression`
	To allow received packets to be sent out of the ingress port, use the `src-suppression disable` command.
Defaults	none
Command Modes	OPENFLOW INSTANCE

Command History

Version	Description
9.7(0.0)	Introduced on the S5000, S6000-ON, and Z9500.
9.3(0.0)	Introduced on the S6000.

Version	Description
9.2(0.2)	Introduced on the S4820T and MXL.
9.2(0.2)	Introduced on the Z9000 and S4810.

Usage Information

Source suppression prevents received packets from being transmitted from the ingress port. Source suppression is enabled by default and is applied to all instances on the switch. If you disable source suppression, received packets can be transmitted from the ingress port.

> **NOTE:** If you disable source suppression, the following conditions apply:
>
> - Dell Networking does not recommend enabling legacy features.
> - You cannot enable Hybrid mode.
> - If you install flows using OFPP_FLOOD or OFPP_ALL, traffic loops may occur. If you disable source suppression, Dell Networking recommends that you do not install flows using these parameters.

Related Commands

shutdown — Enables or disables the OpenFlow instance.

show openflow — Displays general information about OpenFlow instances.

controller — Specifies the OpenFlow controller configuration that the OpenFlow instance uses to establish a connection.