NAME

ovs−fields − protocol header fields supported by Open vSwitch

SYNOPSIS

TUNNEL FIELDS

The fields in this group relate to tunnels, which Open vSwitch supports in several forms (GRE, VXLAN, and so on). Most of these fields do appear in the wire format of a packet, so they are data fields from that point of view, but they are metadata from an OpenFlow flow table point of view because they do not appear in packets that are forwarded to the controller or to ordinary (non-tunnel) output ports.

Open vSwitch supports a spectrum of usage models for mapping tunnels to OpenFlow ports:

‘‘Port-based’’ tunnels

In this model, an OpenFlow port represents one tunnel: it matches a particular type of tunnel traffic between two IP endpoints, with a particular tunnel key (if keys are in use). In this situation, **MFF_IN_PORT** suffices to distinguish one tunnel from another, so the tunnel header fields have little importance for OpenFlow processing. (They are still populated and may be used if it is convenient.) The tunnel header fields play no role in sending packets out such an OpenFlow port, either, because the OpenFlow port itself fully specifies the tunnel headers.

The following Open vSwitch commands create a bridge **br−int**, add port **tap0** to the bridge as OpenFlow port 1, establish a port-based GRE tunnel between the local host and remote IP 192.168.1.1 using GRE key 5001 as OpenFlow port 2, and arranges to forward all traffic from **tap0** to the tunnel and vice versa:

```
ovs−vsctl add−br br−int
ovs−vsctl add−port br−int tap0 −− set interface tap0 ofport_request=1
ovs−vsctl add−port br−int gre0 −−
   set interface gre0 ofport_request=2 type=gre \
                 options:remote_ip=192.168.1.1 options:key=5001
ovs−ofctl add−flow br−int in_port=1,actions=2
ovs−ofctl add−flow br−int in_port=2,actions=1
```

‘‘Flow-based’’ tunnels

In this model, one OpenFlow port represents all possible tunnels of a given type with an endpoint on the current host, for example, all GRE tunnels. In this situation, **MFF_IN_PORT** only indicates that traffic was received on the particular kind of tunnel. This is where the tunnel header fields are most important: they allow the OpenFlow tables to discriminate among tunnels based on their IP endpoints or keys. Tunnel header fields also determine the IP endpoints and keys of packets sent out such a tunnel port.

The following Open vSwitch commands create a bridge **br−int**, add port **tap0** to the bridge as OpenFlow port 1, establish a flow-based GRE tunnel port 3, and arranges to forward all traffic from **tap0** to remote IP 192.168.1.1 over a GRE tunnel with key 5001 and vice versa:

```
ovs−vsctl add−br br−int
ovs−vsctl add−port br−int tap0 −− set interface tap0 ofport_request=1
ovs−vsctl add−port br−int allgre −−
   set interface gre0 ofport_request=2 type=gre \
                 options:remote_ip=flow options:key=flow
ovs−ofctl add−flow br−int \
   ’in_port=1 actions=set_tunnel:5001,set_field:192.168.1.1−>tun_dst,3’
ovs−ofctl add−flow br−int ’in_port=3,tun_src=192.168.1.1,tun_id=5001 actions=1’
```

Mixed models.

One may define both flow-based and port-based tunnels at the same time. For example, it is valid and possibly useful to create and configure both **gre0** and **allgre** tunnel ports described above.

Traffic is attributed on ingress to the most specific matching tunnel. For example, **gre0** is more specific than **allgre**. Therefore, if both exist, then **gre0** will be the input port for any GRE traffic received from 192.168.1.1 with key 5001.

On egress, traffic may be directed to any appropriate tunnel port. If both **gre0** and **allgre** are configured as already described, then the actions **2** and **set_tunnel:5001,set_field:192.168.1.1−>tun_dst,3** send the same tunnel traffic.

Intermediate models.

Ports may be configured as partially flow-based. For example, one may define an OpenFlow port that represents tunnels between a pair of endpoints but leaves the flow table to discriminate on the flow key.

ovs-vswitchd.conf.db(5) describes all the details of tunnel configuration.

These fields do not have any prerequisites, which means that a flow may match on any or all of them, in any combination.

These fields are zeros for packets that did not arrive on a tunnel.

Tunnel ID Field

Name:	**tun_id** (aka **tunnel_id**)
Width:	64 bits
Masking:	arbitrary bitwise masks
Prerequisites:	MFP_NONE
Access:	read/write
OpenFlow 1.0:	no
OpenFlow 1.1:	no
OpenFlow 1.2:	yes (via OpenFlow 1.3 code point)
OpenFlow 1.3:	yes
NXM:	yes
Code Points:	**OXM_OF_TUNNEL_ID** (0x80004c08), introduced in OpenFlow 1.3
	NXM_NX_TUN_ID (0x00012008), introduced in Open vSwitch 1.1

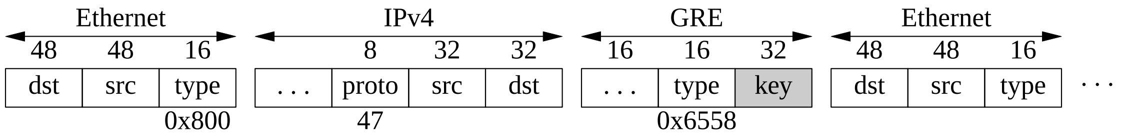
Many kinds of tunnels support a tunnel ID:

- VXLAN has a 24-bit virtual network identifier (VNI).
- LISP has a 24-bit instance ID.
- GRE has an optional 32-bit key.
- GRE64 (a non-standard protocol) has a 64-bit ID constructed from the 32-bit GRE key and 32-bit GRE sequence number.

When a packet is received from a tunnel, this field holds the tunnel ID in its least significant bits, zero-extended to fit. This field is zero if the tunnel does not support an ID, or if no ID is in use for a tunnel type that has an optional ID, or if an ID of zero received, or if the packet was not received over a tunnel.

When a packet is output to a tunnel port, the tunnel configuration determines whether the tunnel ID is taken from this field or bound to a fixed value. See the earlier description of ‘‘port-based’’ and ‘‘flow-based’’ tunnels for more information.

The following diagram shows the origin of this field in a typical keyed GRE tunnel:



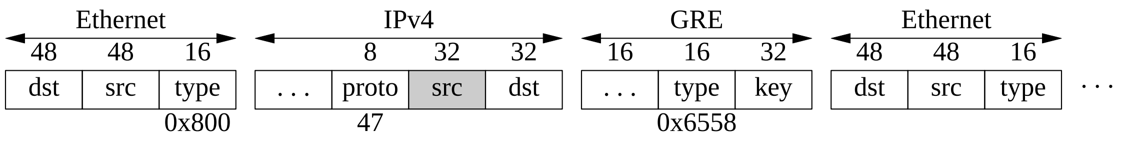
Tunnel IPv4 Source Field

Name:	**tun_src**
Width:	32 bits
Masking:	arbitrary bitwise masks
Prerequisites:	MFP_NONE
Access:	read/write
OpenFlow 1.0:	no
OpenFlow 1.1:	no
OpenFlow 1.2:	yes (via NXM code point)
OpenFlow 1.3:	yes (via NXM code point)
NXM:	yes
Code Points:	**NXM_NX_TUN_IPV4_SRC** (0x00013e04), introduced in Open vSwitch 2.0

When a packet is received from a tunnel, this field is the source address in the outer IP header of the tunneled packet. This field is zero if the packet was not received over a tunnel.

When a packet is output to a flow-based tunnel port, this field influences the IPv4 source address used to send the packet. If it is zero, then the kernel chooses an appropriate IP address based using the routing table.

The following diagram shows the origin of this field in a typical keyed GRE tunnel:



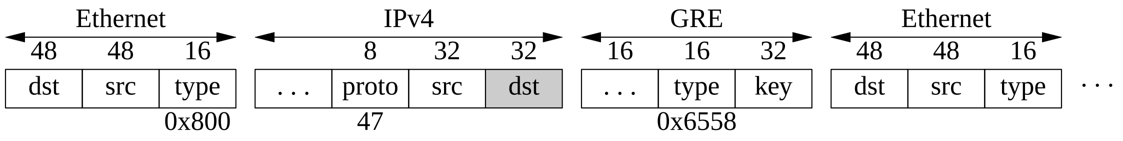
Tunnel IPv4 Destination Field

Name:	**tun_dst**
Width:	32 bits
Masking:	arbitrary bitwise masks
Prerequisites:	MFP_NONE
Access:	read/write
OpenFlow 1.0:	no
OpenFlow 1.1:	no
OpenFlow 1.2:	yes (via NXM code point)
OpenFlow 1.3:	yes (via NXM code point)
NXM:	yes
Code Points:	**NXM_NX_TUN_IPV4_DST** (0x00014004), introduced in Open vSwitch 2.0

When a packet is received from a tunnel, this field is the destination address in the outer IP header of the tunneled packet. This field is zero if the packet was not received over a tunnel.

When a packet is output to a flow-based tunnel port, this field specifies the destination to which the tunnel packet is sent.

The following diagram shows the origin of this field in a typical keyed GRE tunnel:



METADATA FIELDS

These fields relate to the origin or treatment of a packet, but they are not extracted from the packet data itself.

Input Port Field

Name:	**in_port**
Width:	16 bits
Masking:	not maskable
Prerequisites:	MFP_NONE
Access:	read/write
OpenFlow 1.0:	yes
OpenFlow 1.1:	yes
OpenFlow 1.2:	yes (via NXM code point)
OpenFlow 1.3:	yes (via NXM code point)
NXM:	yes
Code Points:	**NXM_OF_IN_PORT** (0x00000002), introduced in Open vSwitch 1.1

The OpenFlow port on which the packet being processed arrived. This is a 16-bit field that holds an OpenFlow 1.0 port number. For receiving a packet, the only values that appear in this field are:

1 through **0xfeff** (65,279), inclusive.
Conventional OpenFlow port numbers.

OFPP_LOCAL (**0xfffe** or 65,534).
The ‘‘local’’ port, which in Open vSwitch is always named the same as the bridge itself. This represents a connection between the switch and the local TCP/IP stack. This port is where an IP address is most commonly configured on an Open vSwitch switch.

OpenFlow does not require a switch to have a local port, but all existing versions of Open vSwitch have always included a local port. (Some future version of Open vSwitch might be able to optionally omit the local port, if someone submits code to implement such a feature.)

OFPP_NONE (**0xffff** or 65,535).
OFPP_CONTROLLER (**0xfffd** or 65,533).
When a controller injects a packet into an OpenFlow switch with a ‘‘packet-out’’ request, it can specify one of these input ports to indicate that the packet was generated internally rather than having been received on some port.

OpenFlow 1.0 specified **OFPP_NONE** for this purpose. Despite that, some controllers used **OFPP_CONTROLLER**, and some switches only accepted **OFPP_CONTROLLER**, so OpenFlow 1.0.2 required support for both ports. OpenFlow 1.1 and later were more clearly drafted to allow only **OFPP_CONTROLLER**. For maximum compatibility, Open vSwitch allows both ports with all OpenFlow versions.

Values not mentioned above will never appear when receiving a packet, including the following notable values:

0 Zero is not a valid OpenFlow port number.

OFPP_MAX (**0xff00** or 65,280).
This value has only been clearly specified as a valid port number as of OpenFlow 1.3.3. Before that, its status was unclear, and so Open vSwitch has never allowed **OFPP_MAX** to be used as a port number, so packets will never be received on this port. (Other OpenFlow switches, of course, might use it.)

OFPP_IN_PORT (**0xfff8** or 65,528)
OFPP_TABLE (**0xfff9** or 65,529)
OFPP_NORMAL (**0xfffa** or 65,530)

OFPP_FLOOD (**0xfffb** or 65,531)
OFPP_ALL (**0xfffc** or 65,532)
These port numbers are used only in output actions and never appear as input ports.

Values that will never appear when receiving a packet may still be matched against in the flow table. There are still circumstances in which those flows can be matched:

- The **resubmit** Nicira extension action allows a flow table lookup with an arbitrary input port.
- An action that modifies the input port field (see below), such as e.g. **load** or **set_field**, followed by an action or instruction that performs another flow table lookup, such as **resubmit** or **goto_table**.

This field is heavily used for matching in OpenFlow tables, but for packet egress, it has only very limited roles:

- OpenFlow requires suppressing output actions to **MFF_IN_PORT**. That is, the following two flows both drop all packets that arrive on port 1:

  in_port=1,actions=1
  in_port=1,actions=drop

  (This behavior is occasionally useful for flooding to a subset of ports. Specifying **actions=1,2,3,4**, for example, outputs to ports 1, 2, 3, and 4, omitting the input port.)
- OpenFlow has a special port **OFPP_IN_PORT** (with value 0xfff8) that outputs to the input port. For example, in a switch that has four ports numbered 1 through 4, **actions=1,2,3,4,in_port** outputs to ports 1, 2, 3, and 4, including the input port.

Because the input port field has so little influence on packet processing, it does not ordinarily make sense to modify the input port field. The field is writable only to support the occasional use case where the input port's roles in packet egress, described above, become troublesome. For example, **actions=load:0−>NXM_OF_IN_PORT[],output:123** will output to port 123 regardless of whether it is in the input port. If the input port is important, then one may save and restore it on the stack:

actions=push:NXM_OF_IN_PORT[],load:0−>NXM_OF_IN_PORT[],output:123,pop:NXM_OF_IN_PORT[]

The ability to modify the input port is an Open vSwitch extension to OpenFlow.

Modifying the input port does not prevent or frustrate specifying an input port in the **resubmit** action, because **resubmit** only (optionally) changes the in_port used for **resubmit**'s flow table lookup. It does not otherwise affect the input port.

OXM Input Port Field

Name:	**in_port_oxm**
Width:	32 bits
Masking:	not maskable
Prerequisites:	MFP_NONE
Access:	read/write
OpenFlow 1.0:	no
OpenFlow 1.1:	yes
OpenFlow 1.2:	yes
OpenFlow 1.3:	yes
NXM:	no
Code Points:	**OXM_OF_IN_PORT** (0x80000004), introduced in OpenFlow 1.2

OpenFlow 1.1 and later use a 32-bit port number, so this field supplies a 32-bit view of the input port. Current versions of Open vSwitch support only a 16-bit range of ports:

- OpenFlow 1.0 ports **0x0000** to **0xfeff**, inclusive, map to OpenFlow 1.1 port numbers with the same values.

- OpenFlow 1.0 ports **0xff00** to **0xffff**, inclusive, map to OpenFlow 1.1 port numbers **0xffffff00** to **0xffffffff**.
- OpenFlow 1.1 ports **0x0000ff00** to **0xfffffeff** are not mapped and not supported.

MFF_IN_PORT and **MFF_IN_PORT_OXM** are two views of the same information, so all of the comments on **MFF_IN_PORT** apply to **MFF_IN_PORT_OXM** too. Modifying **MFF_IN_PORT** changes **MFF_IN_PORT_OXM**, and vice versa.

Setting **MFF_IN_PORT_OXM** to an unsupported value yields unspecified behavior.

Output Queue Field

Name:	**skb_priority**
Width:	32 bits
Masking:	not maskable
Prerequisites:	MFP_NONE
Access:	read-only
OpenFlow 1.0:	no
OpenFlow 1.1:	no
OpenFlow 1.2:	no
OpenFlow 1.3:	no
NXM:	no
Code Points:	none

This field influences how packets in the flow will be queued, for quality of service (QoS) purposes, when they egress the switch. Its range of meaningful values, and their meanings, varies greatly from one OpenFlow implementation to another. Even within a single implementation, there is no guarantee that all OpenFlow ports have the same queues configured or that all OpenFlow ports in an implementation can be configured the same way queue-wise.

Configuring queues on OpenFlow is not well standardized. On Linux, Open vSwitch supports queue configuration via OVSDB, specifically the **QoS** and **Queue** tables (see **ovs−vswitchd.conf.db(5)** for details). Ports of Open vSwitch to other platforms might require queue configuration through some separate protocol (such as a CLI). Even on Linux, Open vSwitch exposes only a fraction of the kernel's queuing features through OVSDB, so advanced or unusual uses might require use of separate utilities (e.g. **tc**). OpenFlow switches other than Open vSwitch might use OF-CONFIG or any of the configuration methods mentioned above. Finally, some OpenFlow switches have a fixed number of fixed-function queues (e.g. eight queues with strictly defined priorities) and others do not support any control over queuing.

The only output queue that all OpenFlow implementations must support is zero, to identify a default queue, whose properties are implementation-defined. Outputting a packet to a queue that does not exist on the output port yields unpredictable behavior: among the possibilities are that the packet might be dropped or transmitted with a very high or very low priority.

OpenFlow 1.0 only allowed output queues to be specified as part of an ‘‘enqueue’’ action that specified both a queue and an output port. That is, OpenFlow 1.0 treats the queue as an argument to an action, not as a field.

OpenFlow switch and controller implementers soon realized that separating the decisions for output queue and output port increased flexibility, so OpenFlow 1.1 added an action to set the output queue. This model was carried forward, without change, through OpenFlow 1.4.

Open vSwitch implements the native queuing model of each OpenFlow version it supports. Open vSwitch also includes an extension for setting the output queue as an action in OpenFlow 1.0.

When a packet ingresses into an OpenFlow switch, the output queue is ordinarily set to 0, indicating the default queue. However, Open vSwitch supports various ways to forward a packet from one OpenFlow switch to another within a single host. In these cases, Open vSwitch maintains the output queue across the forwarding step. For example:

- A hop across a Open vSwitch ‘‘patch port’’ (which does not actually involve queuing) preserves the output queue.

- When a flow sets the output queue then outputs to an OpenFlow tunnel port, the encapsulation preserves the output queue. If the kernel TCP/IP stack routes the encapsulated packet directly to a physical interface, then that output honors the output queue. Alternatively, if the kernel routes the encapsulated packet to another Open vSwitch bridge, then the output queue set previously becomes the initial output queue on ingress to the second bridge and will thus be used for further output actions (unless overridden by a new ‘‘set queue’’ action).

  (This description reflects the current behavior of Open vSwitch on Linux. This behavior relies on details of the Linux TCP/IP stack. It could be difficult to make ports to other operating systems behave the same way.)

Open vSwitch implements the output queue as a field, but does not currently expose it through OXM or NXM for matching purposes. If this turns out to be a useful feature, it could be implemented in future versions.

Packet Mark Field

Name:	**pkt_mark**
Width:	32 bits
Masking:	arbitrary bitwise masks
Prerequisites:	MFP_NONE
Access:	read/write
OpenFlow 1.0:	no
OpenFlow 1.1:	no
OpenFlow 1.2:	yes (via NXM code point)
OpenFlow 1.3:	yes (via NXM code point)
NXM:	yes
Code Points:	**NXM_NX_PKT_MARK** (0x00014204), introduced in Open vSwitch 2.0

Packet mark comes to Open vSwitch from the Linux kernel, in which the **sk_buff** data structure that represents a packet contains a 32-bit member named **skb_mark**. The value of **skb_mark** propagates along with the packet it accompanies wherever the packet goes in the kernel. It has no predefined semantics but various kernel-user interfaces can set and match on it, which makes it suitable for ‘‘marking’’ packets at one point in their handling and then acting on the mark later. With **iptables**, for example, one can mark some traffic specially at ingress and then handle that traffic differently at egress based on the marked value.

Packet mark is an attempt at a generalization of the **skb_mark** concept beyond Linux, at least through more generic naming. Like **MFF_SKB_PRIORITY**, packet mark is preserved across forwarding steps within a machine. Unlike **MFF_SKB_PRIORITY**, packet mark has no direct effect on packet forwarding: the value set in packet mark does not matter unless some later OpenFlow table or switch matches on packet mark, or unless the packet passes through some other kernel subsystem that has been configured to interpret packet mark in specific ways, e.g. through **iptables** configuration mentioned above.

Preserving packet mark across kernel forwarding steps relies heavily on kernel support, which ports to non-Linux operating systems may not have. Regardless of operating system support, Open vSwitch supports packet mark within a single bridge and across patch ports.

The value of packet mark when a packet ingresses into the first Open vSwich bridge is typically zero, but it could be nonzero if its value was previously set by some kernel subsystem.

REGISTER FIELDS

These fields give an OpenFlow switch space for temporary storage while the pipeline is running. Whereas metadata fields can have a meaningful initial value and can persist across some hops across OpenFlow switches, registers are always initially 0 and their values never persist across inter-switch hops.

OpenFlow Metadata Field

Name:	**metadata**
Width:	64 bits
Masking:	arbitrary bitwise masks
Prerequisites:	MFP_NONE
Access:	read/write
OpenFlow 1.0:	no
OpenFlow 1.1:	yes
OpenFlow 1.2:	yes
OpenFlow 1.3:	yes
NXM:	yes (via OXM code point)
Code Points:	**OXM_OF_METADATA** (0x80000408), introduced in OpenFlow 1.2

This field is the only standardized OpenFlow register field. Because ASIC-based switches can carry a limited number of user-defined bits through their pipelines, OpenFlow allows switches to support writing and masking only an implementation-defined subset of bits, even no bits at all. The Open vSwitch software switch always supports all 64 bits, but of course an Open vSwitch port to an ASIC would have the same restriction as the ASIC itself.

This field has an OXM code point, but OpenFlow 1.1 through 1.4 allow it to be modified only with a specialized instruction, not with a ‘‘set-field’’ action. As of this writing, OpenFlow 1.5 seems likely to remove this restriction. Open vSwitch does not enforce this restriction, regardless of OpenFlow version.

Register 0 Field

Name:	**reg0**
Width:	32 bits
Masking:	arbitrary bitwise masks
Prerequisites:	MFP_NONE
Access:	read/write
OpenFlow 1.0:	no
OpenFlow 1.1:	no
OpenFlow 1.2:	yes (via NXM code point)
OpenFlow 1.3:	yes (via NXM code point)
NXM:	yes
Code Points:	**NXM_NX_REG0** (0x00010004), introduced in Open vSwitch 1.1

This is the first of several Open vSwitch registers, all of which have the same properties. Open vSwitch 1.1 introduced registers 0, 1, 2, and 3, version 1.3 added register 4, and version 1.7 added registers 5, 6, and 7.

Register 1 Field

Name:	**reg1**
Width:	32 bits
Masking:	arbitrary bitwise masks
Prerequisites:	MFP_NONE
Access:	read/write
OpenFlow 1.0:	no
OpenFlow 1.1:	no
OpenFlow 1.2:	yes (via NXM code point)
OpenFlow 1.3:	yes (via NXM code point)
NXM:	yes
Code Points:	**NXM_NX_REG1** (0x00010204), introduced in Open vSwitch 1.1

Register 2 Field

Name:	**reg2**
Width:	32 bits
Masking:	arbitrary bitwise masks
Prerequisites:	MFP_NONE
Access:	read/write
OpenFlow 1.0:	no
OpenFlow 1.1:	no
OpenFlow 1.2:	yes (via NXM code point)
OpenFlow 1.3:	yes (via NXM code point)
NXM:	yes
Code Points:	**NXM_NX_REG2** (0x00010404), introduced in Open vSwitch 1.1

Register 3 Field

Name:	**reg3**
Width:	32 bits
Masking:	arbitrary bitwise masks
Prerequisites:	MFP_NONE
Access:	read/write
OpenFlow 1.0:	no
OpenFlow 1.1:	no
OpenFlow 1.2:	yes (via NXM code point)
OpenFlow 1.3:	yes (via NXM code point)
NXM:	yes
Code Points:	**NXM_NX_REG3** (0x00010604), introduced in Open vSwitch 1.1

Register 4 Field

Name:	**reg4**
Width:	32 bits
Masking:	arbitrary bitwise masks
Prerequisites:	MFP_NONE
Access:	read/write
OpenFlow 1.0:	no
OpenFlow 1.1:	no
OpenFlow 1.2:	yes (via NXM code point)
OpenFlow 1.3:	yes (via NXM code point)
NXM:	yes
Code Points:	**NXM_NX_REG4** (0x00010804), introduced in Open vSwitch 1.3

Register 5 Field

Name:	**reg5**
Width:	32 bits
Masking:	arbitrary bitwise masks
Prerequisites:	MFP_NONE
Access:	read/write
OpenFlow 1.0:	no
OpenFlow 1.1:	no
OpenFlow 1.2:	yes (via NXM code point)
OpenFlow 1.3:	yes (via NXM code point)
NXM:	yes
Code Points:	**NXM_NX_REG5** (0x00010a04), introduced in Open vSwitch 1.7

Register 6 Field

Name:	**reg6**
Width:	32 bits
Masking:	arbitrary bitwise masks

Prerequisites:	MFP_NONE
Access:	read/write
OpenFlow 1.0:	no
OpenFlow 1.1:	no
OpenFlow 1.2:	yes (via NXM code point)
OpenFlow 1.3:	yes (via NXM code point)
NXM:	yes
Code Points:	**NXM_NX_REG6** (0x00010c04), introduced in Open vSwitch 1.7

Register 7 Field

Name:	**reg7**
Width:	32 bits
Masking:	arbitrary bitwise masks
Prerequisites:	MFP_NONE
Access:	read/write
OpenFlow 1.0:	no
OpenFlow 1.1:	no
OpenFlow 1.2:	yes (via NXM code point)
OpenFlow 1.3:	yes (via NXM code point)
NXM:	yes
Code Points:	**NXM_NX_REG7** (0x00010e04), introduced in Open vSwitch 1.7

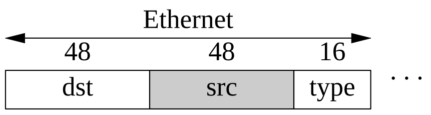
LAYER 2 (ETHERNET) FIELDS

Ethernet is the only layer−2 protocol that Open vSwitch supports. As with most software, Open vSwitch and OpenFlow regard an Ethernet frame to begin with the 14-byte header and end with the final byte of the payload; that is, the frame check sequence is not considered part of the frame.

Ethernet Source Field

Name:	**eth_src** (aka **dl_src**)
Width:	48 bits
Masking:	arbitrary bitwise masks
Prerequisites:	MFP_NONE
Access:	read/write
OpenFlow 1.0:	yes (exact match only)
OpenFlow 1.1:	yes
OpenFlow 1.2:	yes
OpenFlow 1.3:	yes
NXM:	yes (maskable since Open vSwitch 1.8)
Code Points:	**OXM_OF_ETH_SRC** (0x80000806), introduced in OpenFlow 1.2
	NXM_OF_ETH_SRC (0x00000406), introduced in Open vSwitch 1.1

The Ethernet source address:

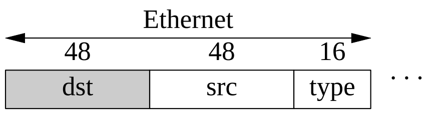


Ethernet Destination Field

Name:	**eth_dst** (aka **dl_dst**)
Width:	48 bits
Masking:	arbitrary bitwise masks
Prerequisites:	MFP_NONE
Access:	read/write
OpenFlow 1.0:	yes (exact match only)
OpenFlow 1.1:	yes
OpenFlow 1.2:	yes
OpenFlow 1.3:	yes

NXM:	yes (only partially maskable before Open vSwitch 1.8, see notes)
Code Points:	**OXM_OF_ETH_DST** (0x80000606), introduced in OpenFlow 1.2
	NXM_OF_ETH_DST (0x00000206), introduced in Open vSwitch 1.1

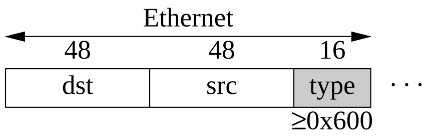
The Ethernet destination address:



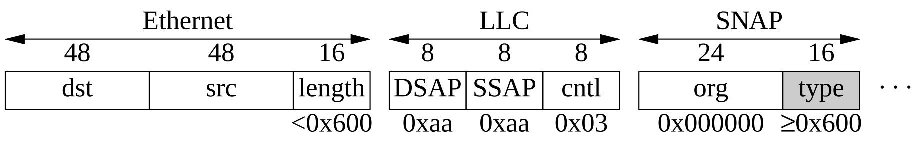
Ethernet Type Field

Name:	**eth_type** (aka **dl_type**)
Width:	16 bits
Masking:	not maskable
Prerequisites:	MFP_NONE
Access:	read-only
OpenFlow 1.0:	yes
OpenFlow 1.1:	yes
OpenFlow 1.2:	yes
OpenFlow 1.3:	yes
NXM:	yes
Code Points:	**OXM_OF_ETH_TYPE** (0x80000a02), introduced in OpenFlow 1.2
	NXM_OF_ETH_TYPE (0x00000602), introduced in Open vSwitch 1.1

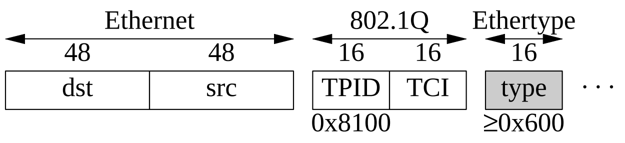
The most commonly seen Ethernet frames today use a format called ‘‘Ethernet II,’’ in which the last two bytes of the Ethernet header specify the Ethertype. For such a frame, this field is copied from those bytes of the header, like so:



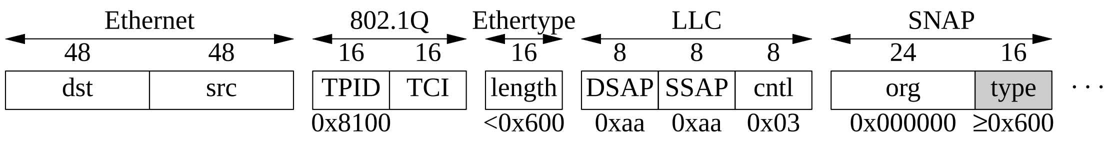
Every Ethernet type has a value 0x600 (1,536) or greater. When the last two bytes of the Ethernet header have a value too small to be an Ethernet type, then the value found there is the total length of the frame in bytes, excluding the Ethernet header. An 802.2 LLC header typically follows the Ethernet header. OpenFlow and Open vSwitch only support LLC headers with DSAP and SSAP **0xaa** and control byte **0x03**, which indicate that a SNAP header follows the LLC header. In turn, OpenFlow and Open vSwitch only support a SNAP header with organization **0x000000**. In such a case, this field is copied from the type field in the SNAP header, like this:



When an 802.1Q header is inserted after the Ethernet source and destination, this field is populated with the encapsulated Ethertype, not the 802.1Q Ethertype. With an Ethernet II inner frame, the result looks like this:



LLC and SNAP encapsulation look like this with an 802.1Q header:



When a packet does’t match any of the header formats described above, Open vSwitch and OpenFlow set this field to **0x5ff** (**OFP_DL_TYPE_NOT_ETH_TYPE**).

VLAN FIELDS

VLAN TCI Field

Name:	**vlan_tci**
Width:	16 bits
Masking:	arbitrary bitwise masks
Prerequisites:	MFP_NONE
Access:	read/write
OpenFlow 1.0:	yes (exact match only)
OpenFlow 1.1:	yes (exact match only)
OpenFlow 1.2:	yes (via NXM code point)
OpenFlow 1.3:	yes (via NXM code point)
NXM:	yes
Code Points:	**NXM_OF_VLAN_TCI** (0x00000802), introduced in Open vSwitch 1.1

OpenFlow 1.0 VLAN ID Field

Name:	**dl_vlan**
Width:	16 bits (only the least-significant 12 bits may be nonzero)
Masking:	not maskable
Prerequisites:	MFP_NONE
Access:	read/write
OpenFlow 1.0:	yes
OpenFlow 1.1:	yes
OpenFlow 1.2:	yes
OpenFlow 1.3:	yes
NXM:	yes
Code Points:	none

OpenFlow 1.0 VLAN Priority Field

Name:	**dl_vlan_pcp**
Width:	8 bits (only the least-significant 3 bits may be nonzero)
Masking:	not maskable
Prerequisites:	MFP_NONE
Access:	read/write
OpenFlow 1.0:	yes
OpenFlow 1.1:	yes
OpenFlow 1.2:	yes
OpenFlow 1.3:	yes
NXM:	yes
Code Points:	none

OpenFlow 1.2+ VLAN ID Field

Name:	**vlan_vid**
Width:	16 bits (only the least-significant 12 bits may be nonzero)
Masking:	arbitrary bitwise masks
Prerequisites:	MFP_NONE
Access:	read/write
OpenFlow 1.0:	yes (exact match only)
OpenFlow 1.1:	yes (exact match only)
OpenFlow 1.2:	yes
OpenFlow 1.3:	yes
NXM:	yes (via OXM code point)
Code Points:	**OXM_OF_VLAN_VID** (0x80000c02), introduced in OpenFlow 1.2

OpenFlow 1.2+ VLAN Priority Field

Name:	**vlan_pcp**
Width:	8 bits (only the least-significant 3 bits may be nonzero)

Masking:	not maskable
Prerequisites:	MFP_VLAN_VID
Access:	read/write
OpenFlow 1.0:	yes
OpenFlow 1.1:	yes
OpenFlow 1.2:	yes
OpenFlow 1.3:	yes
NXM:	yes (via OXM code point)
Code Points:	**OXM_OF_VLAN_PCP** (0x80000e01), introduced in OpenFlow 1.2

LAYER 2.5 (MPLS) FIELDS

MPLS Label Field

Name:	**mpls_label**
Width:	32 bits (only the least-significant 20 bits may be nonzero)
Masking:	not maskable
Prerequisites:	MFP_MPLS
Access:	read/write
OpenFlow 1.0:	no
OpenFlow 1.1:	yes
OpenFlow 1.2:	yes
OpenFlow 1.3:	yes
NXM:	yes (via OXM code point)
Code Points:	**OXM_OF_MPLS_LABEL** (0x80004404), introduced in OpenFlow 1.2

MPLS Traffic Class Field

Name:	**mpls_tc**
Width:	8 bits (only the least-significant 3 bits may be nonzero)
Masking:	not maskable
Prerequisites:	MFP_MPLS
Access:	read/write
OpenFlow 1.0:	no
OpenFlow 1.1:	yes
OpenFlow 1.2:	yes
OpenFlow 1.3:	yes
NXM:	yes (via OXM code point)
Code Points:	**OXM_OF_MPLS_TC** (0x80004601), introduced in OpenFlow 1.2

MPLS Bottom of Stack Field

Name:	**mpls_bos**
Width:	8 bits (only the least-significant 1 bits may be nonzero)
Masking:	not maskable
Prerequisites:	MFP_MPLS
Access:	read-only
OpenFlow 1.0:	no
OpenFlow 1.1:	no
OpenFlow 1.2:	yes (via OpenFlow 1.3 code point)
OpenFlow 1.3:	yes
NXM:	yes (via OXM code point)
Code Points:	**OXM_OF_MPLS_BOS** (0x80004801), introduced in OpenFlow 1.3

LAYER 3 FIELDS

IPv4 Source Address Field

Name:	**ip_src** (aka **nw_src**)
Width:	32 bits
Masking:	arbitrary bitwise masks
Prerequisites:	MFP_IPV4

Access:	read/write
OpenFlow 1.0:	yes (CIDR masks only)
OpenFlow 1.1:	yes
OpenFlow 1.2:	yes
OpenFlow 1.3:	yes
NXM:	yes (CIDR masks only before Open vSwitch 1.8)
Code Points:	**OXM_OF_IPV4_SRC** (0x80001604), introduced in OpenFlow 1.2
	NXM_OF_IP_SRC (0x00000e04), introduced in Open vSwitch 1.1

IPv4 Destination Address Field

Name:	**ip_dst** (aka **nw_dst**)
Width:	32 bits
Masking:	arbitrary bitwise masks
Prerequisites:	MFP_IPV4
Access:	read/write
OpenFlow 1.0:	yes (CIDR masks only)
OpenFlow 1.1:	yes
OpenFlow 1.2:	yes
OpenFlow 1.3:	yes
NXM:	yes (CIDR masks only before Open vSwitch 1.8)
Code Points:	**OXM_OF_IPV4_DST** (0x80001804), introduced in OpenFlow 1.2
	NXM_OF_IP_DST (0x00001004), introduced in Open vSwitch 1.1

IPv6 Source Address Field

Name:	**ipv6_src**
Width:	128 bits
Masking:	arbitrary bitwise masks
Prerequisites:	MFP_IPV6
Access:	read/write
OpenFlow 1.0:	no
OpenFlow 1.1:	no
OpenFlow 1.2:	yes
OpenFlow 1.3:	yes
NXM:	yes (CIDR masks only before Open vSwitch 1.8)
Code Points:	**OXM_OF_IPV6_SRC** (0x80003410), introduced in OpenFlow 1.2
	NXM_NX_IPV6_SRC (0x00012610), introduced in Open vSwitch 1.1

IPv6 Destination Address Field

Name:	**ipv6_dst**
Width:	128 bits
Masking:	arbitrary bitwise masks
Prerequisites:	MFP_IPV6
Access:	read/write
OpenFlow 1.0:	no
OpenFlow 1.1:	no
OpenFlow 1.2:	yes
OpenFlow 1.3:	yes
NXM:	yes (CIDR masks only before Open vSwitch 1.8)
Code Points:	**OXM_OF_IPV6_DST** (0x80003610), introduced in OpenFlow 1.2
	NXM_NX_IPV6_DST (0x00012810), introduced in Open vSwitch 1.1

IPv6 Flow Label Field

Name:	**ipv6_label**
Width:	32 bits (only the least-significant 20 bits may be nonzero)
Masking:	arbitrary bitwise masks
Prerequisites:	MFP_IPV6

Access:	read-only
OpenFlow 1.0:	no
OpenFlow 1.1:	no
OpenFlow 1.2:	yes
OpenFlow 1.3:	yes
NXM:	yes (maskable since Open vSwitch 2.1)
Code Points:	**OXM_OF_IPV6_FLABEL** (0x80003804), introduced in OpenFlow 1.2
	NXM_NX_IPV6_LABEL (0x00013604), introduced in Open vSwitch 1.4

IPv4/v6 Protocol Field

Name:	**nw_proto** (aka **ip_proto**)
Width:	8 bits
Masking:	not maskable
Prerequisites:	MFP_IP_ANY
Access:	read-only
OpenFlow 1.0:	yes
OpenFlow 1.1:	yes
OpenFlow 1.2:	yes
OpenFlow 1.3:	yes
NXM:	yes
Code Points:	**OXM_OF_IP_PROTO** (0x80001401), introduced in OpenFlow 1.2
	NXM_OF_IP_PROTO (0x00000c01), introduced in Open vSwitch 1.1

IPv4/v6 DSCP (Bits 2-7) Field

Name:	**nw_tos**
Width:	8 bits
Masking:	not maskable
Prerequisites:	MFP_IP_ANY
Access:	read/write
OpenFlow 1.0:	yes
OpenFlow 1.1:	yes
OpenFlow 1.2:	yes (via NXM code point)
OpenFlow 1.3:	yes (via NXM code point)
NXM:	yes
Code Points:	**NXM_OF_IP_TOS** (0x00000a01), introduced in Open vSwitch 1.1

IPv4/v6 DSCP (Bits 0-5) Field

Name:	**ip_dscp**
Width:	8 bits (only the least-significant 6 bits may be nonzero)
Masking:	not maskable
Prerequisites:	MFP_IP_ANY
Access:	read/write
OpenFlow 1.0:	yes
OpenFlow 1.1:	yes
OpenFlow 1.2:	yes
OpenFlow 1.3:	yes
NXM:	yes (via OXM code point)
Code Points:	**OXM_OF_IP_DSCP** (0x80001001), introduced in OpenFlow 1.2

IPv4/v6 ECN Field

Name:	**nw_ecn** (aka **ip_ecn**)
Width:	8 bits (only the least-significant 2 bits may be nonzero)
Masking:	not maskable
Prerequisites:	MFP_IP_ANY
Access:	read/write
OpenFlow 1.0:	no

OpenFlow 1.1:	no
OpenFlow 1.2:	yes
OpenFlow 1.3:	yes
NXM:	yes
Code Points:	**OXM_OF_IP_ECN** (0x80001201), introduced in OpenFlow 1.2
	NXM_NX_IP_ECN (0x00013801), introduced in Open vSwitch 1.4

IPv4/v6 TTL/Hop Limit Field

Name:	**nw_ttl**
Width:	8 bits
Masking:	not maskable
Prerequisites:	MFP_IP_ANY
Access:	read/write
OpenFlow 1.0:	no
OpenFlow 1.1:	no
OpenFlow 1.2:	yes (via NXM code point)
OpenFlow 1.3:	yes (via NXM code point)
NXM:	yes
Code Points:	**NXM_NX_IP_TTL** (0x00013a01), introduced in Open vSwitch 1.4

IPv4/v6 Fragment Bitmask Field

Name:	**ip_frag**
Width:	8 bits (only the least-significant 2 bits may be nonzero)
Masking:	arbitrary bitwise masks
Prerequisites:	MFP_IP_ANY
Access:	read-only
OpenFlow 1.0:	no
OpenFlow 1.1:	no
OpenFlow 1.2:	yes (via NXM code point)
OpenFlow 1.3:	yes (via NXM code point)
NXM:	yes
Code Points:	**NXM_NX_IP_FRAG** (0x00013401), introduced in Open vSwitch 1.3

ARP Opcode Field

Name:	**arp_op**
Width:	16 bits
Masking:	not maskable
Prerequisites:	MFP_ARP
Access:	read/write
OpenFlow 1.0:	yes
OpenFlow 1.1:	yes
OpenFlow 1.2:	yes
OpenFlow 1.3:	yes
NXM:	yes
Code Points:	**OXM_OF_ARP_OP** (0x80002a02), introduced in OpenFlow 1.2
	NXM_OF_ARP_OP (0x00001e02), introduced in Open vSwitch 1.1

ARP Source IPv4 Address Field

Name:	**arp_spa**
Width:	32 bits
Masking:	arbitrary bitwise masks
Prerequisites:	MFP_ARP
Access:	read/write
OpenFlow 1.0:	yes (exact match only)
OpenFlow 1.1:	yes
OpenFlow 1.2:	yes

OpenFlow 1.3:	yes
NXM:	yes
Code Points:	**OXM_OF_ARP_SPA** (0x80002c04), introduced in OpenFlow 1.2
	NXM_OF_ARP_SPA (0x00002004), introduced in Open vSwitch 1.1

ARP Target IPv4 Address Field

Name:	**arp_tpa**
Width:	32 bits
Masking:	arbitrary bitwise masks
Prerequisites:	MFP_ARP
Access:	read/write
OpenFlow 1.0:	yes (exact match only)
OpenFlow 1.1:	yes
OpenFlow 1.2:	yes
OpenFlow 1.3:	yes
NXM:	yes
Code Points:	**OXM_OF_ARP_TPA** (0x80002e04), introduced in OpenFlow 1.2
	NXM_OF_ARP_TPA (0x00002204), introduced in Open vSwitch 1.1

ARP Source Ethernet Address Field

Name:	**arp_sha**
Width:	48 bits
Masking:	arbitrary bitwise masks
Prerequisites:	MFP_ARP
Access:	read/write
OpenFlow 1.0:	no
OpenFlow 1.1:	no
OpenFlow 1.2:	yes
OpenFlow 1.3:	yes
NXM:	yes (maskable since Open vSwitch 1.9)
Code Points:	**OXM_OF_ARP_SHA** (0x80003006), introduced in OpenFlow 1.2
	NXM_NX_ARP_SHA (0x00012206), introduced in Open vSwitch 1.1

ARP Target Ethernet Address Field

Name:	**arp_tha**
Width:	48 bits
Masking:	arbitrary bitwise masks
Prerequisites:	MFP_ARP
Access:	read/write
OpenFlow 1.0:	no
OpenFlow 1.1:	no
OpenFlow 1.2:	yes
OpenFlow 1.3:	yes
NXM:	yes (maskable since Open vSwitch 1.9)
Code Points:	**OXM_OF_ARP_THA** (0x80003206), introduced in OpenFlow 1.2
	NXM_NX_ARP_THA (0x00012406), introduced in Open vSwitch 1.1

LAYER 4 FIELDS

TCP Source Port Field

Name:	**tcp_src** (aka **tp_src**)
Width:	16 bits
Masking:	arbitrary bitwise masks
Prerequisites:	MFP_TCP
Access:	read/write
OpenFlow 1.0:	yes (exact match only)
OpenFlow 1.1:	yes (exact match only)

OpenFlow 1.2:	yes
OpenFlow 1.3:	yes
NXM:	yes (maskable since Open vSwitch 1.6)
Code Points:	**OXM_OF_TCP_SRC** (0x80001a02), introduced in OpenFlow 1.2
	NXM_OF_TCP_SRC (0x00001202), introduced in Open vSwitch 1.1

TCP Destination Port Field

Name:	**tcp_dst** (aka **tp_dst**)
Width:	16 bits
Masking:	arbitrary bitwise masks
Prerequisites:	MFP_TCP
Access:	read/write
OpenFlow 1.0:	yes (exact match only)
OpenFlow 1.1:	yes (exact match only)
OpenFlow 1.2:	yes
OpenFlow 1.3:	yes
NXM:	yes (maskable since Open vSwitch 1.6)
Code Points:	**OXM_OF_TCP_DST** (0x80001c02), introduced in OpenFlow 1.2
	NXM_OF_TCP_DST (0x00001402), introduced in Open vSwitch 1.1

TCP Flags Field

Name:	**tcp_flags**
Width:	16 bits (only the least-significant 12 bits may be nonzero)
Masking:	arbitrary bitwise masks
Prerequisites:	MFP_TCP
Access:	read-only
OpenFlow 1.0:	no
OpenFlow 1.1:	no
OpenFlow 1.2:	yes (via NXM code point)
OpenFlow 1.3:	yes (via NXM code point)
NXM:	yes
Code Points:	**NXM_NX_TCP_FLAGS** (0x00014402), introduced in Open vSwitch 2.1

UDP Source Port Field

Name:	**udp_src**
Width:	16 bits
Masking:	arbitrary bitwise masks
Prerequisites:	MFP_UDP
Access:	read/write
OpenFlow 1.0:	yes (exact match only)
OpenFlow 1.1:	yes (exact match only)
OpenFlow 1.2:	yes
OpenFlow 1.3:	yes
NXM:	yes (maskable since Open vSwitch 1.6)
Code Points:	**OXM_OF_UDP_SRC** (0x80001e02), introduced in OpenFlow 1.2
	NXM_OF_UDP_SRC (0x00001602), introduced in Open vSwitch 1.1

UDP Destination Port Field

Name:	**udp_dst**
Width:	16 bits
Masking:	arbitrary bitwise masks
Prerequisites:	MFP_UDP
Access:	read/write
OpenFlow 1.0:	yes (exact match only)
OpenFlow 1.1:	yes (exact match only)
OpenFlow 1.2:	yes

OpenFlow 1.3:	yes
NXM:	yes (maskable since Open vSwitch 1.6)
Code Points:	**OXM_OF_UDP_DST** (0x80002002), introduced in OpenFlow 1.2
	NXM_OF_UDP_DST (0x00001802), introduced in Open vSwitch 1.1

SCTP Source Port Field

Name:	**sctp_src**
Width:	16 bits
Masking:	arbitrary bitwise masks
Prerequisites:	MFP_SCTP
Access:	read/write
OpenFlow 1.0:	no
OpenFlow 1.1:	yes (exact match only)
OpenFlow 1.2:	yes
OpenFlow 1.3:	yes
NXM:	yes (via OXM code point)
Code Points:	**OXM_OF_SCTP_SRC** (0x80002202), introduced in OpenFlow 1.2

SCTP Destination Port Field

Name:	**sctp_dst**
Width:	16 bits
Masking:	arbitrary bitwise masks
Prerequisites:	MFP_SCTP
Access:	read/write
OpenFlow 1.0:	no
OpenFlow 1.1:	yes (exact match only)
OpenFlow 1.2:	yes
OpenFlow 1.3:	yes
NXM:	yes (via OXM code point)
Code Points:	**OXM_OF_SCTP_DST** (0x80002402), introduced in OpenFlow 1.2

ICMPv4 Type Field

Name:	**icmp_type**
Width:	8 bits
Masking:	not maskable
Prerequisites:	MFP_ICMPV4
Access:	read-only
OpenFlow 1.0:	yes
OpenFlow 1.1:	yes
OpenFlow 1.2:	yes
OpenFlow 1.3:	yes
NXM:	yes
Code Points:	**OXM_OF_ICMPV4_TYPE** (0x80002601), introduced in OpenFlow 1.2
	NXM_OF_ICMP_TYPE (0x00001a01), introduced in Open vSwitch 1.1

ICMPv4 Code Field

Name:	**icmp_code**
Width:	8 bits
Masking:	not maskable
Prerequisites:	MFP_ICMPV4
Access:	read-only
OpenFlow 1.0:	yes
OpenFlow 1.1:	yes
OpenFlow 1.2:	yes
OpenFlow 1.3:	yes
NXM:	yes

Code Points:	**OXM_OF_ICMPV4_CODE** (0x80002801), introduced in OpenFlow 1.2 **NXM_OF_ICMP_CODE** (0x00001c01), introduced in Open vSwitch 1.1

ICMPv6 Type Field

Name:	**icmpv6_type**
Width:	8 bits
Masking:	not maskable
Prerequisites:	MFP_ICMPV6
Access:	read-only
OpenFlow 1.0:	no
OpenFlow 1.1:	no
OpenFlow 1.2:	yes
OpenFlow 1.3:	yes
NXM:	yes
Code Points:	**OXM_OF_ICMPV6_TYPE** (0x80003a01), introduced in OpenFlow 1.2 **NXM_NX_ICMPV6_TYPE** (0x00012a01), introduced in Open vSwitch 1.1

ICMPv6 Code Field

Name:	**icmpv6_code**
Width:	8 bits
Masking:	not maskable
Prerequisites:	MFP_ICMPV6
Access:	read-only
OpenFlow 1.0:	no
OpenFlow 1.1:	no
OpenFlow 1.2:	yes
OpenFlow 1.3:	yes
NXM:	yes
Code Points:	**OXM_OF_ICMPV6_CODE** (0x80003c01), introduced in OpenFlow 1.2 **NXM_NX_ICMPV6_CODE** (0x00012c01), introduced in Open vSwitch 1.1

ICMPv6 Neighbor Discovery Target IPv6 Field

Name:	**nd_target**
Width:	128 bits
Masking:	arbitrary bitwise masks
Prerequisites:	MFP_ND
Access:	read-only
OpenFlow 1.0:	no
OpenFlow 1.1:	no
OpenFlow 1.2:	yes
OpenFlow 1.3:	yes
NXM:	yes (CIDR masks only before Open vSwitch 1.8)
Code Points:	**OXM_OF_IPV6_ND_TARGET** (0x80003e10), introduced in OpenFlow 1.2 **NXM_NX_ND_TARGET** (0x00012e10), introduced in Open vSwitch 1.1

ICMPv6 Neighbor Discovery Source Ethernet Address Field

Name:	**nd_sll**
Width:	48 bits
Masking:	arbitrary bitwise masks
Prerequisites:	MFP_ND_SOLICIT
Access:	read-only
OpenFlow 1.0:	no
OpenFlow 1.1:	no
OpenFlow 1.2:	yes
OpenFlow 1.3:	yes
NXM:	yes (maskable since Open vSwitch 1.9)

Code Points:	**OXM_OF_IPV6_ND_SLL** (0x80004006), introduced in OpenFlow 1.2
	NXM_NX_ND_SLL (0x00013006), introduced in Open vSwitch 1.1

ICMPv6 Neighbor Discovery Target Ethernet Address Field

Name:	**nd_tll**
Width:	48 bits
Masking:	arbitrary bitwise masks
Prerequisites:	MFP_ND_ADVERT
Access:	read-only
OpenFlow 1.0:	no
OpenFlow 1.1:	no
OpenFlow 1.2:	yes
OpenFlow 1.3:	yes
NXM:	yes (maskable since Open vSwitch 1.9)
Code Points:	**OXM_OF_IPV6_ND_TLL** (0x80004206), introduced in OpenFlow 1.2
	NXM_NX_ND_TLL (0x00013206), introduced in Open vSwitch 1.1