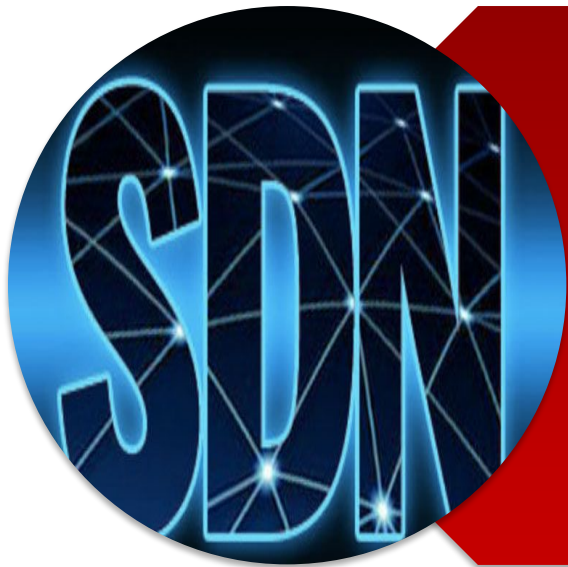


Lecture 6



**Investigating
OpenFlow
negotiations**

Objectives

Introduction to the lecture

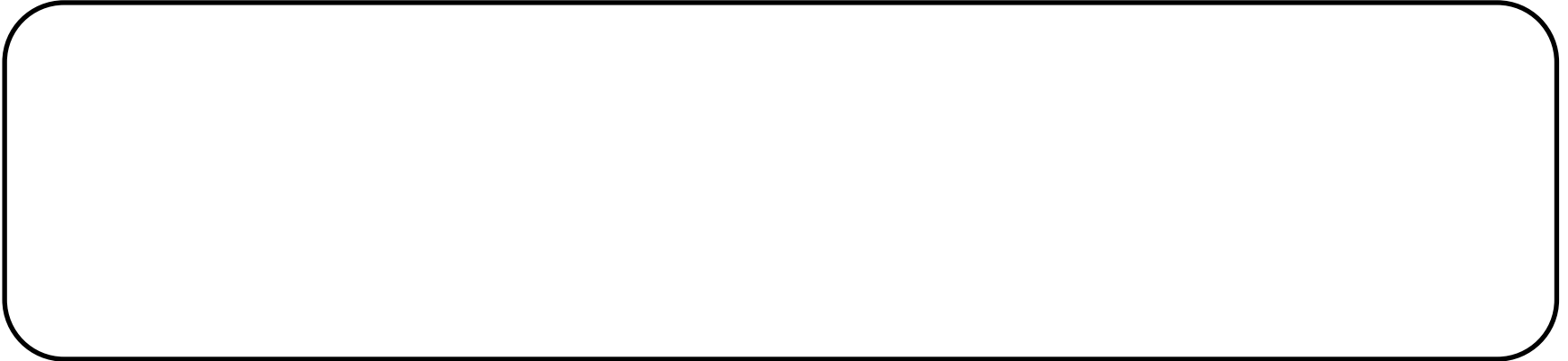
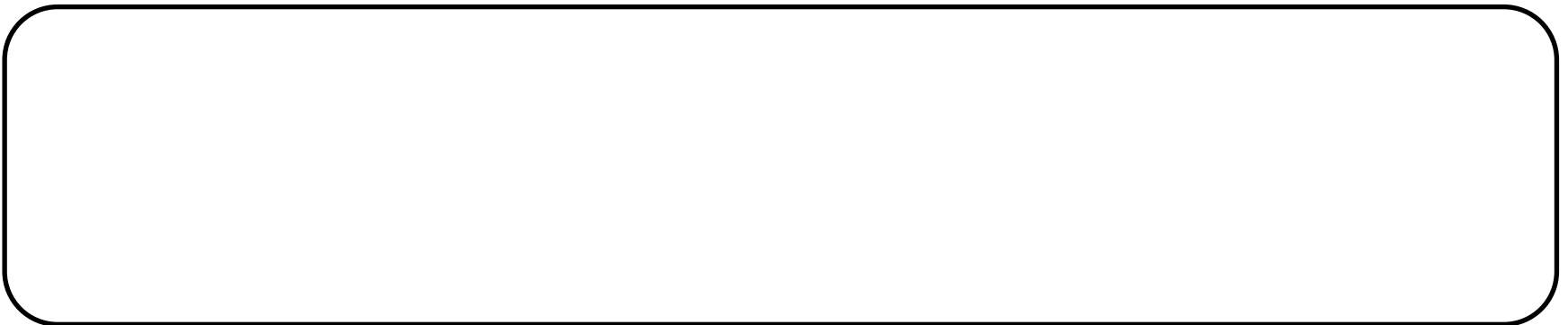
- **Capture OpenFlow messages**
- **Switch features**
- **Switch datapath IDs (DPIDs)**
- **Packet in messages**
- **Buffering**
- **Tables and pipelines**
- **Flow modifications (Flow mod)**
- **Error messages**



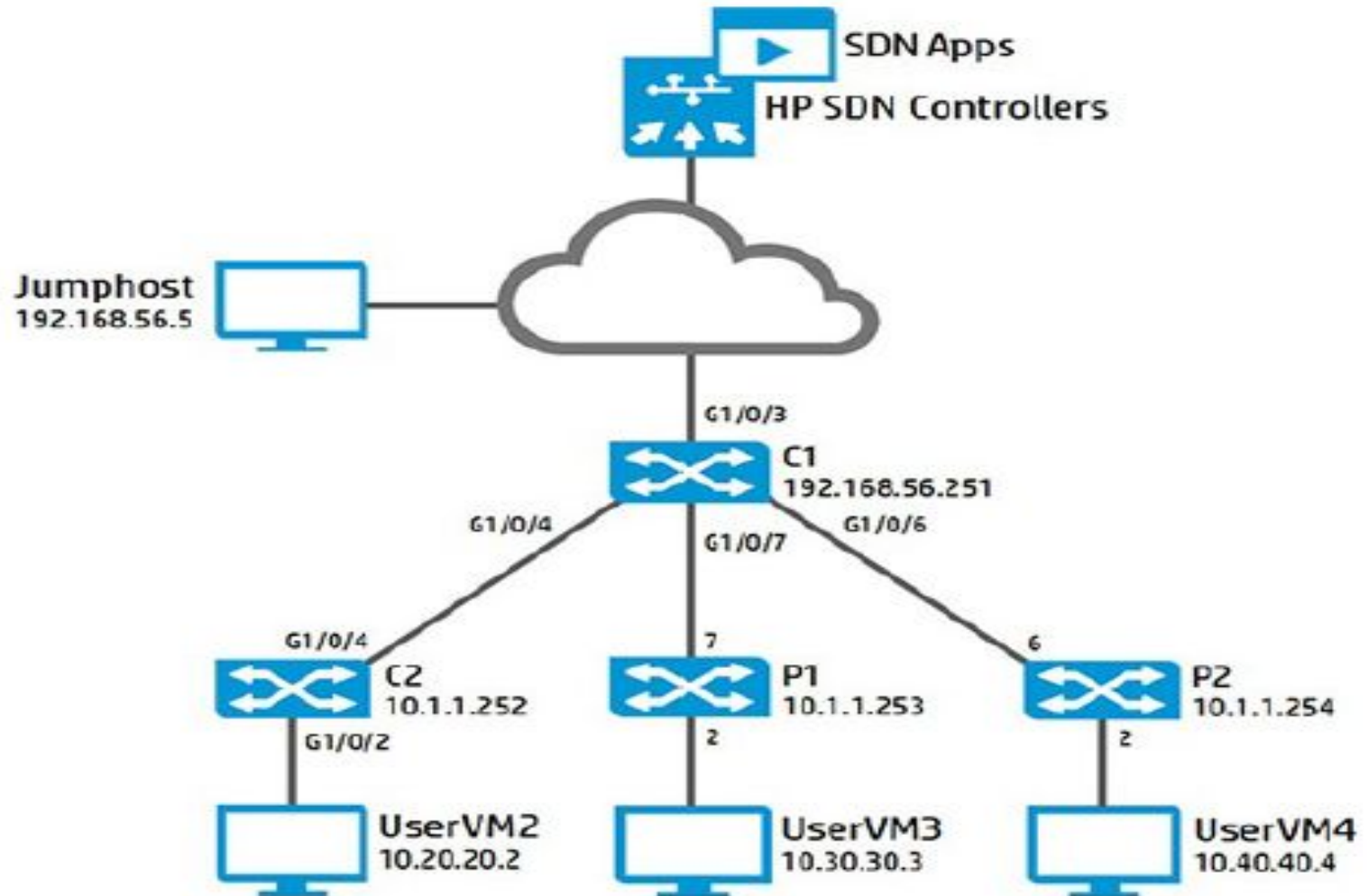
Investigating OpenFlow negotiations



Capture OpenFlow messages

An empty rounded rectangular box with a black border, intended for notes or a diagram.An empty rounded rectangular box with a black border, intended for notes or a diagram.An empty rounded rectangular box with a black border, intended for notes or a diagram.

Capture OpenFlow messages



Capture OpenFlow messages

Device	Description	IP Address
C1 (Comware switch 1)	HP Comware switch	VLAN 1: 10.1.1.251 VLAN 20: 10.20.20.251 VLAN 30: 10.30.30.251 VLAN 40: 10.40.40.251 VLAN 192: 192.168.56.251

Capture OpenFlow messages

**Applications
Disable**

 HP VAN SDN Controller ▾

▾ General

Alerts

Applications

Configurations

Audit Log

Licenses

Team

Flow Maker Deluxe

Support Logs

OpenFlow Monitor

General / Applications

Refresh | New | Upgrade | Uninstall | Enable | Disable

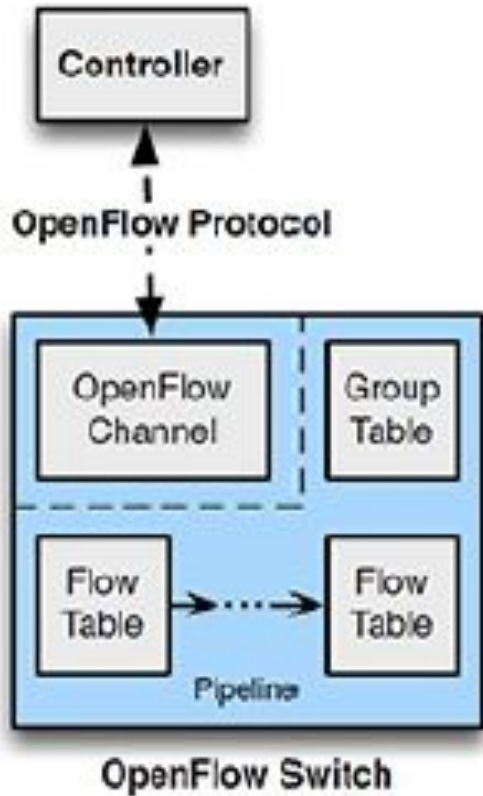
Name	Version	State
▶ Network Protector	1.3.13.458	ACTIVE
▶ Path Diagnostics	2.5.15	ACTIVE
▶ OpenFlow Link Discovery	2.5.15	ACTIVE
▶ OpenFlow Node Discovery	2.5.15	ACTIVE
▶ Path Daemon	2.5.15	ACTIVE
▶ Flow Maker Deluxe	1.0.0	ACTIVE

AppStore - Purchased Applications

Name	Version
------	---------



Capture OpenFlow messages



**controller-to-switch,
asynchronous, and symmetric.**

Capture OpenFlow messages

- **Switch to Controller = Hello**
- **Controller to Switch = Hello**
- **Controller to Switch = Features request**
- **Switch to Controller = Features reply**
- **Controller to Switch = Set config**
- **Switch to Controller = Error**

Capture OpenFlow messages

```
<C2> system-view  
[C2] openflow instance 1  
[C2-of-inst-1] undo classification  
[C2-of-inst-1] active instance
```

```
P1# config
```

```
P1 (config)# openflow
```

```
P1 (openflow)# disable
```

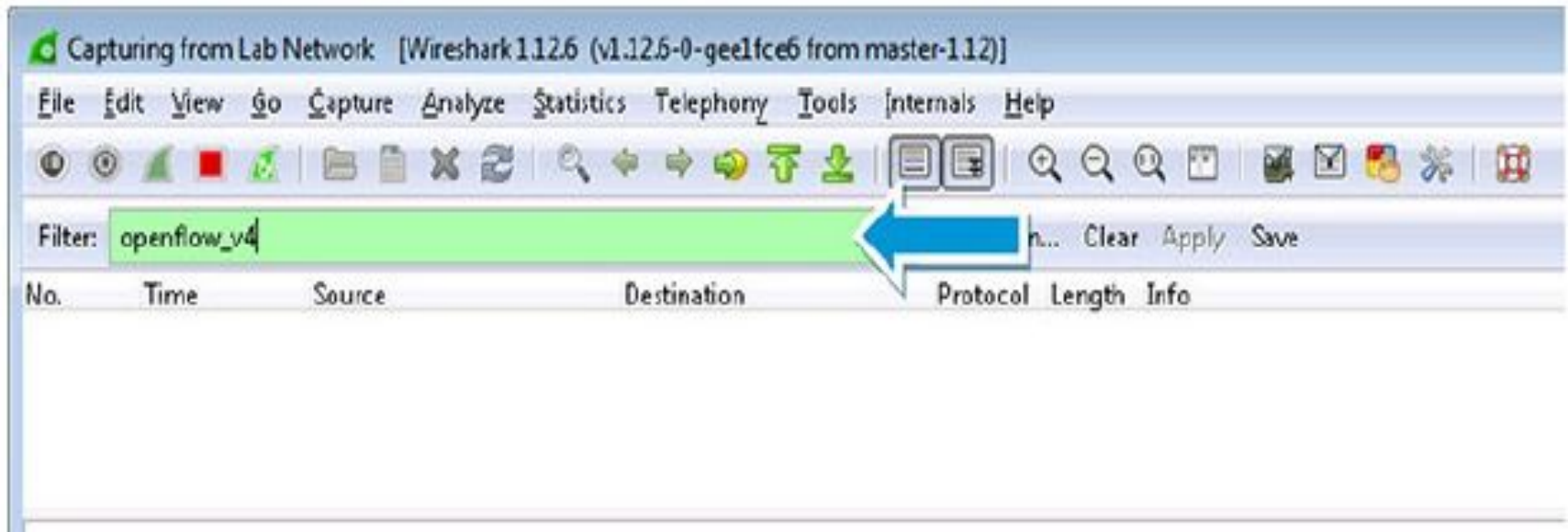
```
P2# config
```

```
P2 (config)# openflow
```

```
P2 (openflow)# disable
```

Capture OpenFlow messages

openflow_v4



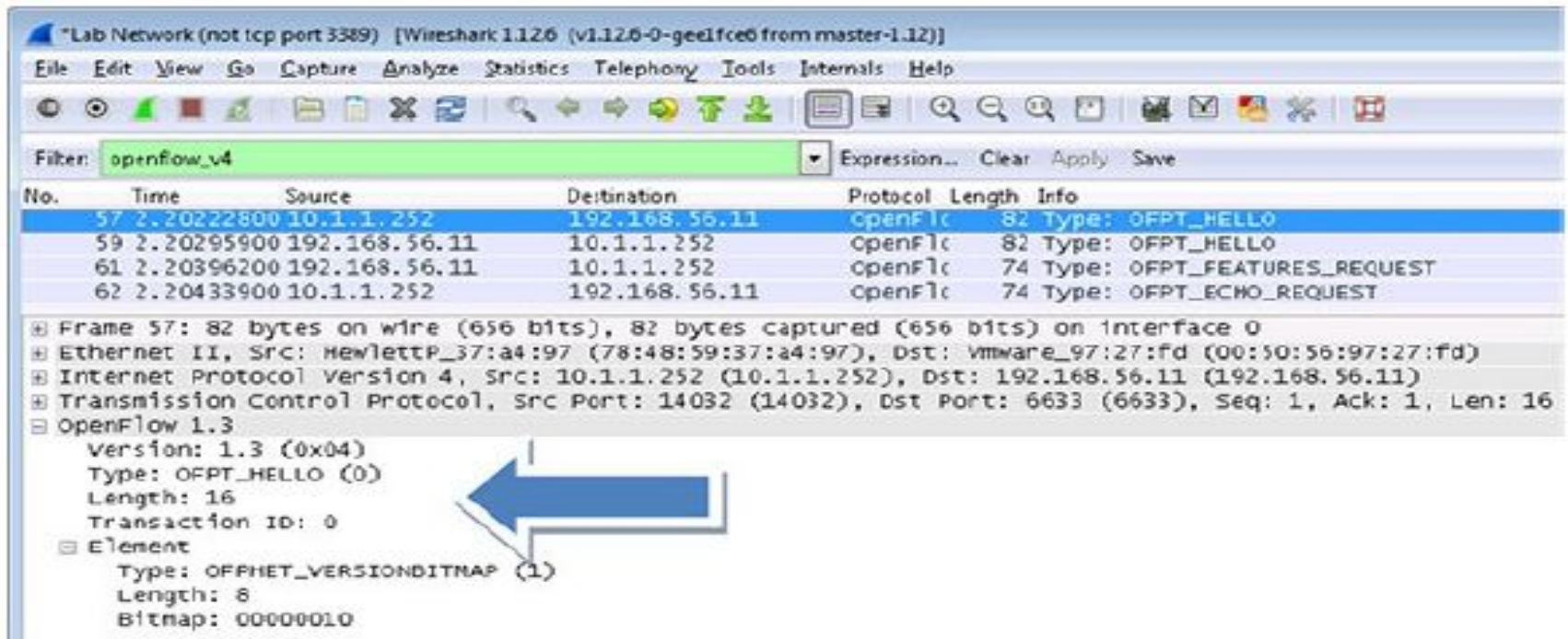
Result:

Capture OpenFlow messages

```
[C2-of-inst-1] classification vlan 20  
[C2-of-inst-1] active instance
```



Capture OpenFlow messages



The image shows a Wireshark capture of OpenFlow messages. The filter is set to 'openflow_v4'. The capture shows four packets:

No.	Time	Source	Destination	Protocol	Length	Info
57	2.20222800	10.1.1.252	192.168.56.11	OpenFlow	82	Type: OFPT_HELLO
59	2.20295900	192.168.56.11	10.1.1.252	OpenFlow	82	Type: OFPT_HELLO
61	2.20396200	192.168.56.11	10.1.1.252	OpenFlow	74	Type: OFPT_FEATURES_REQUEST
62	2.20433900	10.1.1.252	192.168.56.11	OpenFlow	74	Type: OFPT_ECHO_REQUEST

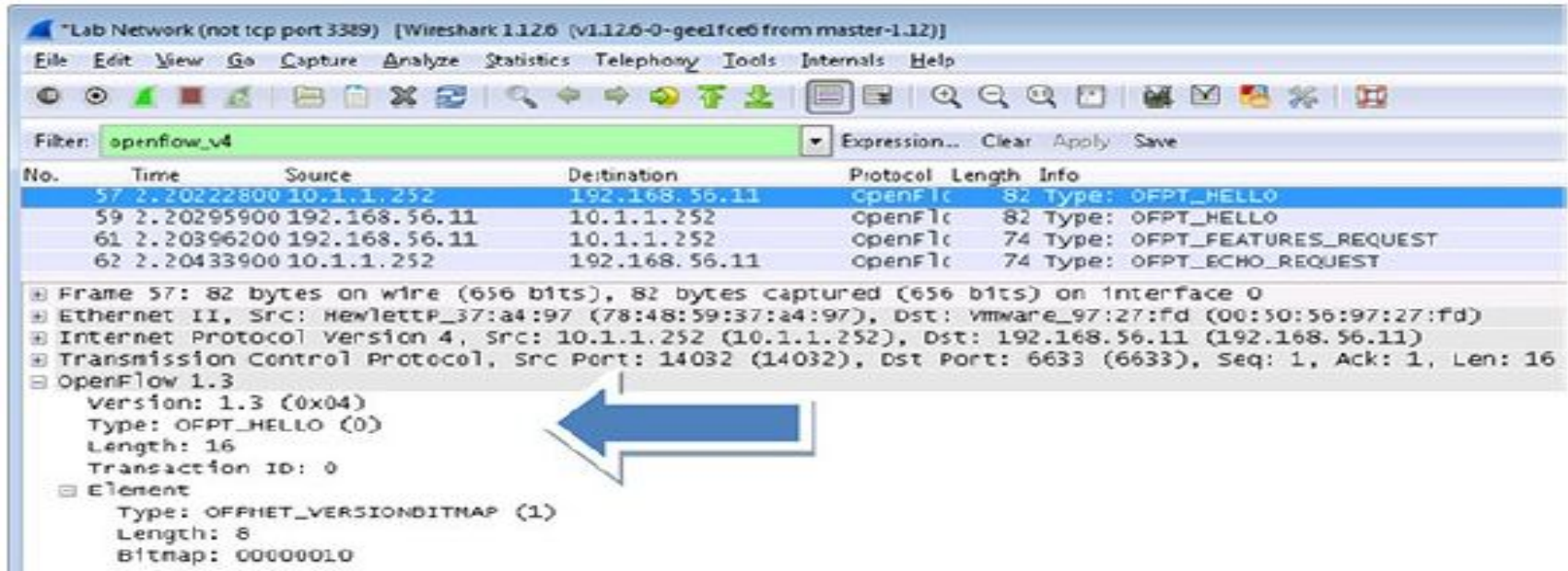
The details pane for packet 57 shows the following structure:

- Frame 57: 82 bytes on wire (656 bits), 82 bytes captured (656 bits) on interface 0
- Ethernet II, Src: HewlettP_37:a4:97 (78:48:59:37:a4:97), Dst: vmware_97:27:fd (00:50:56:97:27:fd)
- Internet Protocol Version 4, Src: 10.1.1.252 (10.1.1.252), Dst: 192.168.56.11 (192.168.56.11)
- Transmission Control Protocol, Src Port: 14032 (14032), Dst Port: 6633 (6633), Seq: 1, Ack: 1, Len: 16
- OpenFlow 1.3
 - Version: 1.3 (0x04)
 - Type: OFPT_HELLO (0)
 - Length: 16
 - Transaction ID: 0
 - Element
 - Type: OFFHET_VERSIONDITMAP (1)
 - Length: 8
 - Bitmap: 0000010

A blue arrow points from the details pane to the first packet in the packet list.

Answer:

Capture OpenFlow messages



The image shows a Wireshark capture of OpenFlow messages. The filter is set to 'openflow_v4'. The capture shows four packets:

No.	Time	Source	Destination	Protocol	Length	Info
57	2.20222800	10.1.1.252	192.168.56.11	OpenFlow	82	Type: OFPT_HELLO
59	2.20295900	192.168.56.11	10.1.1.252	OpenFlow	82	Type: OFPT_HELLO
61	2.20396200	192.168.56.11	10.1.1.252	OpenFlow	74	Type: OFPT_FEATURES_REQUEST
62	2.20433900	10.1.1.252	192.168.56.11	OpenFlow	74	Type: OFPT_ECHO_REQUEST

The details pane for packet 57 is expanded, showing the following information:

- Frame 57: 82 bytes on wire (656 bits), 82 bytes captured (656 bits) on interface 0
- Ethernet II, Src: HewlettP_37:a4:97 (78:48:59:37:a4:97), Dst: vmware_97:27:fd (00:50:56:97:27:fd)
- Internet Protocol Version 4, Src: 10.1.1.252 (10.1.1.252), Dst: 192.168.56.11 (192.168.56.11)
- Transmission Control Protocol, Src Port: 14032 (14032), Dst Port: 6633 (6633), Seq: 1, Ack: 1, Len: 16
- OpenFlow 1.3
 - Version: 1.3 (0x04)
 - Type: OFPT_HELLO (0)
 - Length: 16
 - Transaction ID: 0
 - Element
 - Type: OFFHET_VERSIONBITMAP (1)
 - Length: 8
 - Bitmap: 00000010

A blue arrow points to the 'Element' section of the OpenFlow 1.3 details.

Answer:

Message types

```
enum ofp_type {
/* Immutable messages. */
OFPT_HELLO = 0, /* Symmetric message */
OFPT_ERROR = 1, /* Symmetric message */
OFPT_ECHO_REQUEST = 2, /* Symmetric message */
OFPT_ECHO_REPLY = 3, /* Symmetric message */
OFPT_EXPERIMENTER = 4, /* Symmetric message */
/* Switch configuration messages. */
OFPT_FEATURES_REQUEST = 5, /* Controller/switch message */
```

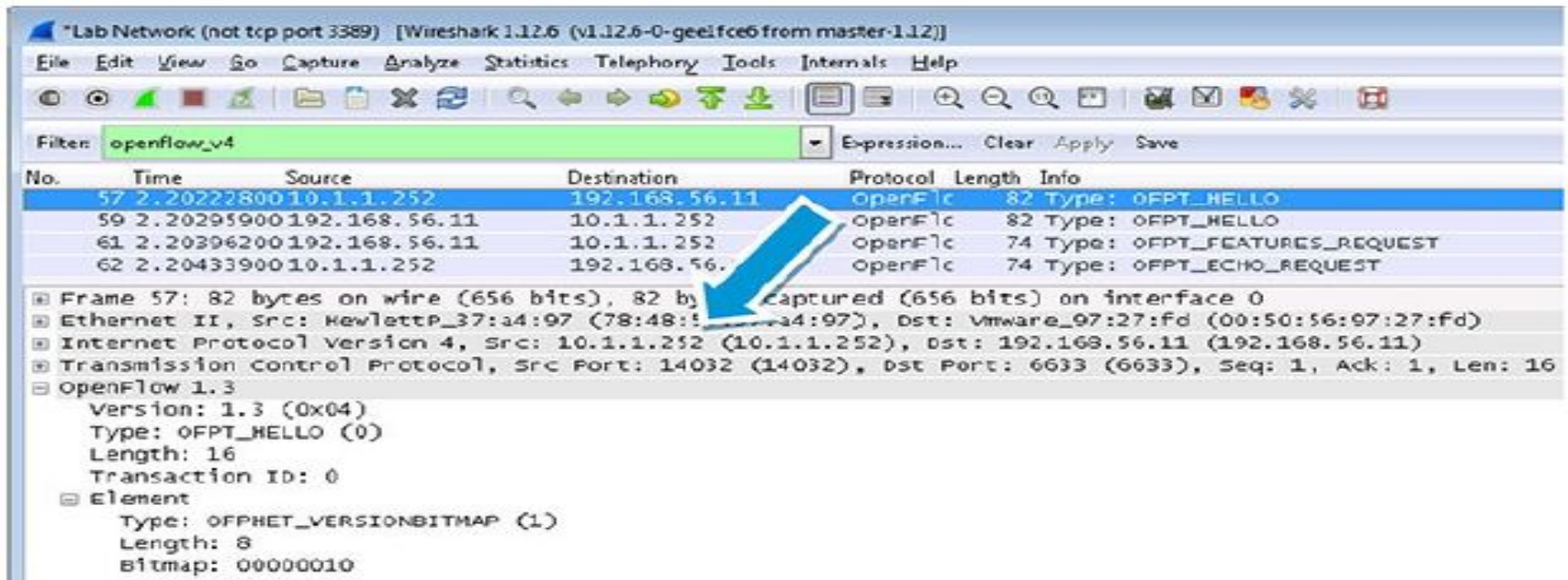

Message types

```
OFPT_FEATURES_REPLY = 6, /* Controller/switch message */
OFPT_GET_CONFIG_REQUEST = 7, /* Controller/switch message */
OFPT_GET_CONFIG_REPLY = 8, /* Controller/switch message */
OFPT_SET_CONFIG = 9, /* Controller/switch message */
/* Asynchronous messages. */
OFPT_PACKET_IN = 10, /* Async message */
OFPT_FLOW_REMOVED = 11, /* Async message */
OFPT_PORT_STATUS = 12, /* Async message */
/* Controller command messages. */
OFPT_PACKET_OUT = 13, /* Controller/switch message */
OFPT_FLOW_MOD = 14, /* Controller/switch message */
OFPT_GROUP_MOD = 15, /* Controller/switch message */
OFPT_PORT_MOD = 16, /* Controller/switch message */
OFPT_TABLE_MOD = 17, /* Controller/switch message */
/* Multipart messages. */
OFPT_MULTIPART_REQUEST = 18, /* Controller/switch message */
```

Message types

```
OFPT_MULTIPART_REPLY = 19, /* Controller/switch message */
/* Barrier messages. */
OFPT_BARRIER_REQUEST = 20, /* Controller/switch message */
OFPT_BARRIER_REPLY = 21, /* Controller/switch message */
/* Queue Configuration messages. */
OFPT_QUEUE_GET_CONFIG_REQUEST = 22, /* Controller/switch message */
OFPT_QUEUE_GET_CONFIG_REPLY = 23, /* Controller/switch message */
/* Controller role change request messages. */
OFPT_ROLE_REQUEST = 24, /* Controller/switch message */
OFPT_ROLE_REPLY = 25, /* Controller/switch message */
/* Asynchronous message configuration. */
OFPT_GET_ASYNC_REQUEST = 26, /* Controller/switch message */
OFPT_GET_ASYNC_REPLY = 27, /* Controller/switch message */
OFPT_SET_ASYNC = 28, /* Controller/switch message */
/* Meters and rate limiters configuration messages. */
OFPT_METER_MOD = 29, /* Controller/switch message */
```

OpenFlow specification



The image shows a Wireshark capture of network traffic. The filter is set to 'openflow_v4'. The packet list shows four OpenFlow messages:

No.	Time	Source	Destination	Protocol	Length	Info
57	2.20222800	10.1.1.252	192.168.56.11	OpenFlow	82	Type: OFPT_HELLO
59	2.20295900	192.168.56.11	10.1.1.252	OpenFlow	82	Type: OFPT_HELLO
61	2.20396200	192.168.56.11	10.1.1.252	OpenFlow	74	Type: OFPT_FEATURES_REQUEST
62	2.20433900	10.1.1.252	192.168.56.11	OpenFlow	74	Type: OFPT_ECHO_REQUEST

The details pane for the selected packet (Frame 57) shows the following structure:

- Frame 57: 82 bytes on wire (656 bits), 82 bytes captured (656 bits) on interface 0
- Ethernet II, Src: HewlettP_37:a4:97 (78:48:56:a4:97), Dst: VMware_97:27:fd (00:50:56:97:27:fd)
- Internet Protocol Version 4, Src: 10.1.1.252 (10.1.1.252), Dst: 192.168.56.11 (192.168.56.11)
- Transmission Control Protocol, Src Port: 14032 (14032), Dst Port: 6633 (6633), Seq: 1, Ack: 1, Len: 16
- OpenFlow 1.3
 - Version: 1.3 (0x04)
 - Type: OFPT_HELLO (0)
 - Length: 16
 - Transaction ID: 0
 - Element
 - Type: OFPHET_VERSIONBITMAP (1)
 - Length: 8
 - Bitmap: 00000010

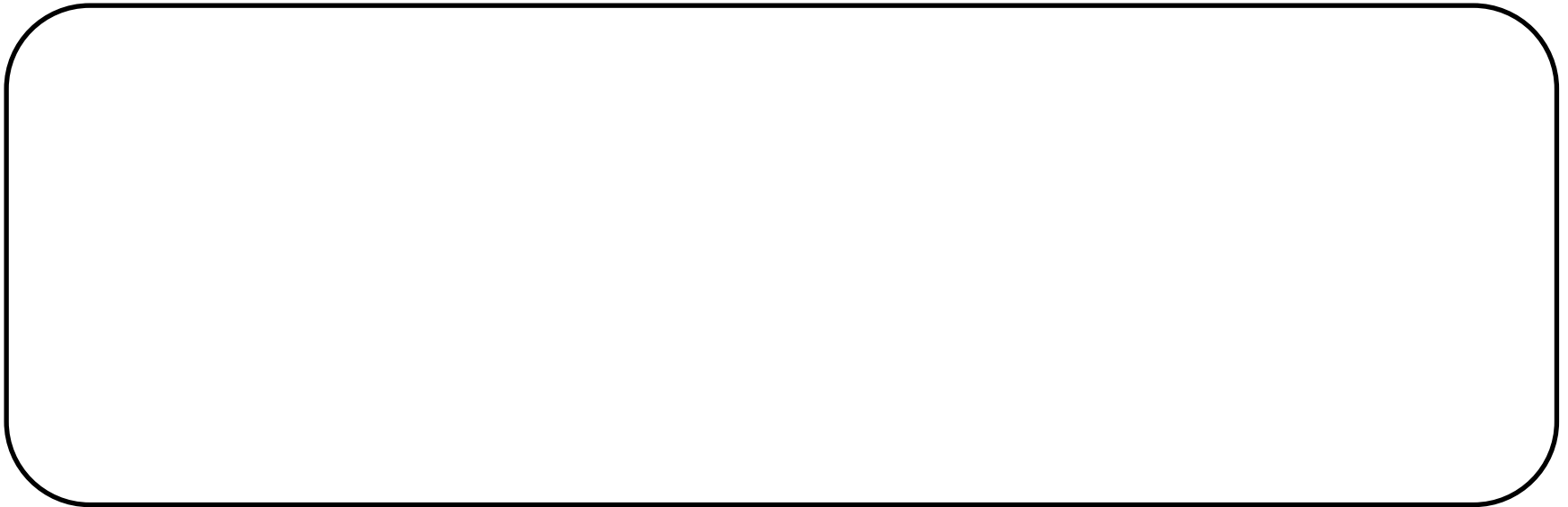
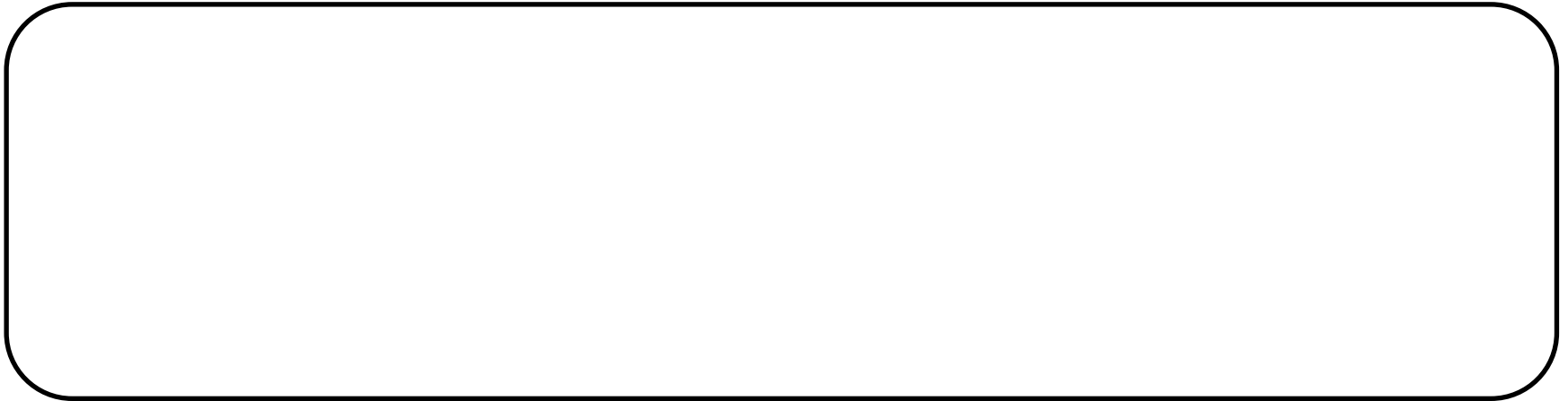
Answer:

OpenFlow specification

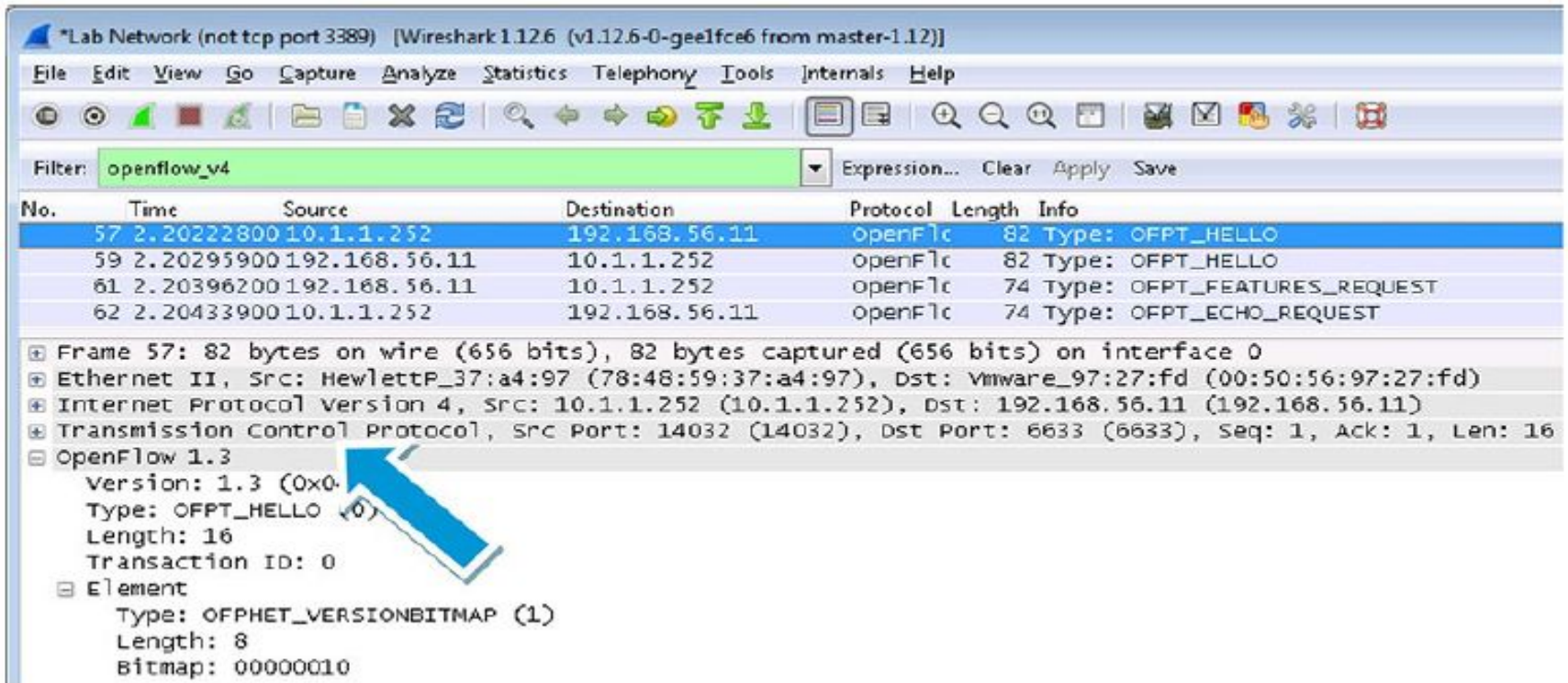
Answer:

Optional:

OpenFlow specification



OpenFlow specification



The image shows a Wireshark capture of an OpenFlow message. The filter is set to 'openflow_v4'. The packet list shows four packets, with the first one selected. The packet details pane shows the following structure:

- Frame 57: 82 bytes on wire (656 bits), 82 bytes captured (656 bits) on interface 0
- Ethernet II, Src: HewlettP_37:a4:97 (78:48:59:37:a4:97), Dst: vmware_97:27:fd (00:50:56:97:27:fd)
- Internet Protocol Version 4, Src: 10.1.1.252 (10.1.1.252), Dst: 192.168.56.11 (192.168.56.11)
- Transmission Control Protocol, Src Port: 14032 (14032), Dst Port: 6633 (6633), Seq: 1, Ack: 1, Len: 16
- OpenFlow 1.3
 - Version: 1.3 (0x0)
 - Type: OFPT_HELLO (0)
 - Length: 16
 - Transaction ID: 0
 - Element
 - Type: OFPHET_VERSIONBITMAP (1)
 - Length: 8
 - Bitmap: 00000010

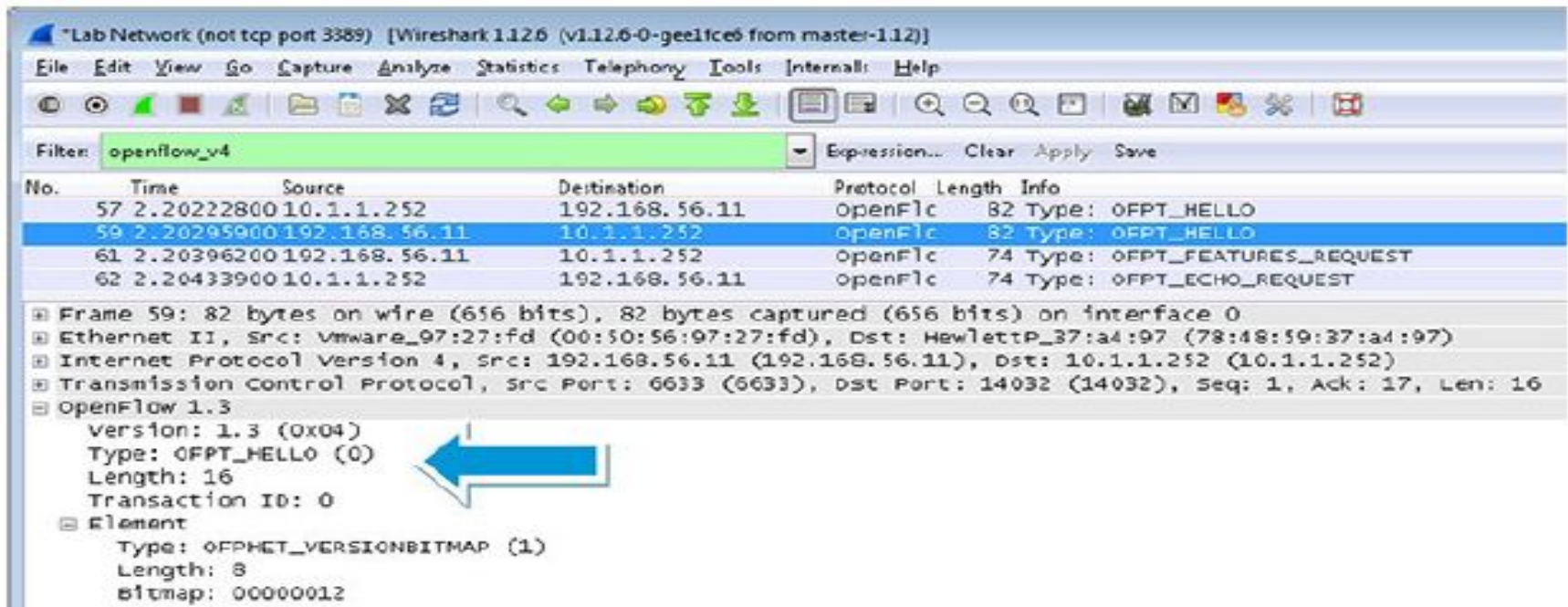
A blue arrow points to the 'Type: OFPT_HELLO (0)' field in the OpenFlow 1.3 section.

Answer:

OpenFlow specification

Answer:

OpenFlow specification



Filter: openflow_v4

No.	Time	Source	Destination	Protocol	Length	Info
57	2.20222800	10.1.1.252	192.168.56.11	OpenFlc	82	Type: OFPT_HELLO
59	2.20295900	192.168.56.11	10.1.1.252	openFlc	82	Type: OFPT_HELLO
61	2.20396200	192.168.56.11	10.1.1.252	OpenFlc	74	Type: OFPT_FEATURES_REQUEST
62	2.20433900	10.1.1.252	192.168.56.11	openFlc	74	Type: OFPT_ECHO_REQUEST

Frame 59: 82 bytes on wire (656 bits), 82 bytes captured (656 bits) on interface 0

- Ethernet II, Src: vmware_97:27:fd (00:50:56:97:27:fd), Dst: HewlettP_37:a4:97 (78:48:59:37:a4:97)
- Internet Protocol Version 4, Src: 192.168.56.11 (192.168.56.11), Dst: 10.1.1.252 (10.1.1.252)
- Transmission Control Protocol, Src Port: 6633 (6633), Dst Port: 14032 (14032), Seq: 1, Ack: 17, Len: 16
- OpenFlow 1.3
 - Version: 1.3 (0x04)
 - Type: OFPT_HELLO (0)
 - Length: 16
 - Transaction ID: 0
 - Element
 - Type: OFPHET_VERSIONBITMAP (1)
 - Length: 8
 - Bitmap: 0000012

Result:

OpenFlow specification

Filter: openflow_v4

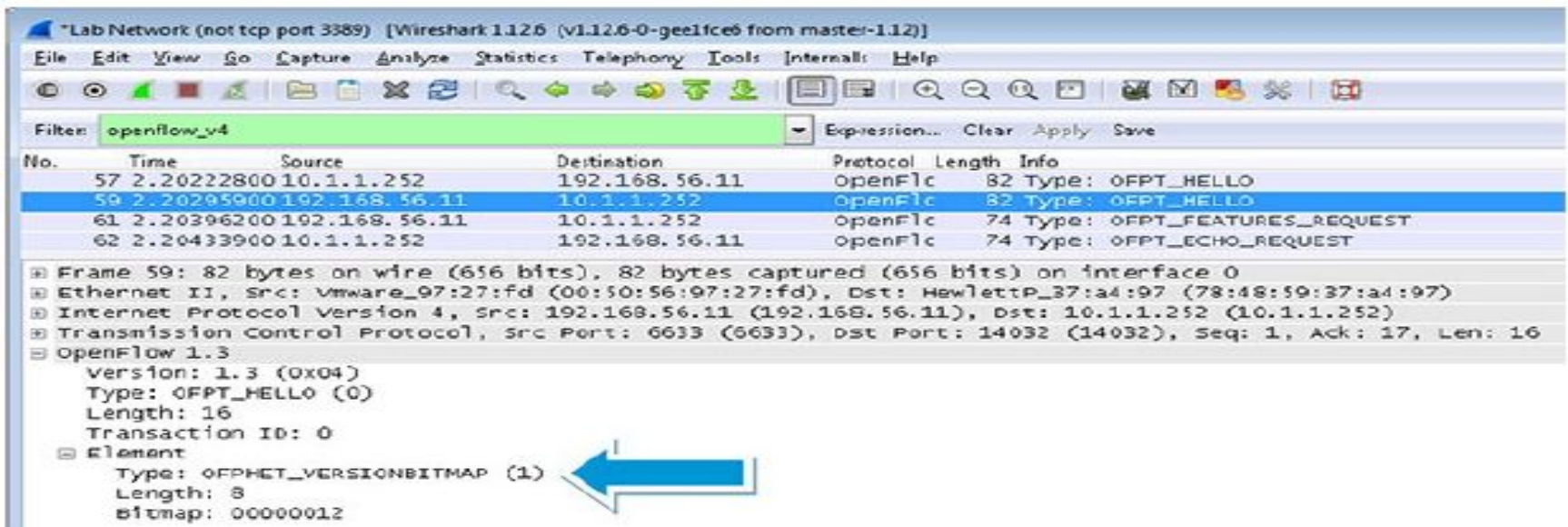
No.	Time	Source	Destination	Protocol	Length	Info
57	2.20222800	10.1.1.252	192.168.56.11	OpenFlc	82	Type: OFPT_HELLO
59	2.20295900	192.168.56.11	10.1.1.252	openFlc	82	Type: OFPT_HELLO
61	2.20396200	192.168.56.11	10.1.1.252	openFlc	74	Type: OFPT_FEATURES_REQUEST
62	2.20433900	10.1.1.252	192.168.56.11	openFlc	74	Type: OFPT_ECHO_REQUEST

Frame 59: 82 bytes on wire (656 bits), 82 bytes captured (656 bits) on interface 0

- Ethernet II, Src: VMware_97:27:fd (00:50:56:97:27:fd), Dst: HewlettP_37:a4:97 (78:48:59:37:a4:97)
- Internet Protocol Version 4, Src: 192.168.56.11 (192.168.56.11), Dst: 10.1.1.252 (10.1.1.252)
- Transmission Control Protocol, Src Port: 6633 (6633), Dst Port: 14032 (14032), Seq: 1, Ack: 17, Len: 16
- OpenFlow 1.3
 - Version: 1.3 (0x04)
 - Type: OFPT_HELLO (0)
 - Length: 16
 - Transaction ID: 0
 - Element
 - Type: OFPHET_VERSIONBITMAP (1)
 - Length: 8
 - Bitmap: 00000012

OpenFlow specification

Answers:



The image shows a Wireshark capture of OpenFlow messages. The filter is set to 'openflow_v4'. The capture shows four packets:

No.	Time	Source	Destination	Protocol	Length	Info
57	2.20222800	10.1.1.252	192.168.56.11	OpenFlc	82	Type: OFPT_HELLO
59	2.20295900	192.168.56.11	10.1.1.252	OpenFlc	82	Type: OFPT_HELLO
61	2.20396200	192.168.56.11	10.1.1.252	openFlc	74	Type: OFPT_FEATURES_REQUEST
62	2.20433900	10.1.1.252	192.168.56.11	openFlc	74	Type: OFPT_ECHO_REQUEST

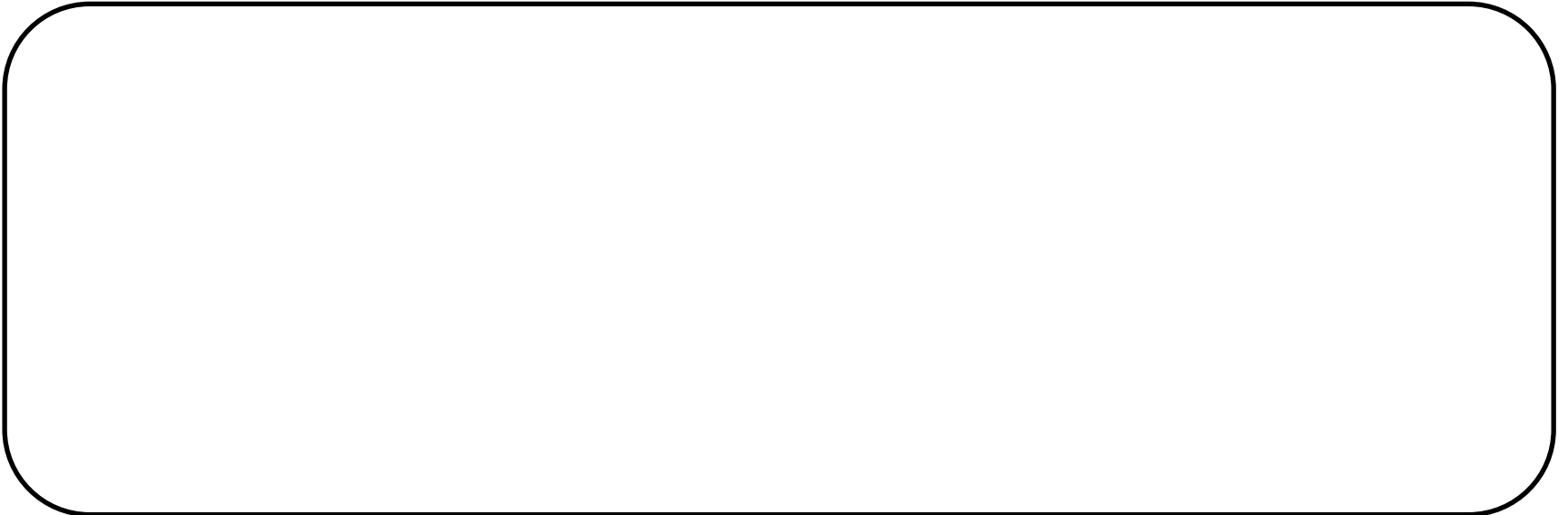
The details pane for packet 59 shows the following structure:

- Frame 59: 82 bytes on wire (656 bits), 82 bytes captured (656 bits) on interface 0
- Ethernet II, Src: Vmware_97:27:fd (00:50:56:97:27:fd), Dst: HewlettP_37:a4:97 (78:48:59:37:a4:97)
- Internet Protocol Version 4, Src: 192.168.56.11 (192.168.56.11), Dst: 10.1.1.252 (10.1.1.252)
- Transmission Control Protocol, Src Port: 6633 (6633), Dst Port: 14032 (14032), Seq: 1, Ack: 17, Len: 16
- OpenFlow 1.3
 - Version: 1.3 (0x04)
 - Type: OFPT_HELLO (0)
 - Length: 16
 - Transaction ID: 0
 - Element
 - Type: OFPHET_VERSIONBITMAP (1)
 - Length: 8
 - Bitmap: 00000012

A blue arrow points to the 'Element' section of the OpenFlow 1.3 details.

Answer:

OFPT_HELLO message

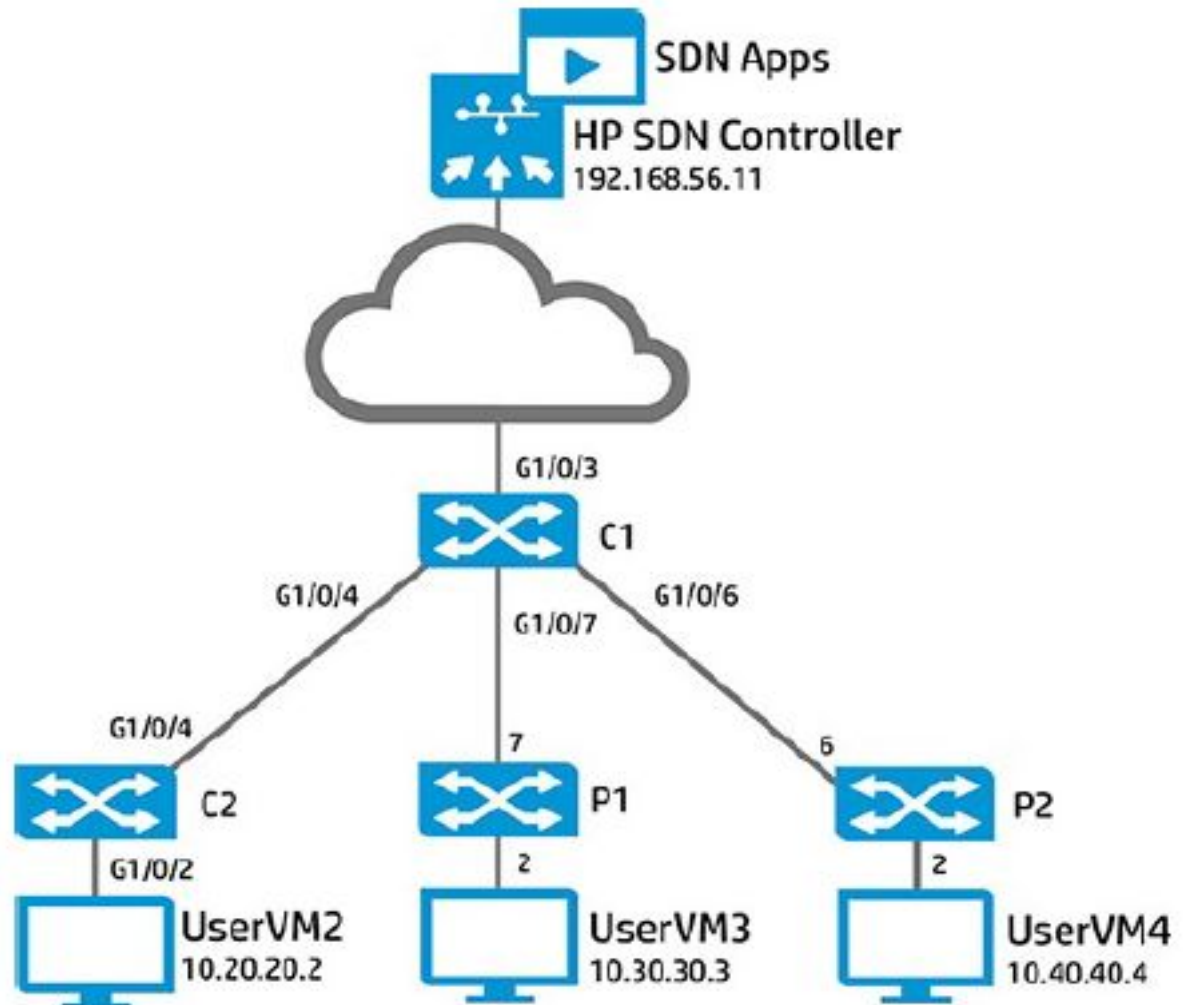
A large, empty rounded rectangular box with a black border, intended for content.A second large, empty rounded rectangular box with a black border, identical to the one above.



Investigating OpenFlow negotiations



Network topology



Configure Comware switch

```
<C2> system-view
```

```
[C2] openflow instance 1
```

```
[C2-of-inst-1] undo classification
```

```
[C2-of-inst-1] active instance
```

```
[C2-of-inst-1] quit
```

Configure Provision switch

```
P1# config
```

```
P1 (config)# openflow
```

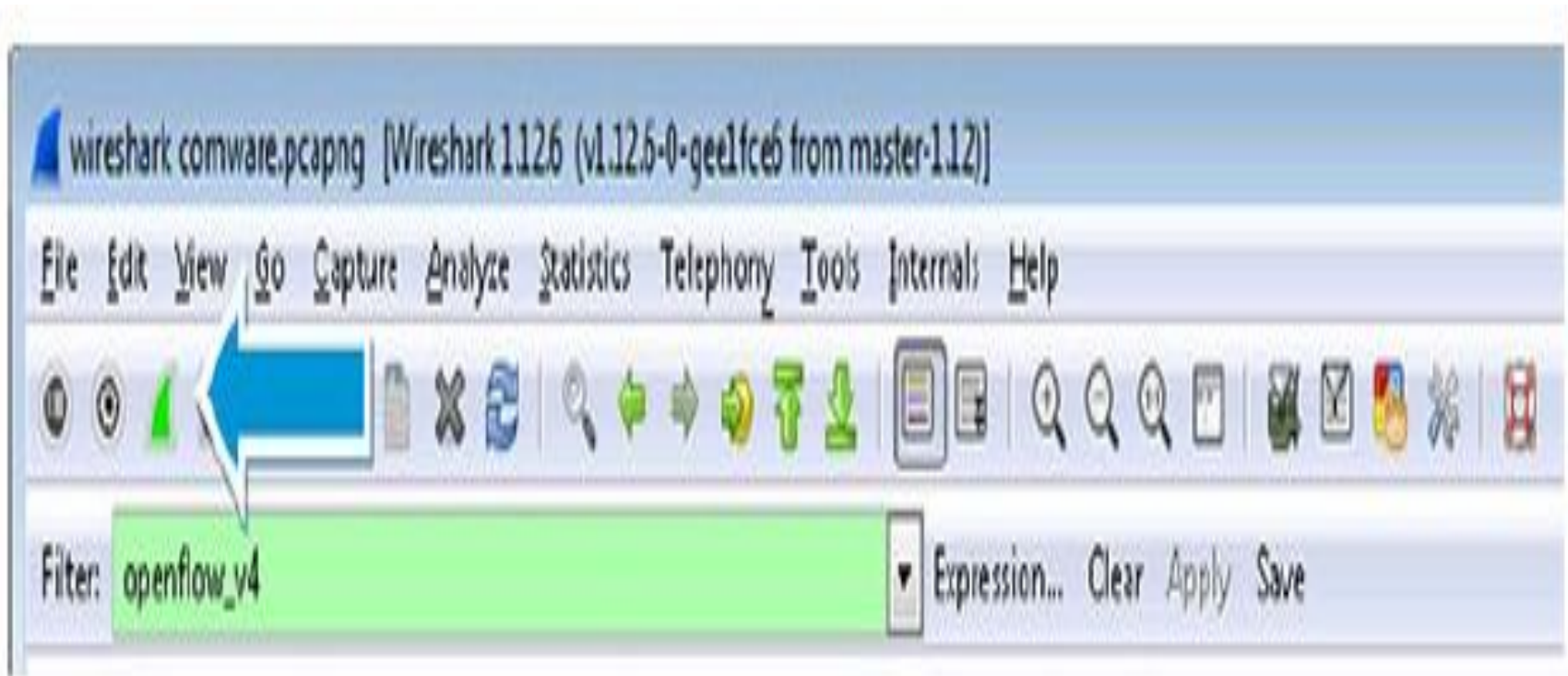
```
P1 (openflow)# instance vlan30
```

```
P1 (of-inst-vlan30)# disable
```

```
P1 (of-inst-vlan30)# no controller-id 3
```

```
P1 (of-inst-vlan30)# controller-id 1
```


Start Wireshark



Enable OpenFlow switches

```
P1 (of-inst-vlan30) # enable
```

```
P1 (of-inst-vlan30) # exit
```

```
P1 (openflow) # enable
```

```
[C2-of-inst-1] classification vlan 20
```

```
[C2-of-inst-1] active instance
```

Clear the Address Resolution Protocol (ARP)



```
C:\Windows\system32> arp -a -d
```

```
C:\Windows\system32>
```

7. Ping UserVM3's default gateway and hp.com:

```
C:\Windows\system32> ping 10.30.30.251
```

```
Pinging 10.30.30.251 with 32 bytes of data:
```

```
Reply from 10.30.30.251: bytes=32 time=1ms TTL=255
```

```
Reply from 10.30.30.251: bytes=32 time<1ms TTL=255
```

```
Reply from 10.30.30.251: bytes=32 time<1ms TTL=255
```

```
Reply from 10.30.30.251: bytes=32 time<1ms TTL=255
```

```
Ping statistics for 10.30.30.251:
```

```
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
```

```
Approximate round trip times in milli-seconds:
```

```
    Minimum = 0ms, Maximum = 1ms, Average = 0ms
```

7. Ping UserVM3's default gateway and hp.com:

```
C:\Windows\system32> ping hp.com
```

```
Pinging hp.com [192.168.56.51] with 32 bytes of data:
```

```
Reply from 192.168.56.51: bytes=32 time<1ms TTL=63
```

```
Reply from 192.168.56.51: bytes=32 time<1ms TTL=63
```

```
Reply from 192.168.56.51: bytes=32 time<1ms TTL=63
```

```
Reply from 192.168.56.51: bytes=32 time<1ms TTL=63
```

```
Ping statistics for 192.168.56.51:
```

```
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
```

```
Approximate round trip times in milli-seconds:
```

```
    Minimum = 0ms, Maximum = 0ms, Average = 0ms
```

Stop Wireshark



Apply

Answer:

Features Reply message

The image shows a Wireshark capture of an OpenFlow 1.3 Features Reply message. The packet list pane shows two packets, both of type OpenFlow, 98 bytes long. The packet details pane shows the structure of the message:

- Frame 18: 98 bytes on wire (784 bits), 98 bytes captured (784 bits) on interface 0
- Ethernet II, Src: HewlettP_37:a4:97 (78:48:59:37:a4:97), Dst: Vmware_97:27:fd (00:50:56:97:27:fd)
- Internet Protocol version 4, Src: 10.1.1.253 (10.1.1.253), Dst: 192.168.56.11 (192.168.56.11)
- Transmission Control Protocol, Src Port: 57946 (57946), Dst Port: 6632 (6632), Seq: 17, Ack: 25, Len: 32
- OpenFlow 1.3
 - Version: 1.3 (0x04)
 - Type: OFPT_FEATURES_REPLY (6)
 - Length: 32
 - Transaction ID: 507
 - datapath_id: 0x001e1458d0f0cb80
 - n_buffers: 0
 - n_tables: 3
 - auxiliary_id: 0
 - pad: 0
 - Capabilities: 0x0000010f
 - OFPC_FLOW_STATS: TRUE
 - OFPC_TABLE_STATS: TRUE
 - OFPC_QUEUE_STATS: TRUE
 - OFPC_PORT_STATE: TRUE
 - OFPC_QUEUE_ASM: FALSE
 - OFPC_QUEUE_STATS: FALSE
 - OFPC_PORT_BLOCKED: TRUE
 - Reserved: 0x00000000

Two blue arrows point from the packet list to the corresponding fields in the packet details pane: one points to the OpenFlow 1.3 section, and the other points to the Capabilities field.

Features Reply message

The image shows a Wireshark packet capture window. The filter is set to `openflow_v4switch.features.capabilities`. Two packets are visible in the packet list:

No.	Time	Source	Destination	Protocol	Length	Info
18	1.62927500	10.1.1.253	192.168.56.11	openFlc	98	Type: OFPT_FEATURES_REPLY
108	10.9978830	10.1.1.252	192.168.56.11	openFlc	98	Type: OFPT_FEATURES_REPLY

The details pane for the selected packet (No. 108) shows the following structure:

- Frame 108: 98 bytes on wire (784 bits), 98 bytes captured (784 bits) on interface 0
- Ethernet II, Src: HewlettP_37:a4:97 (78:48:59:37:a4:97), Dst: VMware_97:27:fd (00:10:56:97:27:fd)
- Internet Protocol Version 4, Src: 10.1.1.252 (10.1.1.252), Dst: 192.168.56.11 (192.168.56.11)
- Transmission Control Protocol, Src Port: 14048 (14048), Dst Port: 6633 (6633), Seq: 25, Ack: 33, Len: 32
- OpenFlow 1.3
 - Version: 1.3 (0x04)
 - Type: OFPT_FEATURES_REPLY (6)
 - Length: 32
 - Transaction ID: 551
 - datapath_id: 0x0001784856392fd6
 - n_buffers: 1024
 - n_tables: 1
 - auxiliary_id: 0
 - pads: 0
 - capabilities: 0x0000016f
 -1... .. = OFPC_FLOW_STATS: True
 -1... .. = OFPC_TABLE_STATS: True
 -1... .. = OFPC_PORT_STATS: True
 -1... .. = OFPC_GROUP_STATS: True
 -1... .. = OFPC_IP_REASM: True
 -1... .. = OFPC_QUEUE_STATS: True
 -1... .. = OFPC_PORT_BLOCKED: True
 - Reserved: 0x00000000

Two blue arrows point from the details pane to the packet list, highlighting the 'Type: OFPT_FEATURES_REPLY' field in the details pane and the corresponding packet in the list.

OpenFlow specification

datapath_id

ProVision switch DPIDs calculation

Answer:

- **The most significant 16 bits are the VLAN number associated with the OpenFlow instance. So for the OpenFlow instance configured on VLAN 30, this number will be “1E”. (30 in decimal equates to 1E in hexadecimal). Hence the switches are identified by 00:1E.**
- **Least significant 48 bits are the switch MAC address.**

OpenFlow Monitor

General / OpenFlow Monitor

Refresh | Summary | Ports | Flows | Groups

Data Path ID	Address	Neg...	Manufacturer	H/W Version	S/W Version	Serial #
00:01:78:48:59:39:21:96	10.1.1.252	1.3.0	HP	HP 5920AF-24...	Comware Soft...	CN46FFT04Z
00:1e:14:58:d0:f0:db:80	10.1.1.253	1.3.0	HP	3800-24G-2SF...	KA.15.17.0007	SG49G0V430

General / OpenFlow Monitor

Refresh | Summary | Ports | Flows | Groups

Data Path ID	Address	Negotiated Versi...	Manufacturer	H/W Version	S/W Version	Serial #
00:00:00:0c:29:e8:22:de	10.20.20.13	1.3.0	Nicira, Inc.	Open vSwitch	2.0.2	None
00:0b:78:acc0:21:2a:00	10.20.20.51	1.3.0	HP	Switch 5406zl	005	SG109SU2MW

Comware switch DPIDs calculation

DPIDs on Comware switches:

- Comprised of the instance ID and the bridge MAC address. The most significant 16 bits are the instance ID.
- The least significant 48 bits are the bridge MAC address.

General / OpenFlow Monitor

Refresh | Summary | Ports | Flows | Groups

Data Path ID	Address	Neg...	Manufacturer	H/W Version	S/W Version	Serial #
00:01:78:48:59:39:21:96	10.1.1.252	1.3.0	HP	HP 5920AF-24...	Comware Soft...	CN46FFT04Z
00:1e:14:58:d0:10:db:80	10.1.1.253	1.3.0	HP	3800-24G-25F...	KA.15.17.0007	5G49G0V430

Open vSwitch DPIDs calculation

**Open vSwitch
switch DPIDs:**

- Comprised of 00:00 and the MAC address of the OVS bridge.

General / OpenFlow Monitor

Refresh | Summary | Ports | Flows | Groups

Data Path ID	Address	Negotiated Versi...	Manufacturer	H/W Version	S/W Version	Serial #
00:00:00:0c:29:e8:22:de	10.20.20.13	1.3.0	ira, Inc.	Open vSwitch	2.0.2	None
00:0b:76:ac:c0:21:2a:00	10.20.20.51	1.3.0	HP	Switch 5406zl	K.15.16.0005	SG109SU2MW

```
sdn@KVMServer1:~$ ifconfig
```

```
...
```

```
ovsbr0  Link encap:Ethernet HWaddr 00:0c:29:e8:22:de
```

```
inet addr:172.16.1.13 Bcast:172.16.1.255 Mask:255.255.255.0
```



Investigating OpenFlow negotiations



Packet_in message

Apply

openflow_v4.packet_in.reason

The image shows a Wireshark packet capture window with the following details:

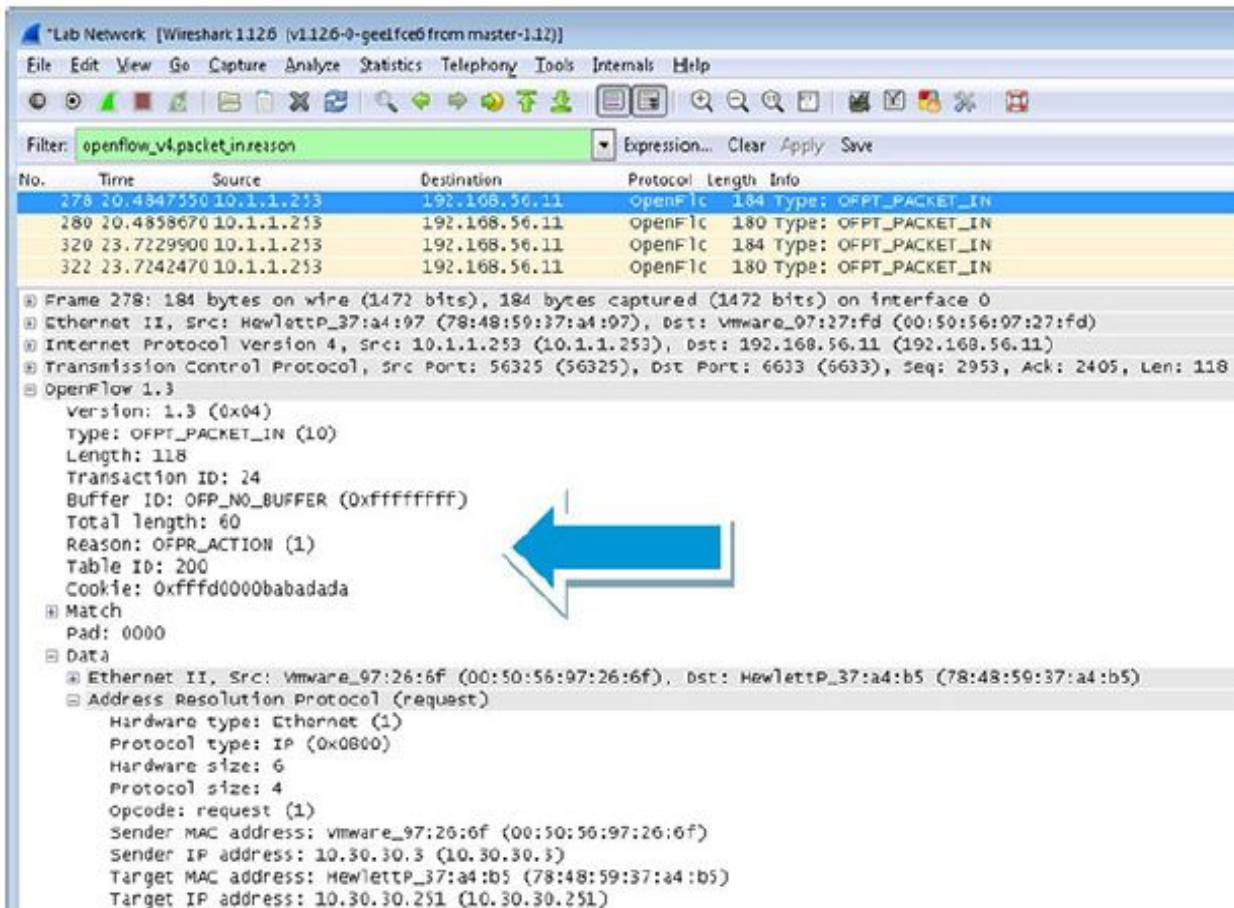
- Filter: `openflow_v4.packet_in.reason`
- Packet list table:

No.	Time	Source	Destination	Protocol	Length	Info
278	20.4847550	10.1.1.253	192.168.56.11	OpenFlc	184	Type: OFPP_PACKET_IN
280	20.4858670	10.1.1.253	192.168.56.11	OpenFlc	180	Type: OFPP_PACKET_IN
320	23.7229900	10.1.1.253	192.168.56.11	openFlc	184	Type: OFPP_PACKET_IN
327	25.7242470	10.1.1.253	192.168.56.11	openFlc	180	Type: OFPP_PACKET_IN
- Packet details for the selected packet (No. 278):
 - Frame 178: 184 bytes on wire (1472 bits), 184 bytes captured (1472 bits) on interface 0
 - Ethernet II, Src: HewlettP_37:a4:97 (78:48:59:37:a4:97), Dst: vmware_97:27:fd (00:50:56:97:27:fd)
 - Internet Protocol Version 4, Src: 10.1.1.253 (10.1.1.253), Dst: 192.168.56.11 (192.168.56.11)
 - Transmission Control Protocol, Src Port: 56325 (56325), Dst Port: 6633 (6633), Seq: 2953, Ack: 2401, Len: 118
 - OpenFlow 1.3
 - Version: 1.3 (0x04)
 - Type: OFPP_PACKET_IN (10)
 - Length: 118
 - Transaction ID: 24
 - Buffer ID: OFP_NO_BUFFER (0xffffffff)
 - Total length: 00
 - Reason: OFPP_ACTION (1)
 - Table ID: 200
 - Cookie: 0xffffd000babadada
 - Match
 - Pad: 0000
 - Data
 - Ethernet II, Src: vmware_97:26:6f (00:50:56:97:26:6f), Dst: HewlettP_37:a4:b5 (78:48:59:37:a4:b5)
 - Address Resolution Protocol (request)
 - Hardware type: Ethernet (1)
 - Protocol type: IP (0x0800)
 - Hardware size: 6
 - Protocol size: 4
 - Opcode: request (1)
 - Sender MAC address: vmware_97:26:6f (00:50:56:97:26:6f)
 - Sender IP address: 10.30.30.3 (10.30.30.3)
 - Target MAC address: HewlettP_37:a4:b5 (78:48:59:37:a4:b5)
 - Target IP address: 10.30.30.251 (10.30.30.251)

Packet_in message

Answer:

OFPR_ACTION (1)



Lab Network [Wireshark:1126 (v1126-0-geelfce6 from master-112)]

File Edit View Go Capture Analyze Statistics Telephony Tools Internals Help

Filter: openflow_v4.packet_in.reason Expression... Clear Apply Save

No.	Time	Source	Destination	Protocol	Length	Info
278	20.4847550	10.1.1.253	192.168.56.11	OpenFlc	184	Type: OFPT_PACKET_IN
280	20.4858670	10.1.1.253	192.168.56.11	OpenFlc	180	Type: OFPT_PACKET_IN
320	23.7229900	10.1.1.253	192.168.56.11	OpenFlc	184	Type: OFPT_PACKET_IN
322	23.7242470	10.1.1.253	192.168.56.11	OpenFlc	180	Type: OFPT_PACKET_IN

Frame 278: 184 bytes on wire (1472 bits), 184 bytes captured (1472 bits) on interface 0

- Ethernet II, Src: HewlettP_37:a4:97 (78:48:59:37:a4:97), Dst: Vmware_97:27:fd (00:50:56:07:27:fd)
- Internet Protocol Version 4, Src: 10.1.1.253 (10.1.1.253), Dst: 192.168.56.11 (192.168.56.11)
- Transmission Control Protocol, Src Port: 56325 (56325), Dst Port: 6633 (6633), Seq: 2953, Ack: 2405, Len: 118
- OpenFlow 1.3
 - Version: 1.3 (0x04)
 - Type: OFPT_PACKET_IN (10)
 - Length: 118
 - Transaction ID: 24
 - Buffer ID: OFP_NO_BUFFER (0xffffffff)
 - Total length: 60
 - Reason: OFPR_ACTION (1)
 - Table ID: 200
 - Cookie: 0xffff0000babadada
- Match
 - Pad: 0000
- Data
 - Ethernet II, Src: Vmware_97:26:6f (00:50:56:97:26:6f), Dst: HewlettP_37:a4:b5 (78:48:59:37:a4:b5)
 - Address Resolution Protocol (request)
 - Hardware type: Ethernet (1)
 - Protocol type: IP (0x0800)
 - Hardware size: 6
 - Protocol size: 4
 - Opcode: request (1)
 - Sender MAC address: vmware_97:26:6f (00:50:56:97:26:6f)
 - Sender IP address: 10.30.30.3 (10.30.30.3)
 - Target MAC address: HewlettP_37:a4:b5 (78:48:59:37:a4:b5)
 - Target IP address: 10.30.30.251 (10.30.30.251)

Packet_in message

```
/* Why is this packet being sent to the controller? */
```

```
enum ofp_packet_in_reason {
```

```
    OFPR_NO_MATCH = 0, /* No matching flow (table-miss flow entry). */
```

```
    OFPR_ACTION = 1, /* Action explicitly output to controller. */
```

```
    OFPR_INVALID_TTL = 2, /* Packet has invalid TTL */
```

Packet_in message



The screenshot shows the HP VAN SDN Controller web interface. The browser address bar displays `https://192.168.56.11:8443/sdn/ui/app/index#ofmon`. The page title is "HP VAN SDN Controller". The left sidebar contains navigation links: General, Alerts, Applications, Configurations, Audit Log, Licenses, Team, Flow Maker Deluxe, and Support Logs. The "OpenFlow Monitor" link is highlighted in blue. The main content area is titled "General / OpenFlow Monitor" and features a "Refresh" button and tabs for "Summary", "Ports", "Flows", and "Groups". The "Summary" tab is active, displaying a table of OpenFlow switches.

Data Path ID	Address	Negotia...	Manufacturer	H/W Version	S/W Version
00:01:78:48:59:39:21:96	10.1.1.252	1.3.0	HP	HP 5920AF-24...	Comware Soft...
00:1e:14:58:d0:f0:db:80	10.1.1.253	1.3.0	HP	3800-24G-2SF...	KA.15.17.0007

Packet_in message

Flows for Data Path ID: 00:1e:14:58:d0:f0:db:80

Summary Ports **Flows**

Table ID	Priority	Packets	Bytes	Match	Actions/Instructions	Flow Class ID
0	0	0	0		goto_table: 100	com.hp.sdn.ip.normal
100	31500	0	0	eth_type: ipv4 ip_proto: udp udp_src: 67 udp_dst: 68	goto_table: 200	com.hp.sdn.dhcp.copy
100	31500	0	0	eth_type: ipv4 ip_proto: udp udp_src: 68 udp_dst: 67	goto_table: 200	com.hp.sdn.dhcp.copy
100	60000	0	0	eth_type: bddp	apply_actions: output: CONTROLLER	com.hp.sdn.bddp.steal
100	31000	40	0	eth_type: arp	goto_table: 200	com.hp.sdn.arp.copy

Duration (secs): 1521
Duration (insecs): 142000000
Idle Timeout: 0
Hard Timeout: 0
Cookie: 0x11fd0000babadada
Buffer ID:
Flow Mod Flags:

Flow Class ID: com.hp.sdn.arp.copy
Base Cookie: 0x11fd
Description: Copies ARP requests for node location



Result: The controller is copying ARP messages so that it can discover hosts on the network.

Table-miss flow entry

Answer:

Answer:

Result:

Flows for Data Path ID: 00:1e:14:58:d0:f0:db:80

						Summary	Ports	Flows
▶	100	31000	42	0	eth_type: arp	goto_table: 200	com.hp.sdn.arp.copy	
▪	100	0	413	1300...		apply_actions: output: NORMAL	com.hp.sdn.normal	

Duration (secs): 1799

Duration (nsecs): 991000000

Idle Timeout: 0

Hard Timeout: 0

Cookie: 0xf1ff000000000000

Buffer id:

Flow Mod Flags: send_flow_rem

Flow Class ID: com.hp.sdn.normal

Base Cookie: 0xf1ff

Description: Default treatment of flow misses via normal switch-based forwarding



Table-miss flow entry

Flows for Data Path ID: 00:01:78:48:59:39:2f:96

Summary Ports **Flows** Groups

Table ID	Priority	Packets	Bytes	Match	Actions/Instructions	Flow Class ID
▸ 0	60000	0	n/a	eth_type: bddp	apply_actions: output: CONTROLLER	com.hp.sdn.bddp.steal
▸ 0	31500	40	n/a	eth_type: ipv4 ip_proto: udp udp_src: 68 udp_dst: 67	apply_actions: output: CONTROLLER write_actions: output: NORMAL	com.hp.sdn.dhcp.copy
▸ 0	31500	0	n/a	eth_type: ipv4 ip_proto: udp udp_src: 67 udp_dst: 68	apply_actions: output: CONTROLLER write_actions: output: NORMAL	com.hp.sdn.dhcp.copy
▸ 0	31000	0	n/a	eth_type: arp	apply_actions: output: CONTROLLER write_actions: output: NORMAL	com.hp.sdn.arp.copy
▸ 0	0	115	n/a		apply_actions: output: NORMAL	com.hp.sdn.ip.normal



Table-miss flow entry

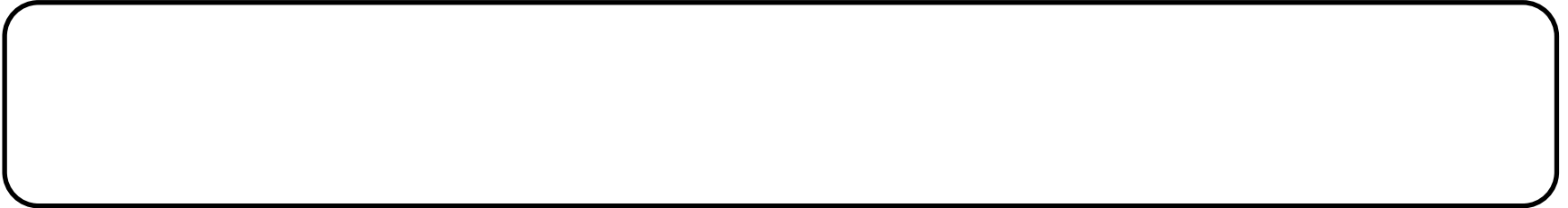
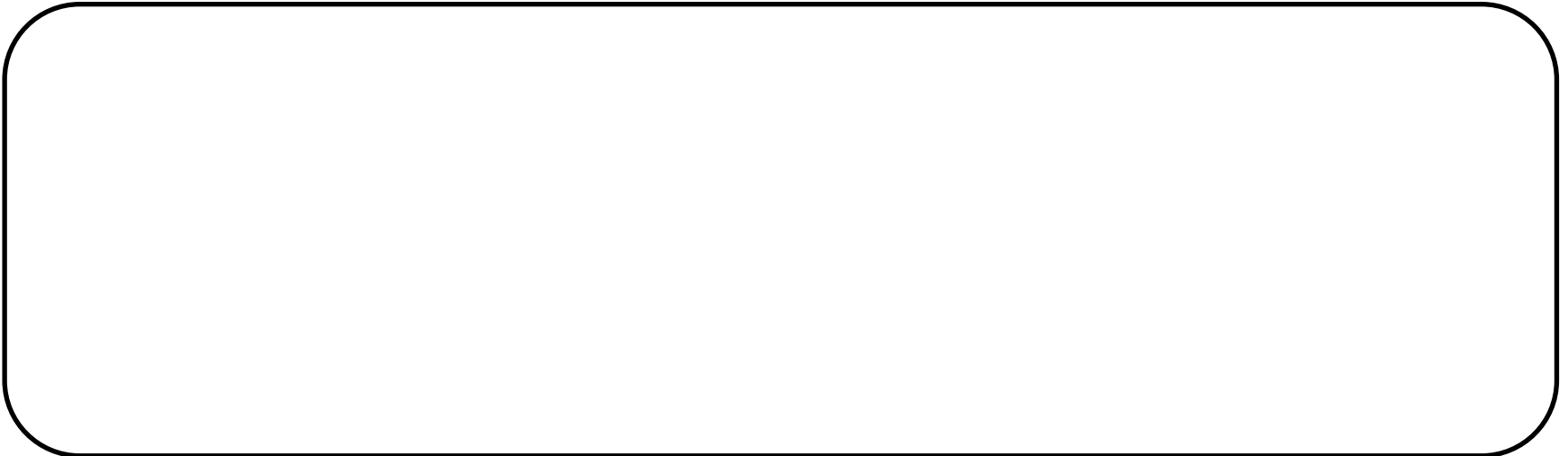
An empty rounded rectangular box with a black border, intended for a diagram or text.An empty rounded rectangular box with a black border, intended for a diagram or text.A large empty rounded rectangular box with a black border, intended for a diagram or text.

Table-miss flow entry

Answer:

Flows for Data Path ID: 00:1e:14:58:d0:f0:db:80

					Summary	Ports	Flows	Groups
Table ID	Priority	Packets	Bytes	Match	Actions/Instructions		Flow Class ID	
▶ 0	0	0	0		igoto_table: 100		com.hp.sdn.ip.normal	
▶ 100	31500	0	0	eth_type: ipv4 ip_proto: udp udp_src: 67 udp_dst: 68	igoto_table: 200		com.hp.sdn.dhcp.copy	
▶ 100	31500	0	0	eth_type: ipv4 ip_proto: udp udp_src: 68 udp_dst: 67	igoto_table: 200		com.hp.sdn.dhcp.copy	
▶ 100	60000	0	0	eth_type: bddp	apply_actions: output: CONTROLLER		com.hp.sdn.bddp.steal	
▶ 100	31000	44	0	eth_type: arp	igoto_table: 200		com.hp.sdn.arp.copy	
▶ 100	0	440	1300...		apply_actions: output: NORMAL		com.hp.sdn.ip.normal	
▶ 200	31000	44	2640	eth_type: arp	apply_actions: output: CONTROLLER output: NORMAL		com.hp.sdn.arp.copy	
▶ 200	31500	0	0	eth_type: ipv4 ip_proto: udp udp_src: 67 udp_dst: 68	apply_actions: output: CONTROLLER output: NORMAL		com.hp.sdn.dhcp.copy	
▶ 200	31500	0	0	eth_type: ipv4 ip_proto: udp udp_src: 68 udp_dst: 67	apply_actions: output: CONTROLLER output: NORMAL		com.hp.sdn.dhcp.copy	
▶ 200	0	0	0		apply_actions: output: NORMAL		com.hp.sdn.ip.normal	

Table-miss flow entry

Answer:

Answer:



Investigating OpenFlow negotiations



OpenFlow tables

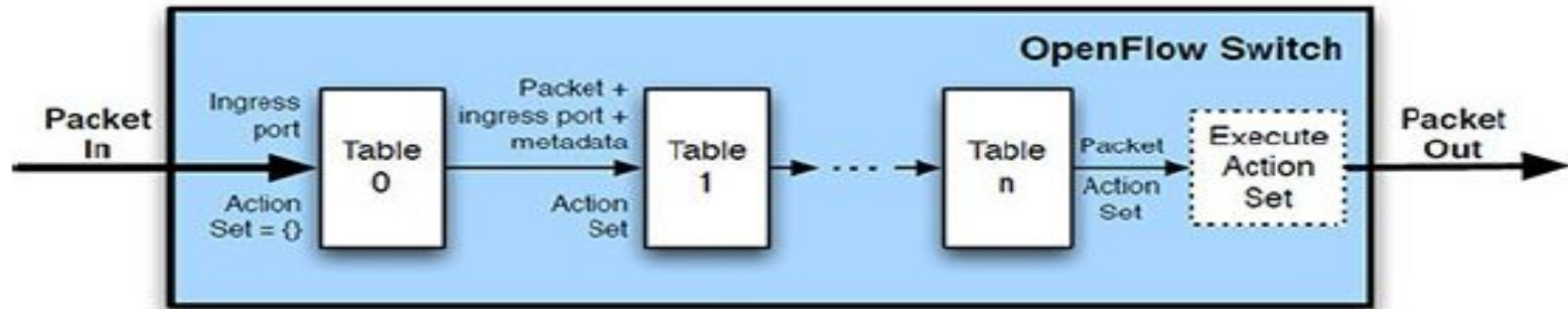
Answer:

Answer:

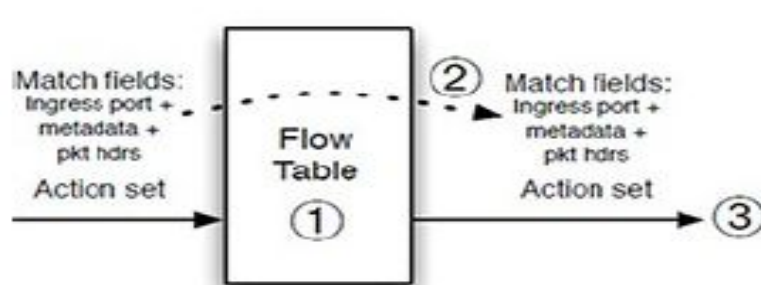
Answer:

Answer:

OpenFlow tables



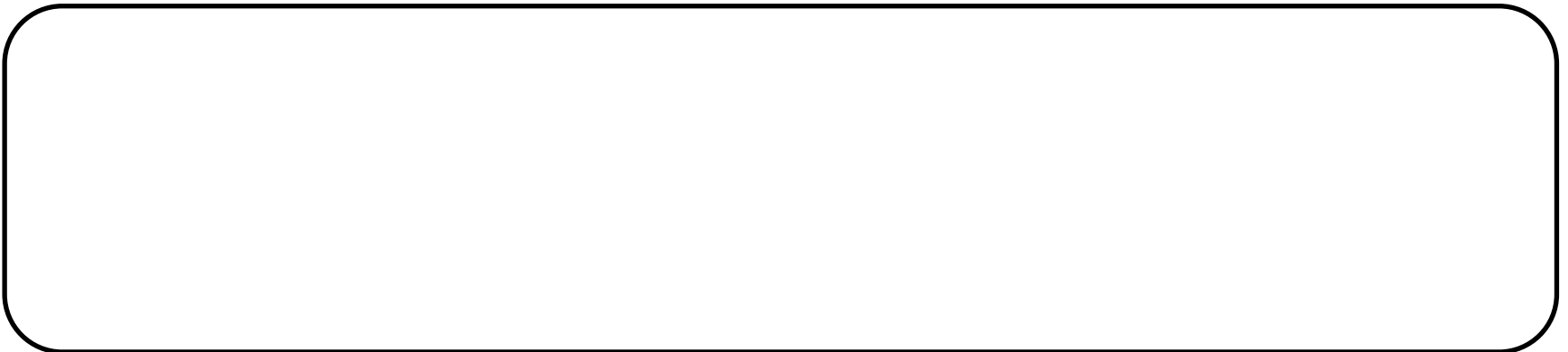
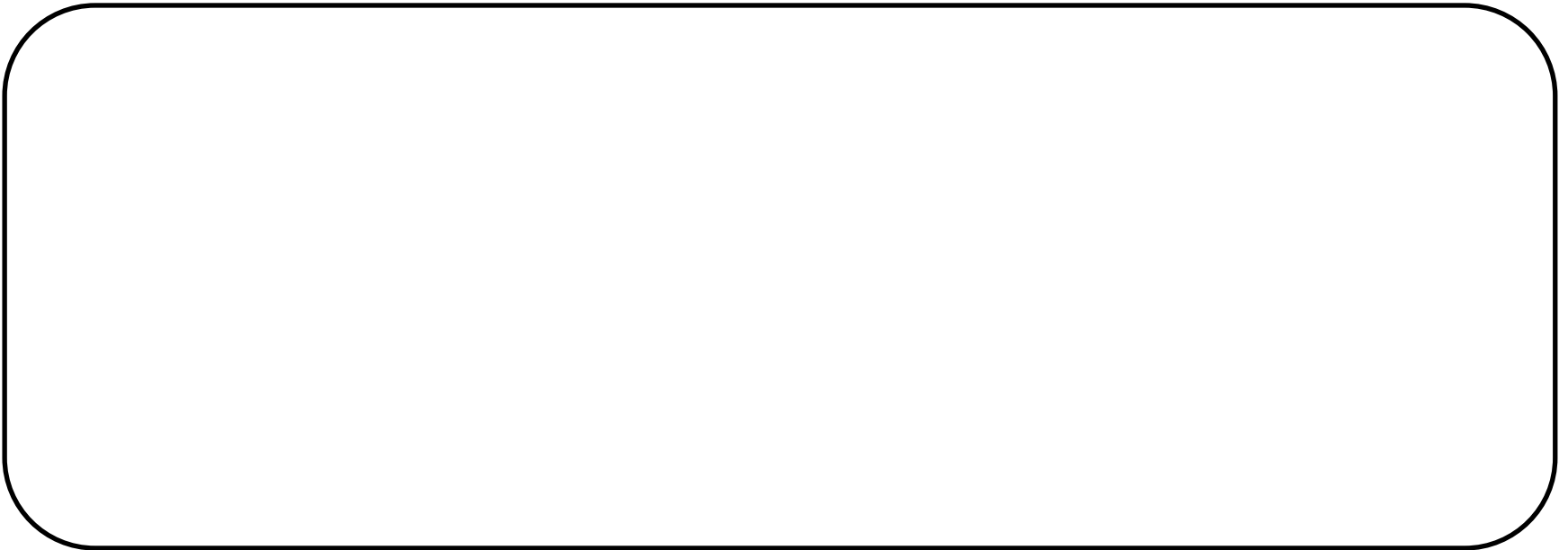
(a) Packets are matched against multiple tables in the pipeline



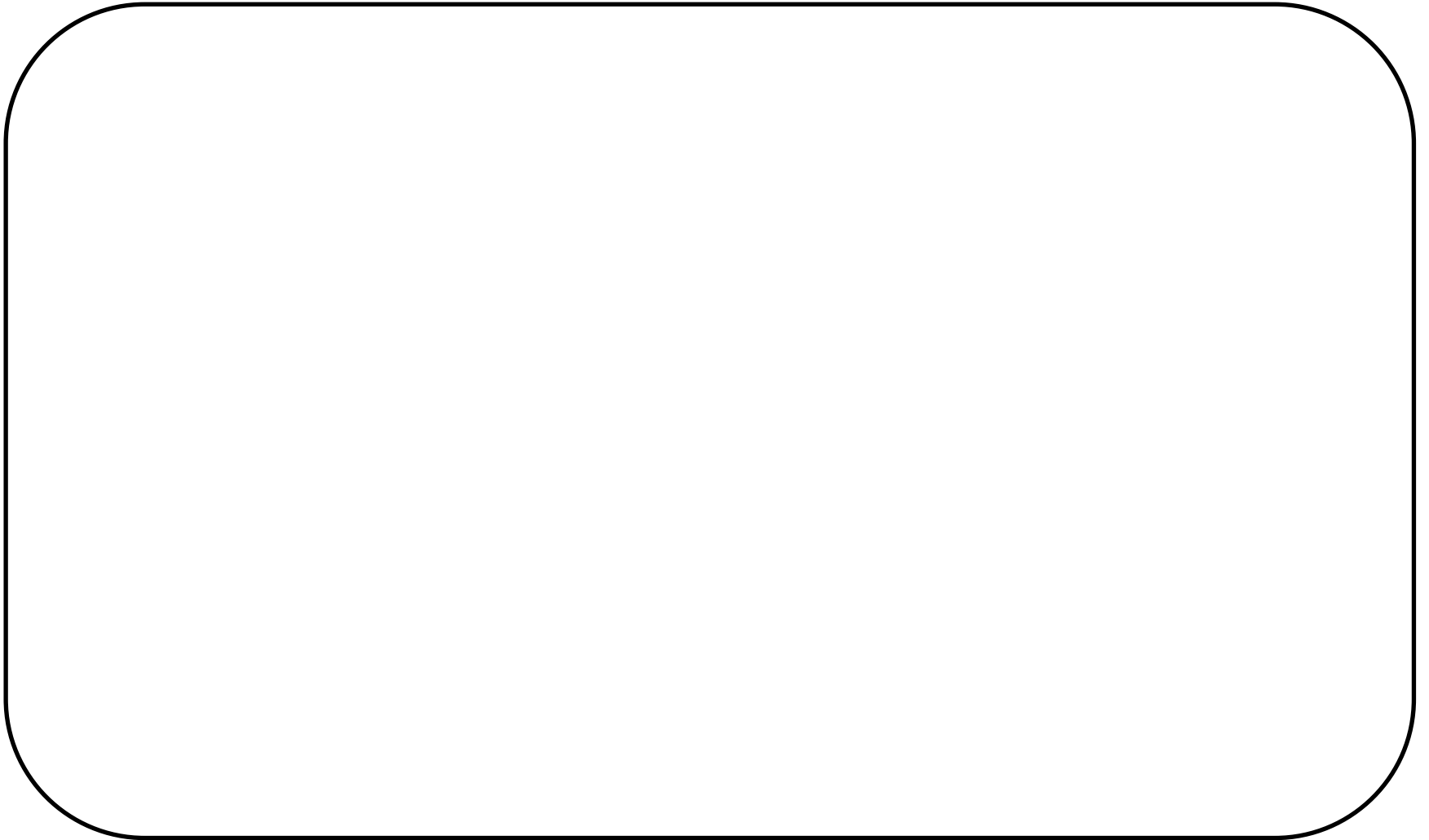
- ① Find highest-priority matching flow entry
- ② Apply instructions:
 - i. Modify packet & update match fields (apply actions instruction)
 - ii. Update action set (clear actions and/or write actions instructions)
 - iii. Update metadata
- ③ Send match data and action set to next table

(b) Per-table packet processing

OpenFlow tables



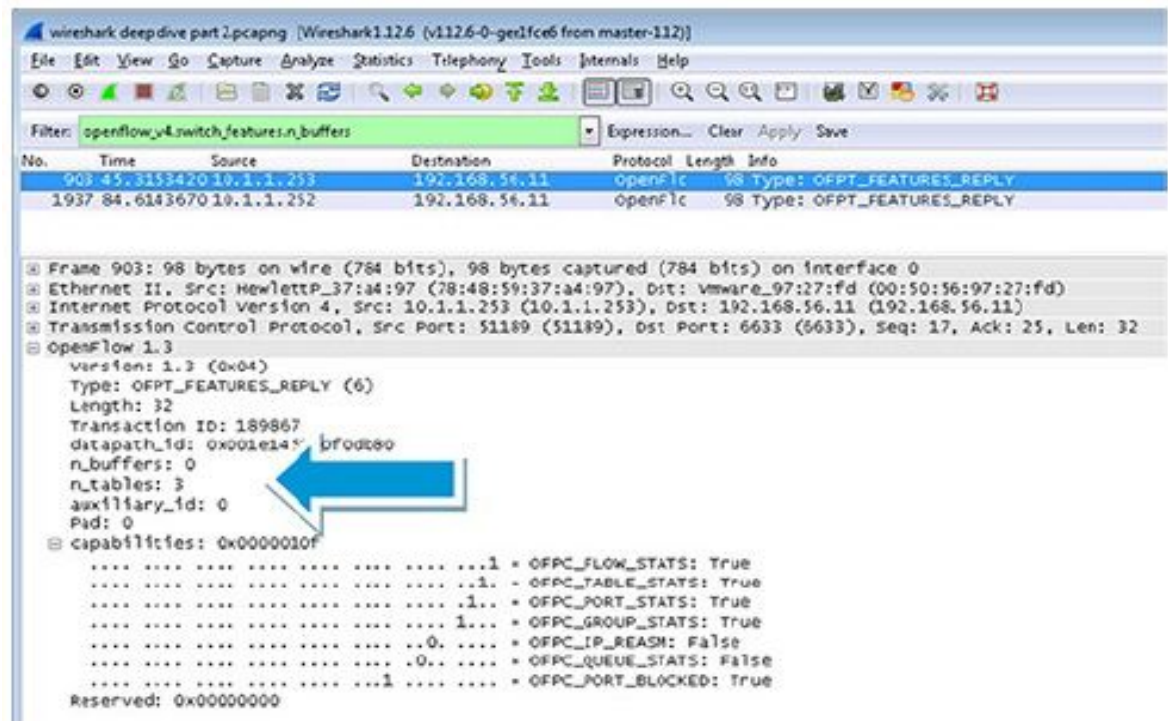
OpenFlow tables



OpenFlow tables

Apply
openflow_v4.switch_features.n_buffers

Result:

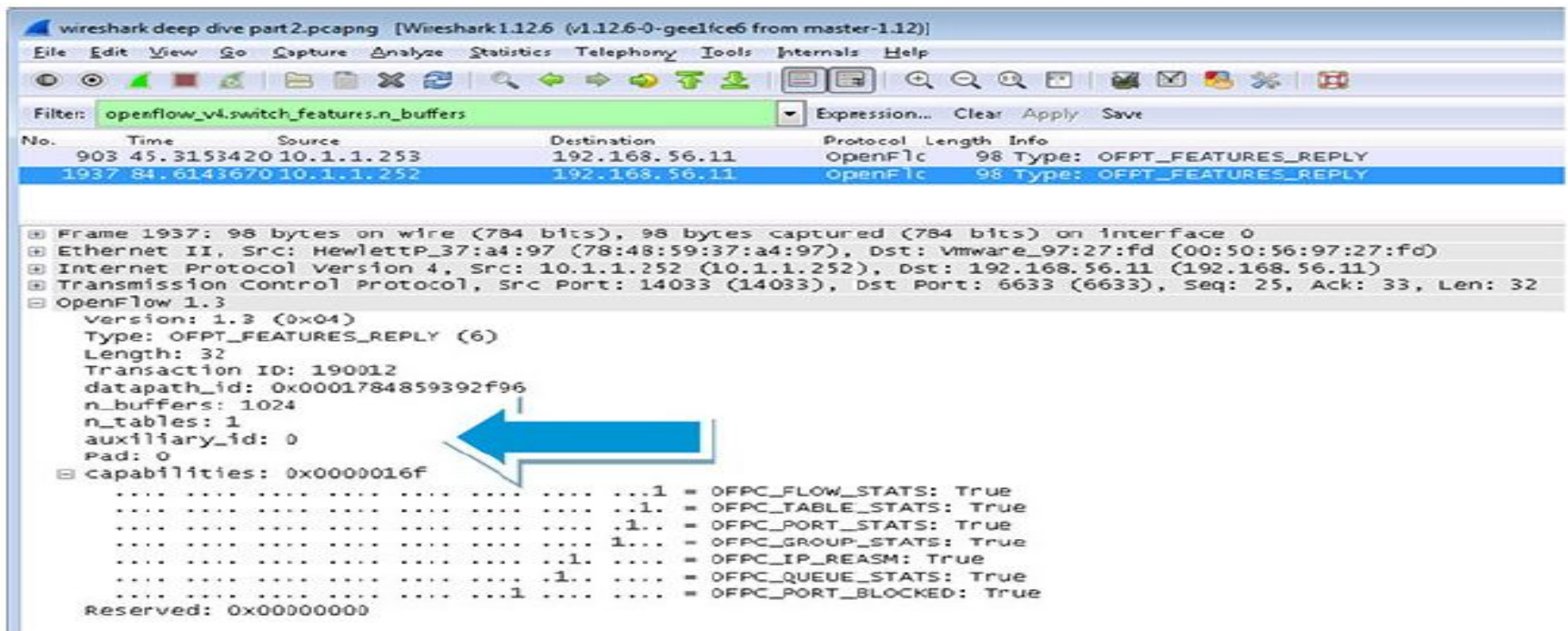


The image shows a Wireshark capture of an OpenFlow 1.3 OFPT_FEATURES_REPLY message. The packet list pane shows two packets: packet 903 (time 45.3153420) and packet 1937 (time 84.6143670). The packet details pane for packet 903 shows the following structure:

```
OpenFlow 1.3
  version: 1.3 (0x04)
  Type: OFPT_FEATURES_REPLY (6)
  Length: 32
  Transaction ID: 189867
  datapath_id: 0x001e245b0f0d00
  n_buffers: 0
  n_tables: 3
  auxiliary_id: 0
  Pad: 0
  capabilities: 0x0000010f
    ..1 = OFFC_FLOW_STATS: True
    ..1. = OFFC_TABLE_STATS: True
    ..1. = OFFC_PORT_STATS: True
    ..1... = OFFC_GROUP_STATS: True
    ..0. = OFFC_IP_REASM: False
    ..0. = OFFC_QUEUE_STATS: False
    ..1 = OFFC_PORT_BLOCKED: True
  Reserved: 0x00000000
```

A blue arrow points to the `n_buffers: 0` field in the packet details pane.

OpenFlow tables



Filter: openflow_v4.switch_features.n_buffers

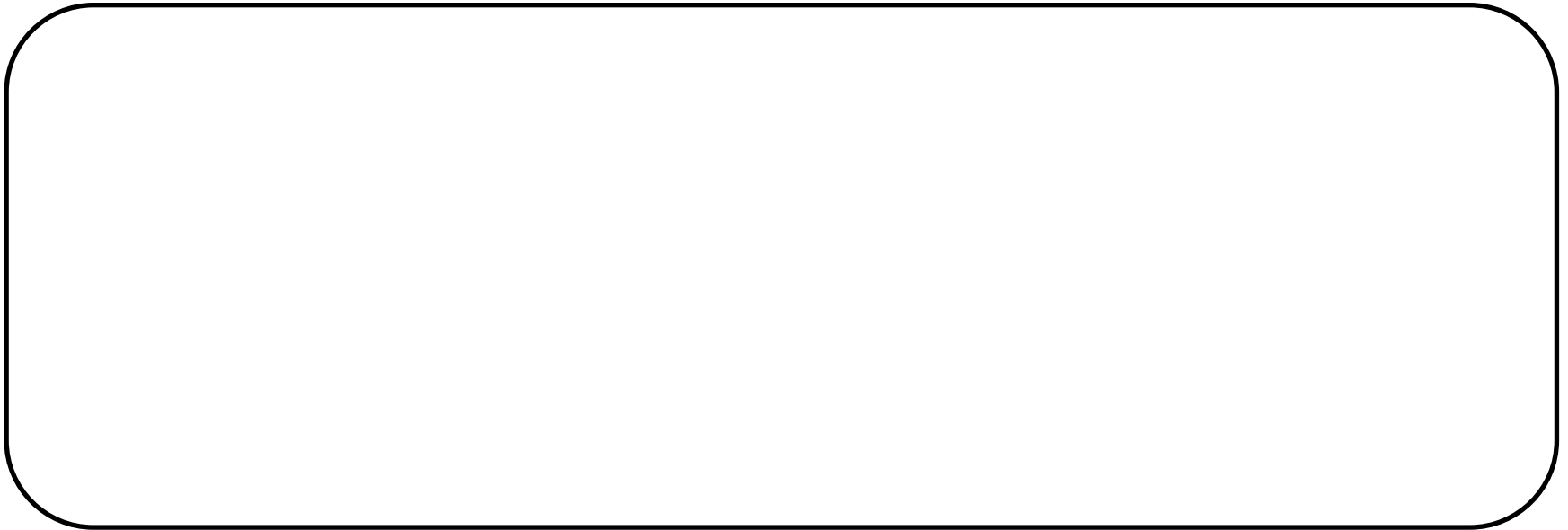
No.	Time	Source	Destination	Protocol	Length	Info
903	45.3153420	10.1.1.253	192.168.56.11	OpenFlc	98	Type: OFPT_FEATURES_REPLY
1937	84.6143670	10.1.1.252	192.168.56.11	OpenFlc	98	Type: OFPT_FEATURES_REPLY

Frame 1937: 98 bytes on wire (784 bits), 98 bytes captured (784 bits) on interface 0

- Ethernet II, Src: HewlettP_37:a4:97 (78:48:59:37:a4:97), Dst: Vmware_97:27:fd (00:50:56:97:27:fd)
- Internet Protocol Version 4, Src: 10.1.1.252 (10.1.1.252), Dst: 192.168.56.11 (192.168.56.11)
- Transmission Control Protocol, Src Port: 14033 (14033), Dst Port: 6633 (6633), Seq: 25, Ack: 33, Len: 32
- OpenFlow 1.3
 - Version: 1.3 (0x04)
 - Type: OFPT_FEATURES_REPLY (6)
 - Length: 32
 - Transaction ID: 190012
 - datapath_id: 0x0001784859392f96
 - n_buffers: 1024
 - n_tables: 1
 - auxiliary_id: 0
 - Pad: 0
 - capabilities: 0x0000016f
 -1 = OFPC_FLOW_STATS: True
 -1 = OFPC_TABLE_STATS: True
 -1 = OFPC_PORT_STATS: True
 -1 = OFPC_GROUP_STATS: True
 -1 = OFPC_IP_REASM: True
 -1 = OFPC_QUEUE_STATS: True
 -1 = OFPC_PORT_BLOCKED: True
 - Reserved: 0x00000000

Result:

OpenFlow tables



OpenFlow Monitor



HP VAN SDN Controller

45 sdn

General

Summary for Data Path ID: 00:1e:14:58:d0:f0:db:80

Summary Ports Flows Groups

Manufacturer:	HP	Data Path ID:	00:1e:14:58:d0:f0:db:80
H/W Version:	3800-24G-2SFP+ Switch	Address:	10.1.1.253
S/W Version:	KA.15.17.0007	Port:	51189
Serial #:	SG49G0V430	Negotiated Version:	1.3.0
Description:		# Tables:	3
		# Buffers:	0

Capabilities

flow_stats
table_stats
port_stats
group_stats
port_blocked



OpenFlow Monitor

OpenFlow Topology

OpenFlow Trace

OpenFlow Classes

Packet Listeners

OpenFlow Monitor



HP VAN SDN Controller

45 sdn

General

Summary for Data Path ID: 00:01:78:48:59:39:2f:96

Summary Ports Flows Groups

Manufacturer:	HP	Data Path ID:	00:01:78:48:59:39:2f:96
H/W Version:	HP 5920AF-24XG Switch	Address:	10.1.1.252
S/W Version:	Comware Software, Version 7.1.045	Port:	14033
Serial #:	CN46FFT04Z	Negotiated Version:	1.3.0
Description:		# Tables:	1
		# Buffers:	1024



Capabilities

flow_stats
table_stats
port_stats
group_stats
ip_reasm
queue_stats
port_blocked

OpenFlow Monitor

OpenFlow Topology

OpenFlow Trace

OpenFlow Classes

Packet Listeners

Flow table of the ProVision switch



Flows for Data Path ID: 00:1e:14:58:d0:f0:db:00

Table ID	Priority	Packets	Bytes	Match	Actions/Instructions	Flow Class ID
0	0	0	0		gate_table: 100	com.hp.sdn.ip.normal
100	31500	0	0	eth_type: ipv4 ip_proto: udp udp_src: 67 udp_dst: 68	gate_table: 200	com.hp.sdn.dhcp.capy
100	31500	0	0	eth_type: ipv4 ip_proto: udp udp_src: 68 udp_dst: 67	gate_table: 200	com.hp.sdn.dhcp.capy
100	60000	0	0	eth_type: bddp	apply_actions: output: CONTROLLER	com.hp.sdn.bddp.sreal
100	31000	44	0	eth_type: arp	gate_table: 200	com.hp.sdn.arp.capy
100	0	440	1300...		apply_actions: output: NORMAL	com.hp.sdn.ip.normal
200	31000	44	2640	eth_type: arp	apply_actions: output: CONTROLLER output: NORMAL	com.hp.sdn.arp.capy
200	31500	0	0	eth_type: ipv4 ip_proto: udp udp_src: 67 udp_dst: 68	apply_actions: output: CONTROLLER output: NORMAL	com.hp.sdn.dhcp.capy
200	31500	0	0	eth_type: ipv4 ip_proto: udp udp_src: 68 udp_dst: 67	apply_actions: output: CONTROLLER output: NORMAL	com.hp.sdn.dhcp.capy
200	0	0	0		apply_actions: output: NORMAL	com.hp.sdn.ip.normal



Flow table of the ProVision switch

Answer

- **(1) Arriving traffic is first matched on the entries in the first OpenFlow table in the pipeline (Table 0). This table has a single entry, which is a table-miss entry (priority zero, match anything). The entry has a goto statement to send traffic to Table 100.**
- **(2) DHCP traffic will match either of the entries in Table 100 with priority of 31500. The entries have a goto statement to send traffic to Table 200. There are two DHCP entries — UDP port 67 is the client DHCP listen port and UDP port 68 is the server DHCP listen port. Two entries have been added to match flows in both directions.**
- **(3) DHCP traffic will match either of the entries in Table 200 with priority of 31500. The entries have an apply action of both output to CONTROLLER and output NORMAL. Thus, DHCP traffic is sent to the normal pipeline (traditional routing and switching) and is also copied to the controller.**

Flow table of the ProVision switch

```
P1# show openflow instance vlan30 flow-table
```

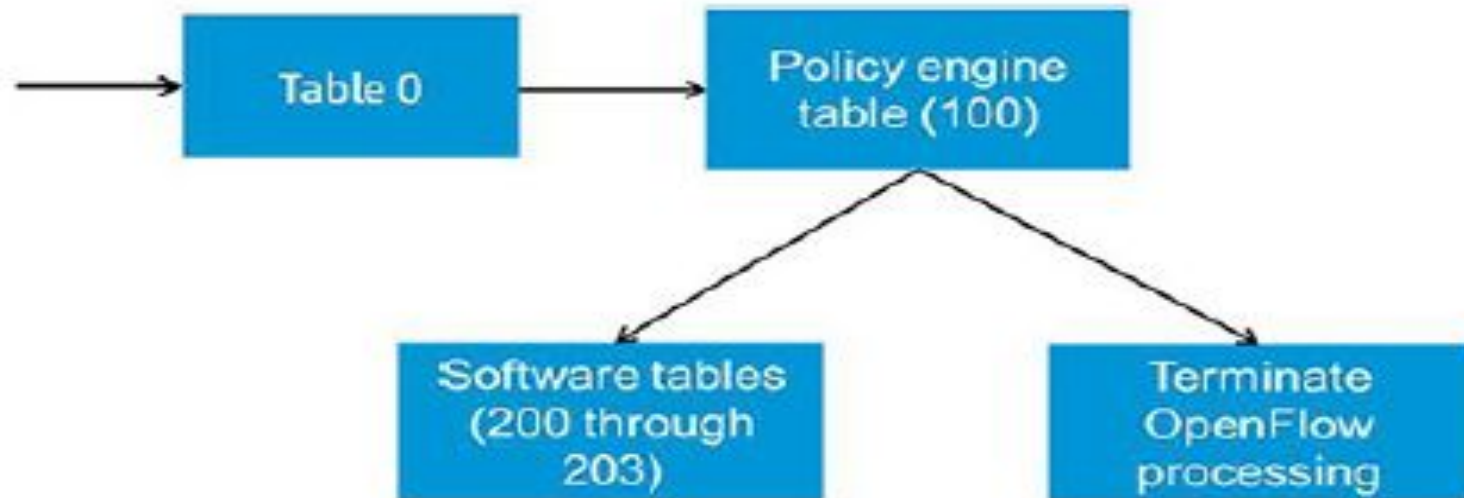
```
OpenFlow Instance Flow Table Information
```

Table	Flow	Available	Free	Miss	
ID	Table Name	Count	Flow Count	Count	Goto Table
0	start	1	NA	0	100
100	Policy Table	5	NA	469	200
200	SW Table 1	4	NA	0	*

```
* Denotes that the pipeline could end here.
```

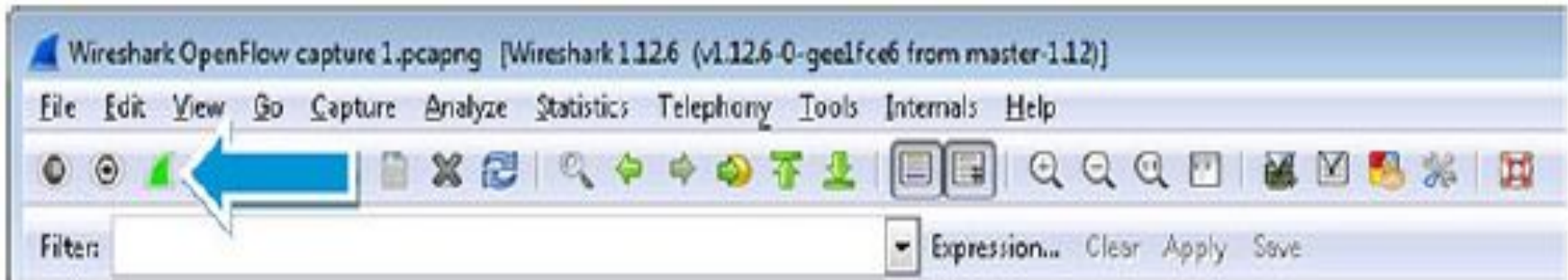
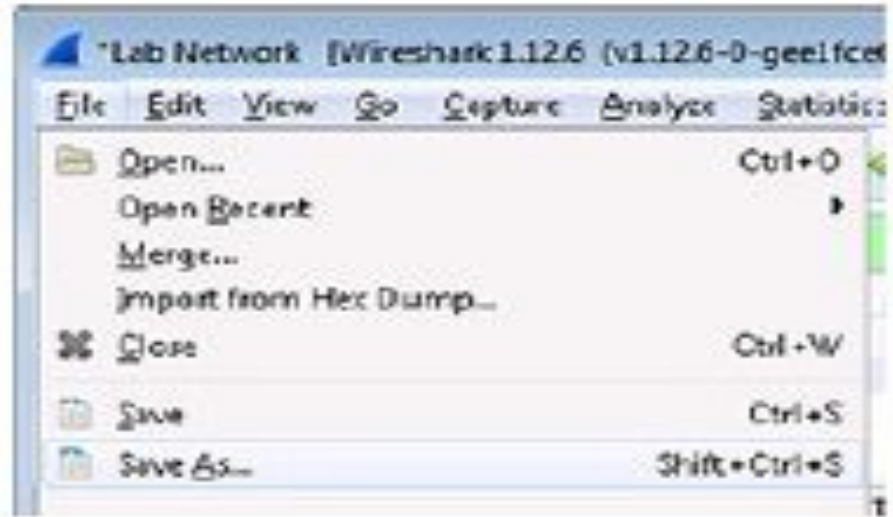
```
P1#
```


Flow table of the ProVision switch

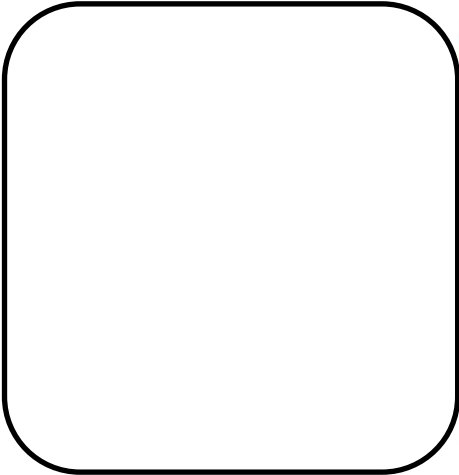


Result:

Flow table of the ProVision switch



Flow table of the ProVision switch



hp HP VAN SDN Controller 53 sda

General / Flow Maker Deluxe

Northbound Refresh

DataPathId	Device IP	Manufacturer	Hardware	OF Version
00:01:78:48:59:39:21:96	10.1.1.252	HP	HP 5920AF-24XGSwi...	1.3.0
00:1e:14:58:d0:f0:db:80	10.1.1.253	HP	3800-24G-2SFP+Swi...	1.3.0



Add

Flows for Data Path ID: 00:1e:14:58:d0:f0:db:80

Northbound Refresh Add Saved Unsaved Other

Table ID	Priority	Packets	Bytes	Match Fields	Actions
0	0	0	0		goto_table: 100
100	31500	0	0	eth_type: ipv4 ip_proto: udp udp_src: 67 udp_dst: 68	goto_table: 200
100	31500	0	0	eth_type: ipv4 ip_proto: udp udp_src: 68 udp_dst: 67	goto_table: 200
100	60000	0	0	eth_type: bddp	apply_actions: output: CONTROLLER
100	31000	90	0	eth_type: arp	goto_table: 200



Flow table of the ProVision switch

31. Program a new flow entry in Table 0 of the ProVision switch 1 (P1) that drops all ingress traffic on port 2.

Will this rule work?

Add a flow entry with the following attributes and then click **Add** (see Figure).

- Table ID: **0**
- Priority: **100**
- In Port: **2**
- Instructions: **Apply Action**
- Action 1: **No Action**
- Save Flow = **True**

■ Add Flow to Data Path ID: 00:1e:14:58:d0:f0:db:80

Northbridge
FABRY CORPORATION

Clear Add

Metadata

Table ID: 0
Priority: 100
Idle Timeout:
Hard Timeout:

Match

Source MAC:
Source IP:
Source Netmask:
Source Port:
VLAN ID:
Dest. MAC:
Dest. IP:
Dest. Netmask:
Dest. Port:
In Port: 2

Protocol

IP Protocol:
Ethernet Type:

Instructions

Instructions: Apply Actions
Table:

Actions

Action 1: No Action
Action 2: No Action
Action 3: No Action
Action 4: No Action
Value:
Value:
Value:
Value:

Options

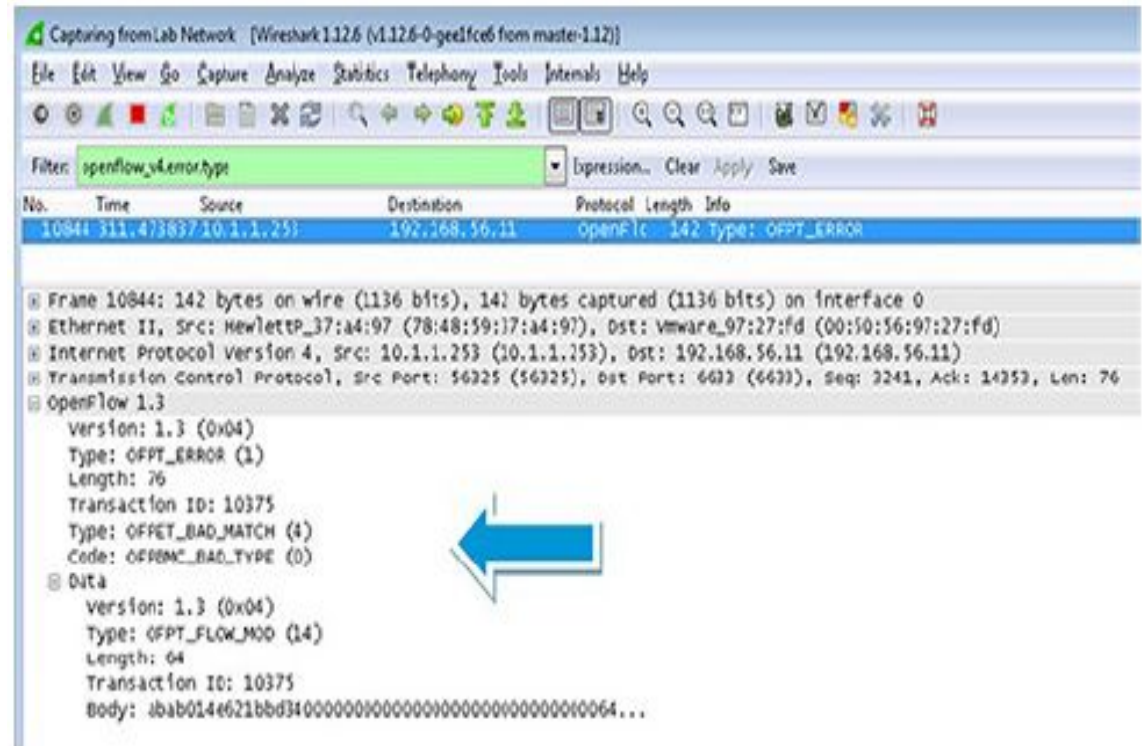
Save Flow

Result:

Flow table of the ProVision switch

Apply

openflow_v4.error.type



Capturing from Lab Network [Wireshark 1.12.6 (v1.12.6-0-geefc6b from master-1.12)]

File Edit View Go Capture Analyze Statistics Telephony Tools Internals Help

Filter: **openflow_v4.error.type** Expression... Clear Apply Save

No.	Time	Source	Destination	Protocol	Length	Info
10844	311.473837	10.1.1.253	192.168.56.11	OpenFlow	142	Type: OFPT_ERROR

Frame 10844: 142 bytes on wire (1136 bits), 142 bytes captured (1136 bits) on interface 0

- Ethernet II, Src: HewlettP_37:a4:97 (78:48:59:17:a4:97), Dst: Vmware_97:27:fd (00:50:56:97:27:fd)
- Internet Protocol Version 4, Src: 10.1.1.253 (10.1.1.253), Dst: 192.168.56.11 (192.168.56.11)
- Transmission Control Protocol, Src Port: 56325 (56325), Dst Port: 6633 (6633), Seq: 2241, Ack: 14253, Len: 76
- OpenFlow 1.3
 - Version: 1.3 (0x04)
 - Type: OFPT_ERROR (1)
 - Length: 76
 - Transaction ID: 10375
 - Type: OFPET_BAD_MATCH (4)
 - Code: OFPBMC_BAD_TYPE (0)
- Data
 - Version: 1.3 (0x04)
 - Type: OFPT_FLOW_MOD (14)
 - Length: 64
 - Transaction ID: 10375
 - Body: :bab014e621bbd3400064...

- **Type: OFPET_BAD_MATCH = 4**
- **Code: OFPBMC_BAD_TYPE = 0**

Flow table of the ProVision switch

```
P1# show openflow instance vlan30 flow-table 0 table-capability
```

```
OpenFlow Flow Table Properties
```

```
Table Match Capabilities:
```

```
Table Instructions:
```

```
Table-Miss Instructions:
```

```
GoTo 100
```

```
P1#
```

Result:

Flow table of the ProVision switch

Will this rule work?
Add a flow entry with the following attributes and then click **Add** (see Figure).

- Table ID: **100**
- Priority: **100**
- Src Mac: **aaaabbbbcccc**
- Instructions: **Apply Action**
- Action 1: **No Action**
- Save Flow = **True**

The screenshot shows the configuration page for adding a flow entry. The title is "Add Flow to Data Path ID: 00:1e:14:3b:00:0c:0b:07". The interface includes several sections:

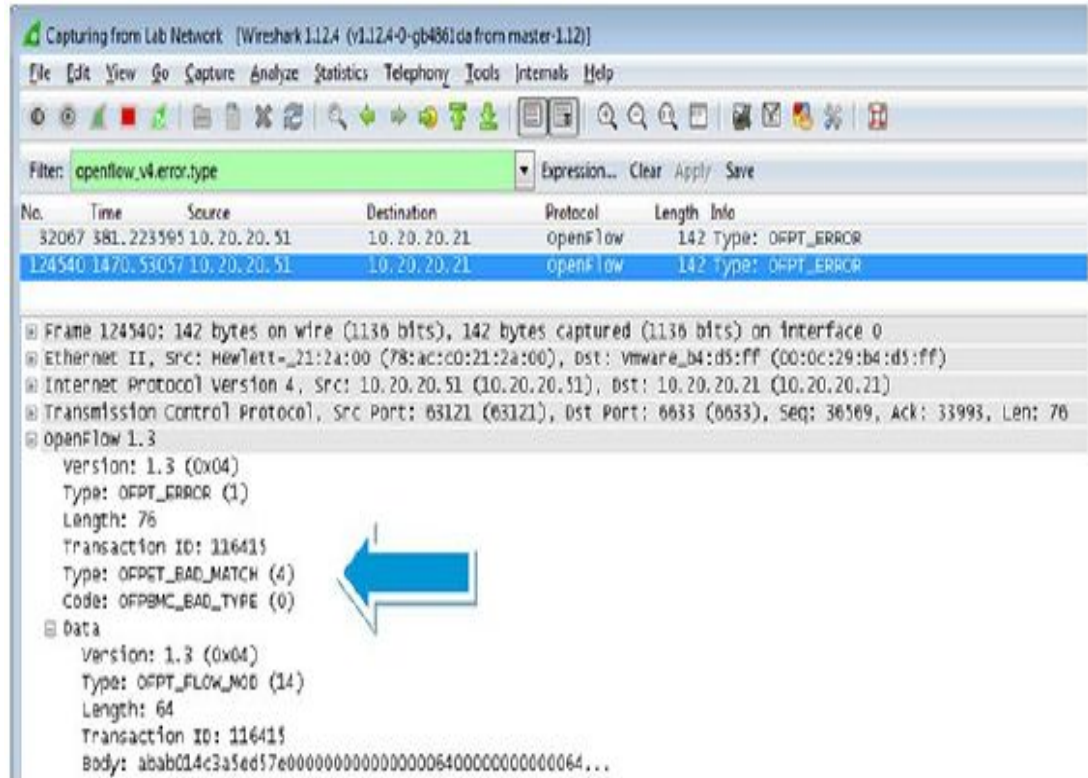
- Metadata:** Table ID (100), Priority (100), Age Timeout, and Hard Timeout.
- Match:** Source MAC (aaaabbbbcccc), Source IP, Source Network, Source Port, VLAN ID, Dest MAC, Dest IP, Dest Network, Dest Port, and In Port.
- Protocol:** IP Protocol and Ethernet Type.
- Instructions:** Instruction (Apply Action) and Table.
- Actions:** Action 1 (No Action), Action 2 (No Action), Action 3 (No Action), and Action 4 (No Action).
- Options:** A checkbox for "Save Flow".

A large blue arrow points to the "Add" button in the top right corner of the form.

Flow table of the ProVision switch

The same error code displays:

- Type:
OFPET_BAD_MATCH = 4
- Code:
OFPBMC_BAD_TYPE = 0



Capturing from Lab Network (Wireshark 1.12.4 (v1.12.4-0-gb4861da from master-1.12))

Filter: openflow.v4.error.type

No.	Time	Source	Destination	Protocol	Length	Info
32067	381.223595	10.20.20.51	10.20.20.21	openFlow	142	Type: OFPT_ERROR
124540	1470.53057	10.20.20.51	10.20.20.21	openFlow	142	Type: OFPT_ERROR

Frame 124540: 142 bytes on wire (1136 bits), 142 bytes captured (1136 bits) on interface 0

- Ethernet II, Src: Hewlett_21:2a:00 (78:ac:co:21:2a:00), Dst: vmware_b4:d5:ff (00:0c:29:b4:d5:ff)
- Internet Protocol Version 4, Src: 10.20.20.51 (10.20.20.51), Dst: 10.20.20.21 (10.20.20.21)
- Transmission Control Protocol, Src Port: 63121 (63121), Dst Port: 6633 (6633), Seq: 36509, Ack: 33993, Len: 76
- OpenFlow 1.3
 - Version: 1.3 (0x04)
 - Type: OFPT_ERROR (1)
 - Length: 76
 - Transaction ID: 116415
 - Type: OFPET_BAD_MATCH (4)
 - Code: OFPBMC_BAD_TYPE (0)
- Data
 - Version: 1.3 (0x04)
 - Type: OFPT_FLOW_MOD (14)
 - Length: 64
 - Transaction ID: 116415
 - Body: abab014c3a5ed57e0000000000000000640000000000064...

Flow table of the ProVision switch



V2 ASICs	3500	3800 V1 ASICs
-----------------	-------------	--------------------------------

Flow table of the ProVision switch

Standard Match Model (v1) K_15_17



OpenFlow Match (H/W) [1.5k Rules on V1]

The following OpenFlow fields can be matched in hardware

IN PORT	VLAN ID	ETHERNET TYPE	IP SRC (=4/v6)	IP DST (=4/v6)	IP PRSTO	IP DSCP	TCP/UDP SRC	TCP/UDP DST
---------	---------	---------------	----------------	----------------	----------	---------	-------------	-------------

OpenFlow Action (H/W)

The following OpenFlow actions can be executed in hardware

Q/P Single Port	Modify VLAN PRIORITY	Modify IP DSCP
-----------------	----------------------	----------------

Flow table of the ProVision switch

Details V1 ASICs:

- **Tables: 0 (read-only), Table 100 (TCAM), Table 200 (Software).**
- **Values that can be matched in hardware: in port, VLAN ID , Ethernet type, IP source address (IPv4 and IPv6), IP destination address (IPv4 and IPv6), IP protocol, TCP/UDP source port, and TCP/UDP destination port.**
- **Actions that can be executed in hardware: destination port (single port), modify VLAN priority, and modify IP differentiated services code point (DSCP).**

Result:

Flow table of the ProVision switch

Standard Match Model (v2 & v3) K, KA, KB, W_15_17



OpenFlow Match (H/W) (4k Rules on V2/V3, 1k Rules on 2920)

The following OpenFlow fields can be matched in hardware

IN PORT	VLAN ID	VLAN PRIORITY	MAC SA	MAC DA	ETHERNET TYPE	IP SRC (v4/v6)	IP DST (v4/v6)	IP PROTO	IP DSCP	TCP/UDP SRC	TCP/UDP DST
---------	---------	---------------	--------	--------	---------------	----------------	----------------	----------	---------	-------------	-------------

OpenFlow Action (H/W)

The following OpenFlow actions can be executed in hardware

OpenFlow Action	Modify MAC SA	Modify MAC DA	Modify VLAN ID	Modify VLAN PRIORITY	Modify IP DSCP
-----------------	---------------	---------------	----------------	----------------------	----------------

The switch still uses three tables by default: Tables: 0 (Read-only), Table 100 (TCAM) and Table 200 (Software).

Result:

Flow table of the ProVision switch

Details V2 ASICs:

- **Ingress Port**
- **VLAN ID**
- **VLAN Priority**
- **Source MAC**
- **Destination MAC**
- **Ethertype**
- **IP source address (IPv4/IPv6)**
- **IP destination address (IPv4/IPv6)**
- **IP protocol**
- **IP DSCP**
- **TCP/UDP source port**
- **TCP/UDP destination port**

Flow table of the ProVision switch

Details V2 ASICs:

- **Destination port (one or more ports)**
- **Modify source MAC address**
- **Modify destination MAC address**
- **Modify VLAN ID**
- **Modify VLAN priority**
- **Modify IP DSCP**

Flow table of the ProVision switch

Custom Pipeline Model (v3) KB_15_17

OpenFlow Match (H/W) [Scale discussed in subsequent slides]

The following OpenFlow fields can be matched in hardware

IN PORT	VLAN ID	VLAN PRIORITY	MAC SA	MAC DA	ETHERNET TYPE	IP SRC (v4/v6)	IP DST (v4/v6)	IP PROTO	IP DSCP	TCP/UDP SRC	TCP/UDP DST
---------	---------	---------------	--------	--------	---------------	----------------	----------------	----------	---------	-------------	-------------

OpenFlow Action (H/W)

The following OpenFlow actions can be executed in hardware

O/P One or More Ports	Modify MAC SA	Modify MAC DA	Modify VLAN ID	Modify VLAN PRIORITY	Modify IP DSCP	Modify IPv4 SRC	Modify IPv4 DST	Modify TCP/UDP SRC (IPv4)	Modify TCP/UDP DST (IPv4)
-----------------------	---------------	---------------	----------------	----------------------	----------------	-----------------	-----------------	---------------------------	---------------------------

The OpenFlow tables can be configured dynamically by SDN Applications.

Result:

Flow table of the ProVision switch

Details V3 ASICs:

- **Ingress Port**
- **VLAN ID**
- **VLAN Priority**
- **Source MAC**
- **Destination MAC**
- **Ethertype**
- **IP source address (IPv4/IPv6)**
- **IP destination address (IPv4/IPv6)**
- **IP protocol**
- **IP DSCP**
- **TCP/UDP source port**
- **TCP/UDP destination port**

Flow table of the ProVision switch

Details V3 ASICs:

- **Destination port (one or more ports)**
- **Modify source MAC address**
- **Modify destination MAC address**
- **Modify VLAN ID**
- **Modify VLAN priority**
- **Modify IP DSCP**
- **Modify IPv4 source address**
- **Modify IPv4 destination address**
- **Modify TCP/UDP source address (IPv4)**
- **Modify TCP/UDP destination address (IPv4)**

Flow table of the ProVision switch

3800 example

```
Pl# show openflow instance vlan30 flow-table 100 table-capability
OpenFlow Flow Table Properties
Table Match Capabilities:
Incoming Port
Ethernet Source
VLAN ID
IP DSCP
IPv4 Source Address
TCP Source Port
UDP Source Port
ICMP Type
IPv6 Source Address
Table Instructions:
Metering
Apply Actions
  Set-Field
    Ethernet Destination Ethernet Source
    VLAN ID              VLAN PCP
    IP DSCP
  Output
GoTo 200
```

Flow table of the ProVision switch

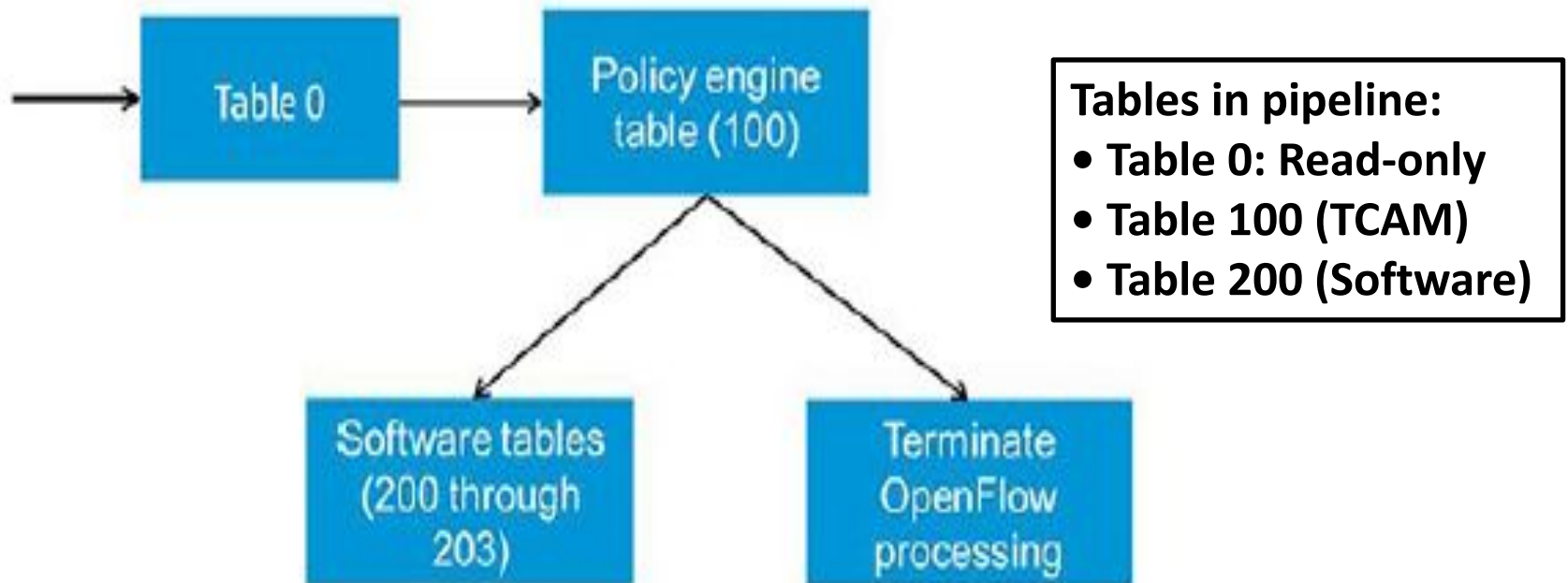
HP VAN SDN Controller - 53 sdn

Flows for Data Path ID: 00:1e:14:58:d0:f0:db:80

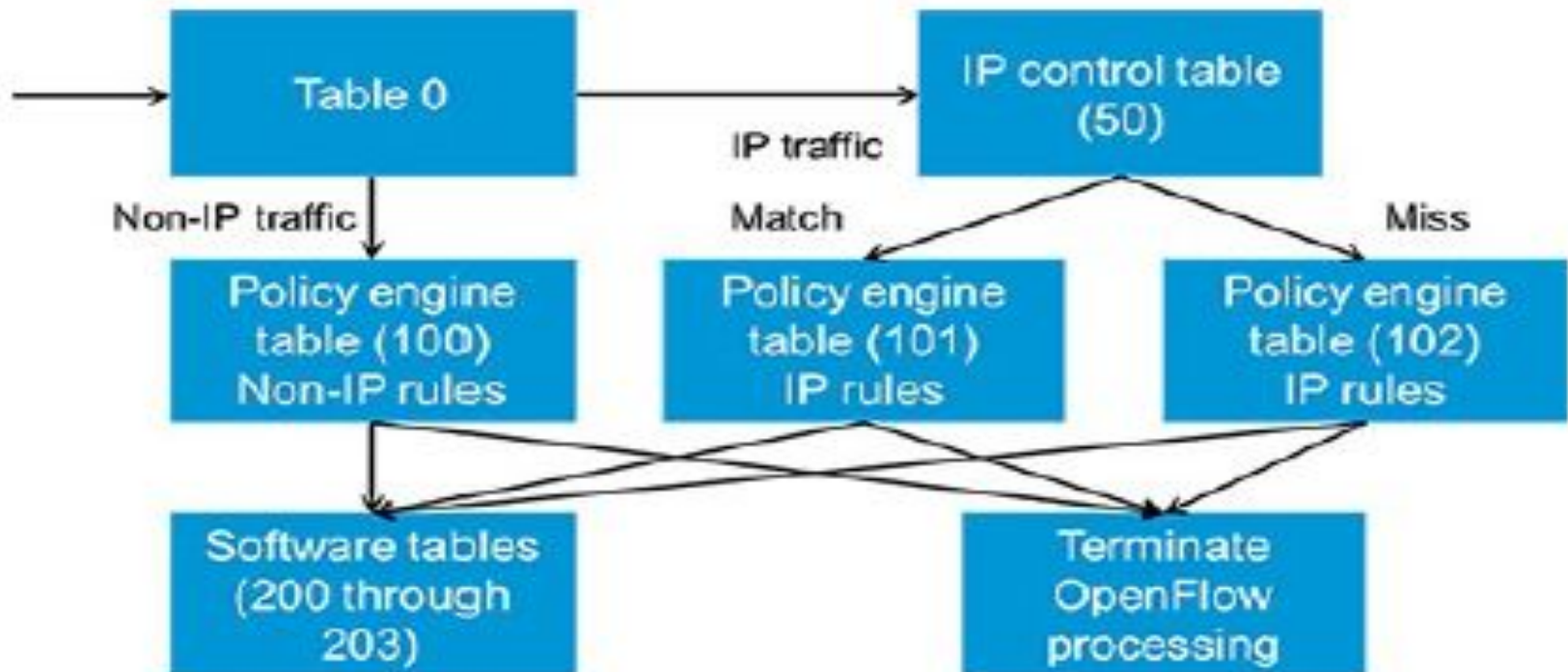
Northbound Refresh Add Delete Unsaved Other

Table ID	Priority	Packets	Bytes	Match Fields	Actions
0	0	0	0		goto_table: 100
100	31500	0	0	eth_type: ipv4 ip_proto: udp udp_src: 67 udp_dst: 68	goto_table: 200
100	31500	0	0	eth_type: ipv4 ip_proto: udp udp_src: 68 udp_dst: 67	goto_table: 200
100	60000	0	0	eth_type: bdep	apply_actions: output: CONTROLLER
100	31000	114	0	eth_type: arp	goto_table: 200
100	0	1147	1412 ...		apply_actions: output: NORMAL
100	100	0	0	eth_src: aa:aa:bb:bb:cc:cc	

Flow table of the ProVision switch



Flow table of the ProVision switch



Flow table of the ProVision switch

Custom Pipeline Model - Default Pipeline

- All the OpenFlow Tables in this mode are in **hardware**.

Table-Number/ Property	Table-0 (HASH)	Table-1 (HASH)	Table-2 (HASH)	Table-3 (TCAM)
Match Key	VLAN_VID & ETH_SRC	VLAN_VID & ETH_DST	ETH_TYPE, IP_SRC, IP_DST, IP_PROTO, SRC_PORT & DST_PORT	IN_PORT, ETH_SRC, ETH_DST, VLAN_VID, VLAN_PCP, ETH_TYPE, IP_SRC, IP_DST, IP_DSCP, IP_PROTO, SRC_PORT & DST_PORT
Instructions	APPLY, WRITE, CLEAR, METER, GOTO	APPLY, WRITE, CLEAR, METER, GOTO	APPLY, WRITE, CLEAR, METER, GOTO	APPLY, WRITE, CLEAR, METER,
Scale	8k	8k	8k	2k



And what's more - The pipeline can be changed on the fly by the controller using standard OpenFlow constructs (OFPMP_TABLE_FEATURES message). **Create a network pipeline of your choice!**

Flow table of the Comware switch

Answer:

Answer:

Answer:

Answer:

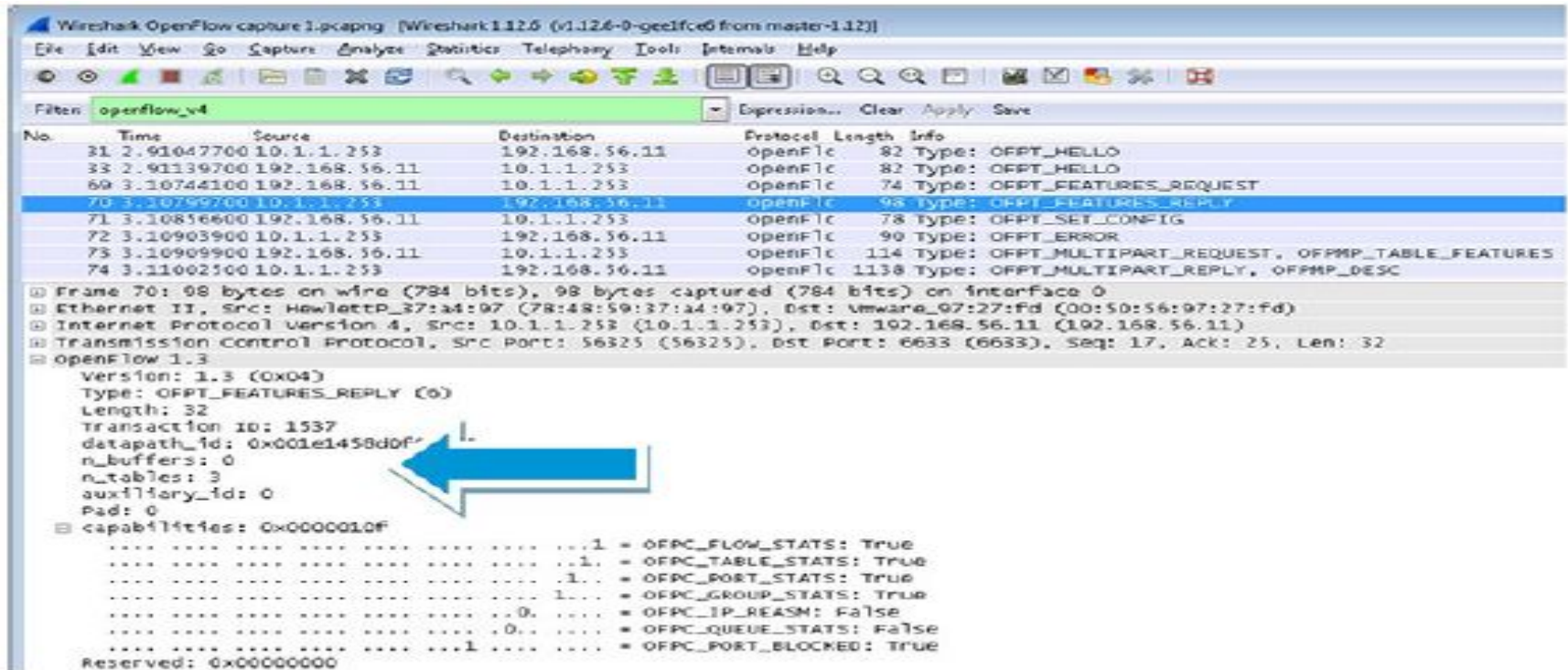
Flow table of the Comware switch

Flows for Data Path ID: 00:01:78:48:59:39:2f:96

Summary Ports Flows Groups

Table ID	Priority	Packets	Bytes	Match	Actions/Instructions	Flow Class ID
▸ 0	60000	0	n/a	eth_type: bddp	apply_actions: output: CONTROLLER	com.hp.sdn.bddp.steal
▸ 0	31500	248	n/a	eth_type: ipv4 ip_proto: udp udp_src: 68 udp_dst: 67	apply_actions: output: CONTROLLER write_actions: output: NORMAL	com.hp.sdn.dhcp.copy
▸ 0	31500	0	n/a	eth_type: ipv4 ip_proto: udp udp_src: 67 udp_dst: 68	apply_actions: output: CONTROLLER write_actions: output: NORMAL	com.hp.sdn.dhcp.copy
▸ 0	31000	0	n/a	eth_type: arp	apply_actions: output: CONTROLLER write_actions: output: NORMAL	com.hp.sdn.arp.copy
▸ 0	0	634	n/a		apply_actions: output: NORMAL	com.hp.sdn.normal

Flow table of the Comware switch



The image shows a Wireshark capture of OpenFlow messages. The filter is set to 'openflow_v4'. The packet list shows several OpenFlow messages, with packet 70 highlighted. The packet details pane shows the structure of an OFPT_FEATURES_REPLY message, including the capabilities field.

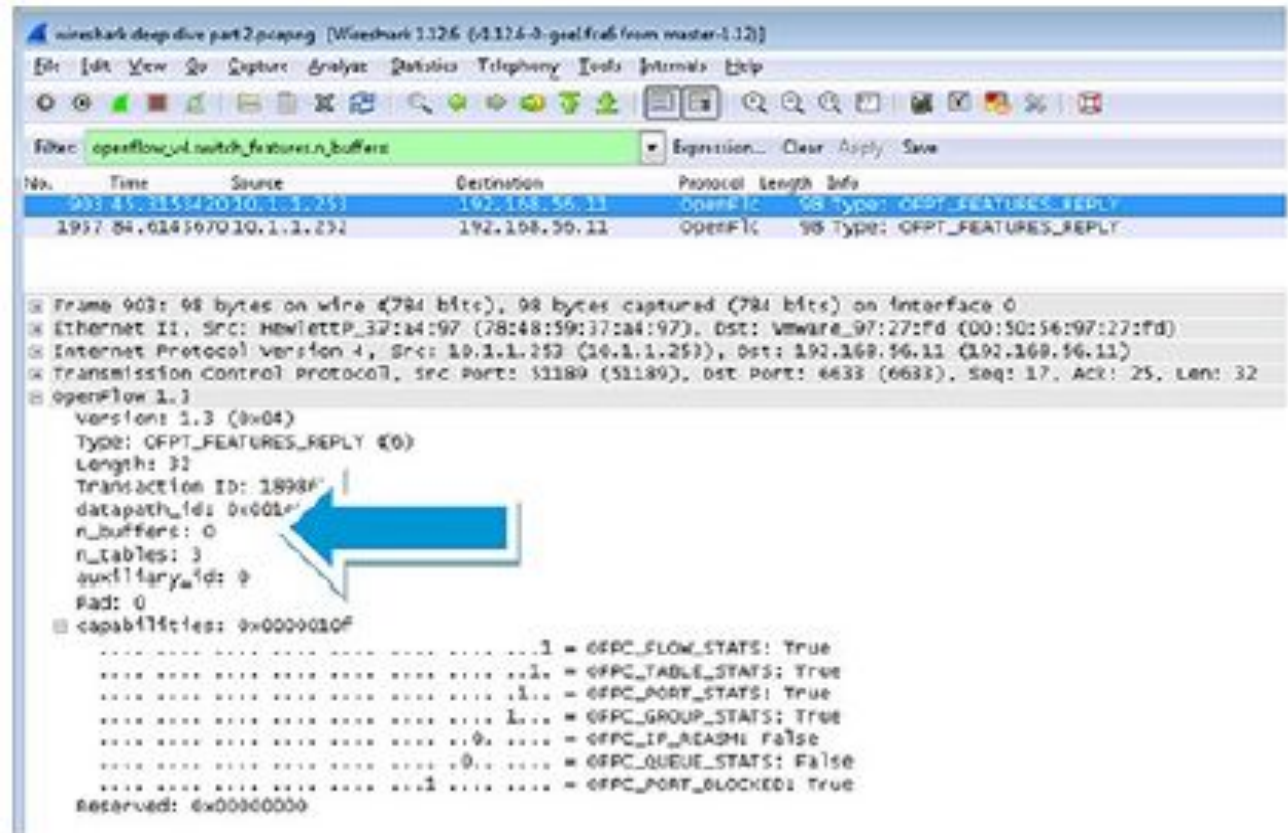
No.	Time	Source	Destination	Protocol	Length	Info
31	2.91047700	10.1.1.253	192.168.56.11	openFlc	82	Type: OFPT_HELLO
33	2.91139700	192.168.56.11	10.1.1.253	openFlc	82	Type: OFPT_HELLO
69	3.10744100	192.168.56.11	10.1.1.253	openFlc	74	Type: OFPT_FEATURES_REQUEST
70	3.10759700	10.1.1.253	192.168.56.11	openFlc	98	Type: OFPT_FEATURES_REPLY
71	3.10816600	192.168.56.11	10.1.1.253	openFlc	78	Type: OFPT_SET_CONFIG
72	3.10903900	10.1.1.253	192.168.56.11	openFlc	90	Type: OFPT_ERROR
73	3.10909900	192.168.56.11	10.1.1.253	openFlc	114	Type: OFPT_MULTIPART_REQUEST, OFFMP_TABLE_FEATURES
74	3.11002100	10.1.1.253	192.168.56.11	openFlc	1138	Type: OFPT_MULTIPART_REPLY, OFFMP_DESC

Frame 70: 98 bytes on wire (784 bits), 98 bytes captured (784 bits) on interface 0
Ethernet II, Src: HewlettP_37:a4:97 (78:48:59:37:a4:97), Dst: vmware_07:27:fd (00:50:56:97:27:fd)
Internet Protocol Version 4, Src: 10.1.1.253 (10.1.1.253), Dst: 192.168.56.11 (192.168.56.11)
Transmission Control Protocol, Src Port: 56325 (56325), Dst Port: 6633 (6633), Seq: 17, Ack: 25, Len: 32
OpenFlow 1.3
Version: 1.3 (0x04)
Type: OFPT_FEATURES_REPLY (6)
Length: 32
Transaction ID: 1537
datapath_id: 0x001e1458d0f
n_buffers: 0
n_tables: 3
auxiliary_id: 0
Pad: 0
Capabilities: 0x0000010f
.....1 = OFFPC_FLOW_STATS: True
.....1 = OFFPC_TABLE_STATS: True
.....1 = OFFPC_PORT_STATS: True
.....1 = OFFPC_GROUP_STATS: True
.....0 = OFFPC_IP_REASM: False
.....0 = OFFPC_QUEUE_STATS: False
.....1 = OFFPC_PORT_BLOCKED: True
Reserved: 0x00000000

Flow table of the Comware switch

`openflow_v4.switch_features.n_buffers.`

ProVision
number of
buffers



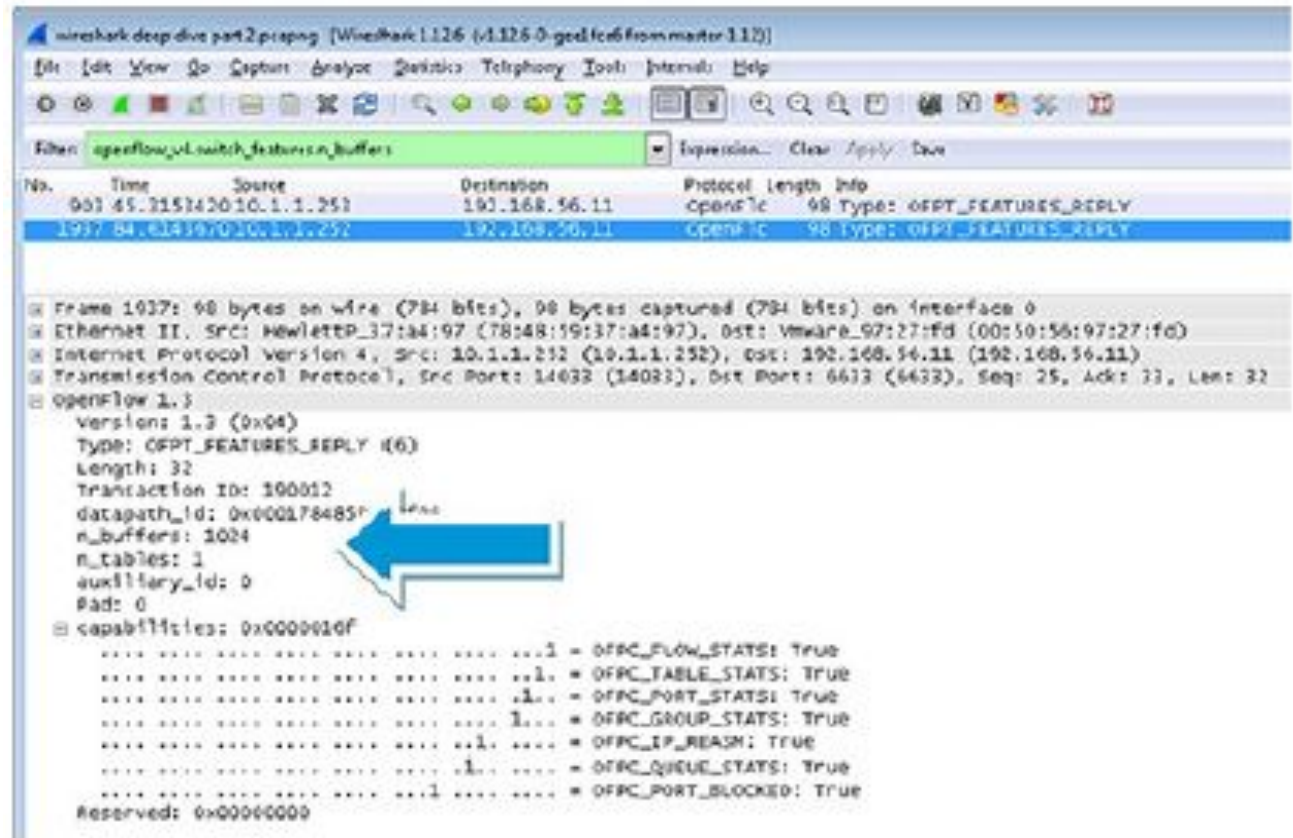
```
Wireshark: deep dive part 2 pcapng [Wireshark 1.12.6 (41124-3-gaef1fab from master-1.12)]
File: openflow_v4.switch_features.n_buffers
Filter: openflow_v4.switch_features.n_buffers
Expression: Clear Apply Save

No.    Time      Source                Destination            Protocol Length Info
---    -
903  45.115342010.1.1.253  192.168.56.11         openFlow 98  Type: OFPT_FEATURES_REPLY
1957  84.014597010.1.1.252  192.168.56.11         openFlow 98  Type: OFPT_FEATURES_REPLY

Frame 903: 98 bytes on wire (784 bits), 98 bytes captured (784 bits) on interface 0
Ethernet II, Src: HewlettP_37:14:97 (78:48:59:37:14:97), Dst: VMware_97:27:fd (00:50:56:97:27:fd)
Internet Protocol Version 4, Src: 10.1.1.253 (10.1.1.253), Dst: 192.168.56.11 (192.168.56.11)
Transmission Control Protocol, Src Port: 51189 (51189), Dst Port: 6633 (6633), Seq: 17, Ack: 25, Len: 32
OpenFlow 1.3
  Version: 1.3 (0x04)
  Type: OFPT_FEATURES_REPLY (0)
  Length: 32
  Transaction ID: 1898f
  datapath_id: 0x001e
  n_buffers: 0
  n_tables: 3
  auxiliary_id: 0
  Pad: 0
  capabilities: 0x0000010f
    .....1 = OFPC_FLOW_STATS: True
    .....2 = OFPC_TABLE_STATS: True
    .....1.. = OFPC_PORT_STATS: True
    .....1... = OFPC_GROUP_STATS: True
    .....0. .... = OFPC_IP_REASM: False
    .....0. .... = OFPC_QUEUE_STATS: False
    .....1 .. ... = OFPC_PORT_BLOCKED: True
  Reserved: 0x00000000
```

Flow table of the Comware switch

Comware
number of
buffers



```
wireshark.deep dive part2.pcapng [Wireshark 1.12.6 (v1.12.6-0-ged1c66f from master 1.12)]
File: openflow_of_switch_features_n_buffers
Expression: Clear Apply Done

No.    Time    Source                Destination            Protocol Length Info
-----
991    45.315143010.1.1.252  192.168.56.11         openFlow 98 Type: OFPT_FEATURES_REPLY
1937   84.6141970100.1.1.252  192.168.56.11         openFlow 98 Type: OFPT_FEATURES_REPLY

Frame 1937: 98 bytes on wire (784 bits), 98 bytes captured (784 bits) on interface 0
Ethernet II, Src: HewlettP_37:a4:97 (78:48:59:37:a4:97), Dst: Vmware_97:27:fd (00:50:56:97:27:fd)
Internet Protocol Version 4, Src: 10.1.1.252 (10.1.1.252), Dst: 192.168.56.11 (192.168.56.11)
Transmission Control Protocol, Src Port: 14032 (14032), Dst Port: 6633 (6633), Seq: 25, Ack: 33, Len: 32
OpenFlow 1.3
  Versions: 1.3 (0x04)
  Type: OFPT_FEATURES_REPLY (6)
  Length: 32
  Transaction ID: 100012
  datapath_id: 0x000178485f
  n_buffers: 1024
  n_tables: 1
  auxiliary_id: 0
  Pad: 0
  capabilities: 0x0000010f
    ..1 = OFFC_FLOW_STATS: True
    ..1 = OFFC_TABLE_STATS: True
    ..1 = OFFC_PORT_STATS: True
    ..1 = OFFC_GROUP_STATS: True
    ..1 = OFFC_IP_REASON: True
    ..1 = OFFC_QUEUE_STATS: True
    ..1 = OFFC_PORT_BLOCKED: True
  Reserved: 0x00000000
```

n_buffers:

Flow table of the Comware switch

Answer:

Answer:

Answer:

Answers:

Flow table of the Comware switch



Flow table of the Comware switch

ProVision switch

Will this rule work?
Add a flow entry with the following attributes and then click Add, as illustrated in Figure.

- Table ID: **200**
- Priority: **100**
- Src Mac: **aaaabbbbcccc**
- Instructions: **Apply Actions**
- Action 1: **No Action**
- Save Flow = **True**

■ Add Flow to Data Path ID: 00:1e:14:58:d6:f0:db:80

Northbound Clear Add

Metadata

Table ID: 200
Priority: 100
Idle Timeout:
Hard Timeout:

Match

Source MAC: aaaabbbbcccc
Source IP:
Source Netmask:
Source Port:
VLANID:
Dest. MAC:
Dest. IP:
Dest. Netmask:
Dest. Port:
In Port:

Protocol

IP Protocol:
Ethernet Type:

Instructions

Instruction: Apply Actions
Table:

Actions

Action 1: No Action
Action 2: No Action
Action 3: No Action
Action 4: No Action
Value:
Value:
Value:
Value:

Options


Save Flow

Flow table of the Comware switch

- Flows for Data Path ID: 00:11e:14:58:d0:f0:db:80

Northbound | Refresh | Add | Delete | Saved | Unsaved | Other

200	31000	114	6840	eth_type: arp	apply_actions: output: CONTROLLER output: NORMAL
200	31500	0	0	eth_type: ipv4 ip_proto: udp udp_src: 67 udp_dst: 68	apply_actions: output: CONTROLLER output: NORMAL
200	31500	0	0	eth_type: ipv4 ip_proto: udp udp_src: 68 udp_dst: 67	apply_actions: output: CONTROLLER output: NORMAL
200	0	0	0		apply_actions: output: NORMAL
200	100	0	0	eth_src: aa:aa:bb:bb:cc:cc	



Result:

Flow table of the Comware switch

Comware switch

- Table ID: **0**
- Priority: **100**
- Src Mac:
bbbbccccdddd
- Instructions: **Apply Actions**
- Action 1: **No Action**
- Save Flow = **True**

■ Add Flow to Data Path ID: 00:01:78:48:59:39:2f:95

Northbound Clear Add

Metadata

Table ID: 0 Idle Timeout:
Priority: 100 Hard Timeout:

Match

Source MAC: bbbccccdddd Dest. MAC:
Source IP: Dest. IP:
Source Netmask: Dest. Netmask:
Source Port: Dest. Port:
VLAN ID: InPort:

Protocol

IP Protocol:
Ethernet Type:

Instructions

Instructions: Apply Actions Table:

Actions

Action 1: No Action Value:
Action 2: No Action Value:
Action 3: No Action Value:
Action 4: No Action Value:

Options

Save Flow

Flow table of the Comware switch



Flows for Data Path ID: 00:01:78:48:59:39:2f:96

Northbound | Refresh | Add | Delete | Saved | Unsaved | Other

Table ID	Priority	Packets	Bytes	Match Fields	Actions
• 0	60000	0	n/a	eth_type: bddp	apply_actions: output: CONTROLLER
• 0	31500	472	n/a	eth_type: ipv4 ip_proto: udp udp_src: 68 udp_dst: 67	apply_actions: output: CONTROLLER write_actions: output: NORMAL
• 0	31500	0	n/a	eth_type: ipv4 ip_proto: udp udp_src: 67 udp_dst: 68	apply_actions: output: CONTROLLER write_actions: output: NORMAL
• 0	31000	0	n/a	eth_type: arp	apply_actions: output: CONTROLLER write_actions: output: NORMAL
• 0	100	0	n/a	eth_src: bb:bb:cc:cc:dd:dd	
• 0	0	1159	n/a		apply_actions: output: NORMAL

Result:

Flow table of the Comware switch



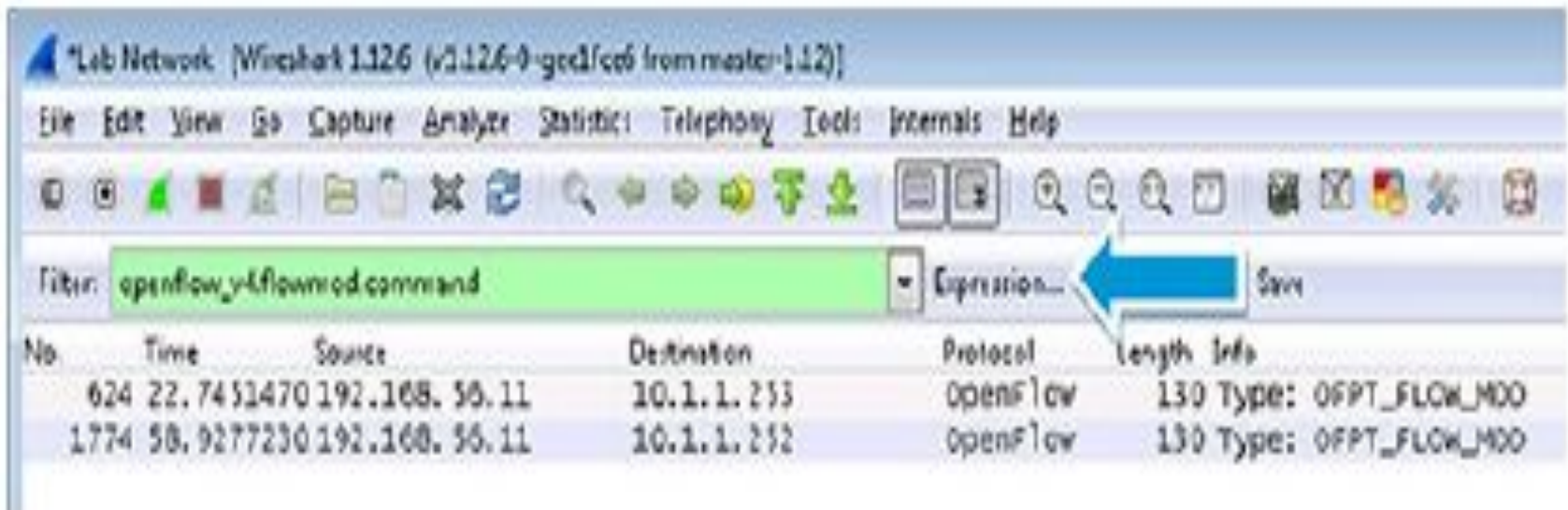


Investigating OpenFlow negotiations



Flow modifications (Flow mod)

- Set the Wireshark filter to: **openflow_v4.flowmod.command**.
- Click Apply.



Flow modifications (Flow mod)

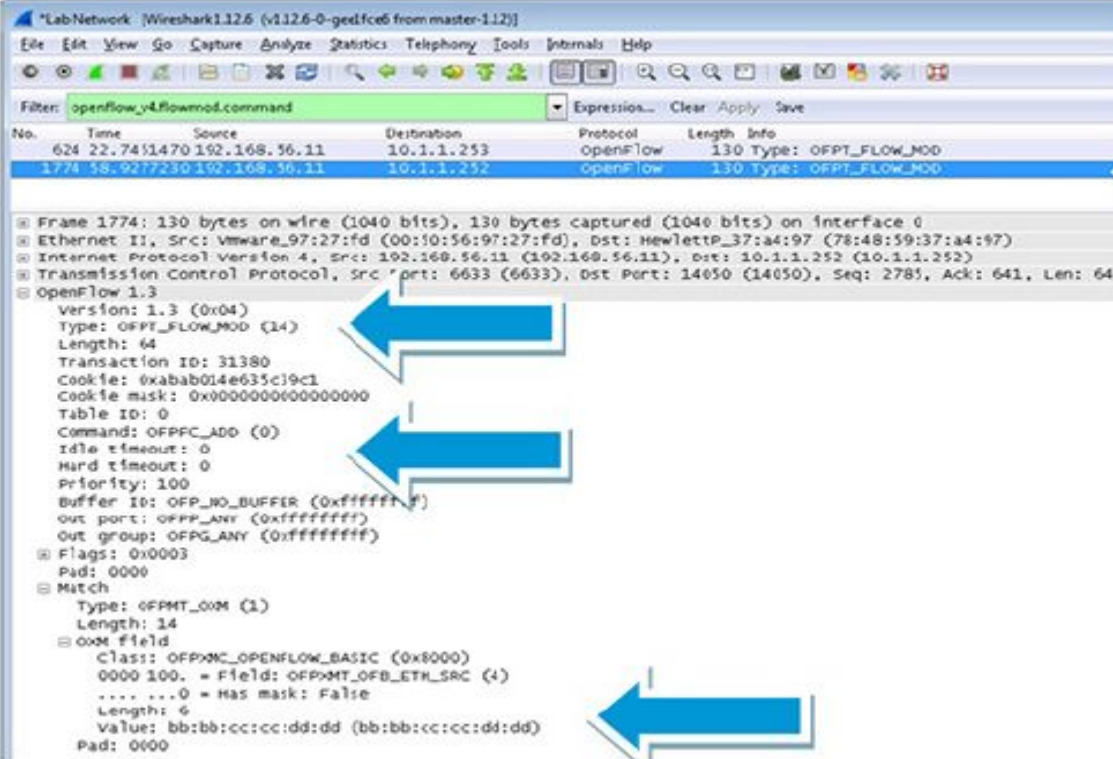
Answer:

```
enum ofp_flow_mod_command {  
    OFPFC_ADD = 0, /* New flow. */  
    OFPFC_MODIFY = 1, /* Modify all matching flows. */  
    OFPFC_MODIFY_STRICT = 2, /* Modify entry strictly matching wildcards and priority.*/  
    OFPFC_DELETE = 3, /* Delete all matching flows. */  
    OFPFC_DELETE_STRICT = 4, /* Delete entry strictly matching wildcards and priority. */  
}
```

Flow modifications (Flow mod)

Comware switch

Result: This is an OFPFC_ADD message. The controller is adding a new flow to the switch.



The image shows a Wireshark capture of an OpenFlow message. The packet list pane shows two packets, with the second packet (No. 1774) selected. The packet details pane shows the structure of the OpenFlow 1.3 message, including the OFPFC_ADD command and the match field.

```
*LabNetwork [Wireshark 1.12.6 (v1.12.6-0-ge1fce6 from master-1.12)]
File Edit View Go Capture Analyze Statistics Telephony Tools Internals Help
Filter: openflow_v4.flowmod.command
No. Time Source Destination Protocol Length Info
624 22.7451470 192.168.56.11 10.1.1.253 OpenFlow 130 Type: OFPT_FLOW_MOD
1774 18.9277230 192.168.56.11 10.1.1.252 OpenFlow 130 Type: OFPT_FLOW_MOD

Frame 1774: 130 bytes on wire (1040 bits), 130 bytes captured (1040 bits) on interface 0
Ethernet II, Src: VMware_97:27:fd (00:50:56:97:27:fd), Dst: HewlettP_37:a4:97 (78:48:59:37:a4:97)
Internet Protocol Version 4, Src: 192.168.56.11 (192.168.56.11), Dst: 10.1.1.252 (10.1.1.252)
Transmission Control Protocol, Src Port: 6633 (6633), Dst Port: 14050 (14050), Seq: 2785, Ack: 641, Len: 64
OpenFlow 1.3
  Version: 1.3 (0x04)
  Type: OFPT_FLOW_MOD (14)
  Length: 64
  Transaction ID: 31380
  Cookie: 0xabab014e635c19c1
  Cookie mask: 0x0000000000000000
  Table ID: 0
  Command: OFPFC_ADD (0)
  Idle timeout: 0
  Hard timeout: 0
  Priority: 100
  Buffer ID: OFF_NO_BUFFER (0xffffffff)
  Out port: OFFP_ANY (0xffffffff)
  Out group: OFFG_ANY (0xffffffff)
  Flags: 0x0003
  Pad: 0000
  Match
    Type: OFPMT_oxm (1)
    Length: 14
    oxm field
      Class: OFFXMC_OPENFLOW_BASIC (0x8000)
      0000 100. = Field: OFFXMT_OFB_ETH_SRC (4)
      .... ..0 = Has mask: False
      Length: 6
      Value: bb:bb:cc:cc:dd:dd (bb:bb:cc:cc:dd:dd)
      Pad: 0000
```


Flow modifications (Flow mod)

ProVision switch

Result:
This is
also an
OFPPC_
ADD
message

```
*Lab Network [Wireshark 1.12.5 (v1.12.6-0-geefce6 from master-112)]
File Edit View Go Capture Analyze Statistics Telephony Tools Internals Help
Filter: openflow.v4.flowmod.command
Expression... Clear Apply Save

No.    Time            Source                Destination           Protocol  Length  Info
--    -
624    22.7451470192.168.56.11  10.1.1.253           OpenFlow  130     Type: OFPT_FLOW_MOD
1774   58.9277230192.168.56.11  10.1.1.252           OpenFlow  130     Type: OFPT_FLOW_MOD

# Frame 624: 130 bytes on wire (1040 bits), 130 bytes captured (1040 bits) on interface 0
# Ethernet II, Src: Vmware_97:27:fd (00:50:56:97:27:fd), Dst: HewlettP_37:a4:97 (78:48:59:37:a4:97)
# Internet Protocol Version 4, Src: 192.168.56.11 (192.168.56.11), Dst: 10.1.1.253 (10.1.1.253)
# Transmission Control Protocol, Src Port: 6633 (6633), Dst Port: 56325 (56325), Seq: 1353, Ack: 265, Len: 64
# OpenFlow 1.3
  Version: 1.3 (0x04)
  Type: OFPT_FLOW_MOD (14)
  Length: 64
  Transaction ID: 31343
  Cookie: 0xabab014e635bac6a
  Cookie mask: 0x0000000000000000
  Table ID: 200
  Command: OFPPC_ADD (0)
  idle timeout: 0
  Hard timeout: 0
  Priority: 100
  Buffer ID: OFP_NO_BUFFER (0xffffffff)
  out port: OFPP_ANY (0xffffffff)
  out group: OFPG_ANY (0xffffffff)
# Flags: 0x0003
  Pad: 0000
# Match
  Type: OFPMT_OXM (1)
  Length: 14
  # OXM field
    Class: OFPXM_OPENFLOW_BASIC (0x8000)
    0000 100. = Field: OFPXM_OFB_ETH_SRC (4)
    .... ...0 = Has mask: False
    Length: 6
    value: aa:aa:bb:bb:cc:cc (aa:aa:bb:bb:cc:cc)
    Pad: 0000
```

Flow modifications (Flow mod)

*Lab Network [Wireshark 1.12.6 (v1.12.6-0-geelfce6 from master-1.12)]

File Edit View Go Capture Analyze Statistics Telephony Tools Internals Help

Filter: openflow_v4.flowmod.command Expression... Clear Apply Save

No.	Time	Source	Destination	Protocol	Length	Info
624	22.7451470	192.168.56.11	10.1.1.253	openFlow	130	Type: OFPT_FLOW_MOD
1774	58.9277230	192.168.56.11	10.1.1.252	openFlow	130	Type: OFPT_FLOW_MOD

*Lab Network [Wireshark 1.12.6 (v1.12.6-0-geelfce6 from master-1.12)]

File Edit View Go Capture Analyze Statistics Telephony Tools Internals Help

Filter: openflow_v4 Expression... Clear Apply Save

No.	Time	Source	Destination	Protocol	Length	Info
624	22.7451470	192.168.56.11	10.1.1.253	openFlow	130	Type: OFPT_FLOW_MOD
634	22.9449760	192.168.56.11	10.1.1.253	openFlow	130	Type: OFPT_MULTIPART_REQUEST, OFFMP_FLOW
635	22.9456680	10.1.1.253	192.168.56.11	openFlow	74	Type: OFPT_BARRIER_REPLY
636	22.9456890	10.1.1.253	192.168.56.11	openFlow	1050	Type: OFPT_MULTIPART_REPLY, OFFMP_FLOW

Flow modifications (Flow mod)

Barrier:

*Lab Network [Wireshark 1.12.6 (v1.12.6-0-geefc66 from master-1.12)]

File Edit View Go Capture Analyze Statistics Telephony Tools Internals Help

Filter: openflow_v4 Expression... Clear Apply Save

No.	Time	Source	Destination	Protocol	Length	Info
624	22.7451470	192.168.56.11	10.1.1.253	openFlow	130	Type: OFPT_FLOW_MOD
634	22.9449760	192.168.56.11	10.1.1.253	openFlow	130	Type: OFPT_MULTIPART_REQUEST, OFFMP_FLOW
635	22.9456680	10.1.1.253	192.168.56.11	openFlow	74	Type: OFPT_BARRIER_REPLY
636	22.9456890	10.1.1.253	192.168.56.11	openFlow	1050	Type: OFPT_MULTIPART_REPLY

Frame 634: 130 bytes on wire (1040 bits), 130 bytes captured (1040 bits) on interface 0

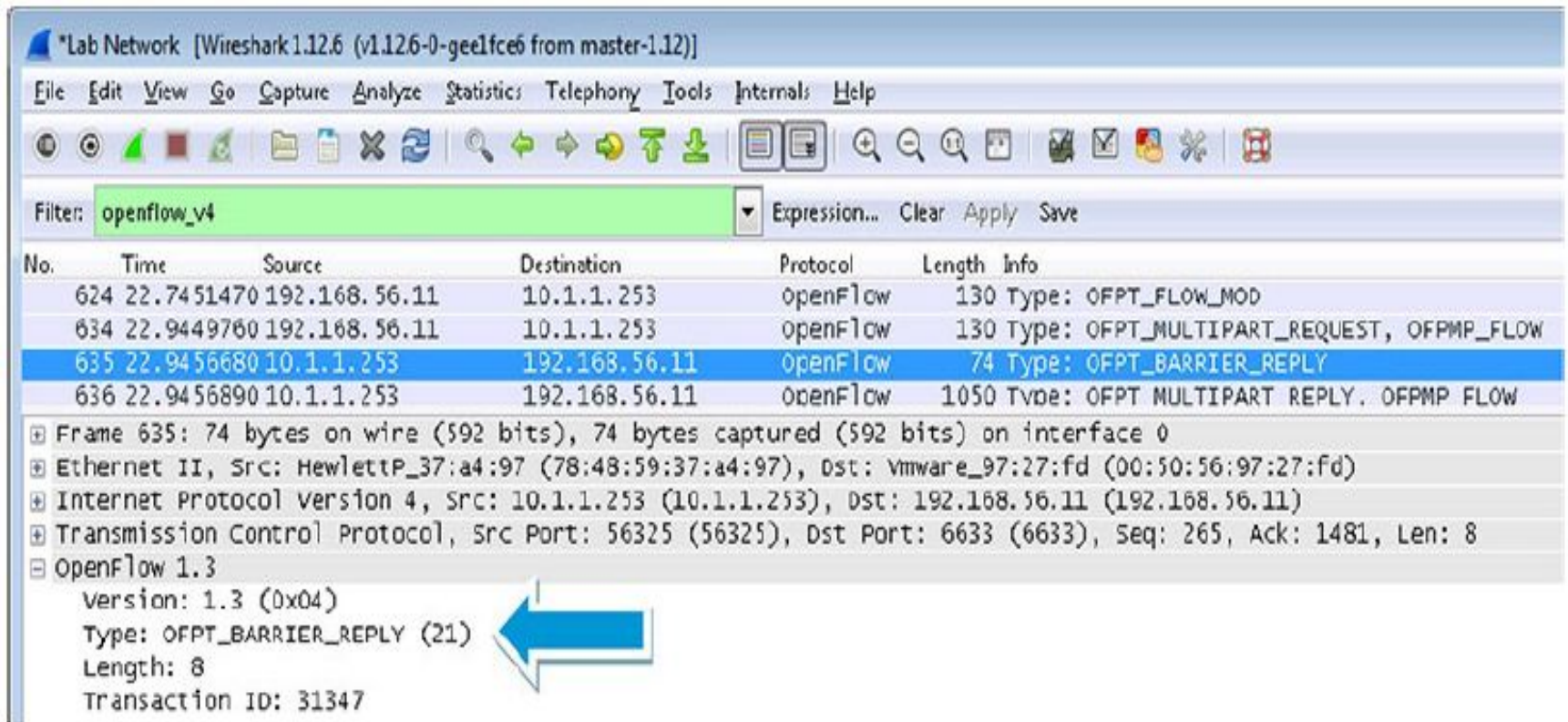
- Ethernet II, Src: vmware_97:27:fd (00:50:56:97:27:fd), Dst: HewlettP_37:a4:97 (78:48:59:37:a4:97)
- Internet Protocol Version 4, Src: 192.168.56.11 (192.168.56.11), Dst: 10.1.1.253 (10.1.1.253)
- Transmission Control Protocol, Src Port: 6633 (6633), Dst Port: 56325 (56325), Seq: 1417, Ack: 265, Len: 130
- OpenFlow 1.3
 - Version: 1.3 (0x04)
 - Type: OFPT_BARRIER_REQUEST (20)
 - Length: 8
 - Transaction ID: 31347
- OpenFlow 1.3
 - Version: 1.3 (0x04)
 - Type: OFFMP_FLOW (1)
 - Length: 56
 - Transaction ID: 31348
 - Type: OFFMP_FLOW (1)
 - Flags: 0x0000
 - Pad: 00000000
 - Table ID: OFPTT_ALL (255)
 - Pad: 00000000
 - Out port: OFFPP_ANY (0xffffffff)
 - Out group: OFFPG_ANY (0xffffffff)
 - Pad: 00000000
 - Cookie: 0x0000000000000000
 - Cookie mask: 0x0000000000000000
 - Match
 - Type: OFFMT_OXM (1)
 - Length: 4
 - Pad: 00000000

Flow modifications (Flow mod)

Message ordering:

- **1. Messages before a barrier must be fully processed before the barrier, including sending any resulting replies or errors.**
- **2. The barrier must then be processed and a barrier reply sent.**
- **3. Messages after the barrier may then begin processing.**

Flow modifications (Flow mod)



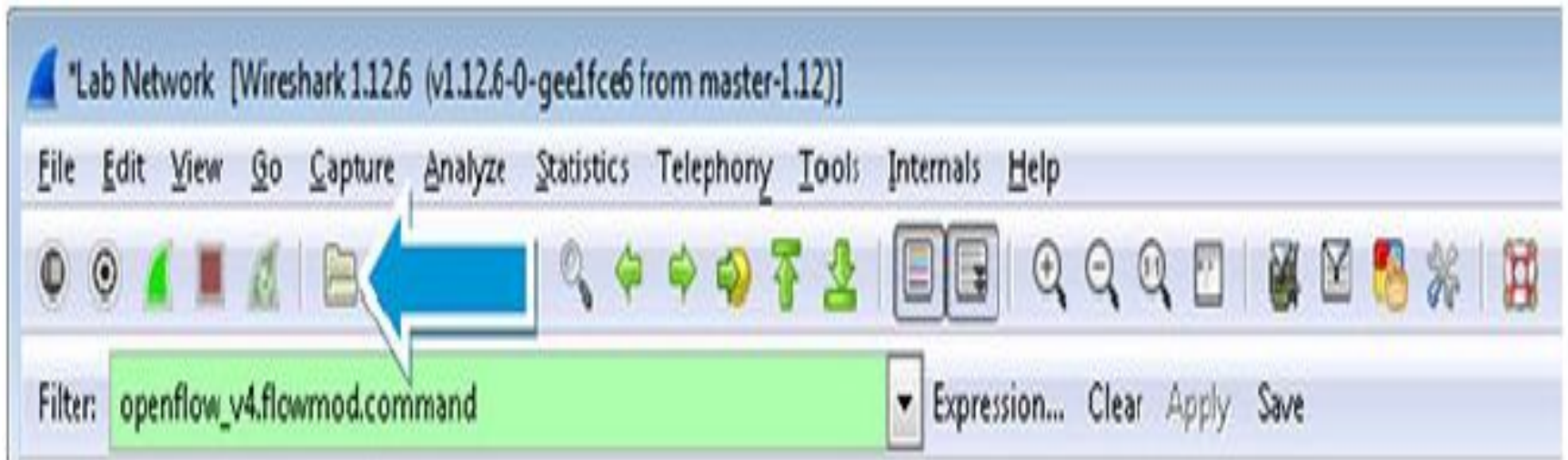
The screenshot shows the Wireshark interface with the following details:

- Filter: `openflow_v4`
- Packet 635: 22.9456680, Source: 10.1.1.253, Destination: 192.168.56.11, Protocol: openFlow, Length: 74, Info: Type: OFPT_BARRIER_REPLY
- Packet 636: 22.9456890, Source: 10.1.1.253, Destination: 192.168.56.11, Protocol: openFlow, Length: 1050, Info: Type: OFPT_MULTIPART_REPLY, OFPMP_FLOW

Packet 635 details:

- Frame 635: 74 bytes on wire (592 bits), 74 bytes captured (592 bits) on interface 0
- Ethernet II, Src: HewlettP_37:a4:97 (78:48:59:37:a4:97), Dst: vmware_97:27:fd (00:50:56:97:27:fd)
- Internet Protocol Version 4, Src: 10.1.1.253 (10.1.1.253), Dst: 192.168.56.11 (192.168.56.11)
- Transmission Control Protocol, Src Port: 56325 (56325), Dst Port: 6633 (6633), Seq: 265, Ack: 1481, Len: 8
- OpenFlow 1.3
 - Version: 1.3 (0x04)
 - Type: OFPT_BARRIER_REPLY (21) ←
 - Length: 8
 - Transaction ID: 31347

Flow modifications (Flow mod)



Flow modifications (Flow mod)

Comware switch

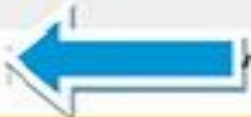


Flows for Data Path ID: 00:01:78:48:59:39:2f:96


Northbound | Refresh | Add | Delete | Unsaved | Other

Table ID	Priority	Packets	Bytes	Match Fields	Actions
▶ 0	60000	0	n/a	eth_type: bddp	apply_actions: output: CONTROLLER
▶ 0	31500	588	n/a	eth_type: ipv4 ip_proto: udp udp_src: 68 udp_dst: 67	apply_actions: output: CONTROLLER write_actions: output: NORMAL
▶ 0	31500	0	n/a	eth_type: ipv4 ip_proto: udp udp_src: 67 udp_dst: 68	apply_actions: output: CONTROLLER write_actions: output: NORMAL
▶ 0	31000	0	n/a	eth_type: arp	apply_actions: output: CONTROLLER write_actions: output: NORMAL
▶ 0	100	0	n/a	eth_src: bb:bb:cc:cc:dd:dd	
▶ 0	0	1462	n/a		apply_actions: output: NORMAL

Flow modifications (Flow mod)

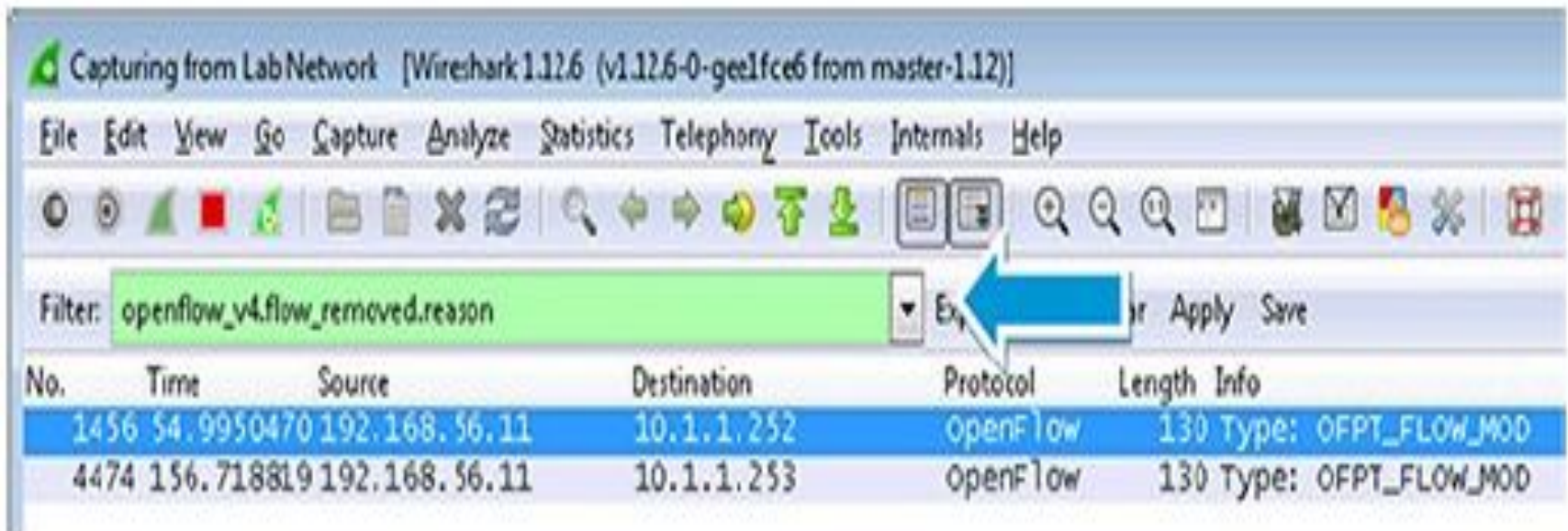
Flows for Data Path ID: 00:1e:14:58:d0:f0:db:80

Northbound | Refresh | Add | Delete |  |  Unsaved |  Other

▶ 200	31000	114	6840	eth_type: arp	apply_actions: output: CONTROLLER output: NORMAL
▶ 200	31500	0	0	eth_type: ipv4 ip_proto: udp udp_src: 67 udp_dst: 68	apply_actions: output: CONTROLLER output: NORMAL
▶ 200	31500	0	0	eth_type: ipv4 ip_proto: udp udp_src: 68 udp_dst: 67	apply_actions: output: CONTROLLER output: NORMAL
▶ 200	0	0	0		apply_actions: output: NORMAL
▶ 200	100	0	0	eth_src: aa:aa:bb:bb:cc:cc	

Flow modifications (Flow mod)

openflow_v4.flow_removed.reason

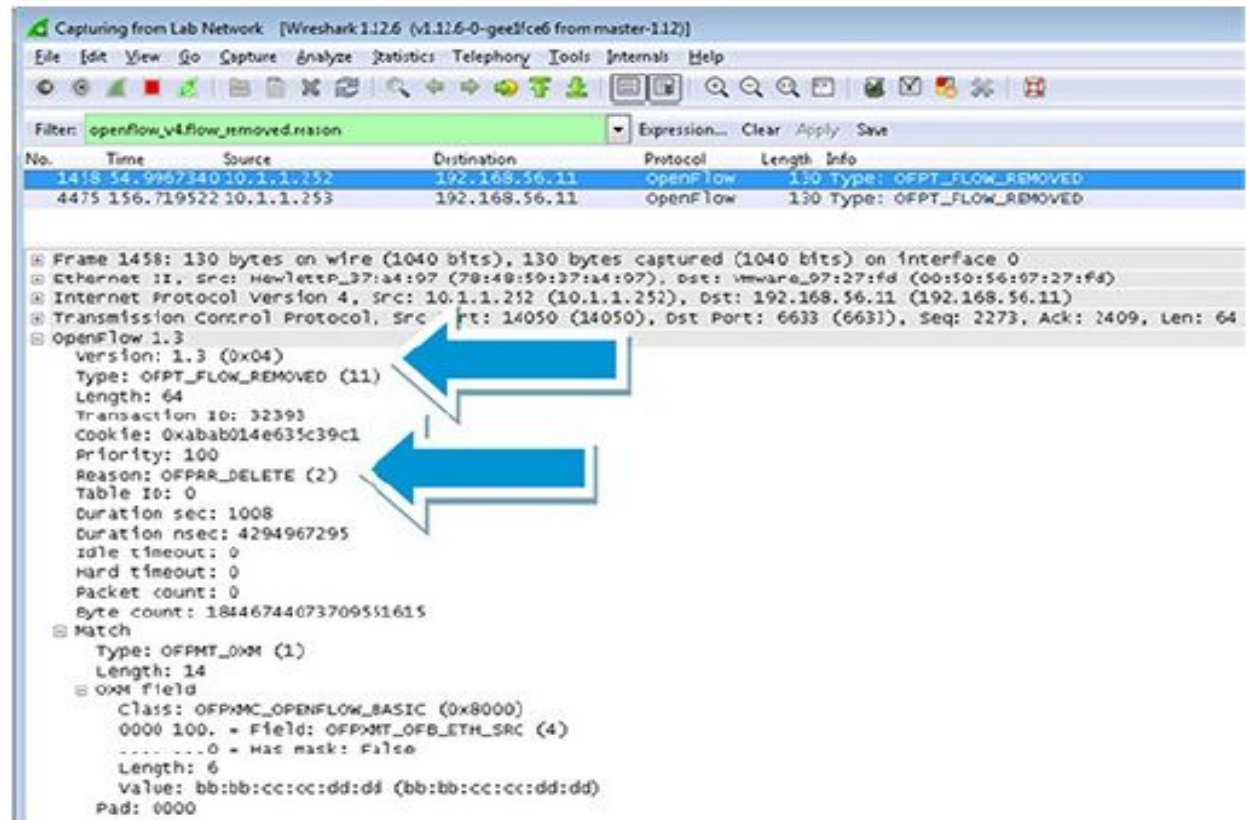


The image shows a screenshot of the Wireshark network protocol analyzer. The title bar indicates it is capturing from 'Lab Network' using version 1.12.6. The menu bar includes File, Edit, View, Go, Capture, Analyze, Statistics, Telephony, Tools, Internals, and Help. The toolbar contains various icons for file operations, search, and analysis. The filter field is set to 'openflow_v4.flow_removed.reason', with a blue arrow pointing to the 'Exp' button. Below the filter, a table displays captured packets:

No.	Time	Source	Destination	Protocol	Length	Info
1456	54.9950470	192.168.56.11	10.1.1.252	OpenFlow	130	Type: OFPT_FLOW_MOD
4474	156.718819	192.168.56.11	10.1.1.253	OpenFlow	130	Type: OFPT_FLOW_MOD

Flow modifications (Flow mod)

In the Wireshark capture, the switch is informing the controller of the flow removal (OFPT_FLOW_REMOVED) and the reason for the removal (OFPRR_DELETE (2)).



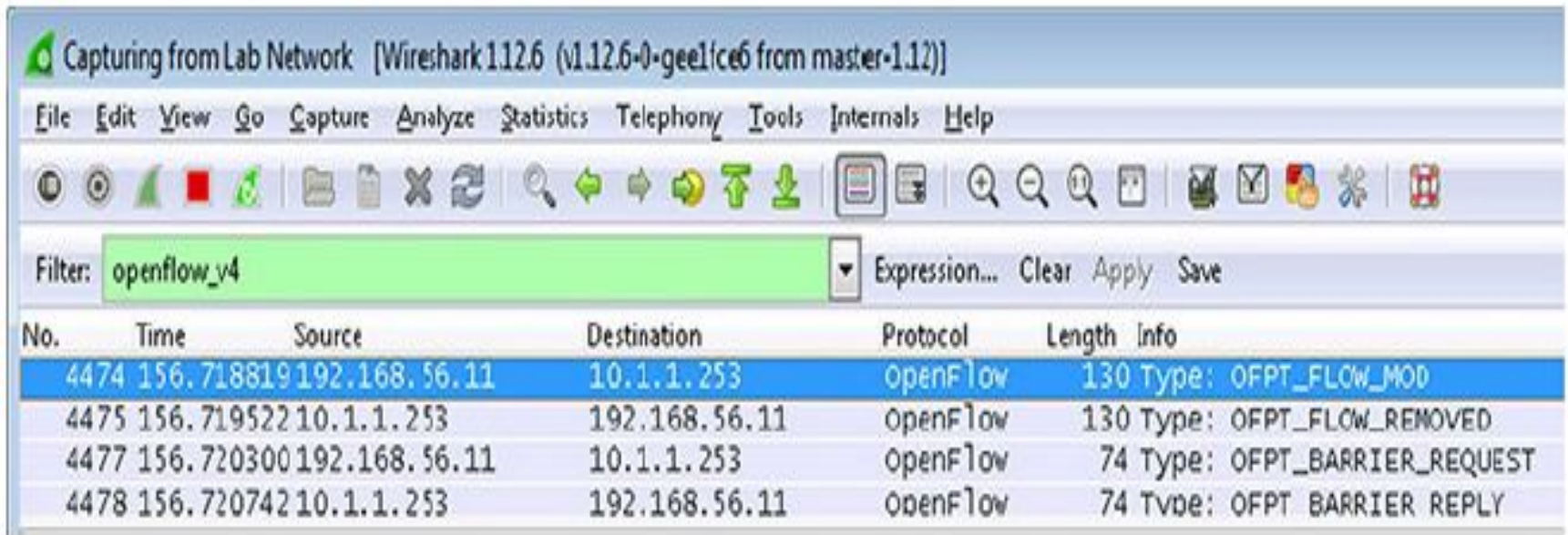
The image shows a Wireshark capture of OpenFlow messages. The filter is set to 'openFlow_v4_flow_removed.reason'. The packet list shows two OpenFlow messages of type OFPT_FLOW_REMOVED. The details pane for the selected packet (No. 4475) shows the following structure:

- OpenFlow 1.3
 - Version: 1.3 (0x04)
 - Type: OFPT_FLOW_REMOVED (11)
 - Length: 64
 - Transaction ID: 32393
 - Cookie: 0xabab014e635c39c1
 - Priority: 100
 - Reason: OFPRR_DELETE (2)
 - Table ID: 0
 - Duration sec: 1008
 - Duration nsec: 4294967295
 - idle timeout: 0
 - Hard timeout: 0
 - Packet count: 0
 - Byte count: 18446744073709551615
 - Match
 - Type: OFPMT_OXM (1)
 - Length: 14
 - OXM field
 - Class: OFPMT_OPENFLOW_BASIC (0x8000)
 - 0000 100. = Field: OFPMT_OFB_ETH_SRC (4)
 -0 = Has mask: False
 - Length: 6
 - Value: bb:bb:cc:cc:dd:dd (bb:bb:cc:cc:dd:dd)
 - Pad: 0000

Two blue arrows point to the 'Reason: OFPRR_DELETE (2)' and the 'Match' section of the details pane.

Flow modifications (Flow mod)

Flow modifications (Flow mod)



Capturing from Lab Network [Wireshark 1.12.6 (v1.12.6-0-ge11ce6 from master-1.12)]

File Edit View Go Capture Analyze Statistics Telephony Tools Internals Help

Filter: openflow_v4 Expression... Clear Apply Save

No.	Time	Source	Destination	Protocol	Length	Info
4474	156.718819	192.168.56.11	10.1.1.253	OpenFlow	130	Type: OFPT_FLOW_MOD
4475	156.719522	10.1.1.253	192.168.56.11	OpenFlow	130	Type: OFPT_FLOW_REMOVED
4477	156.720300	192.168.56.11	10.1.1.253	OpenFlow	74	Type: OFPT_BARRIER_REQUEST
4478	156.720742	10.1.1.253	192.168.56.11	OpenFlow	74	Type: OFPT_BARRIER_REPLY

Flow modifications (Flow mod)

Capturing from Lab Network [Wireshark 1.12.6 (v1.12.6-0-ge1f3ce6 from master-1.12)]

Filter: openflow_v4

No.	Time	Source	Destination	Protocol	Length	Info
4474	156.718819	192.168.56.11	10.1.1.253	OpenFlow	130	Type: OFPT_FLOW_MOD
4475	156.719522	10.1.1.253	192.168.56.11	OpenFlow	130	Type: OFPT_FLOW_REMOVED
4477	156.720300	192.168.56.11	10.1.1.253	OpenFlow	74	Type: OFPT_BARRIER_REQUEST
4478	156.720742	10.1.1.253	192.168.56.11	OpenFlow	74	Type: OFPT_BARRIER_REPLY

Frame 4474: 130 bytes on wire (1040 bits), 130 bytes captured (1040 bits) on interface 0

- Ethernet II, Src: vmware_97:27:fd (00:50:56:97:27:fd), Dst: HewlettP_37:a4:97 (78:48:59:37:a4:97)
- Internet Protocol version 4, Src: 192.168.56.11 (192.168.56.11), Dst: 10.1.1.253 (10.1.1.253)
- Transmission Control Protocol, Src Port: 6633 (6633), Dst Port: 56325 (56325), Seq: 6897, Ack: 1225, Len: 64
- OpenFlow 1.3
 - Version: 1.3 (0x04)
 - Type: OFPT_FLOW_MOD (14)
 - Length: 64
 - Transaction ID: 32496
 - Cookie: exabab014e635bac6a
 - Cookie mask: 0x0000000000000000
 - Table ID: 200
 - Command: OFPPC_DELETE_STRICT (4)
 - Idle timeout: 0
 - Hard timeout: 0
 - Priority: 100
 - Buffer ID: OFP_NO_BUFFER (0xffffffff)
 - Out port: OFPP_ANY (0xffffffff)
 - Out group: OFPG_ANY (0xffffffff)
 - Flags: 0x0000
 - Pad: 0000
 - Match
 - Type: OFPMT_OXM (1)
 - Length: 14
 - OXM Field
 - Class: OFPXM_OPENFLOW_BASIC (0x8000)
 - 0000 100. = Field: OFPXM_OFB_ETH_SRC (4)
 - 0000 - Has mask: False
 - Length: 6
 - Value: aa:aa:bb:bb:cc:cc (aa:aa:bb:bb:cc:cc)
 - Pad: 0000

Flow modifications (Flow mod)

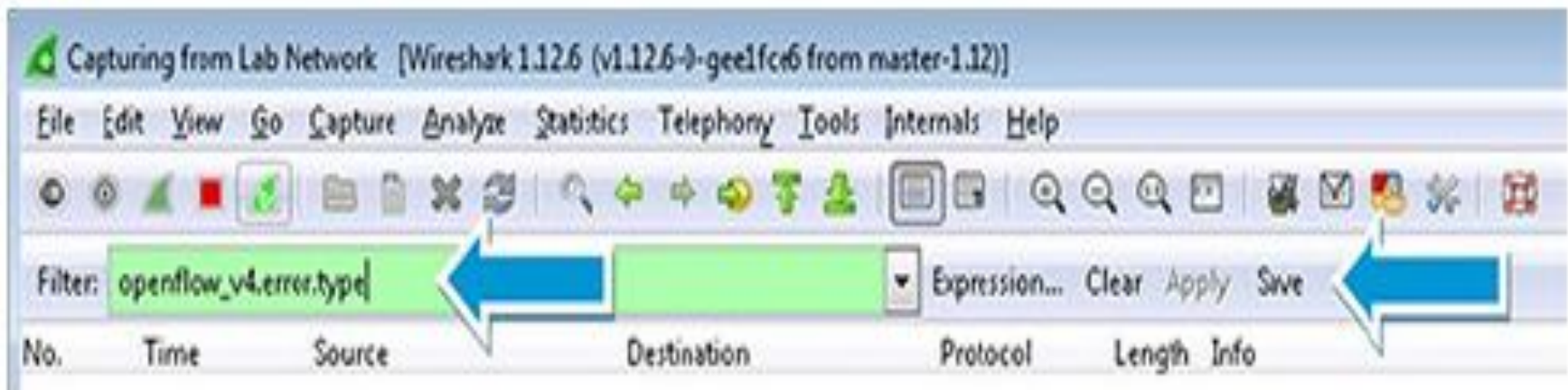
```
enum ofp_flow_mod_command {  
    OFPFC_ADD = 0, /* New flow. */  
    OFPFC_MODIFY = 1, /* Modify all matching flows. */  
    OFPFC_MODIFY_STRICT = 2, /* Modify entry strictly matching wildcards and priority. */  
    OFPFC_DELETE = 3, /* Delete all matching flows. */  
    OFPFC_DELETE_STRICT = 4, /* Delete entry strictly matching wildcards and priority. */  
};
```

Flow modifications (Flow mod)

- **Type: OFPT_FLOW_MOD = 14**
- **Command: OFPFC_DELETE_STRICT = 4**

Flow modifications (Flow mod)

- Set the Wireshark filter to: **openflow_v4.error.type**
- Click Apply
- Click Restart a new live capture



Flow modifications (Flow mod)

In Flow Maker, add a flow entry with the following attributes to the Provision Switch (10.1.1.253) and then click Add (see Figure):

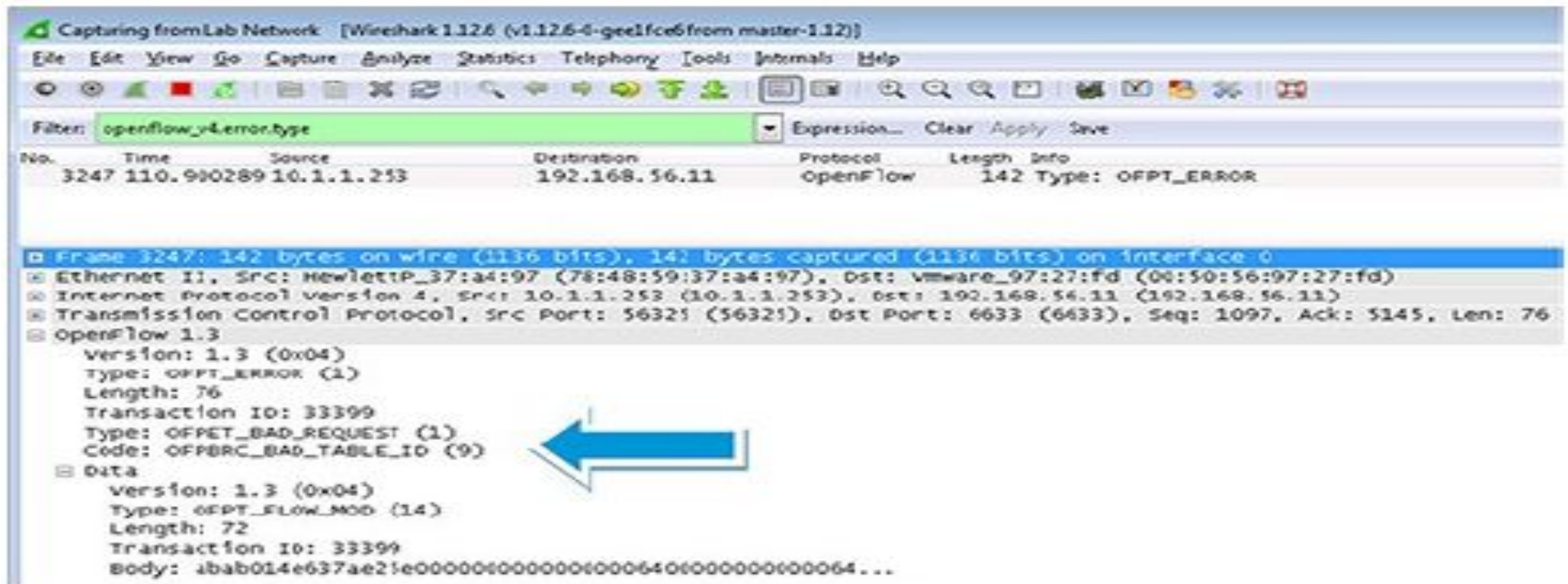
- Table ID: **100**
- Priority: **100**
- In Port: **2**
- Instructions: **Goto Table**
- Table: **150**
- Save Flow: **True**



The screenshot shows the 'Add Flow to Data Path ID: 00:1e:14:58:c0:f0:db:8f' interface. A blue arrow points to the 'Add' button. The form is divided into several sections:

- Metadata:** Table ID: 100, Priority: 100, Idle Timeout: (empty), Hard Timeout: (empty).
- Match:** Source MAC: (empty), Source IP: (empty), Source Netmask: (empty), Source Port: (empty), VLAN ID: (empty), Dest. MAC: (empty), Dest. IP: (empty), Dest. Netmask: (empty), Dest. Port: (empty), In Port: 2.
- Protocol:** IP Protocol: (empty), Ethernet Type: (empty).
- Instructions:** Instructions: Goto Table, Table: 150.
- Actions:** Action 1: No Action, Action 2: No Action, Action 3: No Action, Action 4: No Action, Value: (empty), Value: (empty), Value: (empty), Value: (empty).
- Options:** Save Flow.

Flow modifications (Flow mod)



Capturing from Lab Network [Wireshark 1.12.6 (v1.12.6-4-geelfceb from master-1.12)]

Filter: `openflow_v4.error.type` Expression... Clear Apply Save

No.	Time	Source	Destination	Protocol	Length	Info
3247	110.990289	10.1.1.253	192.168.56.11	OpenFlow	142	Type: OFPT_ERROR

Frame 3247: 142 bytes on wire (1136 bits), 142 bytes captured (1136 bits) on interface 0

- Ethernet II, Src: HewlettP_37:a4:97 (78:48:59:37:a4:97), Dst: vmware_97:27:fd (00:50:56:97:27:fd)
- Internet Protocol Version 4, Src: 10.1.1.253 (10.1.1.253), Dst: 192.168.56.11 (192.168.56.11)
- Transmission Control Protocol, Src Port: 56325 (56325), Dst Port: 6633 (6633), Seq: 1097, Ack: 5145, Len: 76
- OpenFlow 1.3
 - Version: 1.3 (0x04)
 - Type: OFPT_ERROR (1)
 - Length: 76
 - Transaction ID: 33399
 - Type: OFFPET_BAD_REQUEST (1)
 - Code: OFFPRC_BAD_TABLE_ID (9)
 - Data
 - Version: 1.3 (0x04)
 - Type: OFPT_FLOW_MOD (14)
 - Length: 72
 - Transaction ID: 33399
 - Body: 4bab014e637ae21e00000000000000000000640600000000000064...

Result:

Flow modifications (Flow mod)

Add a flow entry to the ProVision switch (10.1.1.253) with the following attributes and then click Add (see Figure):

- Table ID: **100**
 - Priority: **0**
 - Instructions: **Apply**
- Actions**
- Save Flow: **True**

■ Add Flow to Data Path ID: 00:1e:14:58:d0:f0:db:80

Northbound | Gear | Add

Metadata

Table ID: 100
Priority: 0
Idle Timeout:
Hard Timeout:

Match

Source MAC:
Source IP:
Source Netmask:
Source Port:
VLAN ID:
Dest. MAC:
Dest. IP:
Dest. Netmask:
Dest. Port:
In Port:

Protocol

IP Protocol:
Ethernet Type:

Instructions

Instructions: Apply Actions
Table:

Actions

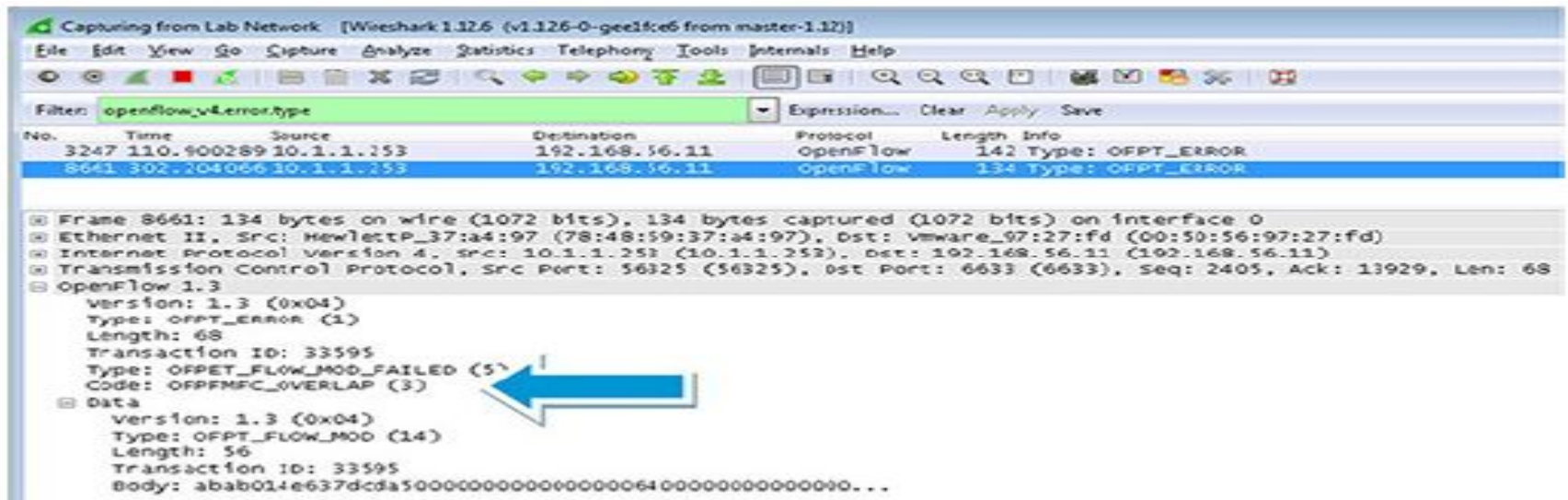
Action 1: No Action
Action 2: No Action
Action 3: No Action
Action 4: No Action
Value:
Value:
Value:
Value:

Options

Save Flow

Flow modifications (Flow mod)

Result:



Capturing from Lab Network [Wireshark 1.12.6 (v1.12.6-0-geef4fce6 from master-1.12)]

File Edit View Go Capture Analyze Statistics Telephony Tools Internals Help

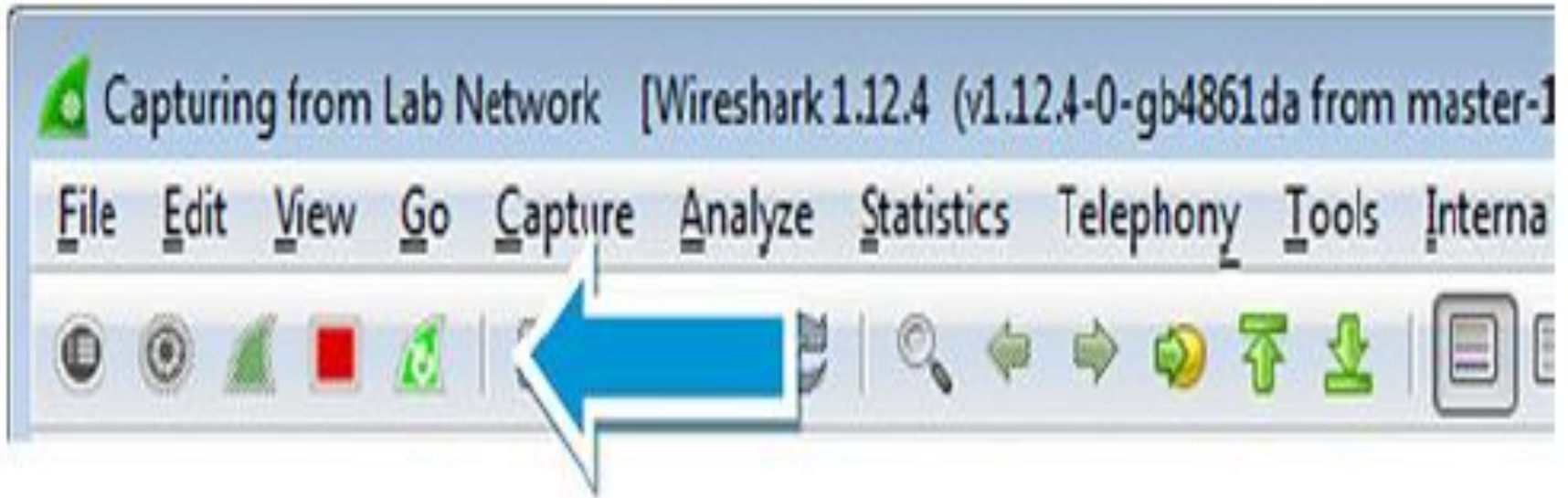
Filter: `openflow_v4.error.type` Expression... Clear Apply Save

No.	Time	Source	Destination	Protocol	Length	Info
3247	110.900289	10.1.1.253	192.168.56.11	OpenFlow	142	Type: OFPT_ERROR
8641	302.204066	10.1.1.253	192.168.56.11	OpenFlow	134	Type: OFPT_ERROR

Frame 8661: 134 bytes on wire (1072 bits), 134 bytes captured (1072 bits) on interface 0

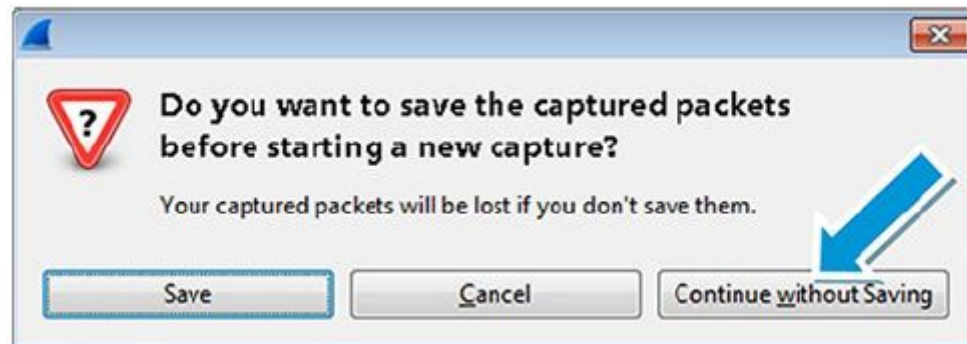
- Ethernet II, Src: HewlettP_37:a4:97 (78:48:59:37:a4:97), Dst: VMware_97:27:fd (00:50:56:97:27:fd)
- Internet Protocol Version 4, Src: 10.1.1.253 (10.1.1.253), Dst: 192.168.56.11 (192.168.56.11)
- Transmission Control Protocol, Src Port: 56325 (56325), Dst Port: 6633 (6633), Seq: 2405, Ack: 13929, Len: 68
- OpenFlow 1.3
 - Version: 1.3 (0x04)
 - Type: OFPT_ERROR (1)
 - Length: 68
 - Transaction ID: 33595
 - Type: OFPET_FLOW_MOD_FAILED (5) ←
 - Code: OFPFMFC_OVERLAP (3)
 - Data
 - Version: 1.3 (0x04)
 - Type: OFPT_FLOW_MOD (14)
 - Length: 56
 - Transaction ID: 33595
 - Body: abab014e637dcd15000000000000000006400000000000000...

Flow modifications (Flow mod)



Flow modifications (Flow mod)

- Set the Wireshark filter to: **openflow_v4.flow_stats.priority**
- Click **Apply**
- Click **Start** to start a new live capture
- Click **Continue without Saving**



Flow modifications (Flow mod)

HP VAN SDN Controller

- General
- Alerts
- Applications
- Configurations
- Audit Log
- Licenses
- Team
- Flow Maker Deluxe
- Support Logs
- OpenFlow Monitor

General / OpenFlow Monitor

Refresh	Summary	Ports	Flows	Groups	
Data Path ID	Address	Negotiated Version	Manufacturer	H/W Version	S/W Version
00:01:78:48:59:39:2f:96	10.1.1.252	1.3.0	HP	HP 5920AF-24XG Sw...	Comware Software...
00:1e:14:58:d0:f0:db...	10.1.1.253	1.3.0	HP	3800-24G-25FP+ Sw...	KA.15.17.0007

Flows for Data Path ID: 00:01:78:48:59:39:2f:96

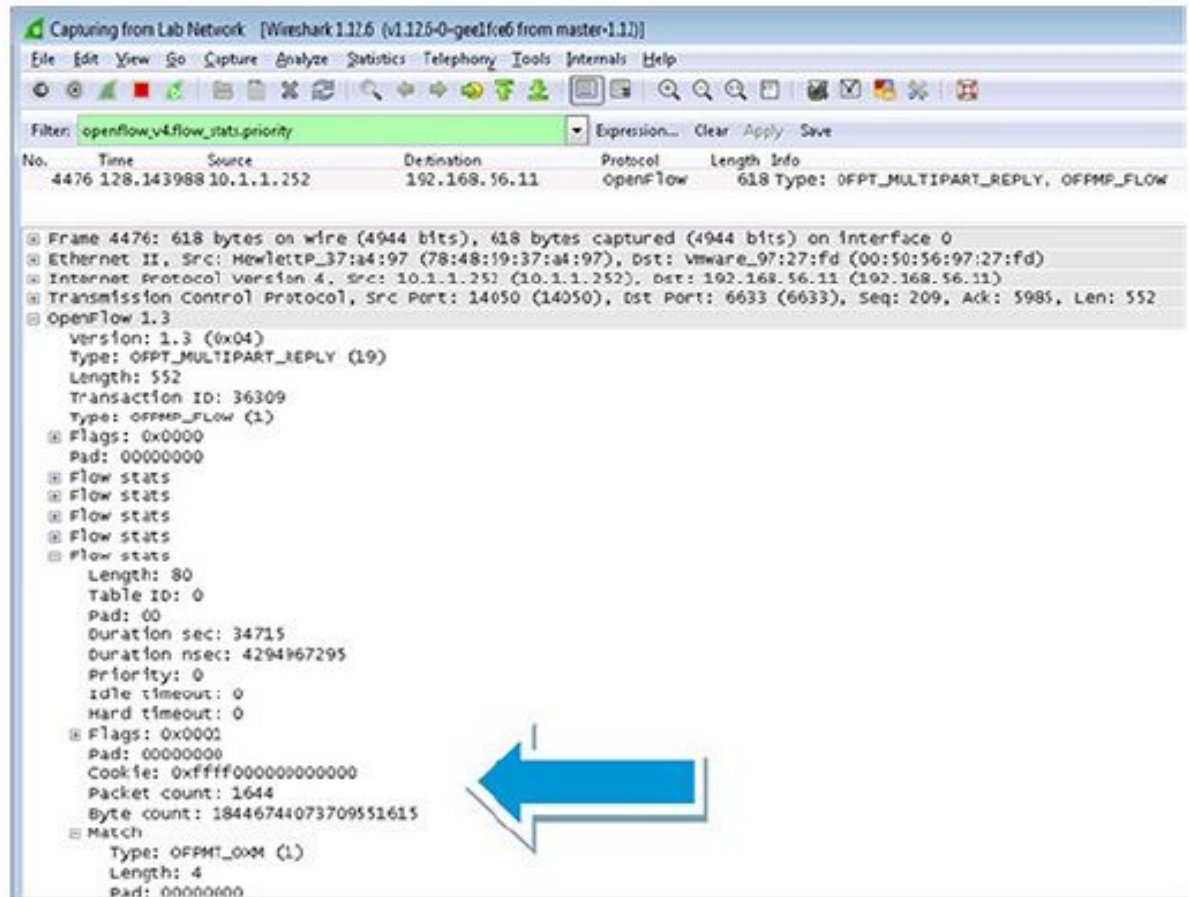
Table ID	Priority	Packets	Bytes	Match	Actions/Instructions
▶ 0	60000	0	n/a	eth_type: bddp	apply_actions: output: CONTROLLER
▶ 0	31500	664	n/a	eth_type: ipv4 ip_proto: udp udp_src: 68 udp_dst: 67	apply_actions: output: CONTROLLER write_actions: output: NORMAL
▶ 0	31500	0	n/a	eth_type: ipv4 ip_proto: udp udp_src: 67 udp_dst: 68	apply_actions: output: CONTROLLER write_actions: output: NORMAL
▶ 0	31000	0	n/a	eth_type: arp	apply_actions: output: CONTROLLER write_actions: output: NORMAL
▶ 0	0	1644	n/a		apply_actions: output: NORMAL

Comware switch

Flows

Flow modifications (Flow mod)

**Packet
count: 1644.**



The screenshot shows a Wireshark capture of an OpenFlow 1.3 OFPT_MULTIPART_REPLY packet. The packet details pane is expanded to show the 'Flow stats' section, which includes the following fields:

- Length: 80
- Table ID: 0
- Pad: 00
- Duration sec: 34715
- Duration nsec: 4294967295
- Priority: 0
- idle timeout: 0
- Hard timeout: 0
- Flags: 0x0001
- Pad: 00000000
- Cookie: 0xffff000000000000
- Packet count: 1644
- Byte count: 18446744073709551615

A blue arrow points to the 'Packet count: 1644' field in the details pane.

Flow modifications (Flow mod)

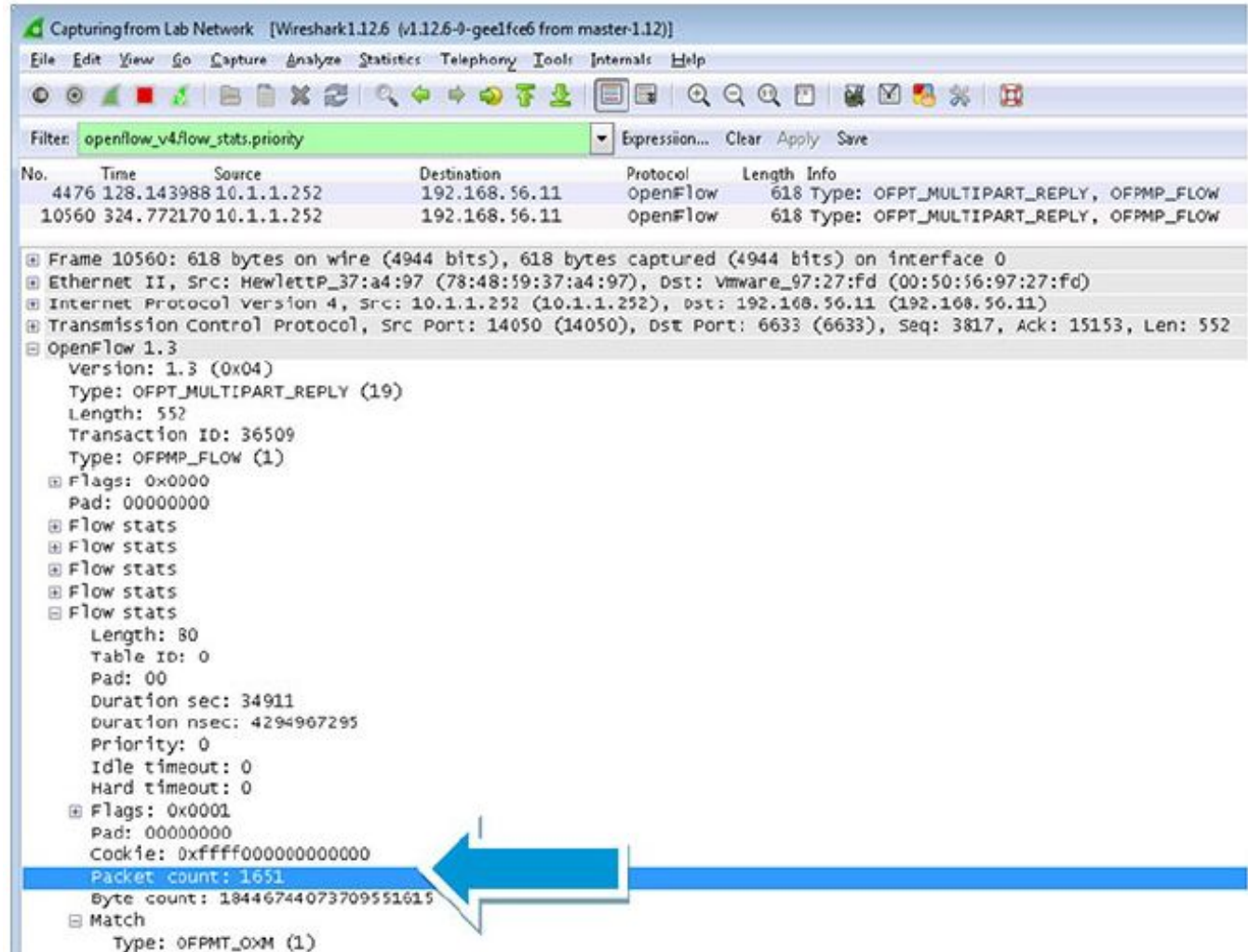
Flows for Data Path ID: 00:01:78:48:59:39:2f:96

SL

Table ID	Priority	Packets	Bytes	Match	Actions/Instructions
▶ 0	60000	0	n/a	eth_type: bddp	apply_actions: output: CONTROLLER
▶ 0	31500	671	n/a	eth_type: ipv4 ip_proto: udp udp_src: 68 udp_dst: 67	apply_actions: output: CONTROLLER write_actions: output: NORMAL
▶ 0	31500	0	n/a	eth_type: ipv4 ip_proto: udp udp_src: 67 udp_dst: 68	apply_actions: output: CONTROLLER write_actions: output: NORMAL
▶ 0	31000	0	n/a	eth_type: arp	apply_actions: output: CONTROLLER write_actions: output: NORMAL
▶ 0	0	1651	n/a		apply_actions: output: NORMAL



Flow modifications (Flow mod)



Capturing from Lab Network [Wireshark1.12.6 (v1.12.6-9-geelfce6 from master-1.12)]

Filter: `openflow_v4.flow_stats.priority` Expression... Clear Apply Save

No.	Time	Source	Destination	Protocol	Length	Info
4476	128.143988	10.1.1.252	192.168.56.11	OpenFlow	618	Type: OFPT_MULTIPART_REPLY, OFPMP_FLOW
10560	324.772170	10.1.1.252	192.168.56.11	OpenFlow	618	Type: OFPT_MULTIPART_REPLY, OFPMP_FLOW

Frame 10560: 618 bytes on wire (4944 bits), 618 bytes captured (4944 bits) on interface 0

- Ethernet II, Src: HewlettP_37:a4:97 (78:48:59:37:a4:97), Dst: vmware_97:27:fd (00:50:56:97:27:fd)
- Internet Protocol Version 4, Src: 10.1.1.252 (10.1.1.252), Dst: 192.168.56.11 (192.168.56.11)
- Transmission Control Protocol, Src Port: 14050 (14050), Dst Port: 6633 (6633), Seq: 3817, Ack: 15153, Len: 552
- OpenFlow 1.3
 - Version: 1.3 (0x04)
 - Type: OFPT_MULTIPART_REPLY (19)
 - Length: 552
 - Transaction ID: 36509
 - Type: OFPMP_FLOW (1)
 - Flags: 0x0000
 - Pad: 00000000
 - Flow stats
 - Flow stats
 - Flow stats
 - Flow stats
 - Flow stats
 - Flow stats
 - Length: 80
 - Table ID: 0
 - Pad: 00
 - Duration sec: 34911
 - Duration nsec: 4294967295
 - Priority: 0
 - Idle timeout: 0
 - Hard timeout: 0
 - Flags: 0x0001
 - Pad: 00000000
 - Cookie: 0xffff000000000000
 - Packet count: 1651**
 - Byte count: 18446744073709551615
 - Match
 - Type: OFPMT_OXM (1)