

BÁO CÁO THỰC HÀNH

Môn học: Công nghệ mạng khả lập trình

Buổi báo cáo: Lab 02

GVHD: Phan Xuân Thiện

Ngày thực hiện: 16/10/2025

THÔNG TIN CHUNG:

Lớp: NT541.Q11.2

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1. ĐÁNH GIÁ KHÁC:

Nội dung	Kết quả
Tổng thời gian thực hiện bài thực hành trung bình	1 ngày
Link Video thực hiện (nếu có)	
Ý kiến (nếu có) + Khó khăn + Đề xuất ...	
Điểm tự đánh giá	10

Phần bên dưới của báo cáo này là báo cáo chi tiết của nhóm thực hiện.

BÁO CÁO CHI TIẾT

I. Yêu cầu 1

1. Cài đặt SDN/OpenFlow Controller (remote controller). Dùng Ryu controller (python)

- Clone Github Repo source code Ryu Controller

```
khanh@ubuntu:~$ git clone https://github.com/faucetsdn/ryu.git
fatal: destination path 'ryu' already exists and is not an empty directory.
khanh@ubuntu:~$ rm -rf ryu/
khanh@ubuntu:~$ git clone https://github.com/faucetsdn/ryu.git
Cloning into 'ryu' ...
remote: Enumerating objects: 26506, done.
remote: Counting objects: 100% (4/4), done.
remote: Compressing objects: 100% (3/3), done.
Receiving objects: 16% (4274/26506), 1.90 MiB | 25.00 KiB/s
```

- Cài đặt Ryu Controller

```
khanh@ubuntu:~$ cd ryu
khanh@ubuntu:~/ryu$ pip install .
Processing /home/khanh/ryu
Requirement already satisfied: eventlet==0.31.1 in /home/khanh/.local/lib/python3.8/site-packages (from ryu==4.34) (0.31.1)
Requirement already satisfied: msgpack>=0.4.0 in /home/khanh/.local/lib/python3.8/site-packages (from ryu==4.34) (1.1.1)
Requirement already satisfied: netaddr in /home/khanh/.local/lib/python3.8/site-packages (from ryu==4.34) (1.3.0)
Requirement already satisfied: oslo.config>=2.5.0 in /home/khanh/.local/lib/python3.8/site-packages (from ryu==4.34) (9.6.0)
Requirement already satisfied: ovs>=2.6.0 in /home/khanh/.local/lib/python3.8/site-packages (from ryu==4.34) (3.6.0)
Requirement already satisfied: packaging==20.9 in /home/khanh/.local/lib/python3.8/site-packages (from ryu==4.34) (20.9)
Requirement already satisfied: routes in /home/khanh/.local/lib/python3.8/site-packages (from ryu==4.34) (2.5.1)
Requirement already satisfied: six>=1.4.0 in /usr/lib/python3/dist-packages (from ryu==4.34) (1.14.0)
Requirement already satisfied: tinyrpc==1.0.4 in /home/khanh/.local/lib/python3.8/site-packages (from ryu==4.34) (1.0.4)
Requirement already satisfied: webob>=1.2 in /home/khanh/.local/lib/python3.8/site-packages (from ryu==4.34) (1.8.9)
Requirement already satisfied: greenlet>=0.3 in /home/khanh/.local/lib/python3.8/site-packages (from eventlet==0.31.1->ryu==4.34) (3.1.1)
Requirement already satisfied: dnspython<2.0.0,>1.15.0 in /home/khanh/.local/lib/python3.8/site-packages (from eventlet==0.31.1->ryu==4.34) (1.16.0)
Requirement already satisfied: requests>=2.18.0 in /usr/lib/python3/dist-packages (from oslo.config>=2.5.0->ryu==4.34) (2.22.0)
Building wheels for collected packages: ryu
  Building wheel for ryu (setup.py) ... done
    Created wheel for ryu: filename=ryu-4.34-py3-none-any.whl size=2203583 sha256=a8bacb58f3b66cb92d324bd410f30166ba1567e5bcfad549241f489c8636a649
    Stored in directory: /tmp/pip-ephem-wheel-cache-5qut6bj/a/wheels/f1/0a/b5/392102aa9e3e938501748f2296ebb89229cd1f14070fc6a81c
Successfully built ryu
Installing collected packages: ryu
  Attempting uninstall: ryu
    Found existing installation: ryu 4.34
    Uninstalling ryu-4.34:
      Successfully uninstalled ryu-4.34
Successfully installed ryu-4.34
khanh@ubuntu:~/ryu$
```

2. Tạo mạng OpenFlow bằng Mininet, kết nối với Ryu Controller

- Viết source code định nghĩa topology. Lưu file dưới tên topo.py

```
khanh@ubuntu:~/nt541/lab2$ cat topo.py
from mininet.topo import Topo
class MyTopo(Topo):
    def build(self):
        # Add hosts and switches
        h1 = self.addHost('h1')
        h2 = self.addHost('h2')
        h3 = self.addHost('h3')
        h4 = self.addHost('h4')

        s1 = self.addSwitch('s1')
        s2 = self.addSwitch('s2')
        s3 = self.addSwitch('s3')
        s4 = self.addSwitch('s4')

        # Add links
        self.addLink(h1, s1)
        self.addLink(h2, s2)
        self.addLink(h3, s3)
        self.addLink(h4, s4)

        self.addLink(s1, s2)
        self.addLink(s1, s3)
        self.addLink(s3, s4)
topos = {'mytopo': (lambda: MyTopo())}
khanh@ubuntu:~/nt541/lab2$
```

- Mở một terminal mới để chạy Ryu controller

```
khanhle@ubuntu:~$ ryu-manager ryu.app.simple_switch_13
loading app ryu.app.simple_switch_13
loading app ryu.controller.ofp_handler
instantiating app ryu.app.simple_switch_13 of SimpleSwitch13
instantiating app ryu.controller.ofp_handler of OFPHandler
[
```

- Ở terminal khác, tiến hành tạo mạng OpenFlow với Mininet, sử dụng lệnh:

"sudo mn --custom topo.py --topo mytopo --controller remote"

```
khanh@ubuntu:~/nt541/lab2$ sudo mn --custom topo.py --topo mytopo --controller remote
*** Creating network
*** Adding controller
Connecting to remote controller at 127.0.0.1:6653
*** Adding hosts:
h1 h2 h3 h4
*** Adding switches:
s1 s2 s3 s4
*** Adding links:
(h1, s1) (h2, s2) (h3, s3) (h4, s4) (s1, s2) (s1, s3) (s3, s4)
*** Configuring hosts
h1 h2 h3 h4
*** Starting controller
c0
*** Starting 4 switches
s1 s2 s3 s4 ...
*** Starting CLI:
mininet>
```

- Kiểm tra lại terminal Ryu controller, thấy rằng đã kết nối thành công

```
packet in 4 06:c4:a0:a4:a7:97 33:33:00:00:00:02 2
packet in 2 06:c4:a0:a4:a7:97 33:33:00:00:00:02 2
packet in 1 6e:d0:8e:48:91:4d 33:33:00:00:00:02 3
packet in 2 6e:d0:8e:48:91:4d 33:33:00:00:00:02 2
packet in 1 de:c8:34:9b:06:6c 33:33:00:00:00:02 2
packet in 1 4e:d7:eb:99:09:d2 33:33:00:00:00:02 1
packet in 2 7a:98:79:5b:0e:07 33:33:00:00:00:02 2
packet in 3 de:c8:34:9b:06:6c 33:33:00:00:00:02 2
packet in 3 4e:d7:eb:99:09:d2 33:33:00:00:00:02 2
packet in 2 4e:d7:eb:99:09:d2 33:33:00:00:00:02 2
packet in 4 de:c8:34:9b:06:6c 33:33:00:00:00:02 2
packet in 4 4e:d7:eb:99:09:d2 33:33:00:00:00:02 2
packet in 4 4a:59:6e:4f:db:a6 33:33:00:00:00:02 2
packet in 3 56:3e:a4:70:67:9f 33:33:00:00:00:02 3
packet in 1 56:3e:a4:70:67:9f 33:33:00:00:00:02 3
packet in 2 56:3e:a4:70:67:9f 33:33:00:00:00:02 2
packet in 4 4a:59:6e:4f:db:a6 33:33:00:00:00:fb 2
packet in 3 56:3e:a4:70:67:9f 33:33:00:00:00:fb 3
packet in 1 56:3e:a4:70:67:9f 33:33:00:00:00:fb 3
packet in 2 56:3e:a4:70:67:9f 33:33:00:00:00:fb 2
packet in 1 de:c8:34:9b:06:6c 33:33:00:00:00:fb 2
packet in 2 7a:98:79:5b:0e:07 33:33:00:00:00:fb 2
packet in 3 de:c8:34:9b:06:6c 33:33:00:00:00:fb 2
packet in 4 de:c8:34:9b:06:6c 33:33:00:00:00:fb 2
packet in 3 7e:99:b1:48:0b:6e 33:33:00:00:00:fb 2
packet in 4 7e:99:b1:48:0b:6e 33:33:00:00:00:fb 2
packet in 1 6e:d0:8e:48:91:4d 33:33:00:00:00:fb 2
packet in 2 6e:d0:8e:48:91:4d 33:33:00:00:00:fb 2
```

- Kiểm tra các node hiện có

```
mininet> nodes
available nodes are:
c0 h1 h2 h3 h4 s1 s2 s3 s4
mininet>
```

- Test ping h1 với h2 và h4

```
mininet> h1 ping h2
PING 10.0.0.2 (10.0.0.2) 56(84) bytes of data.
64 bytes from 10.0.0.2: icmp_seq=1 ttl=64 time=10.8 ms
64 bytes from 10.0.0.2: icmp_seq=2 ttl=64 time=0.357 ms
64 bytes from 10.0.0.2: icmp_seq=3 ttl=64 time=0.075 ms
64 bytes from 10.0.0.2: icmp_seq=4 ttl=64 time=0.068 ms
64 bytes from 10.0.0.2: icmp_seq=5 ttl=64 time=0.095 ms
^C
--- 10.0.0.2 ping statistics ---
5 packets transmitted, 5 received, 0% packet loss, time 4066ms
rtt min/avg/max/mdev = 0.068/2.278/10.797/4.260 ms
mininet> h1 ping h4
PING 10.0.0.4 (10.0.0.4) 56(84) bytes of data.
64 bytes from 10.0.0.4: icmp_seq=1 ttl=64 time=9.61 ms
64 bytes from 10.0.0.4: icmp_seq=2 ttl=64 time=0.373 ms
64 bytes from 10.0.0.4: icmp_seq=3 ttl=64 time=0.080 ms
64 bytes from 10.0.0.4: icmp_seq=4 ttl=64 time=0.077 ms
64 bytes from 10.0.0.4: icmp_seq=5 ttl=64 time=0.082 ms
^C
--- 10.0.0.4 ping statistics ---
5 packets transmitted, 5 received, 0% packet loss, time 4064ms
rtt min/avg/max/mdev = 0.077/2.044/9.608/3.783 ms
mininet>
```

3. Dùng Wireshark tiến hành bắt các gói tin OpenFlow (v1.3)

- OFP Hello: Thiết lập kết nối ban đầu giữa switch và controller

162 27. 515049... 127. 0. 0. 1	127. 0. 0. 1	OpenFlow	76 Type: OFPT_HELLO
264 29. 684509... 127. 0. 0. 1	127. 0. 0. 1	OpenFlow	76 Type: OFPT_HELLO
270 29. 688991... 127. 0. 0. 1	127. 0. 0. 1	OpenFlow	76 Type: OFPT_HELLO
275 29. 698374... 127. 0. 0. 1	127. 0. 0. 1	OpenFlow	76 Type: OFPT_HELLO
280 29. 691386... 127. 0. 0. 1	127. 0. 0. 1	OpenFlow	76 Type: OFPT_HELLO

- OFP Features Request và OFP Features Reply: Cho phép controller lấy thông tin về switch

284 29. 693279... 127. 0. 0. 1	127. 0. 0. 1	OpenFlow	/6 Type: OFPT_FEATURES_REQUEST
287 29. 693663... 127. 0. 0. 1	127. 0. 0. 1	OpenFlow	76 Type: OFPT_FEATURES_REQUEST
290 29. 694250... 127. 0. 0. 1	127. 0. 0. 1	OpenFlow	76 Type: OFPT_FEATURES_REQUEST
293 29. 694991... 127. 0. 0. 1	127. 0. 0. 1	OpenFlow	76 Type: OFPT_FEATURES_REQUEST
296 29. 711598... 127. 0. 0. 1	127. 0. 0. 1	OpenFlow	132 Type: OFPT_PORT_STATUS
299 29. 714950... 127. 0. 0. 1	127. 0. 0. 1	OpenFlow	244 Type: OFPT_FEATURES_REPLY
299 29. 715938... 127. 0. 0. 1	127. 0. 0. 1	OpenFlow	132 Type: OFPT_PORT_STATUS
300 29. 717625... 127. 0. 0. 1	127. 0. 0. 1	OpenFlow	244 Type: OFPT_FEATURES_REPLY
302 29. 718864... 127. 0. 0. 1	127. 0. 0. 1	OpenFlow	132 Type: OFPT_PORT_STATUS
303 29. 720876... 127. 0. 0. 1	127. 0. 0. 1	OpenFlow	292 Type: OFPT_FEATURES_REPLY
305 29. 721739... 127. 0. 0. 1	127. 0. 0. 1	OpenFlow	132 Type: OFPT_PORT_STATUS
306 29. 722074... 127. 0. 0. 1	127. 0. 0. 1	OpenFlow	292 Type: OFPT_FEATURES_REPLY

- OFP Echo Request và OFP Echo Reply: Kiểm tra kết nối giữa controller và switch

1 0. 00000000... 127. 0. 0. 1	127. 0. 0. 1	OpenFlow	/6 Type: OFPT_ECHO_REQUEST
2 0. 00099620... 127. 0. 0. 1	127. 0. 0. 1	OpenFlow	76 Type: OFPT_ECHO_REQUEST
3 0. 00099929... 127. 0. 0. 1	127. 0. 0. 1	OpenFlow	76 Type: OFPT_ECHO_REQUEST
4 0. 00101600... 127. 0. 0. 1	127. 0. 0. 1	OpenFlow	76 Type: OFPT_ECHO_REQUEST
5 0. 00101744... 127. 0. 0. 1	127. 0. 0. 1	OpenFlow	76 Type: OFPT_ECHO_REPLY
6 0. 00111815... 127. 0. 0. 1	127. 0. 0. 1	TCP	68 42470 -- 6653 [ACK] Seq=9 Ack=9 Win=86 Len=0 TStamp=3379093212 TSecr=3379093212
7 0. 00132355... 127. 0. 0. 1	127. 0. 0. 1	OpenFlow	76 Type: OFPT_ECHO_REPLY
8 0. 00132355... 127. 0. 0. 1	127. 0. 0. 1	TCP	68 42510 -- 6653 [ACK] Seq=9 Ack=9 Win=86 Len=0 TStamp=3379093213 TSecr=3379093213
9 0. 00133499... 127. 0. 0. 1	127. 0. 0. 1	OpenFlow	76 Type: OFPT_ECHO_REPLY
10 0. 00133549... 127. 0. 0. 1	127. 0. 0. 1	TCP	68 42592 -- 6653 [ACK] Seq=9 Ack=9 Win=86 Len=0 TStamp=3379093213 TSecr=3379093213
11 0. 00133767... 127. 0. 0. 1	127. 0. 0. 1	OpenFlow	76 Type: OFPT_ECHO_REPLY
12 0. 00133768... 127. 0. 0. 1	127. 0. 0. 1	TCP	68 42486 -- 6653 [ACK] Seq=9 Ack=9 Win=86 Len=0 TStamp=3379093213 TSecr=3379093213
13 5. 00132682... 127. 0. 0. 1	127. 0. 0. 1	OpenFlow	76 Type: OFPT_ECHO_REQUEST
14 5. 00285577... 127. 0. 0. 1	127. 0. 0. 1	OpenFlow	76 Type: OFPT_ECHO_REPLY
15 5. 00286552... 127. 0. 0. 1	127. 0. 0. 1	TCP	68 42470 -- 6653 [ACK] Seq=17 Ack=17 Win=86 Len=0 TStamp=3379098213 TSecr=3379098213
16 5. 00214682... 127. 0. 0. 1	127. 0. 0. 1	OpenFlow	76 Type: OFPT_ECHO_REQUEST
17 5. 00216262... 127. 0. 0. 1	127. 0. 0. 1	OpenFlow	76 Type: OFPT_ECHO_REQUEST
18 5. 00218209... 127. 0. 0. 1	127. 0. 0. 1	OpenFlow	76 Type: OFPT_ECHO_REQUEST
19 5. 00234651... 127. 0. 0. 1	127. 0. 0. 1	OpenFlow	76 Type: OFPT_ECHO_REPLY
20 5. 00234765... 127. 0. 0. 1	127. 0. 0. 1	TCP	68 42592 -- 6653 [ACK] Seq=17 Ack=17 Win=86 Len=0 TStamp=3379098214 TSecr=3379098214

- OFP Packet In và OFP Packet Out: Gửi dữ liệu từ switch lên controller khi switch không biết cách xử lý và ngược lại

684 29. 135585... fe80::dc28:ffff%... ff02::2	OpenFlow	156 Type: OFPT_PACKET_IN
685 29. 135976... fe80::dc28:ffff%... ff02::2	OpenFlow	162 Type: OFPT_PACKET_OUT

- OFP Flow Mod: Là thông điệp điều khiển được Controller gửi xuống Switch nhằm cài đặt, cập nhật hoặc xóa các Flow Entry trong Flow Table của switch

1 207. 12. 106407... 127. 0. 0. 1	127. 0. 0. 1	OpenFlow	146 Type: OFPT_FLOW_MOD
208 12. 106451... ca:89:6a:47:1b:fa:e1:19:57:1a:...	127. 0. 0. 1	OpenFlow	132 Type: OFPT_PACKET_OUT
219 12. 107105... ca:89:6a:47:1b:fa:e1:19:57:1a:...	127. 0. 0. 1	OpenFlow	128 Type: OFPT_PACKET_IN
219 12. 107105... ca:89:6a:47:1b:fa:e1:19:57:1a:...	127. 0. 0. 1	OpenFlow	130 Type: OFPT_PACKET_OUT
212 12. 108426... 127. 0. 0. 1	127. 0. 0. 1	OpenFlow	146 Type: OFPT_FLOW_MOD
213 12. 108483... ca:89:6a:47:1b:fa:e1:19:57:1a:...	127. 0. 0. 1	OpenFlow	132 Type: OFPT_PACKET_OUT
215 12. 109181... 10. 0. 0. 3	10. 0. 0. 4	OpenFlow	182 Type: OFPT_PACKET_IN
216 12. 109983... 127. 0. 0. 1	127. 0. 0. 1	OpenFlow	146 Type: OFPT_FLOW_MOD
217 12. 109983... 10. 0. 0. 3	10. 0. 0. 4	OpenFlow	146 Type: OFPT_PACKET_OUT
217 12. 109983... 10. 0. 0. 3	10. 0. 0. 4	OpenFlow	188 Type: OFPT_PACKET_OUT
218 12. 109765... 10. 0. 0. 3	10. 0. 0. 4	OpenFlow	182 Type: OFPT_PACKET_IN

Frame 287: 146 bytes on wire (1168 bits), 146 bytes captured (1168 bits) on interface lo, id 0
 Ethernet II, Src: 00:00:00:00:00:00 (00:00:00:00:00:00), Dst: 00:00:00:00:00:00 (00:00:00:00:00:00)
 Internet Protocol Version 4, Src: 127.0.0.1, Dst: 127.0.0.1
 Transmission Control Protocol, Src Port: 40256, Dst Port: 40256, Seq: 1297, Ack: 965, Len: 80
 OpenFlow 1.0
 0x0000: 00:00:00:00:00 Version: 1.0 (0x0001)
 Type: OFPT_FLOW_MOD (14)
 Length: 80
 Transaction ID: 1023650818
 Wildcards: 4194290
 In Port: 1
 Ethernet source address: ca:89:6a:47:1b:1b (ca:89:6a:47:1b:1b)
 Ethernet destination address: fa:e1:19:57:1a:2e (fa:e1:19:57:1a:2e)
 Input VLAN id: 0
 Input VLAN priority: 0
 Pad: 00
 01 00 00 00 00 00
 IP ToS: 0
 IP protocol: 0
 Pad: 0000
 Source Address: 0.0.0.0
 Destination Address: 0.0.0.0
 Source Port: 0
 Destination Port: 0
 Cookie: 0x00000000000000000000000000000000
 Command: New flow (0)
 Idle time-out: 0
 hard time-out: 0
 Priority: 32768
 Buffer Id: 0xfffffff
 Out port: 65535
 Flags: 1

4. Liệt kê, mô tả các trường thông tin chính trong mỗi loại thông điệp ở bước 3

- OFP Hello, OFP Features Request, OFP Echo Request, OFP Echo Reply:

- o Version: Phiên bản của giao thức OpenFlow (1.0)
- o Type: Loại thông điệp
- o Length: Độ dài của thông điệp (8), riêng gói tin OFPT_PORT_STATUS có độ dài 64.
- o Transaction ID: Mã để theo dõi yêu cầu và phản hồi

162 27.515049... 127.0.0.1	127.0.0.1	OpenFlow	76 Type: OFPT_HELLO
264 29.684509... 127.0.0.1	127.0.0.1	OpenFlow	76 Type: OFPT_HELLO
270 29.688991... 127.0.0.1	127.0.0.1	OpenFlow	76 Type: OFPT_HELLO
275 29.690374... 127.0.0.1	127.0.0.1	OpenFlow	76 Type: OFPT_HELLO
280 29.691386... 127.0.0.1	127.0.0.1	OpenFlow	76 Type: OFPT_HELLO
284 29.693279... 127.0.0.1	127.0.0.1	OpenFlow	76 Type: OFPT_FEATURES_REQUEST
287 29.693663... 127.0.0.1	127.0.0.1	OpenFlow	76 Type: OFPT_FEATURES_REQUEST
290 29.694250... 127.0.0.1	127.0.0.1	OpenFlow	76 Type: OFPT_FEATURES_REQUEST
293 29.694714... 127.0.0.1	127.0.0.1	OpenFlow	76 Type: OFPT_FEATURES_REQUEST
296 29.711596... 127.0.0.1	127.0.0.1	OpenFlow	132 Type: OFPT_PORT_STATUS
297 29.714959... 127.0.0.1	127.0.0.1	OpenFlow	244 Type: OFPT_FEATURES_REPLY
299 29.715938... 127.0.0.1	127.0.0.1	OpenFlow	132 Type: OFPT_PORT_STATUS
300 29.717625... 127.0.0.1	127.0.0.1	OpenFlow	244 Type: OFPT_FEATURES_REPLY
302 29.718864... 127.0.0.1	127.0.0.1	OpenFlow	132 Type: OFPT_PORT_STATUS
303 29.720870... 127.0.0.1	127.0.0.1	OpenFlow	292 Type: OFPT_FEATURES_REPLY
305 29.721739... 127.0.0.1	127.0.0.1	OpenFlow	132 Type: OFPT_PORT_STATUS
Frame 162: 76 bytes on wire (608 bits), 76 bytes captured (608 bits) on interface any, id 0			
Linux cooked capture			
Internet Protocol Version 4, Src: 127.0.0.1, Dst: 127.0.0.1			
Transmission Control Protocol, Src Port: 6653, Dst Port: 58492, Seq: 1, Ack: 1, Len: 8			
OpenFlow 1.0			
.000 0001 = Version: 1.0 (0x01)			
Type: OFPT_HELLO (0)			
Length: 8			
Transaction ID: 777930874			
284 29.693279... 127.0.0.1	127.0.0.1	OpenFlow	76 Type: OFPT_FEATURES_REQUEST
287 29.693663... 127.0.0.1	127.0.0.1	OpenFlow	76 Type: OFPT_FEATURES_REQUEST
290 29.694250... 127.0.0.1	127.0.0.1	OpenFlow	76 Type: OFPT_FEATURES_REQUEST
293 29.694714... 127.0.0.1	127.0.0.1	OpenFlow	76 Type: OFPT_FEATURES_REQUEST
296 29.711596... 127.0.0.1	127.0.0.1	OpenFlow	132 Type: OFPT_PORT_STATUS
297 29.714959... 127.0.0.1	127.0.0.1	OpenFlow	244 Type: OFPT_FEATURES_REPLY
299 29.715938... 127.0.0.1	127.0.0.1	OpenFlow	132 Type: OFPT_PORT_STATUS
300 29.717625... 127.0.0.1	127.0.0.1	OpenFlow	244 Type: OFPT_FEATURES_REPLY
302 29.718864... 127.0.0.1	127.0.0.1	OpenFlow	132 Type: OFPT_PORT_STATUS
303 29.720870... 127.0.0.1	127.0.0.1	OpenFlow	292 Type: OFPT_FEATURES_REPLY
305 29.721739... 127.0.0.1	127.0.0.1	OpenFlow	132 Type: OFPT_PORT_STATUS
Frame 284: 76 bytes on wire (608 bits), 76 bytes captured (608 bits) on interface any, id 0			
Linux cooked capture			
Internet Protocol Version 4, Src: 127.0.0.1, Dst: 127.0.0.1			
Transmission Control Protocol, Src Port: 6653, Dst Port: 58498, Seq: 9, Ack: 9, Len: 8			
OpenFlow 1.0			
.000 0001 = Version: 1.0 (0x01)			
Type: OFPT_FEATURES_REQUEST (5)			
Length: 8			
Transaction ID: 389645511			
2384 77.030180... 127.0.0.1	127.0.0.1	OpenFlow	76 Type: OFPT_ECHO_REQUEST
2385 77.030292... 127.0.0.1	127.0.0.1	OpenFlow	76 Type: OFPT_ECHO_REQUEST
2386 77.030982... 127.0.0.1	127.0.0.1	OpenFlow	76 Type: OFPT_ECHO_REPLY
2388 77.031085... 127.0.0.1	127.0.0.1	OpenFlow	76 Type: OFPT_ECHO_REPLY
2390 77.350204... 127.0.0.1	127.0.0.1	OpenFlow	76 Type: OFPT_ECHO_REQUEST
2391 77.350722... 127.0.0.1	127.0.0.1	OpenFlow	76 Type: OFPT_ECHO_REPLY
2394 77.857508... 127.0.0.1	127.0.0.1	OpenFlow	76 Type: OFPT_ECHO_REQUEST
2395 77.857932... 127.0.0.1	127.0.0.1	OpenFlow	76 Type: OFPT_ECHO_REPLY
2401 82.032658... 127.0.0.1	127.0.0.1	OpenFlow	76 Type: OFPT_ECHO_REQUEST
Frame 2384: 76 bytes on wire (608 bits), 76 bytes captured (608 bits) on interface any, id 0			
Linux cooked capture			
Internet Protocol Version 4, Src: 127.0.0.1, Dst: 127.0.0.1			
Transmission Control Protocol, Src Port: 58522, Dst Port: 6653, Seq: 11323, Ack: 11529, Len: 8			
OpenFlow 1.0			
.000 0001 = Version: 1.0 (0x01)			
Type: OFPT_ECHO_REQUEST (2)			
Length: 8			
Transaction ID: 0			
2386 77.030982... 127.0.0.1	127.0.0.1	OpenFlow	76 Type: OFPT_ECHO_REPLY
2388 77.031085... 127.0.0.1	127.0.0.1	OpenFlow	76 Type: OFPT_ECHO_REPLY
2390 77.350204... 127.0.0.1	127.0.0.1	OpenFlow	76 Type: OFPT_ECHO_REQUEST
2391 77.350722... 127.0.0.1	127.0.0.1	OpenFlow	76 Type: OFPT_ECHO_REPLY
2394 77.857508... 127.0.0.1	127.0.0.1	OpenFlow	76 Type: OFPT_ECHO_REQUEST
2395 77.857932... 127.0.0.1	127.0.0.1	OpenFlow	76 Type: OFPT_ECHO_REPLY
2401 82.032658... 127.0.0.1	127.0.0.1	OpenFlow	76 Type: OFPT_ECHO_REQUEST
Frame 2386: 76 bytes on wire (608 bits), 76 bytes captured (608 bits) on interface any, id 0			
Linux cooked capture			
Internet Protocol Version 4, Src: 127.0.0.1, Dst: 127.0.0.1			
Transmission Control Protocol, Src Port: 6653, Dst Port: 58524, Seq: 11529, Ack: 11331, Len: 8			
OpenFlow 1.0			
.000 0001 = Version: 1.0 (0x01)			
Type: OFPT_ECHO_REPLY (3)			
Length: 8			
Transaction ID: 0			

305 29.721739... 127.0.0.1	127.0.0.1	OpenFlow	132 Type: OFPT_PORT_STATUS
306 29.722074... 127.0.0.1	127.0.0.1	OpenFlow	292 Type: OFPT_FEATURES_REPLY
312 29.889174... ::	ff02::1:ff5b:b6.. OpenFlow		172 Type: OFPT_PACKET_IN
313 29.890174... ::	ff02::1:ff5b:b6.. OpenFlow		178 Type: OFPT_PACKET_OUT
317 29.890438... ::	ff02::1:ff5b:b6.. OpenFlow		172 Type: OFPT_PACKET_IN
318 29.890961... ::	ff02::1:ff5b:b6.. OpenFlow		178 Type: OFPT_PACKET_OUT
322 29.891208... ::	ff02::1:ff5b:b6.. OpenFlow		172 Type: OFPT_PACKET_IN

```

Frame 305: 132 bytes on wire (1056 bits), 132 bytes captured (1056 bits) on interface any, id 0
Linux cooked capture
Internet Protocol Version 4, Src: 127.0.0.1, Dst: 127.0.0.1
Transmission Control Protocol, Src Port: 58524, Dst Port: 6653, Seq: 9, Ack: 17, Len: 64
OpenFlow 1.0
    .000 0001 = Version: 1.0 (0x01)
    > Type: OFPT_PORT_STATUS (12)
Length: 64
Transaction ID: 0

```

- OFP Features Reply: Có các trường thông tin về switch

- o N_tables: Số flow table mà switch hỗ trợ
- o Capabilities: Các khả năng mà switch hỗ trợ
- o Actions: Các hành động mà switch hỗ trợ
- o Port: Thông tin các port của switch

303 29.720870... 127.0.0.1	127.0.0.1	OpenFlow	292 Type: OFPT_FEATURES_REPLY
305 29.721739... 127.0.0.1	127.0.0.1	OpenFlow	132 Type: OFPT_PORT_STATUS
306 29.722074... 127.0.0.1	127.0.0.1	OpenFlow	292 Type: OFPT_FEATURES_REPLY
312 29.889174... ::	ff02::1:ff5b:b6.. OpenFlow		172 Type: OFPT_PACKET_IN
313 29.890174... ::	ff02::1:ff5b:b6.. OpenFlow		178 Type: OFPT_PACKET_OUT
317 29.890438... ::	ff02::1:ff5b:b6.. OpenFlow		172 Type: OFPT_PACKET_IN
318 29.890961... ::	ff02::1:ff5b:b6.. OpenFlow		178 Type: OFPT_PACKET_OUT
322 29.891208... ::	ff02::1:ff5b:b6.. OpenFlow		172 Type: OFPT_PACKET_IN
323 29.891497... ::	ff02::1:ff5b:b6.. OpenFlow		178 Type: OFPT_PACKET_OUT
331 29.953532... fe80::7486:baff.. ff02::16	OpenFlow		176 Type: OFPT_PACKET_IN
332 29.954410... fe80::7486:baff.. ff02::16	OpenFlow		182 Type: OFPT_PACKET_OUT
338 29.954797... fe80::7486:baff.. ff02::16	OpenFlow		176 Type: OFPT_PACKET_IN
339 29.954822... fe80::7486:baff.. ff02::16	OpenFlow		176 Type: OFPT_PACKET_OUT
340 29.955271... fe80::7486:baff.. ff02::16	OpenFlow		182 Type: OFPT_PACKET_OUT
342 29.955297... fe80::7486:baff.. ff02::16	OpenFlow		182 Type: OFPT_PACKET_OUT
348 29.955562... fe80::7486:baff.. ff02::16	OpenFlow		176 Type: OFPT_PACKET_IN
349 29.955913... fe80::7486:baff.. ff02::16	OpenFlow		182 Type: OFPT_PACKET_OUT
356 30.049566... ::	ff02::16	OpenFlow	176 Type: OFPT_PACKET_IN
357 30.050503... ::	ff02::16	OpenFlow	182 Type: OFPT_PACKET_OUT
373 30.208921... ::	ff02::1:ff43:12.. OpenFlow		172 Type: OFPT_PACKET_IN

```

Frame 303: 292 bytes on wire (2336 bits), 292 bytes captured (2336 bits) on interface any, id 0
Linux cooked capture
Internet Protocol Version 4, Src: 127.0.0.1, Dst: 127.0.0.1
Transmission Control Protocol, Src Port: 58522, Dst Port: 6653, Seq: 73, Ack: 17, Len: 224
OpenFlow 1.0
    .000 0001 = Version: 1.0 (0x01)
    Type: OFPT_FEATURES_REPLY (6)
Length: 224
Transaction ID: 3199340078
    Datapath unique ID: 0x0000000000000000
    n_buffers: 0
    n_tables: 254
    Pad: 000000
    capabilities: 0x000000c7
        .... .... .... .... ..1 = Flow statistics: True
        .... .... .... .... ..1 = Table statistics: True
        .... .... .... .... ..1 = Port statistics: True
        .... .... .... .... ..0 = Group statistics: False
        .... .... .... ..0 ..0 = Can reassemble IP fragments: False
        .... .... .... ..1 ..0 = Queue statistics: True
        .... .... .... ..0 ..0 ..0 = Switch will block looping ports: False
    actions: 0x000000ff
        .... .... .... .... ..1 = Output to switch port: True
        .... .... .... .... ..1 = Set the 802.1q VLAN id: True
        .... .... .... .... ..1 = Set the 802.1q priority: True
        .... .... .... .... ..1 = Strip the 802.1q header: True
        .... .... .... ..1 .... = Ethernet source address: True
        .... .... .... ..1 .... = Ethernet destination address: True
        .... .... .... ..1 .... = IP source address: True
        .... .... .... ..1 .... = IP destination address: True
        .... .... .... ..1 .... = IP ToS (DSCP field, 6 bits): True
        .... .... .... ..1 .... = TCP/UDP source port: True
        .... .... .... ..1 .... = TCP/UDP destination port: True
        .... .... .... ..1 .... = Output to queue: True
    > Port data 1
    > Port data 2

```

- OFP Packet In:

- o In port: Cổng mà switch nhận gói tin.
- o Reason: Lý do gói tin không được xử lý bởi flow rule trong flow table của switch.



```

322 29.891208... :: ff02::1:ff5b:b6.. OpenFlow 172 Type: OFPT_PACKET_IN
323 29.891497... :: ff02::1:ff5b:b6.. OpenFlow 178 Type: OFPT_PACKET_OUT
331 29.953532... fe80::7486:baff.. ff02::16 176 Type: OFPT_PACKET_IN
332 29.954410... fe80::7486:baff.. ff02::16 182 Type: OFPT_PACKET_OUT
338 29.954797... fe80::7486:baff.. ff02::16 176 Type: OFPT_PACKET_IN
339 29.954822... fe80::7486:baff.. ff02::16 176 Type: OFPT_PACKET_IN
340 29.955271... fe80::7486:baff.. ff02::16 182 Type: OFPT_PACKET_OUT
342 29.955297... fe80::7486:baff.. ff02::16 182 Type: OFPT_PACKET_OUT
348 29.955562... fe80::7486:baff.. ff02::16 176 Type: OFPT_PACKET_IN
349 29.955913... fe80::7486:baff.. ff02::16 182 Type: OFPT_PACKET_OUT
356 30.049566... :: ff02::16 176 Type: OFPT_PACKET_IN
357 30.050503... :: ff02::16 182 Type: OFPT_PACKET_OUT
373 30.208921... :: ff02::1:ff43:12.. OpenFlow 172 Type: OFPT_PACKET_IN

> Frame 322: 172 bytes on wire (1376 bits), 172 bytes captured (1376 bits) on interface any, id 0
> Linux cooked capture
> Internet Protocol Version 4, Src: 127.0.0.1, Dst: 127.0.0.1
> Transmission Control Protocol, Src Port: 58510, Dst Port: 6653, Seq: 249, Ack: 17, Len: 104
> OpenFlow 1.0
    .000 0001 = Version: 1.0 (0x01)
    Type: OFPT_PACKET_IN (10)
    Length: 104
    Transaction ID: 0
    Buffer Id: 0xffffffff
    Total length: 86
    In port: 2
    Reason: No matching flow (table-miss flow entry) (0)
    Pad: 00
    > Ethernet II, Src: 96:4b:71:5b:b6:bc (96:4b:71:5b:b6:bc), Dst: IPv6mcast_ff:5b:b6:bc (33:33:ff:5b:b6:bc)
    > Internet Protocol Version 6, Src: ::, Dst: ff02::1:ff5b:b6bc
    > Internet Control Message Protocol v6

```

- OFP Packet Out:

- Action type: Hành động thực hiện với gói tin
- Output port: Cổng mà switch sẽ gửi gói tin đến
- Max length: Độ dài tối đa

```

323 29.891497... :: ff02::1:ff5b:b6.. OpenFlow 178 Type: OFPT_PACKET_OUT
331 29.953532... fe80::7486:baff.. ff02::16 176 Type: OFPT_PACKET_IN
332 29.954410... fe80::7486:baff.. ff02::16 182 Type: OFPT_PACKET_OUT
338 29.954797... fe80::7486:baff.. ff02::16 176 Type: OFPT_PACKET_IN
339 29.954822... fe80::7486:baff.. ff02::16 176 Type: OFPT_PACKET_IN
340 29.955271... fe80::7486:baff.. ff02::16 182 Type: OFPT_PACKET_OUT
342 29.955297... fe80::7486:baff.. ff02::16 182 Type: OFPT_PACKET_OUT
348 29.955562... fe80::7486:baff.. ff02::16 176 Type: OFPT_PACKET_IN
349 29.955913... fe80::7486:baff.. ff02::16 182 Type: OFPT_PACKET_OUT
356 30.049566... :: ff02::16 176 Type: OFPT_PACKET_IN
357 30.050503... :: ff02::16 182 Type: OFPT_PACKET_OUT
373 30.208921... :: ff02::1:ff43:12.. OpenFlow 172 Type: OFPT_PACKET_IN

> Frame 323: 178 bytes on wire (1424 bits), 178 bytes captured (1424 bits) on interface any, id 0
> Linux cooked capture
> Internet Protocol Version 4, Src: 127.0.0.1, Dst: 127.0.0.1
> Transmission Control Protocol, Src Port: 6653, Dst Port: 58510, Seq: 17, Ack: 353, Len: 110
> OpenFlow 1.0
    .000 0001 = Version: 1.0 (0x01)
    Type: OFPT_PACKET_OUT (13)
    Length: 110
    Transaction ID: 2876622058
    Buffer Id: 0xffffffff
    In port: 2
    Actions length: 8
    Actions type: Output to switch port (0)
    Action length: 8
    Output port: 65531
    Max length: 65509
    > Ethernet II, Src: 96:4b:71:5b:b6:bc (96:4b:71:5b:b6:bc), Dst: IPv6mcast_ff:5b:b6:bc (33:33:ff:5b:b6:bc)
    > Internet Protocol Version 6, Src: ::, Dst: ff02::1:ff5b:b6bc
    > Internet Control Message Protocol v6

```

- OFP FlowMod:

- Thông tin chung của gói tin: version, type, length, transaction ID
- Các trường match fields bao gồm: wildcards, in_port, MAC nguồn, MAC đích, IP nguồn, IP đích, port nguồn, port đích ...

- Các trường thiết lập flow bao gồm: cookie, command, idle time-out, hard time-out, priority...

```

207 12.100407. ca:89:6a:47:1b:... 127.0.0.1 OpenFlow 146 Type: OFPT_FLOW_MOD
208 12.100451. ca:89:6a:47:1b:... fa:e1:19:57:1a:... OpenFlow 132 Type: OFPT_PACKET_OUT
210 12.107109. ca:89:6a:47:1b:... fa:e1:19:57:1a:... OpenFlow 126 Type: OFPT_PACKET_IN
211 12.108488. fa:e1:19:57:1a:... Broadcast OpenFlow 132 Type: OFPT_PACKET_OUT
212 12.108426. 127.0.0.1 127.0.0.1 OpenFlow 146 Type: OFPT_FLOW_MOD
213 12.108483. ca:89:6a:47:1b:... fa:e1:19:57:1a:... OpenFlow 132 Type: OFPT_PACKET_OUT
214 12.109101. 10.0.0.3 10.0.0.4 OpenFlow 182 Type: OFPT_PACKET_IN
215 12.109893. 127.0.0.1 127.0.0.1 OpenFlow 146 Type: OFPT_FLOW_MOD
216 12.109937. 10.0.0.3 10.0.0.4 OpenFlow 188 Type: OFPT_PACKET_OUT
219 12.110176. 10.0.0.3 10.0.0.4 OpenFlow 182 Type: OFPT_PACKET_IN

> Frame 207: 146 bytes wire (1168 bits), 146 bytes captured (1168 bits) on interface lo, id 0
> Ethernet II, Src: 00:00:00:00:00:00 (00:00:00:00:00:00), Dst: 00:00:00:00:00:00 (00:00:00:00:00:00)
> Internet Protocol Version 4, Src: 127.0.0.1, Dst: 127.0.0.1
> Transmission Control Protocol, Src Port: 6653, Dst Port: 40256, Seq: 1297, Ack: 965, Len: 80
> OpenFlow 1.0
    .00000000 Version: 1.0 (0x01)
    Flags: OFPT_FLOW_MOD (14)
    Length: 80
    Transaction ID: 1023658018
    Wildcards: 4194290
    In port: 1
    Ethernet source address: ca:89:6a:47:1b:1b (ca:89:6a:47:1b:1b)
    Ethernet destination address: fa:e1:19:57:1a:2e (fa:e1:19:57:1a:2e)
    Input VLAN id: 0
    Input VLAN priority: 0
    Pad: 00
    D1 type: 0
    IP TOS: 0
    IP protocol: 0
    IP options: 0000
    Source Address: 0.0.0.0
    Destination Address: 0.0.0.0
    Source Port: 0
    Destination Port: 0
    Cookie: 0x0000000000000000
    Command: New flow (0)
    Idle time-out: 0
    hard time-out: 0
    Priority: 32768
    Buffer Id: 0xffffffff
    Out port: 65535
    Flags: 1

```

II. Yêu cầu 2

1. Tiến hành cài đặt một loại OpenFlow virtual Switch (vd: Open vSwitch)

- Ở trên máy sẽ làm ovs, cài đặt Open vSwitch với command:

"sudo apt install openvswitch-switch"

```

khanh@khanh:~$ sudo apt install openvswitch-switch
Reading package lists... Done
Building dependency tree... Done
Reading state information... Done
openvswitch-switch is already the newest version (2.17.9-0ubuntu0.22.04.1).
0 upgraded, 0 newly installed, 0 to remove and 10 not upgraded.
khanh@khanh:~$ 

```

- Tạo một bridge interface có tên là labbridge

```

khanh@khanh:~$ sudo ovs-vsctl add-br labbridge
[sudo] password for khanh:
khanh@khanh:~$ sudo ovs-vsctl show
356107dd-67ae-408b-9b9a-922a276a5cfc
    Bridge labbridge
        Port labbridge
            Interface labbridge
                type: internal
            ovs_version: "2.17.9"
khanh@khanh:~$ 

```

- Tao các virtual port vport1 và vport2

```
khanh@khanh:~$ sudo ip tuntap add mode tap vport1
khanh@khanh:~$ sudo ip tuntap add mode tap vport2
khanh@khanh:~$ sudo ifconfig vport1 up
khanh@khanh:~$ sudo ifconfig vport2 up
khanh@khanh:~$ ifconfig -a
ens33: flags=4163<UP,BROADCAST,RUNNING,MULTICAST> mtu 1500
        inet 192.168.160.147 netmask 255.255.255.0 broadcast 192.168.160.255
          inetb fe80::56a7:a304:af49:3b3f prefixlen 64 scopeid 0x20<link>
            ether 00:0c:29:61:b2:24 txqueuelen 1000 (Ethernet)
              RX packets 218418 bytes 325350283 (325.3 MB)
              RX errors 0 dropped 0 overruns 0 frame 0
              TX packets 14649 bytes 1033587 (1.0 MB)
              TX errors 0 dropped 0 overruns 0 carrier 0 collisions 0

labbridge: flags=4098<BROADCAST,MULTICAST> mtu 1500
        ether 62:99:59:ec:3f:43 txqueuelen 1000 (Ethernet)
          RX packets 0 bytes 0 (0.0 B)
          RX errors 0 dropped 0 overruns 0 frame 0
          TX packets 0 bytes 0 (0.0 B)
          TX errors 0 dropped 0 overruns 0 carrier 0 collisions 0

lo: flags=73<UP,LOOPBACK,RUNNING> mtu 65536
        inet 127.0.0.1 netmask 255.0.0.0
          inet6 ::1 prefixlen 128 scopeid 0x10<host>
            loop txqueuelen 1000 (Local Loopback)
              RX packets 272 bytes 28258 (28.2 KB)
              RX errors 0 dropped 0 overruns 0 frame 0
              TX packets 272 bytes 28258 (28.2 KB)
              TX errors 0 dropped 0 overruns 0 carrier 0 collisions 0

ovs-system: flags=4098<BROADCAST,MULTICAST> mtu 1500
        ether 46:56:5c:b4:26:67 txqueuelen 1000 (Ethernet)
          RX packets 0 bytes 0 (0.0 B)
          RX errors 0 dropped 0 overruns 0 frame 0
          TX packets 0 bytes 0 (0.0 B)
          TX errors 0 dropped 0 overruns 0 carrier 0 collisions 0

vport1: flags=4099<UP,BROADCAST,MULTICAST> mtu 1500
        ether aa:dd:c4:08:ef:c5 txqueuelen 1000 (Ethernet)
          RX packets 0 bytes 0 (0.0 B)
          RX errors 0 dropped 0 overruns 0 frame 0
          TX packets 0 bytes 0 (0.0 B)
          TX errors 0 dropped 0 overruns 0 carrier 0 collisions 0

vport2: flags=4099<UP,BROADCAST,MULTICAST> mtu 1500
        ether da:fe:99:e6:de:a6 txqueuelen 1000 (Ethernet)
          RX packets 0 bytes 0 (0.0 B)
          RX errors 0 dropped 0 overruns 0 frame 0
          TX packets 0 bytes 0 (0.0 B)
          TX errors 0 dropped 0 overruns 0 carrier 0 collisions 0
```

- Tiếp theo, thêm 2 port trên vào interface bridge labbridge

```
khanh@khanh:~$ sudo ovs-vsctl add-port labbridge vport1
khanh@khanh:~$ sudo ovs-vsctl add-port labbridge vport2
khanh@khanh:~$ sudo ovs-vsctl show
356107dd-67ae-408b-9b9a-922a276a5cfc
  Bridge labbridge
    Port vport1
      Interface vport1
    Port labbridge
      Interface labbridge
        type: internal
    Port vport2
      Interface vport2
  ovs_version: "2.17.9"
khanh@khanh:~$
```

2. Kết nối switch đã cài đặt với một Ryu controller và một số Host (>= 2 host)

- Tiến hành tạo 2 máy ảo Ubuntu làm Host (một máy có IP .141, và một máy có IP .138)

```

khanhle@khanhle:~$ ifconfig
br-08db97d08ab: flags=4099<UP,BROADCAST,MULTICAST> mtu 1500
    inet 172.24.0.1 netmask 255.255.0.0 broadcast 172.24.255.255
        ether 02:42:7b:04:ed:77 txqueuelen 0 (Ethernet)
        RX packets 0 bytes 0 (0.0 B)
        RX errors 0 dropped 0 overruns 0 frame 0
        TX packets 0 bytes 0 (0.0 B)
        TX errors 0 dropped 0 overruns 0 carrier 0 collisions 0

docker0: flags=4099<UP,BROADCAST,MULTICAST> mtu 1500
    inet 172.17.0.1 netmask 255.255.0.0 broadcast 172.17.255.255
        ether 02:42:3b:d4:26:39 txqueuelen 0 (Ethernet)
        RX packets 0 bytes 0 (0.0 B)
        RX errors 0 dropped 0 overruns 0 frame 0
        TX packets 0 bytes 0 (0.0 B)
        TX errors 0 dropped 0 overruns 0 carrier 0 collisions 0

ens33: flags=4163<UP,BROADCAST,RUNNING,MULTICAST> mtu 1500
    inet 192.168.160.141 netmask 255.255.255.0 broadcast 192.168.160.255
    inet6 fe80::20c:29ff:fe25:1a45 prefixlen 64 scopeid 0x20<link>
        ether 00:0c:29:25:1a:45 txqueuelen 1000 (Ethernet)
        RX packets 52726 bytes 78546346 (78.5 MB)
        RX errors 0 dropped 0 overruns 0 frame 0
        TX packets 3050 bytes 246892 (246.8 KB)
        TX errors 0 dropped 0 overruns 0 carrier 0 collisions 0

lo: flags=73<UP,LOOPBACK,RUNNING> mtu 65536
    inet 127.0.0.1 netmask 255.0.0.0
        inet6 ::1 prefixlen 128 scopeid 0x10<host>

khanhle@ubuntu:~$ ifconfig
docker0: flags=4099<UP,BROADCAST,MULTICAST> mtu 1500
    inet 172.17.0.1 netmask 255.255.0.0 broadcast 172.17.255.255
        ether 16:e4:8d:59:02:62 txqueuelen 0 (Ethernet)
        RX packets 0 bytes 0 (0.0 B)
        RX errors 0 dropped 0 overruns 0 frame 0
        TX packets 0 bytes 0 (0.0 B)
        TX errors 0 dropped 0 overruns 0 carrier 0 collisions 0

docker_gwbridge: flags=4099<UP,BROADCAST,MULTICAST> mtu 1500
    inet 172.18.0.1 netmask 255.255.0.0 broadcast 172.18.255.255
        ether 9a:51:fa:3d:3b:9c txqueuelen 0 (Ethernet)
        RX packets 0 bytes 0 (0.0 B)
        RX errors 0 dropped 0 overruns 0 frame 0
        TX packets 0 bytes 0 (0.0 B)
        TX errors 0 dropped 0 overruns 0 carrier 0 collisions 0

ens33: flags=4163<UP,BROADCAST,RUNNING,MULTICAST> mtu 1500
    inet 192.168.160.138 netmask 255.255.255.0 broadcast 192.168.160.255
    inet6 fe80::20c:29ff:fed2:3ce1 prefixlen 64 scopeid 0x20<link>
        ether 00:0c:29:d2:3c:e1 txqueuelen 1000 (Ethernet)
        RX packets 665 bytes 494043 (494.0 KB)
        RX errors 0 dropped 0 overruns 0 frame 0
        TX packets 427 bytes 84786 (84.7 KB)
        TX errors 0 dropped 0 overruns 0 carrier 0 collisions 0

lo: flags=73<UP,LOOPBACK,RUNNING> mtu 65536
    inet 127.0.0.1 netmask 255.0.0.0
        inet6 ::1 prefixlen 128 scopeid 0x10<host>

```

- Trên máy ảo cài đặt Open vSwitch, kết nối Ryu controller tới với switch (192.168.160.148 là địa chỉ IP của máy Ryu controller)

```

khanh@khanh:~$ sudo ovs-vsctl set-controller labbridge tcp:192.168.160.148:6633
khanh@khanh:~$ sudo ovs-vsctl show
356107dd-67ae-408b-9b9a-922a276a5fcf
  Bridge labbridge
    Controller "tcp:192.168.160.148:6633"
      is_connected: true
    Port vport1
      Interface vport1
    Port labbridge
      Interface labbridge
        type: internal
    Port vport2
      Interface vport2
  ovs_version: "2.17.9"
khanh@khanh:~$ 

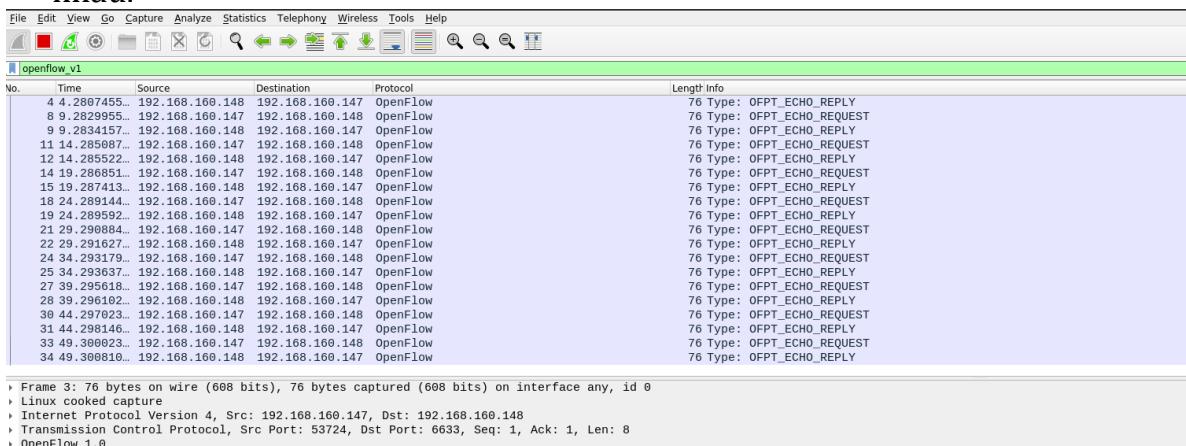
```

- Kiểm tra kết nối ở máy Ryu controller, thấy rằng đã thành công

```
khanh@ubuntu:~$ ryu run ryu.app.simple_switch
loading app ryu.app.simple_switch
loading app ryu.controller.ofp_handler
instantiating app ryu.app.simple_switch of SimpleSwitch
instantiating app ryu.controller.ofp_handler of OFPHandler
packet in 108410778173251 00:23:20:8d:87:74 ff:ff:ff:ff:ff:ff 65534
```

3. Cài Wireshark và tiến hành các bước bắt gói tin trong yêu cầu 1, 2

- Bắt gói tin bằng Wireshark, thấy rằng Switch và Controller đang giao tiếp với nhau.



4. Test performance của mạng đã tạo ra

- Cho máy host 1 với địa chỉ IP .141 làm iperf server

```
khanhle@khanhle:~$ iperf3 -s
-----
[ New connection from 192.168.160.138, port 54216
[Accepted connection from 192.168.160.138, port 54216
[  ] local 192.168.160.141 port 5201 connected to 192.168.160.138 port 54216
[ ID] Interval           Transfer     Bitrate
[ 5]  0.00-1.00   sec    97.5 MBytes  818 Mbits/sec
[ 5]  1.00-2.00   sec   235 MBytes  1.97 Gbits/sec
[ 5]  2.00-3.00   sec   273 MBytes  2.29 Gbits/sec
[ 5]  3.00-4.00   sec   287 MBytes  2.41 Gbits/sec
[ 5]  4.00-5.00   sec   285 MBytes  2.39 Gbits/sec
[ 5]  5.00-6.00   sec   254 MBytes  2.13 Gbits/sec
[ 5]  6.00-7.00   sec   281 MBytes  2.36 Gbits/sec
[ 5]  7.00-8.00   sec   304 MBytes  2.55 Gbits/sec
[ 5]  8.00-9.00   sec   290 MBytes  2.43 Gbits/sec
[ 5]  9.00-10.00  sec   253 MBytes  2.12 Gbits/sec
[ 5] 10.00-10.07  sec   20.5 MBytes  2.48 Gbits/sec
[  ]  Interval           Transfer     Bitrate
[ 5]  0.00-10.07  sec  2.52 GBytes  2.15 Gbits/sec
----- receiver
----- Server listening on 5201
-----
```

- Cho máy host 2 với địa chỉ .138 làm iperf client. Kiểm tra hiệu năng của mạng đã tạo ra

```
khanhle@ubuntu:~$ iperf3 -c 192.168.160.141
Connecting to host 192.168.160.141, port 5201
[ 5] local 192.168.160.138 port 54218 connected to 192.168.160.141 port 5201
[ ID] Interval      Transfer     Bitrate    Retr Cwnd
[ 5]  0.00-1.00   sec   110 MBytes   923 Mbytes/sec   81  1.37 MBytes
[ 5]  1.00-2.00   sec   236 MBytes   1.98 Gbits/sec   0   1.51 MBytes
[ 5]  2.00-3.00   sec   274 MBytes   2.30 Gbits/sec   0   1.63 MBytes
[ 5]  3.00-4.00   sec   289 MBytes   2.42 Gbits/sec   0   1.73 MBytes
[ 5]  4.00-5.00   sec   284 MBytes   2.38 Gbits/sec   0   1.84 MBytes
[ 5]  5.00-6.00   sec   258 MBytes   2.16 Gbits/sec   11  1.43 MBytes
[ 5]  6.00-7.00   sec   282 MBytes   2.37 Gbits/sec   0   1.57 MBytes
[ 5]  7.00-8.00   sec   306 MBytes   2.57 Gbits/sec   0   1.70 MBytes
[ 5]  8.00-9.00   sec   288 MBytes   2.41 Gbits/sec   0   1.82 MBytes
[ 5]  9.00-10.00  sec   256 MBytes   2.15 Gbits/sec  19  1.42 MBytes
-
[ ID] Interval      Transfer     Bitrate    Retr
[ 5]  0.00-10.00  sec   2.52 GBytes  2.17 Gbits/sec  111
[ 5]  0.00-10.07  sec   2.52 GBytes  2.15 Gbits/sec

iperf Done.
khanhle@ubuntu:~$
```

YÊU CẦU CHUNG

1) Đánh giá

- Chuẩn bị tốt các yêu cầu đặt ra trong bài thực hành.
- Sinh viên hiểu và tự thực hiện được bài thực hành, trả lời đầy đủ các yêu cầu đặt ra.
- Nộp báo cáo kết quả chi tiết những đã thực hiện, quan sát thấy và kèm ảnh chụp màn hình kết quả (*nếu có*); giải thích cho quan sát (*nếu có*).
- Sinh viên báo cáo kết quả thực hiện và nộp bài.

2) Báo cáo

- File **.PDF** hoặc **.docx**. Tập trung vào nội dung, giải thích.
- Nội dung trình bày bằng Font chữ **Times New Romans/** hoặc font chữ của mẫu báo cáo này (**UTM Avo**) – **cỡ chữ 13. Canh đều (Justify)** cho văn bản. **Canh giữa (Center)** cho ảnh chụp.
- Đặt tên theo định dạng: LabX_MSSV1_MSSV2. (trong đó X là Thứ tự buổi Thực hành).
Ví dụ: Lab01_21520001_21520002
- Nộp file báo cáo trên theo thời gian đã thống nhất tại courses.uit.edu.vn.

Bài sao chép, trễ, ... sẽ được xử lý tùy mức độ vi phạm.

HẾT