

## Part C

```
INFO:host_tracker:Learned 3 1 00:00:00:00:00:01
INFO:host_tracker:Learned 3 1 00:00:00:00:00:01 got IP 10.0.0.1
INFO:host_tracker:Learned 6 1 00:00:00:00:00:05
INFO:host_tracker:Learned 6 1 00:00:00:00:00:05 got IP 10.0.0.5
DEBUG:forwarding.l2_learning:installing flow for 00:00:00:00:00:05.1 -> 00:00:00:00:00:01.3
DEBUG:forwarding.l2_learning:installing flow for 00:00:00:00:00:05.1 -> 00:00:00:00:00:01.3
DEBUG:forwarding.l2_learning:installing flow for 00:00:00:00:00:05.2 -> 00:00:00:00:00:01.1
DEBUG:forwarding.l2_learning:installing flow for 00:00:00:00:00:05.3 -> 00:00:00:00:00:01.1
DEBUG:forwarding.l2_learning:installing flow for 00:00:00:00:00:05.3 -> 00:00:00:00:00:01.1
DEBUG:forwarding.l2_learning:installing flow for 00:00:00:00:00:01.1 -> 00:00:00:00:00:05.3
DEBUG:forwarding.l2_learning:installing flow for 00:00:00:00:00:01.1 -> 00:00:00:00:00:05.3
DEBUG:forwarding.l2_learning:installing flow for 00:00:00:00:00:01.1 -> 00:00:00:00:00:05.2
DEBUG:forwarding.l2_learning:installing flow for 00:00:00:00:00:01.3 -> 00:00:00:00:00:05.1
DEBUG:forwarding.l2_learning:installing flow for 00:00:00:00:00:01.3 -> 00:00:00:00:00:05.1
POX>
```

The first couple of lines are finding the switches that the hosts h1 and h5 are connected to and probably installing a link/rule. The following lines are installing flows based off the source MAC address, destination MAC address and port number for each switch. The first 5 lines of the DEBUG lines are installing rules on switches s6, s5, s1, s2, and s3, in order and using the respective ports. The next 5 lines of the DEBUG lines are installing rules on switches s3, s2, s1, s5, and s6, in order and using the respective ports. The way the DEBUG lines can be read is:

...flow for <MAC address>.<in port> -> <MAC address>.<out port>

```
mininet> h1 ping h5
PING 10.0.0.5 (10.0.0.5) 56(84) bytes of data.
64 bytes from 10.0.0.5: icmp_seq=1 ttl=64 time=14.9 ms
64 bytes from 10.0.0.5: icmp_seq=2 ttl=64 time=0.043 ms
64 bytes from 10.0.0.5: icmp_seq=3 ttl=64 time=0.045 ms
64 bytes from 10.0.0.5: icmp_seq=4 ttl=64 time=0.143 ms
64 bytes from 10.0.0.5: icmp_seq=5 ttl=64 time=0.089 ms
64 bytes from 10.0.0.5: icmp_seq=6 ttl=64 time=0.099 ms
^C
--- 10.0.0.5 ping statistics ---
6 packets transmitted, 6 received, 0% packet loss, time 5100ms
rtt min/avg/max/mdev = 0.043/2.560/14.944/5.538 ms
```

The first ping takes much longer to finish than the subsequent pings. This is because the first ping has to get the MAC addresses with an ARP packet. This packet will resolve all the MAC addresses to IP addresses of the devices.

```

mininet@mininet-vn:~$ sudo ovs-ofctl dump-flows s1
cookie=0x0, duration=15.370s, table=0, n_packets=0, n_bytes=328, priority=65000,dst=01:23:20:00:00:01,dtype=0x88cc actions=CONTROLLER:65535
cookie=0x0, duration=15.331s, table=0, n_packets=0, n_bytes=0, priority=32769,arp,dst=02:00:00:00:be:ef actions=CONTROLLER:65535
mininet@mininet-vn:~$ sudo ovs-ofctl dump-flows s2
cookie=0x0, duration=18.992s, table=0, n_packets=13, n_bytes=533, priority=65000,dst=01:23:20:00:00:01,dtype=0x88cc actions=CONTROLLER:65535
cookie=0x0, duration=18.950s, table=0, n_packets=0, n_bytes=0, priority=32769,arp,dst=02:00:00:00:be:ef actions=CONTROLLER:65535
mininet@mininet-vn:~$ sudo ovs-ofctl dump-flows s3
cookie=0x0, duration=22.458s, table=0, n_packets=5, n_bytes=205, priority=65000,dst=01:23:20:00:00:01,dtype=0x88cc actions=CONTROLLER:65535
cookie=0x0, duration=22.416s, table=0, n_packets=0, n_bytes=0, priority=32769,arp,dst=02:00:00:00:be:ef actions=CONTROLLER:65535
mininet@mininet-vn:~$ sudo ovs-ofctl dump-flows s4
cookie=0x0, duration=24.324s, table=0, n_packets=6, n_bytes=246, priority=65000,dst=01:23:20:00:00:01,dtype=0x88cc actions=CONTROLLER:65535
cookie=0x0, duration=24.282s, table=0, n_packets=0, n_bytes=0, priority=32769,arp,dst=02:00:00:00:be:ef actions=CONTROLLER:65535
mininet@mininet-vn:~$ sudo ovs-ofctl dump-flows s5
cookie=0x0, duration=27.404s, table=0, n_packets=18, n_bytes=738, priority=65000,dst=01:23:20:00:00:01,dtype=0x88cc actions=CONTROLLER:65535
cookie=0x0, duration=27.362s, table=0, n_packets=0, n_bytes=0, priority=32769,arp,dst=02:00:00:00:be:ef actions=CONTROLLER:65535
mininet@mininet-vn:~$ sudo ovs-ofctl dump-flows s6
cookie=0x0, duration=36.462s, table=0, n_packets=9, n_bytes=369, priority=65000,dst=01:23:20:00:00:01,dtype=0x88cc actions=CONTROLLER:65535
cookie=0x0, duration=36.420s, table=0, n_packets=0, n_bytes=0, priority=32769,arp,dst=02:00:00:00:be:ef actions=CONTROLLER:65535
mininet@mininet-vn:~$ sudo ovs-ofctl dump-flows s7
cookie=0x0, duration=37.954s, table=0, n_packets=9, n_bytes=369, priority=65000,dst=01:23:20:00:00:01,dtype=0x88cc actions=CONTROLLER:65535
cookie=0x0, duration=37.912s, table=0, n_packets=0, n_bytes=0, priority=32769,arp,dst=02:00:00:00:be:ef actions=CONTROLLER:65535
mininet@mininet-vn:~$
mininet@mininet-vn:~$ sudo ovs-ofctl dump-flows s1
cookie=0x0, duration=11.799s, table=0, n_packets=8, n_bytes=672, hard_timeout=1800, priority=65001,dsrc=00:00:00:00:00:05,dst=00:00:00:00:00:01 actions=output:"s1-eth1"
cookie=0x0, duration=11.796s, table=0, n_packets=7, n_bytes=630, hard_timeout=1800, priority=65001,dsrc=00:00:00:00:00:01,dst=00:00:00:00:00:05 actions=output:"s1-eth2"
cookie=0x0, duration=11.045s, table=0, n_packets=55, n_bytes=2255, priority=65000,dst=01:23:20:00:00:01,dtype=0x88cc actions=CONTROLLER:65535
cookie=0x0, duration=131.006s, table=0, n_packets=0, n_bytes=0, priority=32769,arp,dst=02:00:00:00:be:ef actions=CONTROLLER:65535
mininet@mininet-vn:~$ sudo ovs-ofctl dump-flows s2
cookie=0x0, duration=54.496s, table=0, n_packets=8, n_bytes=672, hard_timeout=1800, priority=65001,dsrc=00:00:00:00:00:05,dst=00:00:00:00:00:01 actions=output:"s2-eth1"
cookie=0x0, duration=54.495s, table=0, n_packets=7, n_bytes=630, hard_timeout=1800, priority=65001,dsrc=00:00:00:00:00:01,dst=00:00:00:00:00:05 actions=output:"s2-eth3"
cookie=0x0, duration=173.701s, table=0, n_packets=105, n_bytes=4305, priority=65000,dst=01:23:20:00:00:01,dtype=0x88cc actions=CONTROLLER:65535
cookie=0x0, duration=173.659s, table=0, n_packets=0, n_bytes=0, priority=32769,arp,dst=02:00:00:00:be:ef actions=CONTROLLER:65535
mininet@mininet-vn:~$ sudo ovs-ofctl dump-flows s3
cookie=0x0, duration=56.781s, table=0, n_packets=8, n_bytes=672, hard_timeout=1800, priority=65001,dsrc=00:00:00:00:00:05,dst=00:00:00:00:00:01 actions=output:"s3-eth1"
cookie=0x0, duration=56.780s, table=0, n_packets=7, n_bytes=630, hard_timeout=1800, priority=65001,dsrc=00:00:00:00:00:01,dst=00:00:00:00:00:05 actions=output:"s3-eth3"
cookie=0x0, duration=175.986s, table=0, n_packets=36, n_bytes=1476, priority=65000,dst=01:23:20:00:00:01,dtype=0x88cc actions=CONTROLLER:65535
cookie=0x0, duration=175.944s, table=0, n_packets=0, n_bytes=0, priority=32769,arp,dst=02:00:00:00:be:ef actions=CONTROLLER:65535
mininet@mininet-vn:~$ sudo ovs-ofctl dump-flows s4
cookie=0x0, duration=178.276s, table=0, n_packets=36, n_bytes=1476, priority=65000,dst=01:23:20:00:00:01,dtype=0x88cc actions=CONTROLLER:65535
cookie=0x0, duration=178.228s, table=0, n_packets=0, n_bytes=0, priority=32769,arp,dst=02:00:00:00:be:ef actions=CONTROLLER:65535
mininet@mininet-vn:~$ sudo ovs-ofctl dump-flows s5
cookie=0x0, duration=62.709s, table=0, n_packets=8, n_bytes=672, hard_timeout=1800, priority=65001,dsrc=00:00:00:00:00:05,dst=00:00:00:00:00:01 actions=output:"s5-eth3"
cookie=0x0, duration=62.709s, table=0, n_packets=7, n_bytes=630, hard_timeout=1800, priority=65001,dsrc=00:00:00:00:00:01,dst=00:00:00:00:00:05 actions=output:"s5-eth1"
cookie=0x0, duration=181.913s, table=0, n_packets=110, n_bytes=4510, priority=65000,dst=01:23:20:00:00:01,dtype=0x88cc actions=CONTROLLER:65535
cookie=0x0, duration=181.871s, table=0, n_packets=0, n_bytes=0, priority=32769,arp,dst=02:00:00:00:be:ef actions=CONTROLLER:65535
mininet@mininet-vn:~$ sudo ovs-ofctl dump-flows s6
cookie=0x0, duration=64.314s, table=0, n_packets=8, n_bytes=672, hard_timeout=1800, priority=65001,dsrc=00:00:00:00:00:05,dst=00:00:00:00:00:01 actions=output:"s6-eth3"
cookie=0x0, duration=64.314s, table=0, n_packets=7, n_bytes=630, hard_timeout=1800, priority=65001,dsrc=00:00:00:00:00:01,dst=00:00:00:00:00:05 actions=output:"s6-eth1"
cookie=0x0, duration=183.527s, table=0, n_packets=38, n_bytes=1558, priority=65000,dst=01:23:20:00:00:01,dtype=0x88cc actions=CONTROLLER:65535
cookie=0x0, duration=183.485s, table=0, n_packets=0, n_bytes=0, priority=32769,arp,dst=02:00:00:00:be:ef actions=CONTROLLER:65535
mininet@mininet-vn:~$ sudo ovs-ofctl dump-flows s7
cookie=0x0, duration=185.167s, table=0, n_packets=38, n_bytes=1558, priority=65000,dst=01:23:20:00:00:01,dtype=0x88cc actions=CONTROLLER:65535
cookie=0x0, duration=185.125s, table=0, n_packets=0, n_bytes=0, priority=32769,arp,dst=02:00:00:00:be:ef actions=CONTROLLER:65535
mininet@mininet-vn:~$

```

The initial rules are for the controller.

No not all the switches have newly installed flow rules because only switches s1, s2, s3, s5, and s6 are included in the path from h1 to h5. So the switches s4 and s7 do not have newly installed flow rules.

This controller implements destination packet-forwarding because it allows any traffic to flow between h1 and h5. In parts A and B, we specified the IP addresses which restricts flow.