EE555 Final Project Report

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Part 1: Learn Development Tools

Start network with kernel switch:

```
sudo mn --topo single,3 --switch ovsk --controller remote
```

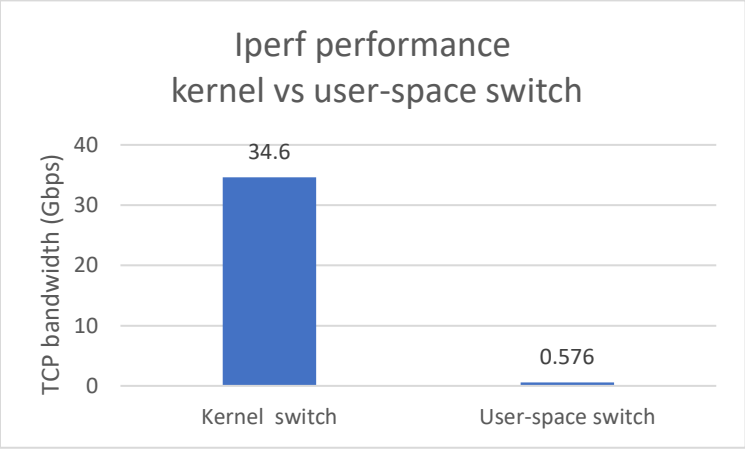
In another ssh terminal, start controller:

```
$sudo controller ptcp:
```

And then run with user space switch

```
sudo mn --topo single,3 --switch user --controller remote
```

Iperf performance comparison.



Part 1: Create a Learning Switch

Our Switch Implementation:

Use mac_to_port as mac address table which maps mac to port.

When controller receives a packet, add src_mac to mac_to_port table, and then look dst_mac in mac_to_port table, if found create a new flow and forward that packet to specified port. If dst_mac not found in table, flood to all ports.

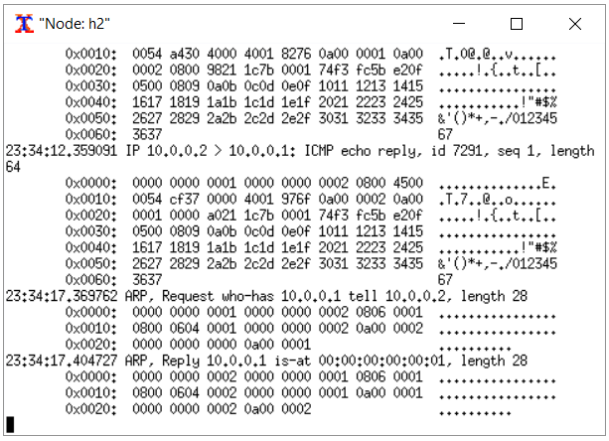
Run hub controller

```
$./pox.py log.level --DEBUG misc.of_tutorial
```

Create virtual net

```
$ sudo mn --topo single,3 --mac --switch ovsk --controller remote
```

Next, use ping to test connection and use tcpdump to view packets.

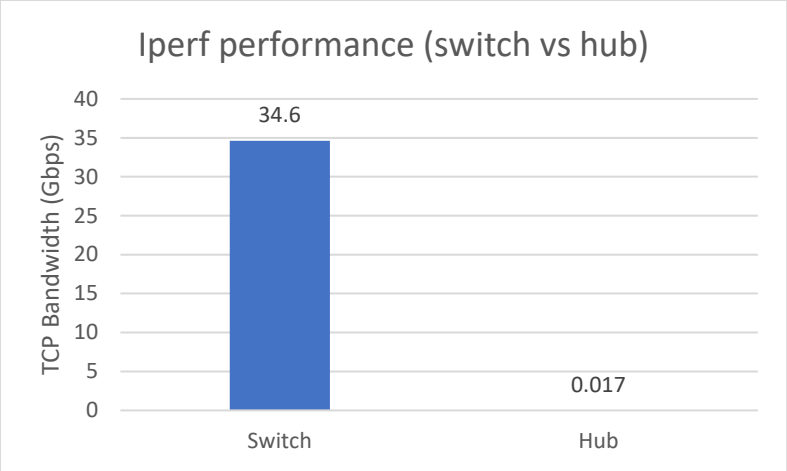


Then, run switch controller and virtual net

(first copy switch.py from part1 to ~/pox/pox/misc directory)

```
$./pox.py log.level --DEBUG misc.switch

$ sudo mn --topo single,3 --mac --switch ovsk --controller remote
```

Iperf performance comparison of hub and switch



Part 1: Router Exercise

Implementation description:

IP packets process:

If dst_ip is router, pass it to icmp handler.

If dst ip is not router, need to check arp table and route table.

If dst ip doesn't match route table, then reply ICMP unreachable packet to src ip.

If dst ip match route table but not in arp table, router need to send arp request to find where dst ip is, at the same time put the original ICMP packet into a buffer. When receive arp reply, then send the buffered ICMP packet to dst ip.

ARP process:

When receive a ARP request, add an entry into arp table, then add a flow rule (match dst_ip = protosrc in arp packet) with action (modify dst_mac and output port).

When receive a ARP reply, add arp entry into arp table, then process arp message queue (buffered packets).

ICMP process:

If dst_ip is router, reply ICMP echo directly.

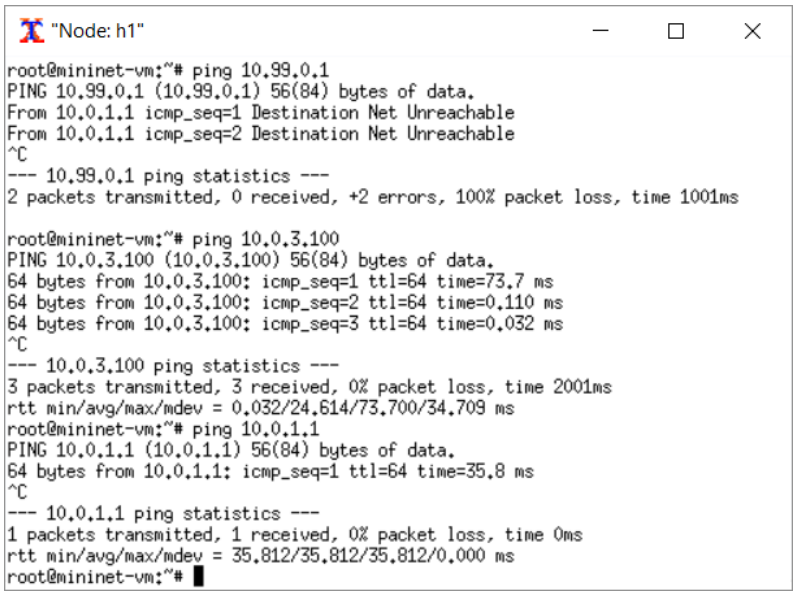
Run router controller and topology:

(copy router.py from part1 to ~/pox/pox/misc directory)

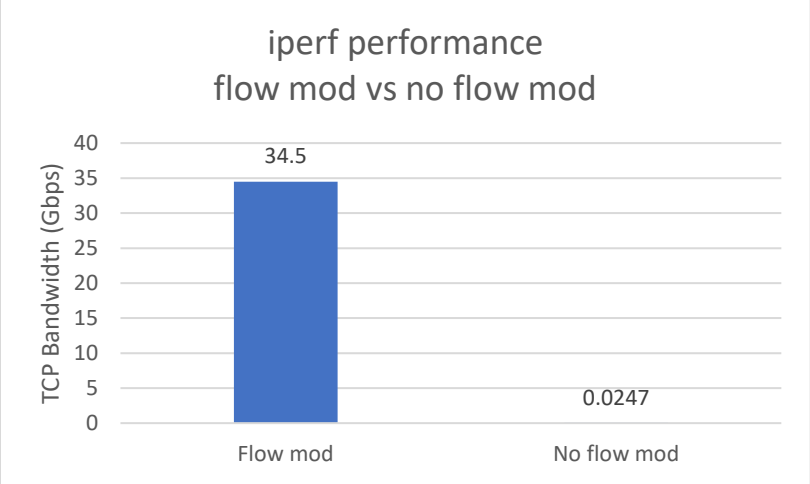
(copy mytopo.py from part1 to current directory)

```
$./pox.py log.level --DEBUG misc.router

$ sudo mn --custom mytopo.py --topo mytopo –mac –-controller remote
```

Next, test ICMP (ping unreachable host, ping h3, ping router)



Then, test Iperf performance between h1 and h3



Part 2: Advanced router

In this part, controller need to support both switching and routing.

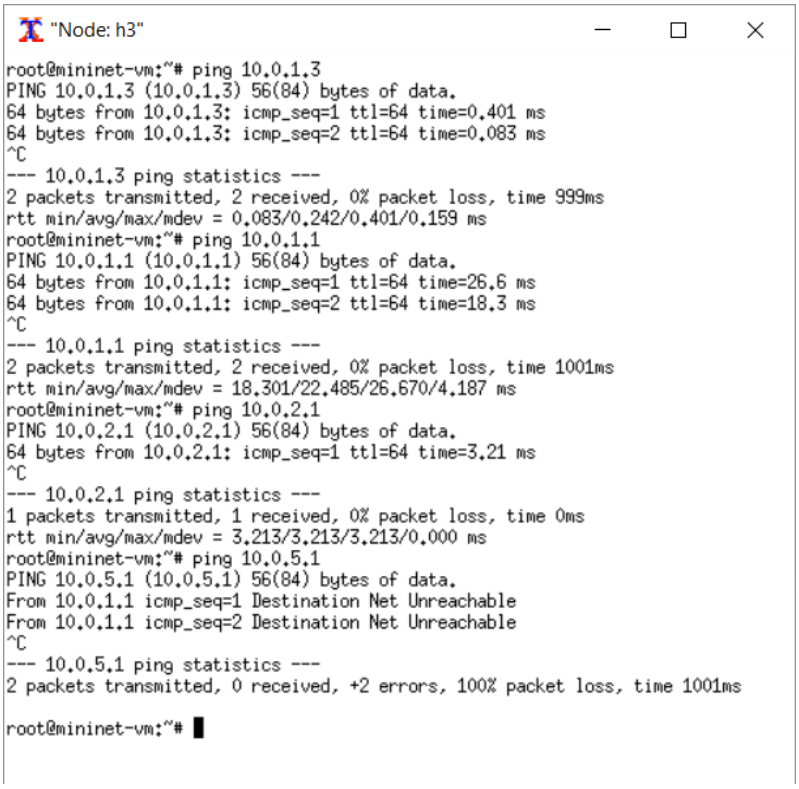
Implementation description:

We use dpid as switch identification to support multi-switch controller, separating route table, arp table, mac table according to dpid. Each switch has its own tables.

Then based on part1, we add switching function to router like this:

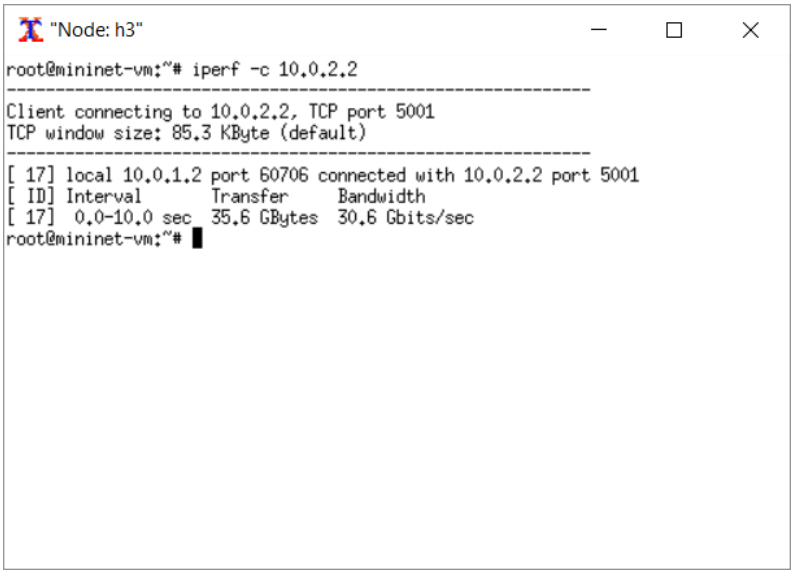
When receiving packet, first handle it using act_like_switch function which use mac table to mod flow, and then pass packet to act_like_router function which use arp and route table to mod flow.

Ping test (on h3 ping h4, ping sw1, ping sw2, ping unreachable host)



Iperf test between h3 and h5

Result: TCP bandwidth 30.6 Gbps



Flow table of s1.

From this table, we can see the last two entries are for L2 switching using mac matching. The others are L3 switching entries which use ip matching.

`00:00:11:00:00:11 is mac address of s1`

`00:00:11:00:00:12 is mac address of s2`

```
mininet@mininet-vm:~$ sudo ovs-ofctl dump-flows s1

NXST_FLOW reply (xid=0x4):

 cookie=0x0, duration=8.973s, table=0, n_packets=2, n_bytes=196, idle_timeout=240,
idle_age=8, priority=200,ip,nw_dst=10.0.1.2
actions=mod_dl_dst:00:00:00:00:00:01,mod_dl_src:00:00:11:00:00:11,output:1

 cookie=0x0, duration=8.813s, table=0, n_packets=2, n_bytes=196, idle_timeout=240,
idle_age=8, priority=200,ip,nw_dst=10.0.1.3
actions=mod_dl_dst:00:00:00:00:00:02,mod_dl_src:00:00:11:00:00:11,output:2

 cookie=0x0, duration=12.62s, table=0, n_packets=4, n_bytes=392, idle_age=8,
ip,nw_dst=10.0.2.0/24
actions=mod_dl_dst:00:00:11:00:00:12,mod_dl_src:00:00:11:00:00:11,output:3

 cookie=0x0, duration=8.852s, table=0, n_packets=1, n_bytes=42, idle_age=3,
dl_dst=00:00:00:00:00:02 actions=output:2

 cookie=0x0, duration=8.861s, table=0, n_packets=2, n_bytes=140, idle_age=3,
dl_dst=00:00:00:00:00:01 actions=output:1
```

Flow table of s2

```
mininet@mininet-vm:~$ sudo ovs-ofctl dump-flows s2

NXST_FLOW reply (xid=0x4):

 cookie=0x0, duration=839.203s, table=0, n_packets=235402, n_bytes=15536668,
idle_age=511, ip,nw_dst=10.0.1.0/24
actions=mod_dl_dst:00:00:11:00:00:11,mod_dl_src:00:00:11:00:00:12,output:2

 cookie=0x0, duration=321.184s, table=0, n_packets=0, n_bytes=0, idle_age=321,
dl_dst=00:00:11:00:00:11 actions=output:2

 cookie=0x0, duration=521.56s, table=0, n_packets=0, n_bytes=0, idle_age=521,
dl_dst=00:00:00:00:00:03 actions=output:1
```

Part 3: Firewall

We use the same topology as part2 but add a firewall rule to s1 dropping all http packet from s3 to s5.

Implementation:

Use higher priority to add firewall rule. In this case, we use OFP_DEFAULT_PRIORITY + 100, which is the highest in the flow table. Every incoming packet will first try to match this firewall rule. It would be dropped if matched, otherwise go to next rule.

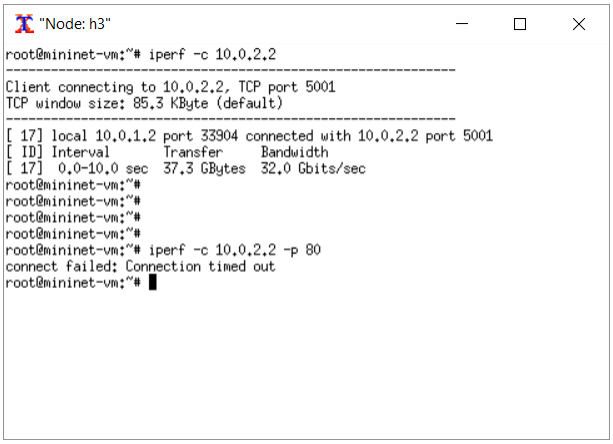
Ping test (pingall)

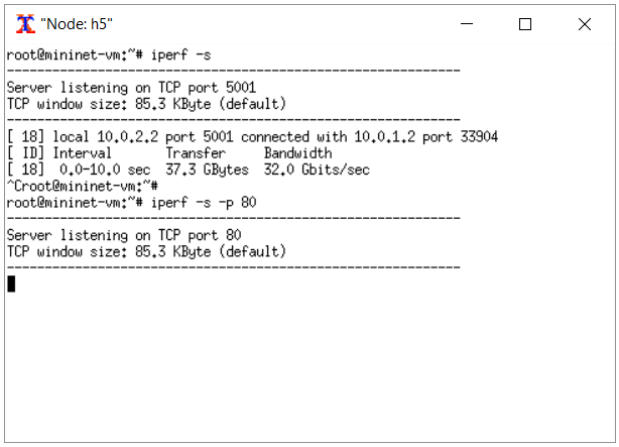
```
mininet> pingall

*** Ping: testing ping reachability

h3 -> h4 h5

h4 -> h3 h5

h5 -> h3 h4

*** Results: 0% dropped (6/6 received)
```

Flow table of s1 (the red one is the firewall rule)

```
mininet@mininet-vm:~$ sudo ovs-ofctl dump-flows s1

NXST_FLOW reply (xid=0x4):

 cookie=0x0, duration=76.466s, table=0, n_packets=162451, n_bytes=10721774,
idle_timeout=240, idle_age=53, ip,nw_dst=10.0.1.2
actions=mod_dl_dst:00:00:00:00:00:01,mod_dl_src:00:00:11:00:00:11,output:1

 cookie=0x0, duration=265.173s, table=0, n_packets=705847, n_bytes=40264194478,
idle_age=53, ip,nw_dst=10.0.2.0/24
actions=mod_dl_dst:00:00:11:00:00:12,mod_dl_src:00:00:11:00:00:11,output:3

 cookie=0x0, duration=265.135s, table=0, n_packets=7, n_bytes=518, idle_age=162,
priority=32868,tcp,nw_src=10.0.1.2,nw_dst=10.0.2.2,tp_dst=80 actions=drop

 cookie=0x0, duration=76.471s, table=0, n_packets=0, n_bytes=0, idle_age=76,
dl_dst=00:00:00:00:00:01 actions=output:1
```

Iperf test





This result shows h3 is able to connect h5's 5001 port and transfer data but cannot connect to port 80.