

CS 580 Mini Project 3

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Task I :

```
$ mn --custom binary_tree.py --topo mytopo
```

```
$ mininet> h1 ping h5
```

```
root@instance-2:/home/adityagawali# mn --custom binary_tree.py --topo mytopo
*** No default OpenFlow controller found for default switch!
*** Falling back to OVS Bridge
*** Creating network
*** Adding controller
*** Adding hosts:
h1 h2 h3 h4 h5
*** Adding switches:
s1 s2 s3 s4 s5 s6
*** Adding links:
(h1, s1) (h2, s1) (h3, s2) (h4, s2) (h5, s3) (s1, s4) (s2, s4) (s3, s5) (s4, s6) (s5, s6)
*** Configuring hosts
h1 h2 h3 h4 h5
*** Starting controller

*** Starting 6 switches
s1 s2 s3 s4 s5 s6 ...
*** Starting CLI:
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=2.56 ms
64 bytes from 10.0.0.5: icmp_seq=2 ttl=64 time=0.084 ms
64 bytes from 10.0.0.5: icmp_seq=3 ttl=64 time=0.075 ms
64 bytes from 10.0.0.5: icmp_seq=4 ttl=64 time=0.104 ms
64 bytes from 10.0.0.5: icmp_seq=5 ttl=64 time=0.106 ms
64 bytes from 10.0.0.5: icmp_seq=6 ttl=64 time=0.060 ms
```

SDN Controller (POX) Installation

Open a new terminal of the running Mininet docker:

```
$ docker exec -it mininet /bin/bash
```

Steps to download POX

```
$ apt-get update
```

```
$ apt-get install git
```

```
$ env GIT_SSL_NO_VERIFY=true git clone https://github.com/noxrepo/pox
```

```
$ apt-get install python3
```

Now commands to start SDN Controller

```
$ cd pox
```

\$ python3 pox.py log.level --DEBUG misc.of_tutorial

```
root@21b1b91d6af8: ~/pox - Google Chrome
ssh.cloud.google.com/projects/advcloud1/zones/us-central1-a/instances/instance-2?useAdminProxy=true&authuser=0&hl=en_US&projectNumber=944764275305

root@instance-2:/home/adityagwal# docker exec -it mininet /bin/bash
root@21b1b91d6af8:~# apt-get update
Get:1 http://security.ubuntu.com/ubuntu bionic-security InRelease [88.7 kB]
Get:2 http://archive.ubuntu.com/ubuntu bionic InRelease [242 kB]
Get:3 http://security.ubuntu.com/ubuntu bionic-security/universe Sources [340 kB]
Get:4 http://security.ubuntu.com/ubuntu bionic-security/multiverse amd64 Packages [15.8 kB]
Get:5 http://security.ubuntu.com/ubuntu bionic-security/main amd64 Packages [1815 kB]
Get:6 http://security.ubuntu.com/ubuntu bionic-security/universe amd64 Packages [1370 kB]
Get:7 http://security.ubuntu.com/ubuntu bionic-security/restricted amd64 Packages [236 kB]
Get:8 http://archive.ubuntu.com/ubuntu bionic-updates InRelease [88.7 kB]
Get:9 http://archive.ubuntu.com/ubuntu bionic-backports InRelease [74.6 kB]
Get:10 http://archive.ubuntu.com/ubuntu bionic/universe Sources [11.5 MB]
Get:11 http://archive.ubuntu.com/ubuntu bionic/main amd64 Packages [1344 kB]
Get:12 http://archive.ubuntu.com/ubuntu bionic/universe amd64 Packages [11.3 MB]
Get:13 http://archive.ubuntu.com/ubuntu bionic/multiverse amd64 Packages [186 kB]
Get:14 http://archive.ubuntu.com/ubuntu bionic/restricted amd64 Packages [13.5 kB]
Get:15 http://archive.ubuntu.com/ubuntu bionic-updates/universe Sources [558 kB]
Get:16 http://archive.ubuntu.com/ubuntu bionic-updates/restricted amd64 Packages [265 kB]
Get:17 http://archive.ubuntu.com/ubuntu bionic-updates/universe amd64 Packages [2134 kB]
Get:18 http://archive.ubuntu.com/ubuntu bionic-updates/multiverse amd64 Packages [54.3 kB]
Get:19 http://archive.ubuntu.com/ubuntu bionic-updates/main amd64 Packages [2243 kB]
Get:20 http://archive.ubuntu.com/ubuntu bionic-backports/main amd64 Packages [11.3 kB]
Get:21 http://archive.ubuntu.com/ubuntu bionic-backports/universe amd64 Packages [11.4 kB]
Fetched 34.0 MB in 4s (8166 kB/s)
Reading package lists... Done
root@21b1b91d6af8:~# $ apt-get install git
bash: $: command not found
root@21b1b91d6af8:~# apt-get install git
Reading package lists... Done
Building dependency tree
Reading state information... Done
The following additional packages will be installed:
  ca-certificates git-man less libcurl3-gnutls libedit2 liberror-perl libgdbm-compat4 libgdbm5 libperl5.26 libssl1.0.0 openssh-client patch perl perl-base perl-modules-5.26
  xauth
Suggested packages:
  gettext-base git-daemon-run | git-daemon-symlinks git-doc git-el git-email git-gui gitk gitweb git-cvs git-mediawiki git-svn gdbm-l10n keychain libpam-ssh monkeysphere
  ssh-addpass ed diffutils-doc perl-doc libterm-readline-gnu-perl | libterm-readline-perl-perl make
The following NEW packages will be installed:
  ca-certificates git git-man less libcurl3-gnutls libedit2 liberror-perl libgdbm-compat4 libgdbm5 libperl5.26 libssl1.0.0 openssh-client patch perl perl-modules-5.26 xauth
The following packages will be upgraded:
  perl-base
1 upgraded, 16 newly installed, 0 to remove and 97 not upgraded.
Need to get 15.0 MB of archives.
After this operation, 65.1 MB of additional disk space will be used.
Do you want to continue? [Y/n] y
```

```
root@21b1b91d6af8: ~/pox - Google Chrome
ssh.cloud.google.com/projects/advcloud1/zones/us-central1-a/instances/instance-2?useAdminProxy=true&authuser=0&hl=en_US&projectNumber=944764275305

root@21b1b91d6af8:~# apt-get install python3
Reading package lists... Done
Building dependency tree
Reading state information... Done
The following additional packages will be installed:
  libpython3-stdlib libpython3.6 libpython3.6-minimal libpython3.6-stdlib libssl1.1 python3-minimal python3.6 python3.6-minimal
Suggested packages:
  python3-doc python3-tk python3-venv python3.6-venv python3.6-doc binutils binfmt-support
The following NEW packages will be installed:
  libpython3-stdlib python3 python3-minimal python3.6 python3.6-minimal
The following packages will be upgraded:
  libpython3.6 libpython3.6-minimal libpython3.6-stdlib libssl1.1
4 upgraded, 5 newly installed, 0 to remove and 93 not upgraded.
Need to get 6851 kB of archives.
After this operation, 10.4 MB of additional disk space will be used.
Do you want to continue? [Y/n] y
Get:1 http://archive.ubuntu.com/ubuntu bionic-updates/main amd64 libssl1.1 amd64 1.1.1-1ubuntu2.1-18.04.6 [1301 kB]
Get:2 http://archive.ubuntu.com/ubuntu bionic-updates/main amd64 libpython3.6 amd64 3.6.9-1-18.04ubuntu1.3 [1414 kB]
Get:3 http://archive.ubuntu.com/ubuntu bionic-updates/main amd64 libpython3.6-stdlib amd64 3.6.9-1-18.04ubuntu1.3 [1713 kB]
Get:4 http://archive.ubuntu.com/ubuntu bionic-updates/main amd64 libpython3.6-minimal amd64 3.6.9-1-18.04ubuntu1.3 [533 kB]
Get:5 http://archive.ubuntu.com/ubuntu bionic-updates/main amd64 python3.6-minimal amd64 3.6.9-1-18.04ubuntu1.3 [1609 kB]
Get:6 http://archive.ubuntu.com/ubuntu bionic-updates/main amd64 python3-minimal amd64 3.6.7-1-18.04 [23.7 kB]
Get:7 http://archive.ubuntu.com/ubuntu bionic-updates/main amd64 python3.6 amd64 3.6.9-1-18.04ubuntu1.3 [203 kB]
Get:8 http://archive.ubuntu.com/ubuntu bionic-updates/main amd64 libpython3-stdlib amd64 3.6.7-1-18.04 [7240 B]
Get:9 http://archive.ubuntu.com/ubuntu bionic-updates/main amd64 python3 amd64 3.6.7-1-18.04 [47.2 kB]
Fetched 6851 kB in 1s (4967 kB/s)
debconf: delaying package configuration, since apt-utils is not installed
(Reading database ... 12237 files and directories currently installed.)
Preparing to unpack .../libssl1.1 1.1.1-1ubuntu2.1-18.04.6 amd64.deb ...
Unpacking libssl1.1:amd64 (1.1.1-1ubuntu2.1-18.04.6) over (1.1.0g-2ubuntu4.1) ...
Preparing to unpack .../libpython3.6 3.6.9-1-18.04ubuntu1.3 amd64.deb ...
Unpacking libpython3.6:amd64 (3.6.9-1-18.04ubuntu1.3) over (3.6.6-1-18.04) ...
Preparing to unpack .../libpython3.6-stdlib 3.6.9-1-18.04ubuntu1.3 amd64.deb ...
find: '/usr/lib/python3': No such file or directory
Unpacking libpython3.6-stdlib:amd64 (3.6.9-1-18.04ubuntu1.3) over (3.6.6-1-18.04) ...
Preparing to unpack .../libpython3.6-minimal 3.6.9-1-18.04ubuntu1.3 amd64.deb ...
find: '/usr/lib/python3': No such file or directory
Unpacking libpython3.6-minimal:amd64 (3.6.9-1-18.04ubuntu1.3) over (3.6.6-1-18.04) ...
Selecting previously unselected package python3.6-minimal.
Preparing to unpack .../python3.6-minimal 3.6.9-1-18.04ubuntu1.3 amd64.deb ...
Unpacking python3.6-minimal (3.6.9-1-18.04ubuntu1.3) ...
Setting up libssl1.1:amd64 (1.1.1-1ubuntu2.1-18.04.6) ...
debconf: unable to initialize frontend: Dialog
debconf: (No usable dialog-like program is installed, so the dialog based frontend cannot be used. at /usr/share/perl5/Debconf/FrontEnd/Dialog.pm line 76.)
debconf: falling back to frontend: Readline
```

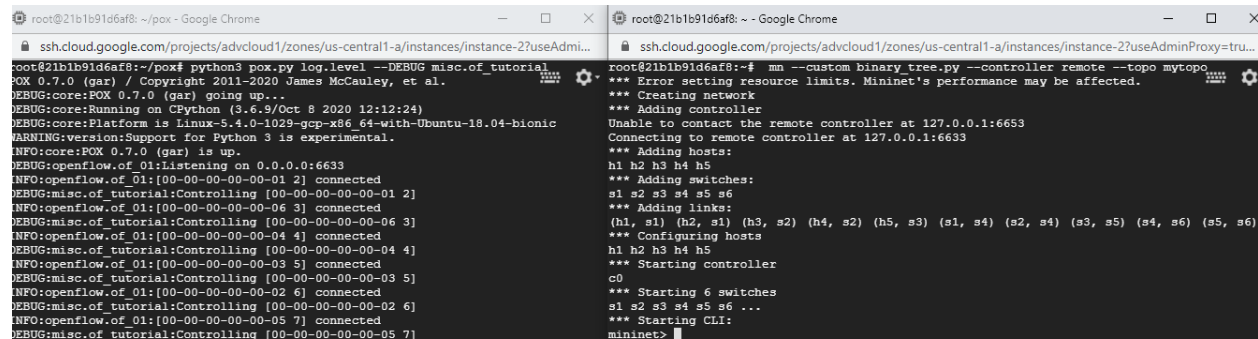
```

root@21b1b91d6af8:~# cd pox
root@21b1b91d6af8:~/pox# python3 pox.py log.level --DEBUG misc.of_tutorial
POX 0.7.0 (gar) / Copyright 2011-2020 James McCauley, et al.
DEBUG:core:POX 0.7.0 (gar) going up...
DEBUG:core:Running on CPython (3.6.9/Oct 8 2020 12:12:24)
DEBUG:core:Platform is Linux-5.4.0-1029-gcp-x86_64-with-Ubuntu-18.04-bionic
WARNING:version:Support for Python 3 is experimental.
INFO:core:POX 0.7.0 (gar) is up.
DEBUG:openflow.of_01:Listening on 0.0.0.0:6633

```

Connect network topology to the controller

\$ mn --custom binary_tree.py --controller remote --topo mytopo



```

root@21b1b91d6af8:~/pox - Google Chrome
ssh.cloud.google.com/projects/advcloud1/zones/us-central1-a/instances/instance-2?useAdmin...
root@21b1b91d6af8:~/pox# python3 pox.py log.level --DEBUG misc.of_tutorial
POX 0.7.0 (gar) / Copyright 2011-2020 James McCauley, et al.
DEBUG:core:POX 0.7.0 (gar) going up...
DEBUG:core:Running on CPython (3.6.9/Oct 8 2020 12:12:24)
DEBUG:core:Platform is Linux-5.4.0-1029-gcp-x86_64-with-Ubuntu-18.04-bionic
WARNING:version:Support for Python 3 is experimental.
INFO:core:POX 0.7.0 (gar) is up.
DEBUG:openflow.of_01:Listening on 0.0.0.0:6633
INFO:openflow.of_01:[00-00-00-00-00-01 2] connected
DEBUG:misc.of_tutorial:Controlling [00-00-00-00-00-01 2]
INFO:openflow.of_01:[00-00-00-00-00-06 3] connected
DEBUG:misc.of_tutorial:Controlling [00-00-00-00-00-06 3]
INFO:openflow.of_01:[00-00-00-00-00-04 4] connected
DEBUG:misc.of_tutorial:Controlling [00-00-00-00-00-04 4]
INFO:openflow.of_01:[00-00-00-00-00-03 5] connected
DEBUG:misc.of_tutorial:Controlling [00-00-00-00-00-03 5]
INFO:openflow.of_01:[00-00-00-00-00-02 6] connected
DEBUG:misc.of_tutorial:Controlling [00-00-00-00-00-02 6]
INFO:openflow.of_01:[00-00-00-00-00-05 7] connected
DEBUG:misc.of_tutorial:Controlling [00-00-00-00-00-05 7]

root@21b1b91d6af8:~ - Google Chrome
ssh.cloud.google.com/projects/advcloud1/zones/us-central1-a/instances/instance-2?useAdminProxy=tru...
root@21b1b91d6af8:~# mn --custom binary_tree.py --controller remote --topo mytopo
*** Error setting resource limits. Mininet's performance may be affected.
*** Creating network
*** Adding controller
Unable to contact the remote controller at 127.0.0.1:6653
Connecting to remote controller at 127.0.0.1:6633
*** Adding hosts:
h1 h2 h3 h4 h5
*** Adding switches:
s1 s2 s3 s4 s5 s6
*** Adding links:
(h1, s1) (h2, s1) (h3, s2) (h4, s2) (h5, s3) (s1, s4) (s2, s4) (s3, s5) (s4, s6) (s5, s6)
*** Configuring hosts
h1 h2 h3 h4 h5
*** Starting controller
c0
*** Starting 6 switches
s1 s2 s3 s4 s5 s6 ...
*** Starting CLI:
mininet>

```

Task II: Study the “of_tutorial” Controller

Q1.

def launch ():

```

    """

```

Starts the component

```

    """

```

def start_switch (event):

```

    log.debug("Controlling %s

```

```

    Tutorial(event.connection)

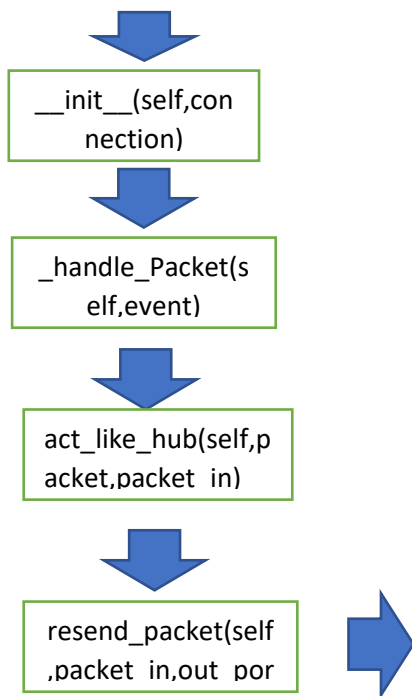
```

```

    core.openflow.addListenerByName("ConnectionUp", start_switch)

```

Flow :



Given flow , so here function start with `_init` function then go to `_handle_packet` and `act_like_hub` which call `resend_packet` function.

Q2.

Terminal Window 1	Terminal Window 2
<pre> root@21b1b91d6af8: ~/pox - Google Chrome ssh.cloud.google.com/projects/advcloud1/zones/us-central1-a/instances/instance-2?useAdmi... root@21b1b91d6af8:~/pox# python3 pox.py log.level --DEBUG misc.of_tutorial POX 0.7.0 (gar) / Copyright 2011-2020 James McCauley, et al. DEBUG:core:POX 0.7.0 (gar) going up... DEBUG:core:Running on CPython (3.6.9/Oct 8 2020 12:12:24) DEBUG:core:Platform is Linux-5.4.0-1029-gcp-x86_64-with-Ubuntu-18.04-bionic WARNING:version:Support for Python 3 is experimental. INFO:core:POX 0.7.0 (gar) is up. DEBUG:openflow.of_01:Listening on 0.0.0.0:6633 INFO:openflow.of_01:[00-00-00-00-00-01 2] connected DEBUG:misc.of_tutorial:Controlling [00-00-00-00-00-01 2] INFO:openflow.of_01:[00-00-00-00-00-06 3] connected DEBUG:misc.of_tutorial:Controlling [00-00-00-00-00-06 3] INFO:openflow.of_01:[00-00-00-00-00-04 4] connected DEBUG:misc.of_tutorial:Controlling [00-00-00-00-00-04 4] INFO:openflow.of_01:[00-00-00-00-00-03 5] connected DEBUG:misc.of_tutorial:Controlling [00-00-00-00-00-03 5] INFO:openflow.of_01:[00-00-00-00-00-02 6] connected DEBUG:misc.of_tutorial:Controlling [00-00-00-00-00-02 6] INFO:openflow.of_01:[00-00-00-00-00-05 7] connected DEBUG:misc.of_tutorial:Controlling [00-00-00-00-00-05 7] </pre>	<pre> root@21b1b91d6af8: ~ - Google Chrome ssh.cloud.google.com/projects/advcloud1/zones/us-central1-a/instances/instance-2?useAdmi... *** Configuring hosts h1 h2 h3 h4 h5 *** Starting controller c0 *** Starting 6 switches s1 s2 s3 s4 s5 s6 ... *** Starting CLI: mininet> h1 ping -c100 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=5.32 ms 64 bytes from 10.0.0.2: icmp_seq=2 ttl=64 time=1.64 ms 64 bytes from 10.0.0.2: icmp_seq=3 ttl=64 time=2.00 ms 64 bytes from 10.0.0.2: icmp_seq=4 ttl=64 time=1.72 ms 64 bytes from 10.0.0.2: icmp_seq=5 ttl=64 time=1.96 ms 64 bytes from 10.0.0.2: icmp_seq=6 ttl=64 time=2.10 ms 64 bytes from 10.0.0.2: icmp_seq=7 ttl=64 time=1.96 ms 64 bytes from 10.0.0.2: icmp_seq=8 ttl=64 time=2.93 ms 64 bytes from 10.0.0.2: icmp_seq=9 ttl=64 time=1.69 ms 64 bytes from 10.0.0.2: icmp_seq=10 ttl=64 time=2.32 ms 64 bytes from 10.0.0.2: icmp_seq=11 ttl=64 time=2.03 ms </pre>
<pre> root@21b1b91d6af8: ~/pox - Google Chrome ssh.cloud.google.com/projects/advcloud1/zones/us-central1-a/instances/instance-2?useAdmi... root@21b1b91d6af8:~/pox# python3 pox.py log.level --DEBUG misc.of_tutorial POX 0.7.0 (gar) / Copyright 2011-2020 James McCauley, et al. DEBUG:core:POX 0.7.0 (gar) going up... DEBUG:core:Running on CPython (3.6.9/Oct 8 2020 12:12:24) DEBUG:core:Platform is Linux-5.4.0-1029-gcp-x86_64-with-Ubuntu-18.04-bionic WARNING:version:Support for Python 3 is experimental. INFO:core:POX 0.7.0 (gar) is up. DEBUG:openflow.of_01:Listening on 0.0.0.0:6633 INFO:openflow.of_01:[00-00-00-00-00-01 2] connected DEBUG:misc.of_tutorial:Controlling [00-00-00-00-00-01 2] INFO:openflow.of_01:[00-00-00-00-00-06 3] connected DEBUG:misc.of_tutorial:Controlling [00-00-00-00-00-06 3] INFO:openflow.of_01:[00-00-00-00-00-04 4] connected DEBUG:misc.of_tutorial:Controlling [00-00-00-00-00-04 4] INFO:openflow.of_01:[00-00-00-00-00-03 5] connected DEBUG:misc.of_tutorial:Controlling [00-00-00-00-00-03 5] INFO:openflow.of_01:[00-00-00-00-00-02 6] connected DEBUG:misc.of_tutorial:Controlling [00-00-00-00-00-02 6] INFO:openflow.of_01:[00-00-00-00-00-05 7] connected DEBUG:misc.of_tutorial:Controlling [00-00-00-00-00-05 7] </pre>	<pre> root@21b1b91d6af8: ~ - Google Chrome ssh.cloud.google.com/projects/advcloud1/zones/us-central1-a/instances/instance-2?useAdmi... 64 bytes from 10.0.0.2: icmp_seq=85 ttl=64 time=1.99 ms 64 bytes from 10.0.0.2: icmp_seq=86 ttl=64 time=2.48 ms 64 bytes from 10.0.0.2: icmp_seq=87 ttl=64 time=1.84 ms 64 bytes from 10.0.0.2: icmp_seq=88 ttl=64 time=2.20 ms 64 bytes from 10.0.0.2: icmp_seq=89 ttl=64 time=2.39 ms 64 bytes from 10.0.0.2: icmp_seq=90 ttl=64 time=3.00 ms 64 bytes from 10.0.0.2: icmp_seq=91 ttl=64 time=2.29 ms 64 bytes from 10.0.0.2: icmp_seq=92 ttl=64 time=2.34 ms 64 bytes from 10.0.0.2: icmp_seq=93 ttl=64 time=2.75 ms 64 bytes from 10.0.0.2: icmp_seq=94 ttl=64 time=2.23 ms 64 bytes from 10.0.0.2: icmp_seq=95 ttl=64 time=2.49 ms 64 bytes from 10.0.0.2: icmp_seq=96 ttl=64 time=1.98 ms 64 bytes from 10.0.0.2: icmp_seq=97 ttl=64 time=2.09 ms 64 bytes from 10.0.0.2: icmp_seq=98 ttl=64 time=2.73 ms 64 bytes from 10.0.0.2: icmp_seq=99 ttl=64 time=1.75 ms 64 bytes from 10.0.0.2: icmp_seq=100 ttl=64 time=2.20 ms --- 10.0.0.2 ping statistics --- 100 packets transmitted, 100 received, 0% packet loss, time 99144ms rtt min/avg/max/mdev = 1.593/2.156/5.325/0.437 ms </pre>

I have attached code task2.py

Task 3:

```
ff:ffff:ffff:ff not known, resend to everybody
2a:2d:b7:e:f:c1 destination known. only send message to it
ff:ffff:ffff:ff not known, resend to everybody
ff:ffff:ffff:ff not known, resend to everybody
806:openflow.o: o11 connection aborted
a:11:7f:73:9b:b9 destination known. only send message to it
2a:2d:b7:e:f:c1 destination known. only send message to it
a:11:7f:73:9b:b9 destination known. only send message to it
2a:2d:b7:e:f:c1 destination known. only send message to it
a:11:7f:73:9b:b9 destination known. only send message to it
2a:2d:b7:e:f:c1 destination known. only send message to it
a:11:7f:73:9b:b9 destination known. only send message to it
2a:2d:b7:e:f:c1 destination known. only send message to it
a:11:7f:73:9b:b9 destination known. only send message to it
2a:2d:b7:e:f:c1 destination known. only send message to it
a:11:7f:73:9b:b9 destination known. only send message to it
2a:2d:b7:e:f:c1 destination known. only send message to it
a:11:7f:73:9b:b9 destination known. only send message to it
2a:2d:b7:e:f:c1 destination known. only send message to it
33:00:00:00:02 not known, resend to everybody
33:00:00:00:02 not known, resend to everybody
33:00:00:00:02 not known, resend to everybody
33:00:00:00:02 not known, resend to everybody
33:00:00:00:02 not known, resend to everybody
33:00:00:00:02 not known, resend to everybody
33:00:00:00:02 not known, resend to everybody
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=5.28 ms
64 bytes from 10.0.0.2: icmp_seq=2 ttl=64 time=2.21 ms
64 bytes from 10.0.0.2: icmp_seq=3 ttl=64 time=2.31 ms
64 bytes from 10.0.0.2: icmp_seq=4 ttl=64 time=2.26 ms
64 bytes from 10.0.0.2: icmp_seq=5 ttl=64 time=2.55 ms
64 bytes from 10.0.0.2: icmp_seq=6 ttl=64 time=2.23 ms
```

```
def act_like_switch (self, packet, packet_in):
    """
    Implement switch-like behavior.
    """

    """ # DELETE THIS LINE TO START WORKING ON THIS (AND THE ONE BELOW!) #
    # Here's some psuedocode to start you off implementing a learning
    # switch. You'll need to rewrite it as real Python code.
    # Learn the port for the source MAC
    self.mac_to_port ... <add or update entry>
    if the port associated with the destination MAC of the packet is known:
        # Send packet out the associated port
        self.resend_packet(packet_in, ...)
```

```

# Once you have the above working, try pushing a flow entry
# instead of resending the packet (comment out the above and
# uncomment and complete the below.)
log.debug("Installing flow...")
# Maybe the log statement should have source/destination/port?
#msg = of.ofp_flow_mod()
#
## Set fields to match received packet
#msg.match = of.ofp_match.from_packet(packet)
#
#< Set other fields of flow_mod (timeouts? buffer_id?) >
#
#< Add an output action, and send -- similar to resend_packet() >
else:
    # Flood the packet out everything but the input port
    # This part looks familiar, right?
    self.resend_packet(packet_in, of.OFPP_ALL)
    """ # DELETE THIS LINE TO START WORKING ON THIS #

if packet.src not in self.mac_to_port:
    print ("Learning that " + str(packet.src) + " is attached at port " + str(packet_in.in_port))
    self.mac_to_port[packet.src] = packet_in.in_port

# if the port associated with the destination MAC of the packet is known:
if packet.dst in self.mac_to_port:
    # Send packet out the associated port
    print (str(packet.dst) + " destination known. only send message to it")
    self.resend_packet(packet_in, self.mac_to_port[packet.dst])

else:
    # Flood the packet out everything but the input port
    # This part looks familiar, right?
    print (str(packet.dst) + " not known, resend to everybody")
    self.resend_packet(packet_in, of.OFPP_ALL)

```

How code works by taking above example h1 ping h2

When h1 ping h2 executes it first go from h1 to s1 means from host h1 to switch s1 and further s1 will send packet to the controller for destination.

After that it will check for port mapping.

If it is in h1 then step 2 else first it will store mapping and go for further steps.

Now it will look for the destination, in our case destination is h2. It will resend the package to destination if it able to find destination mapping and if it cannot find then it will resend packet to each node other than source.


```

08:2a:2d:b7:fef:c1 destination known. only send message to it
08:a1:1f:7f:73:9b:b9 destination known. only send message to it
08:2a:2d:b7:fef:c1 destination known. only send message to it
08:a1:1f:7f:73:9b:b9 destination known. only send message to it
08:2a:2d:b7:fef:c1 destination known. only send message to it
08:a1:1f:7f:73:9b:b9 destination known. only send message to it
08:2a:2d:b7:fef:c1 destination known. only send message to it
08:a1:1f:7f:73:9b:b9 destination known. only send message to it
08:2a:2d:b7:fef:c1 destination known. only send message to it
08:a1:1f:7f:73:9b:b9 destination known. only send message to it
08:2a:2d:b7:fef:c1 destination known. only send message to it
08:a1:1f:7f:73:9b:b9 destination known. only send message to it
08:2a:2d:b7:fef:c1 destination known. only send message to it
08:a1:1f:7f:73:9b:b9 destination known. only send message to it
08:2a:2d:b7:fef:c1 destination known. only send message to it
08:a1:1f:7f:73:9b:b9 destination known. only send message to it
08:2a:2d:b7:fef:c1 destination known. only send message to it
08:a1:1f:7f:73:9b:b9 destination known. only send message to it
08:2a:2d:b7:fef:c1 destination known. only send message to it
08:a1:1f:7f:73:9b:b9 destination known. only send message to it
08:2a:2d:b7:fef:c1 destination known. only send message to it
08:a1:1f:7f:73:9b:b9 destination known. only send message to it
08:2a:2d:b7:fef:c1 destination known. only send message to it
08:a1:1f:7f:73:9b:b9 destination known. only send message to it
64 bytes from 10.0.0.2: icmp seq=82 ttl=64 time=2.05 ms
64 bytes from 10.0.0.2: icmp seq=83 ttl=64 time=2.01 ms
64 bytes from 10.0.0.2: icmp seq=84 ttl=64 time=2.02 ms
64 bytes from 10.0.0.2: icmp seq=85 ttl=64 time=2.08 ms
64 bytes from 10.0.0.2: icmp seq=86 ttl=64 time=2.07 ms
64 bytes from 10.0.0.2: icmp seq=87 ttl=64 time=2.60 ms
64 bytes from 10.0.0.2: icmp seq=88 ttl=64 time=2.16 ms
64 bytes from 10.0.0.2: icmp seq=89 ttl=64 time=2.37 ms
64 bytes from 10.0.0.2: icmp seq=90 ttl=64 time=2.17 ms
64 bytes from 10.0.0.2: icmp seq=91 ttl=64 time=2.11 ms
64 bytes from 10.0.0.2: icmp seq=92 ttl=64 time=2.53 ms
64 bytes from 10.0.0.2: icmp seq=93 ttl=64 time=2.18 ms
64 bytes from 10.0.0.2: icmp seq=94 ttl=64 time=2.23 ms
64 bytes from 10.0.0.2: icmp seq=95 ttl=64 time=2.25 ms
64 bytes from 10.0.0.2: icmp seq=96 ttl=64 time=2.39 ms
64 bytes from 10.0.0.2: icmp seq=97 ttl=64 time=2.04 ms
64 bytes from 10.0.0.2: icmp seq=98 ttl=64 time=2.48 ms
64 bytes from 10.0.0.2: icmp seq=99 ttl=64 time=2.16 ms
64 bytes from 10.0.0.2: icmp seq=100 ttl=64 time=2.45 ms

--- 10.0.0.2 ping statistics ---
100 packets transmitted, 100 received, 0% packet loss, time 99142ms
rtt min/avg/max/mdev = 1.809/2.267/5.441/0.434 ms
```

```

62:eb:b8:27:65:32:d destination known. only send message to it 64 bytes from 10.0.0.5: icmp_seq=87 ttl=64 time=6.10 ms
62:eb:b8:3e:b0:90 destination known. only send message to it 64 bytes from 10.0.0.5: icmp_seq=88 ttl=64 time=7.47 ms
1a:b6:82:76:53:2d destination known. only send message to it 64 bytes from 10.0.0.5: icmp_seq=89 ttl=64 time=7.47 ms
62:eb:b8:3e:b0:90 destination known. only send message to it 64 bytes from 10.0.0.5: icmp_seq=90 ttl=64 time=7.36 ms
1a:b6:82:76:53:2d destination known. only send message to it 64 bytes from 10.0.0.5: icmp_seq=91 ttl=64 time=7.01 ms
62:eb:b8:3e:b0:90 destination known. only send message to it 64 bytes from 10.0.0.5: icmp_seq=92 ttl=64 time=6.88 ms
62:eb:82:76:53:2d destination known. only send message to it 64 bytes from 10.0.0.5: icmp_seq=93 ttl=64 time=6.96 ms
62:eb:b8:3e:b0:90 destination known. only send message to it 64 bytes from 10.0.0.5: icmp_seq=94 ttl=64 time=6.30 ms
62:eb:b8:3e:b0:90 destination known. only send message to it 64 bytes from 10.0.0.5: icmp_seq=95 ttl=64 time=5.99 ms
1a:b6:82:76:53:2d destination known. only send message to it 64 bytes from 10.0.0.5: icmp_seq=96 ttl=64 time=6.08 ms
62:eb:b8:3e:b0:90 destination known. only send message to it 64 bytes from 10.0.0.5: icmp_seq=97 ttl=64 time=6.39 ms
1a:b6:82:76:53:2d destination known. only send message to it 64 bytes from 10.0.0.5: icmp_seq=98 ttl=64 time=6.78 ms
1a:b6:82:76:53:2d destination known. only send message to it 64 bytes from 10.0.0.5: icmp_seq=99 ttl=64 time=6.15 ms
62:eb:b8:3e:b0:90 destination known. only send message to it 64 bytes from 10.0.0.5: icmp_seq=100 ttl=64 time=6.11 ms
1a:b6:82:76:53:2d destination known. only send message to it
62:eb:b8:3e:b0:90 destination known. only send message to it
1a:b6:82:76:53:2d destination known. only send message to it
62:eb:b8:3e:b0:90 destination known. only send message to it
--- 10.0.0.5 ping statistics ---
100 packets transmitted, 100 received, 0% packet loss, time 99118ms
rtt min/avg/max/mdev = 5.962/6.490/14.352/0.856 ms

```

There is a slight better average time in Task 3 compare to Task 2.

```

2a:2a:2d:b7:ef:c1 destination known. only send message to it      --- I/O 0.0 ping statistics ---
2a:2a:2d:b7:ef:c1 destination known. only send message to it      100 packets transmitted, 100 received, 0% packet loss, time 99158ms
2a:2a:2d:b7:ef:c1 destination known. only send message to it      rtt min/avg/max/mdev = 7.401/9.999/24.817/1.962 ms
2a:2a:2d:b7:ef:c1 destination known. only send message to it      mininet> iperf h1 h2
2a:54:8e:44:ea:33 destination known. only send message to it      *** Iperf: testing TCP bandwidth between h1 and h2
2a:54:8e:44:ea:33 destination known. only send message to it      *** Results: ['13.0 Mbits/sec', '14.7 Mbits/sec']
2a:54:8e:44:ea:33 destination known. only send message to it      mininet> iperf h1 h5
2a:54:8e:44:ea:33 destination known. only send message to it      *** Iperf: testing TCP bandwidth between h1 and h5
2a:54:8e:44:ea:33 destination known. only send message to it      *** Results: ['2.91 Mbits/sec', '3.63 Mbits/sec']

```

Throughput is better in Task 3 compare to Task 2.

Task 4:

Q1.

```
root@b1b91d8a18:/pox# python3 pox.py log.level --DEBUG misc.of_tutorial
POX 0.7.0 (gar) / Copyright 2011-2020 James McCauley, et al.
DEBUG:core:POX 0.7.0 (gar) going up...
DEBUG:core:Running on CPython (3.6.9/Oct 8 2020 12:12:24)
DEBUG:core:Platform is Linux-5.4.0-1029-gcp-x86_64-with-Ubuntu-18.04-bionic
WARNING:version:Support for Python 3 is experimental.
INFO:core:POX 0.7.0 (gar) is up.
DEBUG:openflow.of_01:Listening on 0.0.0.0:6633
INFO:openflow.of_01:[00-00-00-00-00-06 2] connected
DEBUG:misc.of_tutorial:Controlling [00-00-00-00-00-06 2]
INFO:openflow.of_01:[00-00-00-00-00-01 3] connected
DEBUG:misc.of_tutorial:Controlling [00-00-00-00-00-01 3]
INFO:openflow.of_01:[00-00-00-00-00-04 4] connected
DEBUG:misc.of_tutorial:Controlling [00-00-00-00-00-04 4]
INFO:openflow.of_01:[00-00-00-00-00-03 5] connected
DEBUG:misc.of_tutorial:Controlling [00-00-00-00-00-03 5]
INFO:openflow.of_01:[00-00-00-00-00-05 6] connected
DEBUG:misc.of_tutorial:Controlling [00-00-00-00-00-05 6]
INFO:openflow.of_01:[00-00-00-00-00-02 7] connected
DEBUG:misc.of_tutorial:Controlling [00-00-00-00-00-02 7]
DEBUG:openflow.of_01:1 connection aborted

64 bytes from 10.0.0.2: icmp_seq=84 ttl=64 time=0.063 ms
64 bytes from 10.0.0.2: icmp_seq=85 ttl=64 time=0.064 ms
64 bytes from 10.0.0.2: icmp_seq=86 ttl=64 time=0.062 ms
64 bytes from 10.0.0.2: icmp_seq=87 ttl=64 time=0.064 ms
64 bytes from 10.0.0.2: icmp_seq=88 ttl=64 time=0.064 ms
64 bytes from 10.0.0.2: icmp_seq=89 ttl=64 time=0.068 ms
64 bytes from 10.0.0.2: icmp_seq=90 ttl=64 time=0.065 ms
64 bytes from 10.0.0.2: icmp_seq=91 ttl=64 time=0.051 ms
64 bytes from 10.0.0.2: icmp_seq=92 ttl=64 time=0.071 ms
64 bytes from 10.0.0.2: icmp_seq=93 ttl=64 time=0.062 ms
64 bytes from 10.0.0.2: icmp_seq=94 ttl=64 time=0.063 ms
64 bytes from 10.0.0.2: icmp_seq=95 ttl=64 time=0.063 ms
64 bytes from 10.0.0.2: icmp_seq=96 ttl=64 time=0.062 ms
64 bytes from 10.0.0.2: icmp_seq=97 ttl=64 time=0.068 ms
64 bytes from 10.0.0.2: icmp_seq=98 ttl=64 time=0.063 ms
64 bytes from 10.0.0.2: icmp_seq=99 ttl=64 time=0.061 ms
64 bytes from 10.0.0.2: icmp_seq=100 ttl=64 time=0.062 ms

--- 10.0.0.2 ping statistics ---
100 packets transmitted, 98 received, 2% packet loss, time 101368ms
rtt min/avg/max/mdev = 0.051/0.067/0.267/0.023 ms

root@b1b91d8a18:/pox# python3 pox.py log.level --DEBUG misc.of_tutorial
POX 0.7.0 (gar) / Copyright 2011-2020 James McCauley, et al.
DEBUG:core:POX 0.7.0 (gar) going up...
DEBUG:core:Running on CPython (3.6.9/Oct 8 2020 12:12:24)
DEBUG:core:Platform is Linux-5.4.0-1029-gcp-x86_64-with-Ubuntu-18.04-bionic
WARNING:version:Support for Python 3 is experimental.
INFO:core:POX 0.7.0 (gar) is up.
DEBUG:openflow.of_01:Listening on 0.0.0.0:6633
INFO:openflow.of_01:[00-00-00-00-00-06 2] connected
DEBUG:misc.of_tutorial:Controlling [00-00-00-00-00-06 2]
INFO:openflow.of_01:[00-00-00-00-00-01 3] connected
DEBUG:misc.of_tutorial:Controlling [00-00-00-00-00-01 3]
INFO:openflow.of_01:[00-00-00-00-00-04 4] connected
DEBUG:misc.of_tutorial:Controlling [00-00-00-00-00-04 4]
INFO:openflow.of_01:[00-00-00-00-00-03 5] connected
DEBUG:misc.of_tutorial:Controlling [00-00-00-00-00-03 5]
INFO:openflow.of_01:[00-00-00-00-00-05 6] connected
DEBUG:misc.of_tutorial:Controlling [00-00-00-00-00-05 6]
INFO:openflow.of_01:[00-00-00-00-00-02 7] connected
DEBUG:misc.of_tutorial:Controlling [00-00-00-00-00-02 7]
DEBUG:openflow.of_01:1 connection aborted

64 bytes from 10.0.0.5: icmp_seq=84 ttl=64 time=0.078 ms
64 bytes from 10.0.0.5: icmp_seq=85 ttl=64 time=0.079 ms
64 bytes from 10.0.0.5: icmp_seq=86 ttl=64 time=0.078 ms
64 bytes from 10.0.0.5: icmp_seq=87 ttl=64 time=0.083 ms
64 bytes from 10.0.0.5: icmp_seq=88 ttl=64 time=0.077 ms
64 bytes from 10.0.0.5: icmp_seq=89 ttl=64 time=0.064 ms
64 bytes from 10.0.0.5: icmp_seq=90 ttl=64 time=0.083 ms
64 bytes from 10.0.0.5: icmp_seq=91 ttl=64 time=0.081 ms
64 bytes from 10.0.0.5: icmp_seq=92 ttl=64 time=0.082 ms
64 bytes from 10.0.0.5: icmp_seq=93 ttl=64 time=0.088 ms
64 bytes from 10.0.0.5: icmp_seq=94 ttl=64 time=0.088 ms
64 bytes from 10.0.0.5: icmp_seq=95 ttl=64 time=0.079 ms
64 bytes from 10.0.0.5: icmp_seq=96 ttl=64 time=0.084 ms
64 bytes from 10.0.0.5: icmp_seq=97 ttl=64 time=0.087 ms
64 bytes from 10.0.0.5: icmp_seq=98 ttl=64 time=0.083 ms
64 bytes from 10.0.0.5: icmp_seq=99 ttl=64 time=0.088 ms
64 bytes from 10.0.0.5: icmp_seq=100 ttl=64 time=0.089 ms

--- 10.0.0.5 ping statistics ---
100 packets transmitted, 100 received, 0% packet loss, time 101363ms
rtt min/avg/max/mdev = 0.063/0.080/0.130/0.014 ms
```

Average Time for h1 ping -c100 h2 -> 0.067ms

Average Time for h1 ping -c100 h5 -> 0.080ms

Difference between h1 ping -c100 h2 and h1 ping -c100 h5 is 0.59 ms.

As per results, Task 4 average time is much better than Task3.

Q2

```
INFO:openflow.of_01:[00-00-00-00-00-05 6] connected
DEBUG:misc.of_tutorial:Controlling [00-00-00-00-00-03 5]
INFO:openflow.of_01:[00-00-00-00-00-05 6] connected
DEBUG:misc.of_tutorial:Controlling [00-00-00-00-00-05 6]
INFO:openflow.of_01:[00-00-00-00-00-02 7] connected
DEBUG:misc.of_tutorial:Controlling [00-00-00-00-00-02 7]
DEBUG:openflow.of_01:1 connection aborted

rtt min/avg/max/mdev = 0.063/0.080/0.130/0.014 ms
mininet> iperf h1 h2
*** Iperf: testing TCP bandwidth between h1 and h2
*** Results: ['24.3 Gbits/sec', '24.3 Gbits/sec']
mininet> iperf h1 h5
*** Iperf: testing TCP bandwidth between h1 and h5
*** Results: ['19.1 Gbits/sec', '19.1 Gbits/sec']
```

iperf h1 h2 -> 24.3 Gbits/sec, 24.3 Gbits/sec

iperf h1 h5 -> 19.1 Gbits/sec, 19.1 Gbits/sec

As per results, Throughput for Task 4 comes in Gbits/sec where in Task 2 and 3 it was Mbits/sec.

Throughput as compare to Task 3 , it is better in Task4.

Q3

As per results, Task 4 performance is better than Task 3. And Task 3 performance is better than Task 2.

Controller with open flow proves to be better than controller mac learning and controller mac learning proves to be better than SDN controller.

Throughput in Task 4 is much better than Task 3 and also throughput of Task 3 is better than Task 2.

Q4

Steps to run pingall to verify connectivity and dump the output:

- 1) \$ mn --custom binary_tree.py --topo mytopo --test pingall &> pingall.txt
- 2) \$ cat pingall.txt

```
root@21bb91d6af8:~/pox# vim pox/misc/of tutorial.py
root@21bb91d6af8:~/pox# python3 pox.py log.level --DEBUG misc.of tutorial
POX 0.7.0 (gar) / Copyright 2011-2020 James McCauley, et al.
DEBUG:core:POX 0.7.0 (gar) going up...
DEBUG:core:Running on CPython (3.6.9/Oct 8 2020 12:12:24)
DEBUG:core:Platform is Linux-5.4.0-1029-gcp-x86_64-with-Ubuntu-18.04-bionic
WARNING:version:Support for Python 3 is experimental.
INFO:core:POX 0.7.0 (gar) is up.
DEBUG:openflow.of_01:Listening on 0.0.0.0:6633
INFO:openflow.of_01:[00-00-00-00-00-06 2] connected
DEBUG:misc.of tutorial:Controlling [00-00-00-00-00-06 2]
INFO:openflow.of_01:[00-00-00-00-00-01 3] connected
DEBUG:misc.of tutorial:Controlling [00-00-00-00-00-01 3]
INFO:openflow.of_01:[00-00-00-00-00-04 4] connected
DEBUG:misc.of tutorial:Controlling [00-00-00-00-00-04 4]
INFO:openflow.of_01:[00-00-00-00-00-05 5] connected
DEBUG:misc.of tutorial:Controlling [00-00-00-00-00-05 5]
INFO:openflow.of_01:[00-00-00-00-00-06 6] connected
DEBUG:misc.of tutorial:Controlling [00-00-00-00-00-06 6]
INFO:openflow.of_01:[00-00-00-00-00-02 7] connected
DEBUG:misc.of tutorial:Controlling [00-00-00-00-00-02 7]
DEBUG:openflow.of_01:1 connection aborted
^CINFO:core:Going down...
ERROR:openflow.of_01:Exception reading connection None
Traceback (most recent call last):
  File "/root/pox/pox/openflow/of_01.py", line 1084, in run
    rlist, wlist, elist = yield Select(sockets, [], sockets, 5)
GeneratorExit
DEBUG:openflow.of_01:No longer listening for connections

root@21bb91d6af8:~# mn --custom binary_tree.py --topo mytopo --test pingall &> pingall.txt
root@21bb91d6af8:~# cat pingall.txt
*** Error setting resource limits. Mininet's performance may be affected.
*** Creating network
*** Adding controller
*** Adding hosts:
h1 h2 h3 h4 h5
*** Adding switches:
s1 s2 s3 s4 s5 s6
*** Adding links:
(h1, s1) (h2, s1) (h3, s2) (h4, s2) (h5, s3) (s1, s4) (s2, s4) (s3, s5) (s4, s6) (s5, s6)
*** Configuring hosts
h1 h2 h3 h4 h5
*** Starting controller
c0
*** Starting 6 switches
s1 s2 s3 s4 s5 s6
*** Waiting for switches to connect
s1 s2 s3 s4 s5 s6
*** Ping: testing ping reachability
h1 -> h2 h3 h4 h5
h2 -> h1 h3 h4 h5
h3 -> h1 h2 h4 h5
h4 -> h1 h2 h3 h5
h5 -> h1 h2 h3 h4
*** Results: 0% dropped (20/20 received)
*** Stopping 1 controllers
c0
*** Stopping 10 links
.....
*** Stopping 6 switches
s1 s2 s3 s4 s5 s6
*** Stopping 5 hosts
h1 h2 h3 h4 h5
*** Done
completed in 6.967 seconds
```

Q5

Step 1:

```
$ mn --custom binary_tree.py --controller remote --topo mytopo
```

```
mininet>pingall
```

Step 2: Open second terminal and controller should be active:

```
$ ovs-ofctl dump-flows s1 > flow.txt
```

```
$ cat flow.txt
```

Output will be as given on below :

The image shows three terminal windows from a Google Chrome browser. The first window shows the installation of POX on a VM. The second window shows the setup of a Mininet network with 5 hosts (h1-h5) and 6 switches (s1-s6), including a ping test showing 70% success. The third window shows the output of the command 'ovs-ofctl dump-flows s1', displaying a table of flow entries for switch s1, including actions like 'normal', 'output:1', 'output:2', and 'output:3'.

Here ,

Cookie is used for storing temporary information.

N packets for total no of packets which have matched the entry from the flow table.

N bytes for total no of bytes from packets that have matched the entry also d1 dst which is destination of mac address.

Task 5:

The image shows two terminal windows. The left window shows the setup of a Mininet network with 5 hosts and 6 switches. The right window shows the execution of the command 'ovs-ofctl add-flow s6 "arp,nw_dst=10.0.0.1 actions=normal"', which adds a new flow entry to switch s6.

- ovs-ofctl add-flow s6 "arp,nw_dst=10.0.0.1 actions=normal"
- new_dst is destination address
- Steps: set the flow table rules to match IP and set ethernet type.

Bonus Question:

```
adityagawali@instance-2: ~/mininet - Google Chrome
ssh.cloud.google.com/projects/advcoud1/zones/us-central1-a/instances/instance-2?useAdminProxy=true&authuser=0&hl=en_US&projectNumber=944764275305

adityagawali@instance-2:~$ sudo add-apt-repository ppa:webupd8team/java -y
Hit:1 http://us-central1.gce.archive.ubuntu.com/ubuntu bionic InRelease
Hit:2 http://us-central1.gce.archive.ubuntu.com/ubuntu bionic-updates InRelease
Hit:3 http://us-central1.gce.archive.ubuntu.com/ubuntu bionic-backports InRelease
Hit:4 http://security.ubuntu.com/ubuntu bionic-security InRelease
Hit:5 https://download.docker.com/linux/ubuntu bionic InRelease
Get:6 http://repo.mysql.com/apt/ubuntu bionic InRelease [19.4 kB]
Hit:7 http://archive.canonical.com/ubuntu bionic InRelease
Get:8 http://ppa.launchpad.net/webupd8team/java/ubuntu bionic InRelease [15.4 kB]
Err:6 http://repo.mysql.com/apt/ubuntu bionic InRelease
  The following signatures were invalid: EXPKEYSIG 8C718D3B5072E1F5 MySQL Release Engineering <mysql-build@oss.oracle.com>
Reading package lists... Done
W: GPG error: http://repo.mysql.com/apt/ubuntu bionic InRelease: The following signatures were invalid: EXPKEYSIG 8C718D3B5072E1F5 MySQL Release Engineering <mysql-build@oss.oracle.com>
E: The repository 'http://repo.mysql.com/apt/ubuntu bionic InRelease' is not signed.
N: Updating from such a repository can't be done securely, and is therefore disabled by default.
N: See apt-secure(8) manpage for repository creation and user configuration details.
adityagawali@instance-2:~$ sudo apt-get update
Hit:1 http://us-central1.gce.archive.ubuntu.com/ubuntu bionic InRelease
Hit:2 http://us-central1.gce.archive.ubuntu.com/ubuntu bionic-updates InRelease
Hit:3 http://us-central1.gce.archive.ubuntu.com/ubuntu bionic-backports InRelease
Get:4 http://repo.mysql.com/apt/ubuntu bionic InRelease [19.4 kB]
Hit:5 http://archive.canonical.com/ubuntu bionic InRelease
Hit:6 https://download.docker.com/linux/ubuntu bionic InRelease
Hit:7 http://ppa.launchpad.net/webupd8team/java/ubuntu bionic InRelease
Hit:8 http://security.ubuntu.com/ubuntu bionic-security InRelease
Err:4 http://repo.mysql.com/apt/ubuntu bionic InRelease
  The following signatures were invalid: EXPKEYSIG 8C718D3B5072E1F5 MySQL Release Engineering <mysql-build@oss.oracle.com>
Reading package lists... Done
W: GPG error: http://repo.mysql.com/apt/ubuntu bionic InRelease: The following signatures were invalid: EXPKEYSIG 8C718D3B5072E1F5 MySQL Release Engineering <mysql-build@oss.oracle.com>
E: The repository 'http://repo.mysql.com/apt/ubuntu bionic InRelease' is not signed.
N: Updating from such a repository can't be done securely, and is therefore disabled by default.
N: See apt-secure(8) manpage for repository creation and user configuration details.
adityagawali@instance-2:~$ git clone git://github.com/mininet/mininet
Cloning into 'mininet'...
remote: Enumerating objects: 9752, done.
remote: Total 9752 (delta 0), reused 0 (delta 0), pack-reused 9752
Receiving objects: 100% (9752/9752), 3.03 MiB | 15.75 MiB/s, done.
Resolving deltas: 100% (6472/6472), done.
adityagawali@instance-2:~$ git clone git://github.com/mininet/mininet
fatal: destination path 'mininet' already exists and is not an empty directory.
adityagawali@instance-2:~$ cd mininet
adityagawali@instance-2:~/mininet$ ~/mininet/util/install.sh -a
Detected Linux distribution: Ubuntu 18.04 bionic amd64
```

Steps for installing opemlight:

```
$ sudo apt-get update
```

```
$ sudo apt-get -y install unzip vim wget
```

```
$ sudo apt-get -y install openjdk-8-jre
```

```
$ sudo update-alternatives --config java
```

```
$ echo 'export JAVA_HOME=/usr/lib/jvm/java-8-openjdk-amd64/jre' >> ~/.bashrc
```

```
$ source ~/.bashrc
```

```
$ echo $JAVA_HOME
```

```
$ wget
```

```
https://nexus.opendaylight.org/content/repositories/opendaylight.release/org/opendaylight/integration/karaf/0.8.4/karaf-0.8.4.zip
```

```
$ sudo mkdir /usr/local/karaf
```

```
$ sudo mv karaf-0.8.4.zip /usr/local/karaf
```

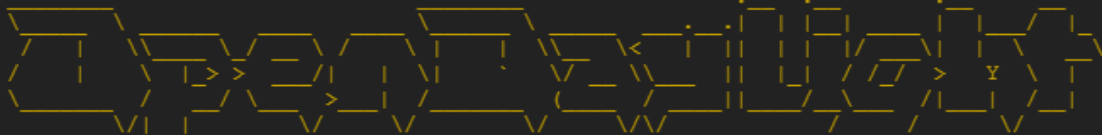
```
$ sudo unzip /usr/local/karaf/karaf-0.8.4.zip -d /usr/local/karaf/
```

```
$ sudo update-alternatives --install /usr/bin/karaf karaf /usr/local/karaf/karaf-0.8.4/bin/karaf 1
```

```
$ sudo update-alternatives --config karaf
```

\$ sudo -E karaf

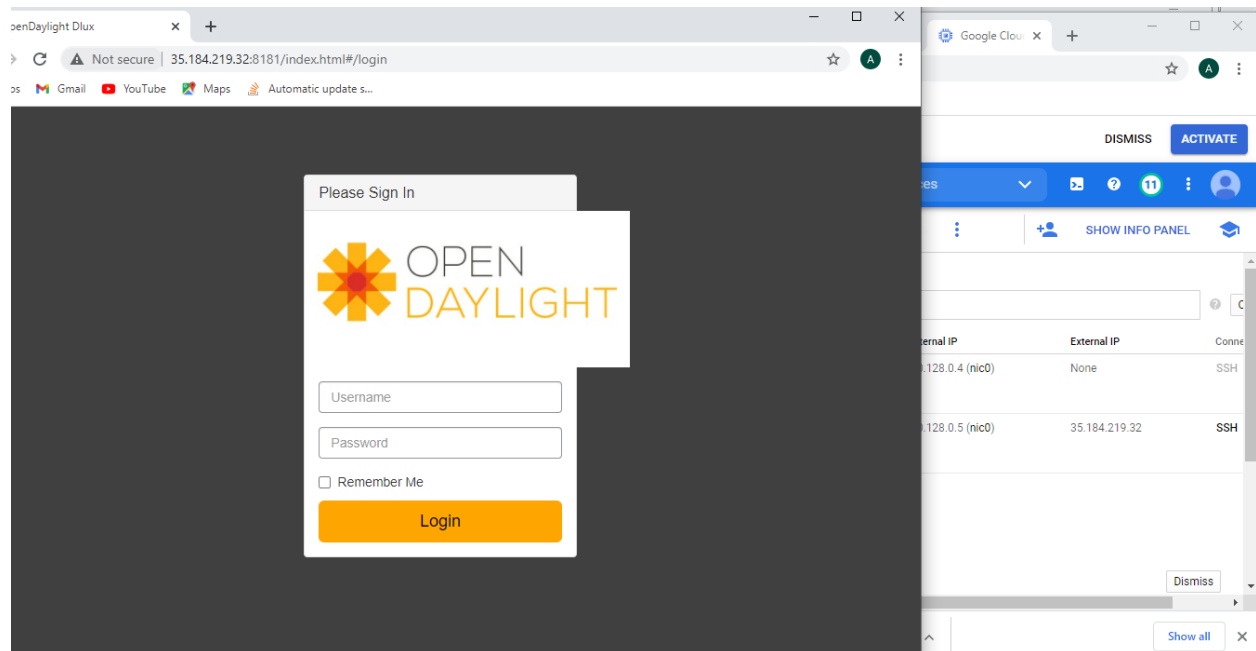
```
adityagawali@instance-2:~$ sudo -E karaf
link: /etc/alternatives/karaf
link: /usr/local/karaf/karaf-0.8.4/bin/karaf
Apache Karaf starting up. Press Enter to open the shell now...
100% [=====]
Karaf started in 5s. Bundle stats: 54 active, 55 total
```



```
Hit '<tab>' for a list of available commands
and '[cmd] --help' for help on a specific command.
Hit '<ctrl-d>' or type 'system:shutdown' or 'logout' to shutdown OpenDaylight.
```

```
opendaylight-user@root>feature:install odl-l2switch-switch-ui
opendaylight-user@root>
```

```
Last login: Mon Dec 7 20:28:05 2020 from 173.194.94.96
adityagawali@instance-2:~$ sudo netstat -an | grep 8181
tcp6      0      0 :::8181          :::*              LISTEN
adityagawali@instance-2:~$
```



Running OPENLIGHT on my gcp ip

Running with same ip which is of openlight on 8181port

Integrating with mininet

```
root@instance-2:/home/adityagawali# sudo mn --controller=remote,ip=35.184.219.32,port=8181
*** Creating network
*** Adding controller
*** Adding hosts:
h1 h2
*** Adding switches:
s1
*** Adding links:
(h1, s1) (h2, s1)
*** Configuring hosts
h1 h2
*** Starting controller
c0
*** Starting 1 switches
s1 ...
*** Starting CLI:
mininet> pingall
*** Ping: testing ping reachability
h1 -> X
h2 -> 
```