

## **TOPOLOGY CODE:**

```
from mininet.topo import Topo

class MyTopo( Topo ):
    "Simple topology example."

    def build( self ):
        "Create custom topo."

        h1 = self.addHost( 'h1' )
        h2 = self.addHost( 'h2' )
        h3 = self.addHost( 'h3' )
        h4 = self.addHost( 'h4' )
        h5 = self.addHost( 'h5' )
        s1 = self.addSwitch( 's1' )
        s2 = self.addSwitch( 's2' )
        s3 = self.addSwitch( 's3' )

        self.addLink( h1, s1 )
        self.addLink( h2, s1 )
        self.addLink( h3, s3 )
        self.addLink( h4, s3 )
        self.addLink( h5, s3 )

        self.addLink( s1, s2 )
        self.addLink( s2, s3 )

topos = { 'mytopo': ( lambda: MyTopo() ) }
```

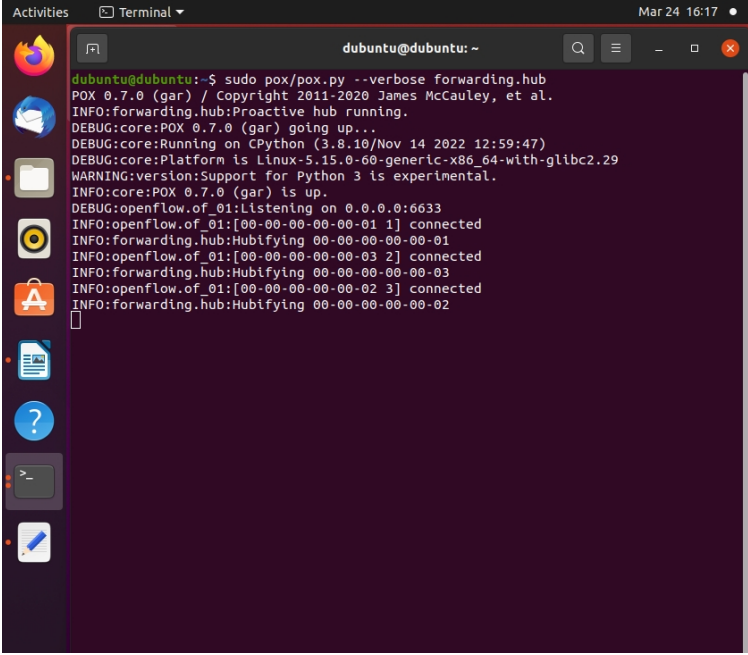
## **OUTPUT:**

### **Terminal – 1:**

```
dubuntu@dubuntu:~$ sudo pox/pox.py --verbose forwarding.hub
POX 0.7.0 (gar) / Copyright 2011-2020 James McCauley, et al.
INFO:forwarding.hub:Proactive hub running.
DEBUG:core:POX 0.7.0 (gar) going up...
DEBUG:core:Running on CPython (3.8.10/Nov 14 2022 12:59:47)
DEBUG:core:Platform is Linux-5.15.0-60-generic-x86_64-with-glibc2.29
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 1] connected
INFO:forwarding.hub:Hubifying 00-00-00-00-00-01
INFO:openflow.of_01:[00-00-00-00-00-03 2] connected
INFO:forwarding.hub:Hubifying 00-00-00-00-00-03
```

INFO:openflow.of\_01:[00-00-00-00-00-02 3] connected

INFO:forwarding.hub:Hubifying 00-00-00-00-00-02



```
dubuntu@dubuntu:~$ sudo pox/pox.py --verbose forwarding.hub
POX 0.7.0 (gar) / Copyright 2011-2020 James McCauley, et al.
INFO:forwarding.hub:Proactive hub running.
DEBUG:core:POX 0.7.0 (gar) going up...
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DEBUG:core:Platform is Linux-5.15.0-60-generic-x86_64-with-glibc2.29
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 1] connected
INFO:forwarding.hub:Hubifying 00-00-00-00-00-01
INFO:openflow.of_01:[00-00-00-00-00-03 2] connected
INFO:forwarding.hub:Hubifying 00-00-00-00-00-03
INFO:openflow.of_01:[00-00-00-00-00-02 3] connected
INFO:forwarding.hub:Hubifying 00-00-00-00-00-02
```

## Terminal – 2:

dubuntu@dubuntu:~\$ **sudo mn --custom ~/mininet/custom/topo\_pox.py --topo=mytopo --controller=remote,0.0.0.0**

[sudo] password for dubuntu:

\*\*\* Creating network

\*\*\* Adding controller

Unable to contact the remote controller at 0.0.0.0:6653

Connecting to remote controller at 0.0.0.0:6633

\*\*\* Adding hosts:

h1 h2 h3 h4 h5

\*\*\* Adding switches:

s1 s2 s3

\*\*\* Adding links:

(h1, s1) (h2, s1) (h3, s3) (h4, s3) (h5, s3) (s1, s2) (s2, s3)

\*\*\* Configuring hosts

h1 h2 h3 h4 h5

\*\*\* Starting controller

c0

\*\*\* Starting 3 switches

s1 s2 s3 ...

\*\*\* Starting CLI:

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=0.052 ms

64 bytes from 10.0.0.2: icmp\_seq=2 ttl=64 time=0.087 ms

64 bytes from 10.0.0.2: icmp\_seq=3 ttl=64 time=0.080 ms

64 bytes from 10.0.0.2: icmp\_seq=4 ttl=64 time=0.085 ms

^C

--- 10.0.0.2 ping statistics ---

4 packets transmitted, 4 received, 0% packet loss, time 3059ms

**rtt min/avg/max/mdev = 0.052/0.076/0.087/0.014 ms**

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=0.241 ms

64 bytes from 10.0.0.5: icmp\_seq=2 ttl=64 time=0.080 ms

64 bytes from 10.0.0.5: icmp\_seq=3 ttl=64 time=0.080 ms

^C

--- 10.0.0.5 ping statistics ---

3 packets transmitted, 3 received, 0% packet loss, time 2044ms

**rtt min/avg/max/mdev = 0.080/0.133/0.241/0.075 ms**

mininet> **iperf h1 h2**

\*\*\* Iperf: testing TCP bandwidth between h1 and h2

.\*\*\* **Results: ['12.2 Gbits/sec', '12.2 Gbits/sec']**

mininet> **iperf h1 h5**

\*\*\* Iperf: testing TCP bandwidth between h1 and h5

.\*\*\* **Results: ['13.6 Gbits/sec', '13.6 Gbits/sec']**

mininet> pingall

\*\*\* 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)

mininet>

### **Time taken to ping:**

**h1 ping h2 -> 0.052ms      Traffic on: Host(h2,h3,h4,h5), Switches(s1,s2,s3)**

**h1 ping h5 -> 0.080ms      Traffic on: Host(h2,h3,h4,h5), Switches(s1,s2,s3)**

**Difference -> 0.028ms**

### **Throughput:**

**iperf h1 h2 -> 12.2Gbits/seec**

**iperf h1 h5 -> 13.6Gbits/sec**

**Difference -> 1.4Gbits/sec**

```
Activities Terminal Mar 24 16:20 dubuntu@dubuntu: ~  
*** Starting 3 switches  
s1 s2 s3 ...  
*** Starting CLI:  
mininet> pingall  
*** 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)  
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=0.052 ms  
64 bytes from 10.0.0.2: icmp_seq=2 ttl=64 time=0.087 ms  
64 bytes from 10.0.0.2: icmp_seq=3 ttl=64 time=0.080 ms  
64 bytes from 10.0.0.2: icmp_seq=4 ttl=64 time=0.085 ms  
^C  
--- 10.0.0.2 ping statistics ---  
4 packets transmitted, 4 received, 0% packet loss, time 3059ms  
rtt min/avg/max/mdev = 0.052/0.076/0.087/0.014 ms  
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=0.241 ms  
64 bytes from 10.0.0.5: icmp_seq=2 ttl=64 time=0.080 ms  
64 bytes from 10.0.0.5: icmp_seq=3 ttl=64 time=0.080 ms  
^C  
--- 10.0.0.5 ping statistics ---  
3 packets transmitted, 3 received, 0% packet loss, time 2044ms  
rtt min/avg/max/mdev = 0.080/0.133/0.241/0.075 ms  
mininet> iperf h1 h2  
*** Iperf: testing TCP bandwidth between h1 and h2  
*** Results: ['12.2 Gbits/sec', '12.2 Gbits/sec']  
mininet> iperf h1 h5  
*** Iperf: testing TCP bandwidth between h1 and h5  
*** Results: ['13.6 Gbits/sec', '13.6 Gbits/sec']  
mininet> pingall  
*** 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)  
mininet> ^
```

## OUTPUT-2:

### Terminal – 1:

dubuntu@dubuntu:~\$ **sudo pox/pox.py --verbose forwarding.l2nt\_learning**

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 (3.8.10/Nov 14 2022 12:59:47)

DEBUG:core:Platform is Linux-5.15.0-60-generic-x86\_64-with-glibc2.29

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 1] connected

DEBUG:forwarding.l2nt\_learning:Connection [00-00-00-00-00-01 1]

INFO:openflow.of\_01:[00-00-00-00-00-03 2] connected

DEBUG:forwarding.l2nt\_learning:Connection [00-00-00-00-00-03 2]

INFO:openflow.of\_01:[00-00-00-00-00-02 3] connected

DEBUG:forwarding.l2nt\_learning:Connection [00-00-00-00-00-02 3]

DEBUG:forwarding.l2nt\_learning:installing flow for de:56:e6:a8:df:8e.2 -> c6:29:cb:33:60:c4.1

DEBUG:forwarding.l2nt\_learning:installing flow for c6:29:cb:33:60:c4.1 -> de:56:e6:a8:df:8e.2

DEBUG:forwarding.l2nt\_learning:installing flow for de:56:e6:a8:df:8e.2 -> c6:29:cb:33:60:c4.1

DEBUG:forwarding.l2nt\_learning:installing flow for de:56:e6:a8:df:8e.2 -> c6:29:cb:33:60:c4.1

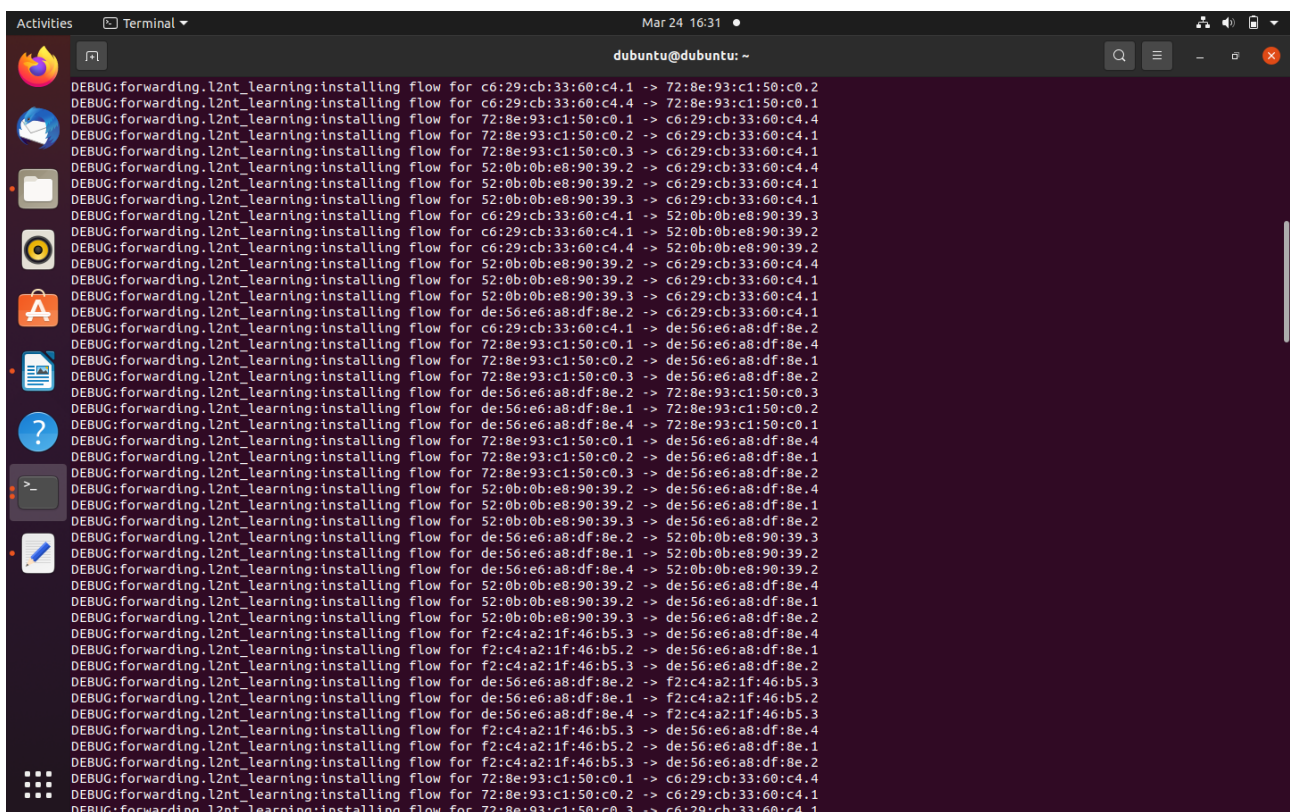
DEBUG:forwarding.l2nt\_learning:installing flow for c6:29:cb:33:60:c4.1 -> de:56:e6:a8:df:8e.2

DEBUG:forwarding.l2nt\_learning:installing flow for f2:c4:a2:1f:46:b5.3 -> c6:29:cb:33:60:c4.4

```

DEBUG:forwarding.l2nt_learning:installing flow for f2:c4:a2:1f:46:b5.2 -> c6:29:cb:33:60:c4.1
DEBUG:forwarding.l2nt_learning:installing flow for f2:c4:a2:1f:46:b5.3 -> c6:29:cb:33:60:c4.1
DEBUG:forwarding.l2nt_learning:installing flow for c6:29:cb:33:60:c4.1 -> f2:c4:a2:1f:46:b5.3
DEBUG:forwarding.l2nt_learning:installing flow for c6:29:cb:33:60:c4.1 -> f2:c4:a2:1f:46:b5.2
DEBUG:forwarding.l2nt_learning:installing flow for c6:29:cb:33:60:c4.4 -> f2:c4:a2:1f:46:b5.3
DEBUG:forwarding.l2nt_learning:installing flow for f2:c4:a2:1f:46:b5.3 -> c6:29:cb:33:60:c4.4
DEBUG:forwarding.l2nt_learning:installing flow for f2:c4:a2:1f:46:b5.2 -> c6:29:cb:33:60:c4.1
DEBUG:forwarding.l2nt_learning:installing flow for f2:c4:a2:1f:46:b5.3 -> c6:29:cb:33:60:c4.1
DEBUG:forwarding.l2nt_learning:installing flow for f2:c4:a2:1f:46:b5.3 -> c6:29:cb:33:60:c4.4
DEBUG:forwarding.l2nt_learning:installing flow for f2:c4:a2:1f:46:b5.2 -> c6:29:cb:33:60:c4.1
DEBUG:forwarding.l2nt_learning:installing flow for f2:c4:a2:1f:46:b5.3 -> c6:29:cb:33:60:c4.1
DEBUG:forwarding.l2nt_learning:installing flow for c6:29:cb:33:60:c4.1 -> f2:c4:a2:1f:46:b5.3
DEBUG:forwarding.l2nt_learning:installing flow for c6:29:cb:33:60:c4.1 -> f2:c4:a2:1f:46:b5.2
DEBUG:forwarding.l2nt_learning:installing flow for c6:29:cb:33:60:c4.4 -> f2:c4:a2:1f:46:b5.3
DEBUG:forwarding.l2nt_learning:installing flow for 72:8e:93:c1:50:c0.1 -> c6:29:cb:33:60:c4.4
DEBUG:forwarding.l2nt_learning:installing flow for 72:8e:93:c1:50:c0.2 -> c6:29:cb:33:60:c4.1
DEBUG:forwarding.l2nt_learning:installing flow for 72:8e:93:c1:50:c0.3 -> c6:29:cb:33:60:c4.1
DEBUG:forwarding.l2nt_learning:installing flow for c6:29:cb:33:60:c4.1 -> 72:8e:93:c1:50:c0.3

```



The screenshot shows a terminal window titled "Terminal" with the prompt "dubuntu@dubuntu: ~". The terminal displays a long list of debug messages, each starting with "DEBUG:forwarding.l2nt\_learning:installing flow for" followed by a source MAC address, a destination MAC address, and an arrow indicating the direction of the flow. The messages are repeated for various MAC addresses, including f2:c4:a2:1f:46:b5.2, f2:c4:a2:1f:46:b5.3, c6:29:cb:33:60:c4.1, c6:29:cb:33:60:c4.4, 72:8e:93:c1:50:c0.1, 72:8e:93:c1:50:c0.2, 72:8e:93:c1:50:c0.3, and 52:0b:0b:e8:90:39.2. The messages are repeated for various MAC addresses, including f2:c4:a2:1f:46:b5.2, f2:c4:a2:1f:46:b5.3, c6:29:cb:33:60:c4.1, c6:29:cb:33:60:c4.4, 72:8e:93:c1:50:c0.1, 72:8e:93:c1:50:c0.2, 72:8e:93:c1:50:c0.3, and 52:0b:0b:e8:90:39.2.

## Terminal – 2:

```

dubuntu@dubuntu:~$ sudo mn --custom ~/mininet/custom/topo_pox.py --topo=mytopo --
controller=remote,0.0.0.0
[sudo] password for dubuntu:

```

```

*** Creating network
*** Adding controller
Unable to contact the remote controller at 0.0.0.0:6653
Connecting to remote controller at 0.0.0.0:6633
*** Adding hosts:
h1 h2 h3 h4 h5
*** Adding switches:
s1 s2 s3
*** Adding links:
(h1, s1) (h2, s1) (h3, s3) (h4, s3) (h5, s3) (s1, s2) (s2, s3)
*** Configuring hosts
h1 h2 h3 h4 h5
*** Starting controller
c0
*** Starting 3 switches
s1 s2 s3 ...
*** Starting CLI:
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=7.48 ms
64 bytes from 10.0.0.2: icmp_seq=2 ttl=64 time=0.356 ms
64 bytes from 10.0.0.2: icmp_seq=3 ttl=64 time=0.091 ms
64 bytes from 10.0.0.2: icmp_seq=4 ttl=64 time=0.081 ms
64 bytes from 10.0.0.2: icmp_seq=5 ttl=64 time=0.063 ms
^C
--- 10.0.0.2 ping statistics ---
5 packets transmitted, 5 received, 0% packet loss, time 4073ms
rtt min/avg/max/mdev = 0.063/1.614/7.482/2.935 ms
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=42.5 ms
64 bytes from 10.0.0.5: icmp_seq=2 ttl=64 time=0.359 ms
64 bytes from 10.0.0.5: icmp_seq=3 ttl=64 time=0.092 ms
64 bytes from 10.0.0.5: icmp_seq=4 ttl=64 time=0.083 ms
64 bytes from 10.0.0.5: icmp_seq=5 ttl=64 time=0.094 ms
64 bytes from 10.0.0.5: icmp_seq=6 ttl=64 time=0.089 ms
64 bytes from 10.0.0.5: icmp_seq=7 ttl=64 time=0.076 ms
^C
--- 10.0.0.5 ping statistics ---
7 packets transmitted, 7 received, 0% packet loss, time 6123ms
rtt min/avg/max/mdev = 0.076/6.189/42.530/14.836 ms
mininet> iperf h1 h2
*** Iperf: testing TCP bandwidth between h1 and h2
.*** Results: ['12.5 Gbits/sec', '12.5 Gbits/sec']
mininet> iperf h1 h5
*** Iperf: testing TCP bandwidth between h1 and h5
.*** Results: ['11.1 Gbits/sec', '11.2 Gbits/sec']
mininet> pingall
*** 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)

mininet>

### Time taken to ping:

h1 ping h2 -> 0.063ms      **Traffic on: Host(h2)**

h1 ping h5 -> 0.076ms      **Traffic on: Host(h5)**

**Difference -> 0.013ms**

### Throughput:

iperf h1 h2 -> 12.5Gbits/seec

iperf h1 h5 -> 11.2Gbits/sec

**Difference -> 1.3Gbits/sec**

In hub controller data packets are flooded to every host and switches whereas in MAC learning controller data packets are sent to destined MAC address only.

```
Activities Terminal Mar 24 16:34 dubuntu@dubuntu: ~
64 bytes from 10.0.0.2: icmp_seq=1 ttl=64 time=7.48 ms
64 bytes from 10.0.0.2: icmp_seq=2 ttl=64 time=0.356 ms
64 bytes from 10.0.0.2: icmp_seq=3 ttl=64 time=0.091 ms
64 bytes from 10.0.0.2: icmp_seq=4 ttl=64 time=0.081 ms
64 bytes from 10.0.0.2: icmp_seq=5 ttl=64 time=0.063 ms
^C
--- 10.0.0.2 ping statistics ---
5 packets transmitted, 5 received, 0% packet loss, time 4073ms
rtt min/avg/max/mdev = 0.063/1.614/7.482/2.935 ms
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=42.5 ms
64 bytes from 10.0.0.5: icmp_seq=2 ttl=64 time=0.359 ms
64 bytes from 10.0.0.5: icmp_seq=3 ttl=64 time=0.092 ms
64 bytes from 10.0.0.5: icmp_seq=4 ttl=64 time=0.083 ms
64 bytes from 10.0.0.5: icmp_seq=5 ttl=64 time=0.094 ms
64 bytes from 10.0.0.5: icmp_seq=6 ttl=64 time=0.089 ms
64 bytes from 10.0.0.5: icmp_seq=7 ttl=64 time=0.076 ms
^C
--- 10.0.0.5 ping statistics ---
7 packets transmitted, 7 received, 0% packet loss, time 6123ms
rtt min/avg/max/mdev = 0.076/6.189/42.530/14.836 ms
mininet> pingall
*** 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)
mininet> iperf h1 h2
*** Iperf: testing TCP bandwidth between h1 and h2
.*** Results: ['12.5 Gbits/sec', '12.5 Gbits/sec']
mininet> iperf h1 h5
*** Iperf: testing TCP bandwidth between h1 and h5
.*** Results: ['11.1 Gbits/sec', '11.2 Gbits/sec']
mininet> pingall
*** 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)
mininet>
```