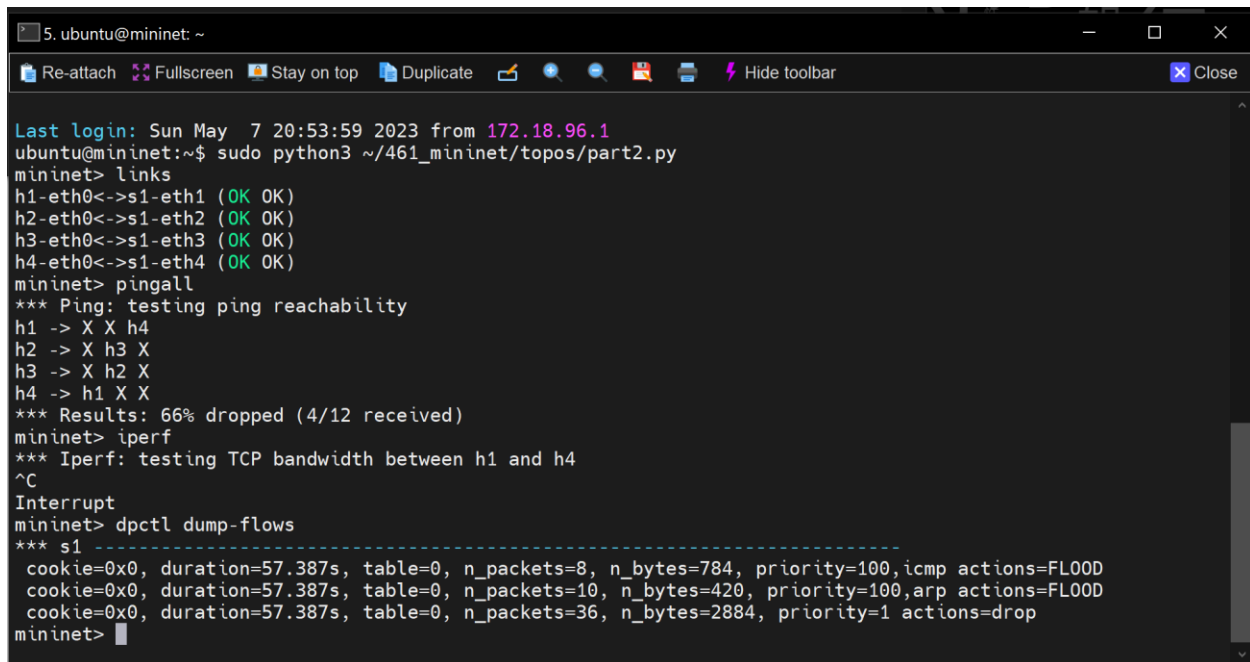


Part 1

```
5. ubuntu@mininet: ~  
Re-attach Fullscreen Stay on top Duplicate Hide toolbar Close  
ubuntu@mininet:~$ sudo mn --custom ~/461_mininet/topos/part1.py --topo=part1  
*** No default OpenFlow controller found for default switch!  
*** Falling back to OVS Bridge  
*** Creating network  
*** Adding controller  
*** Adding hosts:  
h1 h2 h3 h4  
*** Adding switches:  
s1  
*** Adding links:  
(h1, s1) (h2, s1) (h3, s1) (h4, s1)  
*** Configuring hosts  
h1 h2 h3 h4  
*** Starting controller  
  
*** Starting 1 switches  
s1 ...  
*** Starting CLI:  
mininet> iperf  
*** Iperf: testing TCP bandwidth between h1 and h4  
*** Results: ['23.5 Gbits/sec', '23.5 Gbits/sec']  
mininet> dump  
<Host h1: h1-eth0:10.0.0.1 pid=4956>  
<Host h2: h2-eth0:10.0.0.2 pid=4958>  
<Host h3: h3-eth0:10.0.0.3 pid=4960>  
<Host h4: h4-eth0:10.0.0.4 pid=4962>  
<OVSBridge s1: lo:127.0.0.1,s1-eth1:None,s1-eth2:None,s1-eth3:None,s1-eth4:None pid=4967>  
mininet> pingall  
*** Ping: testing ping reachability  
h1 -> h2 h3 h4  
h2 -> h1 h3 h4  
h3 -> h1 h2 h4  
h4 -> h1 h2 h3  
*** Results: 0% dropped (12/12 received)  
mininet> █
```

Figure 1. Screenshots of the `iperf`, `dump`, and `pingall` commands (from mininet)

Part 2

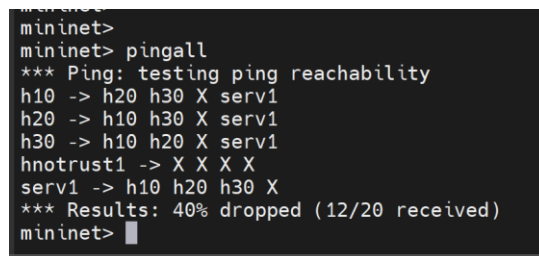


```
5. ubuntu@mininet: ~
Re-attach Fullscreen Stay on top Duplicate Hide toolbar Close

Last login: Sun May  7 20:53:59 2023 from 172.18.96.1
ubuntu@mininet:~$ sudo python3 ~/461_mininet/topos/part2.py
mininet> links
h1-eth0<->s1-eth1 (OK OK)
h2-eth0<->s1-eth2 (OK OK)
h3-eth0<->s1-eth3 (OK OK)
h4-eth0<->s1-eth4 (OK OK)
mininet> pingall
*** Ping: testing ping reachability
h1 -> X X h4
h2 -> X h3 X
h3 -> X h2 X
h4 -> h1 X X
*** Results: 66% dropped (4/12 received)
mininet> iperf
*** Iperf: testing TCP bandwidth between h1 and h4
^C
Interrupt
mininet> dpctl dump-flows
*** s1 -----
cookie=0x0, duration=57.387s, table=0, n_packets=8, n_bytes=784, priority=100,icmp actions=FL00D
cookie=0x0, duration=57.387s, table=0, n_packets=10, n_bytes=420, priority=100,arp actions=FL00D
cookie=0x0, duration=57.387s, table=0, n_packets=36, n_bytes=2884, priority=1 actions=drop
mininet> 
```

Figure 2. Screenshot of the `pingall` command and `dpctl dump-flows` command

Part 3



```
mininet>
mininet> pingall
*** Ping: testing ping reachability
h10 -> h20 h30 X serv1
h20 -> h10 h30 X serv1
h30 -> h10 h20 X serv1
hnotrust1 -> X X X X
serv1 -> h10 h20 h30 X
*** Results: 40% dropped (12/20 received)
mininet> 
```

Figure 3. A screenshot of the `pingall`,

```

"Node: hnotrust1" @mininet
root@mininet:/home/ubuntu# iperf -c 10.0.1.10
connect failed: Operation now in progress
root@mininet:/home/ubuntu#

"Node: h10" @mininet
root@mininet:/home/ubuntu# iperf -s &
[1] 11791
root@mininet:/home/ubuntu# -----
Server listening on TCP port 5001
TCP window size: 85.3 KByte (default)
-----
[ 6] local 10.0.1.10 port 5001 connected with 10.0.2.20 port 37598
[ ID] Interval      Transfer    Bandwidth
[ 6] 0.0-10.0 sec  19.6 GBytes 16.8 Gbits/sec
^C

mininet> dump
<Host h10: h10-eth0:10.0.1.10 pid=11489>
<Host h20: h20-eth0:10.0.2.20 pid=11491>
<Host h30: h30-eth0:10.0.3.30 pid=11493>
<Host hnotrust1: hnotrust1-eth0:172.16.10.100 pid=11495>
<Host serv1: serv1-eth0:10.0.4.10 pid=11497>
<OVSSwitch cores21: lo:127.0.0.1,cores21-eth1:None,cores21-eth2:None,cores21-eth3:None,cores21-eth4:None,cores21-eth5:None pid=11502>
<OVSSwitch dcs31: lo:127.0.0.1,dcs31-eth1:None,dcs31-eth2:None,dcs31-eth3:None,dcs31-eth4:None,dcs31-eth5:None pid=11508>
<OVSSwitch s1: lo:127.0.0.1,s1-eth1:None,s1-eth2:None,s1-eth3:None,s1-eth4:None,s1-eth5:None pid=11511>
<OVSSwitch s2: lo:127.0.0.1,s2-eth1:None,s2-eth2:None,s2-eth3:None,s2-eth4:None,s2-eth5:None pid=11514>
<OVSSwitch s3: lo:127.0.0.1,s3-eth1:None,s3-eth2:None,s3-eth3:None,s3-eth4:None,s3-eth5:None pid=11517>
<RemoteController c0: 127.0.0.1:6653 pid=11483>
mininet> pingall
*** Ping: testing ping reachability
h10 -> h20 h30 X serv1
h20 -> h10 h30 X serv1
h30 -> h10 h20 X serv1
hnotrust1 -> X X X X
serv1 -> h10 h20 h30 X
*** Results: 40% dropped (12/20 received)
mininet> iperf hnotrust1 h10
*** Iperf: testing TCP bandwidth between hnotrust1 and h10
^C
Interrupt
mininet> xterm h10 hnotrust1
mininet> iperf hnotrust1 h10
*** Iperf: testing TCP bandwidth between hnotrust1 and h10
^C
Interrupt
mininet> xterm
usage: xterm node1 node2 ...
mininet> xterm h20

"Node: h10" @mininet
RX packets 149 bytes 10114 (10.1 KB)
root@mininet:/home/ubuntu# iperf -s &
[1] 11791
root@mininet:/home/ubuntu# -----
Server listening on TCP port 5001
TCP window size: 85.3 KByte (default)
-----
[ 6] local 10.0.1.10 port 5001 connected with 10.0.2.20 port 37598
[ ID] Interval      Transfer    Bandwidth
[ 6] 0.0-10.0 sec  19.6 GBytes 16.8 Gbits/sec
^C
[1]+  Killed                  iperf -s
root@mininet:/home/ubuntu# iperf -c 10.0.4.10
-----
Client connecting to 10.0.4.10, TCP port 5001
TCP window size: 3.55 MByte (default)
-----
[ 5] local 10.0.1.10 port 44446 connected with 10.0.4.10 port 5001
[ ID] Interval      Transfer    Bandwidth
[ 5] 0.0-10.0 sec  17.9 GBytes 15.4 Gbits/sec
^C

"Node: serv1" @mininet
root@mininet:/home/ubuntu# iperf -s &
[1] 11831
root@mininet:/home/ubuntu# -----
Server listening on TCP port 5001
TCP window size: 85.3 KByte (default)
-----
[ 6] local 10.0.4.10 port 5001 connected with 10.0.1.10 port 44446
[ ID] Interval      Transfer    Bandwidth
[ 6] 0.0-10.0 sec  17.9 GBytes 15.4 Gbits/sec
^C

mininet> dump
<Host h10: h10-eth0:10.0.1.10 pid=11489>
<Host h20: h20-eth0:10.0.2.20 pid=11491>
<Host h30: h30-eth0:10.0.3.30 pid=11493>
<Host hnotrust1: hnotrust1-eth0:172.16.10.100 pid=11495>
<Host serv1: serv1-eth0:10.0.4.10 pid=11497>
<OVSSwitch cores21: lo:127.0.0.1,cores21-eth1:None,cores21-eth2:None,cores21-eth3:None,cores21-eth4:None,cores21-eth5:None pid=11502>
<OVSSwitch dcs31: lo:127.0.0.1,dcs31-eth1:None,dcs31-eth2:None,dcs31-eth3:None,dcs31-eth4:None,dcs31-eth5:None pid=11508>
<OVSSwitch s1: lo:127.0.0.1,s1-eth1:None,s1-eth2:None,s1-eth3:None,s1-eth4:None,s1-eth5:None pid=11511>
<OVSSwitch s2: lo:127.0.0.1,s2-eth1:None,s2-eth2:None,s2-eth3:None,s2-eth4:None,s2-eth5:None pid=11514>
<OVSSwitch s3: lo:127.0.0.1,s3-eth1:None,s3-eth2:None,s3-eth3:None,s3-eth4:None,s3-eth5:None pid=11517>
<RemoteController c0: 127.0.0.1:6653 pid=11483>
mininet> pingall
*** Ping: testing ping reachability
h10 -> h20 h30 X serv1
h20 -> h10 h30 X serv1
h30 -> h10 h20 X serv1
hnotrust1 -> X X X X
serv1 -> h10 h20 h30 X
*** Results: 40% dropped (12/20 received)
mininet> iperf hnotrust1 h10
*** Iperf: testing TCP bandwidth between hnotrust1 and h10
^C
Interrupt
mininet> xterm h10 hnotrust1
mininet> iperf hnotrust1 h10
*** Iperf: testing TCP bandwidth between hnotrust1 and h10
^C
Interrupt
mininet> xterm
usage: xterm node1 node2 ...
mininet> xterm h20
mininet> xterm serv1
mininet> iperf h10 serv1
*** Iperf: testing TCP bandwidth between h10 and serv1
*** Results: ['19.5 Gbits/sec', '19.5 Gbits/sec']

```

Figure 4. A screenshot of the iperf hnotrust1 h10 and iperf h10 serv1

```

mininet> dpctl dump-flows
*** cores21
cookie=0x0, duration=1442.801s, table=0, n_packets=36, n_bytes=2856, priority=30,ip,nw_src=172.16.10.100 actions=drop
cookie=0x0, duration=1442.801s, table=0, n_packets=0, n_bytes=0, priority=20,ip,nw_src=172.16.10.100,nw_dst=10.0.4.10 actions=drop
cookie=0x0, duration=1442.801s, table=0, n_packets=1046705, n_bytes=21129469586, priority=10,ip,nw_dst=10.0.1.10 actions=output:"cores21-eth1"
cookie=0x0, duration=1442.801s, table=0, n_packets=588723, n_bytes=24856814838, priority=10,ip,nw_dst=10.0.2.20 actions=output:"cores21-eth2"
cookie=0x0, duration=1442.801s, table=0, n_packets=6, n_bytes=588, priority=10,ip,nw_dst=10.0.3.30 actions=output:"cores21-eth3"
cookie=0x0, duration=1442.801s, table=0, n_packets=668307, n_bytes=31510956722, priority=10,ip,nw_dst=10.0.4.10 actions=output:"cores21-eth4"
cookie=0x0, duration=1442.801s, table=0, n_packets=8, n_bytes=688, priority=10,ip,nw_dst=172.16.10.100 actions=output:"cores21-eth5"
cookie=0x0, duration=1442.801s, table=0, n_packets=188, n_bytes=11684, priority=1 actions=FL00D
*** dcs31
cookie=0x0, duration=1442.773s, table=0, n_packets=1174139, n_bytes=31544341142, priority=1 actions=FL00D
*** s1
cookie=0x0, duration=1442.810s, table=0, n_packets=2303924, n_bytes=77497252812, priority=1 actions=FL00D
*** s2
cookie=0x0, duration=1442.783s, table=0, n_packets=1129979, n_bytes=45952924062, priority=1 actions=FL00D
*** s3
cookie=0x0, duration=1442.818s, table=0, n_packets=200, n_bytes=12872, priority=1 actions=FL00D
mininet>

```

Figure 5. A screenshot of the `dpctl dump-flows`

Part 4

```

mininet> pingall
*** Ping: testing ping reachability
h10 -> X X X X
h20 -> h10 X X X
h30 -> h10 h20 X X
hnotrust1 -> X X X X
serv1 -> h10 h20 h30 X
*** Results: 70% dropped (6/20 received)
mininet> pingall
*** Ping: testing ping reachability
h10 -> h20 h30 X serv1
h20 -> h10 h30 X serv1
h30 -> h10 h20 X serv1
hnotrust1 -> X X X X
serv1 -> h10 h20 h30 X
*** Results: 40% dropped (12/20 received)
mininet> iperf hnotrust1 h10
*** Iperf: testing TCP bandwidth between hnotrust1 and h10
^C
Interrupt
mininet> iperf h10 serv1
*** Iperf: testing TCP bandwidth between h10 and serv1
*** Results: [ 25.8 Gbits/sec, 25.9 Gbits/sec ]
mininet> dpctl dump-flows
*** cores21
cookie=0x0, duration=458.493s, table=0, n_packets=18, n_bytes=1644, priority=30,ip,nw_src=172.16.10.100 actions=drop
cookie=0x0, duration=458.492s, table=0, n_packets=0, n_bytes=0, priority=20,ip,nw_src=172.16.10.100,nw_dst=10.0.4.10 actions=drop
cookie=0x0, duration=202.781s, table=0, n_packets=0, n_bytes=0, priority=10,ip,nw_dst=10.0.3.30 actions=mod_dl_src:00:00:00:00:00:15,mod_dl_dst:00:00:00:00:00:03,output:"cores21-eth3"
cookie=0x0, duration=202.781s, table=0, n_packets=0, n_bytes=0, priority=10,ip,nw_dst=10.0.2.20 actions=mod_dl_src:00:00:00:00:00:15,mod_dl_dst:00:00:00:00:00:02,output:"cores21-eth2"
cookie=0x0, duration=202.781s, table=0, n_packets=94110, n_bytes=6211276, priority=10,ip,nw_dst=10.0.1.10 actions=mod_dl_src:00:00:00:00:00:15,mod_dl_dst:00:00:00:00:00:01,output:"cores21-eth1"
cookie=0x0, duration=42.782s, table=0, n_packets=0, n_bytes=0, priority=10,ip,nw_dst=172.16.10.100 actions=mod_dl_src:00:00:00:00:00:15,mod_dl_dst:00:00:00:00:00:05,output:"cores21-eth5"
cookie=0x0, duration=10.527s, table=0, n_packets=1198, n_bytes=62362444, priority=10,ip,nw_dst=10.0.4.10 actions=mod_dl_src:00:00:00:00:00:15,mod_dl_dst:00:00:00:00:00:04,output:"cores21-eth4"
*** dcs31
cookie=0x0, duration=458.493s, table=0, n_packets=404779, n_bytes=16188155638, priority=1 actions=FL00D
*** s1
cookie=0x0, duration=458.501s, table=0, n_packets=404784, n_bytes=16188156016, priority=1 actions=FL00D
*** s2
cookie=0x0, duration=458.502s, table=0, n_packets=30, n_bytes=2492, priority=1 actions=FL00D
*** s3
cookie=0x0, duration=458.511s, table=0, n_packets=29, n_bytes=2394, priority=1 actions=FL00D
mininet>

```

Figure 6. A screenshot of the `pingall`,

`iperf hnotrust1 h10`, `iperf h10 serv1`, and `dpctl dump-flows`

For the first time to `pingall`, host 'h10' failed to ping every other host since the ARP table is empty at the beginning. But the controller will learn where host 'h10' located. Then host 'h20' could successfully ping 'h10' but no more. As every host finished ping process, the controller now knows the locations and paths of all hosts.