Jerry Chen (A13310365)

ECE 158B Project Assignment 2 Report

For the sake of testing data transmission at its margins, all ping and iperf tests are done with the two furthest hosts from one another here (designated as h1 and h16).

Setting up the fat tree topology produced the following results in terminal:

```
root@ubuntu-s-1vcpu-1gb-nyc1-01:~/JChen-ECE158B-PA2# sudo mn --custom
mininet_topo_PA2_fat_tree.py --topo twohop --switch ovsbr
*** Creating network
*** Adding controller
*** Adding hosts:
h1 h2 h3 h4 h5 h6 h7 h8 h9 h10 h11 h12 h13 h14 h15 h16
*** Adding switches:
s1001 s1002 s1003 s1004 s2001 s2002 s2003 s2004 s2005 s2006 s2007
s2008 s3001 s3002 s3003 s3004 s3005 s3006 s3007 s3008
*** Adding links:
(s1001, s2001) (s1001, s2003) (s1001, s2005) (s1001, s2007) (s1002,
s2001) (s1002, s2003) (s1002, s2005) (s1002, s2007) (s1003, s2002)
(s1003, s2004) (s1003, s2006) (s1003, s2008) (s1004, s2002) (s1004,
s2004) (s1004, s2006) (s1004, s2008) (s2001, s3001) (s2001, s3002)
(s2002, s3001) (s2002, s3002) (s2003, s3003) (s2003, s3004) (s2004,
s3003) (s2004, s3004) (s2005, s3005) (s2005, s3006) (s2006, s3005)
(s2006, s3006) (s2007, s3007) (s2007, s3008) (s2008, s3007) (s2008,
s3008) (s3001, h1) (s3001, h2) (s3002, h3) (s3002, h4) (s3003, h5)
(s3003, h6) (s3004, h7) (s3004, h8) (s3005, h9) (s3005, h10) (s3006,
h11) (s3006, h12) (s3007, h13) (s3007, h14) (s3008, h15) (s3008, h16)
*** Configuring hosts
h1 h2 h3 h4 h5 h6 h7 h8 h9 h10 h11 h12 h13 h14 h15 h16
*** Starting controller
c0
*** Starting 20 switches
s1001 s1002 s1003 s1004 s2001 s2002 s2003 s2004 s2005 s2006 s2007
s2008 s3001 s3002 s3003 s3004 s3005 s3006 s3007 s3008 ...
*** Starting CLI:
```

Performing 100 pings for the fat tree topology produced these results:

```
mininet> h16 ping -c100 h1
PING 10.0.0.1 (10.0.0.1) 56(84) bytes of data.
64 bytes from 10.0.0.1: icmp_seq=1 ttl=64 time=3.05 ms
64 bytes from 10.0.0.1: icmp_seq=2 ttl=64 time=0.105 ms
64 bytes from 10.0.0.1: icmp_seq=3 ttl=64 time=0.103 ms
64 bytes from 10.0.0.1: icmp_seq=4 ttl=64 time=0.104 ms
64 bytes from 10.0.0.1: icmp_seq=5 ttl=64 time=0.105 ms
64 bytes from 10.0.0.1: icmp_seq=6 ttl=64 time=0.106 ms
```

```
64 bytes from 10.0.0.1: icmp_seq=7 ttl=64 time=0.111 ms
64 bytes from 10.0.0.1: icmp_seq=8 ttl=64 time=0.122 ms
64 bytes from 10.0.0.1: icmp_seq=9 ttl=64 time=0.108 ms
64 bytes from 10.0.0.1: icmp_seq=10 ttl=64 time=0.122 ms
64 bytes from 10.0.0.1: icmp_seq=11 ttl=64 time=0.113 ms
64 bytes from 10.0.0.1: icmp_seq=12 ttl=64 time=0.107 ms
64 bytes from 10.0.0.1: icmp_seq=13 ttl=64 time=0.108 ms
64 bytes from 10.0.0.1: icmp_seq=14 ttl=64 time=0.109 ms
64 bytes from 10.0.0.1: icmp_seq=15 ttl=64 time=0.106 ms
64 bytes from 10.0.0.1: icmp_seq=16 ttl=64 time=0.149 ms
64 bytes from 10.0.0.1: icmp_seq=17 ttl=64 time=0.126 ms
64 bytes from 10.0.0.1: icmp_seq=18 ttl=64 time=0.110 ms
64 bytes from 10.0.0.1: icmp_seq=19 ttl=64 time=0.113 ms
64 bytes from 10.0.0.1: icmp_seq=20 ttl=64 time=0.127 ms
64 bytes from 10.0.0.1: icmp_seq=21 ttl=64 time=0.156 ms
64 bytes from 10.0.0.1: icmp_seq=22 ttl=64 time=0.115 ms
64 bytes from 10.0.0.1: icmp_seq=23 ttl=64 time=0.111 ms
64 bytes from 10.0.0.1: icmp_seq=24 ttl=64 time=0.113 ms
64 bytes from 10.0.0.1: icmp_seq=25 ttl=64 time=0.120 ms
64 bytes from 10.0.0.1: icmp_seq=26 ttl=64 time=0.115 ms
64 bytes from 10.0.0.1: icmp_seq=27 ttl=64 time=0.118 ms
64 bytes from 10.0.0.1: icmp_seq=28 ttl=64 time=0.129 ms
64 bytes from 10.0.0.1: icmp_seq=29 ttl=64 time=0.121 ms
64 bytes from 10.0.0.1: icmp_seq=30 ttl=64 time=0.116 ms
64 bytes from 10.0.0.1: icmp_seq=31 ttl=64 time=0.134 ms
64 bytes from 10.0.0.1: icmp_seq=32 ttl=64 time=0.158 ms
64 bytes from 10.0.0.1: icmp_seq=33 ttl=64 time=0.127 ms
64 bytes from 10.0.0.1: icmp_seq=34 ttl=64 time=0.152 ms
64 bytes from 10.0.0.1: icmp_seq=35 ttl=64 time=0.157 ms
64 bytes from 10.0.0.1: icmp_seq=36 ttl=64 time=0.155 ms
64 bytes from 10.0.0.1: icmp_seq=37 ttl=64 time=0.144 ms
64 bytes from 10.0.0.1: icmp_seq=38 ttl=64 time=0.118 ms
64 bytes from 10.0.0.1: icmp_seq=39 ttl=64 time=0.116 ms
64 bytes from 10.0.0.1: icmp_seq=40 ttl=64 time=0.145 ms
64 bytes from 10.0.0.1: icmp_seq=41 ttl=64 time=0.127 ms
64 bytes from 10.0.0.1: icmp_seq=42 ttl=64 time=0.115 ms
64 bytes from 10.0.0.1: icmp_seq=43 ttl=64 time=0.120 ms
64 bytes from 10.0.0.1: icmp_seq=44 ttl=64 time=0.151 ms
64 bytes from 10.0.0.1: icmp_seq=45 ttl=64 time=0.117 ms
64 bytes from 10.0.0.1: icmp_seq=46 ttl=64 time=0.128 ms
64 bytes from 10.0.0.1: icmp_seq=47 ttl=64 time=0.130 ms
64 bytes from 10.0.0.1: icmp_seq=48 ttl=64 time=0.117 ms
64 bytes from 10.0.0.1: icmp_seq=49 ttl=64 time=0.131 ms
64 bytes from 10.0.0.1: icmp_seq=50 ttl=64 time=0.119 ms
64 bytes from 10.0.0.1: icmp_seq=51 ttl=64 time=0.108 ms
64 bytes from 10.0.0.1: icmp_seq=52 ttl=64 time=0.121 ms
64 bytes from 10.0.0.1: icmp_seq=53 ttl=64 time=0.124 ms
64 bytes from 10.0.0.1: icmp_seq=54 ttl=64 time=0.114 ms
64 bytes from 10.0.0.1: icmp_seq=55 ttl=64 time=0.118 ms
```

```
64 bytes from 10.0.0.1: icmp_seq=56 ttl=64 time=0.125 ms
64 bytes from 10.0.0.1: icmp_seq=57 ttl=64 time=0.116 ms
64 bytes from 10.0.0.1: icmp_seq=58 ttl=64 time=0.114 ms
64 bytes from 10.0.0.1: icmp_seq=59 ttl=64 time=0.113 ms
64 bytes from 10.0.0.1: icmp_seq=60 ttl=64 time=0.172 ms
64 bytes from 10.0.0.1: icmp_seq=61 ttl=64 time=0.117 ms
64 bytes from 10.0.0.1: icmp_seq=62 ttl=64 time=0.116 ms
64 bytes from 10.0.0.1: icmp_seq=63 ttl=64 time=0.116 ms
64 bytes from 10.0.0.1: icmp_seq=64 ttl=64 time=0.115 ms
64 bytes from 10.0.0.1: icmp_seq=65 ttl=64 time=0.115 ms
64 bytes from 10.0.0.1: icmp_seq=66 ttl=64 time=0.138 ms
64 bytes from 10.0.0.1: icmp_seq=67 ttl=64 time=0.122 ms
64 bytes from 10.0.0.1: icmp_seq=68 ttl=64 time=0.112 ms
64 bytes from 10.0.0.1: icmp_seq=69 ttl=64 time=0.119 ms
64 bytes from 10.0.0.1: icmp_seq=70 ttl=64 time=0.104 ms
64 bytes from 10.0.0.1: icmp_seq=71 ttl=64 time=0.105 ms
64 bytes from 10.0.0.1: icmp_seq=72 ttl=64 time=0.104 ms
64 bytes from 10.0.0.1: icmp_seq=73 ttl=64 time=0.105 ms
64 bytes from 10.0.0.1: icmp_seq=74 ttl=64 time=0.118 ms
64 bytes from 10.0.0.1: icmp_seq=75 ttl=64 time=0.110 ms
64 bytes from 10.0.0.1: icmp_seq=76 ttl=64 time=0.112 ms
64 bytes from 10.0.0.1: icmp_seq=77 ttl=64 time=0.103 ms
64 bytes from 10.0.0.1: icmp_seq=78 ttl=64 time=0.110 ms
64 bytes from 10.0.0.1: icmp_seq=79 ttl=64 time=0.107 ms
64 bytes from 10.0.0.1: icmp_seq=80 ttl=64 time=0.115 ms
64 bytes from 10.0.0.1: icmp_seq=81 ttl=64 time=0.131 ms
64 bytes from 10.0.0.1: icmp_seq=82 ttl=64 time=0.108 ms
64 bytes from 10.0.0.1: icmp_seq=83 ttl=64 time=0.108 ms
64 bytes from 10.0.0.1: icmp_seq=84 ttl=64 time=0.123 ms
64 bytes from 10.0.0.1: icmp_seq=85 ttl=64 time=0.107 ms
64 bytes from 10.0.0.1: icmp_seq=86 ttl=64 time=0.118 ms
64 bytes from 10.0.0.1: icmp_seq=87 ttl=64 time=0.121 ms
64 bytes from 10.0.0.1: icmp_seq=88 ttl=64 time=0.129 ms
64 bytes from 10.0.0.1: icmp_seq=89 ttl=64 time=0.090 ms
64 bytes from 10.0.0.1: icmp_seq=90 ttl=64 time=0.122 ms
64 bytes from 10.0.0.1: icmp_seq=91 ttl=64 time=0.104 ms
64 bytes from 10.0.0.1: icmp_seq=92 ttl=64 time=0.123 ms
64 bytes from 10.0.0.1: icmp_seq=93 ttl=64 time=0.143 ms
64 bytes from 10.0.0.1: icmp_seq=94 ttl=64 time=0.104 ms
64 bytes from 10.0.0.1: icmp_seq=95 ttl=64 time=0.139 ms
64 bytes from 10.0.0.1: icmp_seq=96 ttl=64 time=0.104 ms
64 bytes from 10.0.0.1: icmp_seq=97 ttl=64 time=0.110 ms
64 bytes from 10.0.0.1: icmp_seq=98 ttl=64 time=0.108 ms
64 bytes from 10.0.0.1: icmp_seq=99 ttl=64 time=0.122 ms
64 bytes from 10.0.0.1: icmp_seq=100 ttl=64 time=0.105 ms

--- 10.0.0.1 ping statistics ---
100 packets transmitted, 100 received, 0% packet loss, time 101349ms
rtt min/avg/max/mdev = 0.090/0.148/3.051/0.292 ms
```

The resultant data here suggests that the average round trip time would be around 0.148 seconds for this fat tree topology.

Meanwhile the 100MB iperf TCP transmission produced the following results:

```
mininet> h1 iperf -s &
mininet> h16 time iperf -c h1 -t2 -n 100M
------------------------------------------------------------
Client connecting to 10.0.0.1, TCP port 5001
TCP window size:  357 KByte (default)
------------------------------------------------------------
[  3] local 10.0.0.16 port 38174 connected with 10.0.0.1 port 5001
[ ID] Interval       Transfer     Bandwidth
[  3]  0.0- 0.1 sec   100 MBytes  7.56 Gbits/sec

real0m0.153s
user0m0.003s
sys 0m0.056s
```

The resultant data serves to suggest that the time to transmit 100MB across the iperf connection is about 0.153 seconds.

The simple topology setup produced the following results:

```
root@ubuntu-s-1vcpu-1gb-nyc1-01:~/JChen-ECE158B-PA2# sudo mn --custom
mininet_topo_PA2_simple.py --topo twohop --switch ovsbr
*** Creating network
*** Adding controller
*** Adding hosts:
h1 h2 h3 h4 h5 h6 h7 h8 h9 h10 h11 h12 h13 h14 h15 h16
*** Adding switches:
s1
*** Adding links:
(h1, s1) (h2, s1) (h3, s1) (h4, s1) (h5, s1) (h6, s1) (h7, s1) (h8,
s1) (h9, s1) (h10, s1) (h11, s1) (h12, s1) (h13, s1) (h14, s1) (h15,
s1) (h16, s1)
*** Configuring hosts
h1 h2 h3 h4 h5 h6 h7 h8 h9 h10 h11 h12 h13 h14 h15 h16
*** Starting controller
c0
*** Starting 1 switches
s1 ...
*** Starting CLI:
```

Performing 100 pings for the simple topology produced these results:

```
mininet> h16 ping -c100 h1
PING 10.0.0.1 (10.0.0.1) 56(84) bytes of data.
64 bytes from 10.0.0.1: icmp_seq=1 ttl=64 time=0.287 ms
64 bytes from 10.0.0.1: icmp_seq=2 ttl=64 time=0.087 ms
64 bytes from 10.0.0.1: icmp_seq=3 ttl=64 time=0.069 ms
64 bytes from 10.0.0.1: icmp_seq=4 ttl=64 time=0.096 ms
64 bytes from 10.0.0.1: icmp_seq=5 ttl=64 time=0.074 ms
64 bytes from 10.0.0.1: icmp_seq=6 ttl=64 time=0.084 ms
64 bytes from 10.0.0.1: icmp_seq=7 ttl=64 time=0.081 ms
64 bytes from 10.0.0.1: icmp_seq=8 ttl=64 time=0.071 ms
64 bytes from 10.0.0.1: icmp_seq=9 ttl=64 time=0.069 ms
64 bytes from 10.0.0.1: icmp_seq=10 ttl=64 time=0.082 ms
64 bytes from 10.0.0.1: icmp_seq=11 ttl=64 time=0.069 ms
64 bytes from 10.0.0.1: icmp_seq=12 ttl=64 time=0.070 ms
64 bytes from 10.0.0.1: icmp_seq=13 ttl=64 time=0.088 ms
64 bytes from 10.0.0.1: icmp_seq=14 ttl=64 time=0.070 ms
64 bytes from 10.0.0.1: icmp_seq=15 ttl=64 time=0.070 ms
64 bytes from 10.0.0.1: icmp_seq=16 ttl=64 time=0.067 ms
64 bytes from 10.0.0.1: icmp_seq=17 ttl=64 time=0.081 ms
64 bytes from 10.0.0.1: icmp_seq=18 ttl=64 time=0.068 ms
64 bytes from 10.0.0.1: icmp_seq=19 ttl=64 time=0.076 ms
64 bytes from 10.0.0.1: icmp_seq=20 ttl=64 time=0.068 ms
64 bytes from 10.0.0.1: icmp_seq=21 ttl=64 time=0.068 ms
64 bytes from 10.0.0.1: icmp_seq=22 ttl=64 time=0.068 ms
64 bytes from 10.0.0.1: icmp_seq=23 ttl=64 time=0.069 ms
64 bytes from 10.0.0.1: icmp_seq=24 ttl=64 time=0.086 ms
64 bytes from 10.0.0.1: icmp_seq=25 ttl=64 time=0.072 ms
64 bytes from 10.0.0.1: icmp_seq=26 ttl=64 time=0.068 ms
64 bytes from 10.0.0.1: icmp_seq=27 ttl=64 time=0.068 ms
64 bytes from 10.0.0.1: icmp_seq=28 ttl=64 time=0.138 ms
64 bytes from 10.0.0.1: icmp_seq=29 ttl=64 time=0.068 ms
64 bytes from 10.0.0.1: icmp_seq=30 ttl=64 time=0.068 ms
64 bytes from 10.0.0.1: icmp_seq=31 ttl=64 time=0.068 ms
64 bytes from 10.0.0.1: icmp_seq=32 ttl=64 time=0.067 ms
64 bytes from 10.0.0.1: icmp_seq=33 ttl=64 time=0.091 ms
64 bytes from 10.0.0.1: icmp_seq=34 ttl=64 time=0.068 ms
64 bytes from 10.0.0.1: icmp_seq=35 ttl=64 time=0.072 ms
64 bytes from 10.0.0.1: icmp_seq=36 ttl=64 time=0.095 ms
64 bytes from 10.0.0.1: icmp_seq=37 ttl=64 time=0.070 ms
64 bytes from 10.0.0.1: icmp_seq=38 ttl=64 time=0.067 ms
64 bytes from 10.0.0.1: icmp_seq=39 ttl=64 time=0.070 ms
64 bytes from 10.0.0.1: icmp_seq=40 ttl=64 time=0.071 ms
64 bytes from 10.0.0.1: icmp_seq=41 ttl=64 time=0.080 ms
64 bytes from 10.0.0.1: icmp_seq=42 ttl=64 time=0.088 ms
64 bytes from 10.0.0.1: icmp_seq=43 ttl=64 time=0.071 ms
64 bytes from 10.0.0.1: icmp_seq=44 ttl=64 time=0.070 ms
64 bytes from 10.0.0.1: icmp_seq=45 ttl=64 time=0.069 ms
64 bytes from 10.0.0.1: icmp_seq=46 ttl=64 time=0.072 ms
64 bytes from 10.0.0.1: icmp_seq=47 ttl=64 time=0.071 ms
```

```
64 bytes from 10.0.0.1: icmp_seq=48 ttl=64 time=0.069 ms
64 bytes from 10.0.0.1: icmp_seq=49 ttl=64 time=0.071 ms
64 bytes from 10.0.0.1: icmp_seq=50 ttl=64 time=0.068 ms
64 bytes from 10.0.0.1: icmp_seq=51 ttl=64 time=0.068 ms
64 bytes from 10.0.0.1: icmp_seq=52 ttl=64 time=0.072 ms
64 bytes from 10.0.0.1: icmp_seq=53 ttl=64 time=0.069 ms
64 bytes from 10.0.0.1: icmp_seq=54 ttl=64 time=0.070 ms
64 bytes from 10.0.0.1: icmp_seq=55 ttl=64 time=0.070 ms
64 bytes from 10.0.0.1: icmp_seq=56 ttl=64 time=0.068 ms
64 bytes from 10.0.0.1: icmp_seq=57 ttl=64 time=0.066 ms
64 bytes from 10.0.0.1: icmp_seq=58 ttl=64 time=0.069 ms
64 bytes from 10.0.0.1: icmp_seq=59 ttl=64 time=0.085 ms
64 bytes from 10.0.0.1: icmp_seq=60 ttl=64 time=0.069 ms
64 bytes from 10.0.0.1: icmp_seq=61 ttl=64 time=0.070 ms
64 bytes from 10.0.0.1: icmp_seq=62 ttl=64 time=0.070 ms
64 bytes from 10.0.0.1: icmp_seq=63 ttl=64 time=0.069 ms
64 bytes from 10.0.0.1: icmp_seq=64 ttl=64 time=0.095 ms
64 bytes from 10.0.0.1: icmp_seq=65 ttl=64 time=0.073 ms
64 bytes from 10.0.0.1: icmp_seq=66 ttl=64 time=0.076 ms
64 bytes from 10.0.0.1: icmp_seq=67 ttl=64 time=0.069 ms
64 bytes from 10.0.0.1: icmp_seq=68 ttl=64 time=0.067 ms
64 bytes from 10.0.0.1: icmp_seq=69 ttl=64 time=0.067 ms
64 bytes from 10.0.0.1: icmp_seq=70 ttl=64 time=0.069 ms
64 bytes from 10.0.0.1: icmp_seq=71 ttl=64 time=0.068 ms
64 bytes from 10.0.0.1: icmp_seq=72 ttl=64 time=0.067 ms
64 bytes from 10.0.0.1: icmp_seq=73 ttl=64 time=0.068 ms
64 bytes from 10.0.0.1: icmp_seq=74 ttl=64 time=0.068 ms
64 bytes from 10.0.0.1: icmp_seq=75 ttl=64 time=0.071 ms
64 bytes from 10.0.0.1: icmp_seq=76 ttl=64 time=0.097 ms
64 bytes from 10.0.0.1: icmp_seq=77 ttl=64 time=0.069 ms
64 bytes from 10.0.0.1: icmp_seq=78 ttl=64 time=0.089 ms
64 bytes from 10.0.0.1: icmp_seq=79 ttl=64 time=0.092 ms
64 bytes from 10.0.0.1: icmp_seq=80 ttl=64 time=0.062 ms
64 bytes from 10.0.0.1: icmp_seq=81 ttl=64 time=0.098 ms
64 bytes from 10.0.0.1: icmp_seq=82 ttl=64 time=0.068 ms
64 bytes from 10.0.0.1: icmp_seq=83 ttl=64 time=0.083 ms
64 bytes from 10.0.0.1: icmp_seq=84 ttl=64 time=0.068 ms
64 bytes from 10.0.0.1: icmp_seq=85 ttl=64 time=0.072 ms
64 bytes from 10.0.0.1: icmp_seq=86 ttl=64 time=0.069 ms
64 bytes from 10.0.0.1: icmp_seq=87 ttl=64 time=0.070 ms
64 bytes from 10.0.0.1: icmp_seq=88 ttl=64 time=0.077 ms
64 bytes from 10.0.0.1: icmp_seq=89 ttl=64 time=0.090 ms
64 bytes from 10.0.0.1: icmp_seq=90 ttl=64 time=0.093 ms
64 bytes from 10.0.0.1: icmp_seq=91 ttl=64 time=0.065 ms
64 bytes from 10.0.0.1: icmp_seq=92 ttl=64 time=0.081 ms
64 bytes from 10.0.0.1: icmp_seq=93 ttl=64 time=0.067 ms
64 bytes from 10.0.0.1: icmp_seq=94 ttl=64 time=0.069 ms
64 bytes from 10.0.0.1: icmp_seq=95 ttl=64 time=0.068 ms
64 bytes from 10.0.0.1: icmp_seq=96 ttl=64 time=0.069 ms
```

```
64 bytes from 10.0.0.1: icmp_seq=97 ttl=64 time=0.068 ms
64 bytes from 10.0.0.1: icmp_seq=98 ttl=64 time=0.067 ms
64 bytes from 10.0.0.1: icmp_seq=99 ttl=64 time=0.095 ms
64 bytes from 10.0.0.1: icmp_seq=100 ttl=64 time=0.068 ms

--- 10.0.0.1 ping statistics ---
100 packets transmitted, 100 received, 0% packet loss, time 101366ms
rtt min/avg/max/mdev = 0.062/0.076/0.287/0.023 ms
```

Suggesting that the average round trip time for pings in a simple topology would be around 0.076 seconds.

Meanwhile the 100MB iperf TCP transmission produced the following results:

```
mininet> h1 iperf -s &
mininet> h16 time iperf -c h1 -t2 -n 100M
------------------------------------------------------------
Client connecting to 10.0.0.1, TCP port 5001
TCP window size:  340 KByte (default)
------------------------------------------------------------
[  3] local 10.0.0.16 port 38204 connected with 10.0.0.1 port 5001
[ ID] Interval       Transfer     Bandwidth
[  3]  0.0- 0.1 sec   100 MBytes  8.86 Gbits/sec

real0m0.151s
user0m0.022s
sys 0m0.046s
```

The resultant data serves to suggest that the time to transmit 100MB across the iperf connection is about 0.151 seconds.

Setting up the linear topology produced the following results in terminal:

```
root@ubuntu-s-1vcpu-1gb-nyc1-01:~/JChen-ECE158B-PA2# sudo mn --custom
mininet_topo_PA2_linear.py --topo twohop --switch ovsbr
*** Creating network
*** Adding controller
*** Adding hosts:
h1 h2 h3 h4 h5 h6 h7 h8 h9 h10 h11 h12 h13 h14 h15 h16
*** Adding switches:
s1 s2 s3 s4 s5 s6 s7 s8 s9 s10 s11 s12 s13 s14 s15 s16
*** Adding links:
(s1, h1) (s1, s2) (s2, h2) (s2, s3) (s3, h3) (s3, s4) (s4, h4) (s4,
s5) (s5, h5) (s5, s6) (s6, h6) (s6, s7) (s7, h7) (s7, s8) (s8, h8)
(s8, s9) (s9, h9) (s9, s10) (s10, h10) (s10, s11) (s11, h11) (s11,
s12) (s12, h12) (s12, s13) (s13, h13) (s13, s14) (s14, h14) (s14, s15)
(s15, h15) (s15, s16) (s16, h16)
```

```
*** Configuring hosts
h1 h2 h3 h4 h5 h6 h7 h8 h9 h10 h11 h12 h13 h14 h15 h16
*** Starting controller
c0
*** Starting 16 switches
s1 s2 s3 s4 s5 s6 s7 s8 s9 s10 s11 s12 s13 s14 s15 s16 ...
*** Starting CLI:
```

Performing 100 pings for the linear topology produced these results:

```
mininet> h16 ping -c100 h1
PING 10.0.0.1 (10.0.0.1) 56(84) bytes of data.
64 bytes from 10.0.0.1: icmp_seq=1 ttl=64 time=0.107 ms
64 bytes from 10.0.0.1: icmp_seq=2 ttl=64 time=0.179 ms
64 bytes from 10.0.0.1: icmp_seq=3 ttl=64 time=0.131 ms
64 bytes from 10.0.0.1: icmp_seq=4 ttl=64 time=0.131 ms
64 bytes from 10.0.0.1: icmp_seq=5 ttl=64 time=0.133 ms
64 bytes from 10.0.0.1: icmp_seq=6 ttl=64 time=0.141 ms
64 bytes from 10.0.0.1: icmp_seq=7 ttl=64 time=0.133 ms
64 bytes from 10.0.0.1: icmp_seq=8 ttl=64 time=0.179 ms
64 bytes from 10.0.0.1: icmp_seq=9 ttl=64 time=0.133 ms
64 bytes from 10.0.0.1: icmp_seq=10 ttl=64 time=0.142 ms
64 bytes from 10.0.0.1: icmp_seq=11 ttl=64 time=0.207 ms
64 bytes from 10.0.0.1: icmp_seq=12 ttl=64 time=0.189 ms
64 bytes from 10.0.0.1: icmp_seq=13 ttl=64 time=0.193 ms
64 bytes from 10.0.0.1: icmp_seq=14 ttl=64 time=0.154 ms
64 bytes from 10.0.0.1: icmp_seq=15 ttl=64 time=0.141 ms
64 bytes from 10.0.0.1: icmp_seq=16 ttl=64 time=0.144 ms
64 bytes from 10.0.0.1: icmp_seq=17 ttl=64 time=0.144 ms
64 bytes from 10.0.0.1: icmp_seq=18 ttl=64 time=0.144 ms
64 bytes from 10.0.0.1: icmp_seq=19 ttl=64 time=0.159 ms
64 bytes from 10.0.0.1: icmp_seq=20 ttl=64 time=0.143 ms
64 bytes from 10.0.0.1: icmp_seq=21 ttl=64 time=0.156 ms
64 bytes from 10.0.0.1: icmp_seq=22 ttl=64 time=0.163 ms
64 bytes from 10.0.0.1: icmp_seq=23 ttl=64 time=0.145 ms
64 bytes from 10.0.0.1: icmp_seq=24 ttl=64 time=0.214 ms
64 bytes from 10.0.0.1: icmp_seq=25 ttl=64 time=0.151 ms
64 bytes from 10.0.0.1: icmp_seq=26 ttl=64 time=0.220 ms
64 bytes from 10.0.0.1: icmp_seq=27 ttl=64 time=0.140 ms
64 bytes from 10.0.0.1: icmp_seq=28 ttl=64 time=0.148 ms
64 bytes from 10.0.0.1: icmp_seq=29 ttl=64 time=0.150 ms
64 bytes from 10.0.0.1: icmp_seq=30 ttl=64 time=0.132 ms
64 bytes from 10.0.0.1: icmp_seq=31 ttl=64 time=0.170 ms
64 bytes from 10.0.0.1: icmp_seq=32 ttl=64 time=0.199 ms
64 bytes from 10.0.0.1: icmp_seq=33 ttl=64 time=0.196 ms
64 bytes from 10.0.0.1: icmp_seq=34 ttl=64 time=0.196 ms
64 bytes from 10.0.0.1: icmp_seq=35 ttl=64 time=0.146 ms
64 bytes from 10.0.0.1: icmp_seq=36 ttl=64 time=0.135 ms
64 bytes from 10.0.0.1: icmp_seq=37 ttl=64 time=0.150 ms
```

```
64 bytes from 10.0.0.1: icmp_seq=38 ttl=64 time=0.150 ms
64 bytes from 10.0.0.1: icmp_seq=39 ttl=64 time=0.189 ms
64 bytes from 10.0.0.1: icmp_seq=40 ttl=64 time=0.187 ms
64 bytes from 10.0.0.1: icmp_seq=41 ttl=64 time=0.144 ms
64 bytes from 10.0.0.1: icmp_seq=42 ttl=64 time=0.146 ms
64 bytes from 10.0.0.1: icmp_seq=43 ttl=64 time=0.154 ms
64 bytes from 10.0.0.1: icmp_seq=44 ttl=64 time=0.165 ms
64 bytes from 10.0.0.1: icmp_seq=45 ttl=64 time=0.160 ms
64 bytes from 10.0.0.1: icmp_seq=46 ttl=64 time=0.150 ms
64 bytes from 10.0.0.1: icmp_seq=47 ttl=64 time=0.180 ms
64 bytes from 10.0.0.1: icmp_seq=48 ttl=64 time=0.182 ms
64 bytes from 10.0.0.1: icmp_seq=49 ttl=64 time=0.201 ms
64 bytes from 10.0.0.1: icmp_seq=50 ttl=64 time=0.152 ms
64 bytes from 10.0.0.1: icmp_seq=51 ttl=64 time=0.147 ms
64 bytes from 10.0.0.1: icmp_seq=52 ttl=64 time=0.151 ms
64 bytes from 10.0.0.1: icmp_seq=53 ttl=64 time=0.209 ms
64 bytes from 10.0.0.1: icmp_seq=54 ttl=64 time=0.215 ms
64 bytes from 10.0.0.1: icmp_seq=55 ttl=64 time=0.152 ms
64 bytes from 10.0.0.1: icmp_seq=56 ttl=64 time=0.208 ms
64 bytes from 10.0.0.1: icmp_seq=57 ttl=64 time=0.145 ms
64 bytes from 10.0.0.1: icmp_seq=58 ttl=64 time=0.149 ms
64 bytes from 10.0.0.1: icmp_seq=59 ttl=64 time=0.147 ms
64 bytes from 10.0.0.1: icmp_seq=60 ttl=64 time=0.140 ms
64 bytes from 10.0.0.1: icmp_seq=61 ttl=64 time=0.163 ms
64 bytes from 10.0.0.1: icmp_seq=62 ttl=64 time=0.140 ms
64 bytes from 10.0.0.1: icmp_seq=63 ttl=64 time=0.141 ms
64 bytes from 10.0.0.1: icmp_seq=64 ttl=64 time=0.151 ms
64 bytes from 10.0.0.1: icmp_seq=65 ttl=64 time=0.205 ms
64 bytes from 10.0.0.1: icmp_seq=66 ttl=64 time=0.149 ms
64 bytes from 10.0.0.1: icmp_seq=67 ttl=64 time=0.145 ms
64 bytes from 10.0.0.1: icmp_seq=68 ttl=64 time=0.133 ms
64 bytes from 10.0.0.1: icmp_seq=69 ttl=64 time=0.171 ms
64 bytes from 10.0.0.1: icmp_seq=70 ttl=64 time=0.134 ms
64 bytes from 10.0.0.1: icmp_seq=71 ttl=64 time=0.133 ms
64 bytes from 10.0.0.1: icmp_seq=72 ttl=64 time=0.136 ms
64 bytes from 10.0.0.1: icmp_seq=73 ttl=64 time=0.161 ms
64 bytes from 10.0.0.1: icmp_seq=74 ttl=64 time=0.137 ms
64 bytes from 10.0.0.1: icmp_seq=75 ttl=64 time=0.148 ms
64 bytes from 10.0.0.1: icmp_seq=76 ttl=64 time=0.137 ms
64 bytes from 10.0.0.1: icmp_seq=77 ttl=64 time=0.149 ms
64 bytes from 10.0.0.1: icmp_seq=78 ttl=64 time=0.136 ms
64 bytes from 10.0.0.1: icmp_seq=79 ttl=64 time=0.137 ms
64 bytes from 10.0.0.1: icmp_seq=80 ttl=64 time=0.140 ms
64 bytes from 10.0.0.1: icmp_seq=81 ttl=64 time=0.141 ms
64 bytes from 10.0.0.1: icmp_seq=82 ttl=64 time=0.158 ms
64 bytes from 10.0.0.1: icmp_seq=83 ttl=64 time=0.183 ms
64 bytes from 10.0.0.1: icmp_seq=84 ttl=64 time=0.134 ms
64 bytes from 10.0.0.1: icmp_seq=85 ttl=64 time=0.133 ms
64 bytes from 10.0.0.1: icmp_seq=86 ttl=64 time=0.133 ms
```

```
64 bytes from 10.0.0.1: icmp_seq=87 ttl=64 time=0.192 ms
64 bytes from 10.0.0.1: icmp_seq=88 ttl=64 time=0.146 ms
64 bytes from 10.0.0.1: icmp_seq=89 ttl=64 time=0.204 ms
64 bytes from 10.0.0.1: icmp_seq=90 ttl=64 time=0.205 ms
64 bytes from 10.0.0.1: icmp_seq=91 ttl=64 time=0.137 ms
64 bytes from 10.0.0.1: icmp_seq=92 ttl=64 time=0.153 ms
64 bytes from 10.0.0.1: icmp_seq=93 ttl=64 time=0.135 ms
64 bytes from 10.0.0.1: icmp_seq=94 ttl=64 time=0.147 ms
64 bytes from 10.0.0.1: icmp_seq=95 ttl=64 time=0.144 ms
64 bytes from 10.0.0.1: icmp_seq=96 ttl=64 time=0.144 ms
64 bytes from 10.0.0.1: icmp_seq=97 ttl=64 time=0.156 ms
64 bytes from 10.0.0.1: icmp_seq=98 ttl=64 time=0.212 ms
64 bytes from 10.0.0.1: icmp_seq=99 ttl=64 time=0.144 ms
64 bytes from 10.0.0.1: icmp_seq=100 ttl=64 time=0.146 ms

--- 10.0.0.1 ping statistics ---
100 packets transmitted, 100 received, 0% packet loss, time 101368ms
rtt min/avg/max/mdev = 0.107/0.157/0.220/0.025 ms
```

Suggesting that the average round trip time for pings in a linear topology would be around 0.157 seconds, longer than in the other topologies due to the number of switches needed to pass through.

Meanwhile the 100MB iperf TCP transmission produced the following results:

```
mininet> h1 iperf -s &
mininet> h16 time iperf -c h1 -t2 -n 100M
------------------------------------------------------------
Client connecting to 10.0.0.1, TCP port 5001
TCP window size:  994 KByte (default)
------------------------------------------------------------
[  3] local 10.0.0.16 port 38208 connected with 10.0.0.1 port 5001
[ ID] Interval       Transfer     Bandwidth
[  3]  0.0- 0.2 sec   100 MBytes  5.32 Gbits/sec

real0m0.217s
user0m0.015s
sys 0m0.085s
```

The resultant data serves to suggest that the time to transmit 100MB across the iperf connection is about 0.217 seconds.

I was able to perform simultaneous iperf and ping for a simple topology by running a python script for the simple topology and managed to produce the following results:

```
root@ubuntu-s-1vcpu-1gb-nyc1-01:~/JChen-ECE158B-PA2# python
mininet_topo_PA2_simple2.py
*** Scratch network demo (kernel datapath)
*** Creating nodes
*** Creating links
*** Configuring hosts
h1
h2
h3
h4
h5
h6
h7
h8
h9
h10
h11
h12
h13
h14
h15
h16
*** Running test
*** h1 : ('iperf -s &',)
*** h16 : ('time iperf -c 192.168.123.1 -t2 -n 100M &',)
[1] 253642
*** h16 : ('ping -c100 192.168.123.1',)
PING 192.168.123.1 (192.168.123.1) 56(84) bytes of data.
64 bytes from 192.168.123.1: icmp_seq=1 ttl=64 time=1025 ms
64 bytes from 192.168.123.1: icmp_seq=2 ttl=64 time=6.08 ms
------------------------------------------------------------
Client connecting to 192.168.123.1, TCP port 5001
TCP window size:  646 KByte (default)
------------------------------------------------------------
[  3] local 192.168.123.16 port 59458 connected with 192.168.123.1
port 5001
[ ID] Interval       Transfer     Bandwidth
[  3]  0.0- 0.1 sec   100 MBytes  9.20 Gbits/sec

real0m1.158s
user0m0.010s
sys 0m0.042s
64 bytes from 192.168.123.1: icmp_seq=3 ttl=64 time=0.066 ms
64 bytes from 192.168.123.1: icmp_seq=4 ttl=64 time=0.068 ms
64 bytes from 192.168.123.1: icmp_seq=5 ttl=64 time=0.079 ms
64 bytes from 192.168.123.1: icmp_seq=6 ttl=64 time=0.067 ms
64 bytes from 192.168.123.1: icmp_seq=7 ttl=64 time=0.090 ms
64 bytes from 192.168.123.1: icmp_seq=8 ttl=64 time=0.066 ms
64 bytes from 192.168.123.1: icmp_seq=9 ttl=64 time=0.068 ms
```

```
64 bytes from 192.168.123.1: icmp_seq=10 ttl=64 time=0.070 ms
64 bytes from 192.168.123.1: icmp_seq=11 ttl=64 time=0.069 ms
64 bytes from 192.168.123.1: icmp_seq=12 ttl=64 time=0.105 ms
64 bytes from 192.168.123.1: icmp_seq=13 ttl=64 time=0.065 ms
64 bytes from 192.168.123.1: icmp_seq=14 ttl=64 time=0.074 ms
64 bytes from 192.168.123.1: icmp_seq=15 ttl=64 time=0.070 ms
64 bytes from 192.168.123.1: icmp_seq=16 ttl=64 time=0.103 ms
64 bytes from 192.168.123.1: icmp_seq=17 ttl=64 time=0.070 ms
64 bytes from 192.168.123.1: icmp_seq=18 ttl=64 time=0.093 ms
64 bytes from 192.168.123.1: icmp_seq=19 ttl=64 time=0.068 ms
64 bytes from 192.168.123.1: icmp_seq=20 ttl=64 time=0.067 ms
64 bytes from 192.168.123.1: icmp_seq=21 ttl=64 time=0.068 ms
64 bytes from 192.168.123.1: icmp_seq=22 ttl=64 time=0.076 ms
64 bytes from 192.168.123.1: icmp_seq=23 ttl=64 time=0.068 ms
64 bytes from 192.168.123.1: icmp_seq=24 ttl=64 time=0.067 ms
64 bytes from 192.168.123.1: icmp_seq=25 ttl=64 time=0.085 ms
64 bytes from 192.168.123.1: icmp_seq=26 ttl=64 time=0.068 ms
64 bytes from 192.168.123.1: icmp_seq=27 ttl=64 time=0.068 ms
64 bytes from 192.168.123.1: icmp_seq=28 ttl=64 time=0.068 ms
64 bytes from 192.168.123.1: icmp_seq=29 ttl=64 time=0.096 ms
64 bytes from 192.168.123.1: icmp_seq=30 ttl=64 time=0.069 ms
64 bytes from 192.168.123.1: icmp_seq=31 ttl=64 time=0.068 ms
64 bytes from 192.168.123.1: icmp_seq=32 ttl=64 time=0.074 ms
64 bytes from 192.168.123.1: icmp_seq=33 ttl=64 time=0.069 ms
64 bytes from 192.168.123.1: icmp_seq=34 ttl=64 time=0.079 ms
64 bytes from 192.168.123.1: icmp_seq=35 ttl=64 time=0.076 ms
64 bytes from 192.168.123.1: icmp_seq=36 ttl=64 time=0.089 ms
64 bytes from 192.168.123.1: icmp_seq=37 ttl=64 time=0.075 ms
64 bytes from 192.168.123.1: icmp_seq=38 ttl=64 time=0.087 ms
64 bytes from 192.168.123.1: icmp_seq=39 ttl=64 time=0.086 ms
64 bytes from 192.168.123.1: icmp_seq=40 ttl=64 time=0.086 ms
64 bytes from 192.168.123.1: icmp_seq=41 ttl=64 time=0.093 ms
64 bytes from 192.168.123.1: icmp_seq=42 ttl=64 time=0.085 ms
64 bytes from 192.168.123.1: icmp_seq=43 ttl=64 time=0.084 ms
64 bytes from 192.168.123.1: icmp_seq=44 ttl=64 time=0.069 ms
64 bytes from 192.168.123.1: icmp_seq=45 ttl=64 time=0.070 ms
64 bytes from 192.168.123.1: icmp_seq=46 ttl=64 time=0.068 ms
64 bytes from 192.168.123.1: icmp_seq=47 ttl=64 time=0.069 ms
64 bytes from 192.168.123.1: icmp_seq=48 ttl=64 time=0.068 ms
64 bytes from 192.168.123.1: icmp_seq=49 ttl=64 time=0.076 ms
64 bytes from 192.168.123.1: icmp_seq=50 ttl=64 time=0.085 ms
64 bytes from 192.168.123.1: icmp_seq=51 ttl=64 time=0.066 ms
64 bytes from 192.168.123.1: icmp_seq=52 ttl=64 time=0.072 ms
64 bytes from 192.168.123.1: icmp_seq=53 ttl=64 time=0.068 ms
64 bytes from 192.168.123.1: icmp_seq=54 ttl=64 time=0.077 ms
64 bytes from 192.168.123.1: icmp_seq=55 ttl=64 time=0.069 ms
64 bytes from 192.168.123.1: icmp_seq=56 ttl=64 time=0.070 ms
64 bytes from 192.168.123.1: icmp_seq=57 ttl=64 time=0.070 ms
64 bytes from 192.168.123.1: icmp_seq=58 ttl=64 time=0.069 ms
```

```
64 bytes from 192.168.123.1: icmp_seq=59 ttl=64 time=0.068 ms
64 bytes from 192.168.123.1: icmp_seq=60 ttl=64 time=0.077 ms
64 bytes from 192.168.123.1: icmp_seq=61 ttl=64 time=0.069 ms
64 bytes from 192.168.123.1: icmp_seq=62 ttl=64 time=0.068 ms
64 bytes from 192.168.123.1: icmp_seq=63 ttl=64 time=0.069 ms
64 bytes from 192.168.123.1: icmp_seq=64 ttl=64 time=0.068 ms
64 bytes from 192.168.123.1: icmp_seq=65 ttl=64 time=0.077 ms
64 bytes from 192.168.123.1: icmp_seq=66 ttl=64 time=0.069 ms
64 bytes from 192.168.123.1: icmp_seq=67 ttl=64 time=0.068 ms
64 bytes from 192.168.123.1: icmp_seq=68 ttl=64 time=0.074 ms
64 bytes from 192.168.123.1: icmp_seq=69 ttl=64 time=0.073 ms
64 bytes from 192.168.123.1: icmp_seq=70 ttl=64 time=0.069 ms
64 bytes from 192.168.123.1: icmp_seq=71 ttl=64 time=0.072 ms
64 bytes from 192.168.123.1: icmp_seq=72 ttl=64 time=0.069 ms
64 bytes from 192.168.123.1: icmp_seq=73 ttl=64 time=0.070 ms
64 bytes from 192.168.123.1: icmp_seq=74 ttl=64 time=0.072 ms
64 bytes from 192.168.123.1: icmp_seq=75 ttl=64 time=0.074 ms
64 bytes from 192.168.123.1: icmp_seq=76 ttl=64 time=0.067 ms
64 bytes from 192.168.123.1: icmp_seq=77 ttl=64 time=0.069 ms
64 bytes from 192.168.123.1: icmp_seq=78 ttl=64 time=0.068 ms
64 bytes from 192.168.123.1: icmp_seq=79 ttl=64 time=0.070 ms
64 bytes from 192.168.123.1: icmp_seq=80 ttl=64 time=0.076 ms
64 bytes from 192.168.123.1: icmp_seq=81 ttl=64 time=0.069 ms
64 bytes from 192.168.123.1: icmp_seq=82 ttl=64 time=0.084 ms
64 bytes from 192.168.123.1: icmp_seq=83 ttl=64 time=0.064 ms
64 bytes from 192.168.123.1: icmp_seq=84 ttl=64 time=0.062 ms
64 bytes from 192.168.123.1: icmp_seq=85 ttl=64 time=0.068 ms
64 bytes from 192.168.123.1: icmp_seq=86 ttl=64 time=0.079 ms
64 bytes from 192.168.123.1: icmp_seq=87 ttl=64 time=0.069 ms
64 bytes from 192.168.123.1: icmp_seq=88 ttl=64 time=0.067 ms
64 bytes from 192.168.123.1: icmp_seq=89 ttl=64 time=0.081 ms
64 bytes from 192.168.123.1: icmp_seq=90 ttl=64 time=0.111 ms
64 bytes from 192.168.123.1: icmp_seq=91 ttl=64 time=0.067 ms
64 bytes from 192.168.123.1: icmp_seq=92 ttl=64 time=0.078 ms
64 bytes from 192.168.123.1: icmp_seq=93 ttl=64 time=0.084 ms
64 bytes from 192.168.123.1: icmp_seq=94 ttl=64 time=0.077 ms
64 bytes from 192.168.123.1: icmp_seq=95 ttl=64 time=0.068 ms
64 bytes from 192.168.123.1: icmp_seq=96 ttl=64 time=0.069 ms
64 bytes from 192.168.123.1: icmp_seq=97 ttl=64 time=0.067 ms
64 bytes from 192.168.123.1: icmp_seq=98 ttl=64 time=0.074 ms
64 bytes from 192.168.123.1: icmp_seq=99 ttl=64 time=0.067 ms
64 bytes from 192.168.123.1: icmp_seq=100 ttl=64 time=0.071 ms

--- 192.168.123.1 ping statistics ---
100 packets transmitted, 100 received, 0% packet loss, time 101344ms
rtt min/avg/max/mdev = 0.062/10.378/1024.565/101.931 ms, pipe 2
*** Stopping network
```

I also attempted to produce the same results for linear and fat tree topology, setting up python scripts for simultaneous runs on both topologies in the form of mininet_topo_PA2_linear2.py and mininet_topo_PA2_fat_tree2.py. Though unfortunately, due to some unknown issues that stalled the pinging and iperf including on mininet_topo_PA2_simple2.py later on, I was unable to produce results for the two other topologies simultaneously.

Based on the results above for simple topology alone, we can see that the average round trip time for pinging is about 10.378 ms, a drastic increase from 0.076ms, while the iperf time increased to 1.158 seconds from 0.151 seconds due to elephant - mice stalling collision. We can also see that the first two pings also took a significant amount of time to produce a return, with the first taking over 1000 ms and the second ping over 6 ms to return, whereas for the original independent simple topology pinging, the first two pings took less than a third of a millisecond to produce a response.

As I cannot determine how to perform simultaneous iperf and ping for the linear and fat tree topologies, there is no data for that here, however, I can presume that the fat-tree topology will be less affected by the traffic due to the information between routed through multiple switches, while single and linear will have a longer transmission time due to there being only one route to transmit information between any two hosts.