Pinging the Raspberry PI from the lab machine 10 times at 100ms.

```
manc2957@engs-labb27:~/CWM-ProgNets/assignment2$ ping 192.168.10.1 -c 10 -i 0.1
PING 192.168.10.1 (192.168.10.1) 56(84) bytes of data.
ping: cannot flood; minimal interval allowed for <u>u</u>ser is 200ms
```

We are unable to ping at an interval of 100 ms. (Probably because we lack root permission on the Lab Machine)

Pinging the Raspberry PI from the lab machine 10 times at 200ms.

```
manc2957(dengs-labb27:~/CWM-ProgNets/assignment2$ ping 192.168.10.2 -c 10 -i 0.2
PING 192.168.10.2 (192.168.10.2) 56(84) bytes of data.
64 bytes from 192.168.10.2: icmp_seq=1 ttl=64 time=0.427 ms
64 bytes from 192.168.10.2: icmp_seq=2 ttl=64 time=0.423 ms
64 bytes from 192.168.10.2: icmp_seq=3 ttl=64 time=0.409 ms
64 bytes from 192.168.10.2: icmp_seq=4 ttl=64 time=0.402 ms
64 bytes from 192.168.10.2: icmp_seq=5 ttl=64 time=0.417 ms
64 bytes from 192.168.10.2: icmp_seq=5 ttl=64 time=0.439 ms
64 bytes from 192.168.10.2: icmp_seq=7 ttl=64 time=0.403 ms
64 bytes from 192.168.10.2: icmp_seq=8 ttl=64 time=0.406 ms
64 bytes from 192.168.10.2: icmp_seq=8 ttl=64 time=0.409 ms
64 bytes from 192.168.10.2: icmp_seq=9 ttl=64 time=0.470 ms
64 bytes from 192.168.10.2: icmp_seq=10 ttl=64 time=0.470 ms
65 ctransmitted, 10 received, 0% packet loss, time 1840ms
66 ctransmitted, 10 received, 0% packet loss, time 1840ms
67 ctransmitted
```

We see it takes about 400ms for each packet to be received.

Pinging the lab machine from the Raspberry PI 10 times at 100 ms.

```
pi@p4pi:~$ sudo ping 192.168.10.1 -c 10 -i 0.1
PING 192.168.10.1 (192.168.10.1) 56(84) bytes of data.
64 bytes from 192.168.10.1: icmp_seq=1 ttl=64 time=0.415 ms
64 bytes from 192.168.10.1: icmp_seq=2 ttl=64 time=0.552 ms
64 bytes from 192.168.10.1: icmp_seq=3 ttl=64 time=0.584 ms
64 bytes from 192.168.10.1: icmp_seq=4 ttl=64 time=0.592 ms
64 bytes from 192.168.10.1: icmp_seq=5 ttl=64 time=0.491 ms
64 bytes from 192.168.10.1: icmp_seq=6 ttl=64 time=0.585 ms
64 bytes from 192.168.10.1: icmp_seq=7 ttl=64 time=0.554 ms
64 bytes from 192.168.10.1: icmp_seq=8 ttl=64 time=0.590 ms
64 bytes from 192.168.10.1: icmp_seq=9 ttl=64 time=0.598 ms
64 bytes from 192.168.10.1: icmp_seq=9 ttl=64 time=0.500 ms
64 bytes from 192.168.10.1: icmp_seq=10 ttl=64 time=0.500 ms
65 ctl=64 time=0.500 ms
66 ctl=64 time=0.500 ms
67 ctl=64 time=0.500 ms
68 ctl=64 time=0.500 ms
69 ctl=64 time=0.500 ms
60 ctl=64 time=0.500 ms
60 ctl=64 time=0.500 ms
61 ctl=64 time=0.500 ms
62 ctl=64 time=0.500 ms
63 ctl=64 time=0.500 ms
64 ctl=64 time=0.500 ms
65 ctl=64 time=0.500 ms
66 ctl=64 time=0.500 ms
67 ctl=64 time=0.500 ms
68 ctl=64 time=0.500 ms
69 ctl=64 time=0.500 ms
69 ctl=64 time=0.500 ms
60 ctl=64 time=0.500 ms
60 ctl=64 time=0.500 ms
61 ctl=64 time=0.500 ms
62 ctl=64 time=0.500 ms
63 ctl=64 time=0.500 ms
64 ctl=64 time=0.500 ms
65 ctl=64 time=0.500 ms
66 ctl=64 time=0.500 ms
66 ctl=64 time=0.500 ms
66 ctl=64 time=0.500 ms
67 ctl=64 time=0.500 ms
67 ctl=64 time=0.500 ms
68 ctl=64 time=0.500 ms
69 ctl=64 time=0.500 ms
60 ctl=64 time=0.500 ms
61 ctl=64 time=0.500 ms
61 ctl=64 time=0.500 ms
62 ctl=64 time=0.500 ms
63 ctl=64 time=0.500 ms
64 ctl=64 time=0.500 ms
64 ctl=64 time=0.500 ms
64 ctl=64 time=0.500 ms
65 ctl=64 time=0.500 ms
66 ctl=64 time=0.500 ms
67 ctl=64 time=0.500 ms
67 ctl=64 time=0.500 ms
67 ctl=64 time=0.500 ms
67 ctl
```

We see that it takes about half a second for each packet to be received. This is about the same time as above.

Pinging the lab machine from the Raspberry PI 100 times at 1 ms.

```
pi@p4pi: ~
                          pi@p4pi: ~
                                                                 manc2957@engs-labb27: ~/CWM-ProgNets/assign..
64 bytes from 192.168.10.1:
                                   icmp_seq=53 ttl=64 time=0.323 ms
64 bytes from
                  192.168.10.1:
                                    icmp_seq=54
                                                   ttl=64
                                                            time=0.311 ms
64 bytes from 192.168.10.1:
                                    icmp_seq=55 ttl=64
64 bytes from
                  192.168.10.1:
                                    icmp_seq=56
                                                   ttl=64
                                                            time=0.320 ms
                                                            time=0.312
64 bytes from 192.168.10.1:
                                    icmp_seq=57 ttl=64
64 bytes from 192.168.10.1:
                                   icmp_seq=58 ttl=64
                                                            time=0.313
64 bytes from 192.168.10.1:
                                   icmp_seq=59 ttl=64
                                                            time=0.294
64 bytes from 192.168.10.1:
                                   icmp_seq=60 ttl=64
                                                            time=0.316 ms
                                   tcmp_seq=60 ttl=64
icmp_seq=62 ttl=64
icmp_seq=63 ttl=64
icmp_seq=64 ttl=64
icmp_seq=65 ttl=64
icmp_seq=66 ttl=64
64 bytes from 192.168.10.1:
                                                            time=0.298
   bytes from 192.168.10.1:
                                                            time=0.289
   bytes from 192.168.10.1:
bytes from 192.168.10.1:
                                                            time=0.313
                                                            time=0.314
   bytes from 192.168.10.1:
                                                            time=0.322
   bytes from 192.168.10.1:
                                                            time=0.314
                                   icmp_seq=67 ttl=64 icmp_seq=68 ttl=64
   bytes from 192.168.10.1:
                                                            time=0.311
64 bytes from 192.168.10.1:
   bytes from
                  192.168.10.1:
                                    icmp_seq=69
                                                   ttl=64
64 bytes from 192.168.10.1:
                                    icmp_seq=70 ttl=64
                                                            time=0.314
64 bytes from
                  192.168.10.1:
                                    icmp_seq=71 ttl=64
                                                            time=0.290 ms
64 bytes from 192.168.10.1:
                                    icmp_seq=72 ttl=64
                                                            time=0.295
64 bytes from 192.168.10.1:
                                   icmp_seq=73 ttl=64
                                                            time=0.291 ms
                                   tcmp_seq=73 ttl=64 icmp_seq=74 ttl=64 icmp_seq=75 ttl=64 icmp_seq=77 ttl=64 icmp_seq=78 ttl=64 icmp_seq=79 ttl=64 icmp_seq=80 ttl=64 icmp_seq=81 ttl=64 icmp_seq=81 ttl=64 icmp_seq=81 ttl=64 icmp_seq=82 ttl=64
64 bytes from 192.168.10.1:
                                                            time=0.287
64 bytes from 192.168.10.1:
                                                            time=0.290
64 bytes from 192.168.10.1:
                                                            time=0.317
   bytes from 192.168.10.1:
                                                            time=0.328
   bytes from 192.168.10.1:
                                                            time=0.312
   bytes from 192.168.10.1:
                                                            time=0.310
   bytes from 192.168.10.1:
                                                            time=0.311
64 bytes from 192.168.10.1:
                                                            time=0.320
                                    icmp_seq=82 ttl=64
icmp_seq=83 ttl=64
   bytes from
                  192.168.10.1:
64 bytes from 192.168.10.1:
64 bytes from
                  192.168.10.1:
                                    icmp_seq=84
                                                   ttl=64
                                                            time=0.290
64 bytes from 192.168.10.1:
                                    icmp_seq=85 ttl=64
                                                            time=0.292
64 bytes from 192.168.10.1:
                                   icmp_seq=86 ttl=64
                                                            time=0.312
64 bytes from 192.168.10.1:
                                   icmp_seq=87 ttl=64
                                                            time=0.311
64 bytes from 192.168.10.1: icmp_seq=88 ttl=64
                                                            time=0.312 ms
                                   icmp_seq=89 ttl=64
icmp_seq=90 ttl=64
icmp_seq=91 ttl=64
icmp_seq=92 ttl=64
64 bytes from 192.168.10.1:
                                                            time=0.289
   bytes from 192.168.10.1:
                                                            time=0.313
   bytes from 192.168.10.1:
bytes from 192.168.10.1:
                                                            time=0.310
                                                            time=0.321
                                   icmp_seq=93
icmp_seq=94
   bytes from 192.168.10.1:
                                                   ttl=64
                                                            time=0.291
   bytes from 192.168.10.1:
                                                   ttl=64
                                                            time=0.329
                                   icmp_seq=95
icmp_seq=96
   bytes from 192.168.10.1:
                                                   ttl=64
                                                            time=0.289
64 bytes from 192.168.10.1:
                                                   ttl=64
                                                            time=0.312
64 bytes from
                 192.168.10.1:
                                    icmp_seq=97
                                                   ttl=64
64 bytes from 192.168.10.1:
                                    icmp_seq=98 ttl=64
                                                           time=0.313 ms
64 bytes from 192.168.10.1: icmp_seq=99 ttl=64 time=0.312 ms
64 bytes from 192.168.10.1: icmp_seq=100 ttl=64 time=0.311 ms
    192.168.10.1 ping statistics ---
100 packets transmitted, 100 received, 0% packet loss, time 99ms
rtt min/avg/max/mdev = 0.287/0.318/0.432/0.026 ms
pi@p4pi:~$
```

We see that it takes about 300 ms for each packet to be received. Minimum round trip time is 287 ms, maximum round trip time is 432 ms. Standard deviation is 26 ms. We see that the variance of RTT is actually quite significant, this becomes apparent when we observe a larger sample size of data packets.

```
Pinging the lab machine from the Raspberry PI 10000 times with flooding.

pi@p4pi:~/daoxin/CWM-ProgNets/assignment2$ sudo ping 192.168.10.1 -c 10000 -f

PING 192.168.10.1 (192.168.10.1) 56(84) bytes of data.

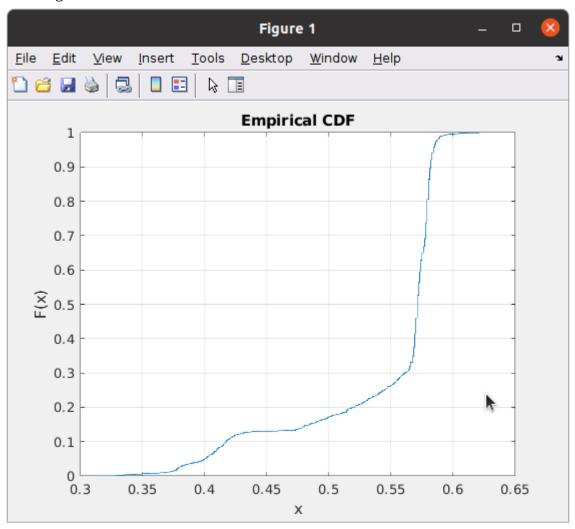
--- 192.168.10.1 ping statistics ---

10000 packets transmitted, 10000 received, 0% packet loss, time 3684ms

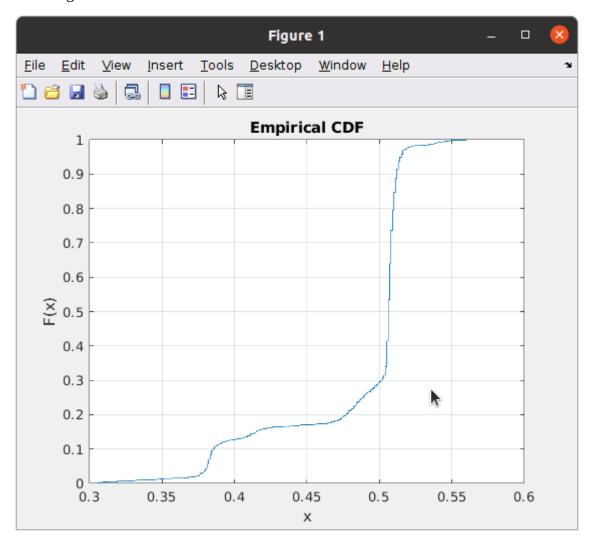
rtt min/avg/max/mdev = 0.157/0.312/0.692/0.021 ms, ipg/ewma 0.368/0.321 ms
```

We still see the same average RTT around 300ms.

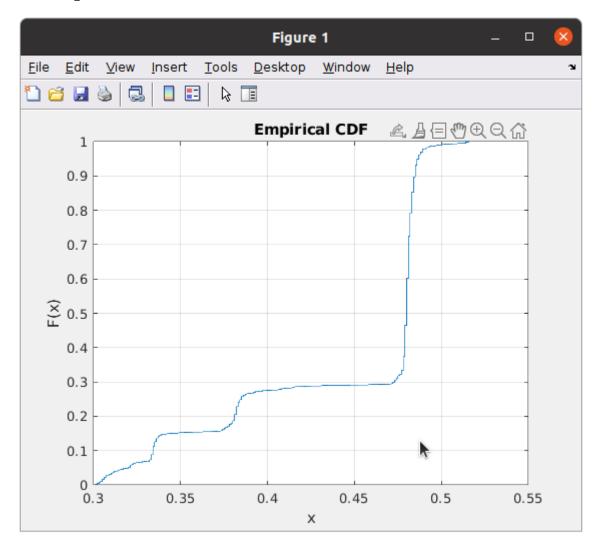
Pinging the lab machine from the Raspberry PI 2000 times at 10 ms. rtt min/avg/max/mdev = 0.313/0.543/0.621/0.060 ms



Pinging the lab machine from the Raspberry PI 2000 times at 1 ms. rtt min/avg/max/mdev = 0.303/0.485/0.560/0.046 ms



Pinging the lab machine from the Raspberry PI 2000 times at 0.1 ms. rtt min/avg/max/mdev = 0.301/0.444/0.516/0.060 ms



The longer RTT for the lower interval experiment can most likely be attributed some higher layer process going on beyond the transport layers. There may be some delay within the Lab computer OS that comes minimised when it is pinged at shorter interval.

Latency is the time it takes for data to travel between the sending endpoint and receiving endpoint alone. Hence, it ignores any higher level delay. Thus the experiment at 0.1ms interval gives a more accurate estimate of latency.

Setting the Lab Machine as the iperf server and the Raspberry PI as the client.

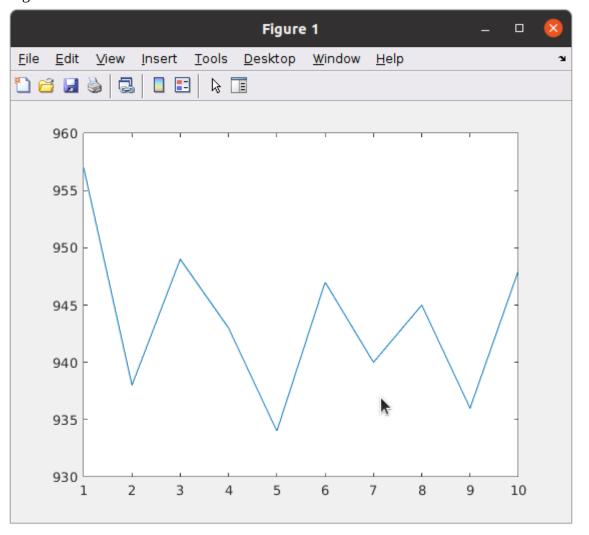
```
pi@p4pi:~/daoxin/CWM-ProgNets/assignment2$ iperf -c 192.168.10.1 -i 1 -t 10
Client connecting to 192.168.10.1, TCP port 5001
TCP window size: 85.0 KByte (default)
  3] local 192.168.10.2 port 39188 connected with 192.168.10.1 port 5001
 ID] Interval
                   Transfer
                                Bandwidth
  3] 0.0000-1.0000 sec
                        114 MBytes
                                     954 Mbits/sec
  3] 1.0000-2.0000 sec
                       112 MBytes
                                     938 Mbits/sec
  3] 2.0000-3.0000 sec 112 MBytes 944 Mbits/sec
  3] 3.0000-4.0000 sec 112 MBytes 944 Mbits/sec
  3] 4.0000-5.0000 sec 112 MBytes
                                     936 Mbits/sec
                                     941 Mbits/sec
                        112 MBytes
  3] 5.0000-6.0000 sec
                        112 MBytes 941 Mbits/sec
  3] 6.0000-7.0000 sec
  3] 7.0000-8.0000 sec
                         113 MBytes
                                     946 Mbits/sec
  3] 8.0000-9.0000 sec
                         112 MBytes
                                     943 Mbits/sec
  3] 9.0000-10.0000 sec
                          112 MBytes
                                      942 Mbits/sec
  3] 10.0000-10.0080 sec
                           256 KBytes
                                       263 Mbits/sec
     0.0000-10.0080 sec 1.10 GBytes
                                      942 Mbits/sec
```

We see that the effective bandwidth of the PI to the Lab Machine is around 942 Mbits/s. Not quite sure about the strange dip to 256 Mbits/s at the 9 sec mark.

Setting the Raspberry PI as the iperf server and the as the Lab Machine client.

```
nanc2957@engs-labb27:~/CWM-ProgNets/assignment2$ iperf -c 192.168.10.2 -i 1 -t 10 > iperf_no_b.log
manc2957@engs-labb27:~/CWM-ProgNets/assignment2$ ls -al
total 444
drwxrwxr-x 2 manc2957 manc2957
                                          4096 Jun 13 16:37
drwxrwxr-x 9 manc2957 manc2957
                                          4096 Jun 13 10:30
rw-rw-r-- 1 manc2957 manc2957
                                           866 Jun 13 16:38 iperf no b.log
rw-rw-r-- 1 manc2957 manc2957
                                           207 Jun 13 16:16 parser.py
rw-rw-r-- 1 manc2957 manc2957 14000 Jun 13 16:16 ping_0.1ms.csv
rw-r--r-- 1 manc2957 manc2957 125129 Jun 13 15:20 ping_0.1ms.log
 rw-rw-r-- 1 manc2957 manc2957
                                         14000 Jun 13 16:12 ping_10ms.csv
rw-r--r-- 1 manc2957 manc2957 125106 Jun 13 15:20 ping_10ms.log
rw-rw-r-- 1 manc2957 manc2957 14000 Jun 13 16:14 ping_1ms.csv
rw-r--r-- 1 manc2957 manc2957 125105 Jun 13 15:20 ping_1ms.log
 rw-rw-r-- 1 manc2957 manc2957
                                             83 Jun 13 16:16 plot_graph.m
 rw-r--r-- 1 manc2957 manc2957
                                             61 Jun 13 15:20 README.md
```

#### Graphing the Bandwidth.

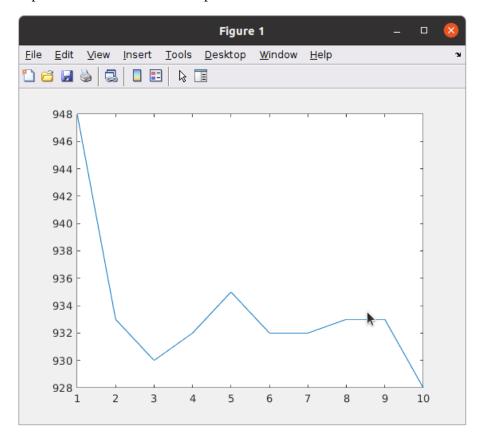


Setting the Raspberry PI as the iperf server and the as the Lab Machine client, **with bi-directional iperf**.

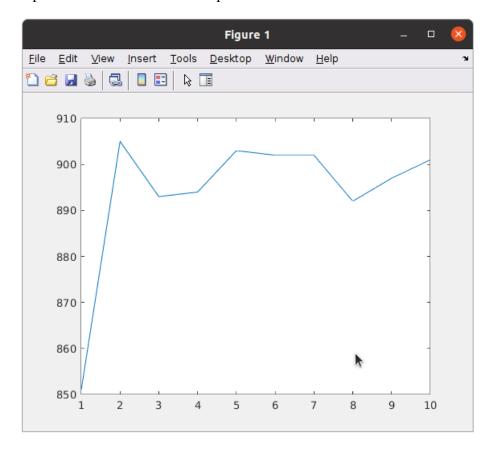
```
^Cmanc2957@engs-labb27:~/CWM-ProgNets/assignment2$ iperf -c 192.168.10.2 -i 1 -t 10 -d
Server listening on TCP port 5001
TCP window size: -1.00 Byte (default)
Client connecting to 192.168.10.2, TCP port 5001
TCP window size: 400 KByte (default)
  4] local 192.168.10.1 port 37986 connected with 192.168.10.2 port 5001
  5] local 192.168.10.1 port 5001 connected with 192.168.10.2 port 39200
 ID] Interval
                  Transfer
                                Bandwidth
  4] 0.0- 1.0 sec
                   113 MBytes
                                948 Mbits/sec
  5] 0.0- 1.0 sec 101 MBytes
                                 851 Mbits/sec
  5]
     1.0- 2.0 sec
                   108 MBytes
                                 905 Mbits/sec
  4]
      1.0- 2.0 sec
                   111 MBytes
                                 933 Mbits/sec
  4]
      2.0- 3.0 sec
                   111 MBytes
                                 930 Mbits/sec
  5]
      2.0- 3.0 sec
                   107 MBytes
                                 893 Mbits/sec
                   111 MBytes
  4]
      3.0- 4.0 sec
                                 932 Mbits/sec
  5]
      3.0- 4.0 sec
                                 894 Mbits/sec
                   107 MBytes
  4]
      4.0- 5.0 sec 112 MBytes
                                 935 Mbits/sec
  5]
                                 903 Mbits/sec
      4.0- 5.0 sec
                   108 MBytes
  5]
                                 902 Mbits/sec
      5.0- 6.0 sec 108 MBytes
                   111 MBytes
                                 932 Mbits/sec
  4]
      5.0- 6.0 sec
                                 932 Mbits/sec
  4]
      6.0- 7.0 sec
                   111 MBytes
  5]
      6.0- 7.0 sec
                   108 MBytes
                                 902 Mbits/sec
                                 933 Mbits/sec
  4]
      7.0- 8.0 sec 111 MBytes
  5]
      7.0- 8.0 sec 106 MBytes
                                 892 Mbits/sec
  4]
      8.0- 9.0 sec 111 MBytes
                                 933 Mbits/sec
  5]
      8.0- 9.0 sec
                   107 MBytes
                                 897 Mbits/sec
  4]
      9.0-10.0 sec
                   111 MBytes
                                 928 Mbits/sec
  4]
      0.0-10.0 sec 1.09 GBytes
                                 934 Mbits/sec
  5]
      9.0-10.0 sec
                   107 MBytes
                                 901 Mbits/sec
      0.0-10.0 sec 1.04 GBytes
                                 894 Mbits/sec
      0.0-10.0 sec
                   1.14 GBytes
                                 979 Mbits/sec
```

Link 4 is the forward connection (from Lab Machine to Raspberry Pi). Link 5 is the backward connection (from Raspberry Pi to the Lab Machine). Note the backward connection is now slower, at 900ms.

### Graph of forward connection speed.



# Graph of backward connection speed.



Setting the Raspberry Pi as a one way iperf **UDP** server and the Lab Machine as the client.

#### At 100kbits/s,

```
anc2957@engs-labb27:~/CWM-ProgNets/assignment2$ iperf -u -c 192.168.10.2 -i 0.5 -t 5 -b 100k
Client connecting to 192.168.10.2, UDP port 5001
Sending 1470 byte datagrams, IPG target: 117600.00 us (kalman adjust)
UDP buffer size: 208 KByte (default)
           local 192.168.10.1 port 48335 connected with 192.168.10.2 port 5001
   ID] Interval
                                                          Bandwidth
                                    Transfer
          Interval Transfer Bandwidth

0.0- 0.5 sec 8.61 KBytes 94.1 Kbits/sec

1.0- 1.5 sec 5.74 KBytes 94.1 Kbits/sec

1.5- 2.0 sec 7.18 KBytes 94.1 Kbits/sec

2.0- 2.5 sec 5.74 KBytes 94.1 Kbits/sec

2.5- 3.0 sec 5.74 KBytes 94.1 Kbits/sec

3.0- 3.5 sec 5.74 KBytes 94.1 Kbits/sec

3.5- 4.0 sec 7.18 KBytes 94.1 Kbits/sec

3.5- 4.0 sec 7.18 KBytes 94.1 Kbits/sec

4.0- 4.5 sec 5.74 KBytes 94.1 Kbits/sec

0.0- 5.1 sec 61.7 KBytes 94.1 Kbits/sec

Sent 43 datagrams
    3]
     3]
     3]
     3]
     3]
     3]
     3]
     3]
     3]
     3]
          Sent 43 datagrams
     3]
           Server Report:
            0.0- 5.1 sec 61.7 KBytes 100 Kbits/sec _ 0.003 ms 0/ 43 (0%)
```

#### At 1 Mbits/s,

```
nanc2957@engs-labb27:~/CWM-ProgNets/assignment2$ iperf -u -c 192.168.10.2 -i 0.5 -t 5 -b 1m
Client connecting to 192.168.10.2, UDP port 5001
Sending 1470 byte datagrams, IPG target: 11760.00 us (kalman adjust)
UDP buffer size: 208 KByte (default)
   3] local 192.168.10.1 port 42698 connected with 192.168.10.2 port 5001
  ID] Interval
                            Transfer Bandwidth
   3] 0.0- 0.5 sec 63.2 KBytes 1.03 Mbits/sec
       0.5- 1.0 sec 61.7 KBytes 1.01 Mbits/sec
1.0- 1.5 sec 60.3 KBytes 988 Kbits/sec
1.5- 2.0 sec 61.7 KBytes 1.01 Mbits/sec
   31
    3]
   3]
   3]
       2.0- 2.5 sec 60.3 KBytes 988 Kbits/sec
2.5- 3.0 sec 61.7 KBytes 1.01 Mbits/sec
3.0- 3.5 sec 60.3 KBytes 988 Kbits/sec
    3]
    3]
        3.5- 4.0 sec 61.7 KBytes 1.01 Mbits/sec
4.0- 4.5 sec 60.3 KBytes 988 Kbits/sec
0.0- 5.0 sec 612 KBytes 1000 Kbits/sec
    3]
    31
    3]
       Sent 426 datagrams
    3]
    3]
        Server Report:
        0.0- 5.0 sec
                              612 KBytes 1.00 Mbits/sec 0.003 ms 0/ 426 (0%)
```

#### At 100 Mbits/s,

```
anc2957@engs-labb27:~/CWM-ProgNets/assignment2$ iperf -u -c 192.168.10.2 -i 0.5 -t 5 -b 100m
Client connecting to 192.168.10.2, UDP port 5001
Sending 1470 byte datagrams, IPG target: 117.60 us (kalman adjust)
UDP buffer size: 208 KByte (default)
   3] local 192.168.10.1 port 48216 connected with 192.168.10.2 port 5001
  ID Interval
                                        Bandwidth
                         Transfer
       0.0- 0.5 sec 5.96 MBytes
0.5- 1.0 sec 5.96 MBytes
1.0- 1.5 sec 5.96 MBytes
                                         100 Mbits/sec
   3]
                                            100 Mbits/sec
                                           100 Mbits/sec
   31
       1.5- 2.0 sec 5.96 MBytes
2.0- 2.5 sec 5.96 MBytes
2.5- 3.0 sec 5.96 MBytes
                                           100 Mbits/sec
   3]
   3]
                                            100 Mbits/sec
   3]
                                            100 Mbits/sec
        3.0- 3.5 sec 5.96 MBytes
3.5- 4.0 sec 5.96 MBytes
                                            100 Mbits/sec
   зj
                                            100 Mbits/sec
   3]
        4.0- 4.5 sec 5.96 MBytes
0.0- 5.0 sec 59.6 MBytes
   3]
                                            100 Mbits/sec
   3]
                                           100 Mbits/sec
       Sent 42517 datagrams
   3]
   3]
       Server Report:
        0.0- 5.0 sec 59.6 MBytes 100 Mbits/sec 0.001 ms 0/42517 (0%)
```

All 3 trials saw no packets dropped. However, if we were to push up the transmission bandwidth to value beyond the carrying bandwidth of the connection (at 10 Gbits/s), we can see some of the packets dropping.

```
anc2957@engs-labb27:~/CWM-ProgNets/assignment2$ iperf -c 192.168.10.2 -i 0.5 -t 5 -b 10G -u
Client connecting to 192.168.10.2, UDP port 5001
Sending 1470 byte datagrams, IPG target: 1.10 us (kalman adjust)
UDP buffer size: 208 KByte (default)
  3] local 192.168.10.1 port 41682 connected with 192.168.10.2 port 5001
 ID] Interval
                  Transfer Bandwidth
      0.0- 0.5 sec 57.1 MBytes 957 Mbits/sec
0.5- 1.0 sec 57.0 MBytes 957 Mbits/sec
1.0- 1.5 sec 57.0 MBytes 957 Mbits/sec
  3]
      1.5- 2.0 sec 57.0 MBytes 957 Mbits/sec
  31
      2.0- 2.5 sec 57.0 MBytes 957 Mbits/sec
   3]
      2.5- 3.0 sec 57.1 MBytes 957 Mbits/sec
  3]
      3.0- 3.5 sec 57.0 MBytes 957 Mbits/sec
      3.5- 4.0 sec 57.0 MBytes
4.0- 4.5 sec 57.0 MBytes
4.5- 5.0 sec 57.0 MBytes
                                      957 Mbits/sec
  3]
                                      957 Mbits/sec
  3]
                                      957 Mbits/sec
                      570 MBytes
      0.0- 5.0 sec
                                      957 Mbits/sec
   3] Sent 406866 datagrams
     Server Report:
     0.0- 5.2 sec 201 MBytes 322 Mbits/sec _15.576 ms 263355/406867 (65%)
```

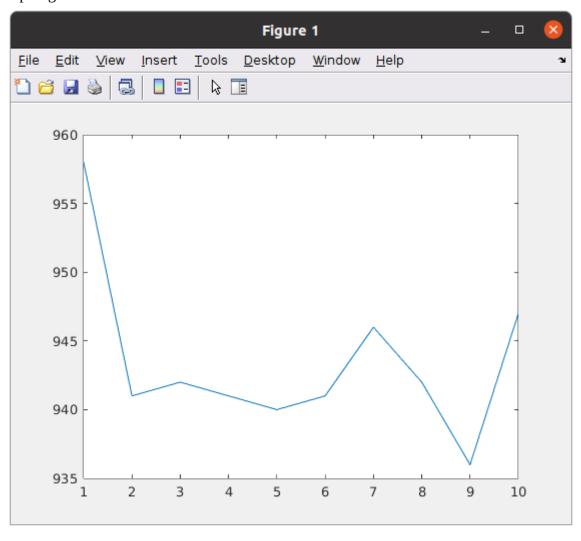
Setting up the Raspberry PI as the **iperf3** server and the Lab Machine as the client.

Sending a message across via TCP.

```
manc2957@engs-labb27:~/CWM-ProgNets/assignment2$ iperf3 -c 192.168.10.2 -i 1 -t 10
Connecting to host 192.168.10.2, port 5201
     5] local 192.168.10.1 port 51450 connected to 192.168.10.2 port 5201
   ID] Interval
                                               Transfer Bitrate
                                                                                         Retr Cwnd
     5]
             0.00-1.00 sec 114 MBytes 958 Mbits/sec 0
1.00-2.00 sec 112 MBytes 941 Mbits/sec 0
                                                                                                                   465 KBytes
     5]
                                                                                                                 465 KBytes
             1.00-2.00 Sec 112 MBytes 941 Mbits/sec 0 465 KBytes 2.00-3.00 sec 112 MBytes 942 Mbits/sec 0 465 KBytes 3.00-4.00 sec 112 MBytes 941 Mbits/sec 0 465 KBytes 4.00-5.00 sec 112 MBytes 940 Mbits/sec 0 465 KBytes 5.00-6.00 sec 112 MBytes 941 Mbits/sec 0 465 KBytes 6.00-7.00 sec 113 MBytes 946 Mbits/sec 0 465 KBytes 7.00-8.00 sec 112 MBytes 942 Mbits/sec 0 489 KBytes 8.00-9.00 sec 112 MBytes 936 Mbits/sec 0 489 KBytes 9.00-10.00 sec 113 MBytes 947 Mbits/sec 0 489 KBytes
     5]
     5]
      5]
      5]
      5]
     5]
     5]
     5]
              nterval Transfer Bitrate
0.00-10.00 sec 1.10 GBytes 943 Mbits/sec
0.00-10.01 sec 1.10 GBytes 940 Mbits/sec
    ID] Interval
                                                                                                      Retr
      5]
                                                                                                      0
                                                                                                                                     sender
      5]
                                                                                                                                     receiver
iperf Done.
```

The bandwidth of the connection is around 940 Mbits/s.

# Graphing the bandwidth.



Sending a message across via UDP at 100kbits/s.

```
gnment2$ iperf3 -c 192.168.10.2 -i 1 -t 10 -u -b 100k
Connecting to host 192.168.10.2, port 5201
   5] local 192.168.10.1 port 39874 connected to 192.168.10.2 port 5201
  ID1 Interval
                                    Transfer
                                                       Bitrate
                                                                               Total Datagrams
                          sec 12.7 KBytes
sec 12.7 KBytes
           0.00-1.00
                                                        104 Kbits/sec
    5]
           1.00-2.00
                                                       104 Kbits/sec
                          sec 11.3 KBytes 92.7 Kbits/sec
sec 12.7 KBytes 104 Kbits/sec
sec 12.7 KBytes 104 Kbits/sec
    5]
           2.00-3.00
           3.00-4.00
    5]
           4.00-5.00
           5.00-6.00 sec 11.3 KBytes 92.7 Kbits/sec
6.00-7.00 sec 12.7 KBytes 104 Kbits/sec
7.00-8.00 sec 12.7 KBytes 104 Kbits/sec
8.00-9.00 sec 11.3 KBytes 92.7 Kbits/sec
9.00-10.00 sec 12.7 KBytes 104 Kbits/sec
    5]
    5]
    5]
    5]
                                                                              8
    5]
  IDl Interval
                                    Transfer
                                                      Bitrate
                                                                              Jitter
                                                                                             Lost/Total Datagrams
                                     123 KBytes 101 Kbits/sec 0.000 ms 0/87 (0%)
123 KBytes 101 Kbits/sec 0.017 ms 0/87 (0%)
           0.00-10.00 sec
    5]
                                                                                                              sender
           0.00-10.00 sec
                                    123 KBytes
                                                                                                             receiver
iperf Done.
```

### Sending a message across via UDP at 1 Mbits/s.

```
CWM-ProgNets/assignment2$ iperf3 -c 192.168.10.2 -i 1 -t 10 -u -b 1m
Connecting to host 192.168.10.2, port 5201
  5] local 192.168.10.1 port 38232 connected to 192.168.10.2 port 5201
  ID] Interval
                          Transfer
                                       Bitrate
                                                         Total Datagrams
        0.00-1.00
                           123 KBytes
                                       1.01 Mbits/sec
  5]
                     sec
                                                        87
   5]
        1.00-2.00
                           122 KBytes
                                       996 Kbits/sec
                                                         86
                    sec
   5]
        2.00-3.00
                           122 KBytes
                                        996 Kbits/sec
                                                         86
                    sec
   5]
        3.00-4.00
                    sec
                           123 KBytes
                                       1.01 Mbits/sec
                                                         87
   5]
        4.00-5.00
                    sec
                           122 KBytes
                                       996 Kbits/sec
                                                         86
                                       996 Kbits/sec
   5]
        5.00-6.00
                           122 KBytes
                    sec
                                                         86
                                       1.01 Mbits/sec
   5]
        6.00-7.00
                    sec
                           123 KBytes
                                                         87
                           122 KBytes
   5]
        7.00-8.00
                                       996 Kbits/sec
                    sec
                                                         86
   5]
        8.00-9.00
                    sec
                           122 KBytes
                                       996 Kbits/sec
                                                         86
                         123 KBytes 1.01 Mbits/sec
   5]
        9.00-10.00 sec
  ID] Interval
                          Transfer Bitrate
                                                         Jitter
                                                                   Lost/Total Datagrams
        0.00-10.00 sec 1.19 MBytes 1.00 Mbits/sec 0.000 ms 0.00-10.00 sec 1.19 MBytes 1.00 Mbits/sec 0.005 ms
  5]
                                                                   0/864 (0%) sender
   5]
                                                                   0/864 (0%)
                                                                               receiver
iperf Done.
```

#### Sending a message across via UDP at 100 Mbits/s.

```
<u>nent2</u>$ iperf3 -c 192.168.10.2 -i 1 -t 10 -u -b 100m
Connecting to host 192.168.10.2, port 5201
[ 5] local 192.168.10.1 port 45989 connected to 192.168.10.2 port 5201
 ID] Interval
                           Transfer
                                                            Total Datagrams
                                          Bitrate
        0.00-1.00
                     sec 11.9 MBytes 99.9 Mbits/sec
  5]
                                                           8626
   5]
        1.00-2.00
                     sec 11.9 MBytes
                                         100 Mbits/sec
                                                            8634
                     sec 11.9 MBytes
sec 11.9 MBytes
                                           100 Mbits/sec
100 Mbits/sec
   5]
        2.00-3.00
                                                            8633
   5]
        3.00-4.00
                                                            8631
   5]
        4.00-5.00
                     sec 11.9 MBytes
                                           100 Mbits/sec
                                                            8633
                     sec 11.9 MBytes
sec 11.9 MBytes
                                           100 Mbits/sec
   5]
        5.00-6.00
                                                            8631
  5]
        6.00-7.00
                                           100 Mbits/sec
                                                            8635
   5]
         7.00-8.00
                     sec 11.9 MBytes
                                           100 Mbits/sec
                     sec
                           11.9 MBytes
   5]
        8.00-9.00
                                           100 Mbits/sec
                                                            8633
        9.00-10.00
                     sec 11.9 MBytes
  5]
                                           100 Mbits/sec
                                                           8632
 ID] Interval
                                          Bitrate
                                                            Jitter
                           Transfer
                                                                       Lost/Total Datagrams
                                          100 Mbits/sec 0.000 ms
                                                                                      sender
  5]
        0.00-10.00 sec
                            119 MBytes
                                                                       0/86320 (0%)
   5]
                            119 MBytes
                                           100 Mbits/sec
                                                                       0/86320 (0%)
        0.00-10.00 sec
                                                            0.010 ms
                                                                                      receiver
iperf Done.
```

Once again because the data rate is so much smaller than no bandwidth, no packets are lost.

Interestingly if we send data over at 10 Gbits/s again.

```
manc2957@engs-labb27:~/CWM-ProgNets/assignment2$ iperf3 -c 192.168.10.2 -i 1 -t 10 -u -b 10G Connecting to host 192.168.10.2, port 5201
  5] local 192.168.10.1 port 54639 connected to 192.168.10.2 port 5201
 ID] Interval
                                                  Total Datagrams
                       Transfer
                                  Bitrate
  5]
      0.00-1.00
                sec
                      114 MBytes 952 Mbits/sec 82225
  5]
      1.00-2.00 sec
                      114 MBytes
                                   956 Mbits/sec 82563
      2.00-3.00
                 sec
                                   956 Mbits/sec 82566
956 Mbits/sec 82560
  5]
                      114 MBytes
  5]
       3.00-4.00
                  sec
                        114 MBytes
                                    956 Mbits/sec
                                   956 Mbits/sec 82560
       4.00-5.00 sec
  5]
                        114 MBytes
                      114 MBytes
  5]
      5.00-6.00 sec
                                   956 Mbits/sec 82561
  5]
      6.00-7.00 sec 114 MBytes 956 Mbits/sec 82561
  5]
       7.00-8.00 sec 114 MBytes 956 Mbits/sec 82560
      5]
  5]
 ID] Interval
                                                  Jitter
                                                           Lost/Total Datagrams
      0.00-10.00 sec 1.11 GBytes 956 Mbits/sec 0.000 ms 0/825276 (0%) sender
  5]
       0.00-10.00 sec 1.04 GBytes 891 Mbits/sec 0.017 ms 56025/825182 (6.8%) receiver
  5]
iperf Done.
```

We notice that our link has a much lower lost rate than before.