

PART C

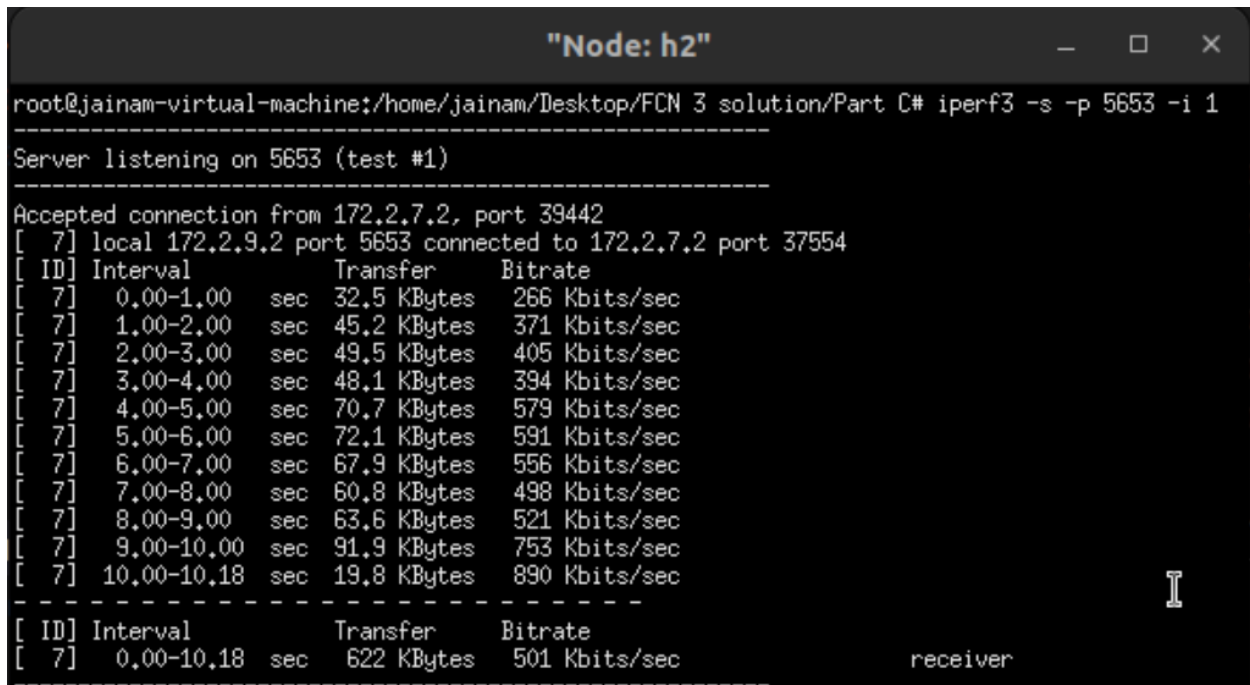
(a) MyIperf.py created

(b) (c) Screenshots for the three scenarios and explanation

Scenario 1 – Buffer Size 10kb

Command used – *xterm h1 h2*

H2



```
root@jainam-virtual-machine:/home/jainam/Desktop/FCN 3 solution/Part C# iperf3 -s -p 5653 -i 1
-----
Server listening on 5653 (test #1)
-----
Accepted connection from 172.2.7.2, port 39442
[ 7] local 172.2.9.2 port 5653 connected to 172.2.7.2 port 37554
[ ID] Interval      Transfer    Bitrate
[ 7] 0.00-1.00    sec  32.5 KBytes  266 Kbits/sec
[ 7] 1.00-2.00    sec  45.2 KBytes  371 Kbits/sec
[ 7] 2.00-3.00    sec  49.5 KBytes  405 Kbits/sec
[ 7] 3.00-4.00    sec  48.1 KBytes  394 Kbits/sec
[ 7] 4.00-5.00    sec  70.7 KBytes  579 Kbits/sec
[ 7] 5.00-6.00    sec  72.1 KBytes  591 Kbits/sec
[ 7] 6.00-7.00    sec  67.9 KBytes  556 Kbits/sec
[ 7] 7.00-8.00    sec  60.8 KBytes  498 Kbits/sec
[ 7] 8.00-9.00    sec  63.6 KBytes  521 Kbits/sec
[ 7] 9.00-10.00   sec  91.9 KBytes  753 Kbits/sec
[ 7] 10.00-10.18  sec  19.8 KBytes  890 Kbits/sec
-----
[ ID] Interval      Transfer    Bitrate
[ 7] 0.00-10.18   sec  622 KBytes  501 Kbits/sec
-----
receiver
```

H1

```

"Node: h1"
root@jainam-virtual-machine:/home/jainam/Desktop/FCN 3 solution/Part C# iperf3 -c 172.2.9.2 -p 5653 -t 10
Connecting to host 172.2.9.2, port 5653
[ 7] local 172.2.7.2 port 37554 connected to 172.2.9.2 port 5653
[ ID] Interval           Transfer     Bitrate      Retr  Cwnd
[ 7]  0.00-1.00   sec    141 KBytes  1.16 Mbits/sec   11   9.90 KBytes
[ 7]  1.00-2.00   sec    49.5 KBytes  406 Kbits/sec    6   9.90 KBytes
[ 7]  2.00-3.00   sec    79.2 KBytes  649 Kbits/sec    2   8.48 KBytes
[ 7]  3.00-4.00   sec     0.00 Bytes  0.00 bits/sec    0  11.3 KBytes
[ 7]  4.00-5.00   sec    80.6 KBytes  661 Kbits/sec    0  15.6 KBytes
[ 7]  5.00-6.00   sec    79.2 KBytes  649 Kbits/sec    1  14.1 KBytes
[ 7]  6.00-7.00   sec    87.7 KBytes  718 Kbits/sec    1  14.1 KBytes
[ 7]  7.00-8.00   sec    63.6 KBytes  521 Kbits/sec    2  11.3 KBytes
[ 7]  8.00-9.00   sec    63.6 KBytes  521 Kbits/sec    0  15.6 KBytes
[ 7]  9.00-10.00  sec    66.5 KBytes  544 Kbits/sec    0  19.8 KBytes
-----
[ ID] Interval           Transfer     Bitrate      Retr
[ 7]  0.00-10.00  sec    711 KBytes  583 Kbits/sec   23
[ 7]  0.00-10.18  sec    622 KBytes  501 Kbits/sec
sender
receiver

iperf Done.

```

RTT

Command used - *H1 ping h2 -c 10*

```

mininet> h1 ping h2 -c 10
PING 172.2.9.2 (172.2.9.2) 56(84) bytes of data:
64 bytes from 172.2.9.2: icmp_seq=1 ttl=61 time=182 ms
64 bytes from 172.2.9.2: icmp_seq=2 ttl=61 time=182 ms
64 bytes from 172.2.9.2: icmp_seq=3 ttl=61 time=181 ms
64 bytes from 172.2.9.2: icmp_seq=4 ttl=61 time=185 ms
64 bytes from 172.2.9.2: icmp_seq=5 ttl=61 time=186 ms
64 bytes from 172.2.9.2: icmp_seq=6 ttl=61 time=184 ms
64 bytes from 172.2.9.2: icmp_seq=7 ttl=61 time=183 ms
64 bytes from 172.2.9.2: icmp_seq=8 ttl=61 time=186 ms
64 bytes from 172.2.9.2: icmp_seq=9 ttl=61 time=185 ms
64 bytes from 172.2.9.2: icmp_seq=10 ttl=61 time=184 ms

--- 172.2.9.2 ping statistics ---
10 packets transmitted, 10 received, 0% packet loss, time 9016ms
rtt min/avg/max/mdev = 180.744/183.857/186.421/1.881 ms

```

Created a client2.json

```

"end": {
  "streams": [{
    "sender": {
      "socket": 7,
      "start": 0,
      "end": 10.000533,
      "seconds": 10.000533,
      "bytes": 942648,
      "bits_per_second": 583078.207631533,
      "retransmits": 23,
      "max_snd_cwnd": 24616,
      "max_snd_wnd": 208896,
      "max_rtt": 185203,
      "min_rtt": 181001,
      "mean_rtt": 182444,
      "sender": true
    },
    "receiver": {
      "socket": 7,
      "start": 0,
      "end": 10.18072,
      "seconds": 10.000533,
      "bytes": 861560,
      "bits_per_second": 677013.02069008863
    }
  ]
}

```

Explanation:

Here I take the bits_per_second and mean_rtt values

$BDP = \text{Average Bandwidth} * \text{Average RTT} = 583078.207631533 * 182444 / 1000000 \text{ bits} = 132.973\text{kb}$.

Here is buffer size is 10kb. Now here we can see that there are 23 retransmissions. This happened because the buffer size is too low compares to the BDP, so the buffer gets full and the packets get lost. Since the buffer size is just 10 kb/s, we receive a bandwidth of 583 kb/s. Prior to using our entire 100 mbps of bandwidth, our buffer fills up a couple times.

Scenario 2 – Buffer Size 10mb

Command used – *xterm h1 h2*

H2

```
"Node: h2"
root@jainam-virtual-machine:/home/jainam/Desktop/FCN 3 solution/Part C# iperf3
-s -p 4545 -i 1
-----
Server listening on 4545 (test #1)
-----
Accepted connection from 172.2.7.2, port 45894
[ 7] local 172.2.9.2 port 4545 connected to 172.2.7.2 port 45910
[ ID] Interval      Transfer    Bitrate
[ 7]  0.00-1.00    sec    376 KBytes  3.08 Mbits/sec
[ 7]  1.00-2.00    sec    6.75 MBytes 56.7 Mbits/sec
[ 7]  2.00-3.00    sec    11.4 MBytes 95.6 Mbits/sec
[ 7]  3.00-4.00    sec    11.4 MBytes 95.7 Mbits/sec
[ 7]  4.00-5.00    sec    11.4 MBytes 95.6 Mbits/sec
[ 7]  5.00-6.00    sec    11.4 MBytes 95.6 Mbits/sec
[ 7]  6.00-7.00    sec    11.4 MBytes 95.7 Mbits/sec
[ 7]  7.00-8.00    sec    11.4 MBytes 95.6 Mbits/sec
[ 7]  8.00-9.00    sec    11.4 MBytes 95.6 Mbits/sec
[ 7]  9.00-10.00   sec    11.4 MBytes 95.7 Mbits/sec
[ 7] 10.00-10.33   sec     3.80 MBytes 95.4 Mbits/sec
-----
[ ID] Interval      Transfer    Bitrate
[ 7]  0.00-10.33   sec    102 MBytes 82.9 Mbits/sec
-----
receiver
```

H1

```

"Node: h1"
root@jainam-virtual-machine:/home/jainam/Desktop/FCN 3 solution/Part C# iperf3
-c 172.2.9.2 -p 4545 -t 10
Connecting to host 172.2.9.2, port 4545
[ 7] local 172.2.7.2 port 45910 connected to 172.2.9.2 port 4545
[ ID] Interval      Transfer    Bitrate      Retr  Cwnd
[ 7]  0.00-1.00    sec   1.84 MBytes  15.4 Mbits/sec    0   390 KBytes
[ 7]  1.00-2.00    sec  16.2 MBytes  136 Mbits/sec    0   2.85 MBytes
[ 7]  2.00-3.00    sec  11.2 MBytes  94.4 Mbits/sec    0   3.42 MBytes
[ 7]  3.00-4.00    sec  11.2 MBytes  94.4 Mbits/sec    4   3.68 MBytes
[ 7]  4.00-5.00    sec  11.2 MBytes  94.4 Mbits/sec    0   3.68 MBytes
[ 7]  5.00-6.00    sec  11.2 MBytes  94.4 Mbits/sec    0   3.69 MBytes
[ 7]  6.00-7.00    sec  12.5 MBytes  105 Mbits/sec    0   3.70 MBytes
[ 7]  7.00-8.00    sec  11.2 MBytes  94.4 Mbits/sec    0   3.72 MBytes
[ 7]  8.00-9.00    sec  11.2 MBytes  94.4 Mbits/sec    0   3.76 MBytes
[ 7]  9.00-10.00   sec  11.2 MBytes  94.4 Mbits/sec    0   3.82 MBytes
-----
[ ID] Interval      Transfer    Bitrate      Retr
[ 7]  0.00-10.00   sec   109 MBytes  91.6 Mbits/sec    4
[ 7]  0.00-10.33   sec   102 MBytes  82.9 Mbits/sec
sender
receiver

iperf Done.

```

RTT

Command used - *H1 ping h2 -c 10*

```

mininet> h1 ping h2 -c 10
PING 172.2.9.2 (172.2.9.2) 56(84) bytes of data:
64 bytes from 172.2.9.2: icmp_seq=1 ttl=61 time=181 ms
64 bytes from 172.2.9.2: icmp_seq=2 ttl=61 time=183 ms
64 bytes from 172.2.9.2: icmp_seq=3 ttl=61 time=183 ms
64 bytes from 172.2.9.2: icmp_seq=4 ttl=61 time=185 ms
64 bytes from 172.2.9.2: icmp_seq=5 ttl=61 time=186 ms
64 bytes from 172.2.9.2: icmp_seq=6 ttl=61 time=184 ms
64 bytes from 172.2.9.2: icmp_seq=7 ttl=61 time=184 ms
64 bytes from 172.2.9.2: icmp_seq=8 ttl=61 time=185 ms
64 bytes from 172.2.9.2: icmp_seq=9 ttl=61 time=184 ms
64 bytes from 172.2.9.2: icmp_seq=10 ttl=61 time=185 ms

--- 172.2.9.2 ping statistics ---
10 packets transmitted, 10 received, 0% packet loss, time 9013ms
rtt min/avg/max/mdev = 181.211/184.032/185.996/1.269 ms

```

Created a client1.json

```

    },
    "end": {
      "streams": [{
        "sender": {
          "socket": 7,
          "start": 0,
          "end": 10.000317,
          "seconds": 10.000317,
          "bytes": 110755840,
          "bits_per_second": 91601863.3209327,
          "retransmits": 4,
          "max_snd_cwnd": 7147328,
          "max_snd_wnd": 8387584,
          "max_rtt": 602676,
          "min_rtt": 181534,
          "mean_rtt": 400517,
          "sender": true
        },
        "receiver": {
          "socket": 7,
          "start": 0,
          "end": 10.382661,
          "seconds": 10.000317
        }
      ]
    }
  }
}

```

Explanation:

Here I take the bits_per_second and mean_rtt values

$BDP = \text{Average Bandwidth} * \text{Average RTT} = 91601863.320937 * 400517 / 1000000 \text{ bits} = 4.586\text{mb}$.

Here is buffer size is 5mb. We receive 4 retransmissions as the buffer fills up since the buffer size is smaller than BDP, which results in packet loss. As expected, we see that this time around, we receive less retransmissions than we did in the previous instance. With a larger buffer, fewer packets are lost. Here, because our buffer size is higher than in previous instances, we achieve a bandwidth of 91.6 mbps. We are using the majority of our 100 mbps maximum bandwidth.

Scenario 3 – Buffer Size 25mb

Command used – *xterm h1 h2*

H2


```
"Node: h2"
-----
Server listening on 4545 (test #1)
-----
Accepted connection from 172.2.7.2, port 35674
[ 7] local 172.2.9.2 port 4545 connected to 172.2.7.2 port 35686
[ ID] Interval          Transfer    Bitrate
[ 7] 0.00-1.00    sec      376 KBytes  3.08 Mbits/sec
[ 7] 1.00-2.00    sec      6.88 MBytes  57.7 Mbits/sec
[ 7] 2.00-3.00    sec      11.4 MBytes  95.6 Mbits/sec
[ 7] 3.00-4.00    sec      11.4 MBytes  95.6 Mbits/sec
[ 7] 4.00-5.00    sec      11.4 MBytes  95.7 Mbits/sec
[ 7] 5.00-6.00    sec      11.4 MBytes  95.6 Mbits/sec
[ 7] 6.00-7.00    sec      11.4 MBytes  95.6 Mbits/sec
[ 7] 7.00-8.00    sec      11.4 MBytes  95.6 Mbits/sec
[ 7] 8.00-9.00    sec      11.4 MBytes  95.7 Mbits/sec
[ 7] 9.00-10.00   sec      11.4 MBytes  95.6 Mbits/sec
[ 7] 10.00-10.65  sec       7.37 MBytes  95.6 Mbits/sec
-----
[ ID] Interval          Transfer    Bitrate
[ 7] 0.00-10.65   sec      106 MBytes  83.4 Mbits/sec
-----
receiver
```

H1

```

"Node: h1"
root@jainam-virtual-machine:/home/jainam/Desktop/FCN 3 solution/Part C# iperf3
-c 172.2.9.2 -p 4545 -t 10
Connecting to host 172.2.9.2, port 4545
[ 7] local 172.2.7.2 port 35686 connected to 172.2.9.2 port 4545
[ ID] Interval      Transfer    Bitrate      Retr  Cwnd
[ 7]  0.00-1.00    sec   2.09 MBytes  17.5 Mbits/sec    0   390 KBytes
[ 7]  1.00-2.00    sec  15.9 MBytes  134 Mbits/sec    0   2.83 MBytes
[ 7]  2.00-3.00    sec  11.2 MBytes  94.4 Mbits/sec    0   3.40 MBytes
[ 7]  3.00-4.00    sec  11.2 MBytes  94.4 Mbits/sec    0   3.97 MBytes
[ 7]  4.00-5.00    sec  11.2 MBytes  94.4 Mbits/sec    0   4.54 MBytes
[ 7]  5.00-6.00    sec  11.2 MBytes  94.4 Mbits/sec    0   5.11 MBytes
[ 7]  6.00-7.00    sec  12.5 MBytes  105 Mbits/sec    0   5.68 MBytes
[ 7]  7.00-8.00    sec  11.2 MBytes  94.4 Mbits/sec    0   6.25 MBytes
[ 7]  8.00-9.00    sec  11.2 MBytes  94.4 Mbits/sec    0   6.82 MBytes
[ 7]  9.00-10.00   sec  11.2 MBytes  94.4 Mbits/sec    0   7.39 MBytes
-----
[ ID] Interval      Transfer    Bitrate      Retr
[ 7]  0.00-10.00   sec   109 MBytes  91.6 Mbits/sec    0
[ 7]  0.00-10.65   sec   106 MBytes  83.4 Mbits/sec
sender
receiver

iperf Done.

```

RTT

Command used - *H1 ping h2 -c 10*

```

mininet> h1 ping h2 -c 10
PING 172.2.9.2 (172.2.9.2) 56(84) bytes of data:
64 bytes from 172.2.9.2: icmp_seq=1 ttl=61 time=181 ms
64 bytes from 172.2.9.2: icmp_seq=2 ttl=61 time=183 ms
64 bytes from 172.2.9.2: icmp_seq=3 ttl=61 time=183 ms
64 bytes from 172.2.9.2: icmp_seq=4 ttl=61 time=186 ms
64 bytes from 172.2.9.2: icmp_seq=5 ttl=61 time=185 ms
64 bytes from 172.2.9.2: icmp_seq=6 ttl=61 time=184 ms
64 bytes from 172.2.9.2: icmp_seq=7 ttl=61 time=184 ms
64 bytes from 172.2.9.2: icmp_seq=8 ttl=61 time=185 ms
64 bytes from 172.2.9.2: icmp_seq=9 ttl=61 time=186 ms
64 bytes from 172.2.9.2: icmp_seq=10 ttl=61 time=184 ms

--- 172.2.9.2 ping statistics ---
10 packets transmitted, 10 received, 0% packet loss, time 9016ms
rtt min/avg/max/mdev = 181.181/184.139/185.919/1.293 ms

```

Created a client.json


```

"end": {
  "streams": [{
    "sender": {
      "socket": 7,
      "start": 0,
      "end": 10.000122,
      "seconds": 10.000122,
      "bytes": 114556928,
      "bits_per_second": 91644424.3380231,
      "retransmits": 0,
      "max_snd_cwnd": 5904944,
      "max_snd_wnd": 8388608,
      "max_rtt": 492745,
      "min_rtt": 183725,
      "mean_rtt": 378451,
      "sender": true
    },
    "receiver": {
      "socket": 7,
      "start": 0,
      "end": 10.494545,
      "seconds": 10.000122,

```

Explanation

Here I take the `bits_per_second` and `mean_rtt` values

$BDP = \text{Average Bandwidth} * \text{Average RTT} = 91644424.3380231 * 378451 / 1000000 \text{ bits} = 4.335\text{mb}$.

Here is buffer size is 25mb. Since the buffer size exceeds BDP, there is no packet loss and no retransmission, which is what was anticipated. Here, because our buffer size is higher than in previous instances, we achieve a bandwidth of 91.6 mbps. We are using the majority of our 100 mbps maximum bandwidth. We can see that the bandwidth in this situation and the one before is nearly identical.