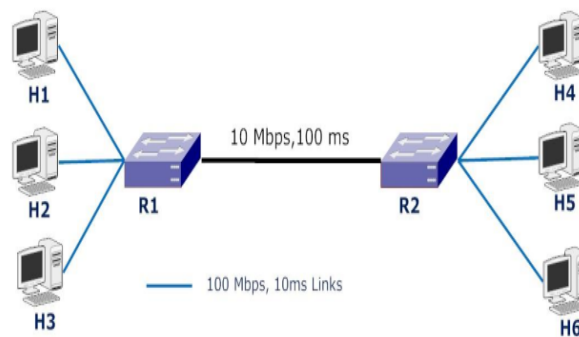


**CS342 LAB ASSIGNMENT - 4**  
**NETWORK SIMULATION USING NS3**  
**GROUP 33**

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**NETWORK TOPOLOGY**



We have 4 TCP Reno Flows and 2 UDP Flows.

**TCP Flows-**

1. Host 4 to Host 5 (TCP1)
2. Host 1 to Host 5 (TCP2)
3. Host 4 to Host 6 (TCP3)
4. Host 1 to Host 6 (TCP4)

**UDP Flows-**

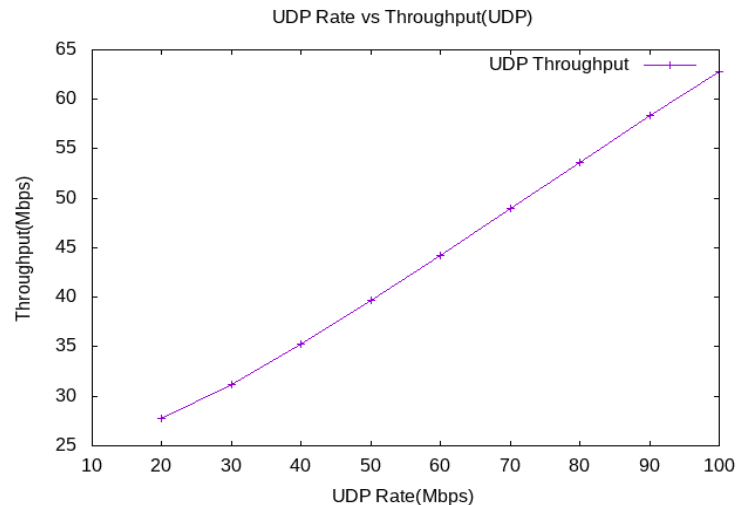
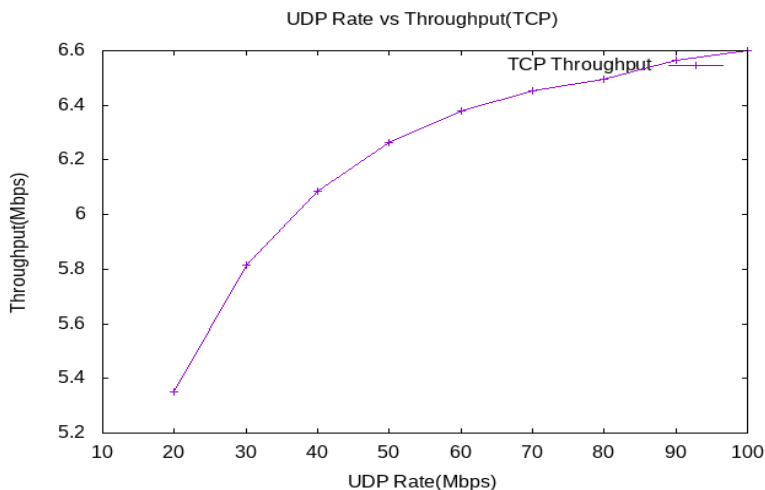
1. Host 4 to Host 1 (UDP1)
2. Host 2 to Host 3 (UDP2)

Given in the question

- Here we have 2 routers R1 and R2 connected by a 10 Mbps, 100 ms link.
- Dumbbell topology is followed with all links with 100 Mbps, 10 ms.
- R1 and R2 use drop-tail queues with equal queue size set according to bandwidth-delay product.
- We have a packet size of 1500 Bytes.

## UDP RATE vs THROUGHPUT:

All the connections have an initial data rate of 20 Mbps and later, keeping the buffer size constant, we have increased the rate of one UDP connection to 100 Mbps linearly incrementing 10Mbps per second.



### FOR TCP:-

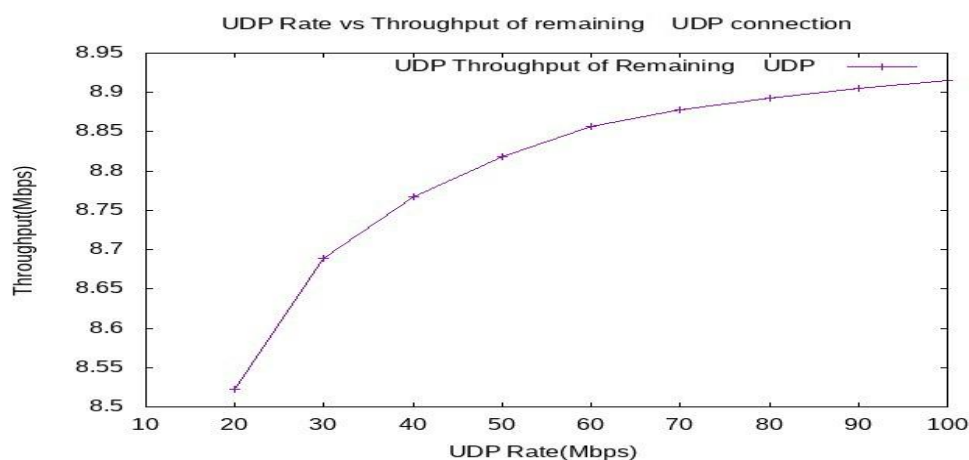
From the above left graph we see the effect of increasing UDP rate of UDP2 connection (H2 to H3) on the total TCP throughput of 4 TCP connections.

As the UDP rate is increased, the shared link is getting more and more occupied by UDP packets and hence the rate of increase of TCP throughput decreases.

### FOR UDP:-

From the above right graph we see the effect of increasing UDP rate of UDP2 connection (H2 to H3) on the total UDP throughput of the two UDP connections.

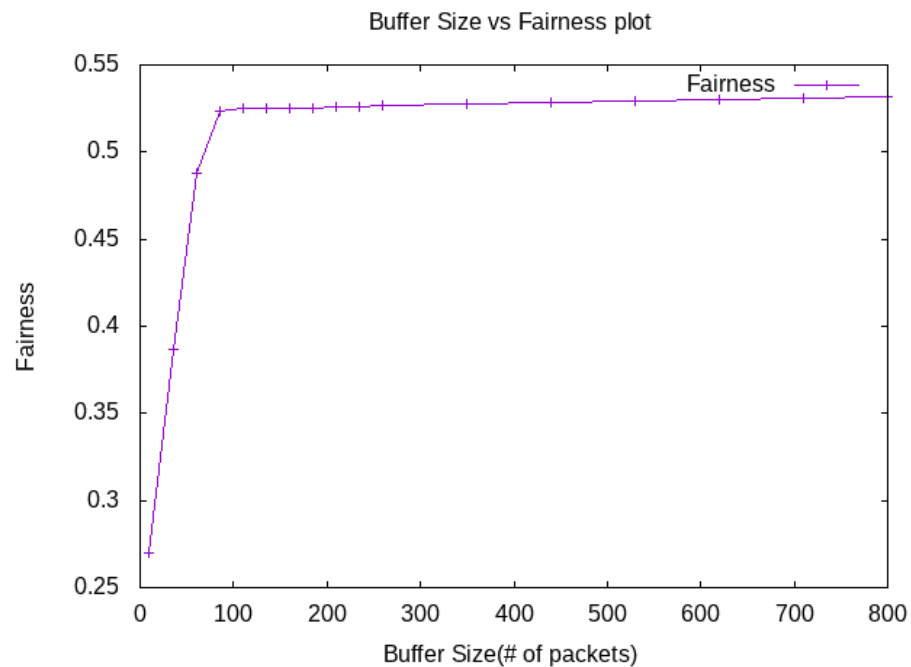
As the UDP rate of flow number 6 increases linearly with time, the overall UDP Throughput of both UDP connections also increases linearly as expected.



The above graph depicts the UDP throughput from the UDP1 connection as a function of the UDP rate of UDP2. We observe that this is similar to the case of TCP explained above. With the increasing UDP rate of UDP2, the shared link is occupied more by UDP2 connection. Hence, the rate of increase of UDP throughput from UDP1 connection decreases.

## BUFFER SIZE VS FAIRNESS

$$\text{Fairness Index} = \frac{(\sum_1^6 T_{put})^2}{6 * \sum_1^6 T_{put}^2}$$

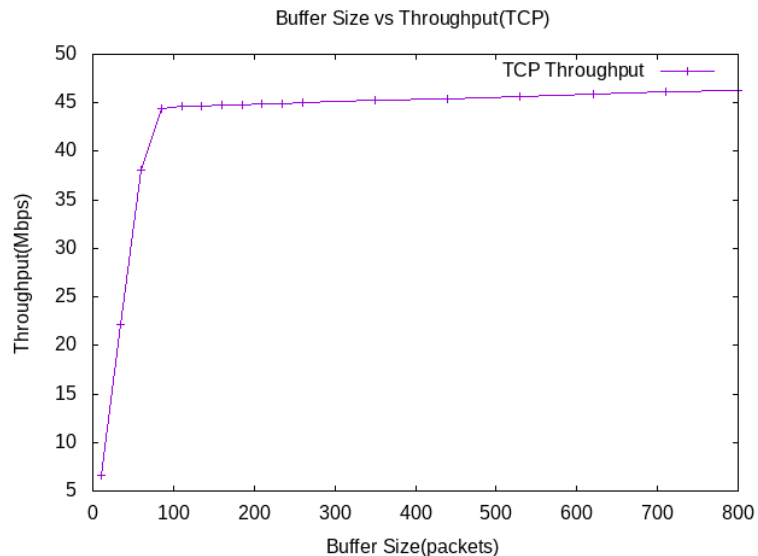


We observe that as buffer size increases, the fairness index increases, and then the fairness index settles at a constant value.

This is because the throughput of each connection is limited by the link bandwidth and thus it can't increase further.

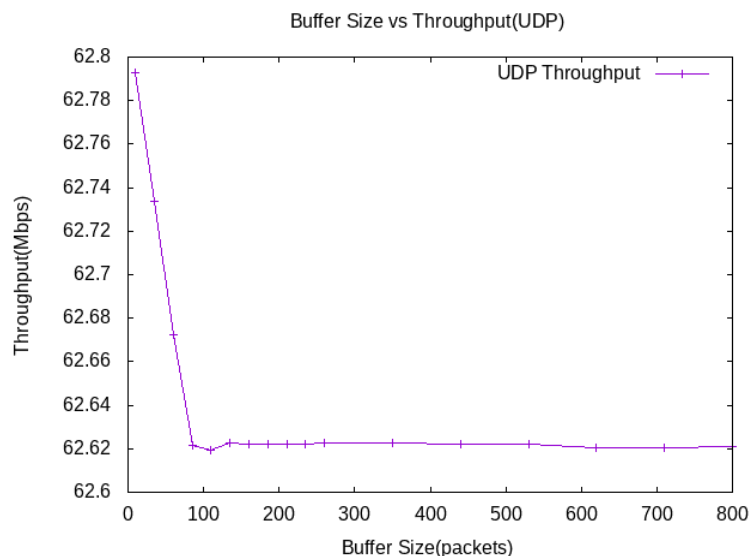
## BUFFER SIZE VS THROUGHPUT

### TCP :

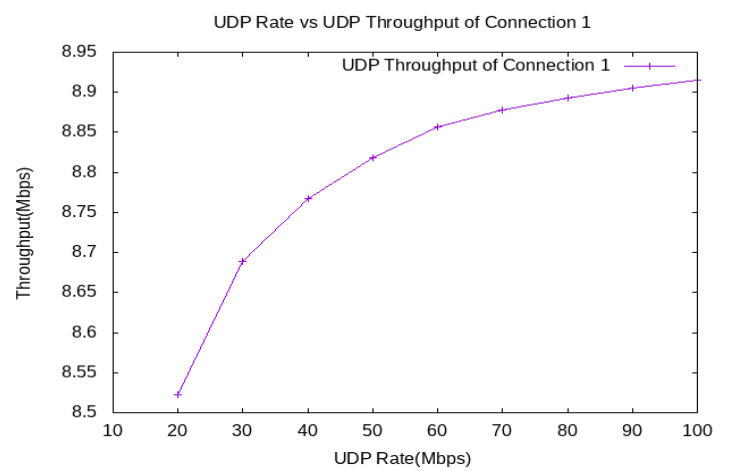
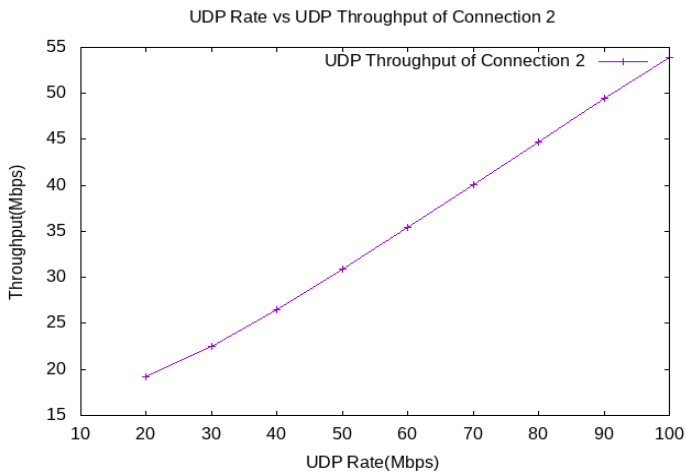
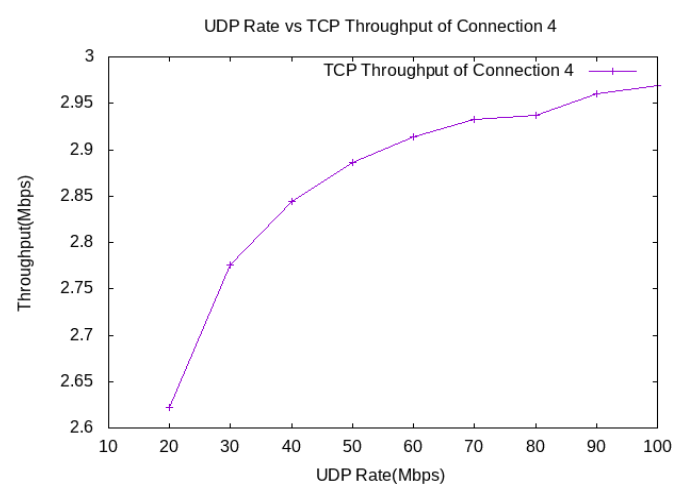
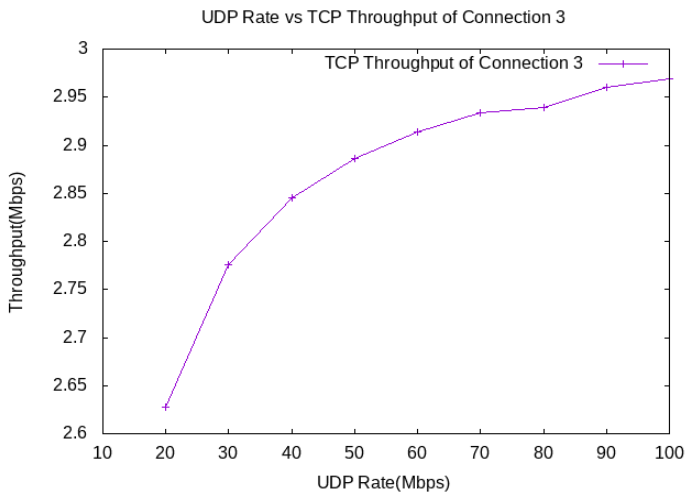
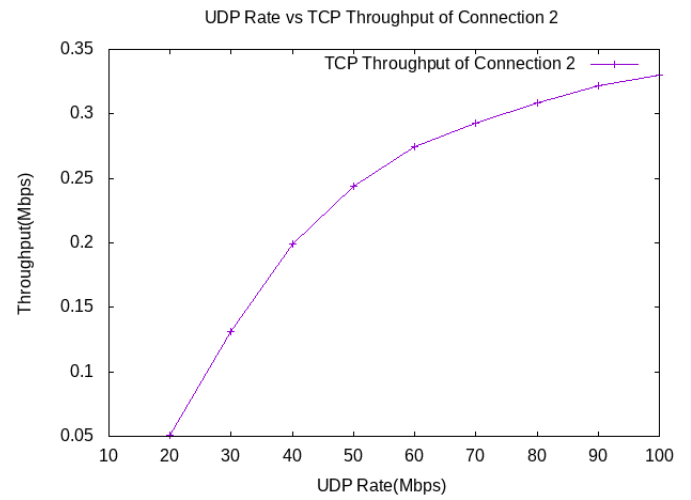
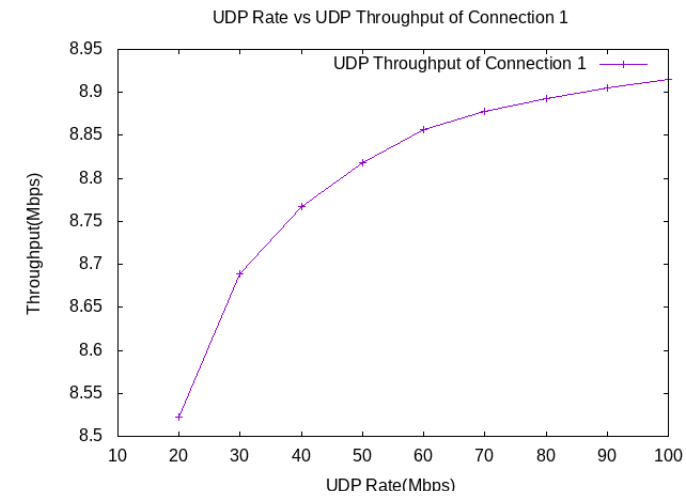


From this graph, we can observe that when buffer size is less, throughput is low as there are too many packets contending for the queue buffer due to less buffer size. This results in delays and dropping of packets. But as the buffer size increases, TCP throughput increases, and then saturates.

### UDP :



We can observe from the above graph, UDP throughput decreases as the buffer size is increased, and then it remains constant after the buffer size of 100 packets is reached. Hence, the increase in buffer size has no effect on the UDP throughput.



```
rishi@rishi: ~/Desktop/ns-allinone-3.31/ns-3.31
Buffer Size: 10packets,      Fairness Index: 0.269903,      TCP Throughput: 6.59993,      UDP Throughput: 62.7928
^CInterrupted
rishi@rishi:~/Desktop/ns-allinone-3.31/ns-3.31$ ./waf --run scratch/source_code
Waf: Entering directory `/home/rishi/Desktop/ns-allinone-3.31/ns-3.31/build'
[2350/2402] Compiling scratch/source_code.cc
[2363/2402] Linking build/scratch/source_code
Waf: Leaving directory `/home/rishi/Desktop/ns-allinone-3.31/ns-3.31/build'
Build commands will be stored in build/compile_commands.json
'build' finished successfully (3.357s)

UDP Data Rate: 20Mbps,      TCP Throughput: 5.35104,      UDP Throughput: 27.7611,      Remaining UDP Throughput: 8.52244
UDP Data Rate: 30Mbps,      TCP Throughput: 5.8143,      UDP Throughput: 31.1618,      Remaining UDP Throughput: 8.68845
UDP Data Rate: 40Mbps,      TCP Throughput: 6.08482,      UDP Throughput: 35.2869,      Remaining UDP Throughput: 8.76739
UDP Data Rate: 50Mbps,      TCP Throughput: 6.26174,      UDP Throughput: 39.7087,      Remaining UDP Throughput: 8.81796
UDP Data Rate: 60Mbps,      TCP Throughput: 6.37769,      UDP Throughput: 44.2811,      Remaining UDP Throughput: 8.85708
UDP Data Rate: 70Mbps,      TCP Throughput: 6.45425,      UDP Throughput: 48.927,      Remaining UDP Throughput: 8.87729
UDP Data Rate: 80Mbps,      TCP Throughput: 6.49562,      UDP Throughput: 53.6266,      Remaining UDP Throughput: 8.89283
UDP Data Rate: 90Mbps,      TCP Throughput: 6.56466,      UDP Throughput: 58.3617,      Remaining UDP Throughput: 8.9056
UDP Data Rate: 100Mbps,     TCP Throughput: 6.59993,      UDP Throughput: 62.7928,      Remaining UDP Throughput: 8.91497
Buffer Size: 10packets,     Fairness Index: 0.269903,     TCP Throughput: 6.59993,     UDP Throughput: 62.7928
Buffer Size: 35packets,     Fairness Index: 0.386456,     TCP Throughput: 22.1996,     UDP Throughput: 62.7336
Buffer Size: 60packets,     Fairness Index: 0.487859,     TCP Throughput: 38.1136,     UDP Throughput: 62.6721
Buffer Size: 85packets,     Fairness Index: 0.523123,     TCP Throughput: 44.4042,     UDP Throughput: 62.6217
Buffer Size: 110packets,    Fairness Index: 0.524746,     TCP Throughput: 44.6173,     UDP Throughput: 62.6199
Buffer Size: 135packets,    Fairness Index: 0.525126,     TCP Throughput: 44.689,      UDP Throughput: 62.622
Buffer Size: 160packets,    Fairness Index: 0.525269,     TCP Throughput: 44.7377,     UDP Throughput: 62.6206
Buffer Size: 185packets,    Fairness Index: 0.525536,     TCP Throughput: 44.7991,     UDP Throughput: 62.6206
Buffer Size: 210packets,    Fairness Index: 0.525803,     TCP Throughput: 44.8606,     UDP Throughput: 62.6206
Buffer Size: 235packets,    Fairness Index: 0.52607,      TCP Throughput: 44.9221,     UDP Throughput: 62.6206
Buffer Size: 260packets,    Fairness Index: 0.526459,     TCP Throughput: 44.996,      UDP Throughput: 62.622
Buffer Size: 350packets,    Fairness Index: 0.527413,     TCP Throughput: 45.2172,     UDP Throughput: 62.622
Buffer Size: 440packets,    Fairness Index: 0.528236,     TCP Throughput: 45.4259,     UDP Throughput: 62.6206
Buffer Size: 530packets,    Fairness Index: 0.529176,     TCP Throughput: 45.6471,     UDP Throughput: 62.6206
Buffer Size: 620packets,    Fairness Index: 0.530136,     TCP Throughput: 45.8717,     UDP Throughput: 62.6205
Buffer Size: 710packets,    Fairness Index: 0.531062,     TCP Throughput: 46.0928,     UDP Throughput: 62.6205
Buffer Size: 800packets,    Fairness Index: 0.531967,     TCP Throughput: 46.312,      UDP Throughput: 62.6195
rishi@rishi:~/Desktop/ns-allinone-3.31/ns-3.31$
```