CS 342: Networks Lab - Assignment: 4

APPLICATION – 4

Group – G29

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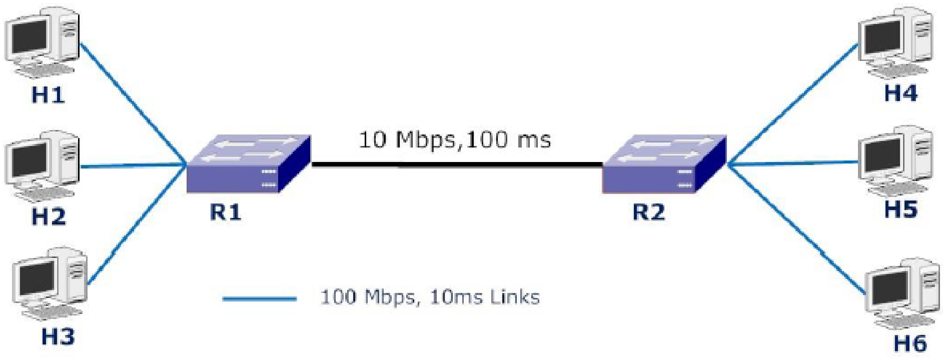
1 NETWORK CONFIGURATION -



- Following network connections are created among the hosts –

1. **TCP New Reno:**
   a. H1 and H4
   b. H2 and H5
   c. H3 and H6
   d. H1 and H2
2. **CBR over UDP:**
   a. H2 and H6
   b. H3 and H4

As specified in the question, drop-tail queues are used with size set equal to bandwidth-delay product.

Bandwidth-delay product = (Link capacity of the channel) * (Round-trip delay time of the transmission)
= 10 Mbps * 100 ms
= 85 p *(p = packet size)*

Packet size = 1.5KB

- The simulation runs for a total of 76 seconds for a fixed buffer size. The TCP flows start at t = 0 sec, while UDP flows start at t = 30 sec.

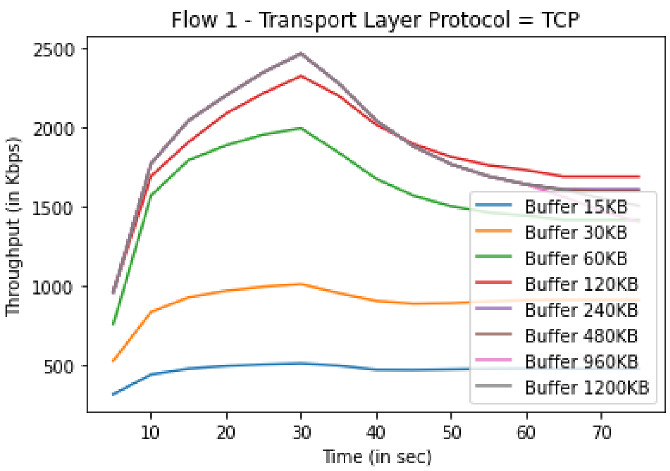
- The rate of one of the UDP flow (**flow id = 9**) increases from 20 Mbps to 100 Mbps. At an interval of 5 seconds, the rate increases by 10 Mbps.
- The statistics of the network is observed at every 5 seconds interval and data is recorded in the .txt files.
- Since each TCP connections consist of 2 flows while UDP connection is a single flow, there are 10 flows (= 4*2 + 2) in total.
- Following table summarises this:

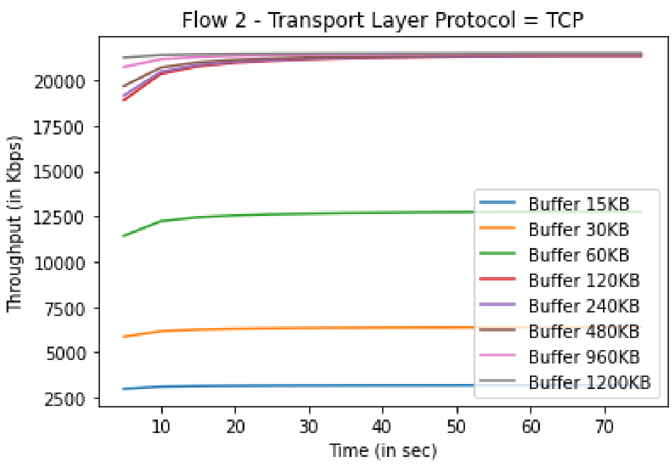
Flow ID	Transport Layer	Source	Destination
1	TCP	H1	H4
2	TCP	H1	H2
3	TCP	H2	H5
4	TCP	H3	H6
5	TCP	H2	H1
6	TCP	H4	H1
7	TCP	H5	H2
8	TCP	H6	H3
9	UDP	H2	H6
10	UDP	H3	H4

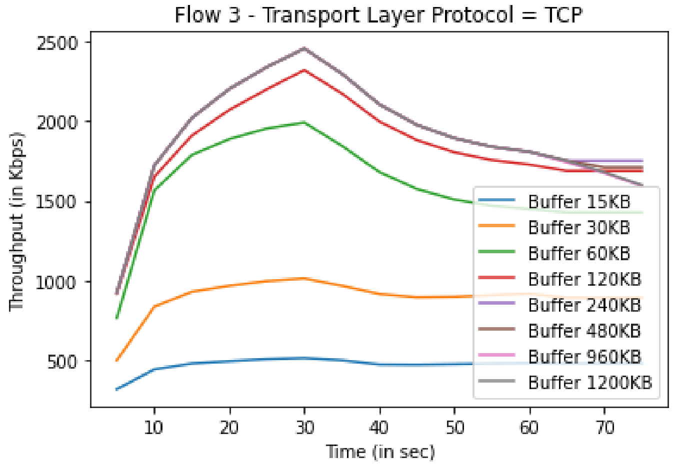
- The buffer size at the nodes is varied from 10 packets to 800 packets. Since each packet is of 1.5KB, this means variation is from 15 KB to 1200 KB. In every next iteration, we are doubling the buffer size (except for the last one) for ease of understanding and data collection.

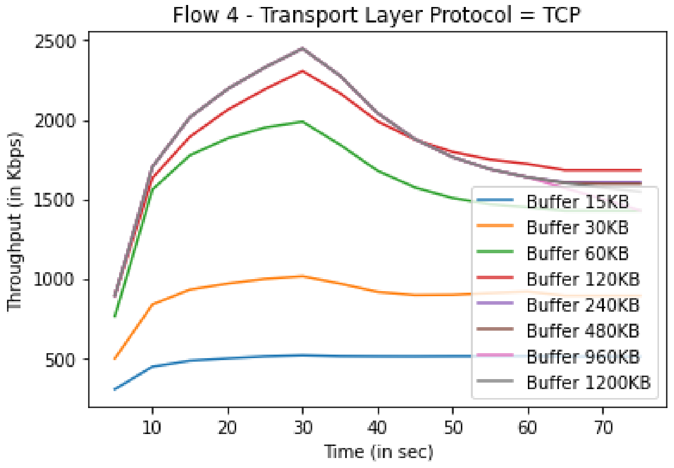
2 Impact of Buffer size & changing UDP flow rate on the Throughput of the TCP flows

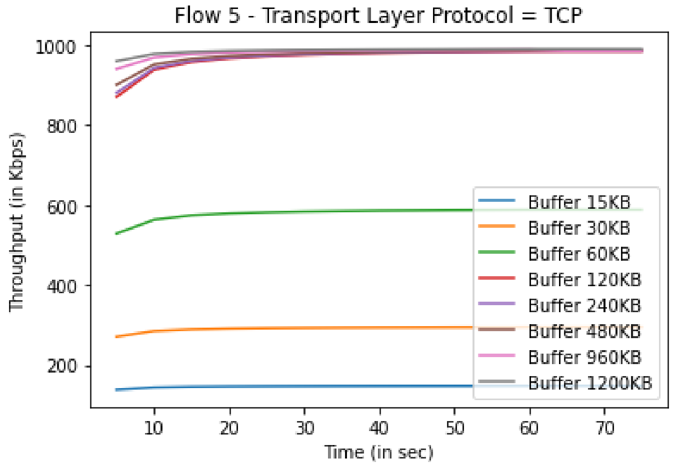
- The various plots are:

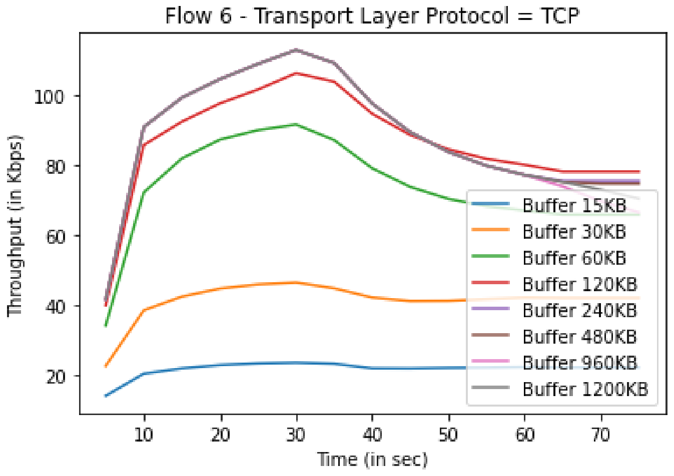


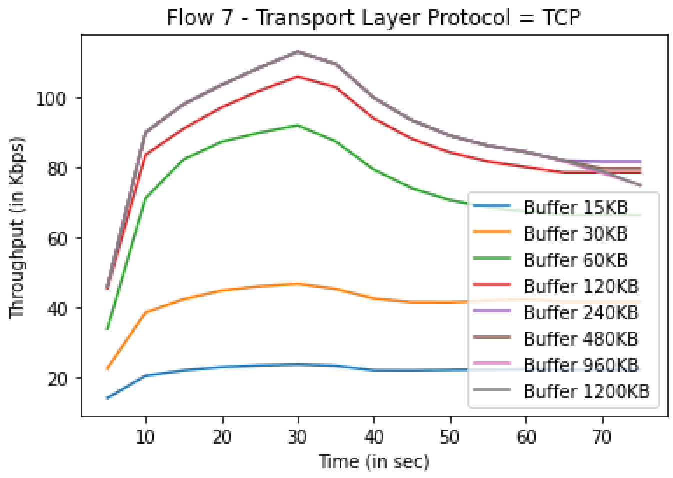


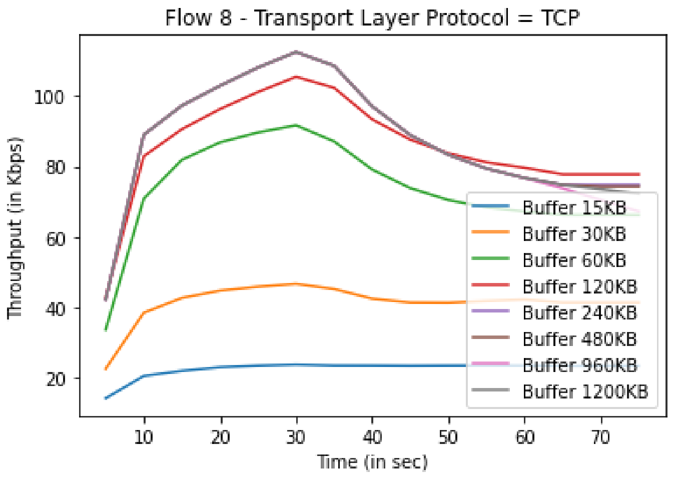

Flow 3 - Transport Layer Protocol = TCP
Throughput (in Kbps)
Time (in sec)
Buffer 15KB
Buffer 30KB
Buffer 60KB
Buffer 120KB
Buffer 240KB
Buffer 480KB
Buffer 960KB
Buffer 1200KB


Flow 4 - Transport Layer Protocol = TCP
Throughput (in Kbps)
Time (in sec)
Buffer 15KB
Buffer 30KB
Buffer 60KB
Buffer 120KB
Buffer 240KB
Buffer 480KB
Buffer 960KB
Buffer 1200KB


Flow 5 - Transport Layer Protocol = TCP
Throughput (in Kbps)
Time (in sec)
Buffer 15KB
Buffer 30KB
Buffer 60KB
Buffer 120KB
Buffer 240KB
Buffer 480KB
Buffer 960KB
Buffer 1200KB


Flow 6 - Transport Layer Protocol = TCP
Throughput (in Kbps)
Time (in sec)
Buffer 15KB
Buffer 30KB
Buffer 60KB
Buffer 120KB
Buffer 240KB
Buffer 480KB
Buffer 960KB
Buffer 1200KB


Flow 7 - Transport Layer Protocol = TCP
Throughput (in Kbps)
Time (in sec)
Buffer 15KB
Buffer 30KB
Buffer 60KB
Buffer 120KB
Buffer 240KB
Buffer 480KB
Buffer 960KB
Buffer 1200KB

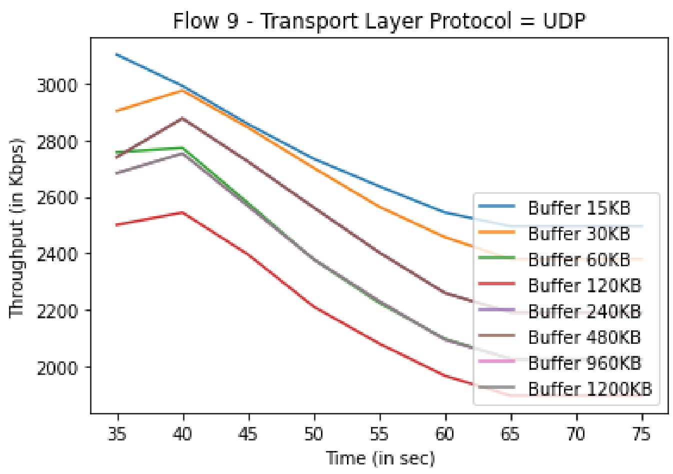

Flow 8 - Transport Layer Protocol = TCP
Throughput (in Kbps)
Time (in sec)
Buffer 15KB
Buffer 30KB
Buffer 60KB
Buffer 120KB
Buffer 240KB
Buffer 480KB
Buffer 960KB
Buffer 1200KB

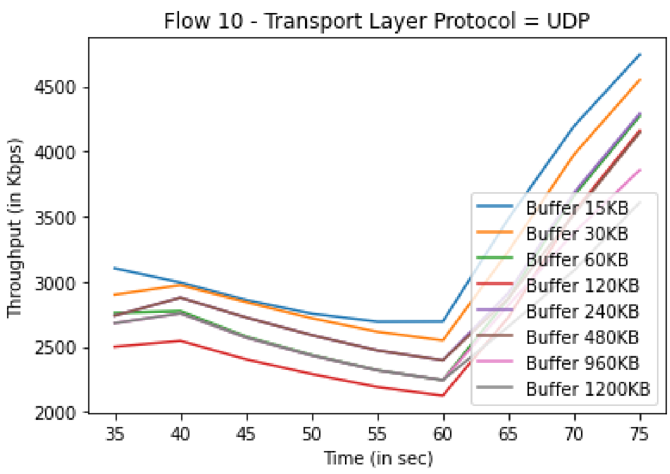
Observations and Analysis:

- One of the TCP connection is within the same local network (between H1 and H2), and rest 3 are across the networks (via 2 routers).
- For the connections within the same network (across H1 and H2), the throughput of the respective flows was observed to be larger than that of other flows. We can clearly see that for flow with flow id = 2 and flow id = 5, the throughput is higher than the other ones. This is because packets need not travel across the congested bottleneck link in this scenario.
- As the time progresses, the throughput of each of the flows continue to increase. But when at t = 30 sec, the UDP flows are initiated, the throughput decreases slightly and attains an almost constant value as the simulation progresses.
- This drop in throughput was found to be quite low for the flow 2 and flow 5. This behaviour may be given to the fact that the packets in these flows didn't have to cross the bottleneck link between the 2 routers, which has become quite congested due to the increasing UDP flows.
- Across the buffer size, the throughput values experience increase as the buffer size is increased. But this increase is not linear because the rate of increase slows down as the buffer size increases. We can see clearly that when the buffer size is around 480KB – 1200 KB, the plots overlap. This can be attributed to the fact that the throughput values have reached saturation with respect to buffer size, and further increase in buffer size does not considerably affect the throughput. This observation holds true for all the flows.
- Flow 5, 6, 7 and 8 are initiated by destination host. We can observe that the throughput of these flows are comparatively less than the flows generated by their respective source host of the TCP connection.

3 Impact of Buffer size & changing UDP flow rate on the throughput of the UDP flows

- The various plots are:



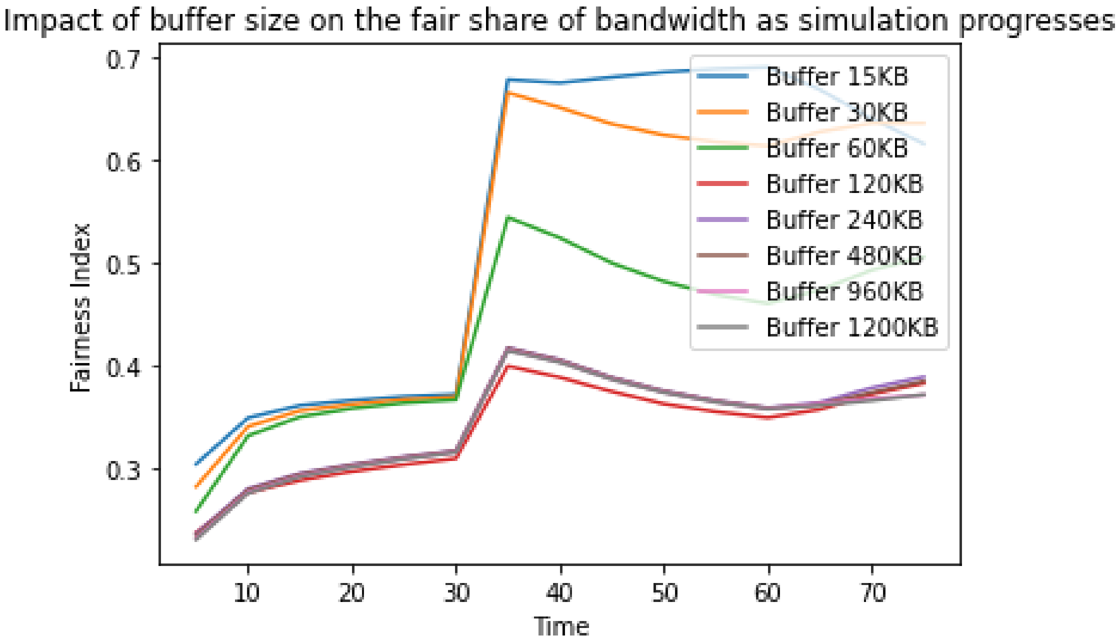


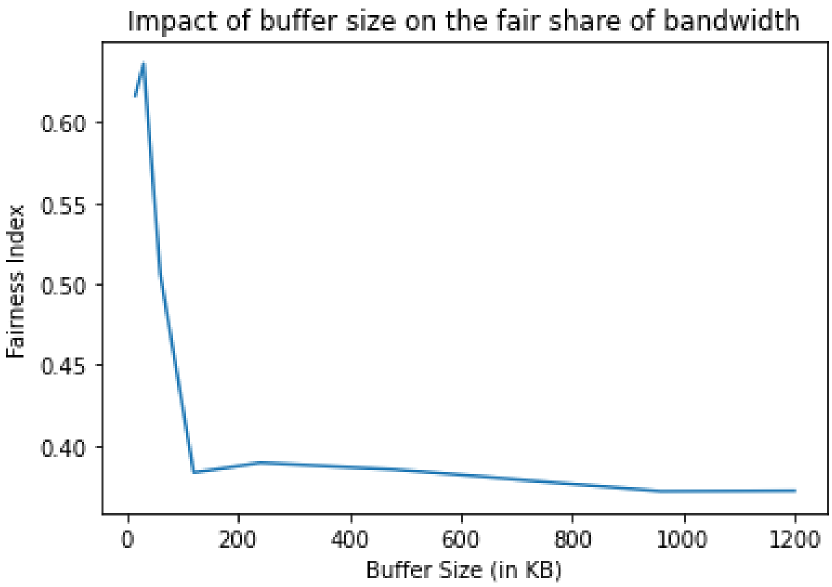
Observations and Analysis:

- **Flow 9** is the UDP flow whose flow rate is increased uniformly at every 5 seconds.
- As we can see that as the flow rate increases, the throughput decreases and this rate of decreases of throughput becomes less and less as the time passes. Ultimately, the throughput stagnates around 2000 – 2400 Kbps. This range of values matches with the throughput of the TCP flows which are generated by the host of the TCP connection, and are across the routers (i.e., flow 1, 3 and 4).
- One possible explanation for this behaviour can be that as the UDP flow sends more and more packets at an increasing rate, the bottleneck link becomes congested a lot. This lead to loss of packets, and throughput values of all the flows achieve some sort of equilibrium at this point of time. The TCP congestion mechanism prevents UDP from achieving increased throughput although UDP rate is increased.
- Another interesting observation is that as the buffer size increases, the plot shifts downward until buffer size = 120 KB. Further increase on buffer size now slightly shifts the plot upward. Further increase doesn't affect the throughput much and plots begin to overlap. This observation holds true for the second plot too.
- In the plot for **Flow 10**, the nature of the curve is similar to that of Flow 9 until t = 60 sec. Beyond this point, the throughput of the Flow 10 begins to increase almost linearly. This feature of Flow 10 is strikingly different from that of Flow 9.
- Beyond t = 60 sec, on one hand throughput of Flow 9 becomes almost constant while on the other hand that of Flow 10 starts to increase linearly.

4 IMPACT OF BUFFER SIZE ON THE FAIRSHARE OF THE BANDWIDTH

- The plots are as follows:





Observations and Analysis:

- One criteria to determine the fair share of the bandwidth is **Fairness Index**.

$$\text{Fairness Index} = \frac{(\sum x_i)^2}{n \sum x_i^2}$$

where, n = no of flows across the bottleneck link

X_i = Throughput of the i^{th} flow

- The **first plot** captures the fairness index at each point of the simulation, and we repeat this process for various buffer sizes.
- So, we can observe that fairness index increases as the time increases when there are only TCP flows in the network. But this rate of increase decreases with time until t = 30 sec. This variation is because TCP throughput increases during this time.
- At t = 30 sec, UDP flows are initiated in the network, and the fairness index takes a steep increase. But as the rate of UDP flow increases, the bottleneck becomes more and more congested. Due to this, the fairness index decreases a bit and show no sharp changes for the rest time of the simulation.
- The **second plot** specifically shows the behaviour of fairness index with the buffer size. For this plot, the fairness index at t = 75 sec is collected for various buffer sizes and plotted suitably.
- The plot starts at sufficiently high value. It then increases for some point of time and takes a steep downward turn when the buffer size is further increased. As the buffer size is increased more and more, the fairness index stagnates without much deviation. It stays at a low value of about 0.4.
- This small rise in value of fairness index can be attributed to the fact that the throughput of TCP connection initially increases with buffer size, and then becomes almost constant. Also, since throughput of UDP flow decreases when buffer size increases, this trend dominates at buffer size of around 100 – 200 KB. As a result, after initial rise, we observe a fall in the value of fairness index. Since when buffer size increases to a large value, the throughput value becomes almost constant for the both flows, hence, the fairness index is almost constant at larger buffer size.