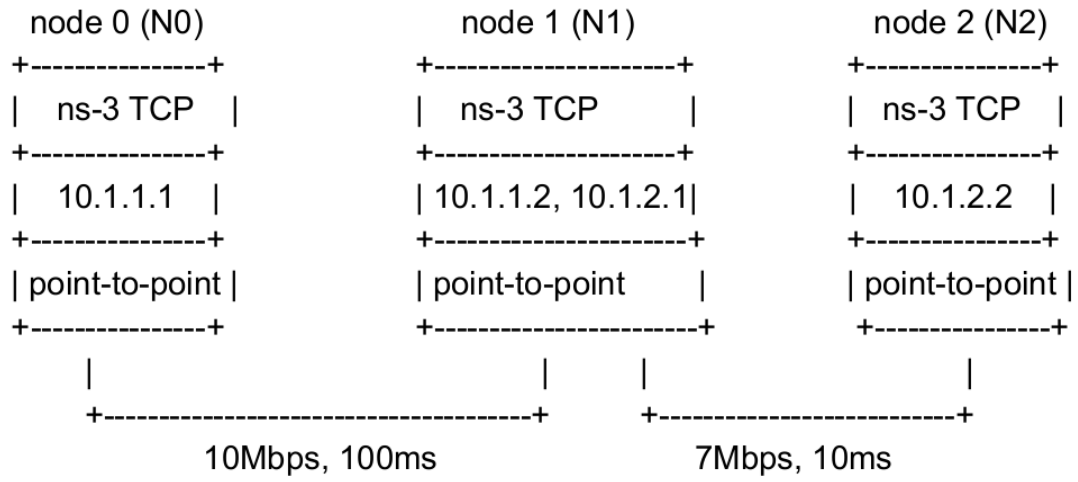
Assignment-3

Answer-1



a. The **maximum expected bandwidth is 7Mbps**. This is because the bottleneck bandwidth between the two links is 7 Mbps. Hence the net bandwidth between the two nodes is 7 Mbps.

b. Bandwidth delay product: Bandwidth delay product is defined as the bottleneck bandwidth in the network path taken(or the bandwidth observed) times the round trip time of the packet.

BDP = bandwidth * RTT

In our case:

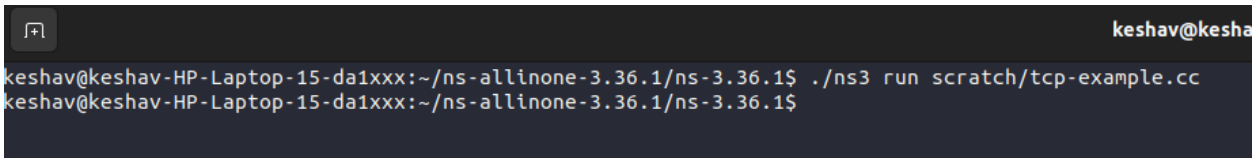
bandwidth = 7Mbps (bottleneck bandwidth)
⇒ 7 x 10^6 bits/sec
packet size is of 1460 bytes (excluding header)
⇒ 1460 * 8 bits
⇒ 11680 bits
Hence bandwidth in terms of packets = (7 x 10^6)/(11680) packets/sec
⇒ 599.31 ≈ 600 packets/sec

RTT = (100 + 10)*2 ms = 220 ms
⇒ 220/10^3 = 0.22 sec

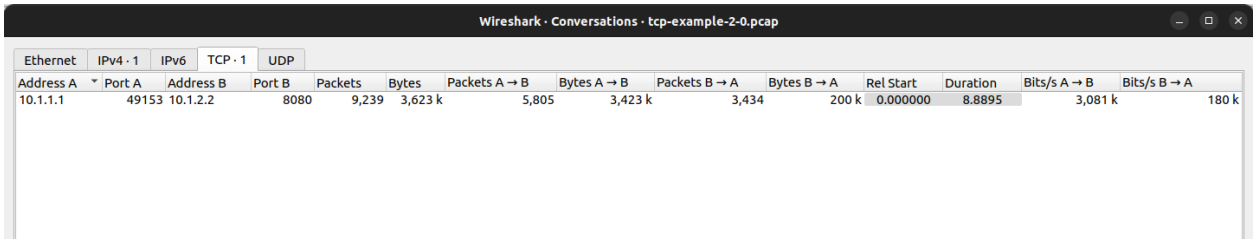
BDP = 600 * 0.22= 132 packets

c. We ran the simulation using ns3. The following was the command used to run the simulation on ns3.

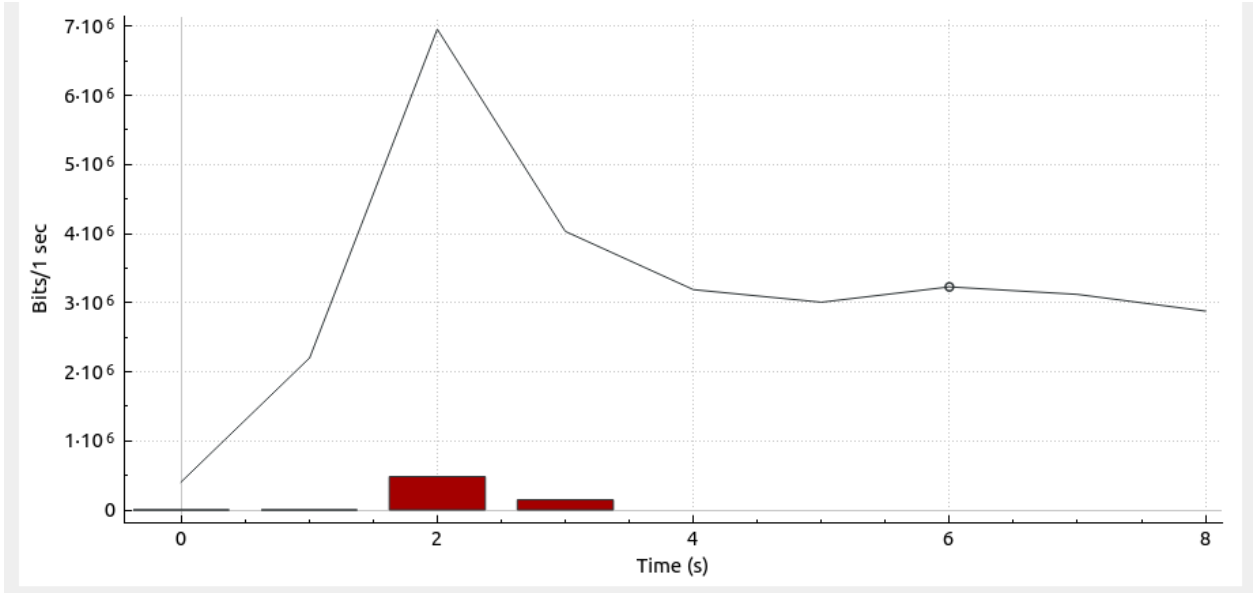
Command: ./ns3 run scratch/tcp-example.cc



The simulation gave out the 4 pcap files along with the trace file and the cwnd file denoting the congestion window. To get the average throughput/bandwidth we need to open the pcap file for the receiver that is tcp-example-2-0.pcap and use the statistics tab to get the bandwidth. Here are some results from the pcap file.

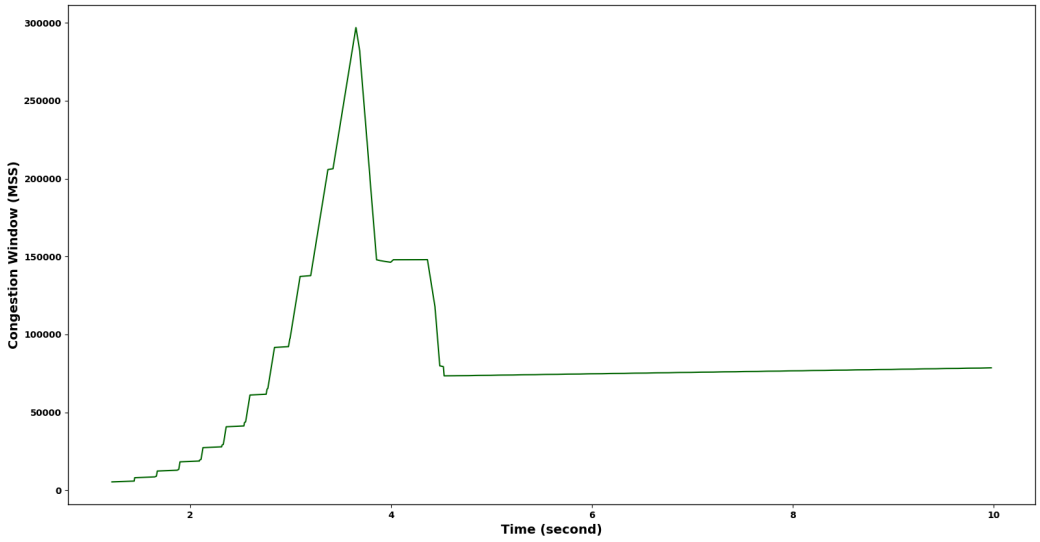


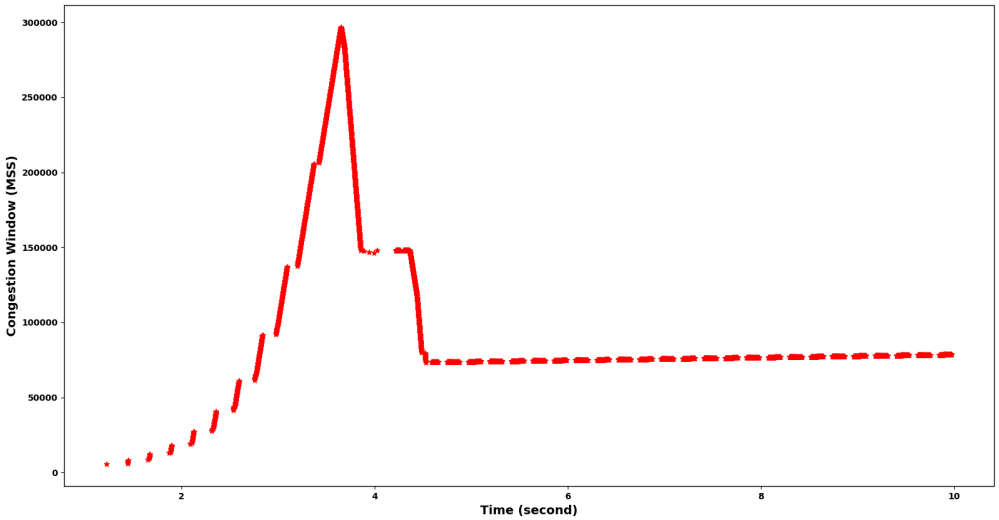
As we can see from the image the average bandwidth comes out to be 3081k bits/sec or 3.081 Mbps which is less than 7 Mbps. But once we plot the graph for the bandwidth we see that the bandwidth is reaching approximately 7Mbps at a point.



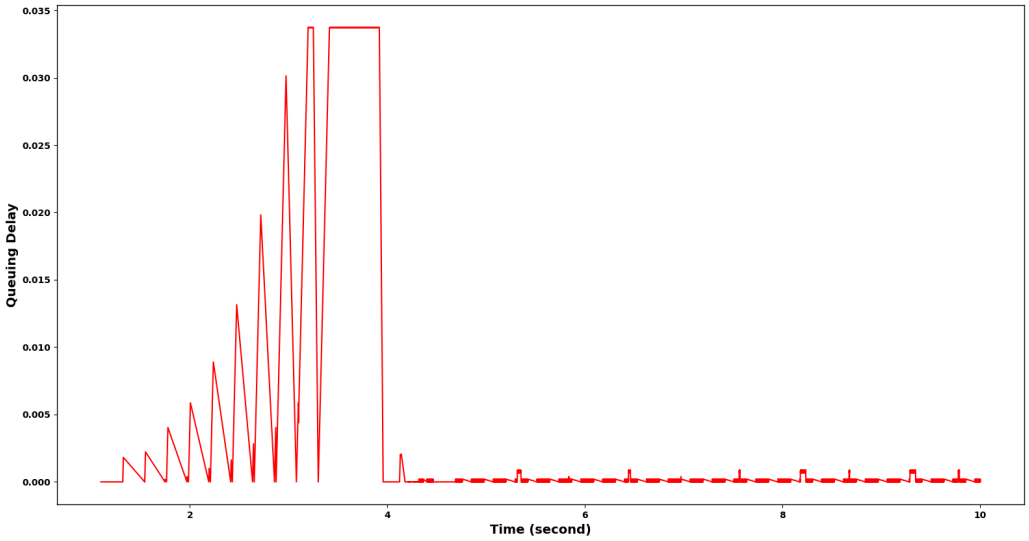
d. The achieved throughput is not equal to the maximum bandwidth expected. The reduced bandwidth is observed due to queuing delay and errors in transmission. The existence of these parameters lead to a drop in the throughput which was ideally expected to be 7 Mbps (bottleneck bandwidth) but the observed bandwidth is 3.081 Mbps

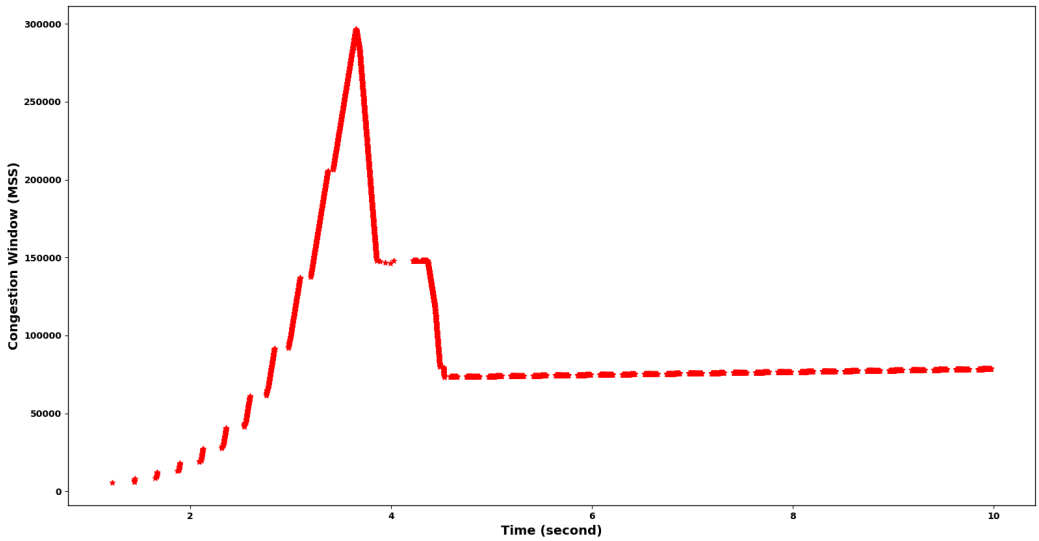
e. The congestion window with time is as follows: these graphs are generated using the tcp-example.cwnd file where the first parameter is time and the second parameter is the congestion window at that time for tcpNewReno. The first graph is a line graph showing the congestion window while the second graph a scatter plot





f. The queuing delay is obtained for Node-1 that is the router node at the NIC interface 1 that is the outgoing queue. The first graph is a line plot while the second graph is a scatter plot showing the queuing delay.



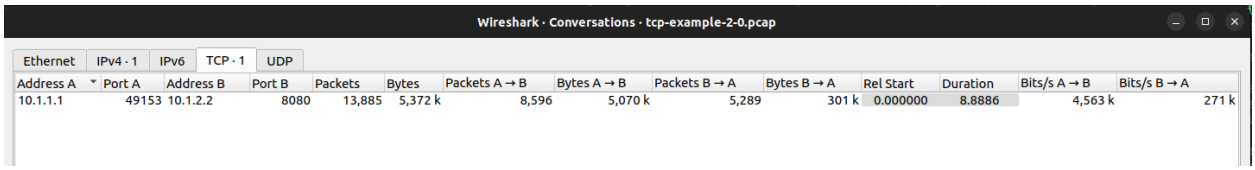


g. Both the graphs follow the same trend that is peeking between 2 and 4 and then dropping down. This trend is observed because at the start the phase is a slow start phase and then it moves to congestion avoidance phase until congestion gets too high. The second reason is that as the queues start filling the crowd more and more signals

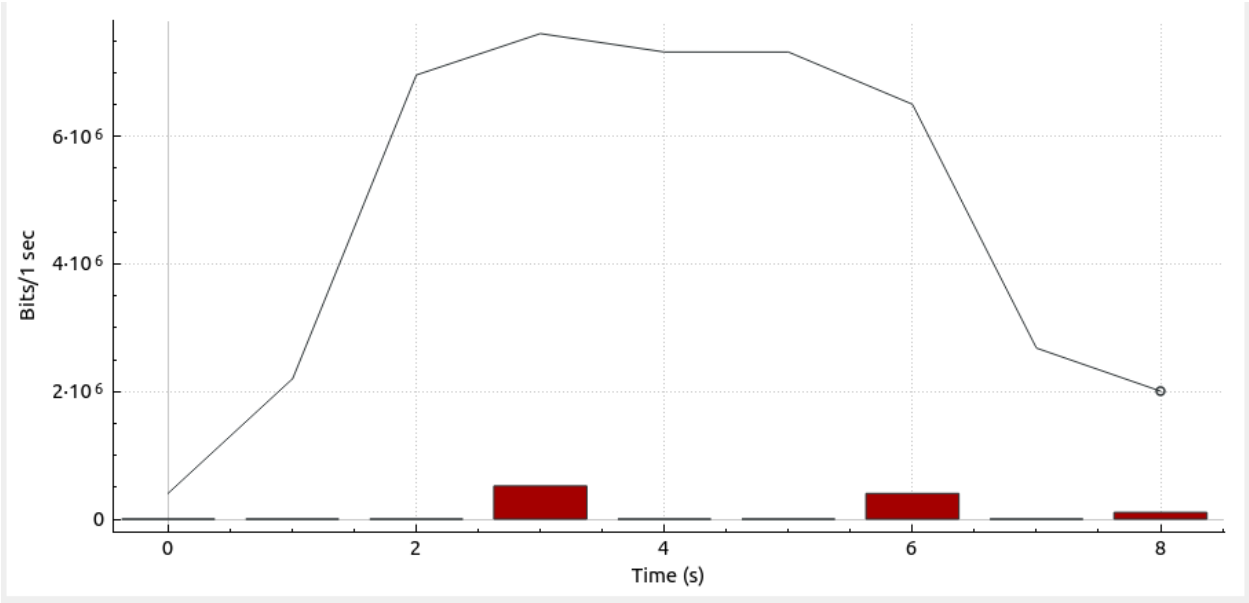
crowd. Finally no more packets fit in the queue leading to packet loss leading to retransmissions. Since we are using TCP new reno, hence fast retransmission also happens on seeing 3 dup acks.

Answer-2

a. The average computed throughput/bandwidth for queue size 1000 is 4.563bits/sec. The value is obtained in the similar manner as that in question-1 by going to the conversation tab in wireshark.

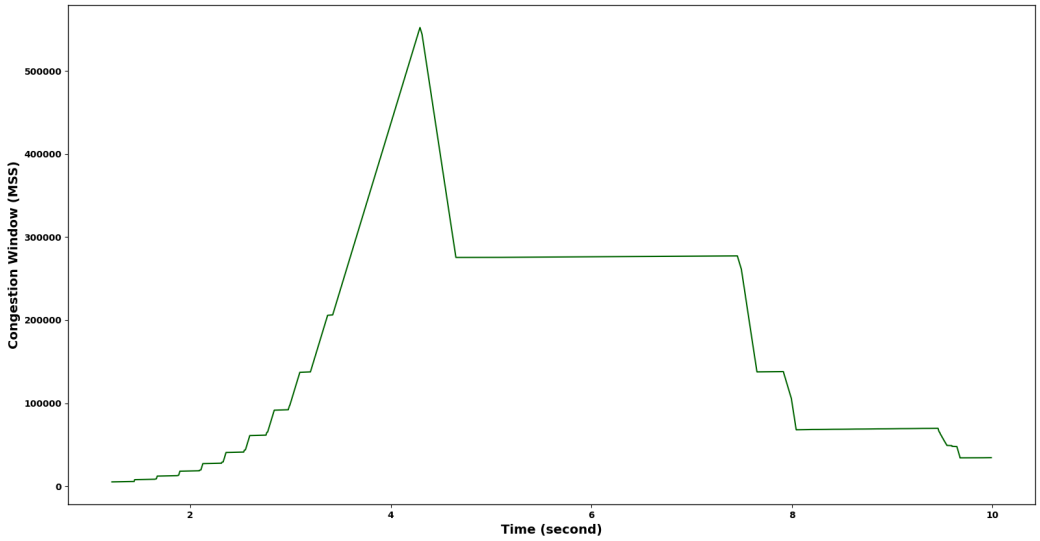


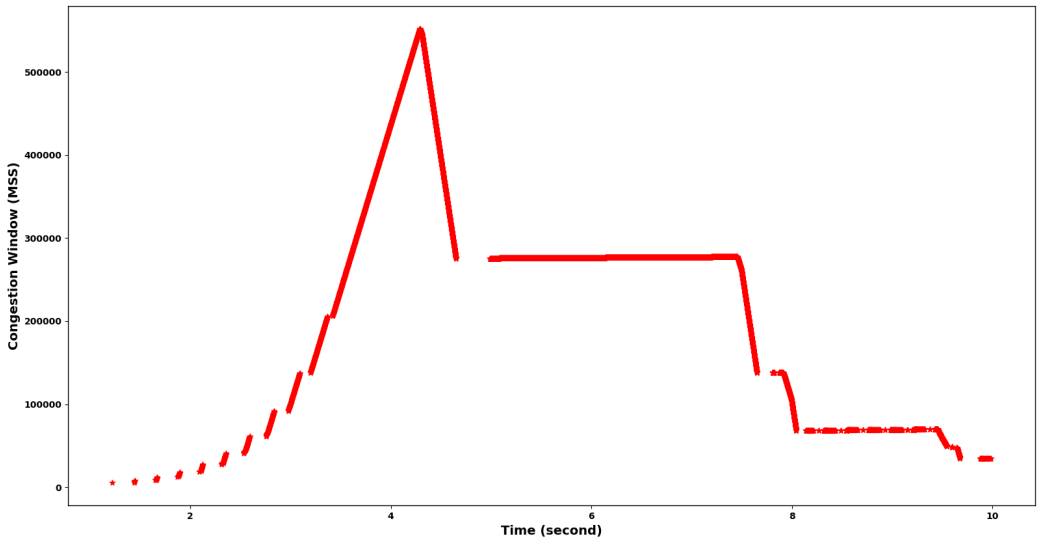
The is the average throughput but distribution of throughput is shown in the graph below



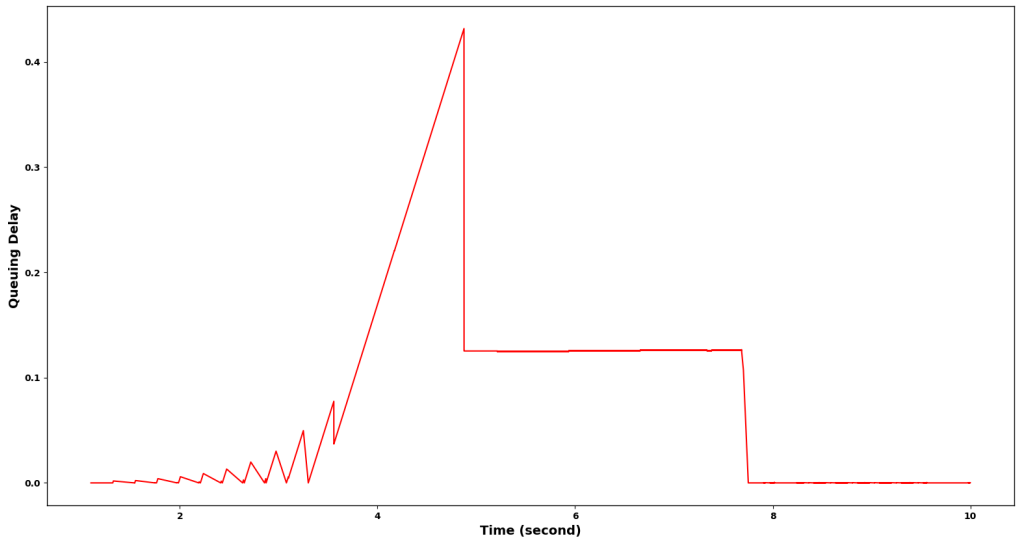
From the above graphs we can see that the throughput on increasing the queue size increases as compared to the queue size of 50.

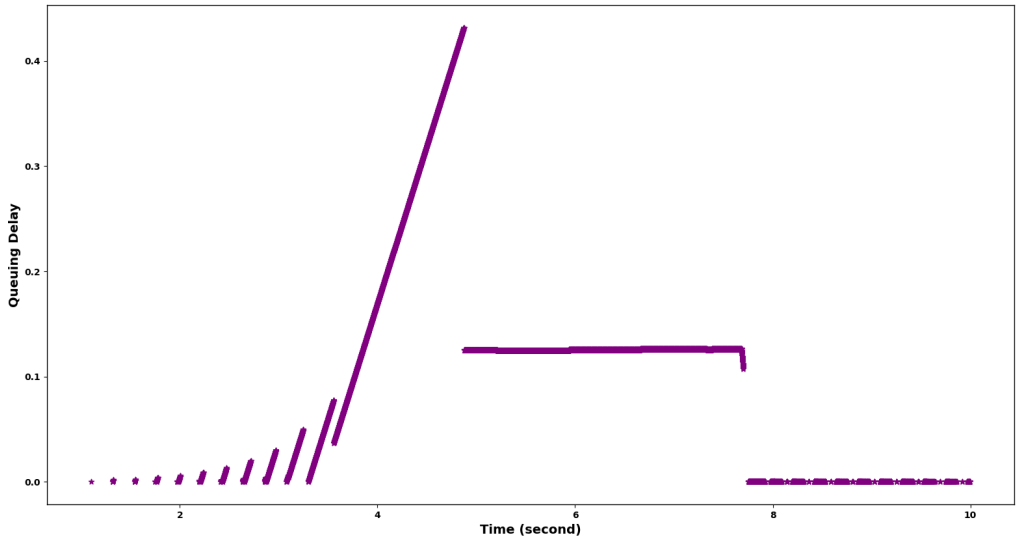
b. The congestion window after changing the queue size is shown below. The first plot is the line plot and the second plot is a scatter plot.





c. The queueing delay for the queue size 1000 is shown in the plots below. The first plot is a line plot and the second is a scatter plot.





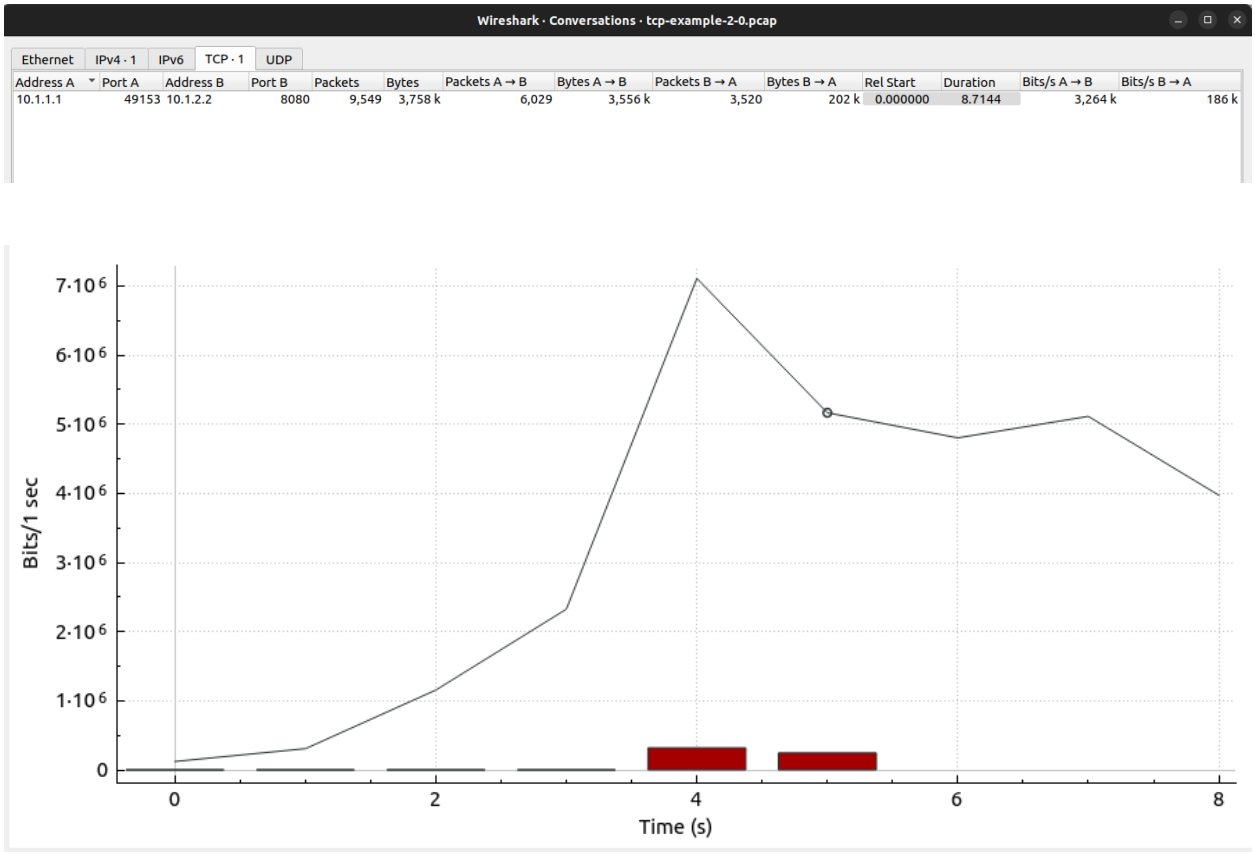
d. The graphs in both the questions 1 and 2 have similar shape and structures. The difference is in the values where the peak occurs. For question 1 the peak occur before 4 secs in both congestion window and queuing delay graph while the later peaks at near 4 secs. Also the value of peaks vary for both the graphs. For the question 1 congestion window graph the peak is at 300000 MSS while for the second question the peak is at

500000 MSS. For the queuing delay graph: the peak in the first question is around 0.030 ms while for the second question the peak is greater than 0.4 seconds.

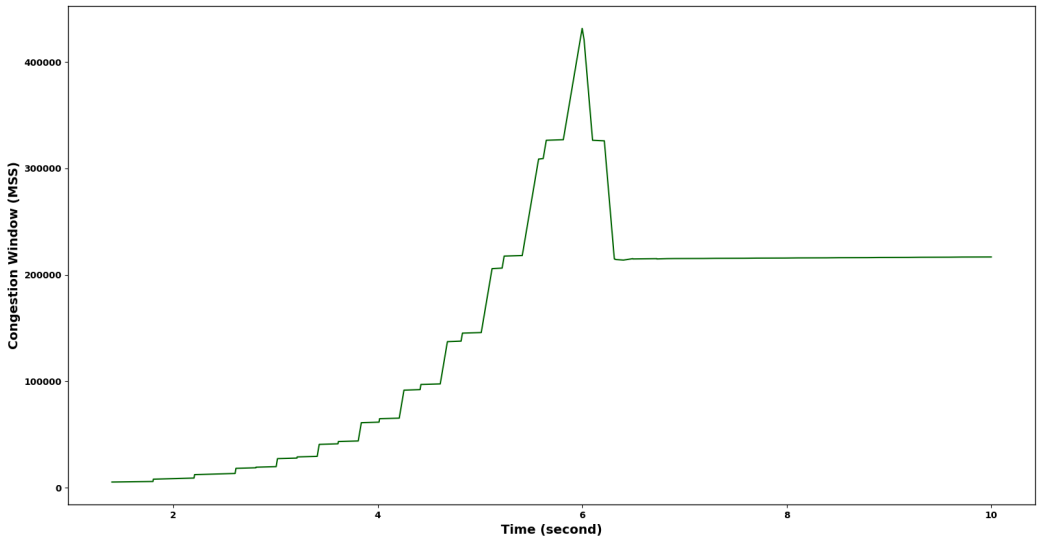
The reason for such observations is that since we increase the queue size from 50 packets to 1000 packets hence more packets can be accommodated in the queue hence the queuing delay increases. This also increases the congestion window as if the network is congested more packets can stay in the queue compared to the earlier case where only 50 packets can be accommodated in the queue. So the peaks are higher and more delayed compared to question 1.

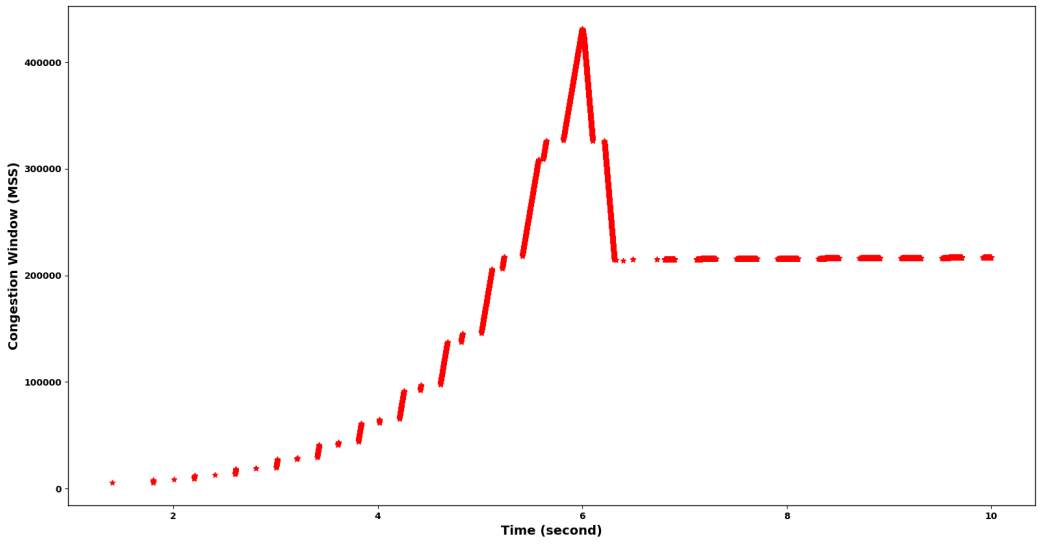
Answer-3

a. The average computed throughput is 3.764 Mbps.

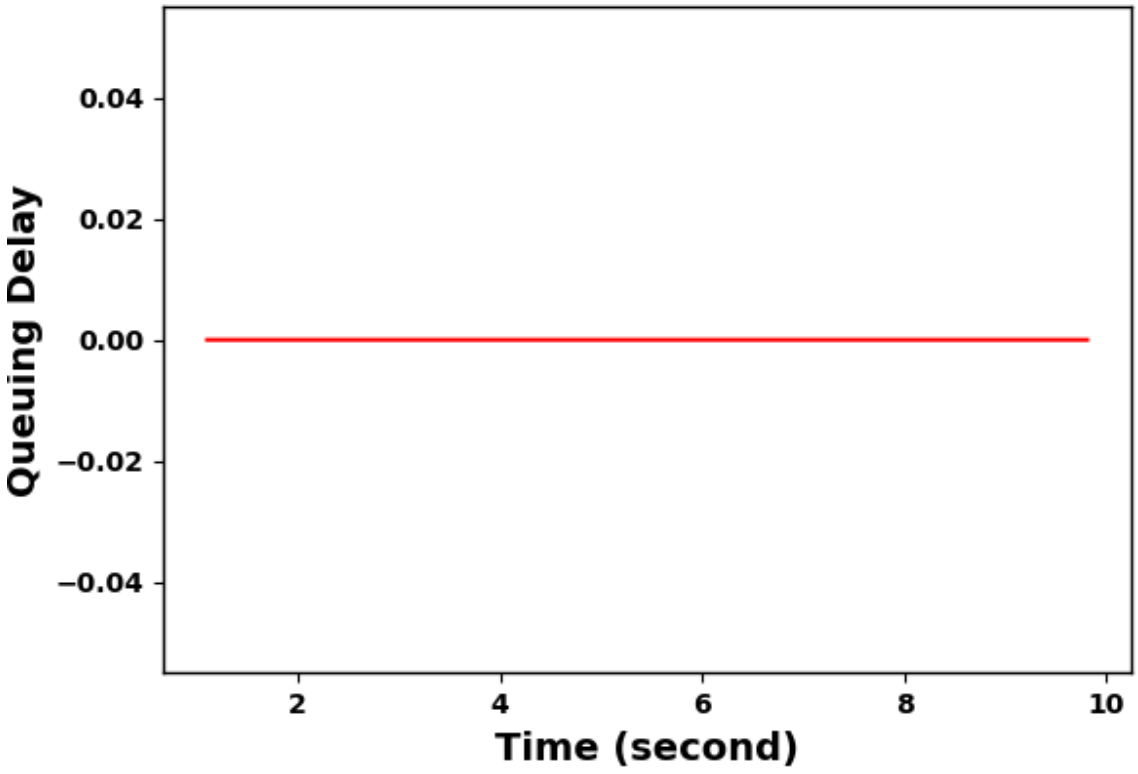


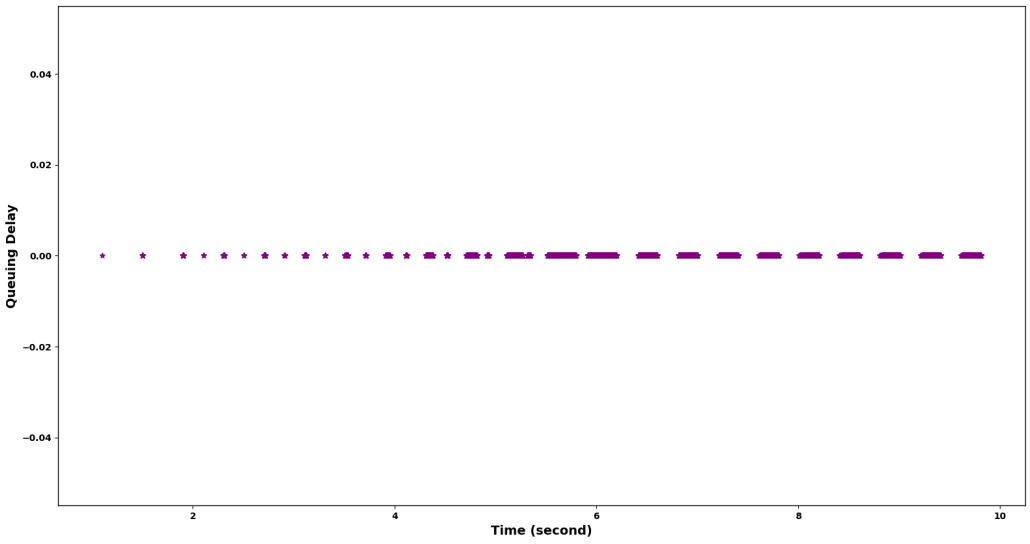
b. The plot for the congestion window is shown in the figure below. The first plot is a line graph and the second plot is a scatter plot.


Congestion Window (MSS)
0
100000
200000
300000
400000
2
4
6
8
10
Time (second)


Congestion Window (MSS)
0
100000
200000
300000
400000
2
4
6
8
10
Time (second)

c. The line plot and the scatter plot is shown below





d. The queuing delay in this question is 0 while it attains non zero values in the previous questions. The queuing delay in this question 0 because the bottleneck bandwidth is 10

Mbps which is equal to bandwidth between node 0 and node 1 and bandwidth between node 1 and node 2 is 10 Mbps.

Since

Bottleneck bandwidth == bandwidth of N0 and N1 == bandwidth of N1 and N2

Hence there won't be any queuing (assuming processing delay = 0). The incoming rate Is equal to outgoing rate hence packet incoming from nic 0 of N1 will just be forwarded to nic 1 of N1 without observing any queuing at node 1

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