CN Assignment - 3

Problem 1:-

a) The maximum theoretical throughput is defined by the 7 Mbps N1-N2, i.e. the bottleneck bandwidth between the links. Hence, Max theoretical throughput is 7 Mbps.

b) BDP = max_theoretical_throughput * RTT_Time

BDP = $7 * 10^{6} * 2 * (100 + 10) * 10^{-3}$

BDP = $154 * 10^{4}\ bits$

Let's calculate BDP in terms of packets per second, denotes the following value.

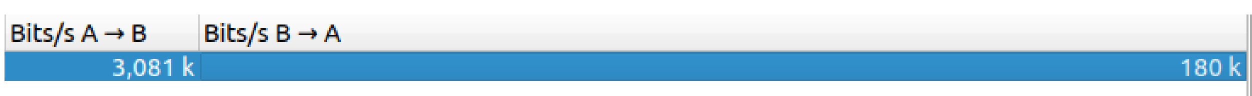
packet size = 1460 bytes = 1460 * 8 bits

BDP = $154 * 10^{4} / (1460 * 8)$

BDP = $131.849315068\ packets$

c) Average throughput from node 0 to node 2 is given as:

here: A = 0, and B = 2



Bits/s A → B	Bits/s B → A
3,081 k	180 k

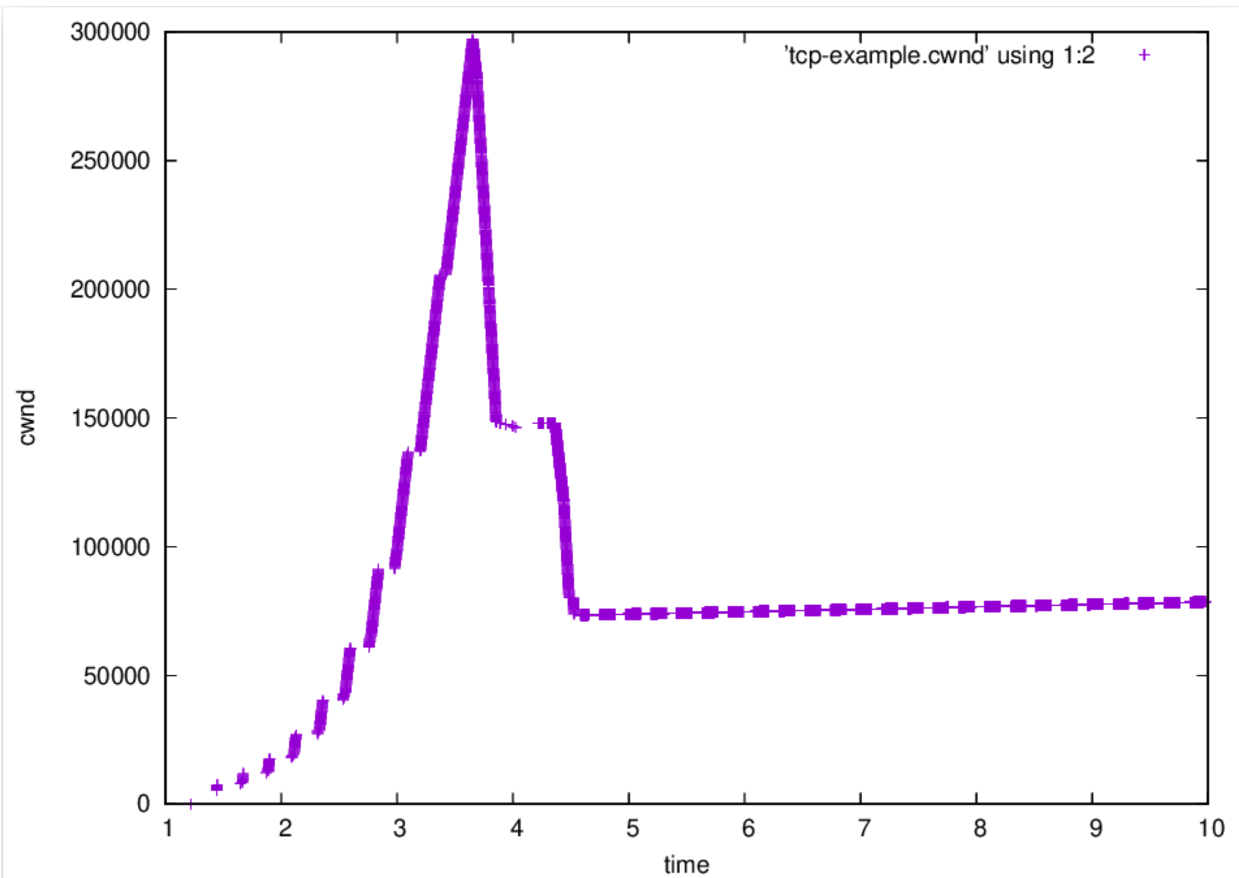
So (A→ B) is 3081 kbps

(B→A) is 180 kbps

Hence the total is 3261 kbps

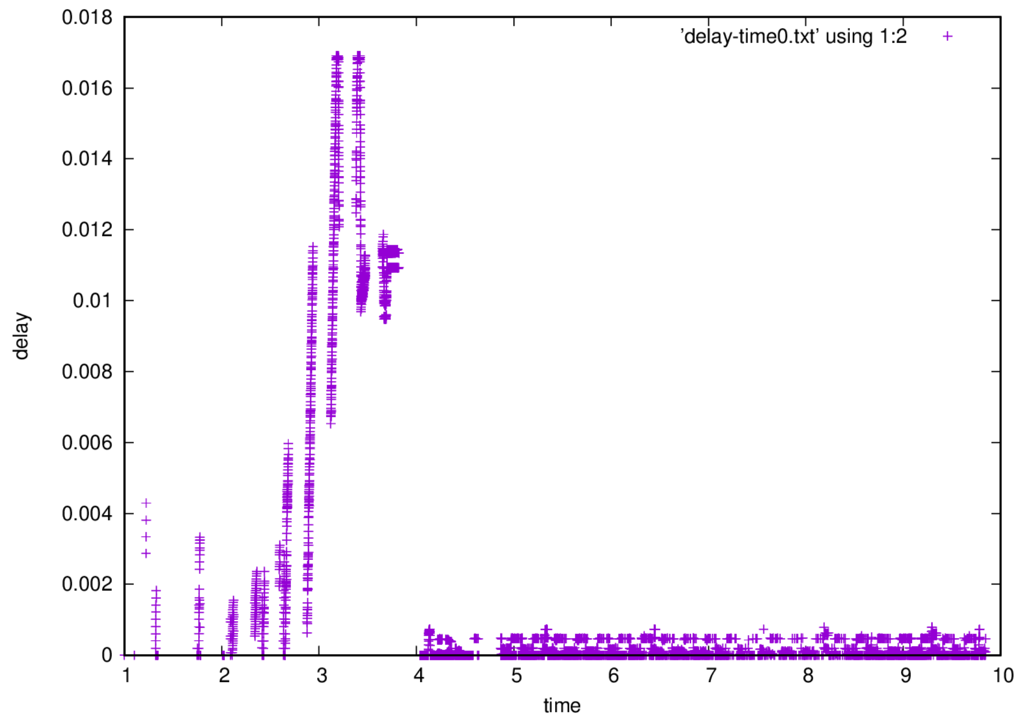
d) No, the average throughput is not equal to the theoretical throughput, this is because there is random packet loss, compounded with maximum queue size, queueing delays and changing the value of cwnd (congestion window). So, in practice, it is not possible to achieve theoretical throughput.

e) cwnd graph plotted with time

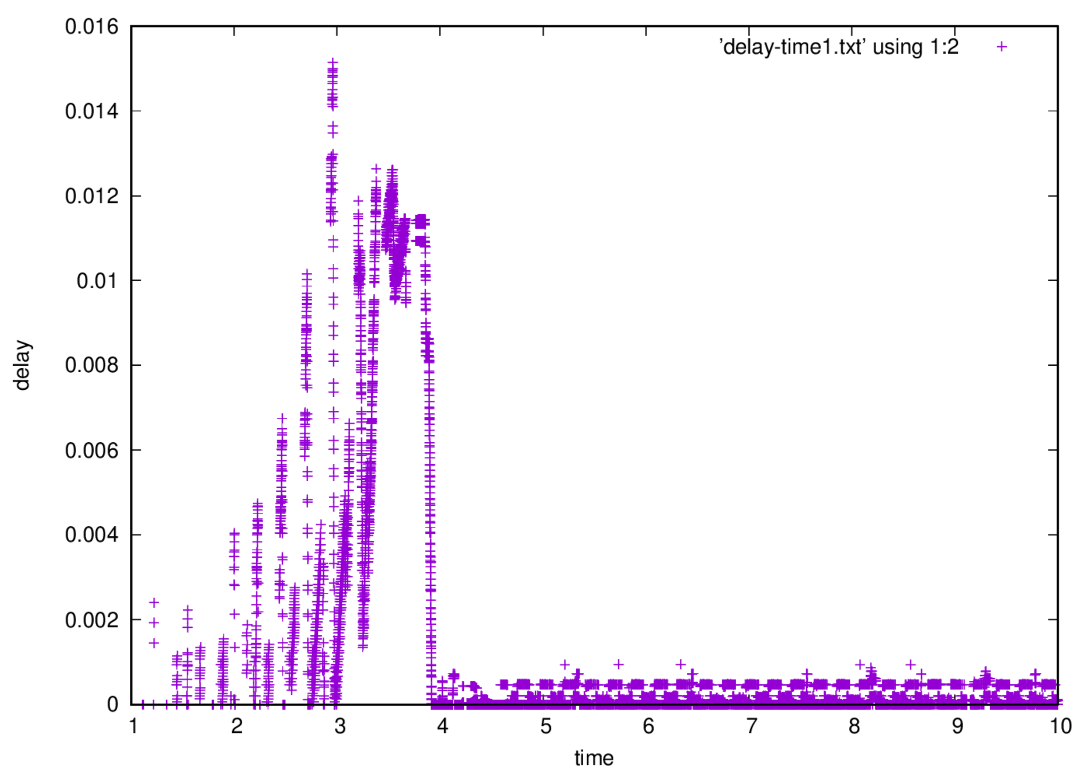


f) queue delay vs time

Node0:-



Node1:-



g) Yes, the cwnd and delay plots are closely related. Initially, the congestion control mechanism is in the slow start phase. The value of cwnd increases to 300000 between 3s to 4s. Due to the very large cwnd, there are many packets in the flight. This causes queuing delay at nodes N0 and N1. As we can see from the plots, when the cwnd is at its peak the delays at nodes are also at a peak (3s to 4s). When the queue is full there is packet loss and TCP enters into the fast recovery phase by decreasing the cwnd by half. After receiving the new acknowledgements, TCP enters the congestion avoidance phase. Consequently, the delay drops nearly to 0.

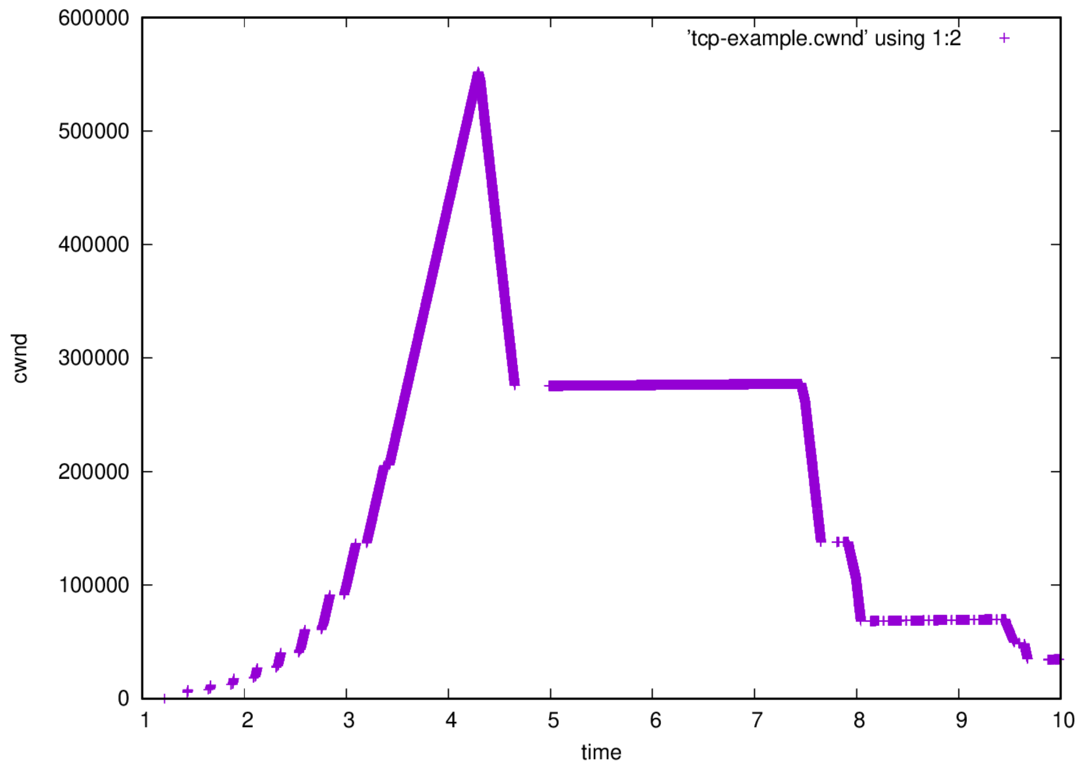
Problem 2:-

a) The average throughput from node 0 to node 2 is given as:
here: A = 0, and B = 2

Bits/s A → B	Bits/s B → A
4,563 k	271 k

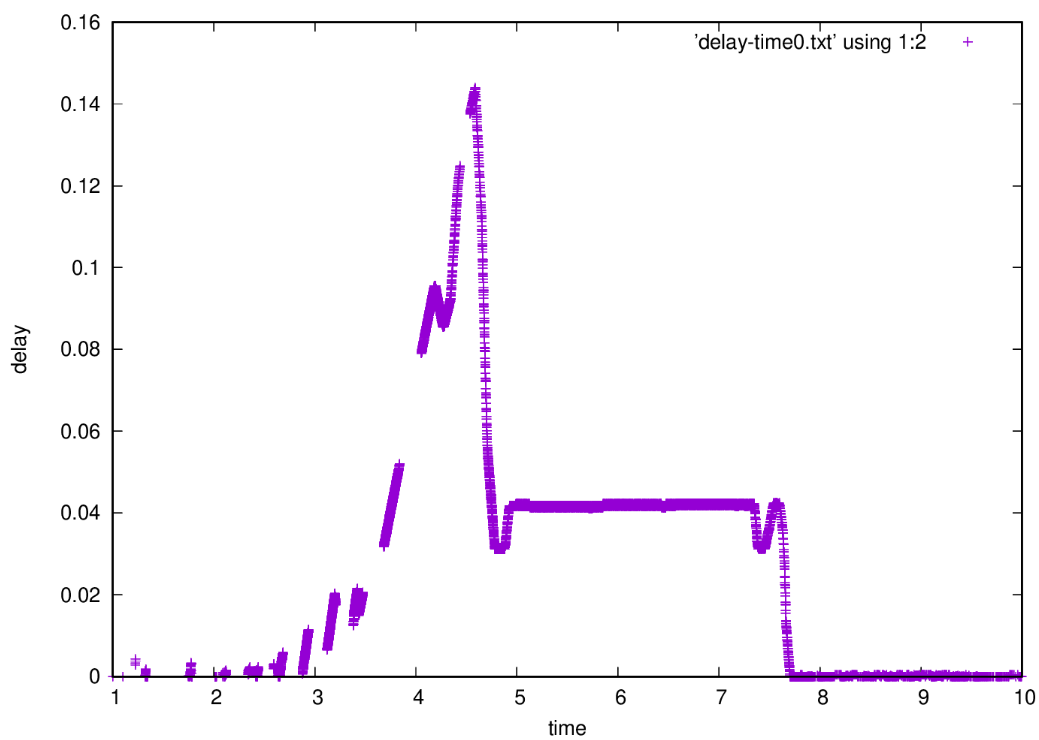
So (A→ B) is 4563 kbps
(B→A) is 271 kbps
Hence the total is 4834 kbps

b) cwnd graph plotted with time

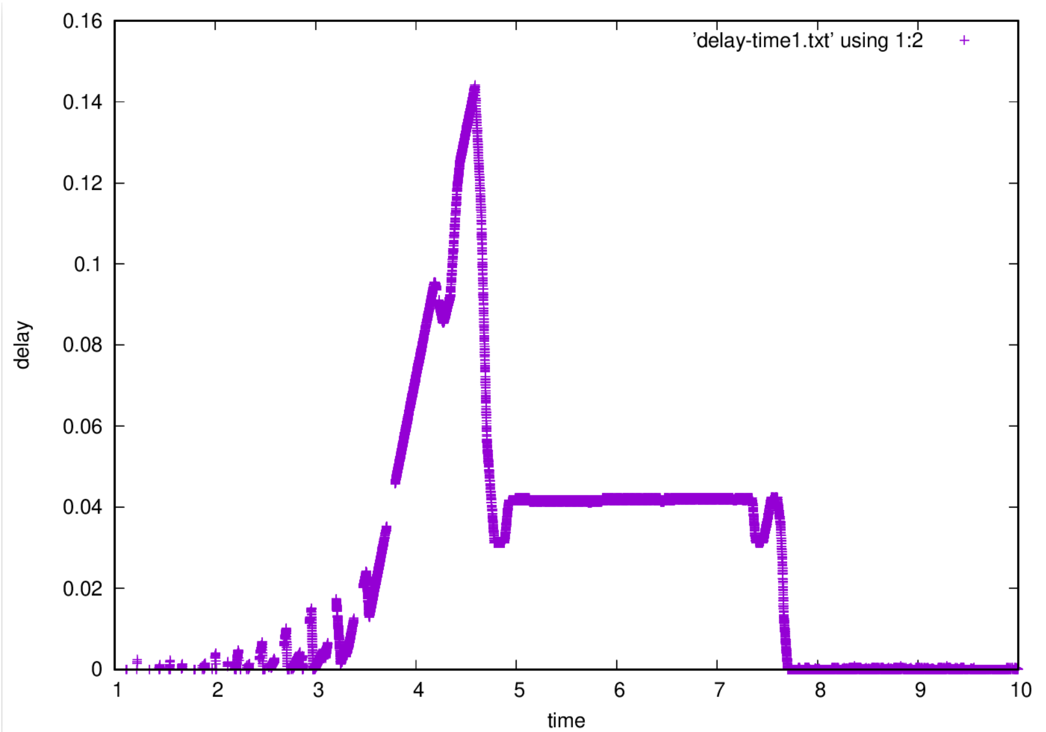


c) queue delay vs time

Node 0:-



Node1:-



d) Increasing the queue size will increase the no of packets in the flight. More queue sizes will increase the congestion tolerance as more and more packets can be stored without getting dropped. As we can see max value of cwnd has now increased up to 600000 due to which the packets can be stored for a longer time in a larger queue. The time of peak cwnd has also increased to 4s to 5s. All the state transitions are similar to the case1. One can note that this cwnd plot is very similar in topology to the one in problem 1, this can be attributed to the fact that the limit of the second link is the same in both cases. Avg throughput has also increased.

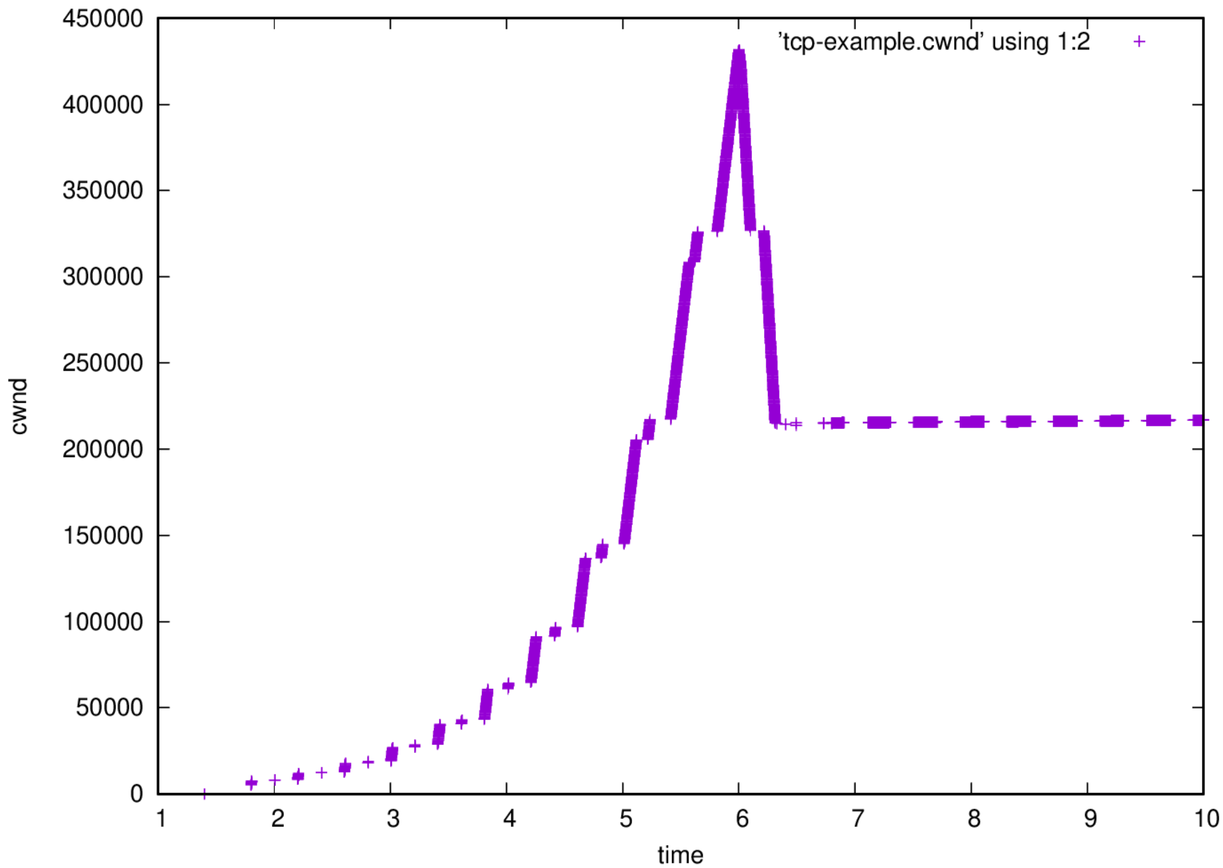
Problem 3:-

a) The average throughput from node 0 to node 2 is given as:
here: A = 0, and B = 2

Bits/s A → B	Bits/s B → A
3,264 k	186 k

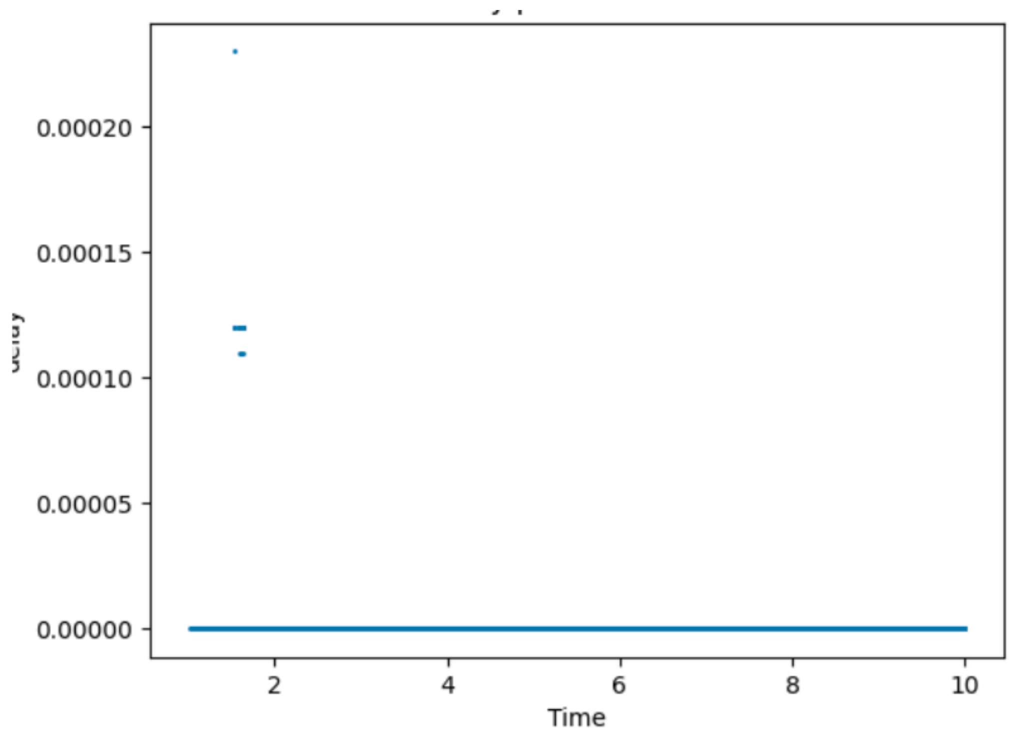
So (A→ B) is 3264 kbps
(B→A) is 186 kbps
Hence the total is 3450 kbps

b) The plot of cwnd with time:-



c) delay vs time

Node 1:



d) Since the bandwidth of the N1-N2 network has increased to 10Mbps as compared to 7 Mbps in part Q1, the rate of packet transfer is faster. Consequently, the value of cwnd has also increased to 450000 as compared to 300000 in part a. Now the bandwidth of N0-N1 and N1-N2 is the same the queue delay has significantly reduced. We can clearly see from the plot in Q3, there are very few packets with a queue delay as compared to Q1. This is evident from the intensity of the plots. It is very little to no queueing delay in Q3.

Harjeet Singh Yadav
Roll No:- 2020561
CSAI