CN Assignment 3

Problem 1

- The maximum theoretical is defined by the 5 Mbps N1-N2, i.e. the bottleneck bandwidth between the links. Hence, Max theoretical throughput is 5 Mbps.

- BDP = max_theoretical_throughput * RTT_Time

  $BDP = 5 * 10^5 * 2 * (10 + 15)/10^3$

  $BDP = 25 * 10^3$ bits

  Let's calculate BDP in terms packets per seconds, BDP_2 denotes the following value.

  packet size = 1460 bytes = 1460 * 8 bits

  $BDP_2 = 25 * 10^3/(1460 * 8)$

  $BDP_2 = 21.4041$ packets

- Average throughput from node 0 to node 2 is given as :

  here : A = 0, and B = 2

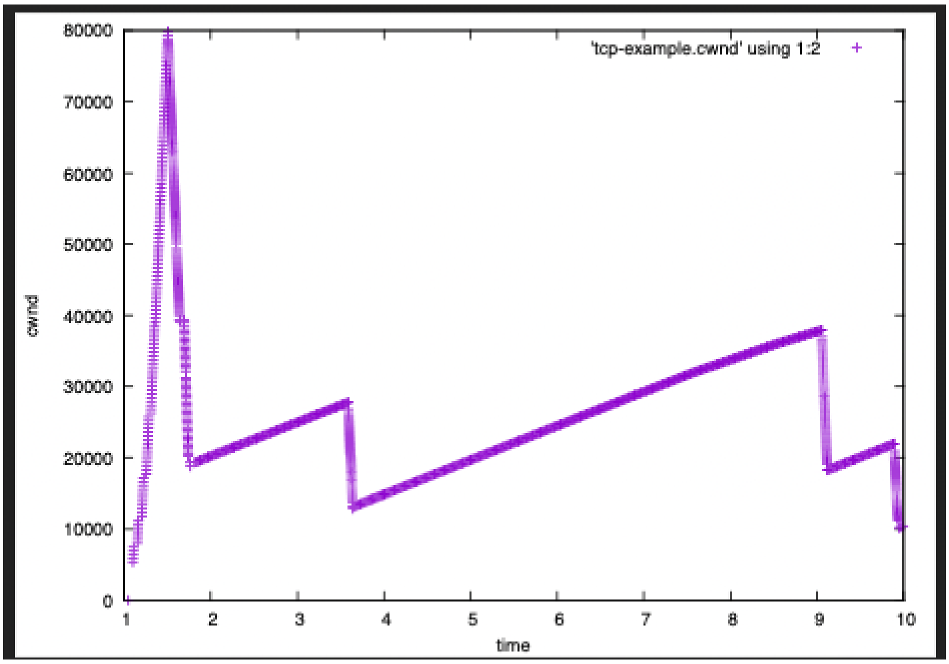
  So (A→ B) is 3895 kbps

  (B→A) is 193 kbps

  Hence the total is 4088 kpbs

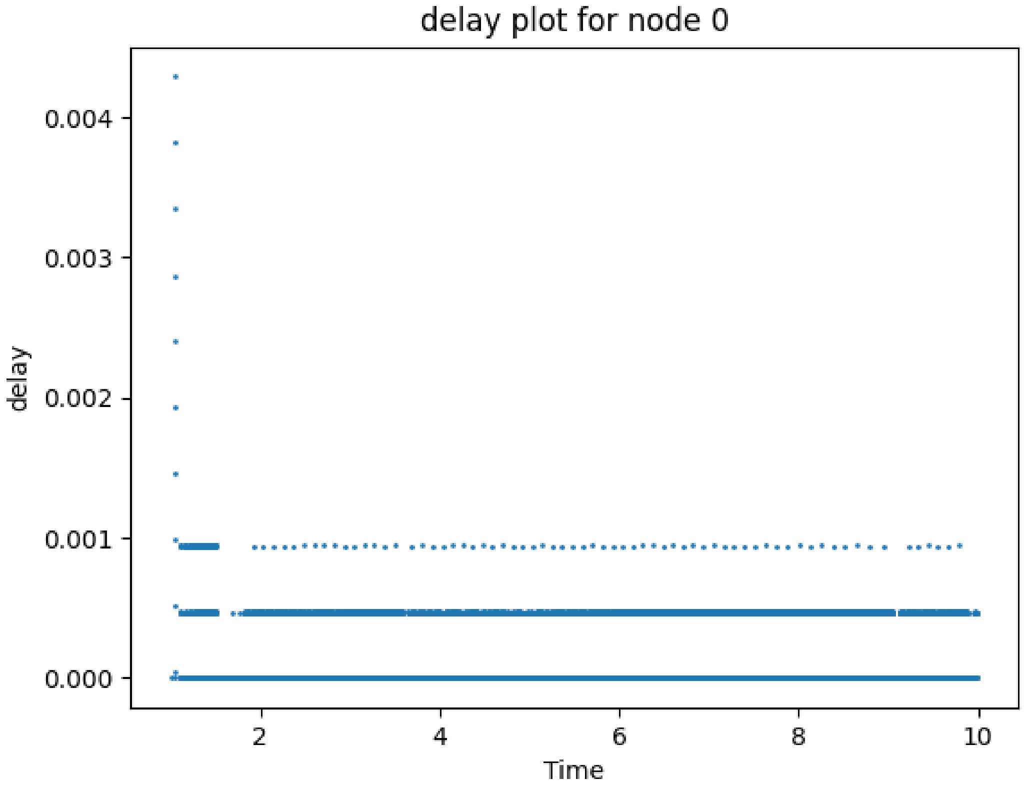
- There are is a sense of randomness in the network due to random packet drops, compounded with maximum queue size, queueing delays and changing value of cwnd. Therefore in a real world scenario, it is nearly impossible to achieve maximum theoretical throughput.

- cwnd graph plotted with time.

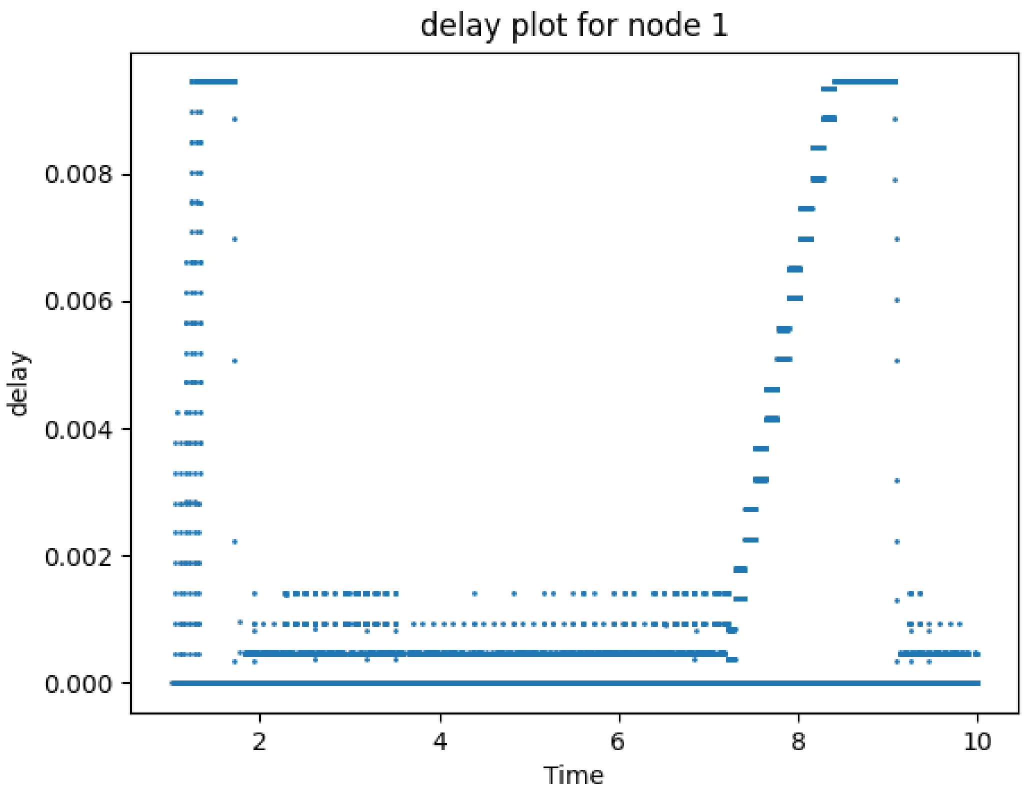


- Queueing delaying plotted with time

Node 0:


delay plot for node 0
0.004
0.003
0.002
0.001
0.000
delay
2
4
6
8
10
Time

Node 1:



- Firstly the TCP congestion control mechanism is in the slow start state, where the cwnd value increase exponentially evert RTT. We can see that if increases to 80000 which turns out to be too much can starts causing queueing delays at the routers (can be seen in the delay plot for node 1), now when the queue gets full some packets are dropped due to which the TCP congestion control halfs with value of cwnd and enters fast recovery mode, shortly after receiving the correct ack it transfers to congestion avoidance state where cwnd growing linearly, since cwnd here is well below is the capacity of router (dominated by 5 Mbps) the delay is close to 0 (nothing very large). The delay increase again around 9 seconds when the cwnd begins to approach the router's limit. Another state transition occurs and same halfing of cwnd is occurred resulting a decreasing in delay.

Problem 2

a. 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
4024k	205k

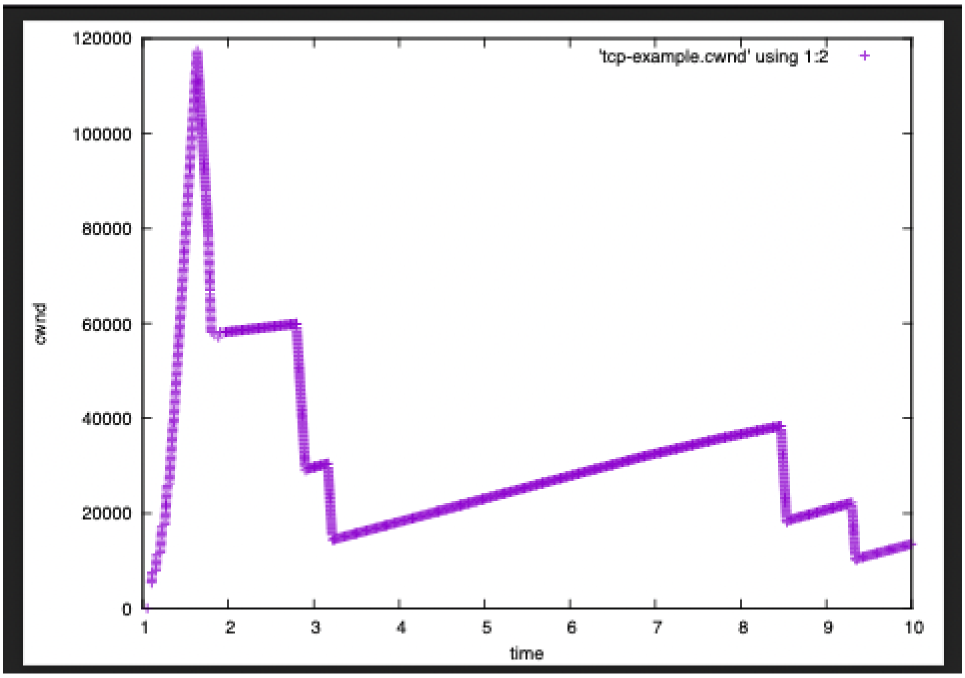
So (A→ B) is 4024 kbps

(B→A) is 205 kbps

Hence the total is 4229 kpbs

b.

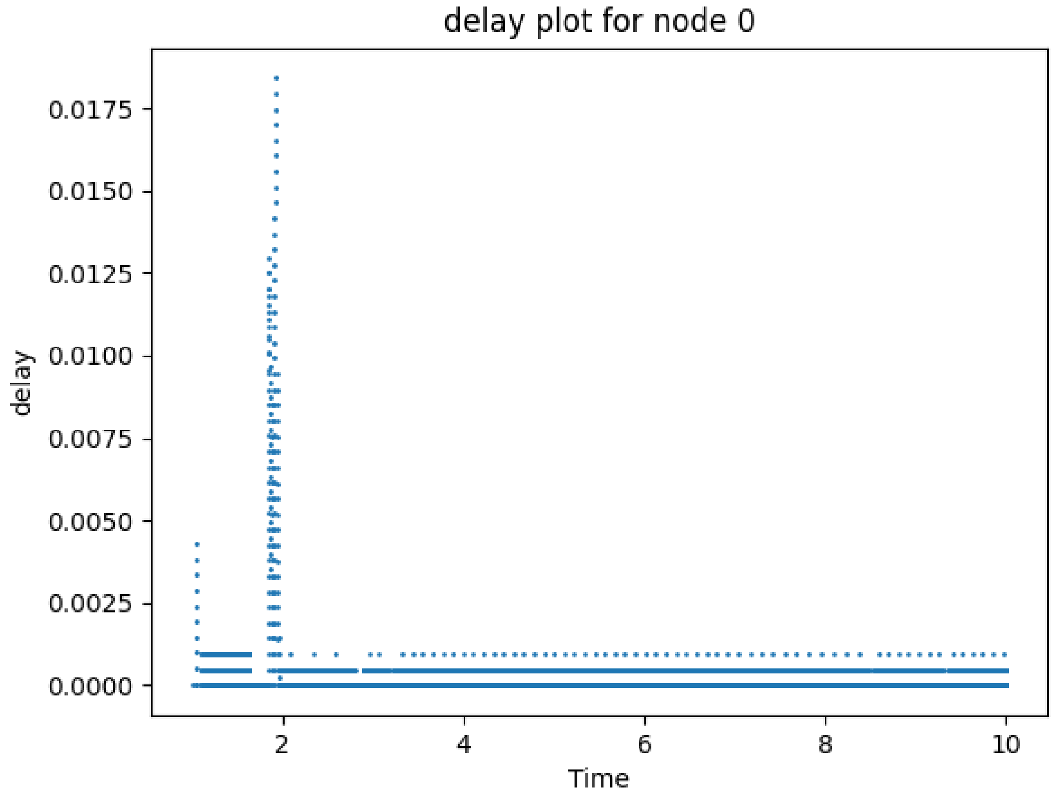
cwnd plotted with time



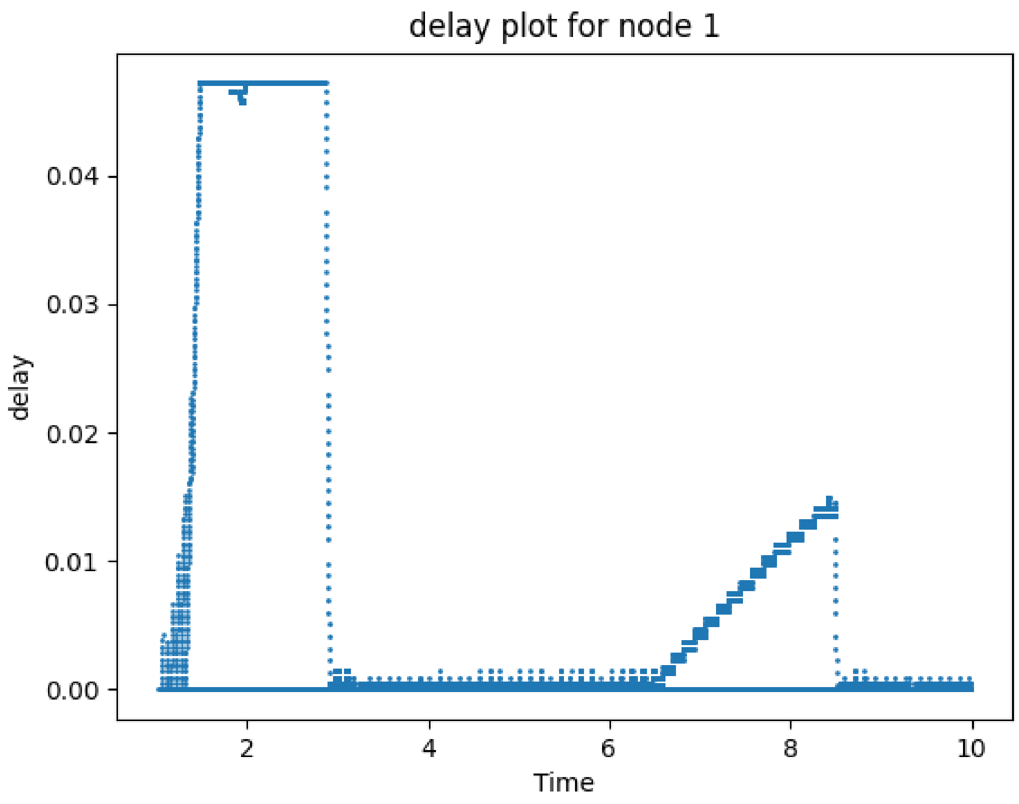
c.

Queuing delay plotted with time

Node 0:


delay plot for node 0
0.0175
0.0150
0.0125
0.0100
0.0075
0.0050
0.0025
0.0000
delay
2
4
6
8
10
Time

Node 1:

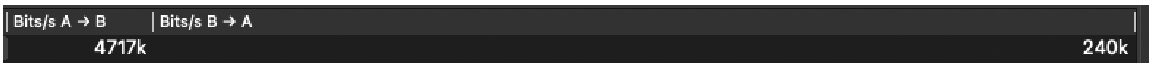


d. Increasing the queue size makes the router tolerate increase in flow (congestion) for a bit longer (as packets can be stored for a longer time in the longer queue). Therefore the exponential growth is larger (upto 120000) in this case, at which point in time the first packet drop occurs, and subsequently state transition in algorithms occurs similar to that in problem 1. 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.

Problem 3

a. Average throughput from node 0 to node 2 is given as :

here : A = 0, and B = 2



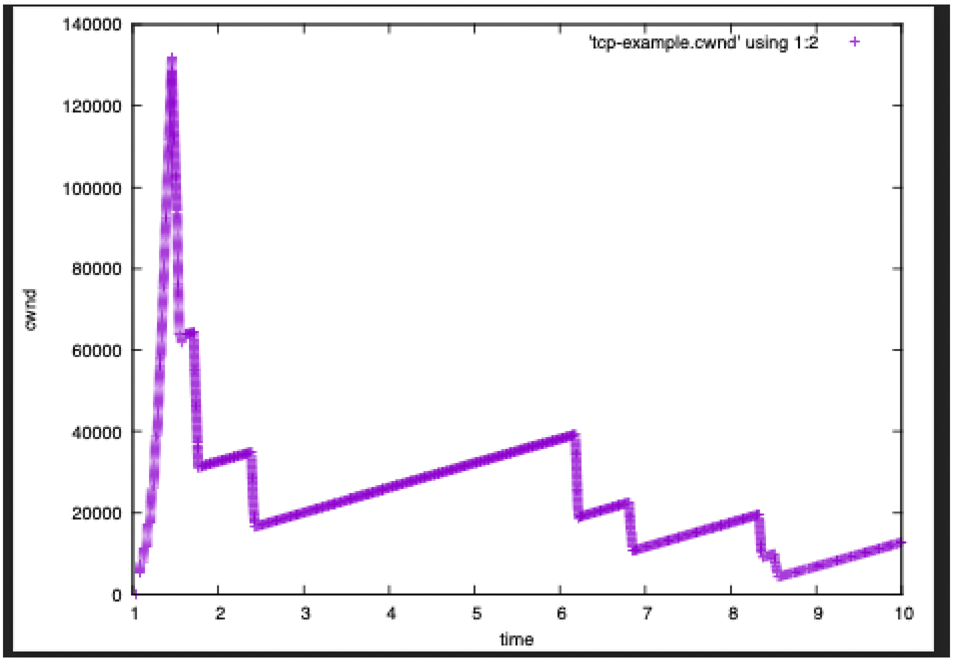
So (A→ B) is 4717 kbps

(B→A) is 240 kbps

Hence the total is 4957 kpbs

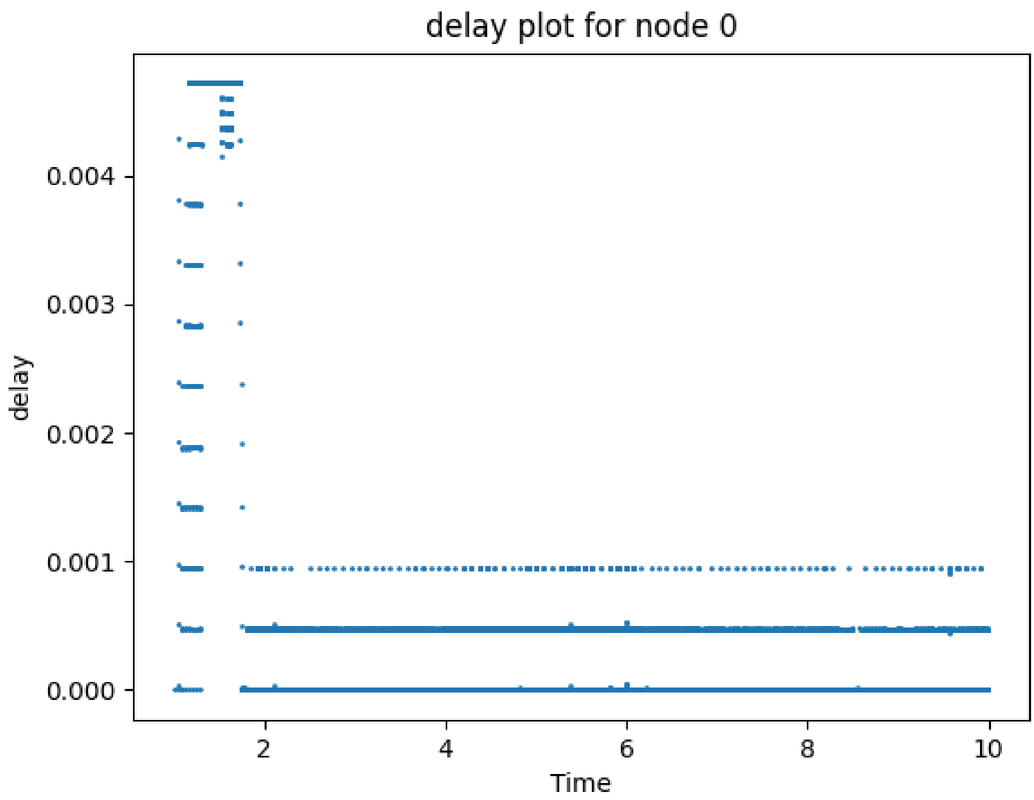
b.

Plot of cwnd with time:

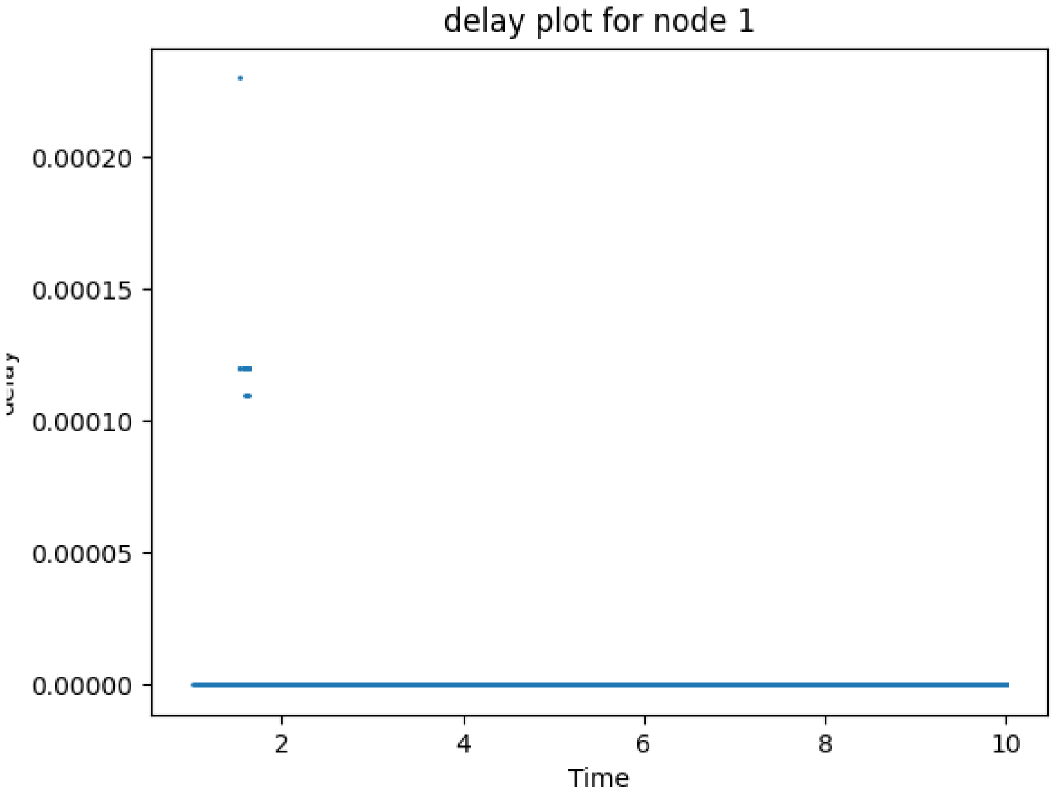


c. Queueing delay plotted with time

Node 0:


delay plot for node 0
0.004
0.003
0.002
0.001
0.000
delay
2
4
6
8
10
Time

Node 1:



d. Here, the N1-N2 bandwidth is increased, hence the pack transfer rate in the router to be faster, making it tolerate higher values of cwnd, upto 140000 compared to just 80000, around double. Now brining this to queue delay, we can see that since N0 - N1 and N1-N2 have the same bandwidth there is little to no delay at node1, compared to problem 1 where delay is increase a lot with growing cwnd. One can notice there is some delay initially in N0 this is due to the exponential growth in the slow start phase of TCP congestion control algorithm, which is higher here (upto 140000) that in problem 1.

Problem 4

a. Average throughput from node 0 to node 2 is given as :

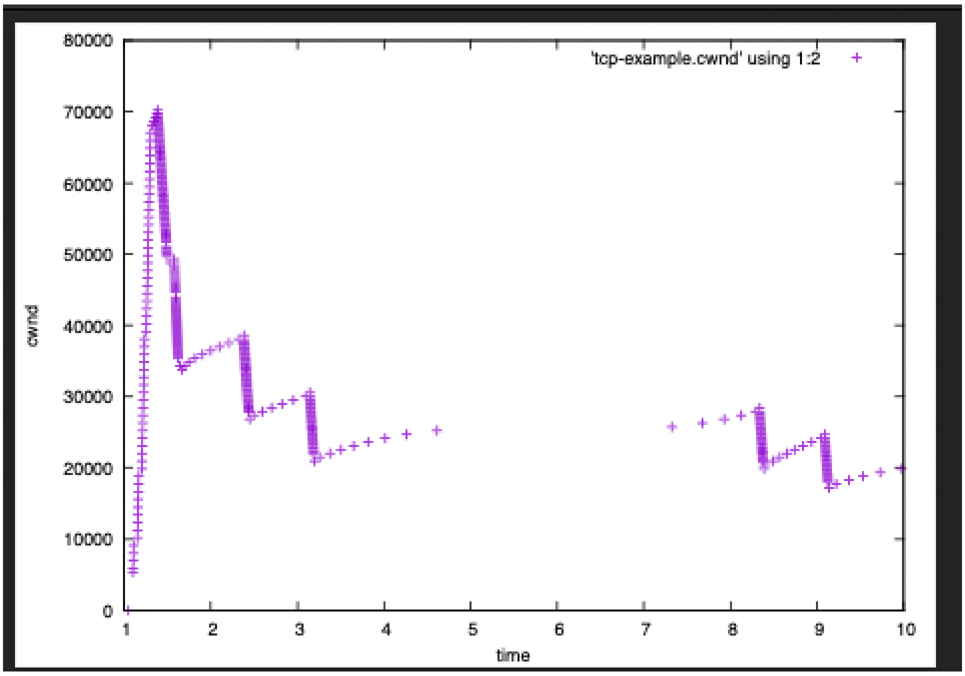
here : A = 0, and B = 2

So (A→ B) is 4195 kbps

(B→A) is 210 kbps

Hence the total is 4405 kpbs

b. cwnd plotted with time



c.

In this problem, TCP CUBIC version is used to perform congestion control. TCP CUBIC allow fast window expansion but at the same time slows the growth with cwnd reaches maximum capacity.

On can see the in the cwnd plot the growth mimics the concave shape of cubic polynomial plot. This is different from the straight line growth in problem 1.

Also, the max peak in this case is smaller that in problem 1, this is due to differences in the increase algorithm used in both the versions.

The third, difference is that when a pack loss/drop is encoutered, instead of halfing the value, TCP CUBIC takes the three-fourth of the last peak encountered. This difference can clearly be seen in the graph.