Analyzing simulation results

1) Average TCP throughput at the receiver

Throughput for N0 2.5 Mbps

Throughput for N1 2.52 Mbps

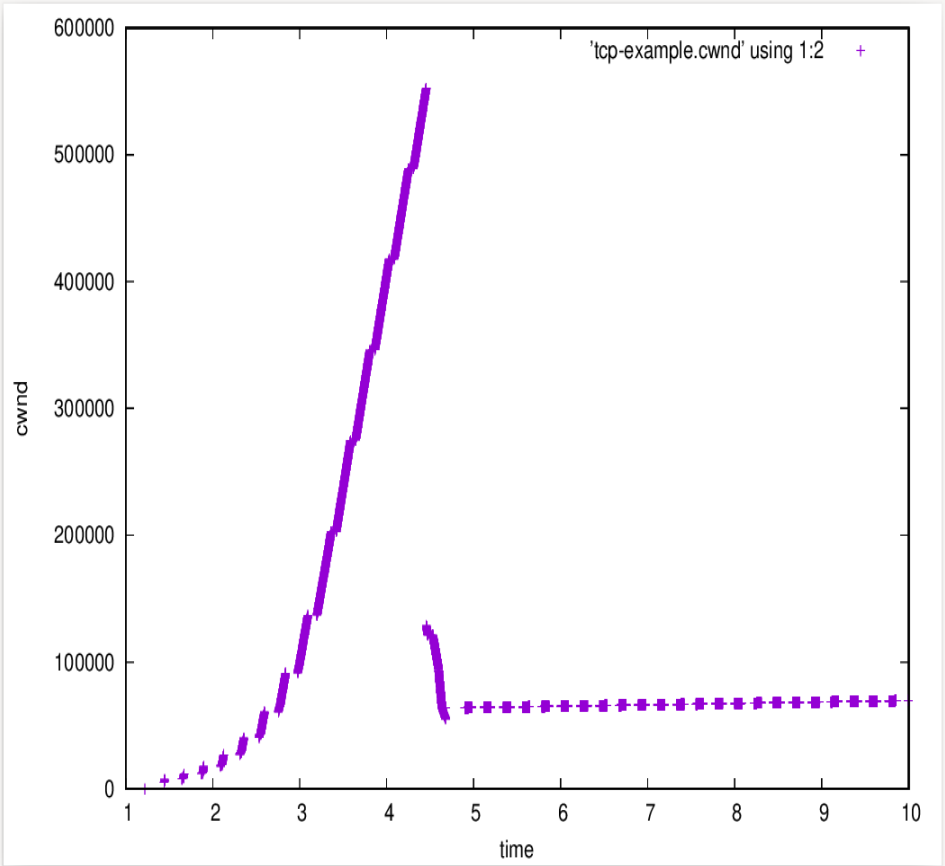
Throughput for N2 2.53 Mbps

2) Evolution of the sender's congestion window (cwnd) over time

Code on terminal->

gnuplot example.gp

evince cwnd.eps

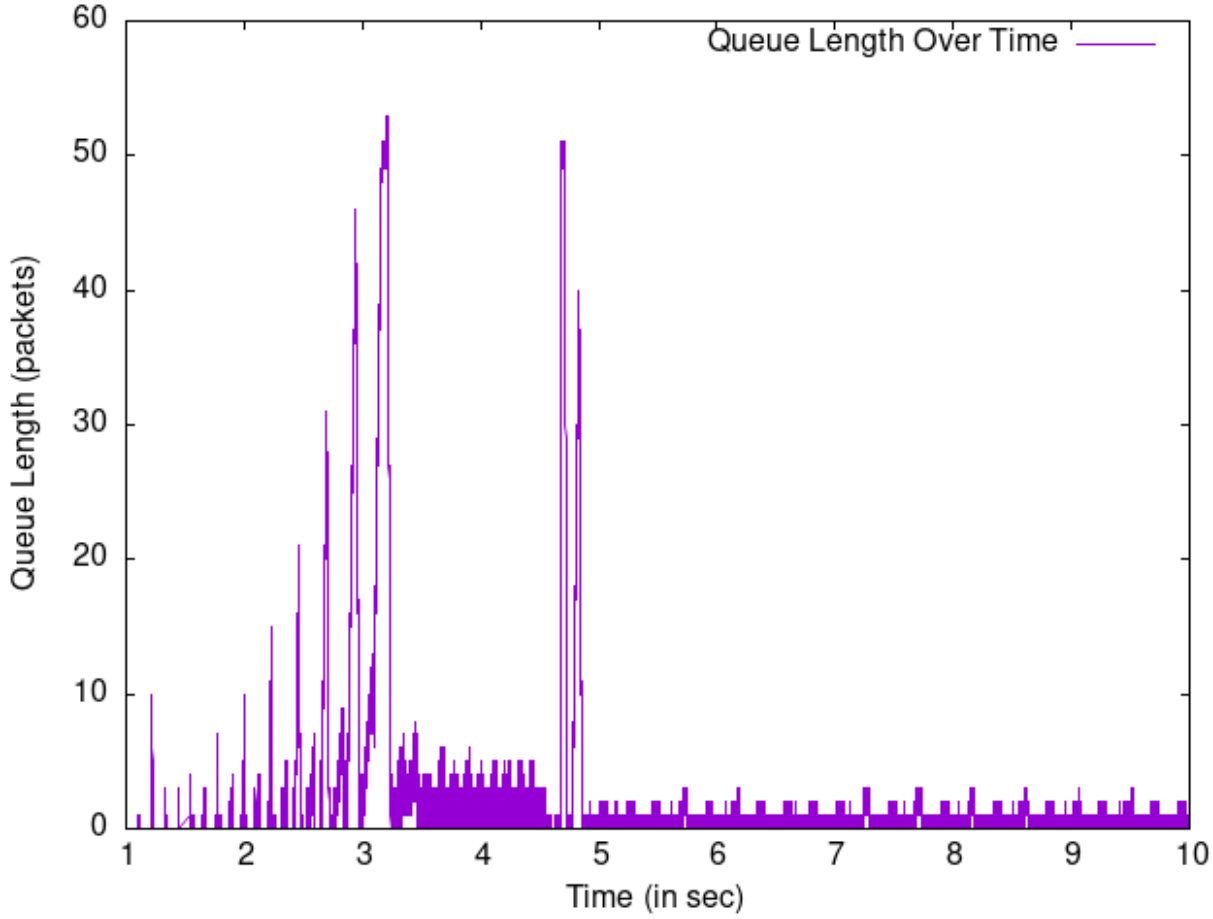


3) Queue length (occupancy) at the sender's buffer as a function of time

Code on terminal

python3 que_len_send.py tcp-example.tr queue_length.txt

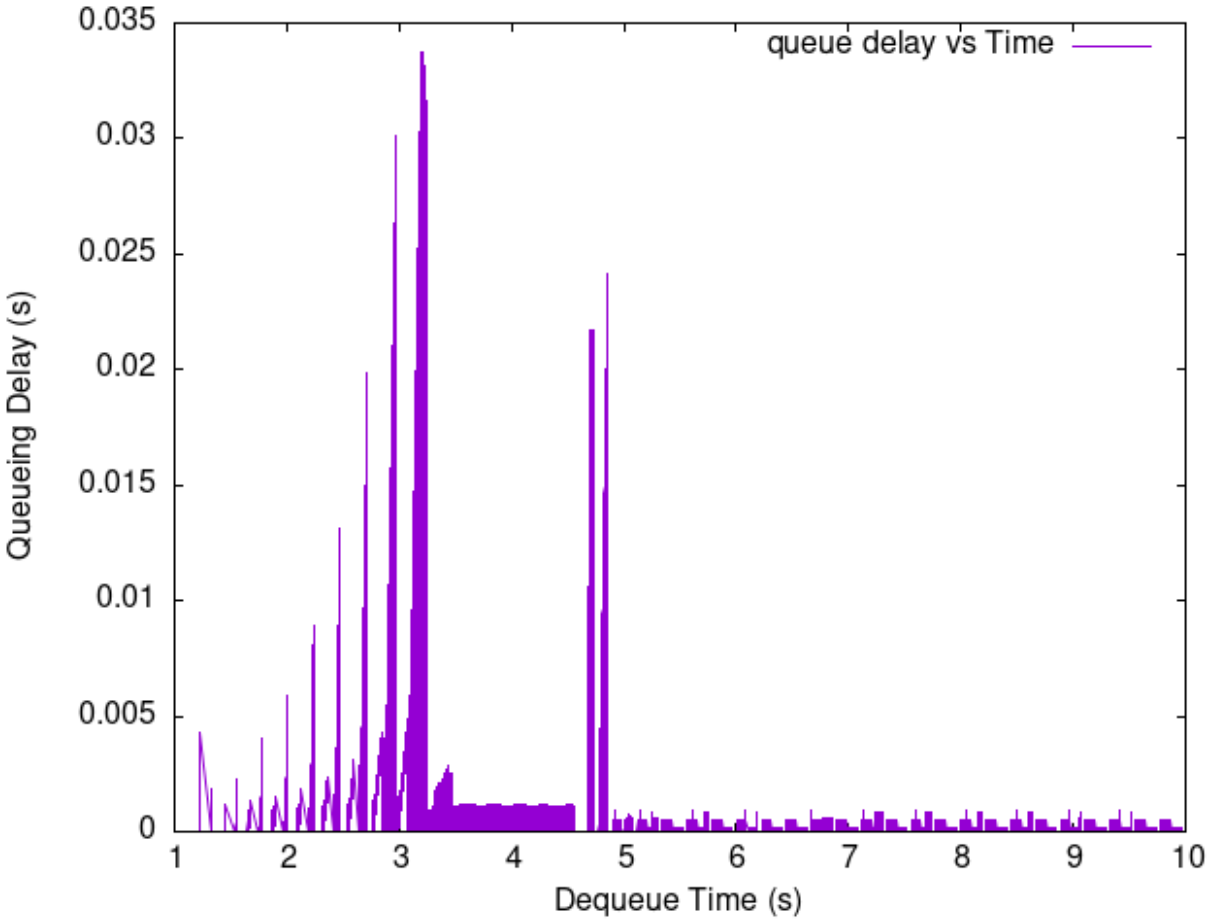
gnuplot que_len.qp



4) Queueing delay (wait time in queue) at the sender's buffer as a function of time

Code on terminal->

gnuplot que_del_sender.gp


queue delay vs Time
Queueing Delay (s)
Dequeue Time (s)
0.035
0.03
0.025
0.02
0.015
0.01
0.005
0
1
2
3
4
5
6
7
8
9
10

Problem Statement-

Question 1)

a) 7Mbps is the maximum expected value (theoretical) of throughput. Because the maximum possible throughput is depend on the bottleneck link as shows much data can possible transfer through network in one second. 10 Mbps link layer possible send data faster than the 7 Mbps link can handle, so packets will queue or drop at the bottleneck link. Also TCP adjust sending rate according to the bottleneck link.

b) RTT=2*(n0->n1 delay)+ (n1->n2 delay)

=2*(100 + 11) ms

=220ms

=0.22 sec

Packet size=1460 bytes

=11,680 bits

Bandwidth=7Mbps(as it is bottleneck link)

Bandwith Delay Product(BDP)=7*(10)^6*0.22=1,540,000 bits

BDP(in packet)= 1,540,000 bits/11,680 bits=132 packets(approx).

c)Average throughput at the receiver end.

Throughput for N0 2.5 Mbps

Throughput for N1 2.52 Mbps

Throughput for N2 2.53 Mbps

Is the achieved throughput approximately equal to the maximum expected value? If it is

not, explain the reason for the difference.

d) No theoretical throughput is higher than actual throughput. This could be due to the following reasons.

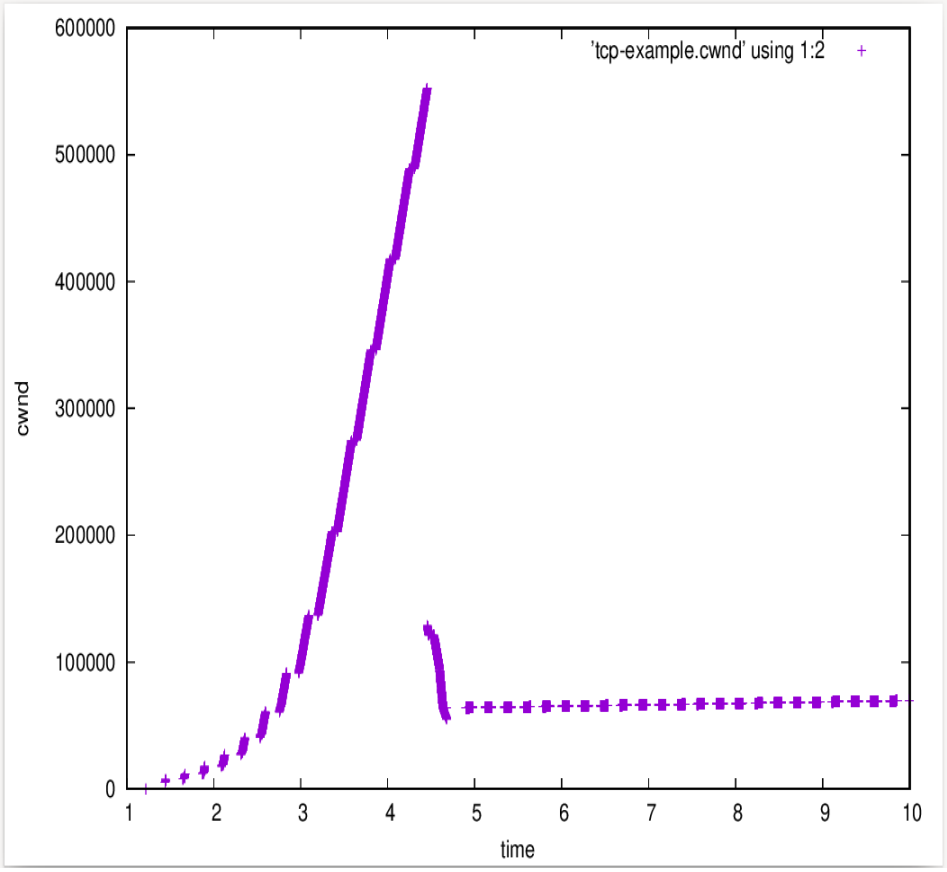
1) Packet loss during transmission.

2) Queueing delay at intermediate node.

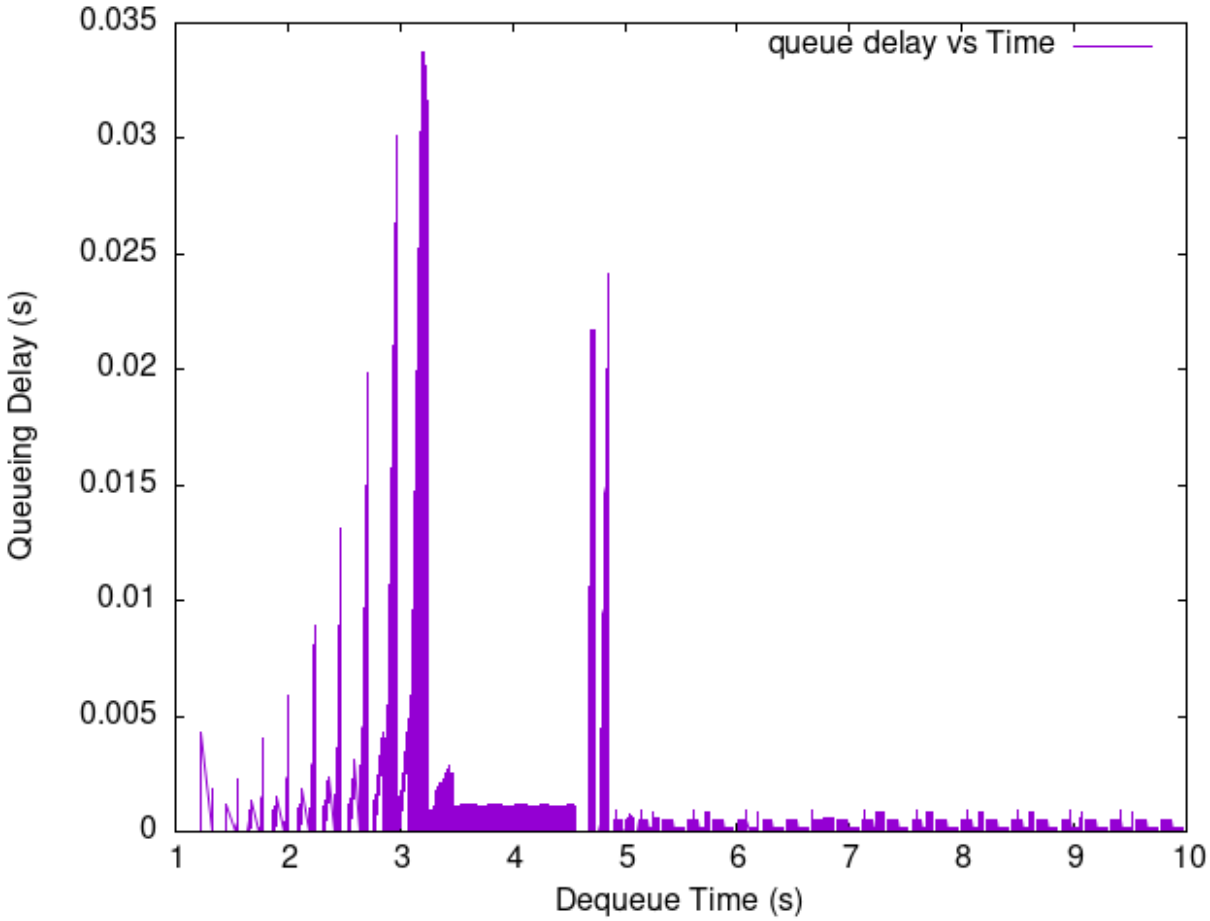
3) There is changes of overhead at application layer.

4) Congestion control mechanism that reduces the transmission during packet loss or network congestion.

e)


'tcp-example.cwnd' using 1:2
cwnd
time
600000
500000
400000
300000
200000
100000
0
1
2
3
4
5
6
7
8
9
10

f)



g)

In f) part it follows it is the graph between cwnd which vary on time and in g) queuing delay varies with time Both their process dependency can be verified from time Upto 4 sec . cwnd increase exponential as and delay is also increase after cwnd descrease linearly and queuing delay is also start decreasing.

Question 2)

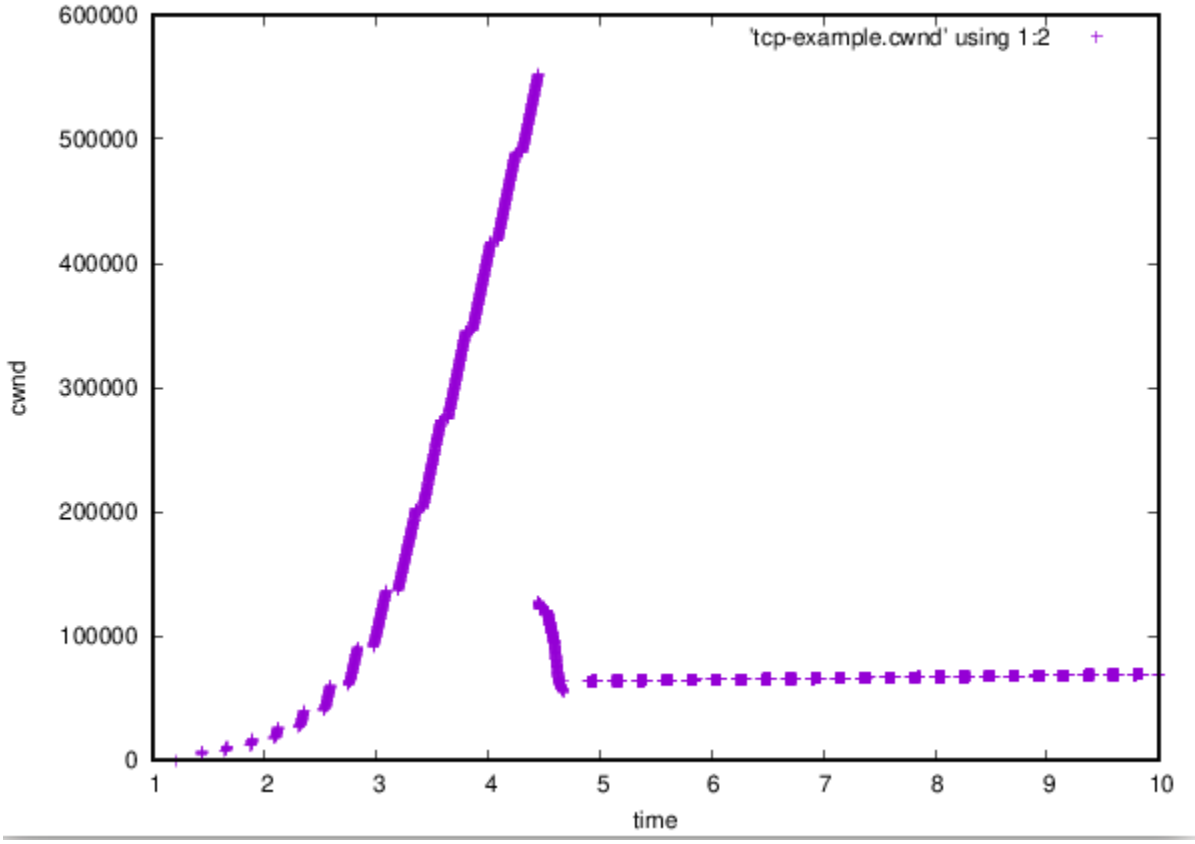
a) Average throughput at the receiver end

Throughput for N0 2.5 Mbps

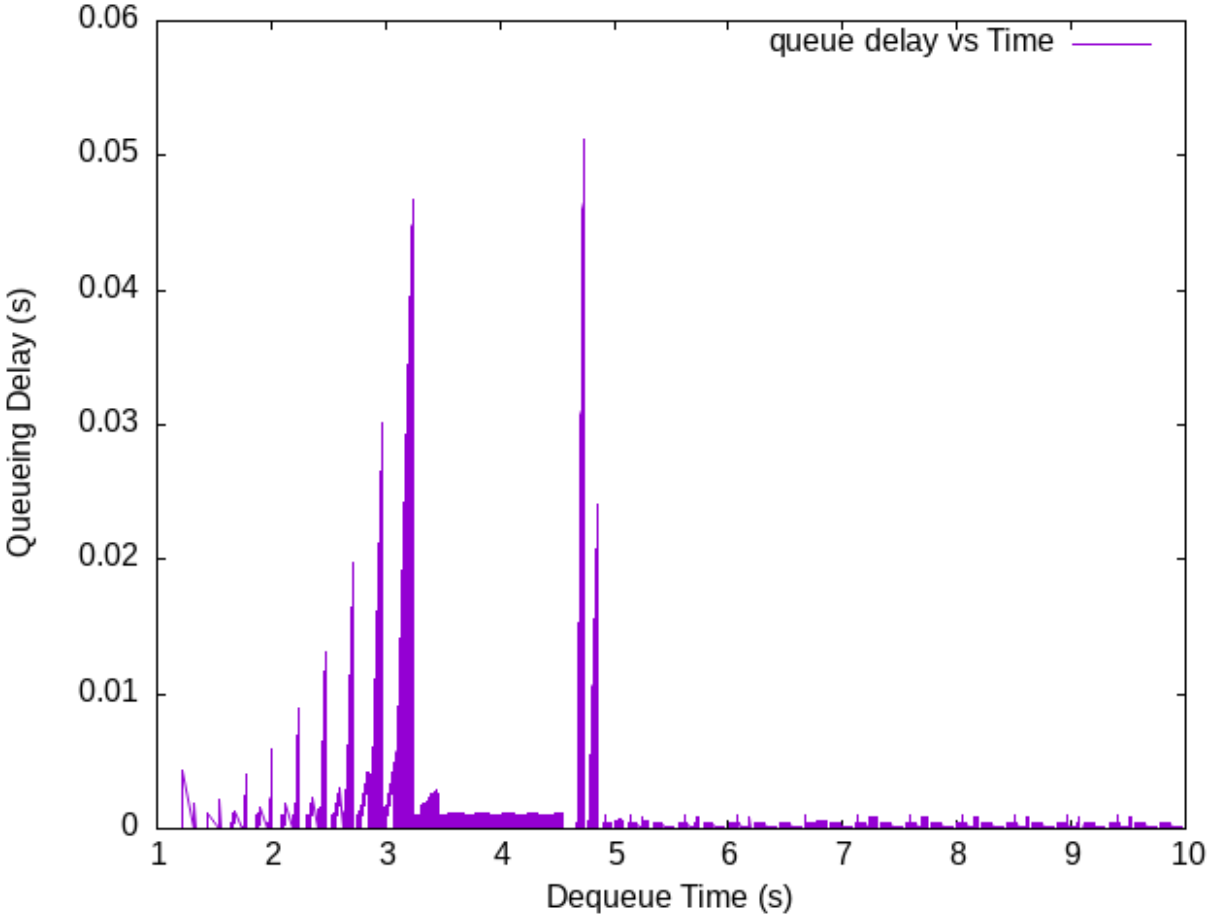
Throughput for N1 2.52 Mbps

Throughput for N2 2.53 Mbps

b)



c)



d)

On comparison with 1) part both the graph of cwnd vs time appears to be same.

Question 3)

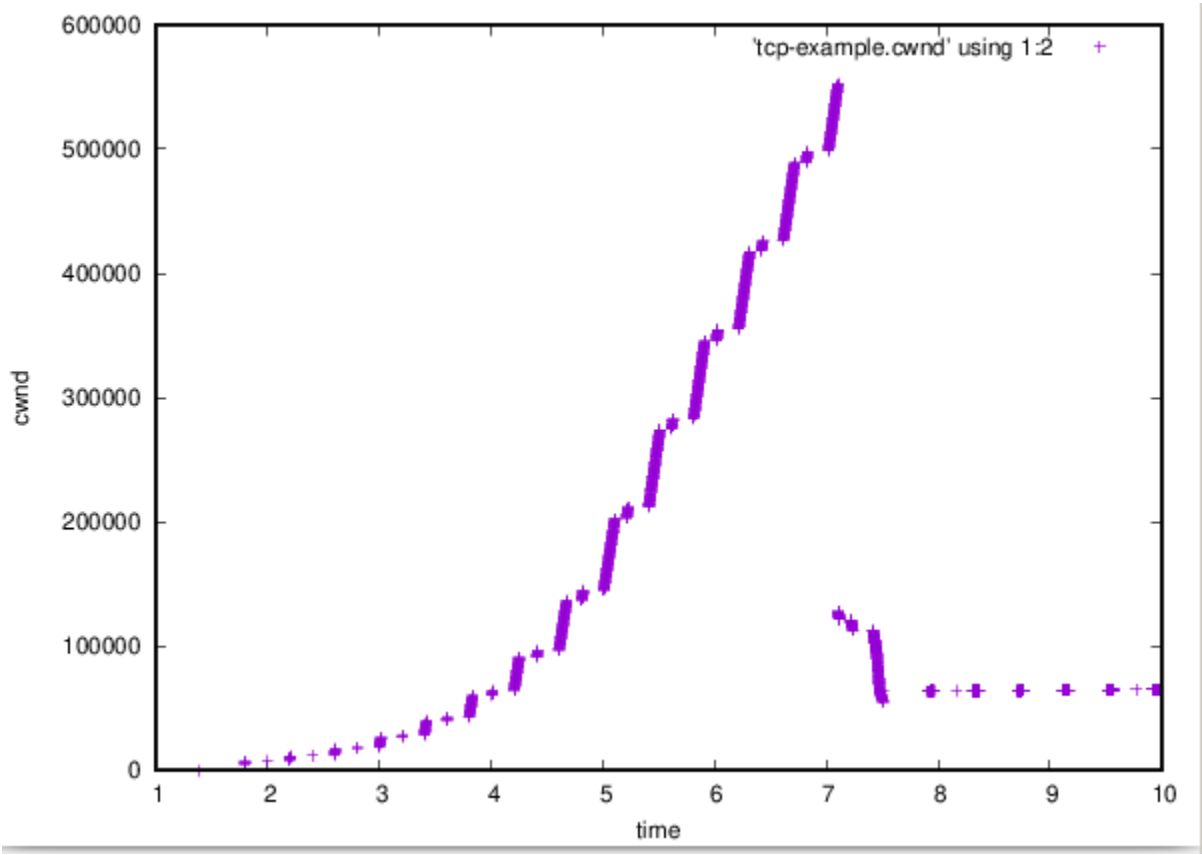
b) Average throughput at the receiver end

Throughput for N0 1.48 Mbps

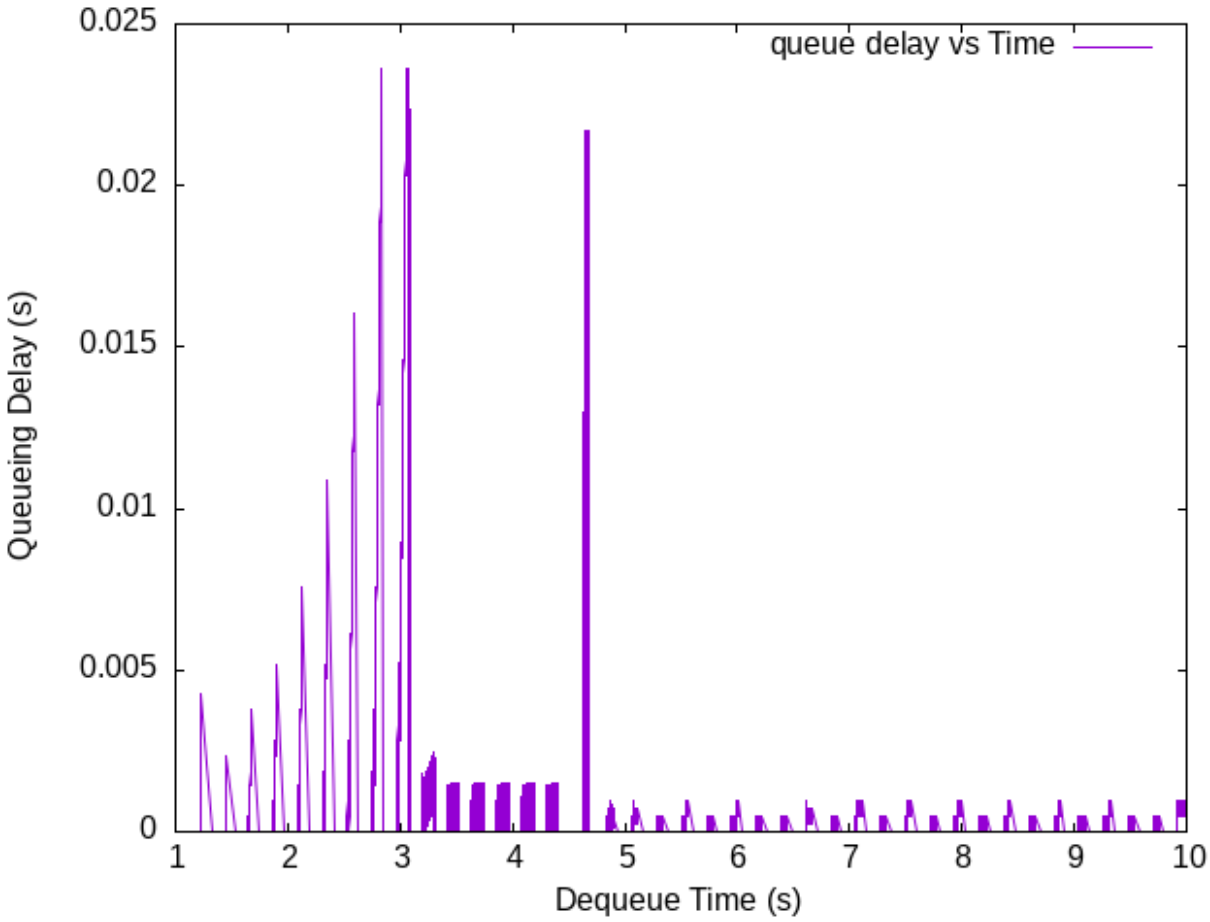
Throughput for N1 1.46 Mbps

Throughput for N2 1.46 Mbps

b)



c)



d)

So on comparison with 1) there is no delay for some event when operation time on queue is happen in 1) happens.