CN Assignment-4

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Q1. (A) Since the link with the lowest bandwidth limits the overall throughput, therefore the bottleneck bandwidth would be taken as the maximum expected throughput. In the given question, the link between N1 and N2 has the minimum bandwidth. Therefore, the maximum throughput = 7 Mbps

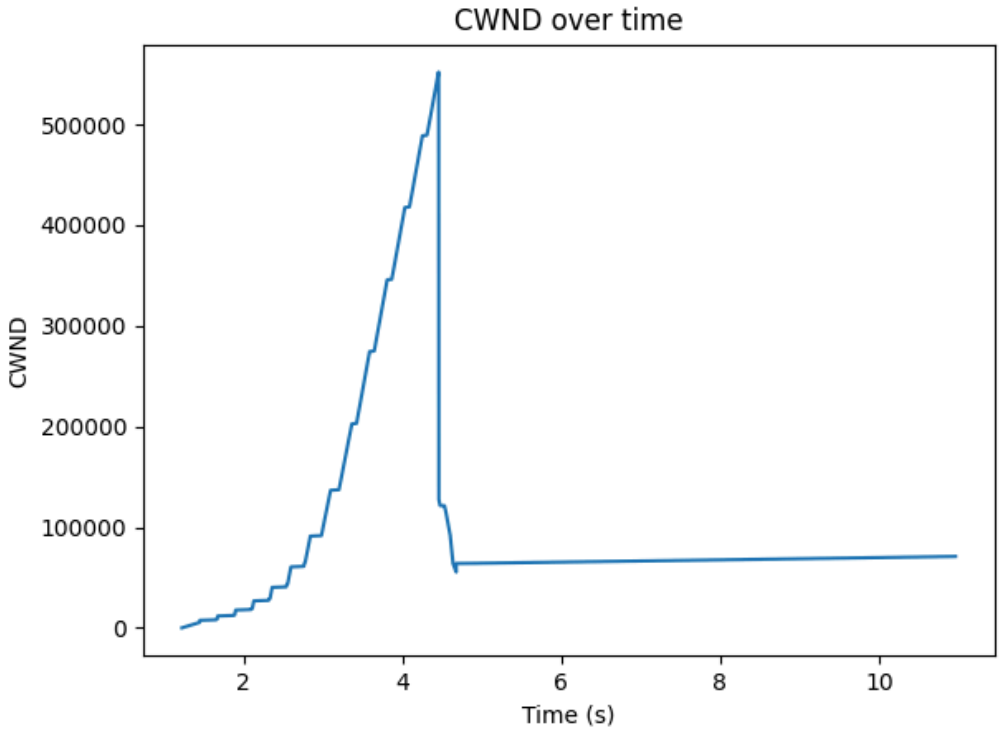
(B) BDP (N0 to N1) = 10 Mbps x 100 ms = 10^6 bits
BDP (N1 to N2) = 7 Mbps x 10 ms = 7 x 10^4 bits
Packet Size = 1460 x 8 = 11680 bits
We would take bottleneck BDP to characterize BDP of whole network therefore,
BDP = 7 x 10^4 / 11680 = 5.993 Packets
Therefore the BDP is approximately 6 Packets

(C) Wireshark shows that the average throughput was around 2.928 Mbps

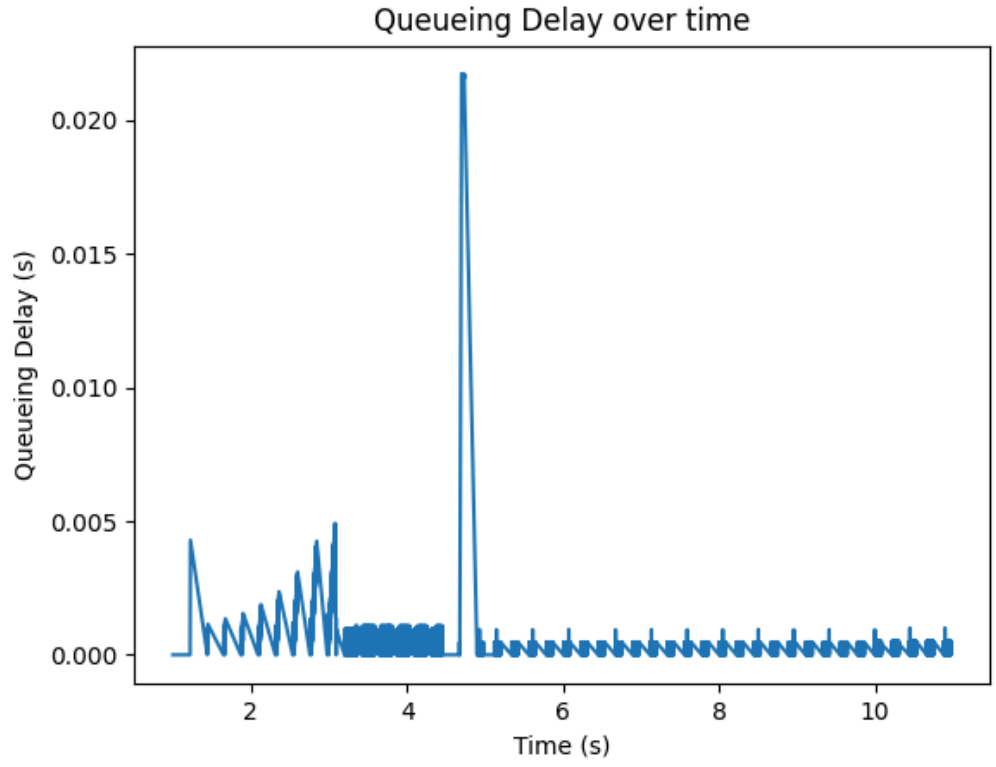
Measurement	Captured
Packets	9180
Time span, s	9.968
Average pps	921.0
Average packet size, B	397
Bytes	3648552
Average bytes/s	366 k
Average bits/s	2928 k

(D) The achieved throughput is significantly lower than the theoretical throughput, this is due to the fact that the theoretical throughput was the maximum achievable throughput in this particular configuration and also does not take into account the queuing delays. The simulation time not being sufficiently large enough also lets the delays take a toll on the achieved throughput. TCP congestion control mechanisms utilize slow start for congestion avoidance which also affects the throughput.

(E)


CWND over time
CWND
500000
400000
300000
200000
100000
0
2
4
6
8
10
Time (s)

(F)

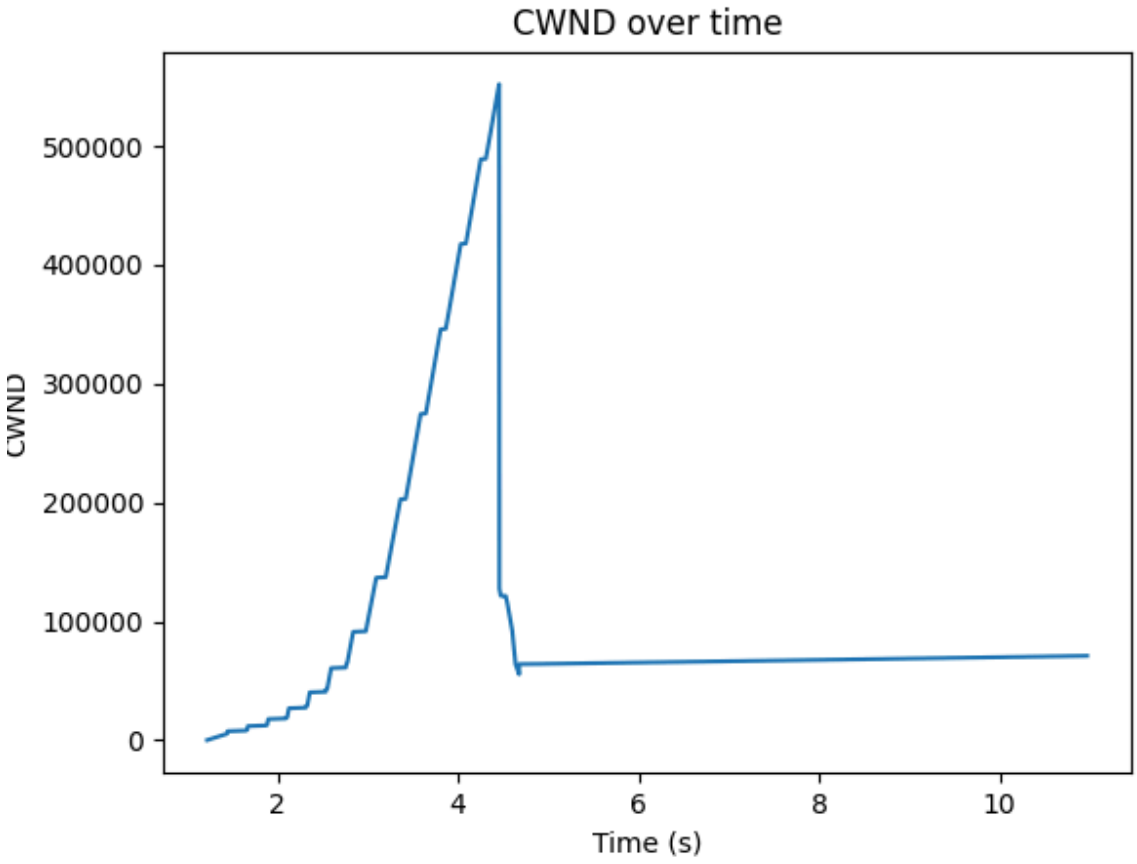

Queueing Delay over time
Queueing Delay (s)
0.020
0.015
0.010
0.005
0.000
2
4
6
8
10
Time (s)

(G) As we kept on increasing the congestion window, we reached a point around t = 5 where we reached the global cwnd maximum, but due to the congestion window being too large, we saw that we also reached a global maximum of queuing delay, thereby inducing a timeout which makes the cwnd plummet.

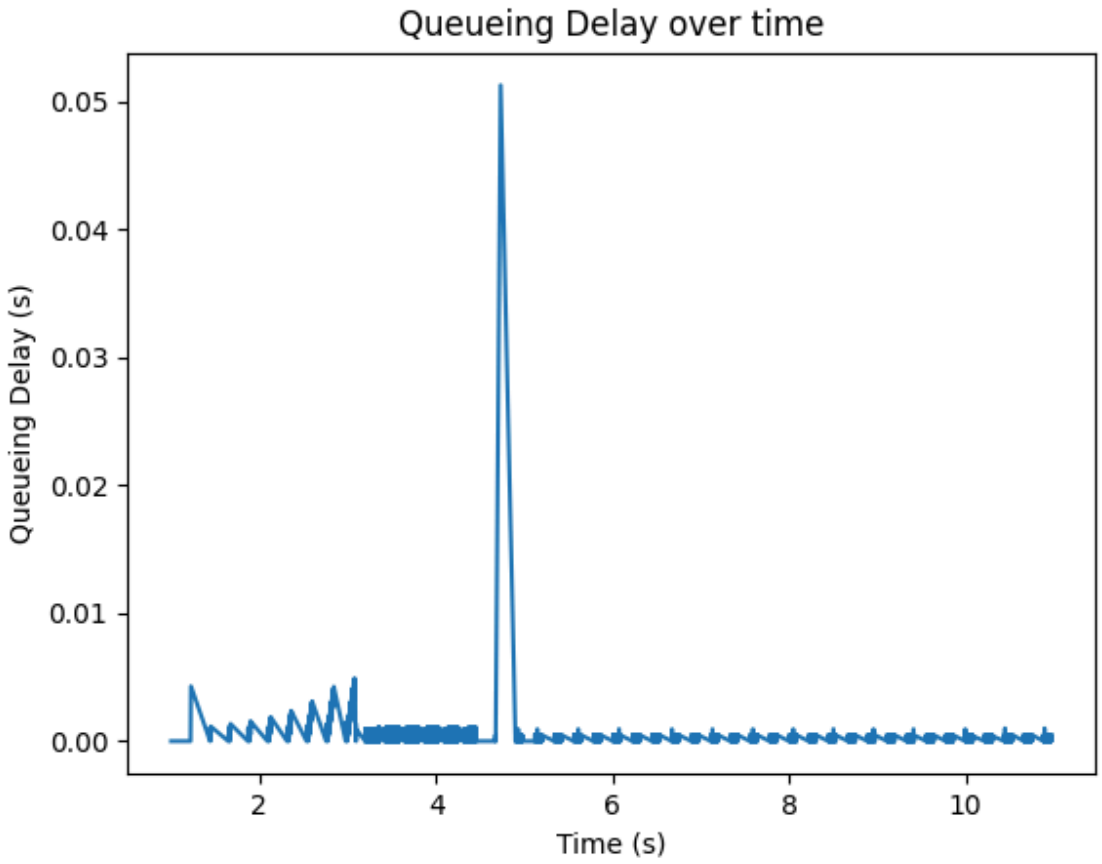
Q2 (A) The average computed throughput after the change was same as before at 2.928 Mbps

Measurement	Captured
Packets	9180
Time span, s	9.968
Average pps	921.0
Average packet size, B	397
Bytes	3648552
Average bytes/s	366 k
Average bits/s	2928 k

(B)



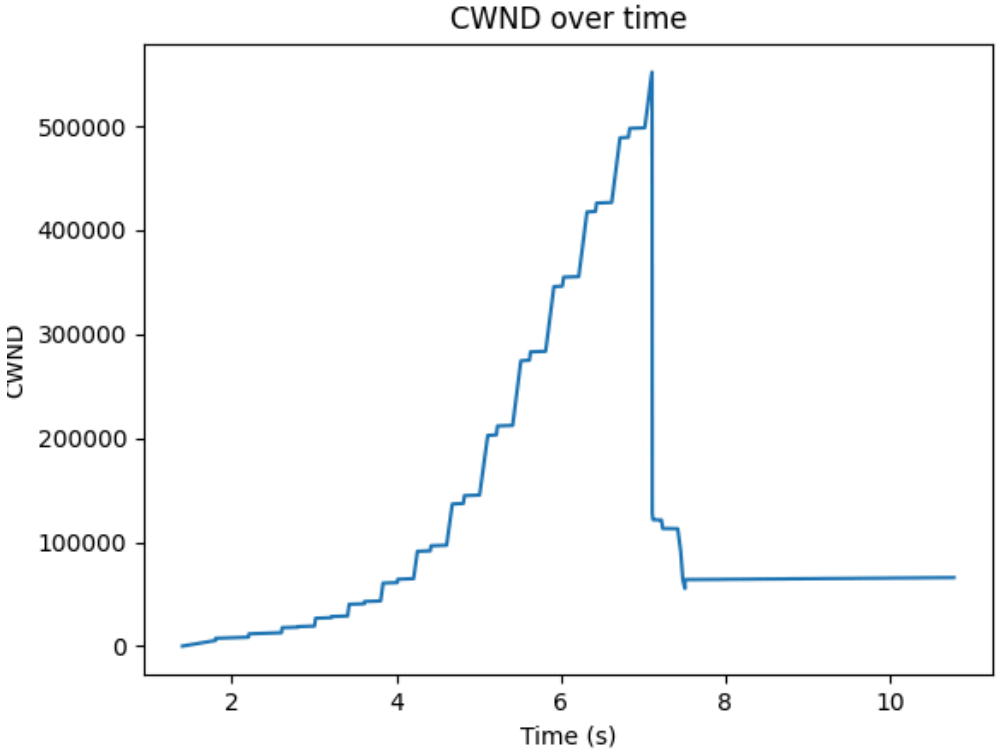
(C)



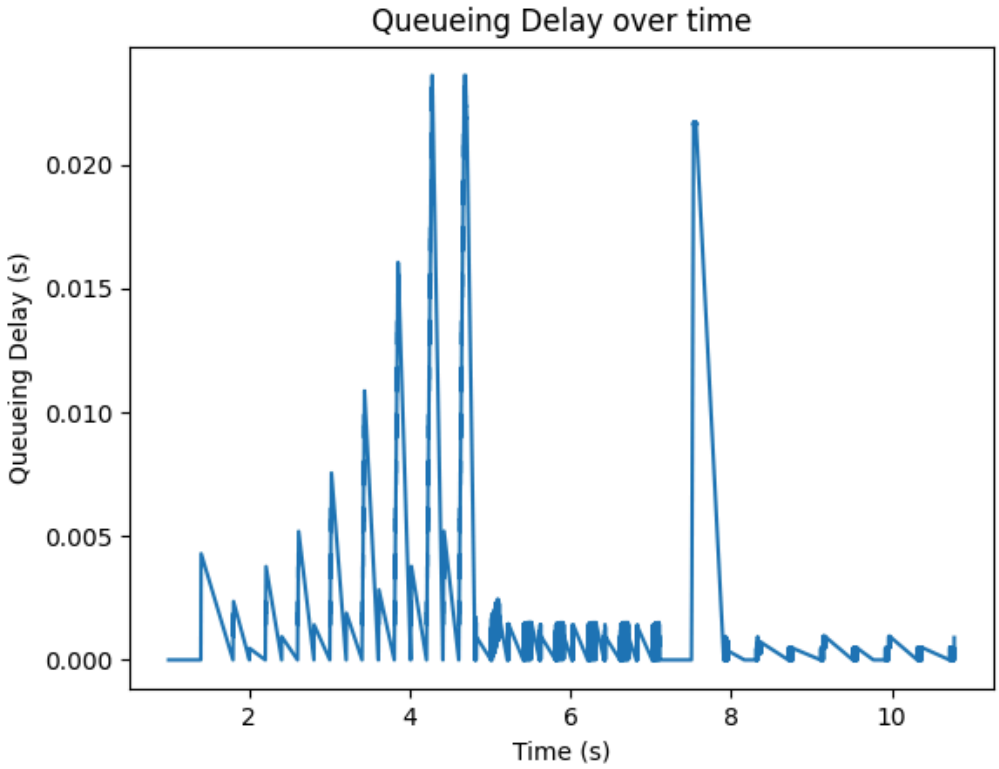
(D) In both the cases, I got the exact same plot for cwnd, this suggests that the reason for timeout was not the queuing delay rather some issue which might be related to the bandwidth.

Q3 (A) The average computed threshold in this case came out to be 1.706 Mbps

Measurement	Captured
Packets	5386
Time span, s	9.778
Average pps	550.8
Average packet size, B	387
Bytes	2085988
Average bytes/s	213 k
Average bits/s	1706 k


CWND over time
CWND
500000
400000
300000
200000
100000
0
2
4
6
8
10
Time (s)

(B)


Queueing Delay over time
Queueing Delay (s)
0.020
0.015
0.010
0.005
0.000
2
4
6
8
10
Time (s)

(C)

(D) As we increased both the bandwidth and delay of the N1-N2 link, the delays of this link would contribute towards the more frequent and higher spikes in queuing delay as observed, since the packets now need to be held in the queue for longer durations of time.