

## 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)  $RTT = 2 \times (100 + 10) = 220 \text{ ms}$

$BDP = 7 \text{ Mbps} \times 220 \text{ ms} = 1.54 \text{ Mbits}$

$\text{Packet Size} = 1460 \times 8 = 11680 \text{ bits}$

$BDP = 1.54 \times 10^6 / 11680 = 131.849 \text{ Packets}$

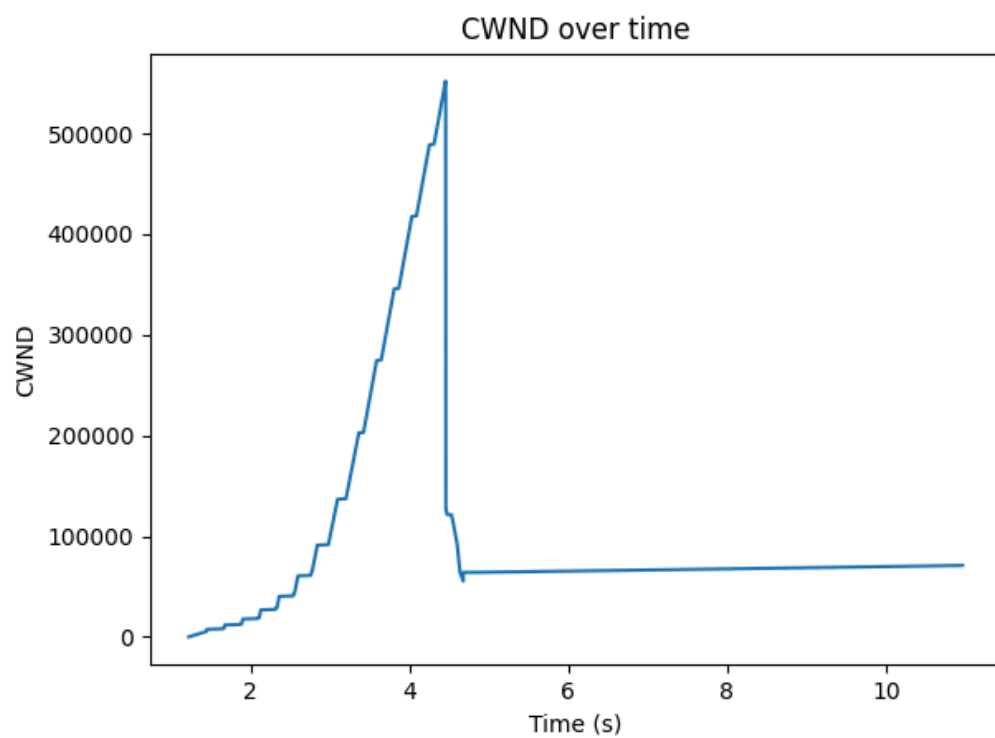
Therefore the BDP is approximately 131 Packets

(C) Wireshark shows that the average throughput was around 2.894 Mbps

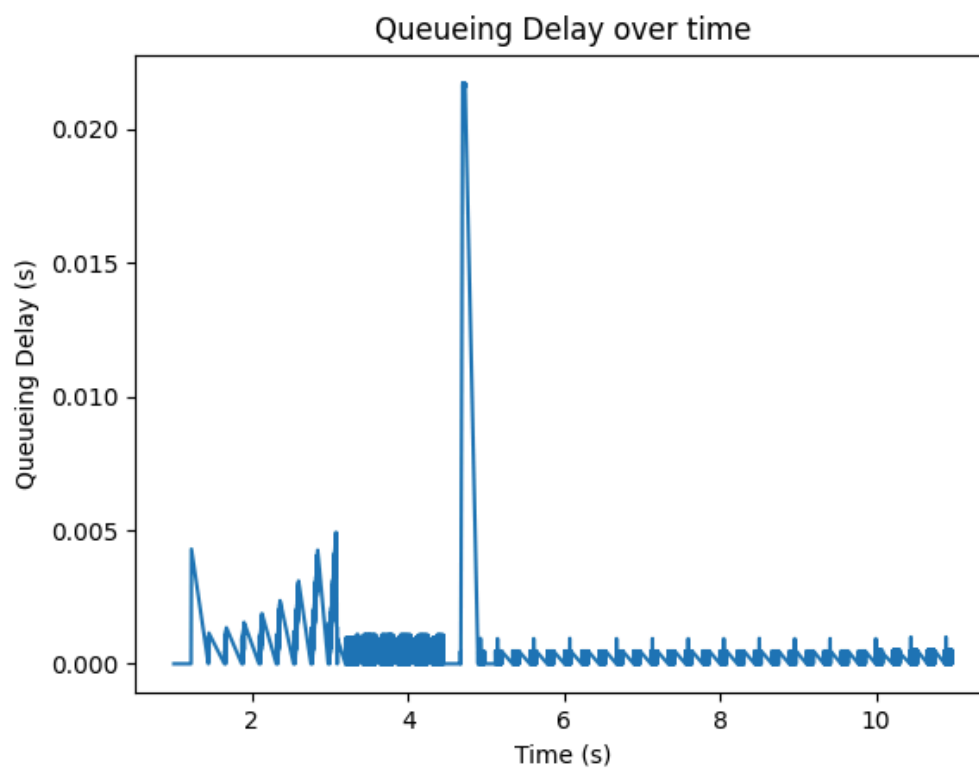
Measurement	Captured
Packets	9066
Time span, s	9.889
Average pps	916.7
Average packet size, B	395
Bytes	3578076
Average bytes/s	361 k
Average bits/s	2894 k

(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)



(F)

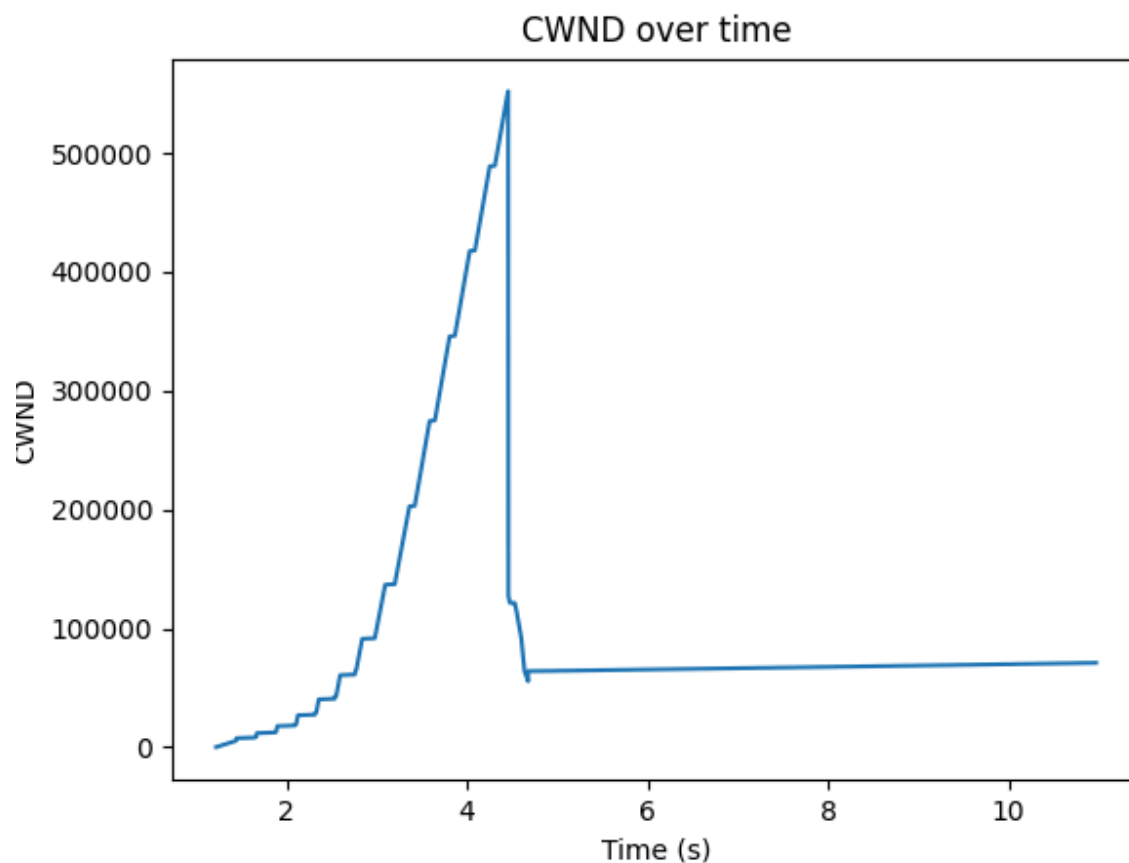


(G) As we kept on increasing the congestion window, we reached a point around  $t = 5$  where we reached the global cwnd maximum, but due to the congestion window being too large, we saw that we also reached a global maximum of queuing delay, thereby inducing a timeout which makes the cwnd plummet.

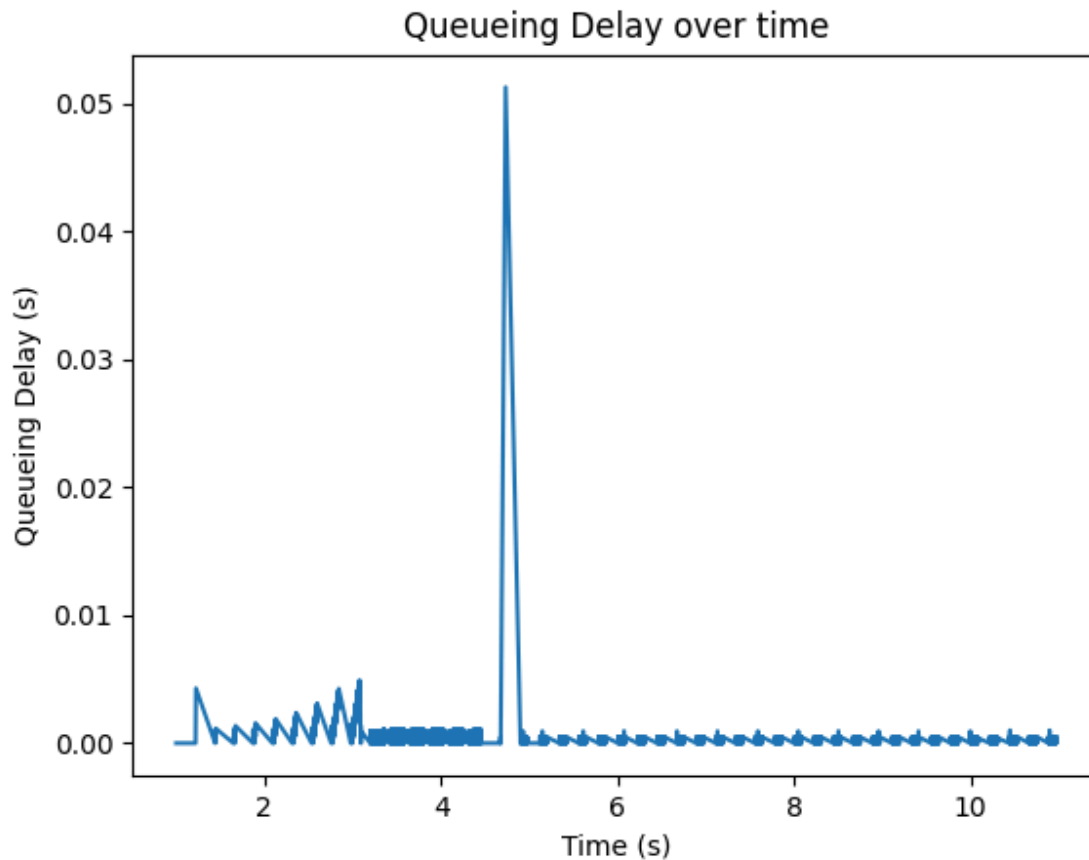
Q2 (A) The average computed throughput after the change was same as before at 2.894 Mbps

Measurement	Captured
Packets	9066
Time span, s	9.889
Average pps	916.7
Average packet size, B	395
Bytes	3578076
Average bytes/s	361 k
Average bits/s	2894 k

(B)



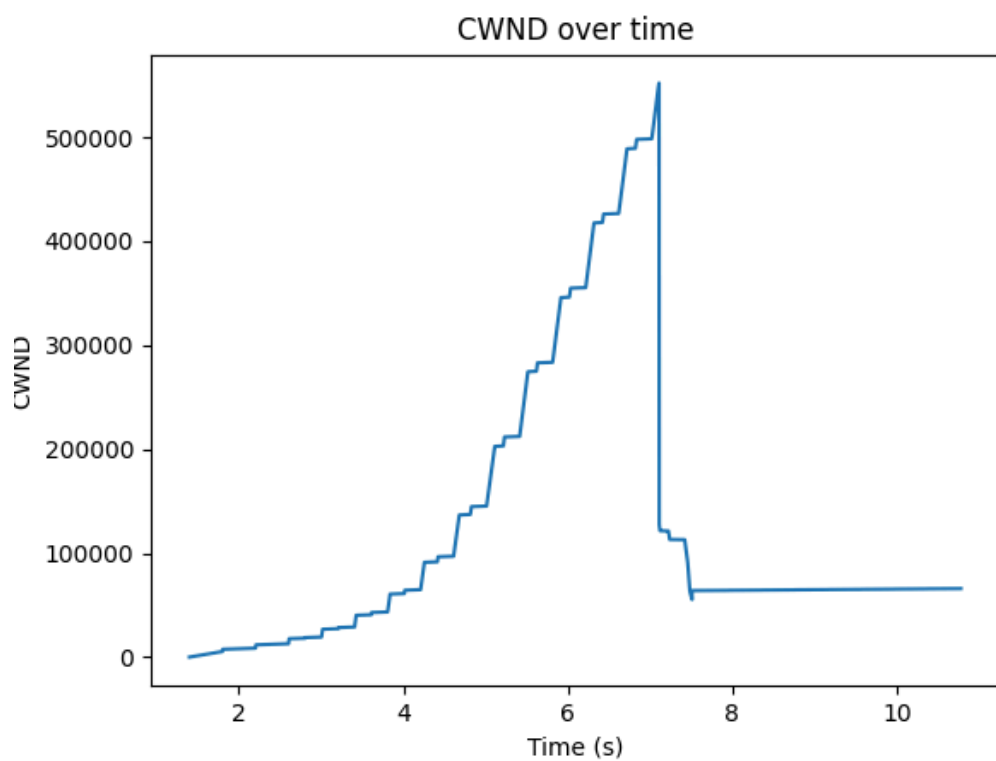
(C)



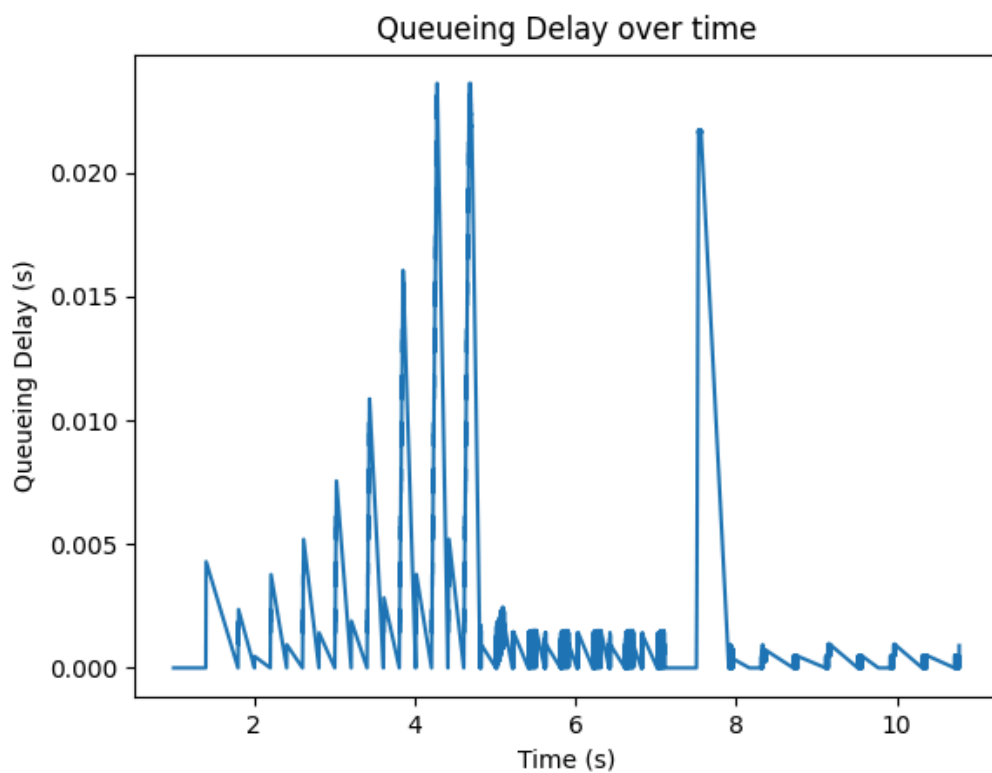
(D) In both the cases, I got the exact same plot for cwnd, this suggests that the reason for timeout was not the queueing delay rather some issue which might be related to the bandwidth.

Q3 (A) The average computed threshold in this case came out to be 1.708 Mbps

<u>Measurement</u>	<u>Captured</u>
Packets	5446
Time span, s	9.779
Average pps	556.9
Average packet size, B	384
Bytes	2088692
Average bytes/s	213 k
Average bits/s	1708 k



(B)



(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.