Computer Networks
Assignment 3

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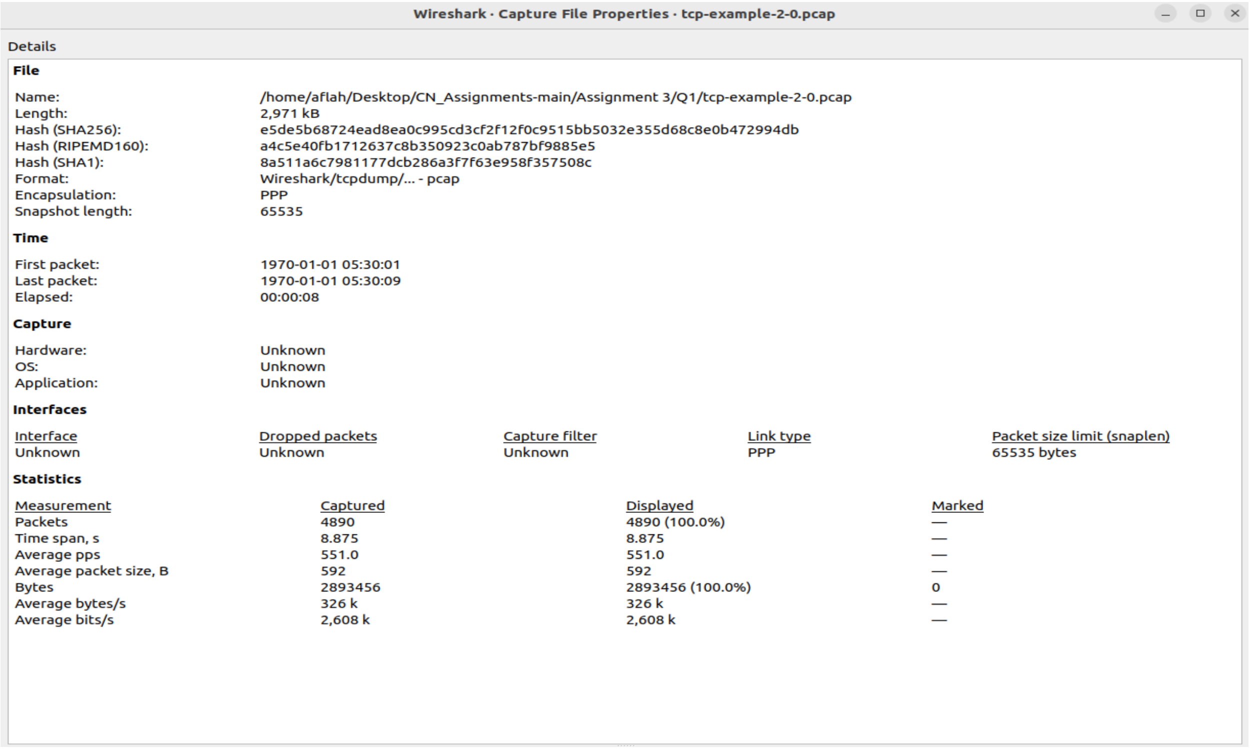
2020082

Ans 1)
a)
Since the maximum throughput is dictated by the bottleneck link in this case it would be 7 Mbps as the N0-N1 link has 10 Mbps bandwidth while the N1-N2 link only has 7 Mbps bandwidth. Hence the expected throughput is minimum of 7 and 10 that is 7 Mbps

b)
Total End-End Delay between N0-N2 = Round Trip Delay N0-N1 + Round Trip Delay N1-N2
Total End-End Delay between N0-N2 = 2 * (One Way Delay N0-N1 + One Way Delay N1-N2)
Total End-End Delay between N0-N2 = 2 * (100 ms + 10 ms) = 220 ms
Bandwidth Delay Product = 7 Mbps * 220 ms = 7 * 220 * 10^-3 = 1.54 Mb

If we assume 1 payload/packet
Packet Size = 1460 bytes = 11680 bits
Number of Packets = 1.54 * 10^6 / 11680 ≈ 131 Packets
So we can say BDP is 131 Packets

c)



Wireshark · Capture File Properties · tcp-example-2-0.pcap

Details

File

Name:	/home/aflah/Desktop/CN_Assignments-main/Assignment 3/Q1/tcp-example-2-0.pcap
Length:	2,971 kB
Hash (SHA256):	e5de5b68724ead8ea0c995cd3cf2f12f0c9515bb5032e355d68c8e0b472994db
Hash (RIPEMD160):	a4c5e40fb1712637c8b350923c0ab787bf9885e5
Hash (SHA1):	8a511a6c7981177dcb286a3f7f63e958f357508c
Format:	Wireshark/tcpdump/... - pcap
Encapsulation:	PPP
Snapshot length:	65535

Time

First packet:	1970-01-01 05:30:01
Last packet:	1970-01-01 05:30:09
Elapsed:	00:00:08

Capture

Hardware:	Unknown
OS:	Unknown
Application:	Unknown

Interfaces

Interface	Dropped packets	Capture filter	Link type	Packet size limit (snaplen)
Unknown	Unknown	Unknown	PPP	65535 bytes

Statistics

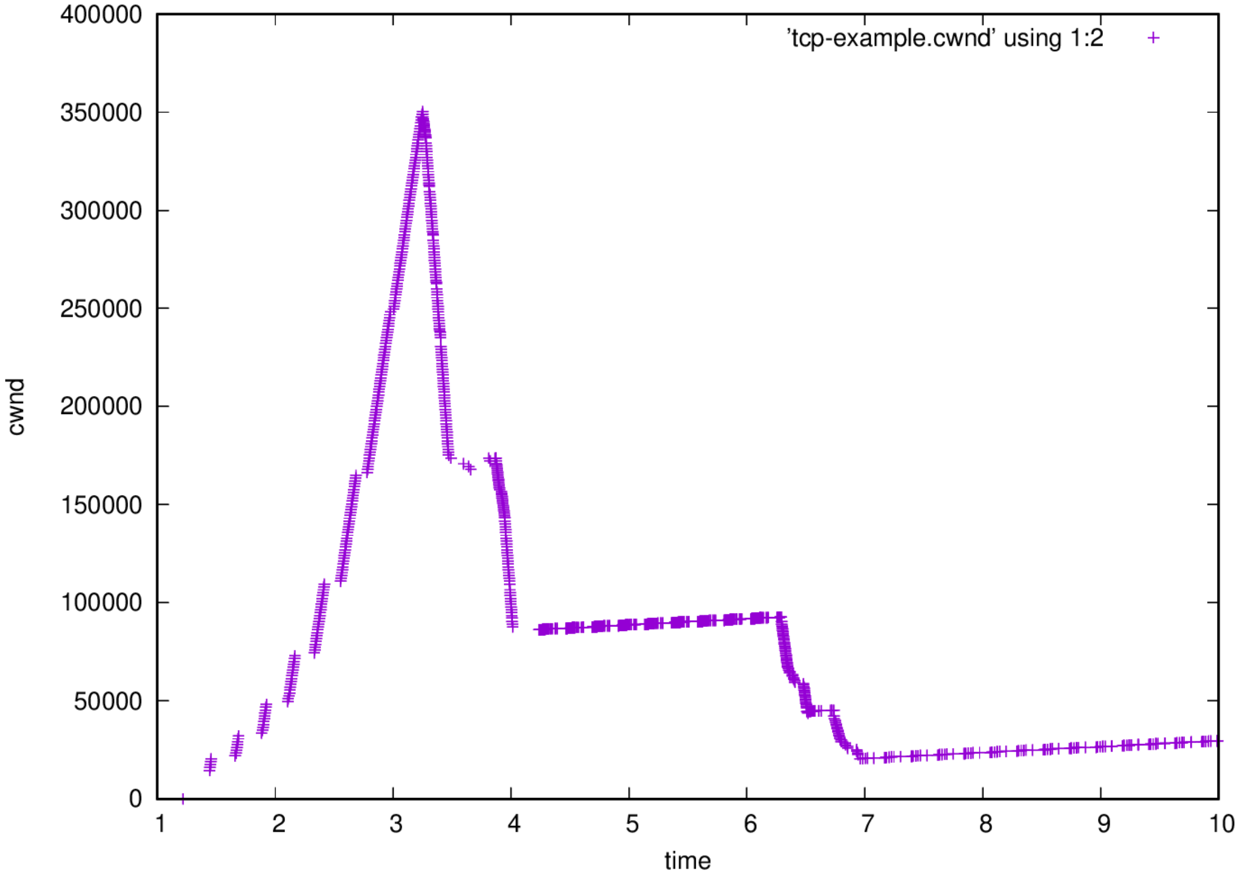
Measurement	Captured	Displayed	Marked
Packets	4890	4890 (100.0%)	—
Time span, s	8.875	8.875	—
Average pps	551.0	551.0	—
Average packet size, B	592	592	—
Bytes	2893456	2893456 (100.0%)	0
Average bytes/s	326 k	326 k	—
Average bits/s	2,608 k	2,608 k	—

Total Data Length Sent = 2893456 Bytes
Time Span for Sending = 8.875 Seconds
Throughput = Total Data Length Sent / Time Span for Sending = 2893456 * 8 / (8.875 * 10^6) = 2.60818569014 Mbps

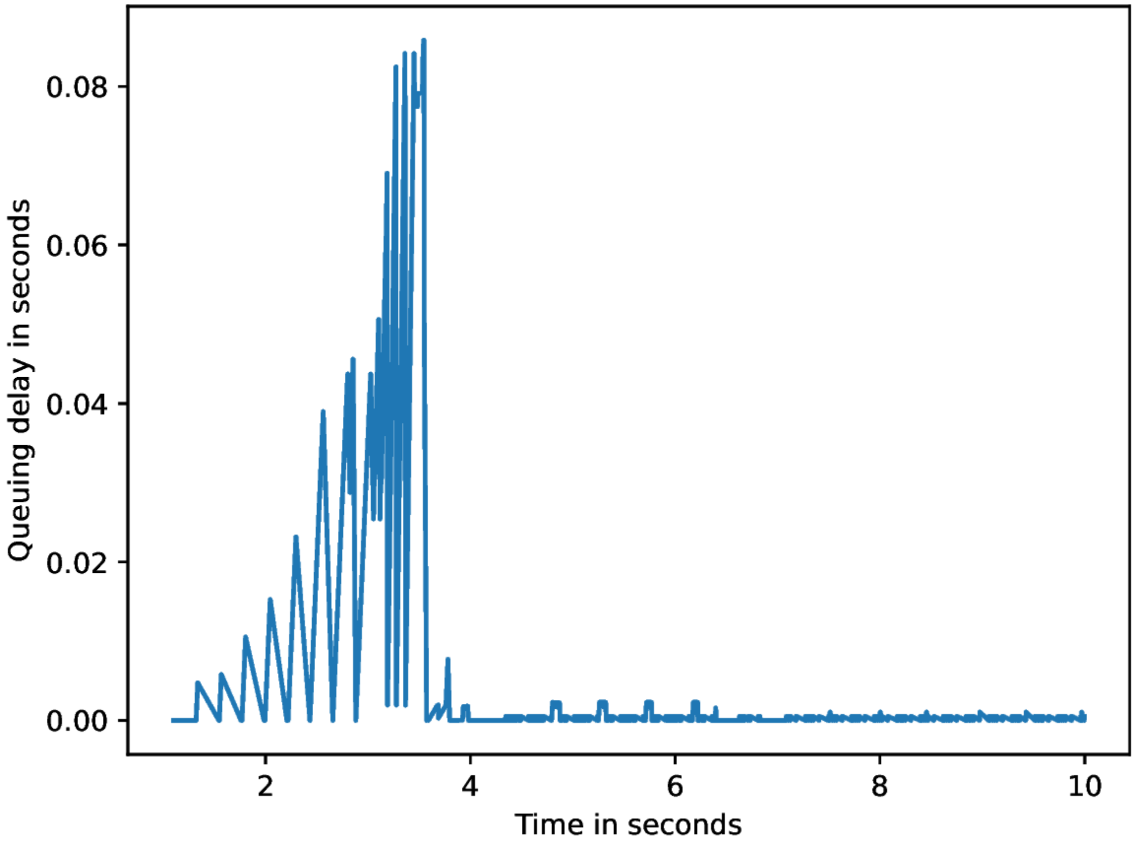
d)
The obtained throughput is much lesser than the expected throughput because of the following reasons -

1) Packets might be retransmitted due to lost acknowledgements
2) Packets might be retransmitted due to being dropped off at the buffer due to large queues

e)
Congestion Window Plot -



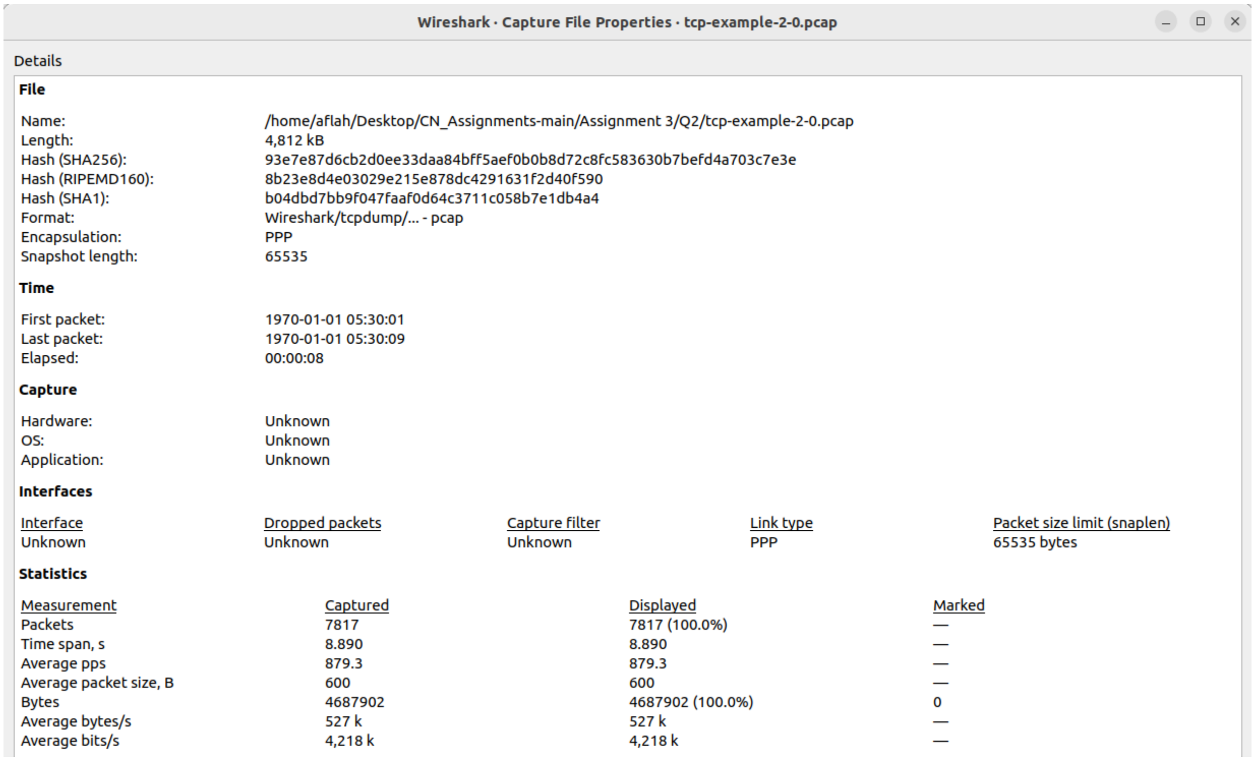
f)
Plot for Queueing Delay



g)
Yes, Congestion Window is related to the Queuing Delay
We can see initially that there is an exponential increase in the queueing delay when the network is in the slow start phase. Once it hits the maximum capacity the packets are dropped from the buffer which causes retransmissions. Once packets begin dropping the sender goes into fast recovery. In fast recovery the cwnd is halved and the delay also goes down.
Upon investigating we can also see that when the queue delay is very high the queue length is also 50 and then we see that our cwnd is halved indicating that we are in Fast Recovery. This keeps happening till more packets are lost and for that we have a very low cwnd.

Ans 2)

a)



Details

File

Name:	/home/aflah/Desktop/CN_Assignments-main/Assignment 3/Q2/tcp-example-2-0.pcap
Length:	4,812 kB
Hash (SHA256):	93e7e87d6cb2d0ee33daa84bff5aef0b0b8d72c8fc583630b7befd4a703c7e3e
Hash (RIPEMD160):	8b23e8d4e03029e215e878dc4291631f2d40f590
Hash (SHA1):	b04dbd7bb9f047faaf0d64c3711c058b7e1db4a4
Format:	Wireshark/tcpdump/... - pcap
Encapsulation:	PPP
Snapshot length:	65535

Time

First packet:	1970-01-01 05:30:01
Last packet:	1970-01-01 05:30:09
Elapsed:	00:00:08

Capture

Hardware:	Unknown
OS:	Unknown
Application:	Unknown

Interfaces

Interface	Dropped packets	Capture filter	Link type	Packet size limit (snaplen)
Unknown	Unknown	Unknown	PPP	65535 bytes

Statistics

Measurement	Captured	Displayed	Marked
Packets	7817	7817 (100.0%)	—
Time span, s	8.890	8.890	—
Average pps	879.3	879.3	—
Average packet size, B	600	600	—
Bytes	4687902	4687902 (100.0%)	0
Average bytes/s	527 k	527 k	—
Average bits/s	4,218 k	4,218 k	—

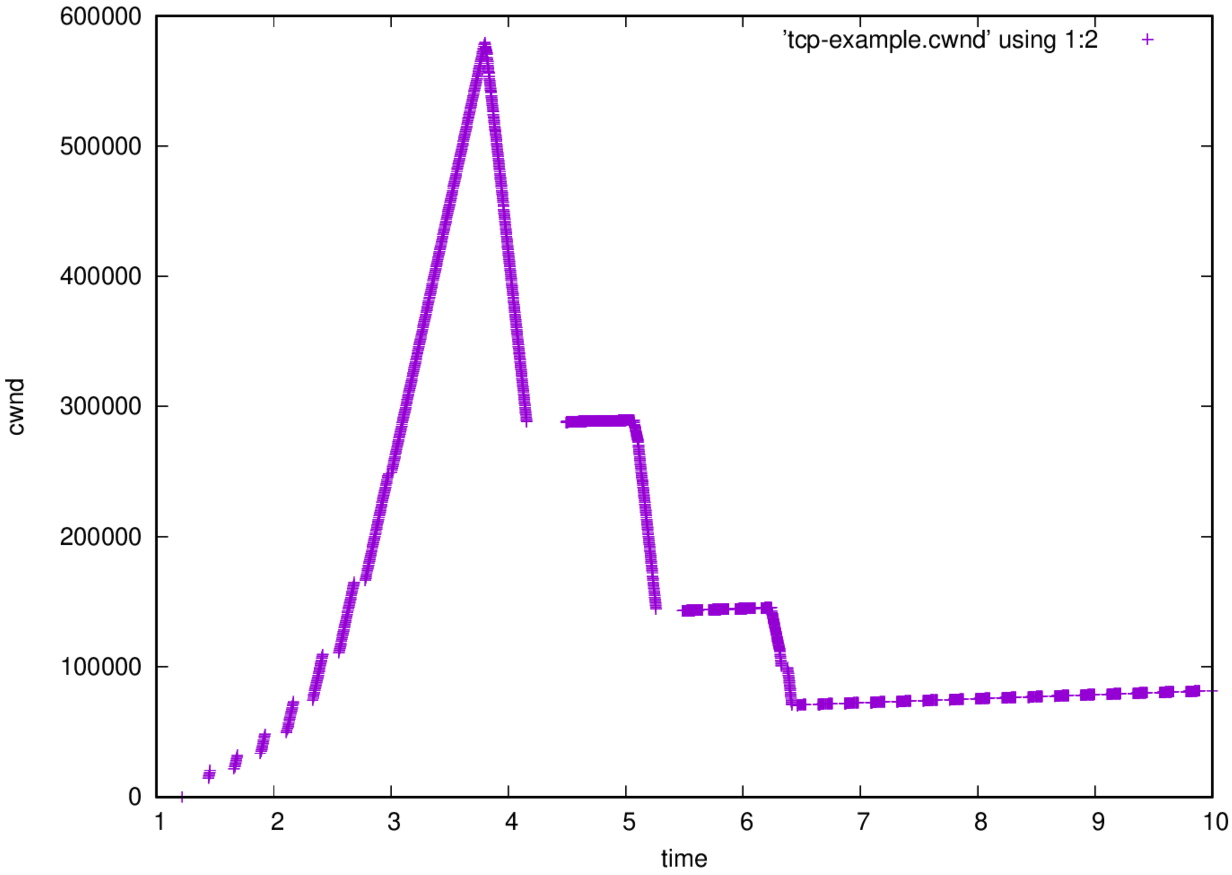
Total Data Sent = 4687902 Bytes

Total Time Span = 8.890 Seconds

Throughput = 4687902 * 8 / (8.890*10^6) = 4.21858447694 Mbps

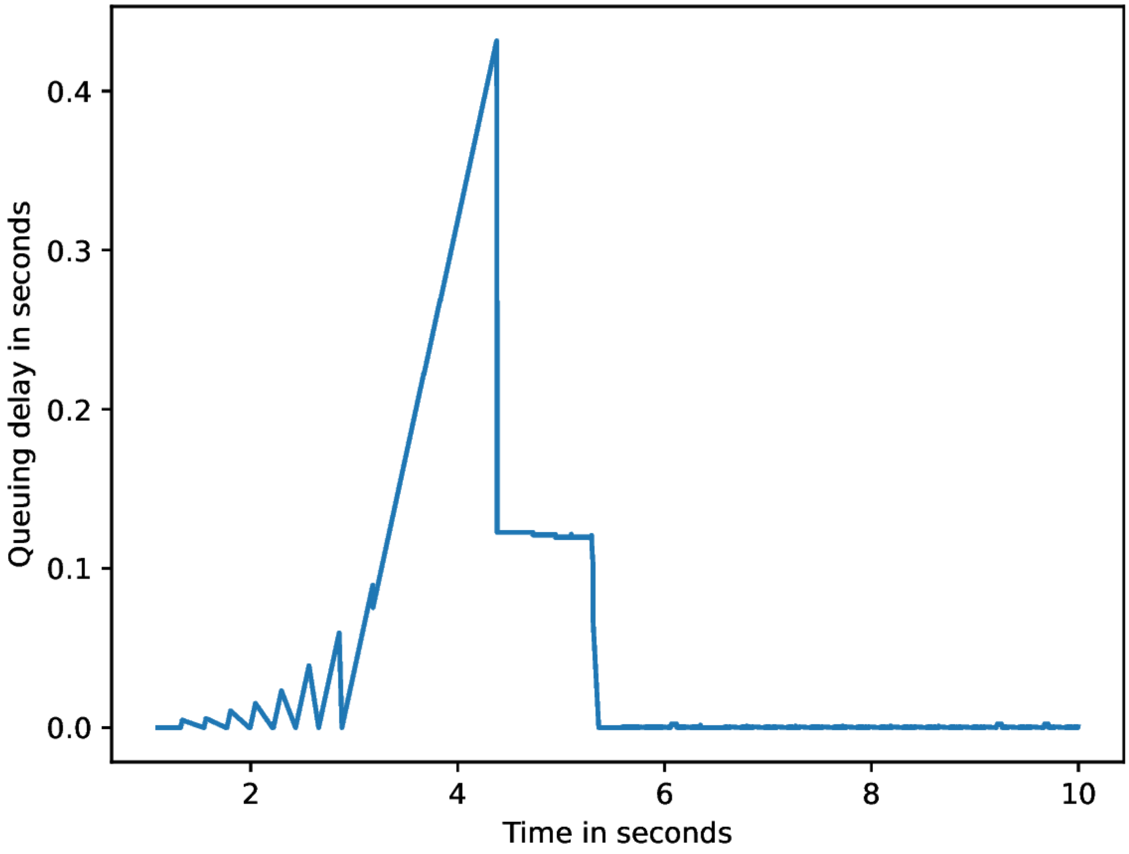
b)

Congestion Window Plot -



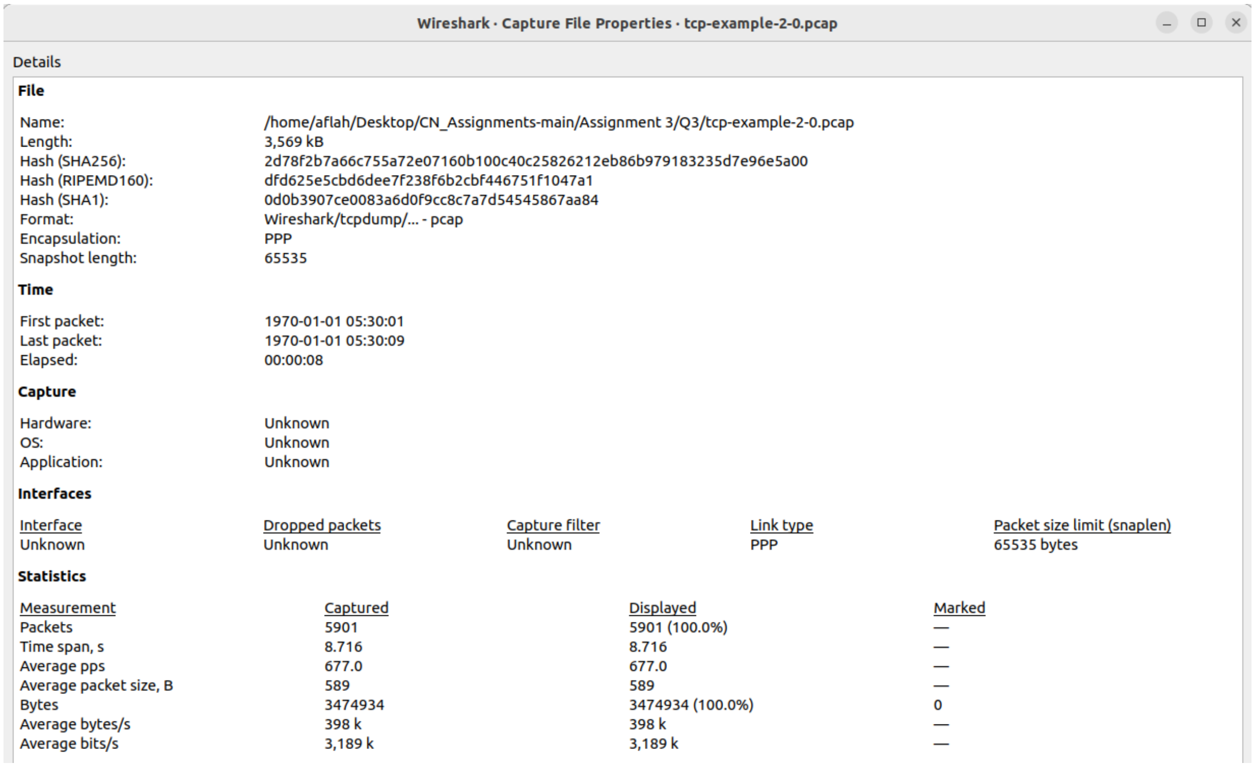
c)

Queueing Delay Plot



d)
If we compare congestion window size we see that the maximum congestion in Q2 is nearly double that of Q1. Since the buffer size is larger in Q2 the overflow doesn't occur as fast as Q1. Overflow of the buffer leads to packet losses amongst other issues which leads to duplicate acks, retransmissions, timeouts etc. leading to decrease of cwnd. Hence the cwnd increases for a longer time in Q1.

Ans 3)
a)



Wireshark · Capture File Properties · tcp-example-2-0.pcap

Details

File

Name:	/home/aflah/Desktop/CN_Assignments-main/Assignment 3/Q3/tcp-example-2-0.pcap
Length:	3,569 kB
Hash (SHA256):	2d78f2b7a66c755a72e07160b100c40c25826212eb86b979183235d7e96e5a00
Hash (RIPEMD160):	dfd625e5cbd6dee7f238f6b2cbf446751f1047a1
Hash (SHA1):	0d0b3907ce0083a6d0f9cc8c7a7d54545867aa84
Format:	Wireshark/tcpdump/... - pcap
Encapsulation:	PPP
Snapshot length:	65535

Time

First packet:	1970-01-01 05:30:01
Last packet:	1970-01-01 05:30:09
Elapsed:	00:00:08

Capture

Hardware:	Unknown
OS:	Unknown
Application:	Unknown

Interfaces

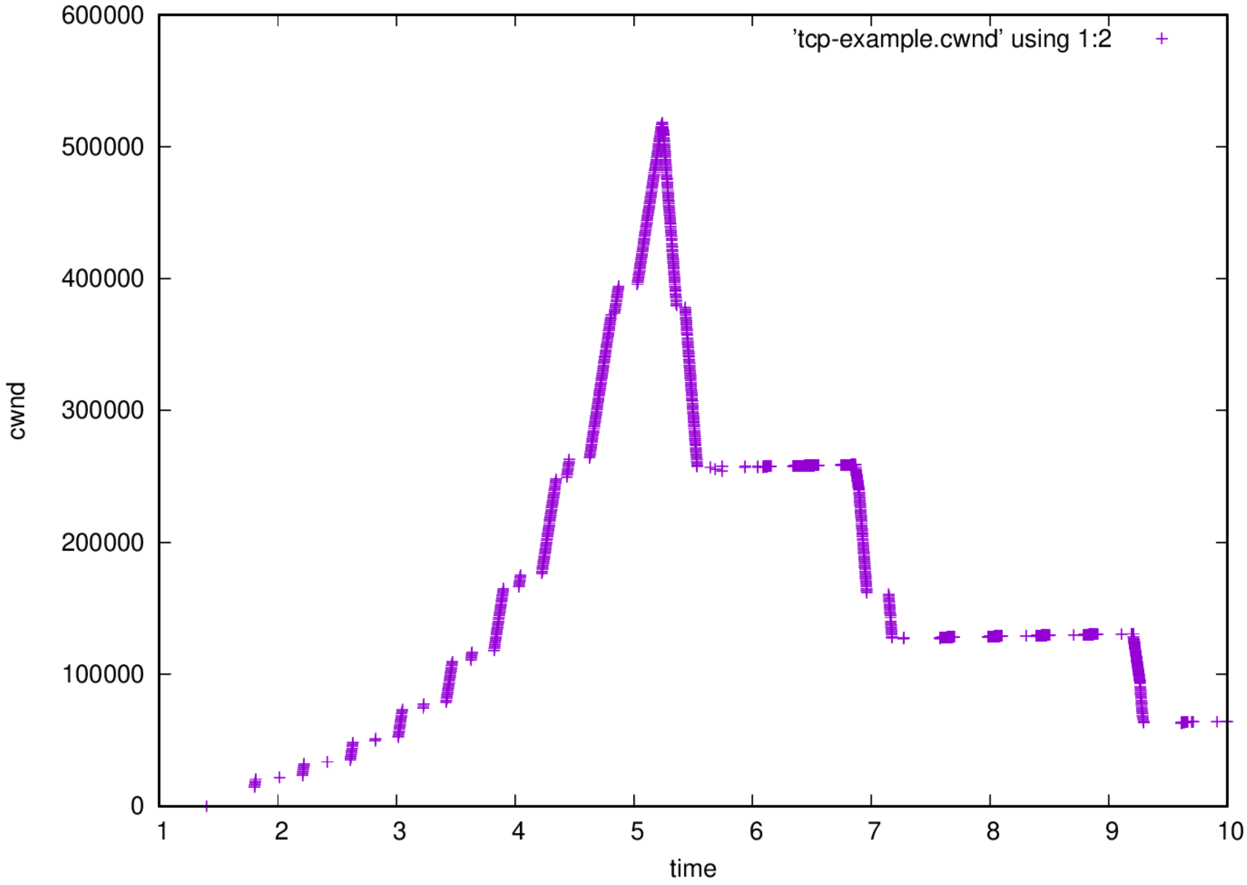
Interface	Dropped packets	Capture filter	Link type	Packet size limit (snaplen)
Unknown	Unknown	Unknown	PPP	65535 bytes

Statistics

Measurement	Captured	Displayed	Marked
Packets	5901	5901 (100.0%)	—
Time span, s	8.716	8.716	—
Average pps	677.0	677.0	—
Average packet size, B	589	589	—
Bytes	3474934	3474934 (100.0%)	0
Average bytes/s	398 k	398 k	—
Average bits/s	3,189 k	3,189 k	—

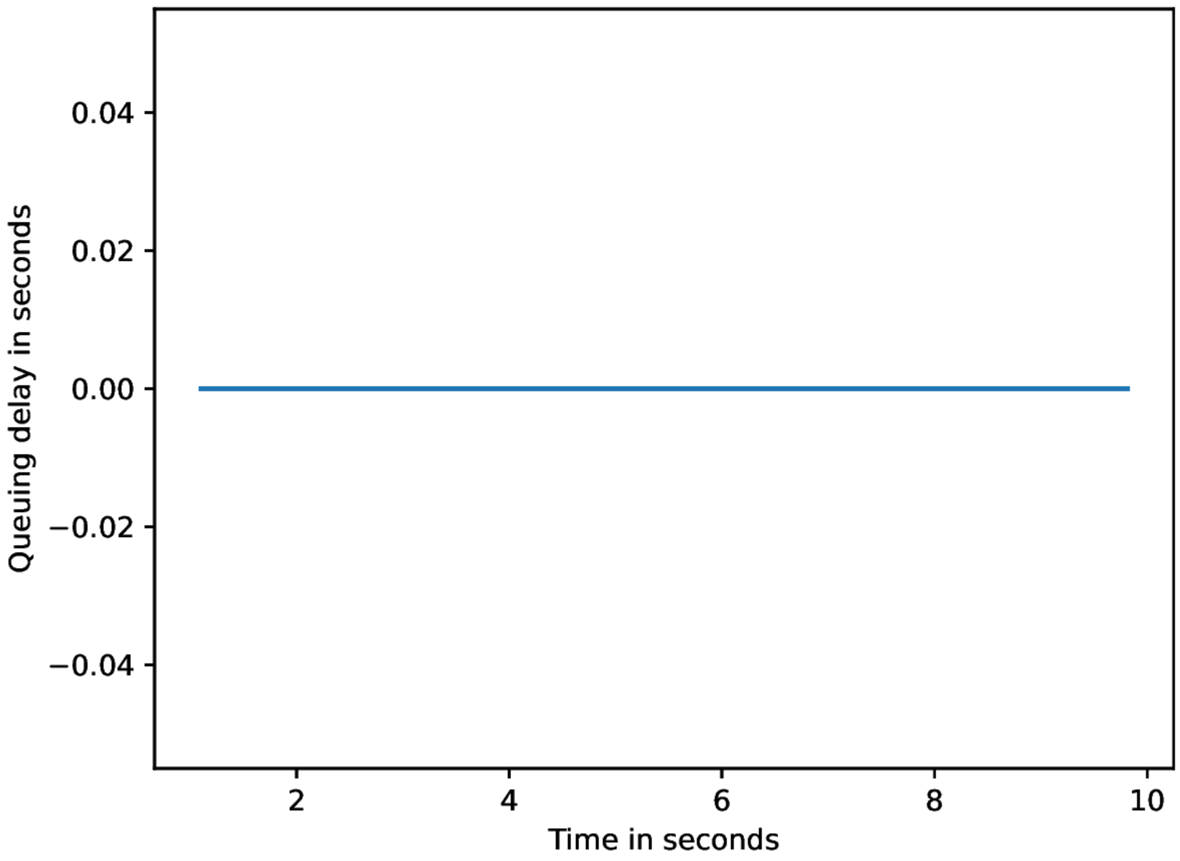
Total Data Sent = 3474934 Bytes
Total Time Span = 8.716 Seconds
Throughput = 3474934 * 8 / (8.716 * 10^6) = 3.18947590638 Mbps

b)
Congestion Window Plot



c)

Queuing Delay Plot -



d)

If we compare the queuing delay plot from Q1 to that of Q3 we see that in Q1 it’s near 0.08 while in Q3 it’s 0 (infinitesimally small). This happens because in Q3 the sender and receiver transmit at the same rate so a packet is forwarded instantly leading to no queuing delay.

However in Q1 this is not the case and there is a mismatch prompting a queue to build up as the transmission rate is slower than the arrival. Also since some packets are broken down into fragments it also affects the queue