CSE232: Assignment 3

Mihir Chaturvedi (2019061)

Question 1

a. Bandwidth between N0--N1 (R_1) = 10Mbps
Bandwidth between N1--N2 (R_2) = 5Mbps
Theoretical maximum throughput = $min\{R_1, R_2\}$
= $min\{$10Mbps, 5Mbps$\}$
= **5Mbps**

b. *Link N0--N1:*
Number of packets transferred per second = 10Mbps / 1460bytes
= 10,000,000/(1460 * 8) packets
= 856.16 packets
Total RTT delay between N0 and N1 = 10ms * 2 = 20ms = 0.02s
Bandwidth-delay-product (in terms of packets) = Pkts/second * RTT Delay
= 856.16 * 0.02
= **17.123 packets**

Link N1--N2:
Number of packets transferred per second = 5Mbps / 1460bytes
= 5,000,000/(1460 * 8) packets
= 428.08 packets
Total RTT delay between N0 and N1 = 15ms * 2 = 30ms = 0.03s
Bandwidth-delay-product (in terms of packets) = Pkts/second * RTT Delay
= 428.08 * 0.03
= **12.842 packets**

Path N0--N2:
Number of packets transferred per second = 5Mbps / 1460bytes
= 5,000,000/(1460 * 8) packets
= 428.08 packets
Total RTT delay between N0 and N1 = (10+15)ms * 2 = 50ms = 0.05s
Bandwidth-delay-product (in terms of packets) = Pkts/second * RTT Delay
= 428.08 * 0.05
= **21.404 packets**

c. Number of bits transferred through N0--N2 = 4587000 bytes * 8
= 36696000 bits
= 36.696 Megabits

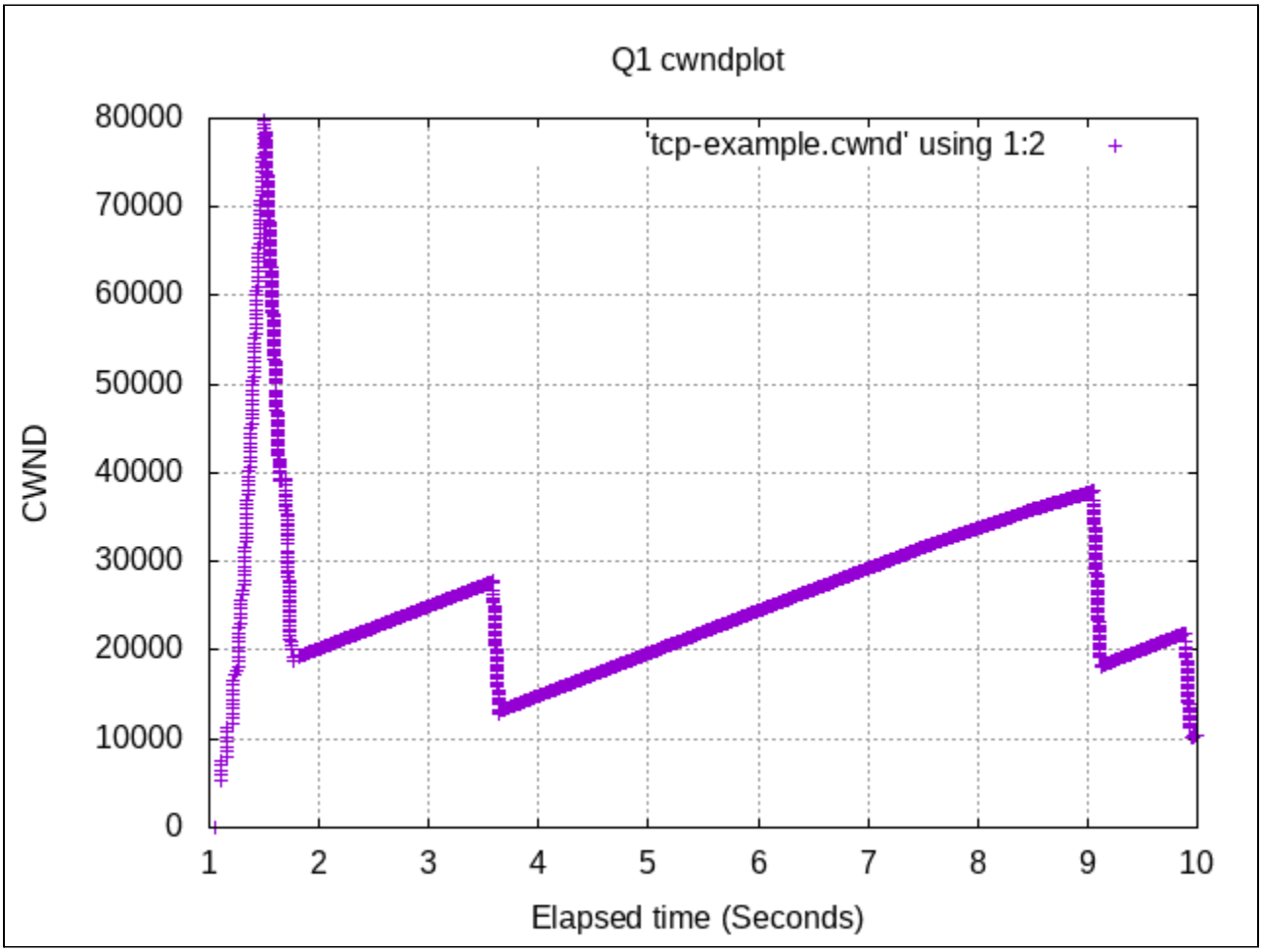
Total duration of transfer = 8.9737s

Average throughput = 36.696 / 8.9737 Mbps
= **4.089 Mbps**

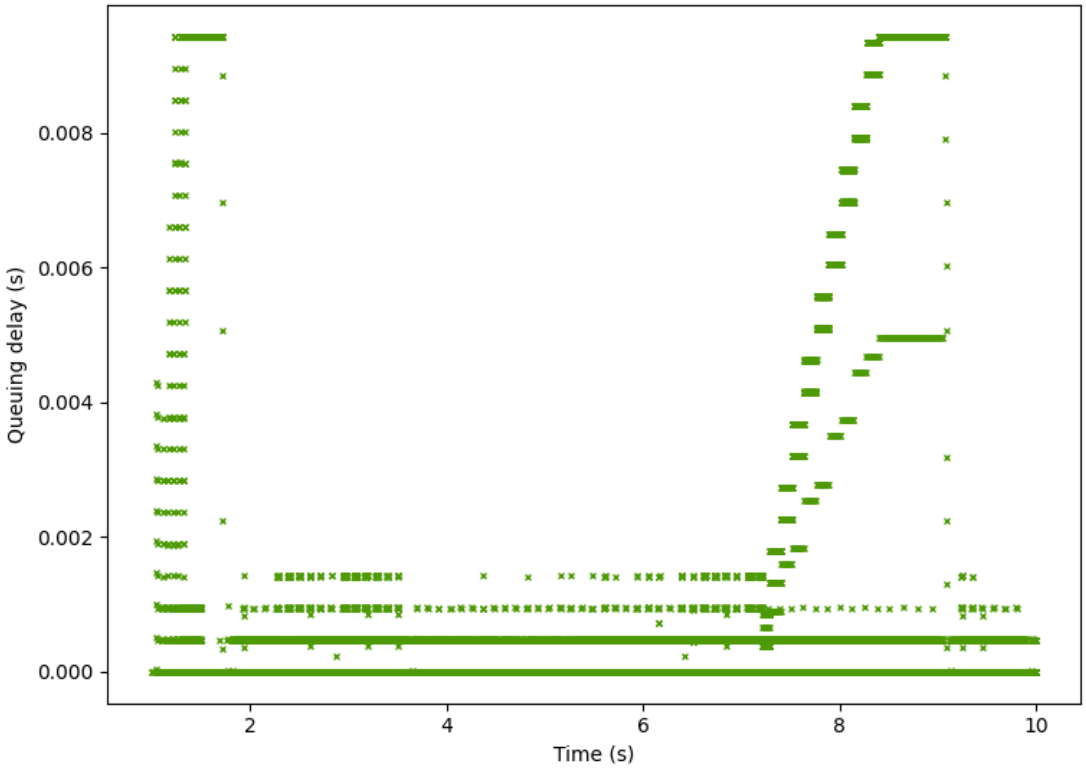
d. Actual throughput is always lesser than theoretical throughput value. Possible reasons for the delay include:

- Due to buffer overflow, the dropped packets must be retransmitted by the sender, which causes additional time and adds to the total duration of packets sent.
- Sometimes, due to low timeout configuration, the sender might assume a packet is lost in transmission when in fact it is delayed in reaching the client and sending an acknowledgement. This causes a retransmission of a successful packet.
- Transmission capacity used by the link upto the point where the packet is dropped is wasted, which could have otherwise been used to send other packets. This adds to the reduced actual throughput.

e.



f.



g. Yes, there is a relation that can be formed between the two graphs.

- The queuing delays increase along with an increase in CWND.
- The CWND keeps increasing until its size has reached the maximum capacity the network link can handle, or the utilization of the access link has reached its limit, or the threshold for the CWND has been reached.
- When this happens, the network throughput is also high, thereby causing a large increase in queuing delays in the network.

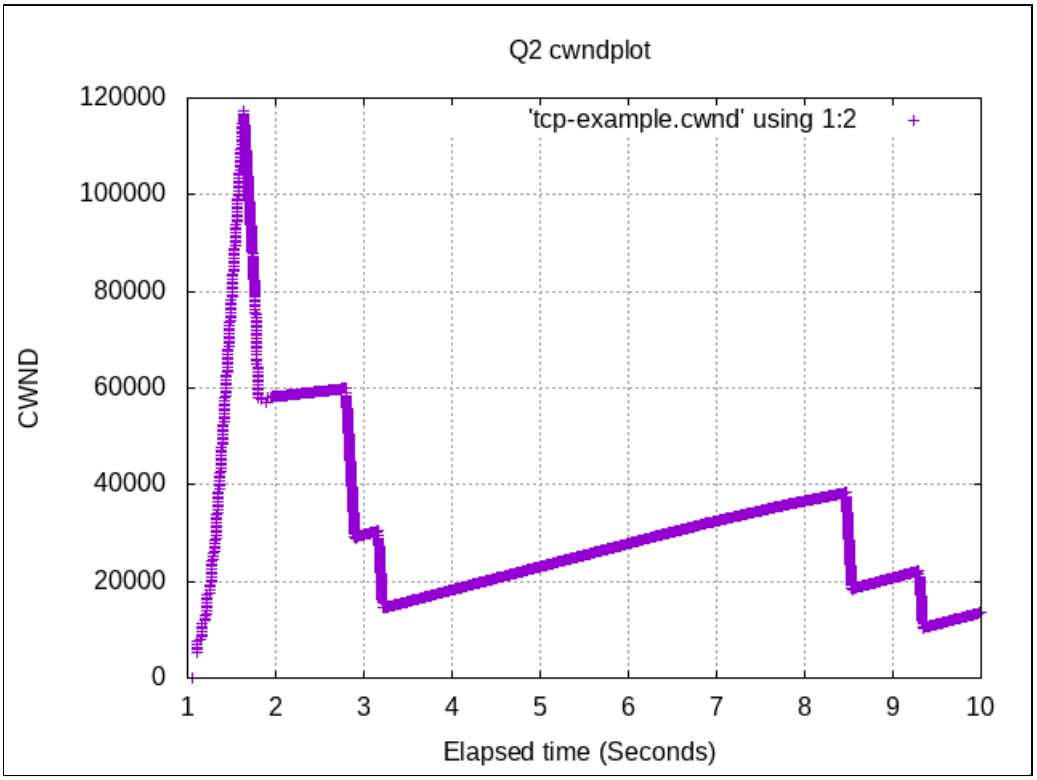
Question 2

a. Number of bits transferred through N0--N2 = 4745572 bytes * 8
= 37964576 bits
= 37.96 Megabits

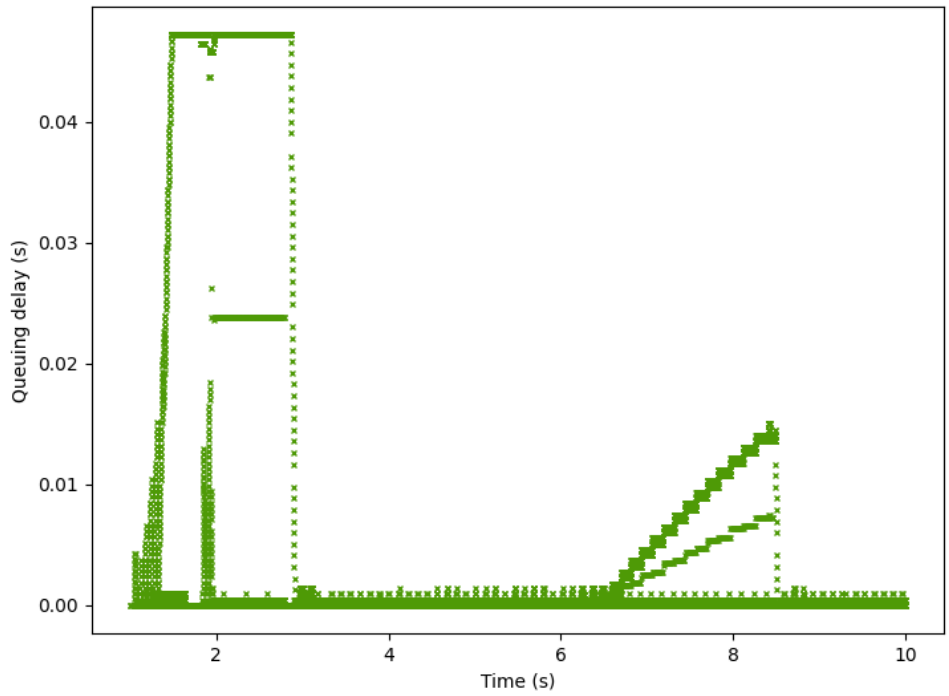
Total duration of transfer = 8.975s

Average throughput = 37.96 / 8.975 Mbps
= **4.229 Mbps**

b.



c.



d. We observe that the maximum congestion window size in Q2's plot (~120000 bytes) is fifty percent greater than the maximum congestion window size in Q1's plot (~80000 bytes). The reason for this is because of the larger queue size in Q2 as compared to Q1. Due to that, buffer overflows took a longer time to take place in Q2, thereby allowing the congestion window to increase for a longer period of time. The overall shape of the graph and pattern followed by the congestion window is roughly the same.

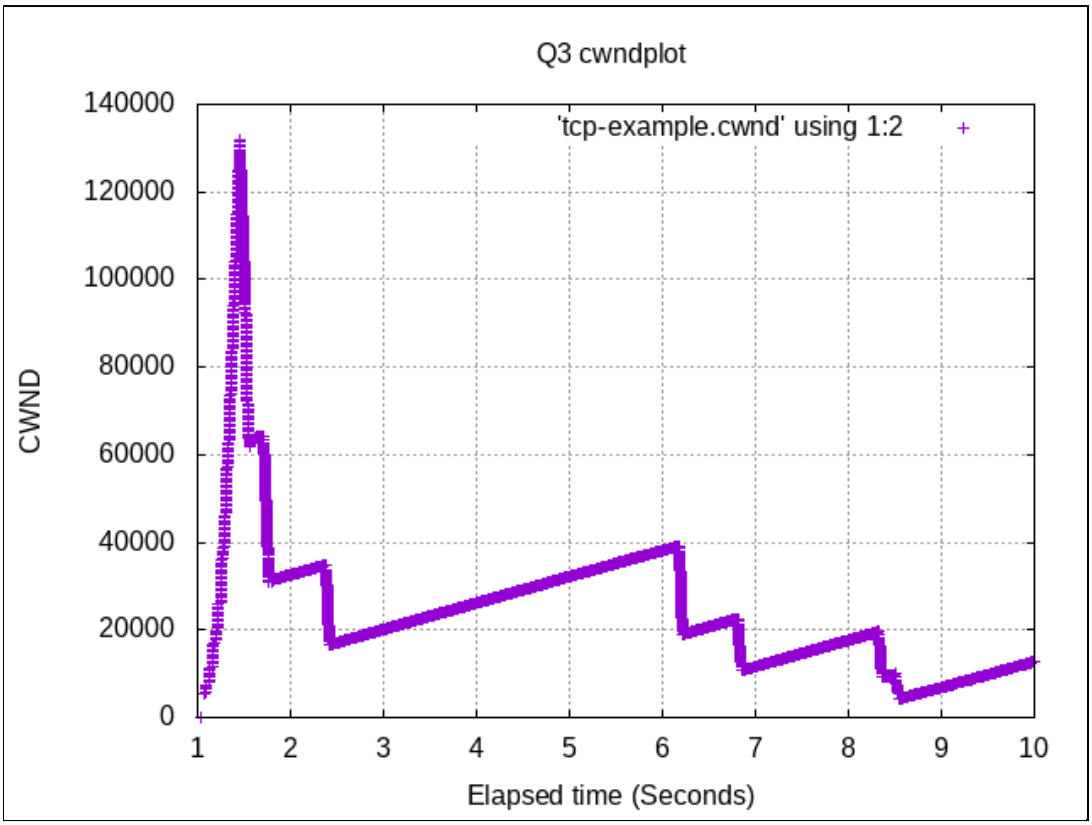
Question 3

a. Number of bits transferred through N0--N2 = 5562308 bytes * 8
= 44498464 bits
= 44.49 Megabits

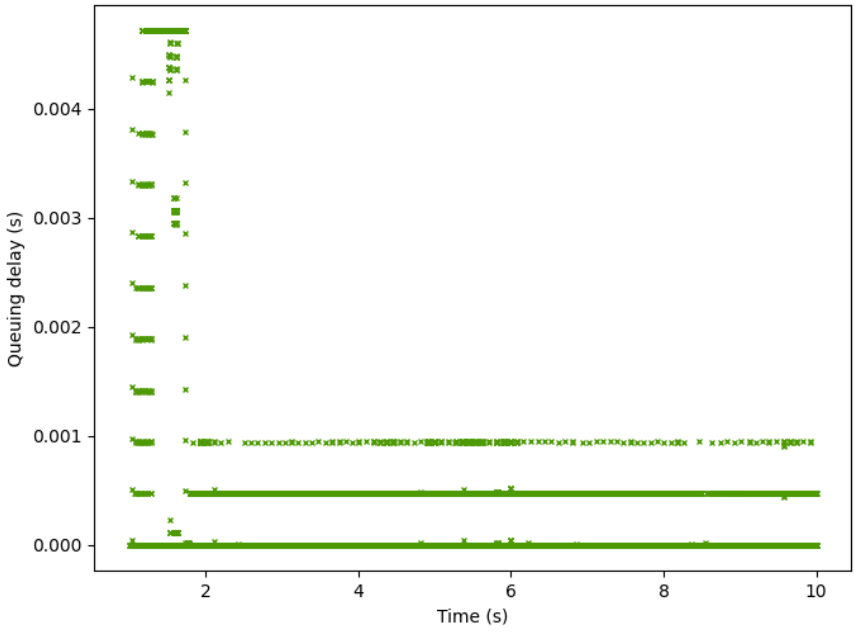
Total duration of transfer = 8.975s

Average throughput = 44.49 / 8.975 Mbps
= **4.957 Mbps**

b.



c.



d. In this question, bandwidth of the two links N0--N1 and N1--N2 are equal, both are 10Mbps. Thus, the rate at which packets are arriving at the N1 node is almost equal to the rate at which they are leaving N1. Thus, there is very little queue build-up, and delays caused by queuing are low.
   Contrastingly, in Q1, the rate at which packets are arriving at N1 is greater than them leaving it, thus a queue is built up and delays are caused due to queuing.

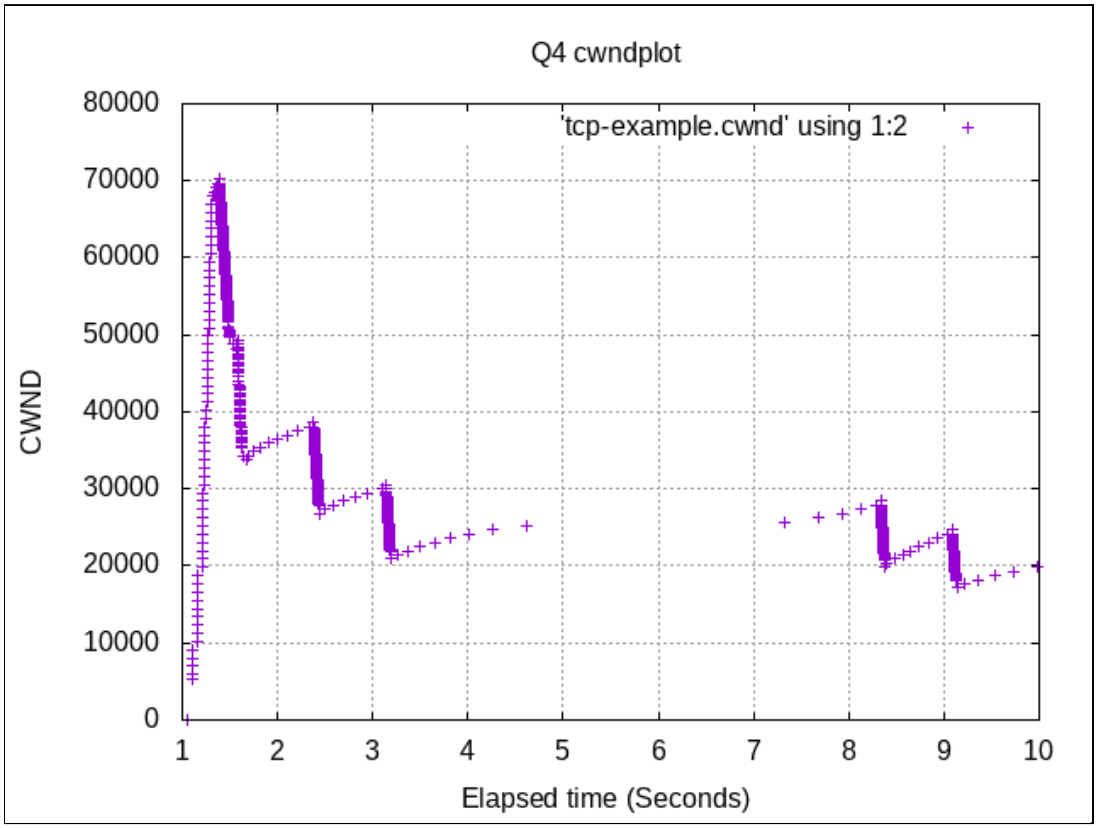
Question 4

a. Number of bits transferred through N0--N2 = 4941746 bytes * 8
= 39533968 bits
= 39.53 Megabits

Total duration of transfer = 8.973s

Average throughput = 39.53 / 8.973 Mbps
= **4.405 Mbps**

b.



c. For the two graphs, we shall compare the 3 phases of CWND of the two configurations:

i. Slow start

The shape of the graphs in this phase is similar: both CWND's rise exponentially until they reach the threshold or experience a packet loss.

ii. Congestion avoidance

The NewReno algorithm follows a linear increase in CWND size whereas the Cubic algorithm follows a cubic increase.

iii. Fast recovery

The NewReno algorithm reduces the CWND size by half (0.5) and Cubic algorithm reduces the CWND size by 0.7. Thus we see shorter drops in Q4's graph when CWND has reached a limit, as compared to Q1.