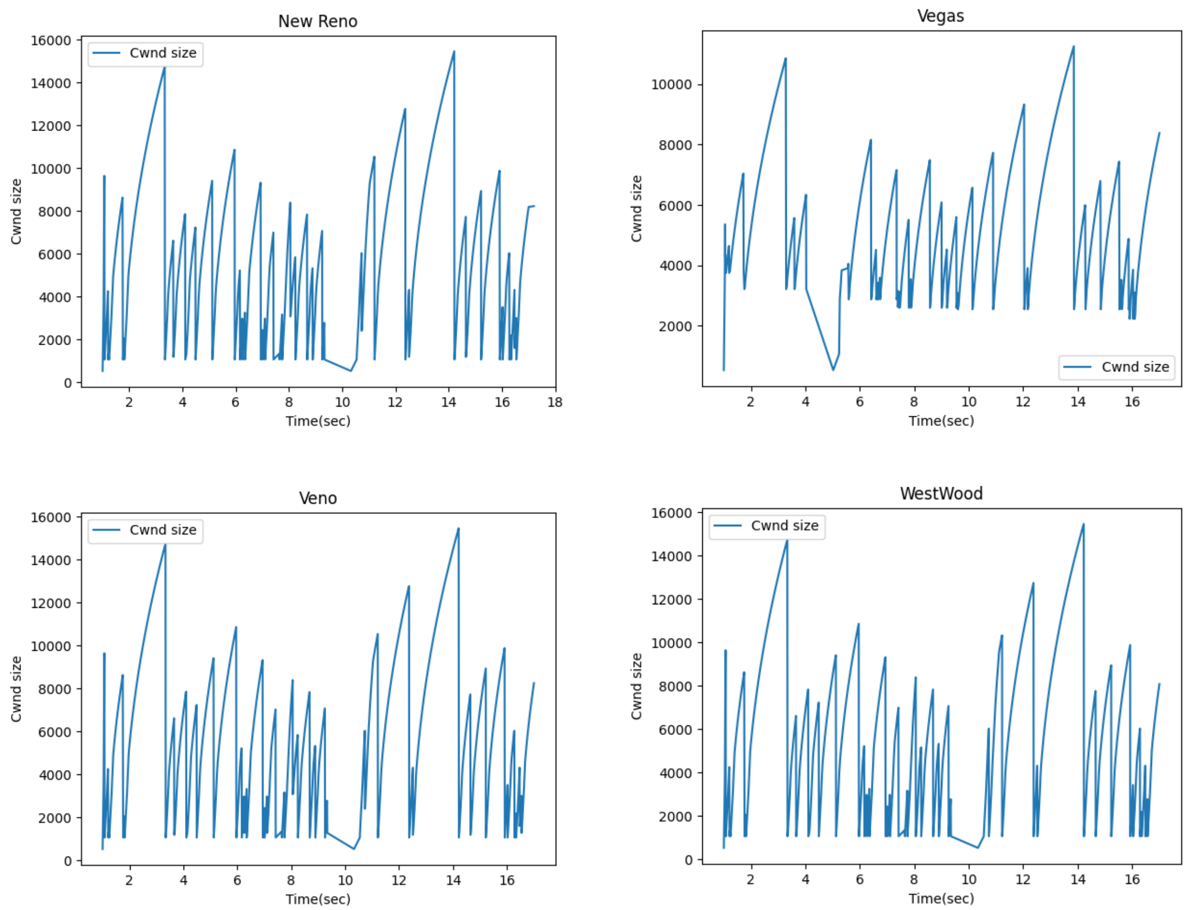
Task 1:

1)

Protocol Name	Max Window Size	Packets Dropped
NewReno	15462	43
Vegas	11252	42
Veno	15462	43
Westwood	15471	43

2)



1. NewReno Protocol: From the graph, we can see that when there is congestion in the network, then the congestion window is dropped to a low value. In slow start phase, cwnd = cwnd + SegmentSize and in congestion avoidance phase, cwnd = cwnd + max(1, $SegmentSize^2$/cwnd).

2. Vegas Protocol: This protocol uses packet delay to identify congestion in the network unlike New reno which uses packet loss as an indicator for congestion. So, it detects congestion faster than other protocols, so the maximum cwnd size will be less than other protocols. This can be observed from the plot in which maximum cwnd size of Vegas is less than max cwnd size of other protocols
3. Veno Protocol: This protocol decides about the congestion in the network by monitoring network congestion level. This is a slight modification to Reno protocol (refines multiplicative decrease and linear increase algorithms). So, the plot of this protocol is almost similar to New Reno protocol.
4. Westwood: It is a sender side only modification to New Reno to better handle large bandwidth-delay product paths,with potential packet loss due to transmission or other errors hence the graph is similar to New Reno.

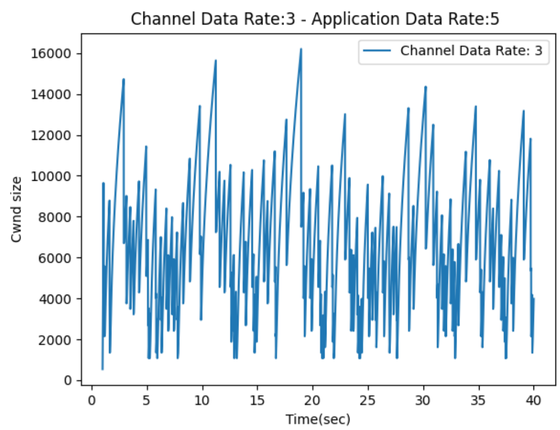
3) Vegas protocol is different than the rest as when congestion occurs, the window size is halved, also the maximum window size is smaller than the other protocols. The other protocols are quite similar as described above, and are modifications of New Reno protocol only, hence the graphs are very similar.

4) BBR ("Bottleneck Bandwidth and Round-trip propagation time") is a new congestion control algorithm developed at Google.Higher throughput: BBR enables big throughput improvements on high-speed, long-haul links.Lower latency: BBR enables significant reductions in latency in last-mile networks that connect users to the internet. The BBR model is rate-based and delay-based. It is vaguely similar to TCP-Vegas in its partial reliance on latency to detect congestion, without the downsides. BBR limits its number of packets in flight to be a multiple of the bandwidth-delay product (BDP) and also uses pacing to control the inter-packet spacing.

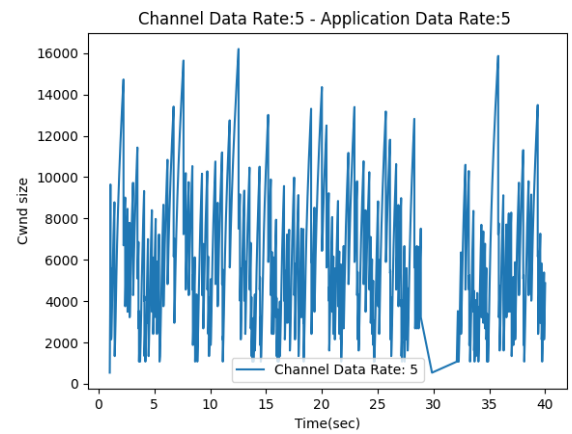
I used sixth.cc from examples to write my code, I updated the RxDrop function to count the number of dropped packets.

Task 2

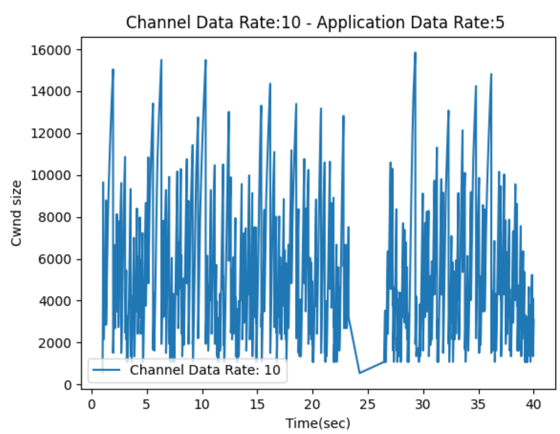
1.



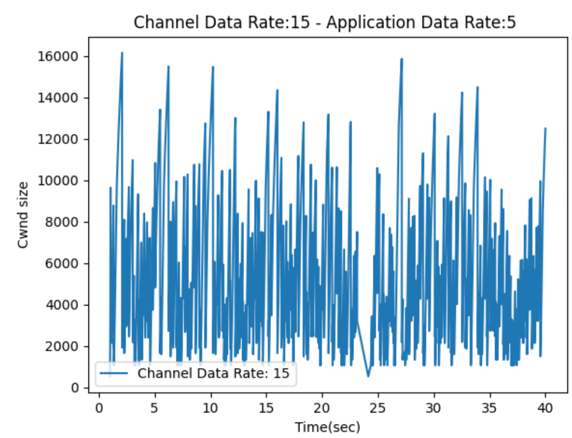
Channel Data Rate:3 - Application Data Rate:5
Channel Data Rate: 3
Cwnd size
Time(sec)



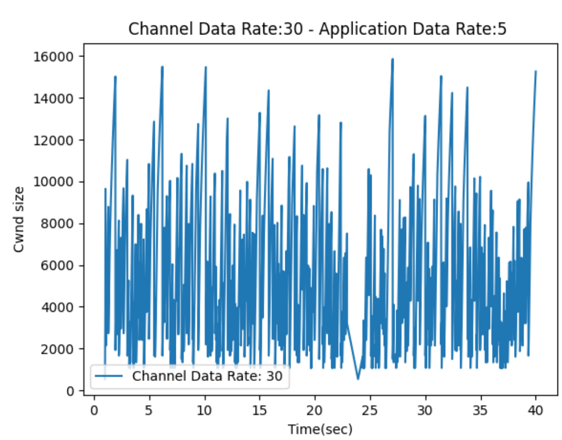
Channel Data Rate:5 - Application Data Rate:5
Channel Data Rate: 5
Cwnd size
Time(sec)



Channel Data Rate:10 - Application Data Rate:5
Channel Data Rate: 10
Cwnd size
Time(sec)



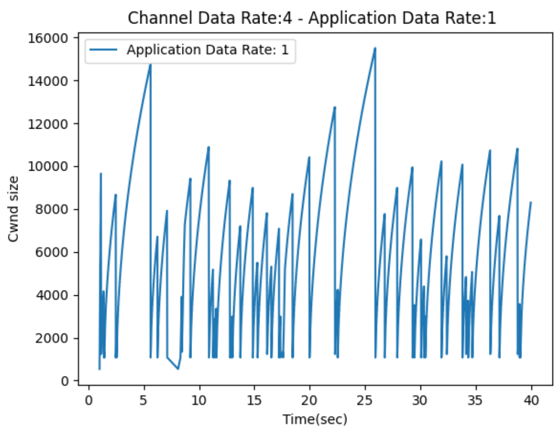
Channel Data Rate:15 - Application Data Rate:5
Channel Data Rate: 15
Cwnd size
Time(sec)

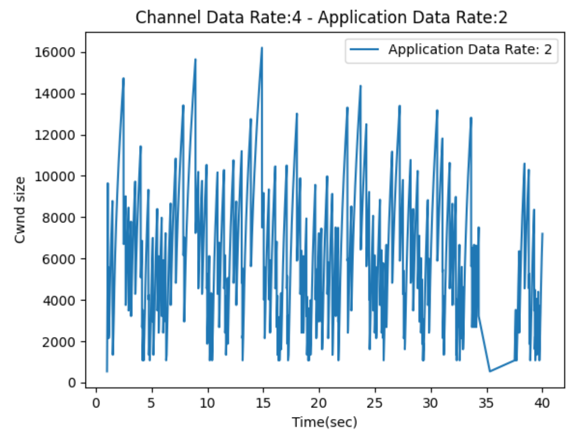


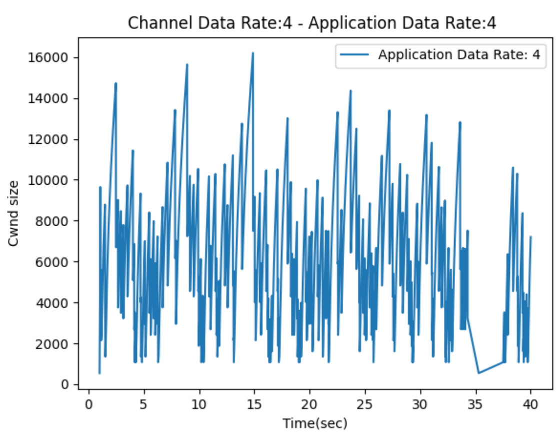
Channel Data Rate:30 - Application Data Rate:5
Channel Data Rate: 30
Cwnd size
Time(sec)

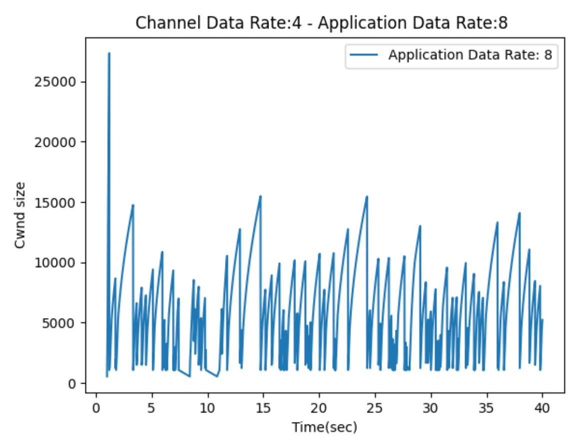
Here, we can see that all the plots are almost same i.e, if Application data rate is constant, channel data rate has almost no effect on congestion window. The reason is that Application is sending data at a constant rate of 3 Mbps and channel data rate is greater than 3 Mbps in all the cases. So even if the channel data rate varies, as application data rate is constant size of congestion window will be same. So, here all the plots are same.

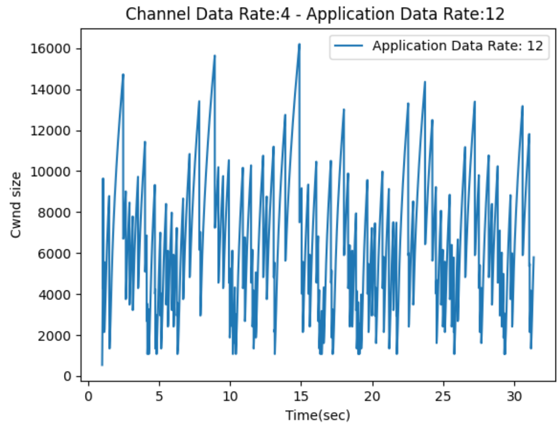
2.









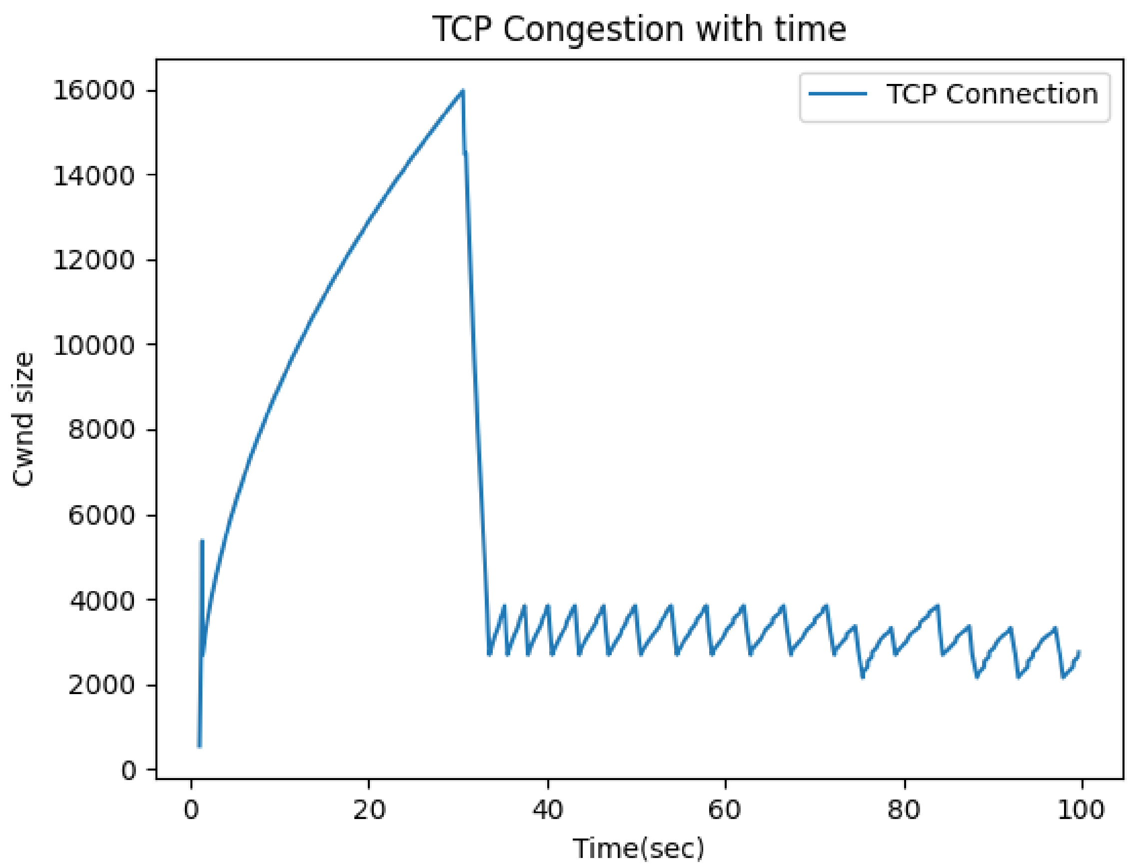


Here, channel data rate is constant 4Mbps. So, if application data rate is low, channel can transmit data with less frequent packet loss. As application data rate increases and since channel data rate is constant, packet loss will occur more frequently. This trend can be observed in the graphs. As application data rate is increasing, pakcets get dropped frequently, so graph congestion window will drop more frequently.

We can see the relation that if channel data rate is less than application data rate, packet loss happens frequently while if channel data rate is more than application data rate, the graph does not change much even on increasing channel data rate more and more.

Task-3

1.



2. We notice the effect in congestion window size when UDP connection is started that, the rate of increase of the window size decreases and when data rate is changed, we see a huge drop in the window size.

3. Pcap files generated