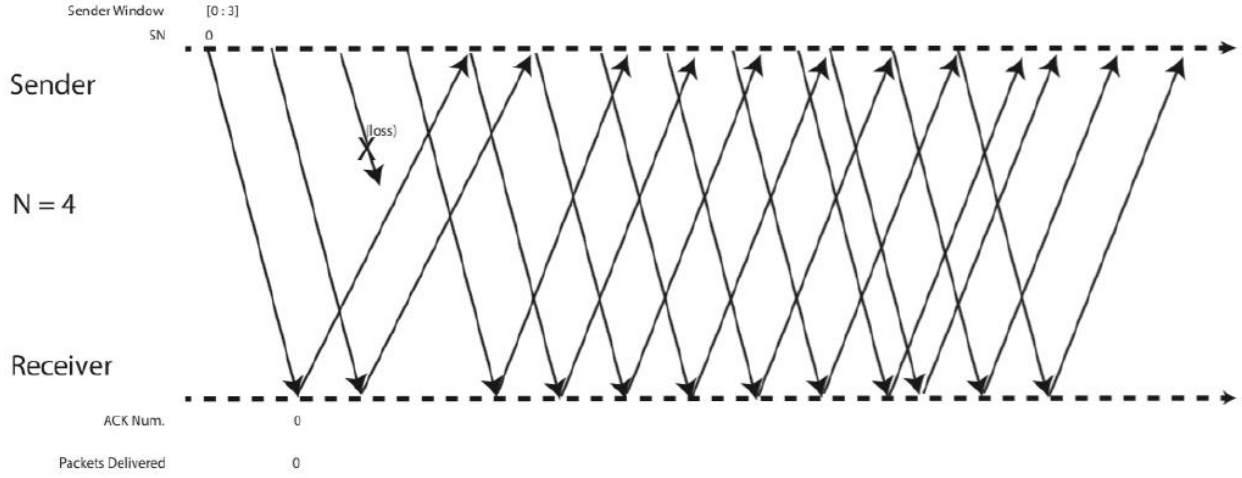
Assignment 3

Assignments Instructions:

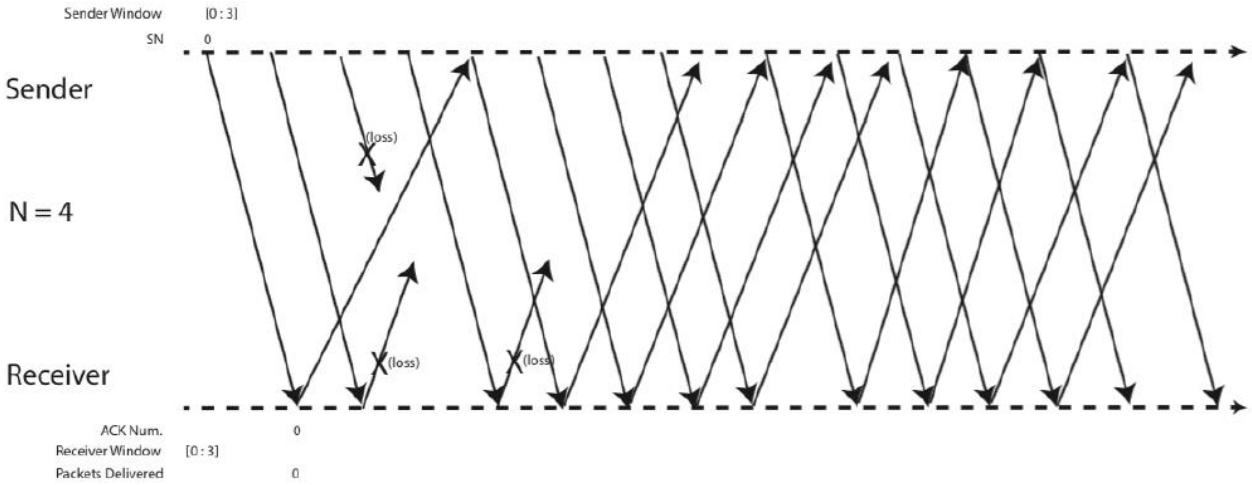
1- Please briefly justify/explain your approach and/or answers.
2- In addition to your approach, please calculate the final answer when applicable.
3- Use the coversheet provided in the course page.
4- If you decide to team up with another student in an assignment, please recall that you are NOT allowed to team up with one student more than once in this course for all assignments (no matter if required or optional) .

Problem 1: Go back N and Selective Repeat

a) Go-Back-N ARQ (N = 4): Fill in the values for SN, ACK Number, sender's sliding window boundaries, and the packets delivered to the next higher layer.



b) Selective Repeat ARQ (N = 4): Fill in the values for SN, ACK Number, sliding window boundaries of the sender and the receiver, and the packets delivered to the next higher layer.



Problem 2: TCP

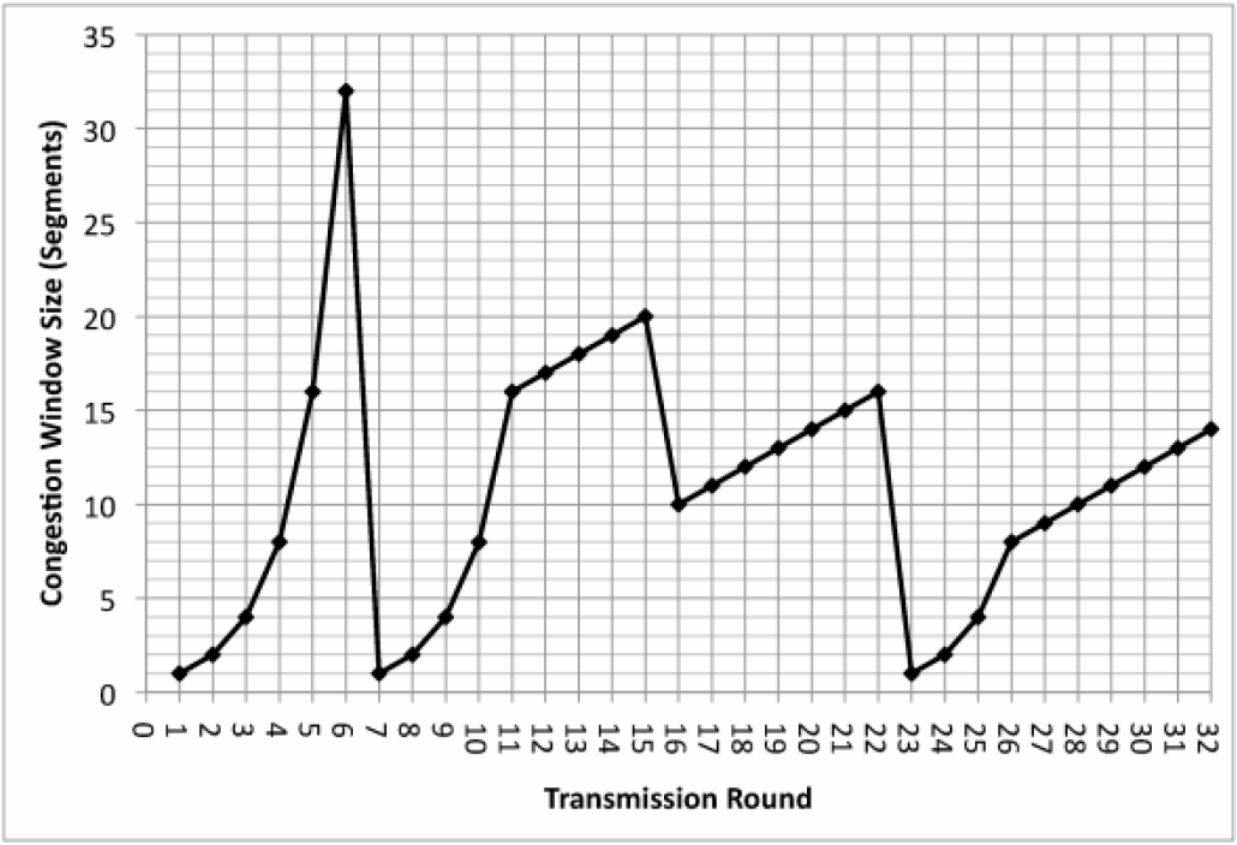
Consider the figure depicted below where the *x*-axis indicates time and the *y*-axis indicates congestion window size. Using TCP Reno, answer the following questions:

a) During which time-frame(s) is Slow Start operating?

b) During which time-frame(s) is Congestion Avoidance operating?

c) During which time-frame(s) is Fast retransmit/recovery operating?

d) During which time interval(s) fast recovery could have happened, but did not? Identify one specific example of a circumstance that may prevent fast recovery from happening



Problem 3: TCP Throughput

Assume a 15Mbps link between two hosts *x* and *y*. A TCP Reno connection is used for communication between these two hosts. Further, assume that this link is the only congested link between *x* and *y*. Now suppose that *x* wants to send a huge file to *y*, and the *y*'s receive buffer is much larger than the congestion window. Consider that each TCP segment size is

1,200 bytes and *RTT* = 160 msec; and, this TCP connection is always in congestion avoidance phase (ignore slow start).

a) What is the maximum window size (in segment) that this TCP connection can achieve?

b) What is the average window size (in segment) and average throughput (in bps) of this TCP connection?

c) How long would it take for this TCP connection to reach its maximum window again after recovering from a packet loss?

Problem 4: Sequence Number and Timestamp

We have a 10Gbps link and use TCP for data transfer.

a) If the TCP is continuously utilizing the full bandwidth, how long would it take for the sequence number to wrap around completely?

b) If we have a 32-bit timestamp that is incremented 100,000 during the wraparound time that you calculated in previous part, how long will it take for this timestamp to wrap around?

Problem 5: TCP Failed Connection; TCP Delay

a) The web server on host B receives two SYN packets from host A. How can it decide whether the second SYN packets a retransmission of the first one, or a request for a separate connection?

b) Consider the delay introduced by the TCP slow-start phase. Consider a client and a Web server directly connected by one link of rate *R*. Suppose the client wants to retrieve an object whose size is exactly equal to 7 *S*, where *S* is the maximum segment size (MSS). Denote the round-trip time between client and server as RTT (assumed to be constant). Ignoring protocol headers, determine the time to retrieve the object (including TCP connection establishment) when

I. $4\,S/R > S/R + RTT > 2S/R$

II. $S/R + RTT > 4\,S/R$

III. $S/R > RTT$.