(a) During which interval is slow start operating.

(b) During which interval is congestion avoidance is operating.

(c) According to the plot. what is the threshold?

(d) Suppose that a packet loss, due to a timeout. occurs at the 10 round. what is the new threshold?

(e) What is the window size at the 11 th round?

(f) Can a packet loss be detected before a timeout occurs? if so what is the new threshold and the new congestion window?

(g) During which round is segment 35 sent?

(h) What is the average throughput between the first and 10th round?

(i) By how much is the window incremented when the sender receives an acknowledgement for the first segment in round 4?

(j) By how much is the window incremented when the sender receives an acknowledgement for the first segment in round 6?

3. (15pts) Host X and Y are exchanging data using a TCP connection. Suppose that at $t=0$ estimatedRTT$=10$ and DevRTT$=2$. Host X transmits a segment at $t=0$ and receives an acknowledgement at $t=8$. At $t=14$ X sends another segment and does not receive an acknowledgement. At $t = T_r$, X retransmits the segment.

(a) What is the value of T_r? (show all your work)

(b) What is the value of timeout at $t > T_r$?

You might need the following information:
TimeoutInterval$=$EstimatedRTT$+4*$DevRTT,
EstimatedRTT$=(1 - \alpha)$EstimatedRTT$+\alpha$ SampleRTT
DevRTT$=(1 - \beta)$DevRTT$+\beta$ |SampleRTT-EstimatedRTT|
With $\alpha = 0.1$ and $\beta = 0.25$

X

T=0

t=8

t=14

4. (15pts)Host X and Y are exchanging data using a TCP connection. Both hosts use a timeout period of 2 seconds. At t=0 host X sends two back-to-back segments, of size 50 and 30 bytes, to Y with the TCP header of the first segment having the following values: sequence number=42, receive window=70, A-bit =1, Acknowledgement number=123, source port=567, destination port=80. Suppose that Y sends it own data to X only when it receives data from X (i.e. sends data and ack in the same segment).

(a) Y needs to send 87 bytes. How many segments does Y use to send the 87 bytes. Explain.

(b) What are the header values in those segments?

(c) Suppose that the last segment in 4a arrives at X at t=1.8 s and that the **first** in 4a never reached X. How many segments are retransmitted by X? Explain.

1. (20pts) A sender having window size=4 transmits at 1 million bits per second. The packet size is 1000 bits and the round trip time between sender and receiver is 6 ms. The sender starts a timer for a packet when it **finishes** transmitting it and uses a timeout period of 8 ms. The receiver sends an acknowledgement immediately after it receives the last bit of a packet. Assume that the transmission of acknowledgements takes 0ms, the sender needs to send a total of 8000 bits and the first bit is transmitted at t=0. The protocol in use is GBN.

   (a) How many bits are sent before the sender receives the first acknowledgement.

   (b) At what time the last bit arrives at the receiver if no packet is lost.

   (c) At what time the last bit arrives at the receiver if only one loss occurs (packet numbering starts at 0), the first transmission of packet number 1.

   (d) What is the total number of transmitted packets in 1b and 1c.

   (e) redo 1b, 1c and 1d in the case of sender and receiver using a selective repeat protocol.