**Chapter 3**

1. Compare GBN, SR, and TCP (no delayed ACK). Assume that the timeout values for all three protocols are sufficiently long such that 5 consecutive data segments and their corresponding ACKs can be received (if not lost in the channel) by the receiving host (Host B) and the sending host (Host A) respectively. Suppose Host A sends 5 data segments to Host B, and the 2nd segment (sent from A) is lost. In the end, all 5 data segments have been correctly received by Host B.
2. How many segments has Host A sent in total and how many ACKs has Host B sent in total? What are their sequence numbers? Answer this question for all three protocols.
3. If the timeout values for all three protocol are much longer than 5 RTT, then which protocol successfully delivers all five data segments in shortest time interval?

**Answer:**

1. Go Back N:

A sends 9 segments in total. They are initially sent segments 1, 2, 3, 4, 5 and later re-sent segments 2, 3, 4, and 5.

B sends 8 ACKs. They are 4 ACKS with sequence number 1, and 4 ACKS with sequence numbers 2, 3, 4, and 5.

Selective Repeat:

A sends 6 segments in total. They are initially sent segments 1, 2, 3, 4, 5 and later re-sent segments 2.

B sends 5 ACKs. They are 4 ACKS with sequence number 1, 3, 4, 5. And there is one ACK with sequence number 2.

TCP:

A sends 6 segments in total. They are initially sent segments 1, 2, 3, 4, 5 and later re-sent segments 2.

B sends 5 ACKs. They are 4 ACKS with sequence number 2. There is one ACK with sequence numbers 6. Note that TCP always send an ACK with expected sequence number.

1. TCP. This is because TCP uses fast retransmit without waiting until time out.
2. Consider that only a single TCP (Reno) connection uses one 15Mbps link which does not buffer any data. Suppose that this link is the only congested link between the sending and receiving hosts. Assume that the TCP sender has a huge file to send to the receiver, and the receiver’s receive buffer is much larger than the congestion window. We also make the following assumptions: each TCP segment size is 1,200 bytes; the two-way propagation delay of this connection is 160 msec; and this TCP connection is always in congestion avoidance phase, that is, ignore slow start.
3. What is the maximum window size (in segment) that this TCP connection can achieve?
4. What is the average window size (in segment) and average throughput (in bps) of this TCP connection?
5. How long would it take for this TCP connection to reach its maximum window again after recovering from a packet loss?

**Answer:**

1. Let W denote the max window size measured in segments. Then, W\*MSS/RTT = 15Mbps, as packets will be dropped if the maximum sending rate exceeds link capacity. Thus, we have W\*1200\*8/0.16=15\*10^6, then W is about 250.
2. As congestion window size varies from W/2 to W, then the average window size is 0.75W=187.5 segments. Average throughput is 187.5\*1200\*8/0.16=11.25Mbps.
3. (250/2) \*0.16= 20 seconds, as the number of RTTs (that this TCP connections needs in order to increase its window size from W/2 to W) is given by W/2. Recall the window size increases by one in each RTT.