P40. Consider Figure 3.61. Assuming TCP Reno is the protocol experiencing the behavior shown above, answer the following questions. In all cases, you should provide a short discussion justifying your answer.

a. Identify the intervals of time when TCP slow start is operating.

b. Identify the intervals of time when TCP congestion avoidance is operating.

c. After the 16th transmission round, is segment loss detected by a triple duplicate ACK or by a timeout?

d. After the 22nd transmission round, is segment loss detected by a triple duplicate ACK or by a timeout?

e. What is the initial value of ssthresh at the first transmission round?

f. What is the value of ssthresh at the 18th transmission round?

g. What is the value of ssthresh at the 24th transmission round?

h. During what transmission round is the 70th segment sent?

i. Assuming a packet loss is detected after the 26th round by the receipt of a triple duplicate ACK, what will be the values of the congestion window size and of ssthresh?

j. Suppose TCP Tahoe is used (instead of TCP Reno), and assume that triple duplicate ACKs are received at the 16th round. What are the ssthresh and the congestion window size at the 19th round?

k. Again suppose TCP Tahoe is used, and there is a timeout event at 22nd round. How many packets have been sent out from 17th round till 22nd round, inclusive?

a. TCP slow start is operating in the intervals (1,6) and (23,26).

b. TCP congestion avoidance is operating in the intervals (6,16) and (17,22).

c. After the 16th transmission round, segment loss is detected by a triple duplicate ACK, because Congestion window size is not set to 1 but to 1/2 of its value.

d. After the 22th transmission round, segment loss is detected by a timeout, because Congestion window size is set to 1.

e. The initial value of ssthresh at the first transmission round is 32, because Congestion window size stops slow start and begins CA at this time.

f. The value of ssthresh at the 18th transmission round is 21, because Congestion window size is 42 at the 16th transmission and then segment loss is detected.

g. The value of ssthresh at the 24th transmission round is 13 or 14. Because timeout occurs and , the Congestion window size is 26 or 29 at the 22nd transmission round, the ssthresh is set to 13 or 14 after the 22nd transmission round.

h. The 70th segment is sent at the 7th transmission round.

i. If a packet loss is detected after the 26th round by the receipt of a triple duplicate ACKs, because Congestion window size is 8 at the 26th round, the values of Congestion window size will be 8/2=4 or 8/2+3=7 and ssthresh will be 4.

j. If TCP Tahoe is used and triple duplicate ACKs are received at the 16th round, because the congestion window size is 42 at the 16th round, the congestion window size is 1 and ssthresh is 42/2=21 at the 17th round. So the congestion window size is 4 and ssthresh is 21.

k. From j. above we can know that the congestion window size is 1 and ssthresh is 21 at the 17th round.

​ At the 17th round 1 packet has been sent out.

​ At the 18th round 2 packets have been sent out.

​ At the 19th round 4 packets have been sent out.

​ At the 20th round 8 packets have been sent out.

​ At the 21st round 16 packets have been sent out. The congestion window size is still less then ssthresh at this time.

​ At the 22nd round, 21 packets have been sent out because the congestion window size is reach to ssthresh.

​ So, 1+2+4+8+16+21=52 packets have been sent out.

P44. Consider sending a large file from a host to another over a TCP connection that has no loss.

a. Suppose TCP uses AIMD for its congestion control without slow start. Assuming cwnd increases by 1 MSS every time a batch of ACKs is received and assuming approximately constant round-trip times, how long does it take for cwnd increase from 6 MSS to 12 MSS (assuming no loss events)?

b. What is the average throughput (in terms of MSS and RTT) for this connection up through time = 6 RTT?

a. Because cwnd increases by 1 MSS every time, it takes 6 RTT to increase from 6 MSS to 12 MSS.

b. Average throughout =(6+7+8+9+10+11)/6 = 8.5 MSS/RTT