Tutorial problems for TCP

Review Questions:

1. In TCP, why did we need to introduce sequence numbers?

2. In TCP, why did we need to introduce timers?

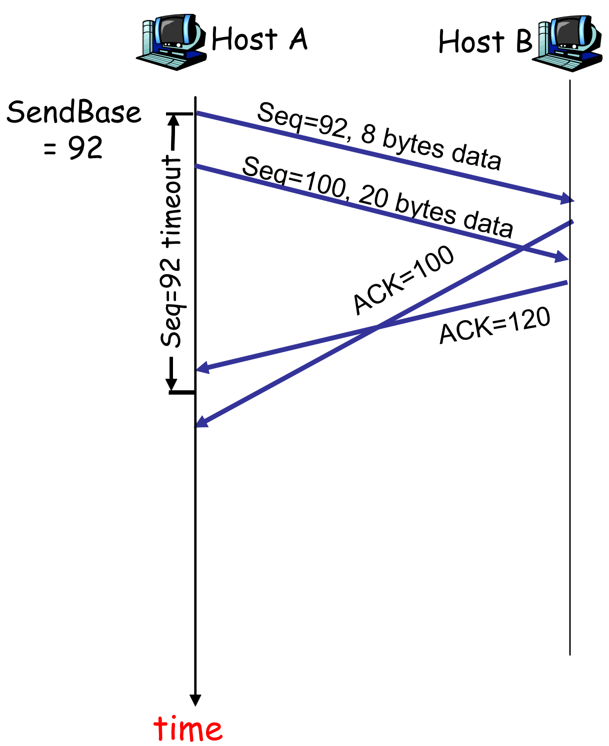
3. Suppose that the round trip time between the sender and the receiver is constant and known to the sender. Would a timer still be necessary in TCP, assuming that packets can be lost? Explain.

4. How does Fast Retransmit work? What is the basic idea behind it?

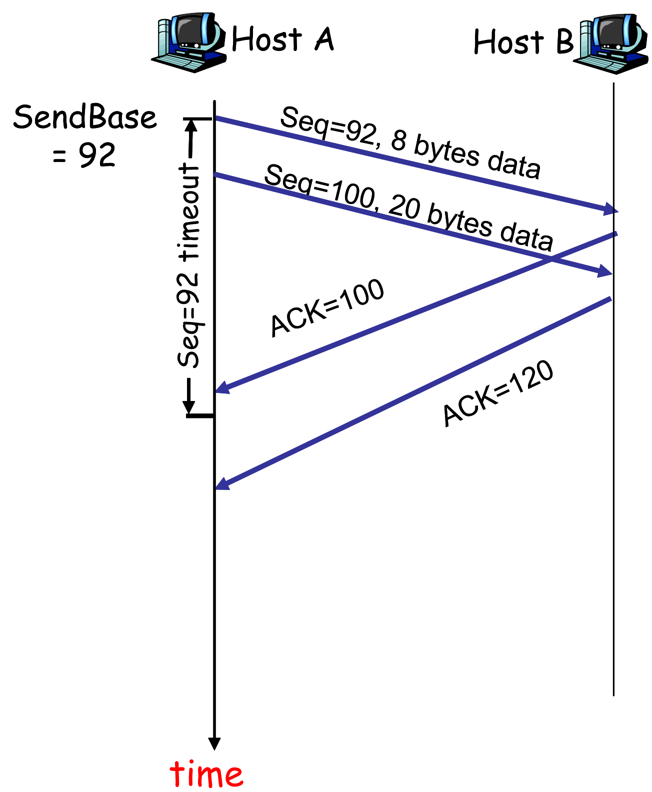
5. Why is a various-size (credit) sliding window scheme better than a fixed-size sliding window scheme for TCP?

Problems

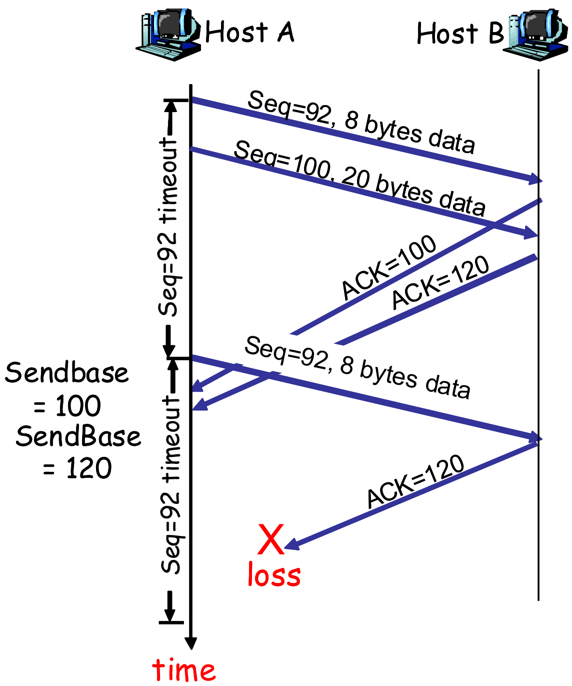
1. Describe what will happen after Host A timeouts in the following four situations.



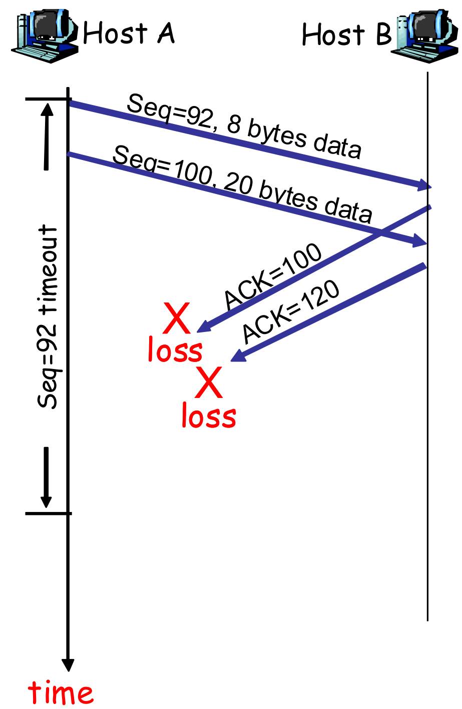
(a)



(b)



(c)



(d)

2. a) With reference to Fig. Q2 showing TCP disconnection procedure, when TCP receives a FIN from the other TCP, TCP needs to go through two wait states (CLOSE WAIT and LAST ACK) before closing the connection. Please state the action after TCP receives the FIN and the rationale behind each wait state.

   b) Why does the TCP at Site 2 not to send ACK x+1 and "FIN seq=y, ACK x+1" at the same time. What will be the problem if they are sent out at the same time either by sending out "ACK" later or by sending "FIN, ACK" earlier?

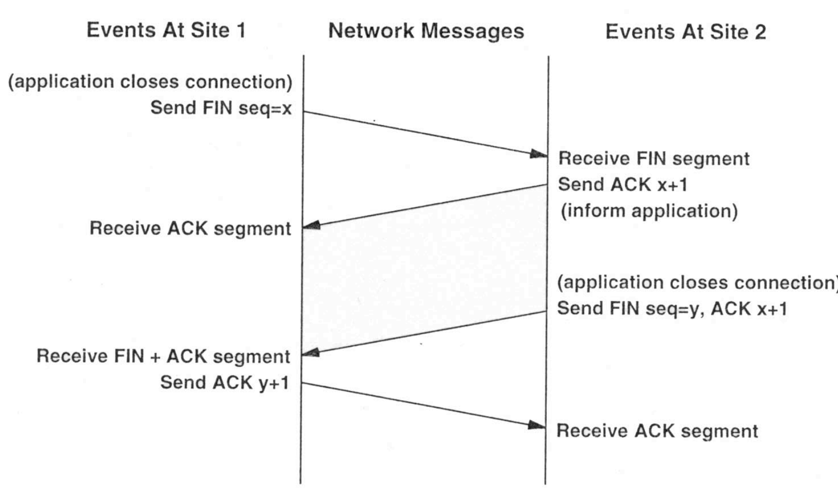


Figure Q2: TCP Connection Termination

3. One difficulty with the original TCP EA-RTT estimator (Exponential Average Round-Trip Time estimator) is the choice of an initial value. In the absence of any special knowledge of network conditions, the typical approach is to pick an arbitrary value, such as 3 seconds, and hope that this will converge quickly to an accurate value. If this estimate is too small, TCP will perform unnecessary retransmissions. If it is too large, TCP will wait a long time before retransmitting if the first segment is lost. Also, the convergence may be slow, as this problem indicates. Note that

$$\text{EA-RTT}(K + 1) = \alpha \times \text{EA-RTT}(K) + (1 - \alpha) \times \text{RTT}(K + 1).$$

a) Choose α = 0.90 and EA-RTT(0) = 1 seconds, and assume all measured RTT values = 4 second and no packet loss. What is EA-RTT(20)? *Hint:* The equation for calculating EA-RTT can be rewritten to simplify the calculation, using the equation $(1 + \ldots + \alpha^{n-2} + \alpha^{n-1}) = (1 - \alpha^n)/(1- \alpha)$.

b) Now let α = 0.25 and EA-RTT(0) = 4 second and assume measured RTT values = 1 seconds and no packet loss. What is EA-RTT(20)?

4. A TCP entity opens a connection and uses slow start. Approximately how many round-trip times are required before TCP can send *N* segments?

5. Consider the following plot of TCP window as a function of time.

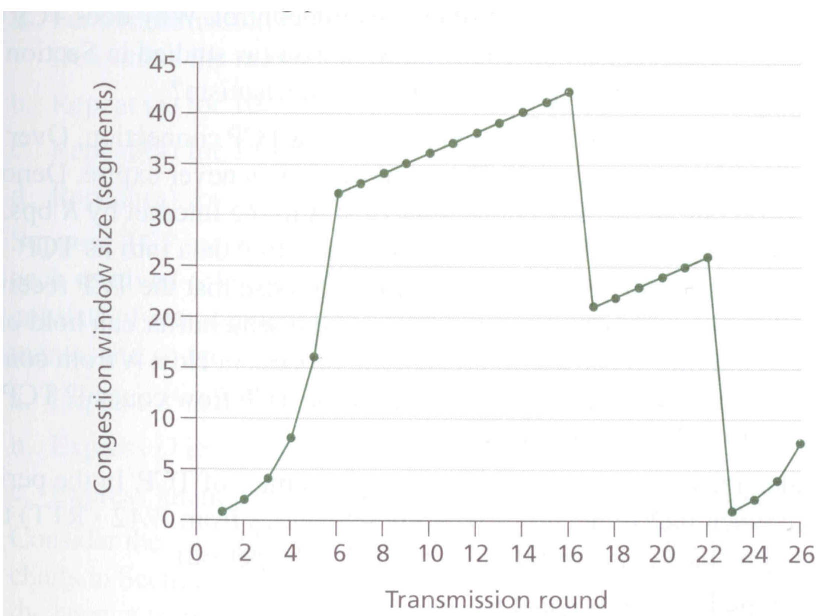


Figure Q3: TCP congestion control

Assuming TCP Reno (i.e. Slow Start + Congestion Avoidance + Fast Retransmit + Fast Recovery) is the protocol experiencing the behavior shown above, answer the following questions. In all cases, you should provide a short discussion justifying the 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 Threshold at the first transmission round?
f) What is the value of Threshold at the 18th transmission round?
g) What is the value of Threshold 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 Threshold?

6. In this problem we 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 15 S, where S is the maximum segment size (MSS). Denote the round-trip time between client and server as RTT (assume to be constant). Ignoring protocol headers, determine the time to retrieve the object (including TCP connection establishment) when

a) $4\,S/R > S/R + RTT > 2S/R$
b) $S/R + RTT > 4\,S/R$