# Problem 1

Answer True or False to the following questions and briefly justify your answer:

(a) With the Selective Repeat protocol, it is possible for the sender to receive an ACK for a packet that falls outside of its current window.

(b) With Go-Back-N, it is possible for the sender to receive an ACK for a packet that falls outside of its current window.

(c) The Stop&Wait protocol is the same as the SR protocol with a sender and receiver window size of 1.

(d) Selective Repeat can buffer out-of-order-delivered packets, while GBN cannot. Therefore, SR saves network communication cost (by transmitting less) at the cost of additional memory.

Write your solution to Problem 1 in this box

(a) True. It could happen when the delay is high. Suppose the sender sent a suquence of packests, and then the receiver sent the corresponding ACKs back. If the network is slow, the sender times out and resend the packets before it gets the ACKs. Afte that, the sender receives the ACKs and moves on. So, when the sender receives the smae ACKs for the second time, those ACKs are outside of its current window.

(b) True. Same principle in (a)

(c) True. SR protocol with window size 1 is identical to Stop&Wait protocol

(d) True. SR protocol can buffer out-of-order-delivered packets within the window. When the loss rate is high, resending the whole window of packets is expensive. So, SR protocol saves network communication cost.

# Problem 2

Host A and B are communicating over a TCP connection, and Host B has already received from A all bytes up through byte 226. Suppose Host A then sends two segments to Host B back-to-back. The first and second segments contain 80 and 40 bytes of data, respectively. In the first segment, the sequence number is 227, the source port number is 30002, and the destination port number is 80. Host B sends an acknowledgment whenever it receives a segment from Host A. Fill in the blanks for questions (a) – (c) directly; work out the diagram in the box for question (d).

(a) In the second segment sent from Host A to B, the sequence number is ______, source port number is ______, and destination port number is ______.

(b) If the first segment arrives before the second segment, in the acknowledgment of the first arriving segment, the ACK number is ______, the source port number is ______, and the destination port number is ______.

(c) If the second segment arrives before the first segment, in the acknowledgment of the first arriving segment, the ACK number is ______.

(d) Suppose the two segments sent by A arrive in order at B. The first acknowledgment is lost and the second acknowledgment arrives after the first timeout interval. Draw a timing diagram in the box below, showing these segments and all other segments and acknowledgment sent. Assume no additional packet loss. For each segment in your diagram, provide the sequence number and the number of bytes of data; for each acknowledgment that you add, provide the ACK number.

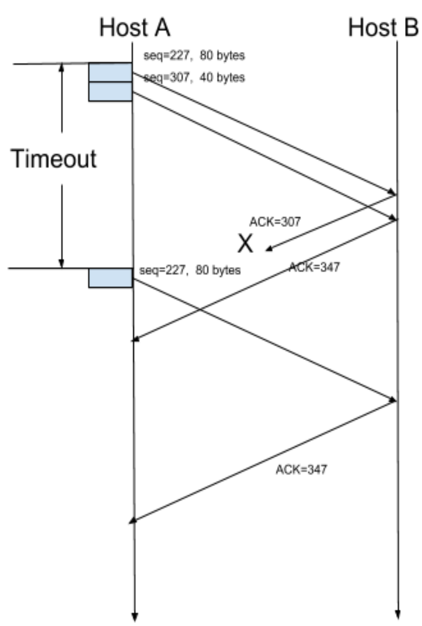
Write your solution to Problem 2 in this box

(a) 307; 30002; 80

(b) 307; 80; 30002

(c) 227

(d)



# Problem 3

In Fast Retransmit algorithm, we saw TCP waits until it has received three duplicate ACKs before performing a fast retransmit. Why do you think the TCP designers chose not to perform a fast retransmit after the first or second duplicate ACKs for a segment received?

Write your solution to Problem 3 in this box

Because TCP designers want to minimize the retransmission rate.
If the TCP designers decided to perform a fast retransmit after the first or second duplicate ACKs for a segment received, a packet is retransmitted as long as it is not delivered in order. This will cause much more unnecessary traffiic which makes the TCP less efficient.

# Problem 4

Suppose that three measured SampleRTT values are 106 ms, 120 ms, and 140 ms. Compute the EstimatedRTT after each of these SampleRTT values is obtained, assuming that the value of EstimatedRTT was 100 ms just before the first of these three samples were obtained. Compute also the DevRTT after each sample is obtained, assuming the value of DevRTT was 5 ms just before the first of these three samples was obtained. Last, compute the TCP TimeoutInterval after each of these samples is obtained.

Write your solution to Problem 4 in this box

Since alpha and beta are not given, I will assume the typical values, 0.125 and 0.25 respectively.

EstimatedRTT = alpha * SampleRTT + (1 – alpha) * EstimatedRTT
DevRTT = beta * | SampleRTT – EstimatedRTT | + (1 – beta) * DevRTT
TimeoutInterval = EstimatedRTT + 4 * DevRTT

(1) SampleRTT = 106ms
EstimatedRTT = 0.125 * 106 + (1 – 0.125) * 100 = 100.75ms
DevRTT = 0.25 * | 106 – 100.75 | + (1 – 0.25) * 5 = 5.06ms
TimeoutInterval = 100.75 + 4 * 5.06 = 120.99ms

(2) SampleRTT = 120ms
EstimatedRTT = 0.125 * 120 + (1 – 0.125) * 100.75 = 103.15ms
DevRTT = 0.25 * | 120 – 103.15 | + (1 – 0.25) * 5.06 = 8ms
TimeoutInterval = 103.15 + 4 * 8 = 135.15ms

(3) SampleRTT = 140
EstimatedRTT = 0.125 * 140 + (1 – 0.125) * 103.15 = 107.75ms
DevRTT = 0.25 * | 140 – 107.75 | + (1 – 0.25) * 8 = 14.06ms
TimeoutInterval = 107.75 + 4 * 14.06 = 164ms

# Problem 5

Compare Go-Back-N, Selective Repeat, and TCP (no delayed ACK). Assume that 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.

(a) 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.

(b) If the timeout values for all three protocols are much longer than 5RTT, then which protocol successfully delivers all five data segments in shortest time interval?

Write your solution to Problem 5 in this box

(a) Go-Back-N:
9 segments sent by A and 8 ACKs sent by B. Since 2 is lost, A wil retransmit 2,3,4,5 after it sent 1,2,3 4, 5. B will first sent 4 ACKs 1 indicating 2 is lost and then sent ACK 2, 3, 4, 5.

Selective Repeat:
6 segments sent by A and 5 ACKs sent by B. Since 2 is lost, A will retransmit 2 while the rest remained in buffer. B will send ACKs in the order it receives the segments: 1, 3, 4, 5, 2

TCP:
6 segments sent by A and 5 ACKs sent by B. Since 2 is lost, A will retransimit 2 while the rest remained in the buffer. B will sent 4 ACK 2, and one ACK 6 (if there is segment 6).

(b) TCP. because TCP use fast retransmit algorithm.