Due Sep 17th before 10 am on Gradescope

**Problem 1.** [2 points] Consider a reliable data transfer protocol that uses only negative acknowledgments. Suppose the sender sends data only infrequently.

a) Would a NAK-only protocol be preferable to a protocol that uses ACKs? Why?

Now suppose the sender has a lot of data to send and the end-to-end connection experiences few losses.

b) In this second case, would a NAK-only protocol be preferable to a protocol that uses ACKs? Why?

**Problem 2.** [2 points]

Consider the Go-Back-N and Selective-Repeat protocols. Suppose the sequence number space is of size k. What is the largest allowable sender window that will avoid the occurrence of problems such as that in Figure 3.27 below for each of these protocols?

![Figure 3.27](image-url)
Problem 3. [5 points]

Consider the TCP procedure for estimating RTT. Let $\text{SampleRTT}_1$ be the most recent sample RTT, let $\text{SampleRTT}_2$ be the next most recent sample RTT, and so on.

a) For a given TCP connection, suppose four acknowledgements have been returned with corresponding sample RTTs $\text{SampleRTT}_4$, $\text{SampleRTT}_3$, $\text{SampleRTT}_2$, and $\text{SampleRTT}_1$. Express $\text{EstimatedRRT}$ in terms of the four sample RTTs.

b) Generalize your formula for $n$ sample round-trip times.

c) For the formula in part (b) above let $n$ approach infinity. Comment on why this averaging procedure is called an exponential moving average.

Problem 4. [4 points]

Consider a scenario in which Host A wants to simultaneously send packets to Hosts B and C. A is connected to B and C via a broadcast channel—a packet sent by A is carried by the channel to both B and C. Suppose that the broadcast channel connecting A, B, and C can independently lose and corrupt packets (and so, for example, a packet sent from A might be correctly received by B, but not by C).

Design a stop-and-wait-like error-control protocol for reliably transferring packets from A to B and C, such that A will not get new data from the upper layer until it knows that both B and C have correctly received the current packet. Give FSM descriptions of A and C.

(Hint: The FSM for B should be essentially the same as for C.) Also, give a description of the packet format(s) used, if needed.)