CSEE 4119: Computer Networks

Homework 3 — Due: 03/18/2018

1. True or False?

   a. Host A is sending Host B a large file over a TCP connection. Assume Host B has no data to send Host A. Host B will not send acknowledgments to Host A because Host B cannot piggyback the acknowledgments on data.

   b. The size of the TCP `rwnd` never changes throughout the duration of the connection.

   c. Suppose Host A is sending Host B a large file over a TCP connection. The number of unacknowledged bytes that A sends cannot exceed the size of the receive buffer.

   d. Suppose Host A is sending a large file to Host B over a TCP connection. If the sequence number for a segment of this connection is m, then the sequence number for the subsequent segment will necessarily be m + 1.

   e. The TCP segment has a field in its header for `rwnd`.

   f. Suppose that the last `SampleRTT` in a TCP connection is equal to 1 sec. The current value of `TimeoutInterval` for the connection will necessarily be ≥ 1 sec.

   g. Suppose Host A sends one segment with sequence number 38 and 4 bytes of data over a TCP connection to Host B. In this same segment the acknowledgment number is necessarily 42.

2. UDP and TCP use 1s complement for calculate checksums. Suppose you have the following three 8-bit bytes: 01010011, 01100110, 01110100. What is the 1s complement of the sum of these 8-bit bytes? (Note that although UDP and TCP use 16-bit words in computing the checksum, for this problem you are being asked to consider 8-bit sums.) Show all work. With the 1s complement scheme, how does the receiver detect errors? Is it possible that a 1-bit error will go undetected? How about a 2-bit error?

3. Draw the FSM for the receiver side of protocol `rdt3.0`. (You can draw this by hand or use any other way that you prefer, and attach a figure).

4. Consider two hosts, A and B, which are connected by a perfect bidirectional channel (i.e., any message sent will be received correctly; the channel will not corrupt, lose, or re-order packets). A and B are to deliver data messages to each other in an alternating manner: First, A must deliver a message to B, then B must deliver a message to A, then A must deliver a message to B and so on. If a host is in a state where it should not attempt to deliver a message to the other host, and there is an event like `rdt_send(data)` call from above, this call can simply be ignored and replaced with a call to `rdt_unable_to_send(data)`, which informs the higher layer that it is currently not able to send data. [Note: This simplifying assumption is made so you don't have to worry about buffering data.]

   Draw a FSM specification for this protocol (one FSM for A, and one FSM for B). You should use the following events and actions that have the same meaning as protocol `rdt1.0` in class: `rdt_send(data)`, `packet = make_pkt(data)`, `udt_send(packet)`, `rdt_rcv(packet)`, `extract(packet,data)`, `deliver_data(data)`. Make sure to indicate the initial states for A and B in your FSM descriptions.

5. Answer true or false to the following questions and briefly justify your answer:

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

   b. With GBN, it is possible for the sender to receive an ACK for a packet that falls outside of its current window.

   c. The alternating-bit protocol is the same as the SR protocol with a sender and receiver window size of 1.

   d. The alternating-bit protocol is the same as the GBN protocol with a sender and receiver window size of 1.

6. Consider the TCP procedure for estimating RTT. Suppose that $\alpha = 0.1$. Let SampleRTT1 be the most recent sample RTT, let SampleRTT2 be the next most recent sample RTT, and so on.

   a. For a given TCP connection, suppose four acknowledgments have been returned with corresponding sample RTTs: SampleRTT4, SampleRTT3, SampleRTT2, and SampleRTT1. Express EstimatedRTT in terms of the four sample RTTs.

   b. Generalize your formula for n sample RTTs.

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

7. Recall the description of TCP throughput in congestion avoidance phase. In the period of time from when the connection's rate varies from W/(2 RTT) to W/RTT, only one packet is lost (at the very end of the period).

   a. Show that the loss probability (fraction of packets lost) is equal to

   $$L = \frac{1}{3/8W^2 + 3/4W}$$

   b. Use this result to show that the average throughput is

   $$\approx \frac{1.22 \times MSS}{RTT \times \sqrt{L}}$$