CS164 Midterm
Winter 2014

Problem 1. State whether each of the following statements is **true** or **false**.
(**Two points for each correct answer, –1 point for each incorrect answer.**)

____ The speed of light in a fiber optic cable is *less* than the speed of electrical signals in a copper cable.

____ If Alice applies the *Hamming Code* to an n-bit frame, then Bob can *detect up to* $log_2(n)$ *bit errors*, but cannot correct any of them.

____ The design of the global Internet *exactly* follows the 7-Layer OSI Reference Model.

____ Inserting too many *stuff bits* raises the pressure on the data link and may result in a *burst error*.

____ The *bit-wise exclusive-OR* of *any two* frames that have *even parity* will also have even parity.

____ The *bit-wise exclusive-OR* of *any two* frames that have *odd parity* will also have odd parity.

____ Without some additional mechanism to support a variable-sized payload field, the *Alternating Bit Protocol* would force Alice and Bob to send the same amount of data in each direction.

____ The *propagation delay* for a frame is proportional to its length (in bits).

____ A *half-duplex* link can carry data from Alice to Bob, or from Bob to Alice, but *not* in both directions at the same time.

____ If a data link protocol *does not* support *data transparency*, then Alice could create a file that disrupts the Layer-2 connection when she sends it to Bob over this link.

Problem 2. Alice and Bob are using the *cyclic redundancy check (CRC)* method for Data Link Layer error control, with generator polynomial $D^3 + D^2 + 1$.

a State the *length* (in bits) of the CRC field that Alice must add to the end of each data frame.

b Calculate the *value* of the CRC field that Alice must append to the data frame "1001100". *SHOW YOUR WORK!*

c Repeat part(b) if we change the generator polynomial to $D^5 + D^4 + D^2$ and Alice tries to send the same data frame.

d How are the values of the CRC fields you calculated in parts(b-c) related?

e How are the values of the two rightmost bits of the CRC for part(c) related to the value of data frame?

f Explain why the degree-5 polynomial introduced in part(c) is actually *worse* than the original degree-3 polynomial. [HINT: Which patterns of bit errors can be detected by the degree-5 polynomial but not the degree-3 polynomial, or vice-versa?]

Problem 3. Alice and Bob have established a *sliding window data link* connection, based on the rules established in Kruth's protocol verification paper. Assume that (i) Alice uses a transmit window size of $W = 4$ frames, (ii) Bob has a receive window size of $R = 2$ frames, (iii)Alice's first data frame has sequence number 0, and (iv) Bob sends *cumulative acknowledgements* back to Alice, where an acknowledgement with value $b \geq 0$ means that Bob has successfully received the first b consecutive frames (up to frame number $b-1$).

a Briefly explain the difference between *Selective Repeat* and *Go-back-N*. Do either of these terms apply to this problem? Why or why not?

b Suppose Alice begins the protocol by transmitting her first data frame. Give a list of all possible frame numbers that Alice could have chosen to transmit.

Problem 4. Suppose you walk up to the system described in the previous problem and see that Alice is currently sending frame 10. Even though you have no other information about which frames were previously sent by Alice and/or received by Bob before your arrival, you can use this observation to establish some restrictions on which frames must/may/cannot be in Bob's possession at this time.

a List all frame numbers from the *smallest* set of frames that Bob *must have already received* before you saw Alice sending frame 10. Explain.

b List all frame numbers from the *largest* set of frames numbers that Bob *could have received* before you saw Alice sending frame 10. Explain.

c Is 4 bits the *smallest* number of bits that Alice and Bob could use to store the frame sequence number and/or cumulative acknowledgement number in the frame header? Explain your answer.

Problem 5. For this problem, assume that Alice is transmitting data from the Mount Palomar Observatory to Bob's lab at UCR, using a dedicated point-to-point link that is 100 kilometers long and provides a data rate of 10^9 bits/sec.

a If the length of each packet is exactly 10,000 bits, including all framing overhead, find the transmission time for a single packet.

b Find the one-way propagation delay from Alice to Bob, if signals travel at a speed of $\frac{2}{3}C \equiv 2 \times 10^8$ meters/sec.

c Draw and label a space-time diagram to show the latency for transferring one packet from Alice to Bob, starting at time 0.

d What is the maximum throughput, in packets per second, that Alice can send to Bob using the stop-and-wait data link protocol, assuming Bob's acknowledgments have zero length? Show your work!

e If there are no errors, what happens to the maximum throughput if Alice and Bob switch to a sliding window protocol with a window size of 10, 100, or 1000 packets?

f Suppose Bob is too lazy to implement the sliding window protocol, and instead suggest that they keep using stop-and-wait, but simply increase the packet size to 100,000 bits, 1,000,000 bits or 10,000,000 bits? How do the results of this approach compare to your answer to part (e). Why is this?