American University of Beirut
Department of Electrical and Computer Engineering
EECE 350 – Computer Networks
Homework 3

Due Friday March 6 in class.

Problem 1. [17 points]

a) Compute the overhead of error-correction, in number of *additional* bits, when sending a file of size 20 million Bytes, using 8,000-bit frames. You need to determine first the number of bits (r) you need for error correction, using Hamming's formula. Assume that the header of a frame includes the error correction bits *only*. This means that 8,000+r bits are sent for each frame. [7 points]
b) If single-bit errors (per frame) occur during the transmission of the 20-million Byte file, the error will be automatically corrected using the error-correction scheme. An alternative is to use error detection, by sending a single parity bit with every 8,000 bits of data. When the error is detected, the corresponding frame is re-transmitted (assume that the overhead of feedback, when the receiver informs the sender that the frame is in error, is 400 bits). At what BER does the overhead of error detection (in additional number of bits, on top of file size) become equal to that of error correction? [10 points]

Problem 2. [21 points]

T = 1010101111001010 is a CRC-coded message using generator $G(x) = x^4 + x + 1$
a) Find the original message D. Express D in *hexadecimal*. [7 points]
b) Given that the received message is T^* = 1011101110111100, what bits are in error? [7 points]
c) Is the error detected or not, and why? [7 points]

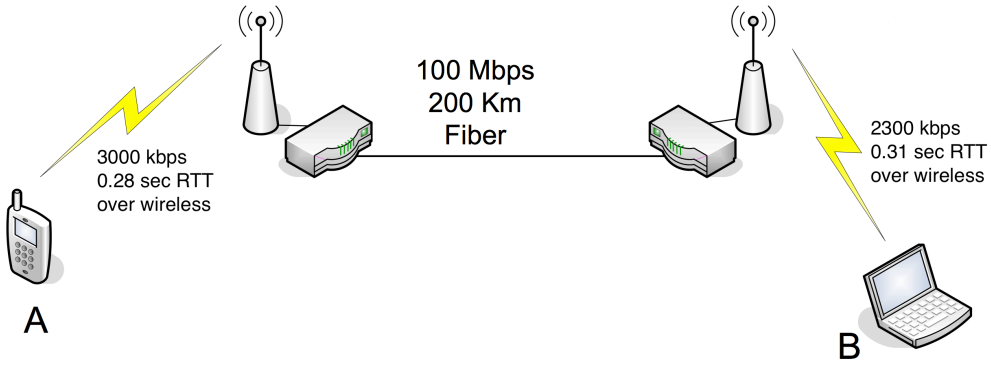
Problem 3. [32 points]

Consider a full-duplex 2 Mbps satellite link with a 250 msec propagation delay from sender (via satellite) to receiver. The data frames carry a *useful* data payload of size 10,000 bits. Assume that both ACK and data frames have 400 bits of header information, and that ACK frames carry no data.

What is the effective useful data throughput:
a) When using Stop-and-Wait? [8 points]
b) When using sliding windows with a sender window size W
    1. What is the maximum possible effective useful data throughput? [8 points]
    2. What minimum value of W will give this maximum? [8 points]
    3. How many bits are needed in the frame header for such a window size for Go-Back-N? For Selective Repeat? [8 points]

Problem 4. [30 points]

Two 3G users A and B are communicating using the system shown in the figure below. The frames have 4000 bits, ACKs are negligible in size, and the processing time at intermediate switches is 10 microseconds (at each switch, and in the two directions). Assume that frame transmission is error-free and that the signal propagation speed in the fiber is 0.7c.



a) Find the maximum throughput from A to B when *each* wireless link uses Stop-and-Wait. [15 points]
b) Repeat the calculation assuming now that Stop-and-Wait is used *end-to-end* between A and B. [15 points]