College of Computer and Information Science Fall 2011
Northeastern University
CS4700 & CS5700: Fundamentals of Computer Networks

Problem Set 2 (due September 29, 2010).
[100 points]

Important Notes:

1. Team work is **only** allowed for Problem 5 (2 students per team).
2. Late submissions will result in a 10% penalty per day (e.g., 2.5 days late result in 25% penalty).
3. You can use the Internet to get some help, but you should use your own words, examples, and code when answering the questions.

Problem 1 [10 points]: Channel Capacity

Assume that a transmitter and a receiver are communicating over a channel such that the signal to noise ratio (S/N) is equal to 1000. Assume that the channel bandwidth is 10 MHz. Assume that the channel is AWGN and use Shannon channel capacity theorem.

1. What is the maximum data rate that can be achieved with this communication?

2. Assume that the transmitter only needs to send (one-way) a packet of 1Kbytes every 1 millisecond. How much capacity does the transmitter need? What percentage of energy can the sender save by reducing its signal power to exactly meet its packet transmission requirement?

Problem 2 [10 points]: Framing

1. Consider the framing mechanism based on bit-stuffing and using flag 01111110.
   a) Build the frame corresponding to the following sequence of bits:
   0101111111111100111111100000011

   b) Recover the data from the following frame (note that the frame includes the flags)
   01111110001011111011111100101111110

2. Consider the character-based framing mechanism. Build the frame corresponding to the following sequence of characters (assume no Header is used):
   Data Packet = A C B STX D DLE G DLE DLE ETX A DLE DL

Problem 3 [10 points]: CRC Computation.

Let $g(X) = X^4 + X^3 + X + 1$ be the generator polynomial used for CRC generation.

1. Draw the circuit that can generate the CRC (in hardware).
2. Using the hardware circuit, compute the CRC of the data stream S = 0 1 0 1 1.
3. Compute the CRC using polynomial division.

Problem 4 [10 points]: ARQ Mechanism.

Assume that we are using an Automatic Repeat reQuest (ARQ) protocol, where the Sender-Window-Size (SWS) is equal to n (e.g., 10), and the Receiver-Window-Size (RWS) is equal to 2. What should be the constraint on **MaxSeqNum** for the protocol to work correctly? Graphically show an example of problem when **MaxSeqNum** is not set correctly.

Problem 5 [60 points]: ARQ Mechanism Implementation
Note: Can be done in teams of 2 students using Java or C/C++, or Python.
Write a program that allows a user to download a file from one machine to another using UDP sockets. There should be a server and a client program. Use a stop and wait ARQ mechanism. You can implement your system in Java, or C/C++, or python. The server accepts one download request at a time. A sample run of the server and client can be:

Login.ccs.neu.edu> server 1234 Download request for *filename* requested by workstation2. Download in progress: ############## Download complete.	**client-machine**> download-client workstation1 1234 *filename* Download in progress: ############## Download complete.

1. Run your server and client on login.ccs.neu.edu. What is the average delay, throughput, and packet loss rate that you are experiencing?

2. Run your server on login.ccs.neu.edu and your client on a machine outside the college. What is the average delay, throughput, and packet loss rate that you are experiencing?

3. Artificially introduce an additional error probability of packets by dropping packets with probability *p.* What is the average throughput that you get for the following values of *p: p* = 0.2, 0.1, 0.01.