15-441: Computer Networks
Homework 1

Assigned: January 29, 2008
Due: February 7, 2008

1. Suppose a 100-Mbps point-to-point link is being set up between Earth and a new lunar colony. The distance from the moon to Earth is approximately 385,000 km, and data travels over the link at the speed of light—$3 * 10^8$ m/s.
   (a) Calculate the minimum RTT for the link.
   (b) Suppose Mission Control on Earch wishes to download a 25MB image from a camera on the lunar base. What is the minimum amount of time that will elapse between when the request for the data goes out and the transfer is finished?
   (c) Using the RTT as the delay, calculate the delay*bandwidth product for the link.
   (d) Imagine that Mission Control requests one 25MB image and then waits until it starts receiving the file before sending another request (the size of the request is negligible). Use the delay*bandwidth product to determine what percentage of the link is utilized.

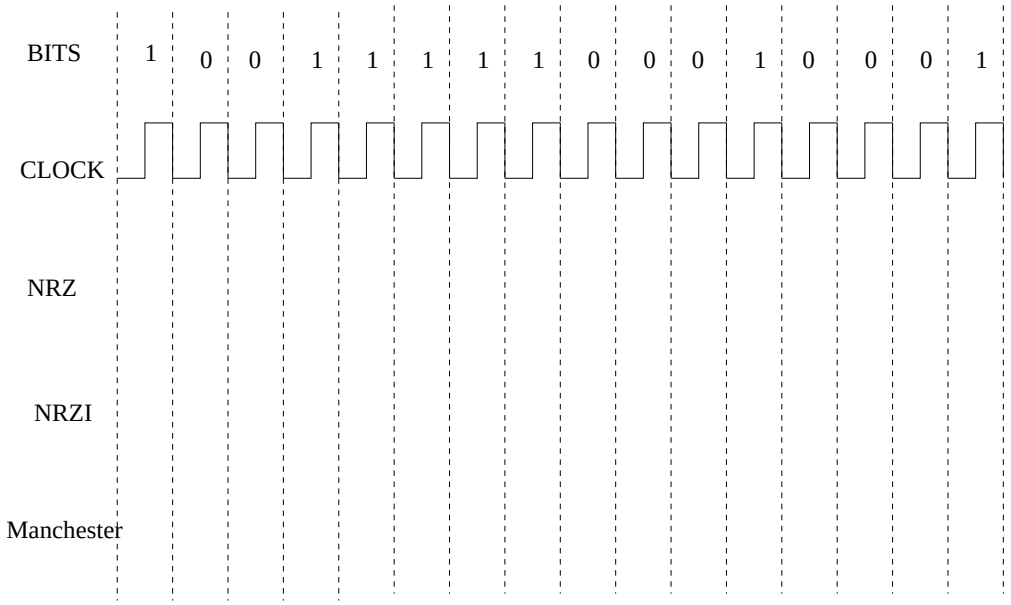
2. Calculate the latency (from first bit sent to last bit received) for the following:
   (a) A 10-Mbps link with a single store-and-forward switch in the path, and a packet size of 5,000 bits. Assume that each section of the link introduces a propogation delay of 10 microseconds, and that the switch begins retransmitting immediately after it has finished receiving the packet.
   (b) Same as (a) but with three switches
   (c) Same as (a) but assume the switch implements cut-through switching: it is able to begin retransmitting the packet after the first 200 bits have been received.

3. Do Exercise 1 from Chapter 3 in the textbook (Computer Networks: A Systems Approach Edition 4).

   For each connection it is fine to write out only the new table entries that would be added for each router instead of rewriting the full table each time.

4. Look in the book at section 2.3.2 to learn about HDLC
   (a) Assuming that we are using the HDLC protocol for bit stuffing, show the bit sequence transmitted over the link when the frame contains the following bit sequence:
   110100011011111100110100111110011000000111111100010011
   Mark the stuffed bits
   (b) Supposed the following sequence of bits arrives over a link:
   110110001011111010010000011011111000010110111111 0010
   Show the resulting frame after any stuffed bits have been removed. Indicate any errors that might have been introduced into the frame.
   (c) Given an original data size of 64 bits, what is the largest number of bits that may need to be transmitted (using HDLC)? What is the smallest number of bits? Remember to include both begin and end HDLC frame markers.

5. Show the NRZ, Manchester, and NRZI encodings for the bit pattern shown in the figure below. Assume that the NRZI signal starts out low



Charles, an ex-441 student, is given the task of building a new network link technology. Unfortunately, many of his beta-testers complain that their packets get corrupted when using his technology! He tracks the problem down to time synchronization problems between the sender and receiver on the link. Perhaps you can help Charles solve his problems by telling him a little about different encoding methods. Identify the problem and give a 1-2 sentence explanation about why this occurs.

For each of these sub-parts, identify whether the encoding can have problems with:

A. Long strings of 0s

B. Long strings of 1s

C. Both long strings of 1s or long strings of 0s

D. None of the above

(a) Manchester encoding

(b) NRZ

(c) NRZI

6. You are working for a company that delivers digital pictures to users over different types of networks. You are developing a new product that will use a network link that has a bandwidth of 1MHz. Your boss asks two of your colleagues, Bob and Jane, to estimate how long it will take to transfer 1 MByte images over the channel.

(a) Jane took a networking course and vaguely remembers something about Nyquist. She uses the Nyquist limit - what answer does she get?

(b) Bob took the same course but was more impressed by the slide on Shannon. He applies the Shannon formula. He assumes that the signal-to-noise-ratio is 30 dB (that is after all, what was on the slide in class). What answer does he get?

(c) Your boss is unhappy. He did not expect to get two different answers and he calls you in to explain the difference. What do you say?