15-441: Computer Networks
Homework 1

Assigned: Jan 21, 2010
Due: Feb 4, 2010
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1. Calculate the latency (from first bit sent to last bit received) for the following:
   (a) 100-Mbps Ethernet with a single store-and-forward switch in the path, and a packet size of 1500 bytes. Assume that each link introduces a propagation delay of $10\mu s$ and that the switch begins retransmitting immediately after it has finished receiving the packet.
   (b) If there are three switches?
   (c) Same as (b), but assume that the switches implement cut-through switching, i.e. it is able to begin transmitting the packet after the first 200 bits have been received.

2. Consider the HDLC protocol where the start and end of frames are marked by the flag byte '01111110'. To ensure that this pattern never appears in normal data, a 0 bit is stuffed after every five 1 bits in the data. Suppose a network device captures the following bit sequence on the link layer (read left to right):

   100111110100000000011111010110111111101101111101000001001111110

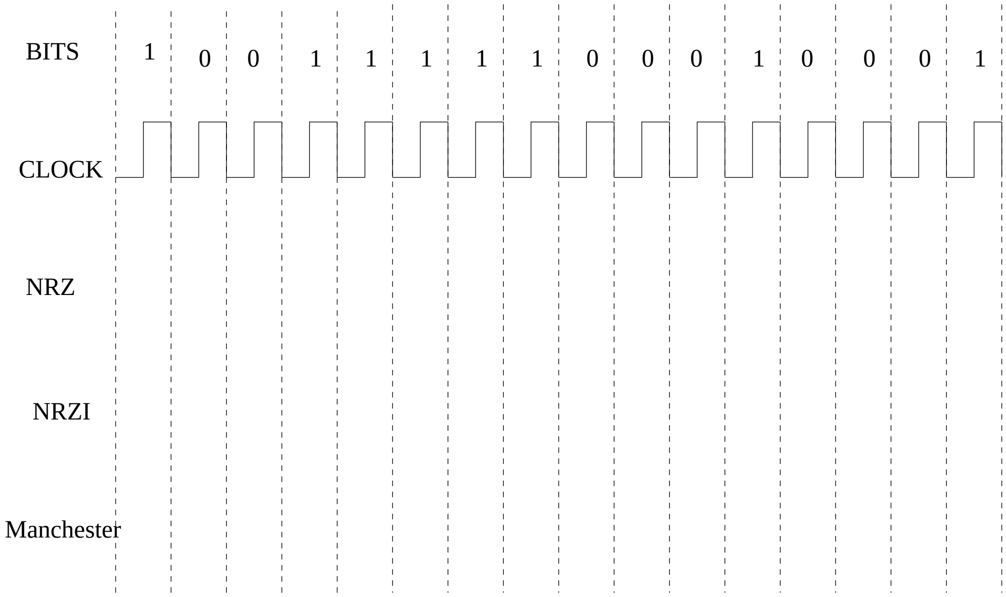
   Show the resulting frame after any stuffed bits have been removed. Indicate stuffed bits that have been removed by '*', any errors that might have been introduced into the frame by 'err' and flag byte by 'f'.

3. George wants to setup a wireless network in a reserved frequency band for only the 15-441 staff to use. **The frequency band reserved for the staff is 500MHz** wide, for which Peter, Bruce, David, George, and Jacob will share. George, who did not pay attention during lecture, is trying to figure out the best way to multiplex the channel such that each member can achieve the best throughput in the network. The only method he can currently remember is time division multiple access (TDMA). To test the network the staff will **perform a 500KB file transfer** simultaneously. Ignore propagation delay and handshaking, and assume **each user has one transceiver that is tunable to any frequency and can transmit data at a maximum rate of 2Mbps, using 100MHz** of the channel. There is a **maximum packet size of 1000 bytes**, no header is used. Assume a noiseless channel (no loss will occur), such that no ACKing or collision detection scheme is needed. Assume kilo means 1000 in all cases (e.g. $1000KB = 1 * 10^6 bytes$).

   (a) In the TDMA protocol that George develops, each staff member is allowed to transmit a single packet, to avoid interference 5ms of silence is required, followed by the next staff member's packet transmission. Therefore, a single 'round' of transmissions looks like this, note the order: George, 5ms, Bruce, 5ms, David, 5ms, Peter, 5ms, Jacob, 5ms. Using this protocol, how long will it take George's 500KB file transmission to finish?

   (b) TDMA is not the optimal way to multiplex the given channel. There is a more efficient way which allows all staff member's transmissions to finish faster. Name the technique and briefly describe how it works. How fast can George's file transmission finish now?

4. Show the NRZ, Manchester, and NRZI encodings for the bit pattern shown in the figure below. Assume that the NRZI signal starts out low (Exercise 1, Chapter 2, Peterson and Davie)



5. Consider the following error control schemes:

   - **Stop-and-wait ARQ:** The sender sends the next packet only after the receiver sends the ACK for the previous packet. The receiver sends an ACK only if the packet is correctly received, else it does not send anything. If the sender does not receive an ACK for *timeout* sec, it sends the packet again. The sender uses an extra **1 byte** of redundant data to send a checksum at the end of the packet which can be used to detect errors. ACK is **1 byte** long. Assume that the value of *timeout* is equal to the time required to send **6 bytes**.
   - **Forward Error Correction (FEC):** The sender sends a packet and does not wait for an ACK from the receiver to send the next packet. Any errors in the packet can be detected by the receiver and fixed. This is made possible by sending error-correcting (redundant) data of length **7 bytes**.

   Assume the following for the sake of simplicity:

   1. Any packet in error can be detected by the ARQ scheme and corrected by the FEC scheme
   2. All packets (without redundancy) sent on the link are of the same length (**43 bytes**)
   3. There is no latency in sending a packet on the link and successive packets (data/ACK) are sent immediately after the previous packet
   4. ACKs and retransmitted packets (in ARQ) do not have error

   Let the probability that a data packet (excluding retransmissions) is in error be p_{err}.

   Which is scheme is more efficient and why, for the following cases:

   (a) $p_{err} = 0.5$

   (b) $p_{err} = 0.1$

   (c) $p_{err} = 0.01$

   Based on your calculations, under what conditions would you use

   A. ARQ

   B. FEC

   Please show all your calculations.