CS 6380 Computer Networks **Fall Quarter, 1995**

Midterm Examination

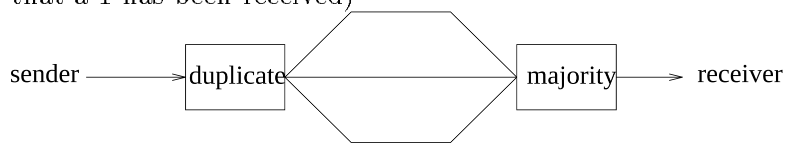
October 25

Be neat and concise. Show your work. Good luck!

Name: ______________________________

Problem	Points	Score
1	20	
2	15	
3	15	
4	10	
5	10	
6	10	
7	20	
Total	100	

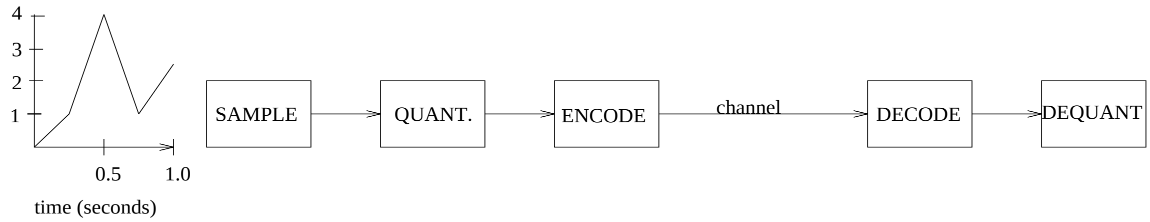
1. Consider sending bits over a *composite* channel that consists of three parallel, independent, binary symmetric channels. At the sending end, the bit to send is duplicated and transmitted on all three channels; at the receiving end, the three received bits are collected and the majority is taken. The received bit is whatever bit value is agreed upon by the majority of the binary symmetric channels. (e.g., if 011 is received on the three channels, the composite channel says that a 1 has been received)



   (a) Derive the error model for the composite channel. That is, determine the possible outcomes (and their probabilities) when a 0 is sent and when a 1 is sent. It may be helpful to draw a diagram of the possibilities.

   (b) Can the composite channel be represented as a single binary symmetric channel? Justify your answer.

2. The following is a diagram of the steps involved in pulse code modulation. Assume samples are taken at a rate of 4 times per second, beginning at $t = 0$. Assume one-bit quantization, with quantization levels evenly spaced in the range 0 to 4 to minimize error for sample values uniformly distributed in the range 0 to 4. Assume the encoder uses NRZ (non-return-to-zero) encoding.



At each point indicated below, draw the signal.

(a) Output of sampler.

(b) Output of quantizer.

(c) Output of encoder.

(d) Output of dequantizer.

(e) In one sentence, state the purpose of pulse code modulation.

3. The *three-way majority code* works as follows. Each bit in the frame is replicated three times to form the codeword. Thus, a frame of 011 is coded as 000111111.

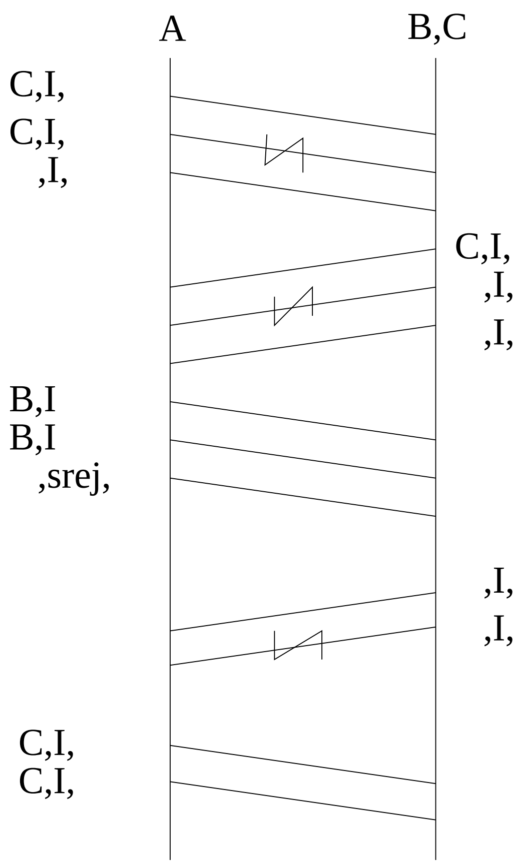
   (a) What is the Hamming distance of this code? Based only on the Hamming distance, what are the error detection and correction capabilities of the code?

   (b) What additional error detection and correction capabilities does this code have?

   (c) Given the fact that bit errors tend to occur in "runs" of consecutive bits, would an alternative arrangement of the bits in the codeword make it more robust against errors? Explain.

4. Give the codeword for CRC encoding using a frame $M = 00011$ and a divisor $P = 1011$. Show both the long division calculation of the codeword and the shift register implementation and calculation.

5. Fill in the blanks in the HDLC diagram below. Assume normal response mode with one primary (A) and two secondaries (B,C). Assume the sequence numbers start with 0.



6. Give concise justification of your answers to the following questions:

   (a) Would you prefer a channel with bandwidth 50 MHz and signal to noise power ratio of 100, or a channel with bandwidth 100 MHz and signal to noise power ratio of 10?

   (b) Why should bit stuffing be done after computing the CRC in a data link protocol?

   (c) All else equal, does selective-reject become more or less advantageous over go-back-N as the transmission time increases?

7. Consider the following modification to the Go-back-N ARQ protocol. Rather than acknowledging each frame separately, the receiver collects three frames and then sends an ACK (if all three were received correctly), or a NACK (if any of the three were received in error or lost). Upon receiving a NACK, the sender backs up to the first frame in the group, retransmitting all three frames in the group.

   (a) Draw a picture of the normal (error-free) operation of this protocol for sending and acknowledging six I-frames.

   (b) Assuming the sender uses a sliding window of size W, what range of sequence numbers are needed on the ACK and NACKs? Justify your answer.

   (c) If p is the probability of an error in an I-frame, on average how many times will a particular I-frame be retransmitted? (You may assume that the ACKs and NACKs are always error-free.)