CS 4380 Data Communications **Spring Quarter, 1994**

Midterm Examination

October 21

Be neat and concise. You may use your calculator and one page cheat sheet. Show your work. Good luck!

Name: _____

Problem	Points	Score
1	20	
2	15	
3	15	
4	15	
5	25	
6	10	
Total	100	

1. The binary symmetric channel (BSC) model from class assumes that the channel will deliver a bit correctly or invert it (change a one to a zero or vice versa). In a practical channel, it is possible that a bit put on the channel by the sender is "lost", so that the receiver does not receive anything.

(10) a. Modify the diagram for the BSC model to include the loss of a bit as a possibility. Be sure to state clearly the meaning of any variables in your diagram.

(5) b. Give the expression for the probability the sender transmits 1011 and the receiver receives 1001 in your new model. Is this more or less likely than it was in the original model?

(5) c. Give the expression for the probability the sender transmits 10 and the receiver receives 1.

2(5) a. Generate the Hamming codeword for the data bits 01100010.

(5) b. What is the minimum number of undetectable errors in the Hamming code? Give an example of a minimum size set of undetectable errors in the codeword for part (a).

(5) c. Generate the CRC codeword for the data bits 100001 using the predefined divisor 101. Show the calculation at the receiver to check if the codeword is free of errors.

3. Consider the two dimensional parity code for frames of nine bits arranged in a matrix with three rows and three columns. Assume that odd parity is used.

(10) a. Give an example of a codeword in which the corner bit differs depending on whether it is taken over the row parity bits or the column parity bits.

(5) b. Suppose the corner bit is computed over the row parity bits when using odd parity. Are the error detection/correction properties of the code affected by the use of odd versus even parity? Justify your answer.

4(8) a. Explain the difference between forward error control and backward error control. List three important factors that affect which should be used and indicate how each factor affects the decision.

(7) b. Give one advantage and one disadvantage of using a shorter flag marker in a bit-oriented framing protocol. (That is, shorter than the eight bit marker 01111110 discussed in class.)

5. Consider a modification of the Stop-and-Wait ARQ protocol called Stop-and-Wait-Two. In this new protocol, the sender transmits two I-frames before waiting for an acknowledgement. The receiver waits for the pair of I-frames and then sends an ACK (if *both* were received correctly) or a NACK (if *either* is received incorrectly). Upon receipt of an ACK, the sender goes on to the next two I-frames. Upon receipt of a NACK, the sender retransmits *both* frames.

(10) a. Draw a timing diagram for error-free operation showing the transmission and acknowledgement of four I-frames. Label the time components in the diagram using the following variables:

T_t = I-frame transmission time
T_p = propagation delay
T_c = processing time on receiving I-frame, ACK or NACK
T_a = ACK/NACK transmission time

(5) b. Give the equation for the throughput during error-free operation using the variables from part (a). How does this compare to the throughput for Stop-and-Wait?

(10) c. Draw a timing diagram for the case in which the second I-frame of a pair is lost. Show the original transmission of the pair and the subsequent transmission to recover from this problem. Give a brief explanation of what is happening at the sender and receiver.

6(5) a. Briefly define the concept of maximum likelihood decoding.

(5) b. Suppose the set of valid codewords sent by the sender is the following: $\{0000, 1011, 1111\}$. Explain what circumstances would cause a receiver doing maximum likelihood decoding to receive the valid codeword 0000 from the physical channel and decode it as 1011.