18-345
Introduction to Telecommunication Networks
Homework 2

September 23rd, 2007 **Due: September 29th, 2007**

1. ATM uses an eight-bit CRC on the information contained in the header. The header has six fields:

First 4 bits: GFC field
Next 8 bits: VPI field
Next 16 bits: VCI field
Next 3 bits: Type field
Next 1 bit: CLP field
Next 8 bits: CRC

The CRC is calculated using the following generator polynomial g(x): $x^8 + x^2 + x + 1$. Find the CRC bits if the GFC, VPI, Type, and CLP fields are all zero, and the VCI field is 00000000 00001111. Assume the GFC bits correspond to the highest-order bits in the polynomial.

2. A proposed encoding scheme applies 6 error correction/error detection bits to a 16-bit long data word. The probability of a bit being in error is PB, and is an independent random variable. This encoding scheme promises that all single bit errors can be corrected, and all double will be detected (but not corrected). Assuming that all combinations of three or more errors will not be detected or corrected, find mathematical expressions for:

a). The probability that no errors occur

b). The probability that a correctable error occurs

c). The probability that a detectable but not correctable error occurs

d). The probability that an undetectable/uncorrectable error occurs

3. Given a set of codewords, the “minimum Hamming distance” is defined as the smallest number of bits that two codewords differ. For example, the minimum Hamming distance of the set of codewords{000 , 001 , 111} is 1.

a) Determine the minimum Hamming distance of the following set of codewords.

1100110111001
1000101001001
1101000110100
0111011110101

b) One of the codewords from the set given above is transmitted across a noisy channel, and d is received as: 1100000110000. Given that the received sequence has 2 bit-errors, is it possible to detect the errors? Correct the errors?

4. Suppose a multiplexer in a TDM (circuit switched) network has two input streams, each at a nominal rate of 1 Mbps. To accommodate deviations from the nominal rate, the multiplexer transmits at a rate of 2.2 Mbps as follows. Each group of 22 bits in the output of the multiplexer contains 18 positions that always carry information bits, nine from each input. The remaining four positions consist of two flag bits and two data bits. Each flag bit indicates whether the corresponding data bit carries user information or a stuff bit because user information was not available at the input.

a). Suppose that the two input lines operate at exactly 1 Mbps. How frequently are the stuff bits used?
b). How much does this multiplexer allow the input lines to deviate from their nominal rate?

5. SONET allows positive or negative byte stuffing to take place at most once every four frames. Calculate the minimum and maximum rates of the payload that can be carried within an STS-1 SPE.

6. Consider the multistage switch in Figure 4.35 in the textbook with N = 16, n = 4, k = 2.

a). What is the maximum number of connections that can be supported at any given time? Repeat for k = 4 and k = 10.
b). For a given set of input-output pairs, is there more than one way to arrange the connections over the multistage switch?

7. Illustrate graphically the complexity of a crossbar switch and the complexity of a Clos network relatively to N (= #inputs = #outputs). Briefly describe what you observe from the graph.