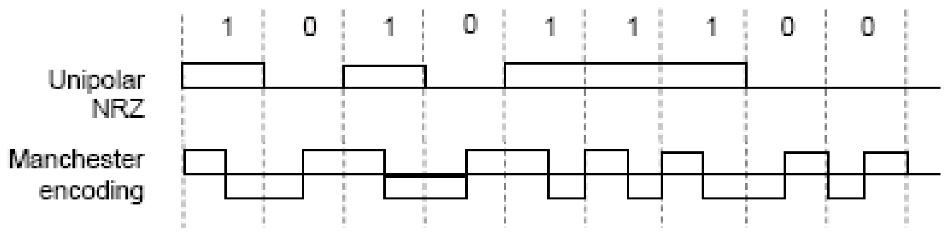
18-345 Introduction to Telecommunication Networks
Quiz 2 Solution October 1st 2008

Name ____________ AndrewID _______________

Problem 1 (4 points)



Consider the two encoding schemes shown above and compare them with regards to the following:

a) Recovering clock skew (2 points)

In unipolar NRZ recovering from clock skew is a problem since there is no transition between or within pulses. As a result, long strings of 0s and 1s are hard to decode. Manchester encoding solves this problem by defining a transition inside every pulse.

b) Bandwidth efficiency (2 points)

Manchester encoding using more bandwidth (roughly twice) compared to unipolar NRZ.

Problem 2: (4 points)

For each scenario listed below, choose the appropriate switching mode (circuit switching or packet switching), and explain why.

a) A sensor network that sends time critical data item (8 bytes) once in a while. (2 points)

Packet switching is more suitable since setting up a circuit for each data item would be slow and expensive and keeping a circuit open all the time would be inefficient.

b) A new Windows Vista Service Pack is available (some day in the future). It is big, but you still want to download the content to your computer. (2 points)

Packet switch is favored since it will allow you to opportunistically use whatever bandwidth is available and there is no need to maintain a minimum bandwidth (as in voice, for example).

Problem 3 (6 points)
Hamming(5,3) is a Hamming code that encodes 3 bits of data into 5 bits by adding 2 parity bits. Suppose we use a Hamming(5,3) codeword set $\{(b_1, b_2, b_3, b_4, b_5)\}$, where b_1, b_2, b_3 are information bits, and the equations for parity checks b_4, b_5 are:

$$b_4 = b_1 + b_2;$$
$$b_5 = b_2 + b_3;$$

a) How many codewords are there in the codeword set? Determine the minimum Hamming distance of the codeword set. (3 points)

Parity bits are determined by data bits.
There are 8 codewords in the codeword set.
(00000, 00101,01011,01110,10010,10111,11001,11100)

The minimum Hamming distance is 2.
Consider any two different codewords:
(1) the distance between data bits $d \geq 1$.
(2) When $d = 1$, one of the parity bits must be different as well.

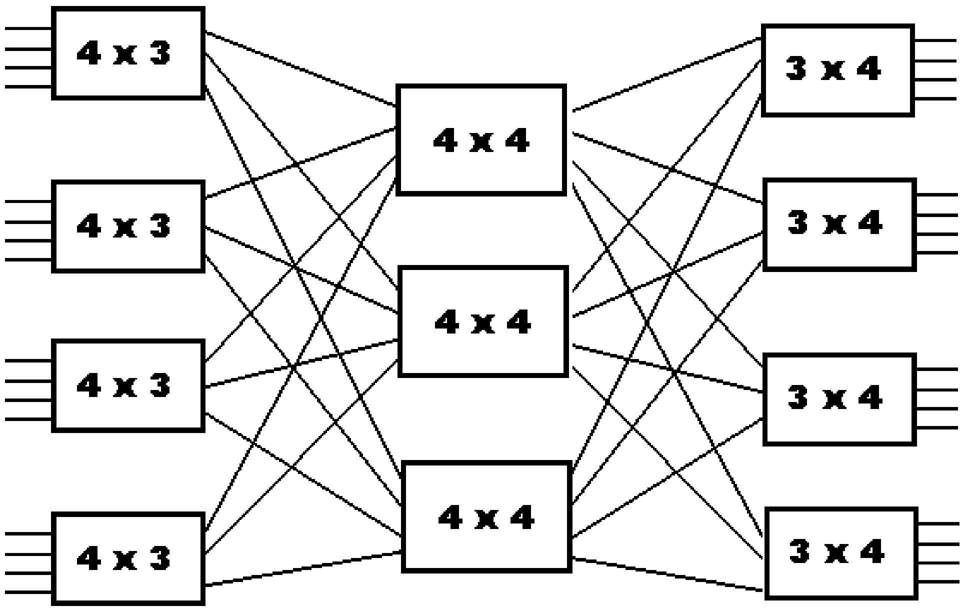
Thus, the minimum Hamming distance has a lower bound of 2. An example is the first two code words listed above.

b) One of the codeword ***C*** from the codeword set given above is transmitted across an unreliable channel. Assume that there is at most 1 error in the received sequence. If the received sequence ***C**** is 00110, is there any error in ***C****? If there is, can you find out which codeword ***C*** has been sent? Please explain your answer. (3 points)

Yes, there is error in *C, because *C** does not match any codeword in the set.**

Since there is only 1 single error in *C, the Hamming Distance between *C* and *C** is 1. In theory, for codeword set that has minimum Hamming distance of 2, we can detect all 1 bit error and correct some 1 bit error. Fortunately, among all the valid codewords, only 01110 is 1 bit away from *C**. Therefore original codeword *C* is 01110. (If there exists another codeword has Hamming distance of 1 from *C**, we will not be able to correct the error in *C**.)**

Problem 4 (6 points)



Here is a multistage switch diagram with $\boldsymbol{N} = 16$, $\boldsymbol{n} = 4$, and $\boldsymbol{k} = 3$.

a) How many cross points do we have? (2 points)

The number of cross points is: $2(N/n)nk + k(N/n)^2 = 96 + 48 = 144$

b) What is *Clos Non-Blocking Condition*? Does this switch satisfy that condition? (2 points)

Clos Non-Blocking Condition: $\boldsymbol{k \geq 2n\text{-}1}$
Since k = 3, and n = 4, the switch does not satisfy Clos Non-Blocking Condition.

c) If the non-blocking condition is met, can you reduce the amount of hardware (# of switches) needed? If not, how can you change the number of inputs $\boldsymbol{n}$ so it is met? Please explain your answer. (2 points)

(From $k \geq 2n$-1, we have $n \leq (k+1)/2 = (3+1)/2 = 2$)
If we reduce n from 4 to 2 (have N/n = 16/2 = 8 switches in the 1^{st} and 3^{rd} stage), the switch will meet the Clos Non-Blocking Condition.