CS/ECE 438: Communication Networks Fall 2006
Problem Set 2 Due: start of class, Wednesday, September 20th

Direct Link Networks

1. Encoding and Channel Capacity

a. Show the NRZ, Manchester, NRZI and 4B/5B encoding signals (the resulting NRZI signal for 4B/5B), using a diagram similar to that in the lecture slides for the data bit sequence 1111 1101 1011 0101. To be definite, suppose the NRZI signals begin at low voltage. The encoding table for 4B/5B is included at the end of this homework.

b. A standard analog broadcast television channel is 6MHz wide (i.e., it has a bandwidth of 6 MHz in the terminology of communications engineers). How many bits/second can be transmitted using a quadrature amplitude modulated (QAM) signal with M = 256 possible symbol values in the QAM signal constellation? Assume that bandwidth efficient pulse shapes are used so that the baud rate $6x10^6$ QAM symbols per second can be achieved.

c. Assuming that Shannon's law applies, what ration S/N of signal power to in-band noise power would be needed to support communication at the data rate you found in part (b), assuming an optimal communication scheme?

d. How much smaller could the transmit power S be to send at the same data rate as in part (c), but using twice the bandwidth (i.e., 12 MHz)? Assume that the in-band noise power N in Shannon's capacity formula is proportional to the bandwidth.

2. Noisy Channel Data Rates

The decibel is a measure of the ratio between two signal levels: $N_{db} = 10 \log_{10} (P_2/P_1)$, where N_{db} = the number of decibels, P_1 = the input power level and P_2 = the output power level.

a. A telephone line is known to have a loss of 15dB. The input signal power is measured as 0.7 watt and the output noise is measured as 5 μwatt. Using this information, calculate the output signal-to-noise ratio in dB.

b. What is the capacity of this phone line with a frequency range of 300 Hz – 3300 Hz?

c. If the attenuation rate of this phone line is 4db/km, and the minimum output signal is 0.001 watt, given the input signal from part a), how long can the phone line be before requiring a repeater?

3. Framing

Consider the data bit sequence 1101 1101 0111 0011 0010 0101 1101 1111. In this problem, you will frame these bits in three ways.

a. First, frame the bits with byte stuffing as used in the BISYNC protocol. You need show only the body (including stuffed bytes) and the sentinel bits. DLE is ASCII character 16 (decimal), STX is 2, and ETX is 3.

b. Second, frame the bits using bit stuffing as defined by the HDLC protocol. Again, you need show only the (stuffed) data bits and the sentinel bits.

c. Third, frame the bits into 8-bit RS-232 characters. Use "0" to represent start bits and "1" to represent stop bits.

d. Now, counting only the bits that you wrote, calculate the efficiency (as a percentage of real data per bit sent) of your answers to (a), (b), and (c).

4. Error Detection

a. A CRC is constructed to generate a 4-bit checksum for an 11-bit message. The generator polynomial is $x^4 + x^2 + 1$. Encode the data bit sequence 11010110111. Now assume that bit 7 (counting from the least significant bit) in the code word is in error and show how the error is detected.

b. The bit sequence **10010110011** corresponds to the polynomial $x^{10}+x^7+x^5+x^4+x+1$. Divide this polynomial by the CRC generator polynomial x^3+x+1 and report the remainder as a polynomial. Is the bit sequence correctly encoded with the given generator (i.e., is the remainder 0)?

c. A block of bits with n rows and k columns uses horizontal and vertical parity bits for error detection. Suppose that exactly 3 bits are inverted due to transmission errors. Derive an expression for the probability that the error will be undetected.

5. Networking Utilities

Read the manual pages for the Unix utility `netstat` on an `glsnxx.ews.uiuc.edu` machine. Try running the command using five different options. (Not all options at the same time!) Among other things, you can use the command: to find out the status of the interfaces the machine has to the network, to see the routing table in the machine, to see what ports are in use, and to see how many packets are sent and how many packets are received by the machine within time intervals of specified length.

a. Find and report the local and remote socket addresses (where a socket address is a host address plus a port number) for three TCP sockets in use (any status) on an glsn workstation.

b. Find the (six byte) Ethernet address of `glsn24` and `glsn25`. (Hint: You needn't log onto these stations. You might have to ping them though, in order to make sure the glsn machine you are on has recently seen an Ethernet packet from each of the two machines.)

c. Report the number of packets sent and the number of packets received by an glsn machine in each of three 10 second intervals (report the machine name and time of day for this data collection). Use the main interface, bge0.

4B/5B encoding table

0000	11110
0001	01001
0010	10100
0011	10101
0100	01010
0101	01011
0110	01110
0111	01111
1000	10010
1001	10011
1010	10110
1011	10111
1100	11010
1101	11011
1110	11100
1111	11101