Digital Communications in the Modern World
2004/5

Exercise 5

Hand in by Thursday 20/1-2005 at 23:59

Note: Specify all your calculations, not only the final result.

1. (*15 points*)
    a. Which fields in IP header should be identical for IP fragments built from the same IP packet?
    b. Assume that a packet was IP fragmented to 3 chunks. Describe an efficient way to calculate the amount of the data sent by the transport level protocol in this packet.
    c. When a minimum-sized IP datagram travels across an Ethernet, how large is the frame?
    d. A computer receives its IP from a DHCP server. Is this computer suitable to be a server? If yes, how can clients connect to it?

2. (*15 points*)
    a. Recall that when there are *N* active nodes the efficiency of slotted ALOHA is $Np(1-p)^{N-1}$. Find the value of *p* that maximizes this expression.
    b. Using the value of *p* found in (a), derive the efficiency of slotted ALOHA by letting N approach infinity.
    c. Show that the maximum efficiency of pure ALOHA is $\frac{1}{2e}$.

3. (*20 points*) Suppose a transport-layer packet is split into 10 link-layer frames, each of which has an 80 percent chance of arriving undamaged. If no error control is done by the data link protocol, how many times must the packet be sent on average to get the entire thing through? (Hint: use the well-known formula for the sum of an infinite geometric series $\sum_{i=1}^{\infty} \alpha^i = \frac{1}{1-\alpha}$).

4. (*15 points*) A bit stream 10011101 is transmitted using the standard CRC method described in class. The generator polynomial is x^3+1.
    a. What is the remainder obtained by dividing some polynomial x^5+x^3+1 by our generator polynomial x^3+1?
    b. Show the actual bit string transmitted.
    c. Suppose the third bit from the left is inverted during transmission. Show that this error is detected at the receiver's end.
    d. Data link protocols always put the CRC in the trailer rather than in the header of the frame. Why?

5. (*15 points*)
    a. Describe the state diagram for the following Convolution Code. The initial state is 00 (The comma separator is for convenience, it is not part of the string):

$$x_j = (m_{j-2} \otimes m_{j-1} \otimes m_j, m_{j-1} \otimes m_j)$$

    b. What is the code for the input: 0010?
    c. What is the original code (with high probability) of the received string: 11 10 10 11 00 ?

6. (*20 points*) With Manchester encoding, each bit period is divided into two equal intervals. A binary "1" bit is sent by having the voltage set high during the first interval and low in the second. A binary "0" bit is just the reverse: first low and then high.
    a. What is the advantage of Manchester encoding over binary encoding?
    b. What is the advantage of binary encoding over Manchester encoding?
    c. Does using Manchester encoding affect the bandwidth?
    d. Sketch the Manchester encoding of 0001110101.
    e. How can you change the Manchester encoding scheme so that the disadvantage in (b) is eased? (*8 points out of the 20*)