Homework for Chapter 3

1. You receive the following data fragment: `0110 0111 1100 1111 0111 1101`. You know that the protocol uses bit stuffing. Show the data after destuffing.

2. An 8 bit byte with binary value 10101111 is to be encoded using an even-parity Hamming code. What is the binary value after encoding?

3. A 12 bit odd-parity Hamming code whose hexadecimal value is 0xB4D arrives at a receiver. What was the original value in hexadecimal? Assume that not more than 1 bit is in error.

4. Hamming codes have a distance of three and can be used to correct a single error or detect a double error. Can they be used to do both at the same time? Explain why or why not.

   In general, if the Hamming distance is *n*, how many errors can be corrected? How many errors can be detected?

5. Give a formula for the lower limit on the number of redundant bits *r*, that need to be added to a message *m*, to correct all single and double errors.

6. Suppose that a message 1001 1100 1010 0011 is transmitted using the Internet Checksum (4 bit word). What is the value of the checksum?

7. A bit stream 10011101 is transmitted using the standard CRC method described in the text. The generator polynomial is $x^3 + 1$. Show the actual bit string transmitted. Suppose that the third bit from the left is inverted during transmission. Show that this error is detected at the receiver's end. Give an example of bit errors in the bit string transmitted that will not be detected by the receiver.

8. Data link protocols always put the CRC in a trailer rather than in a header. Why?

9. A stop-and-wait protocol achieves 25% bandwidth efficiency using 900 bit frames over a channel with a one-way propagation delay of 50 msec. What is the bandwidth of this channel in bits per second?

10. A 3000-km-long T1 trunk is used to transmit 64 byte frames using protocol 5. If the propagation speed is 6 μsec/km, how many bits should the sequence numbers be?

11. Imagine a sliding window protocol using so many bits for sequence numbers that wraparound never occurs. What relations must hold among the four window edges and the window size, which is constant and the same for both the sender and the receiver?

12. In protocol 6, when a data frame arrives, a check is made to see if the sequence number differs from the one expected and *no_nak* is true. If both conditions hold, a NAK is sent. Otherwise, the auxiliary timer is started. Suppose that the else clause were omitted. Would this change affect the protocol's correctness?

13. Frames of 1000 bits are sent over a 1 Mbps channel using a geostationary satellite whose propagation time from the earth is 270 msec. Acknowledgements are always piggybacked onto data frames. The headers are very short. Three-bit sequence numbers are used. What is the maximum achievable channel utilization for

    1. Stop-and-wait?
    2. Protocol 5?
    3. Protocol 6?

14. Give at least one reason why PPP uses byte stuffing instead of bit stuffing to prevent accidental flag bytes within the payload from causing confusion.

15. What is the minimum overhead to send an IP packet using PPP? Count only the overhead introduced by PPP itself, not the IP header overhead. What is the maximum overhead?