Assignment 2: Data Link Layer

1) Suppose that a synchronous serial data transmission is clocked by two clocks (one at the sender and one at the receiver) that each have a drift of 1 minute in one year. How long a sequence of bits can be sent before possible clock drift could cause a problem? Assume that a bit waveform will be good if it is sampled within 40% of its center and that the sender and receiver are resynchronized at the beginning of each frame. Note that the transmission rate is not a factor, as both the bit period and the absolute timing error decrease proportionately at higher transmission rates.

2) Two communicating devices are using a single-bit even parity check for error detection. The transmitter sends the byte 10101010 and, because of channel noise, the receiver gets the byte 10011010. Will the receiver detect the error? Why or why not?

3) One way of detecting errors is to transmit data as a block of n rows of k bits per row and add parity bits to each row and each column. The bit in the lower-right corner is a parity bit that checks its row and its column. Will this scheme detect all single errors? Double errors? Triple errors? Show that this scheme cannot detect some four-bit errors.

4) Answer the following questions:
   (a) In a CRC error-detecting scheme, choose $\mathbf{P(x) = x^4 + x + 1}$. Encode the bits 10010011011.
   (b) Suppose the channel introduces an error pattern 100010000000000 (i.e., a flip from 1 to 0 or from 0 to 1 in position 1 and 5).What is received? Can the error be detected?
   (c) Repeat part (b) with error pattern 100110000000000.

5) Consider the use of 1000-bit frames on a 1-Mbps satellite channel with a 270-ms delay. What is the maximum link utilization for:
   (a) Stop-and-wait flow control?
   (b) Continuous flow control with a window size of 7?
   (c) Continuous flow control with a window size of 127?
   (d) Continuous flow control with a window size of 255?

6) Two stations communicate via a 1-Mbps satellite link with a propagation delay of 270 ms. The satellite serves merely to retransmit data received from one station to another, with negligible switching delay. Using HDLC frames of 1024 bits with 3-bit sequence numbers, what is the maximum possible data throughput; that is, what is the throughput of data bits carried in HDLC frames?

7) Sixteen-bit messages are transmitted using a Hamming code. How many check bits are needed to ensure that the receiver can detect and correct single-bit errors? Show the bit pattern transmitted for the message 1101001100110101. Assume that even parity is used in the Hamming code.

8) 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?

9) The distance from earth to a distant planet is approximately 9×10^{10} m. What is the channel utilization if a stop-and-wait protocol is used for frame transmission on a 64 Mbps point-to-point link? Assume that the frame size is 32 KB and the speed of light is 3×10^{8} m/s.

   Suppose a sliding window protocol is used instead. For what send window size, will the link utilization be 100%? You may ignore the protocol processing times at the sender and the receiver.

10) The following character encoding is used in a data link protocol:

A: 01000111 B: 11100011

FLAG: 01111110 ESC: 11100000

Show the bit sequence transmitted (in binary) for the four-character frame A B ESC FLAG when each of the following framing methods is used:

(a) Byte count.

(b) Flag bytes with byte stuffing.

(c) Starting and ending flag bytes with bit stuffing.