**Assignment 2: Data Link Layer**

1. Suppose the information content of a packet is the bit pattern 1110 0110 1001 1101 and an even parity scheme is being used. What would the value of the field containing the parity bits be for the case of a two-dimensional parity scheme? Your answer should be such that a minimum-length checksum field is used.
2. 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.
3. A block of bits with n rows and k columns uses horizontal and vertical parity bits for error detection. Suppose that exactly 4 bits are inverted due to transmission errors. Derive an expression for the probability that the error will be undetected.
4. A 1024-bit message is sent that contains 992 data bits and 32 CRC bits. CRC is computed using the IEEE 802 standardized 32-degree CRC polynomial. For each of the following, explain whether the errors during message transmission will be detected by the receiver:

(a) There was a single-bit error.

(b) There were two isolated bit errors.

(c) There were 18 isolated bit errors.

(d) There were 47 isolated bit errors.

(e) There was a 24-bit long burst error.

(f) There was a 35-bit long burst error.

1. 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:
2. Stop-and-wait flow control?
3. Continuous flow control with a window size of 7?
4. Continuous flow control with a window size of 127?
5. 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. To provide more reliability than a single parity bit can give, an error-detecting coding scheme uses one parity bit for checking all the odd-numbered bits and a second parity bit for all the even-numbered bits. What is the Hamming distance of this 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 × 1010 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 × 108 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.

1. Consider a protocol, *Selective repeat,* which accepts frames out of order but passes packets to the network layer in order. Associated with each outstanding frame is a timer. When the timer expires, only that frame is retransmitted, not all the outstanding frames.

Compute the fraction of the bandwidth that is wasted on overhead (headers and retransmissions) for this protocol on a heavily loaded 50-kbps satellite channel with data frames consisting of 40 header and 3960 data bits. Assume that the signal propagation time from the earth to the satellite is 270 msec. ACK frames never occur. NAK frames are 40 bits. The error rate for data frames is 1%, and the error rate for NAK frames is negligible. The sequence numbers are 8 bits.