<u>Chapter 3: Data Link Layer Numericals</u>

Q 1.

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 are used:

a. Character count.

b. Flag bytes with byte stuffing.

c. Starting and ending flag bytes, with bit stuffing.

A.1.

a. 00000100 01000111 11100011 11100000 01111110

b. 01111110 01000111 11100011 11100000 11100000 11100000 01111110 01111110

c. 01111110 01000111 110100011 111000000 011111010 01111110

Q 2.

The following data fragment occurs in the middle of a data stream for which the byte-stuffing algorithm described in the text is used:

A B ESC C ESC FLAG FLAG D. What is the output after stuffing?

A.2.

After stuffing the output is

A B ESC ESC C ESC ESC ESC FLAG ESC FLAG D

Q.3.

What is the maximum overhead in byte-stuffing algorithm?

A.3.

The maximum overhead in byte stuffing algorithm is 100%(i.e. when the payload contains only ESC and Flag bytres).

Q 4.

A bit string, 0111101111101111110, needs to be transmitted at the data link layer. What is the string actually transmitted after bit stuffing?

A.4.

The actual transmitted bit string after bit stuffing is

011110111110011111010

Q.5.

Let us assume that m = 3 and *n* = 4. Find the list of valid datawords and codewords assuming the check bit is used to indicate even parity in the code word.

A.5.

Valid datawords : 000, 001,010, 011,100,101,110,111

Valid codewords : 0000, 0011, 0101, 0110, 1001, 1010, 1100, 1111

Q.6.

What is the Hamming distance for each of the following codewords:

a. (10000, 00000)

b. (10101, 10000)

c. (11111,11111)

d. (000, 000)

A.6.

a. **1**

b. **2**

c. **0**

d. **0**

Q.7.

Given the codeword of size 4 bit. If the size of dataword is 3 bit. What is the value of hamming distance for the codeword?

A. 7.

Hamming distance = 2

Q 8.

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?

A.8.

Making one change to any valid character cannot generate another valid character due to the nature of parity bits. Making two changes to even bits or two changes to odd bits will give another valid character, so the distance is 2.

Q. 9.

Find the minimum Hamming distance to be implemented in codeword for the following cases:

a. Detection of two errors.

b. Correction of two errors.

c. Detection of 3 errors or correction of 2 errors.

d. Detection of 6 errors or correction of 2 errors.

A.9.

a. For error detection → Hamming distance = d + 1 = 2 + 1 = **3**

b. For error correction → Hamming distance = 2d + 1 = 2 × 2 + 1 = **5**

c. For error detection → Hamming distance = d + 1 = 3 + 1 = **4**

For error correction → Hamming distance = 2d + 1 = 2 × 2 + 1 = **5**

Therefore minimum Hamming distance should be **5**.

d. For error detection → Hamming distance = d + 1 = 6 + 1 = **7**

For error correction → Hamming distance = 2d + 1 = 2 × 2 + 1 = **5**

Therefore minimum Hamming distance should be **7**.

Q.10.

Given in the table a set of valid dataword and codeword.

Dataword	**Codeword**
00	00000
01	01011
10	10101
11	11110

What is the dataword transmitted for the following codewords received assuming there is 1 bit error?

a. 01010

b. 11010

A.10.

a. 01

b. 11

Q 11.

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.

A.11.

5 check bits are needed at positions 1, 2, 4, 8, and 16.

The bit pattern transmitted for the message 1101001100110101 is 011010110011001110101

Q.12.

An 8 bit message using even-parity Hamming code is received as **101001001111**. Find the 8 bit message after getting decoded assuming no error during transmission?

A.12.

The 8 bit message after decoding is 10101111.

Q.13.

A 12-bit Hamming code whose hexadecimal value is 0xE4F arrives at a receiver. What was the original value in hexadecimal? Assume that not more than 1 bit is in error.

A.13.

If we number the bits from left to right starting at bit 1, in this example bit 2 (a parity bit) is incorrect. The 12-bit value transmitted (after Hamming encoding) was 0xA4F. The original 8-bit data value was 0xAF.

Q.14.

Suppose that data are transmitted in blocks of sizes 1000 bits. What is the maximum error rate under which error detection and retransmission mechanism (1 parity bit per block) is better than using Hamming code? Assume that bit errors are independent of one another and no bit error occurs during retransmission.

A.14.

From Eq. $\mathbf{(m+r+1)\leq 2^r}$, we know that 10 check bits are needed for each block in case of using Hamming code. Total bits transmitted per block are 1010 bits. In case of error detection mechanism, one parity bit is transmitted per block (i.e.1001). Suppose error rate is x per bit. Thus, a block may encounter a bit error $1000x$ times. Every time an error is encountered, 1001 bits have to be retransmitted. So, total bits transmitted per block are $1001+1000x \times 1001$ bits. For error detection and retransmission to be better, $1001 + 1000x \times 1001 < 1010$. So, the error rate must be less than 9×10^{-6}.

Q.15.

What is the remainder obtained by dividing x^7+x^5+1 by the generator polynomial x^3+1?

A.15.

The remainder is x^2+x+1.

Q.16.

Given the dataword 101001111 and the divisor 10111. Show the generation of the CRC codeword at the sender site (using binary division).

A.16.

The codeword at the sender site is 1010011110001

Q.17.

A bit stream 10101010 is transmitted using the standard CRC method. The generator polynomial is x^3+x^2+1. Show the actual bit string transmitted. Suppose the second bit from the left is inverted during transmission. Show that this error is detected at the receiver's end.

A.17.

The frame is 10101010. The generator is 1101. We must append 3 zeros to the message (i.e. 10101010000).The remainder after dividing 10101010000 by 1101 is 110. So actual bit string transmitted is 10101010110.Since the second bit from left is inverted during transmission, the bits received are 11101010110. Dividing this by 1101 doesn't give remainder 0. So the received bits contain error.

Q.18.

A bit stream 10011101 is transmitted using the standard CRC method. 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.

A.18.

The frame is 10011101. The generator is 1001. The message after appending three zeros is 10011101000. The remainder on dividing

10011101000 by 1001 is 100. So, the actual bit string transmitted is 10011101100. The received bit stream with an error in the third bit from the left is 10111101100. Dividing this by 1001 produces a remainder 100, not 0. So the received bits contain error and needs retransmission.

Q.19.

A channel has a bit rate of 4 kbps and a propagation delay of 20 msec. For what range of frame sizes does stop-and-wait give an efficiency of at least 50%?

A.19.

Efficiency will be 50% when the time required to transmit the frame equals the round-trip propagation delay. At a transmission rate of 4 bits/msec, 160 bits takes 40 msec. For frame sizes above 160 bits, stop-and-wait is reasonably efficient.

Q.20.

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?

A.20.

To operate efficiently, the sequence space (actually, the send window size) must be large enough to allow the transmitter to keep transmitting until the first acknowledgement has been received. The propagation time is 18 ms. At T1 speed, which is 1.536 Mbps (excluding the 1 header bit), a 64-byte frame takes 0.300 msec. Therefore, the first frame fully arrives 18.3 msec after its transmission was started. The acknowledgement takes another 18 msec to get back, plus a small (negligible) time for the acknowledgement to arrive fully. In all, this time is 36.3 msec. The transmitter must have enough window space to keep going for 36.3 msec. A frame takes 0.3 ms, so it takes 121 frames to fill the pipe. Seven-bit sequence numbers are needed.