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Q.1. Find the Hamming distance between two pairs of words.

(i) The Hamming distance d(0001, 0011)?

(ii) The Hamming distance d(10111, 11110)?

Solution: (i) $0001 \oplus 0011 = 0010$

As there is only one 1 in 0010,

∴ Hamming distance d(0001, 0011) = 1

(ii) $10111 \oplus 11110 = 01001$

As there are two ones in 01001,

∴ Hamming distance, d(10111, 11110) = 2

Q.2. A code scheme has a Hamming distance dmin = 7. What is the error detection and correction of this scheme?

Solution: dmin = 7.

So, $s = d_{min} - 1 = 7 - 1 = 6$.

∴ The code scheme can detect upto six errors.

And, $t = \frac{d_{min}-1}{2} = \frac{7-1}{2} = 3$

∴ The code scheme can ~~detect~~ correct upto three errors.

Q.3. We need a dataword of at least 11 bits. Find the values of k and n in the Hamming Code C(n,k) with dmin = 3.

Solution: We need to make $K = 2^{n-m} - n \geq 11$

Using trial and error method,

1. Let, m = 3, so, $n = 2^3 - 1 = 7$; $K = 7 - 3 = 4$ (Rejected)
2. Let, m = 4, so, $n = 2^4 - 1 = 15$; $K = 15 - 4 = 11$ (Accepted)

K = 11 satisfies the condition.

∴ K = 11, n = 15

∴ Hamming Code C(15, 11) with dmin = 3 guarantees a dataword of at least 11 bits.

Q.4. Which of the following CRC generators guarantee the detection of 2 single bit error?

a. $x^3 + x + 1$

b. $x^4 + x^2$

c. 1

d. $x^2 + 1$

Solution: Single Bit Property: To detect single bit error,

(i) a CRC generator must have more than one term

(ii) The coefficient of x^0 must be non-zero.

Given these two restrictions, (b) and (c) are rejected.

Therefore, (a) $x^3 + x + 1$ and (d) $x^2 + 1$ guarantee the detection of a single bit error.

Q.5. What kind of error is undetectable by the checksum?

Solution: The checksum cannot detect error under following three conditions:

(i) When bits are swapped. If two bits are swapped during transmission, i.e, 1001 becomes 1100, in such cases, the checksum value remains the same and passes undetectable.

(ii) When data value is increased. If the value of one data item is increased and the value of another data item is decreased by the same amount.

(iii) If data is changed. If one or more data is changed such that the change is a multiple of $2^{16}-1$, the checksum cannot detect the changes.