COMPUTER NETWORKS

TUTORIAL - 3

U19CS012
[BHAGYA RANA]

1. What will be the "Hamming Distance" for all the different combination and minimum "Hamming Distance" for given codewords.

1.

	DATA WORDS	CODEWORDS
(a)	00	00000
(b)	01	01011
(c)	10	10111
(d)	11	11111

(i) Combination 1 : (a) - (b)
d(00000, 01011)
= 3

(ii) Combination 2 : (a) - (c)
d(00000, 10111)
= 4

[Hamming distance b/w 2 words = No. of differences between corresponding bits]

(iii) Combination (3) : (a) - (d)
d(00000, 11111)
= 5

(iv) Combination 4 : (b) (c)
d(01011, 10111)
= 3

(V) Combination 5 : (b) (d)
d(01011, 11111) = 2

(VI) Combination 6 : (c) (d)
d(10111, 11111) = 1

∴ "minimum "Hamming Distance" = d_{min} = $\boxed{1}$ = min { 3, 4, 5, 3, 2, 1 }

[The minimum Hamming distance is the smallest hamming distance between all possible pairs in a set of words]

Ans: Hamming distances of all Combination = $\boxed{\{3, 4, 5, 3, 2, 1\}}$

$\boxed{d_{min} = 1}$

2. Find ~~the~~ minimum "Hamming distance" for →

a) Detection of two errors = d_{min} = 2+1 = $\boxed{3}$ (Ans)

To guarantee the detection of up to "s" errors in all cases, the minimum hamming distance in block code must be $d_{min} = s + 1$.

U19CS012 [BHAGYA RANA]

(b) Correction of two errors = $d_{min} = 2(2)+1 = 5$

To guarantee correction up to t errors in all cases, the minimum hamming distance must be $d_{min} = 2t+1$

∴ for 2 errors correction

$$d_{min} = 2 \times (2) + 1 = \boxed{5}$$

Ans: d_{min} (correction of 2 errors) = 5

d_{min} (detection of 2 errors) = 3

(3) Check whether the given codewords are linear code or not. Give justification of your answer.

In a Linear Block Code, the exclusive OR (XOR) of any two valid codewords creates another VALID codeword.

	Data Word	Code Word
(a)	00	00000
(b)	01	01011
(c)	10	10111
(d)	11	11111

	Codeword 1	Code Word 2	XOR	Valid or Not
(1)	00000 (a)	01011 (b)	01011	✓
(2)	00000 (a)	10111 (c)	10111	✓
(3)	00000 (a)	11111 (d)	11111	✓
(4)	01011 (b)	10111 (c)	11100	X NOT VALID
(5)	01011 (b)	11111 (d)	10100	X NOT VALID
(6)	10111 (c)	11111 (d)	01000	X NOT VALID

Therefore, The Given code words are Not Linear.

{∵ XOR of ((b) & (c)) → does not generate valid code word
" ((b) & (d)) " "
" ((c) & d)) " " }

Ans: Not a Linear Code. { only one case of violation was enough as well }

U19CS012 [BHAGYA RANA]

(4) In CRC, (Cyclic Redundancy Check), given the dataword 10100 11110 and the divisor 10111.

a) Show the generation of codeword at sender side

Divisor = 10111 ($x^4 + x^2 + x + 1$)

```
                          Dataword
              1 1 1 1 1 1
Divisor 10111 ) 10100 11110  0000   <- augmented dataword
              ^ 10111
                00011 111
                ^ 10 111
                  01 0001
                  ^ 10111
                    00110 00
                    ^ 10111
                      01000 0
                      ^ 1011 1
                        0100 1 0
                        ^ 101 1 1
                          001 0 1 0      ( SENDER SIDE )
```

Ans:

Codeword : 10100 11110 1010 (14 bits)
(from sender side) Dataword Remainder

(b) Show checking of codeword at the receiver site.

Assumming No error in Transmission,

The received Codeword = 10100 11110 1010

Divisor = 10111

continued

```
              1001110111
10111 ) 10100 11110 1010
      ^ 10111
        0001111
          ^ 10111
            010001
            ^ 10111
              0011001
              ^ 10111
                011100
                ^ 10111
                  010111
                  ^ 10111
                    00[0000]
```

∴ Remainder = 0000

∴ Codeword is accepted at Receiver's End.

⑤ In hamming code C(7,4)

(a) If dataword at sender location is 0101, what will be the codeword?

(a) For C(7,4) Dataword → Codeword

$A_3 A_2 A_1 A_0 \longrightarrow A_3 A_2 A_1 A_0 R_2 R_1 R_0$

0 1 0 1

Where

$R_0 = (A_2 + A_1 + A_0)$ modulo 2 $= (1+0+1) \% 2 = 0$

$R_1 = (A_3 + A_2 + A_1)$ modulo 2 $= (0+1+0) \times 2 = 1$

$R_2 = (A_0 + A_1 + A_3)$ modulo 2 $= (0+1+0) \times 2 = 1$

Ans: ∴ Codeword for dataword 0101 ⇒ $\boxed{0101\ 110}$

(b) If receiver receives 0001110, what will be the syndrome value ($S_2 S_1 S_0$) and which bit is corrupted during transmission? What will be the derived dataword from received codeword?

(b) Codeword Sender ⟶ Received Codeword

010 1110 ⟶ 000 1110

Single Error

Now, for calculating error & syndrome value,

0 0 0 1 1 1 0

b_3 b_2 b_1 b_0 q_2 q_1 q_0

$S_0 = (b_2 + b_1 + b_0 + q_0) \% 2 = (0+0+1+0) \% 2 = 1$

$S_1 = (b_3 + b_2 + b_1 + q_1) \% 2 = (0+0+0+1) \% 2 = 1$

$S_2 = (b_1 + b_0 + b_3 + q_2) \% 2 = (0+1+0+1) \% 2 = 0$

∴ $S_2 S_1 S_0 = 011$ which means S_1 & S_0 are having errors

∵ b_2 is common in both, the error bit is b_2.

Answer:

∴ Syndrome Value ($S_2 S_1 S_0$) = $\boxed{011}$

→ error bit = $\boxed{b_2 \text{ ie. corrupt bit is } b_2}$

→ Derived ~~bit~~ dataword = Flip b_2 and drop q_2, q_1, q_0

= 010 1110 [Flipped b_2] original codeword.

Ans: = $\boxed{0101}$ [Derived Dataword]

SUBMITTED BY:

BHAGYA VINOD RANA

U19CS012

—x—