Error correction / detec

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Hamming Code :-

* It can correct 1 bit error
* can detect up 2 bit error.

Msg m bits → n = m+r (Total data transmit)

r = redundant bit / Parity bit / extra bit / Checkbits

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* According to the hamming code, number of redundant bits

$$m + r + 1 \leq 2^r$$

where r = lower limition.

How many bits to be added

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eg:- data (m) = 1010111 (or msg) length 7

r=1 $\quad 7 + 1 + 1 \leq 2^1$

$9 \leq 2$ [No]

$r=2 \rightarrow 7+2+1 \leq 2^2$, $10 \leq 4$ No

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$r=3 \rightarrow 7+3+1 \leq 2^3$, $11 \leq 8$ No

$r=4 \rightarrow 7+4+1 \leq 2^4$, $12 \leq 16$ Yes ✓ lower.

$r=5 \rightarrow 7+5+1 \leq 2^5$, $13 \leq 32$ Yes

$r=6 \rightarrow 7+6+1 \leq 2^6$ $14 \leq 64$ Yes

$n = m+r$

$7+4 = 11$ bit almost 50% bits add

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where to add bits position

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2^i where $i \geq 0$

$2^0, 2^1, 2^2, 2^3 \ldots$ Position

$1, 2, 4, 8 \ldots$

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11 Bits data

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$1 = 2^0$ ~

$2 = 2^1$ ~

$3 = 2^1 + 2^0$ ~

$4 = 2^2$ ~

$5 = 2^2 + 2^0$ ~

$6 = 2^2 + 2^1$ ~

$7 = 2^2 + 2^1 + 2^0$ ~

$8 = 2^3$ ~

$9 = 2^3 + 2^0$ ~

$10 = 2^3 + 2^1$ ~

$11 = 2^3 + 2^1 + 2^0$ ~

P_1 = 1 से Start
Skip 1
1, 3, 5, 7, 9, 11

Use even - 1 0 0 1 1 no of 1's even

P_2 = 2 3 6 7 10 11
2 से Start
2 Skip
1 1 0 1 1

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P_4 = 4 से Start 4 Skip
4 5 6 7
0 1 0

P	P		P				P			
1	2	3	4	5	6	7	8	9	10	11
2^0	2^1		2^2				2^3			
		1		0	1	0		1	1	1
1	0		1				1			

P_8 = 8 9 10 11
8 से Start 8 Skip
1 1 1

Transmitted

1	0	1	0	1	0	1	1	1	1

(1) If Receiver Received uncorrupted data

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1 0 1 1 0 1 0 1 1 1 1
1 2 3 4 5 6 7 8 9 10 11

P_1
1 3 5 7 9 11
1 1 0 0 1 1 → even ($P_1 = 0$)

P_2 2 3 6 7 10 11
0 1 1 0 1 1 → even
($P_2 = 0$)

P_4 4 5 6 7
1 0 1 0 → even
($P_4 = 0$)

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P_8 8 9 10 11
1 1 1 1
↳ even
($P_8 = 0$)

P_8	P_4	P_2	P_1	
0	0	0	0	no error.

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Q. If Receiver Received Corrupted data [1 bit error]

[0] Change

1 0 1 1 0 1 0 1 1 1 1
1 2 3 4 5 6 7 8 9 10 11

$P_1 \rightarrow$ 1 3 5 7 9 11
1 1 0 0 0 1
↳ odd ($P_1 = 1$) false

$P_2 \rightarrow$ 2 3 6 7 10 11
0 1 1 0 1 1
↳ even ($P_2 = 0$)

$P_4 \rightarrow$
4 5 6 7
1 0 1 0
↳ even ($P_4 = 0$)

$P_8 \rightarrow$ 8 9 10 11
1 0 1 1
↳ odd ($P_8 = 1$) false

P_8	P_4	P_2	P_1	
1	0	0	1	non error
8	4	2	1	

To correct it

Convert it into decimal = 9

9th bit change

. Receiver correct it by itself.

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(3) If Receiver Received corrupted data (2 bit error)

1	0	1	1	0	1	0	1	1	1	1
1	2	3	4	5	6	7	8	9	10	11

P_1

1	3	5	7	9	11
1	1	1	0	0	1

↳ even $[P_1 = 0]$

P_2

2	3	6	7	10	11
0	1	1	0	1	1

↳ even $[P_2 = 0]$

P_4

4	5	6	7
1	1	1	0

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↳ odd $[P_4 = 1]$ false

P_8

8	9	10	11
1	0	1	1

↳ odd $[P_8 = 1]$ false

P_8	P_4	P_2	P_1
1	1	0	0
8	4	2	1

12 bit ✗

Non zero
Error.
Hamming code not
Correct 2 bit but
detect.

Ques:- If a 7 bit hamming code word received by receiver is 1011011 assume even parity State whether the received code word is correct or not? If it is incorrect then locate the bit having error.

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P_1	P_2		P_4			
1	0	1	1	0	1	1
1	2	3	4	5	6	7

P_1 1 3 5 7

1 1 0 1

↳ odd ($P_1 = 1$) false

P_2 2 3 6 7

0 1 1 1

↳ odd ($P_2 = 1$) false

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P_4 4 5 6 7

1 0 1 1

↳ odd ($P_4 = 1$) false

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P_4	P_2	P_1	
1	1	1	= 7 Position error.

(2) Assume that a 12-bit hamming codeword consisting of 8-bit data and 4 check bits is

$d_8 d_7 d_6 d_5 c_8 d_4 d_3 d_2 c_4 d_1 c_2 c_1$

where data bits and check bits are given

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Data bits

d_8	d_7	d_6	d_5	d_4	d_3	d_2	d_1
1	1	0	x	0	1	0	1

Check bits

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c_8	c_4	c_2	c_1
y	0	1	0

(A) x is 1 y is 0

✓ (B) x is 0 y is 0

(C) x is 1 y is 1

(d) x is 0 y is 1

1 2 3 4 5 6 7 8 9 10 11 12

0 1 1 0 0 0 y x 0 1 1

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C_1

1 3 5 7 9 11

0 1 0 0 x 1

even = x = 0

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C_2 2 3 6 7 10 11

1 0 1 0 0 1

↳ even $C_2 = 0$

C_4 4 5 6 7 8 2

0 0 1 0 1

↳ even $C_4 = 0$ even

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C_8 8 9 10 11 12

y x 0 1 1

0 0

↳ even $C_8 = 0$