

# Hamming, CRC and subnetting Tutorial Solutions

14 November 2021 10:26

Q1 6 bits data required No. of Hamming bits

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

where  $m =$  No. of Data bits = 6

need to find  $r$  where is smallest No. of bits

$$6 + r + 1 \leq 2^r$$

if  $r = 4$

$$6 + 4 + 1 \leq 16 \quad \text{True}$$

$$\text{So No. of Hamming bits} = 4 \leq$$

(Q2) 16 bits of data

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

$$16 + r + 1 \leq 2^r$$

$$17 + r \leq 2^r$$

$$r = 5$$

$$22 \leq 32 \quad \text{True}$$

Any smaller  $r$  condition fails

No. of Hamming bits = 5

(Q3)

Data packet = 1011010

7 bits in length

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

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

$$8 + r \leq 2^r$$

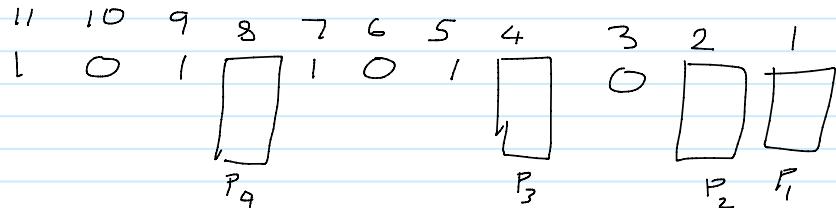
let  $r = 4$

$$12 \leq 2^4 \quad \text{True}$$

(16)

Hamming bits = 4  $p_0, p_1, p_2, p_3$

1 2 4 8



Message bit	Value	8	check bits	4	2	1
11	1	1	0	1	1	
10	0	1	0	1	0	
9	1	1	0	0	1	
7	1	0	1	1	1	
6	0	0	1	1	0	
5	1	00	1	0	1	
3	0	0	0	1	1	

Parity

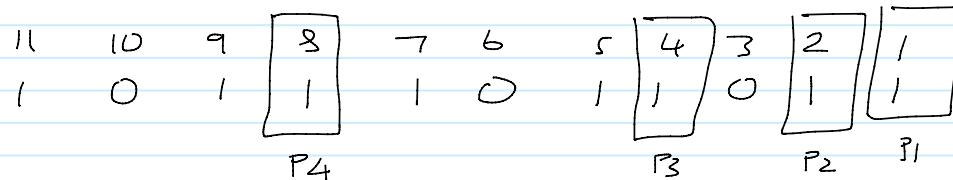
$$(8) + 11 + 10 + 9 \\ (1) + 1 + 0 + 1 = \text{odd } (3)$$

$$(4) + 7 + 6 + 5 \\ (1) + 1 + 0 + 1 = \text{odd } (3)$$

$$(2) + 11 + 10 + 7 + 6 + 3 \\ (1) + 1 + 0 + 1 + 0 + 0 = \text{odd } (3)$$

$$(1) + 11 + 9 + 7 + 5 + 3 \\ (1) + 1 + 1 + 1 + 1 + 0 = \text{odd } (5)$$

Data to be sent

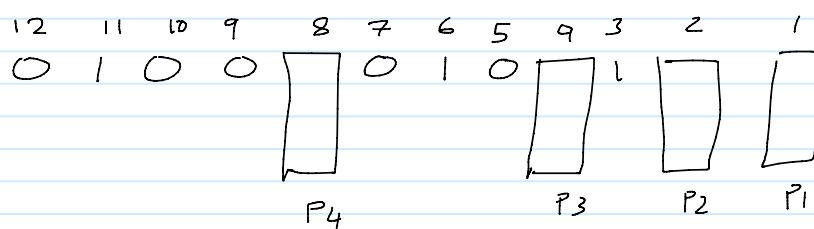


(P4+5) ASCII E =  $69_{10} \Rightarrow 01000101_2 \quad \{ 8 \text{ bits} \}$

$$\text{using } m+r+1 \leq 2^r$$

$$8+r+1 \leq 2^r$$

$$r = 4$$



Parity bits.

P4

(2)	1	2	1	1	10	9
	0		1		0	0
1						Even
0						odd

P 3

(4)	1	2	7	6	5
	0	0	1	0	
1					Even
0					odd

P 2

(2)	11	10	7	6	3
	1	0	0	1	1
1					Even
0					odd

P |

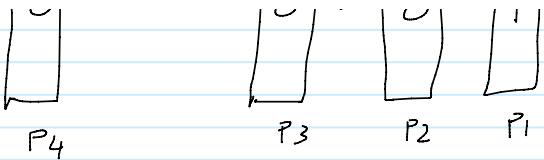
(1)	1	1	9	7	5	3	
	1		0	0	0	1	
0							Even
1							odd

Even

The diagram shows a sequence of binary digits (0s and 1s) above a sequence of vertical rectangles. The rectangles are labeled  $P_4$ ,  $P_3$ ,  $P_2$ , and  $P_1$  from right to left. Below the rectangles are labels  $P_1$ ,  $P_2$ ,  $P_3$ , and  $P_4$ .

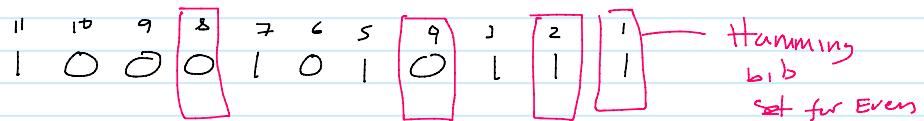
ODD

12 11 10 9 8 7 6 5 9 3 2 1  
○ 1 ○ ○ | 0 ○ 1 0 | 0 1 | 0 | 1 |



(Q6)

data with Hamming lib



bit 8	8 0	11 1	10 1	9 1	odd (3)	$\times$	1
bit 4	4 0	7 1	6 0	5 1	even (2)	$\checkmark$	0
bit 2	2 1	11 1	10 0	7 1	6 0	3 1	even (4) $\checkmark$ 0
bit 1	1 1	11 1	9 0	7 1	5 1	3 1	odd (5) $\times$ 1

$1001_2 \Rightarrow 9$  is in error

Q7

$$x^{16} + x^{15} + x^2 + x^0$$

where  $x = 2$

$$2^{16} + 2^{15} + 2^2 + 2^0$$

$$\begin{array}{r} \text{binary} & 1\ 1\ 0\ 0 : 0\ 0\ 0\ 0 : 0\ 0\ 0\ 0 : 0\ 0\ 0\ 0 : 1\ 0\ 1 \\ & 2^{16} 2^{15} \end{array}$$

$$x^{16} + x^{12} + x^5 + x^0$$

$$\begin{array}{r} 1000010000001000001 \\ 2^{16} \quad | 2^{12} \quad | \quad | 2^5 \quad | \quad | 2^6 \end{array}$$

Q8

$$\begin{array}{r}
 & 1 & 1 & 1 & 0 \\
 1 & 0 & 1 & 0 & 1 \\
 | & | & | & | & | \\
 1 & 0 & 1 & 0 & 0 \\
 \hline
 1 & 0 & 1 & 0 & 0 \\
 | & | & | & | & | \\
 1 & 0 & 1 & 0 & 1 \\
 \hline
 1 & 0 & 0 & 1 & 0 \\
 1 & 0 & 1 & 0 & 1
 \end{array}$$

$$\begin{array}{r}
 10010 \\
 10101 \\
 \hline
 110
 \end{array}
 \quad \text{--- remainder}$$

(Q9)

data 10111 polynomial divisor 10101  
5 bits

pad 5-1  $\Rightarrow$  4 bits

$$\begin{array}{r}
 10000 \\
 10101 \overline{)101110000} \\
 10101 \downarrow \downarrow \downarrow \\
 10000 \\
 10101 \downarrow \\
 1010 \quad \} \text{ remainder}
 \end{array}$$

bit to be transmitted

101111010<sub>2</sub>

(Q10)

$$\begin{array}{r}
 11010 \\
 10101 \overline{)11101000} \\
 10101 \downarrow \downarrow \downarrow \\
 10000 \\
 10101 \downarrow \downarrow \\
 10100 \\
 10101 \downarrow \\
 11 \quad \} \text{ remainder}
 \end{array}$$

We have a remainder data has changed. / Error

(D) 11

IP address

195.164.123.0

Subnets	1	2	4	8	16	32	64	128	256
Hobs	256	128	64	32	16	8	4	2	1
Sub Net mark	124	125	126	127	128	129	130	131	132

we want 12 subnets  $\therefore$  smallest No we can have is 16

Starting IP address

195.164.123.0  
195.164.123.16  
" " " " " 32  
• 48  
• 64  
• 80  
• 96  
• 112  
• 128  
• 144  
• 160  
" " " " " • 176

- 1st subnet

Subnets Not used

Start addresses

$\therefore$  room for expansion.

{  
• 192  
• 208  
• 224  
• 240

Note 1st and last addresses Not used for each Subnet

e.g 1st SubNet used addresses for devices:

195.164.123.1 — 195.164.123.14

2nd 195.164.123.17 — 195.164.123.30 etc... .