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Data Communication
Chapter 6

Eng. Ahmed M. Ayash

Problems :-

6.1 file of 10,000 bytes, R = 2400 bps :-

(a) Calculate overhead in bits and time using asynchronous com., one start bit and one stop bit.

Solution:-

overhead for each char = $\frac{2}{8} * 100\% = 25\%$ ⇒ 10 bit each char.

$\therefore$ overhead$_{bits}$ = 100,000 − 80,000 = **20,000** extra bits

$\therefore$ overhead$_{s}$ = $\frac{20,000 \text{ bits}}{2400 \text{ bps}}$ = **8.33 s**

(b) Find overhead for syn. com., each frame consists of 1000 char and overhead of 48 control bits per frame.

Solution:

# of frames = $\frac{10,000}{1000}$ = 10 frames

# of additional bits = **480** bits (overhead$_{bits}$)

$\therefore$ overhead$_{(s)}$ = $\frac{480 \text{ bit}}{2400 \text{ bps}}$ = **0.2** seconds.

(c) Repeat a, b for 100,000 char.?

(a) overhead$_{bits}$ = 1,000,000 − 800,000 = **200,000** bits

overhead$_{s}$ = $\frac{200,000}{2400}$ = **83.3 s**

(b) overhed$_{bits}$ = 48 * 100 = **4800** bits

overhed$_{s}$ = $\frac{4800}{2400}$ = **2** seconds

(d) Repeat a, b for R = 9600 bps ?

(a) $\text{overhead}_{\text{bits}} = \boxed{20{,}000}$ bits

$\text{overhead}_{s} = \frac{20{,}000}{9600} = \boxed{2.08\ s}$

(b) $\text{overhead}_{\text{bits}} = \boxed{480 \text{ bits}}$

$\text{overhead}_{s} = \frac{480}{9600} = \boxed{0.05\ s}$

6.2 data Source produce 7-bit IRA char. Find expression of the maximum data rate over an x-bps line :-

(a) Asyn with 1.5-unit stop element and a parity bit.

Solution :-

Asyn ⟹ 7 data bits , 1.5 stop bits , 1 start bit , 1 parity bit

$R = gx$

$g = \frac{7}{7+1.5+1+1} = 0.67$

$\therefore \boxed{R = 0.67x}$

(b) Syn , frame consists of 48 control bits and 128 information bits , The information field Contains (8-bit) (parity included).

Solution :-

# of bits each frame = 48 + 128 = 176 bits

# of char = $\frac{128}{8}$ = 16 char

# of data bits = 16 × 7 = 112 bits

$\therefore g = \frac{112}{176} = 0.64$

$\therefore \boxed{R = 0.64x}$

(c) Repeat b for 1024 bits information field?

Solution:

# of bits each frame = 48 + 1024 = 1072 bits

# of char = $\frac{1024}{8}$ = 128 char

# of data bits = 128 + 7 = 896 bits

$\therefore \eta = \frac{896}{1072} = 0.84$

$\therefore \boxed{R = 0.84x}$

Note :- for asyn ⇒ The start bit is always a 0, and the stop bit is always a 1.

6.10 frame consists of 2 char, each has 4-bits, Probability of bit error is 10^{-3}.

(a) what is the probability that the recieved frame contains at least one error?

Solution:

P_r(at least one error) = 1 − P_r(8-bits not in error)

= $1 - (1-10^{-3})^8$ = 0.008

(b) Now add a parity bit to each char. what P_r?

Solution:

$P_r = 1 - (1-10^{-3})^{10}$ = 0.01

6.8 Even parity check used for error detection, Sender sends 10101010, the reciever gets 10011010. will the reciever detect the error? why or why not?

Solution:-

* The receiver won't detect the error, as a parity check bit only detects inversion of an odd number of bits.

6.13 For $P = 110011$ and $M = 11100011$, find the CRC.

Solution:-

* $M \Rightarrow$ data word of length K
* Codewords $\Rightarrow$ data word + redundant bits $\Rightarrow$ Length of codeword is n, where $n = K + r$
* Remainder $= n - K$
* divisor $=$ rem $+1$
* The length of the redundant bits $=$ the length of remainder.

$\therefore$ redundant bits $= 6 - 1 = (5) \Rightarrow$ So, I will use five zeros.

```
          10110110
      ------------
110011 | 11100011000000
         110011
         -------
          010111
           000000
           ------
            10111
            11001
            -----
             11100
             11001
             -----
              10110
              11001
              -----
               11111
               11001
               -----
                 110
```

CRC = 11010

6.15 @ $P(x) = x^4 + x + 1$, Encode this bits 1001001101111 using CRC.

Solution:-

$D(x) = x^{10} + x^7 + x^4 + x^3 + x + 1$

$$
\begin{array}{r|l}
 & x^{10} + x^6 + x^4 + x^2 \quad \leftarrow Q(x) \\
\hline
x^4 + x + 1 & x^{14} + x^{11} + x^8 + x^7 + x^5 + x^4 \quad \leftarrow x^4 D(x) \\
 & x^{14} + x^{11} + x^{10} \\
\hline
 & x^{10} + x^8 + x^7 + x^5 + x^4 \\
 & x^{10} + x^7 + x^6 \\
\hline
 & x^8 + x^6 + x^5 + x^4 \\
 & x^8 + x^5 + x^4 \\
\hline
 & x^6 \\
 & x^6 + x^3 + x^2 \\
\hline
 & x^3 + x^2 \quad \leftarrow R(x)
\end{array}
$$

CRC = 1100

∴ The string 1001001101111100 is sent.

⇒ The Reminder will be zero if you divide the previous result by $x^4 + x + 1$

(b) Suppose the channel introduces an error pattern 1000100000000000 (flip from 1 to 0 or from 0 to one in position 1 and 5). what is recieved? can the error be detected?

The original string is ⇒ $x^8 + x^7 + x^5 + x^4 + x^3 + x^2$ = 1001001101111100 $\xrightarrow[\text{Error}]{\text{after}}$ 0001101101111100 ⇒ $x^{11} + x^{10} +$

* divide the previous code by $x^4 + x + 1$ will produce $x^3 + x^2 + * \neq 0$

∴ The error will be detected

(c) Repeat part (b) with error pattern 1001100000000000.

⇒ 0000101101111100 ⇒ $x^{10} + x^8 + x^7 + x^5 + x^4 + x^3 + x^2 = 0$ divided by $x^4 + x + 1$ ⇒ the remainder is zero ⇒ ∴ The errors are not detected.

[6.17] Calculate the Hamming pairwise distances among the following codewords :-

(a) 00000, 10101, 01010

Solution :-

	00000	10101	01010
00000	0	3	2
10101	3	0	5
01010	2	5	0

* How to find the minimum hamming distance :-

$d(000000, 10101) = (3)$, $d(000000, 01010) = (2)$

$d(10101, 01010) = (5)$

$\therefore d_{min} = \boxed{2}$