1. (a) In a communication network with a shared medium, assume all frames have the same size of 1000 bytes and the transmission rate is 8 Mbps. What is the vulnerable period of frame transmission using slotted Aloha? [1]

Vulnerable period for Aloha $= 2 \times$ frame time (T_{Fr})

$$= 2 \times \frac{8 \times 10^{6} \text{ bps}}{1000 \times 8 \text{ bits}}$$

$= 2 \times 10000$ seconds

$= 20\,000$ seconds

0/1

(b) Use an example to show the hidden terminal problem in wireless ad hoc networks. [1]

Suppose we have the following wireless network configuration :-

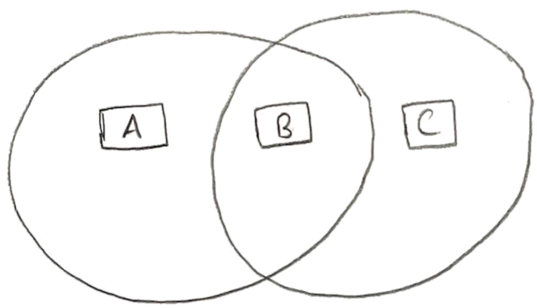


Figure 1.

1

In the configuration depicted above, network A and network B are in the range of each other, as are network C and network B. However, network A and network C are outside each other's range and therefore cannot communicate with each other. The problem arises when both network A and network C simultaneously try to communicate with B. As both A and C can't sense each other, when they both communicate with B the packets collide during transmission and are rendered useless. This is what is known as the hidden terminal problem.

3 5 6 7 9 10 11 12

2. (a) Given the frame flag 01111110, please write down the bit stuffed string (**including flags**) for the following bit string: 01111111111110111110. [2]

Bit stuffing prevents the Flag from appearing in transmitted data.

In this case anytime the data stream has 5 consecutive 1's, a 0 bit is stuffed.

Here is the bit-stuffed string: 011111101111110101111100.

3

(b) A character is represented in its binary format: 10101111. Please write down the character in Hamming coded format with even parity. [4]

We have a 8-bit character. We need 4 check bits ($2^0=0$, $2^1=2$, $2^2=4$, $2^3=8$).

Binary Table:-

Value:-	2^3	2^2	2^1	2^0
1	0	0	0	1
2	0	0	1	0
3	0	0	1	1
4	0	1	0	0
5	0	1	0	1
6	0	1	1	0
7	0	1	1	1
8	1	0	0	0
9	1	0	0	1
10	1	0	1	0
11	1	0	1	1
12	1	1	0	0

Check bit positions:-

check bit positions for 1:- 3, 5, 7, 9, 11

for 2:- 3, 6, 7, 10, 11

for 4 :- 5, 6, 7, 12

for 8 :- 9, 10, 11, 12

1

Bit position	1	2	3	4	5	6	7	8	9	10	11	12
Data Bits			0		1	1	1		1	1	1	0
Check Bits	0	0		1				1				

After Encoding $\boxed{0\ 0\ 0\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 0}$

(c) Given the generator polynomial $x^3 + x + 1$, please write down the **CRC-appended bit string** of the following data sting: 001100110011. [3]

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

$\therefore$ $G(x) = 1011$

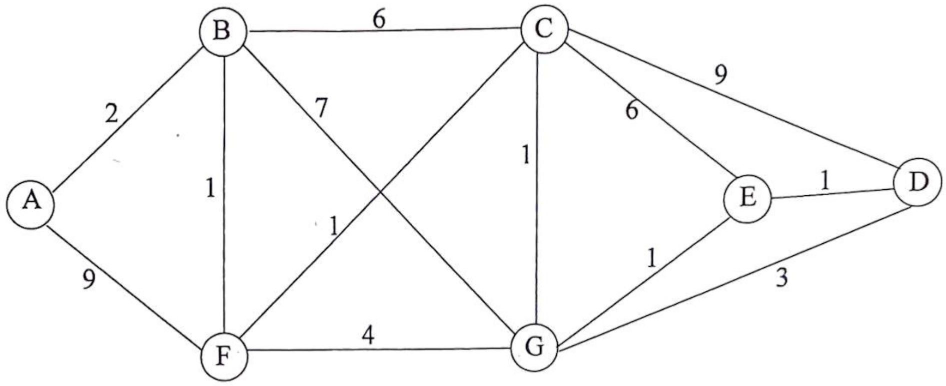
Now compute Polynomial division

```
        001110101101
1011 ) 00110011001100̶0
       0000
       0110
       0000
        1100
        1011
         1111
         1011
          1001
          1011
           0100
           0000
            1000
            1011
             0111
             0000
              1111
              1011
               1000
               1011
                0110
                0000
                 1100
                 1011
                  111
```

3

CRC append bit string = 001100110011 111

3. In the following graph that represents the topology of a network, vertexes represent network routers, and edges represent bidirectional, symmetric communication links and are labeled by the link cost.



With link-state routing, please find the paths with the least cost from router A to all other routers, respectively. **You need to show each step of your work using the following tables.** [6]

Iterations	B	C	D	E	F	G
Initially	(2, A)	(∞, .)	(∞, .)	(∞, .)	(9, A)	(∞, .)
1	(2, A)	(8, B)	(∞, .)	(∞, .)	(3, B)	(9, B)
2	(2, A)	(4, F)	(∞, .)	(∞, .)	(3, B)	(7, F)
3	(2, A)	(4, F)	(13, C)	(10, C)	(3, B)	(5, C)
4	(2, A)	(4, F)	(13, C)	(6, G)	(3, B)	(5, C)
5	(2, A)	(4, F)	(7, E)	(6, G)	(3, B)	(5, C)

6

Give the least cost **path** and cost from A to other routers in the following table.

	Full Path	Cost
From A to B:	A → B	2
From A to C:	A → F → C	4
From A to D:	A → B → F → C → G → E → D	7
From A to E:	A → B → F → C → G → E	6
From A to F:	A → B → F	3
From A to G:	A → B → F → C → G	5

4. An IP packet (with no IP header options) has the length of 4000 bytes. The packet has been forwarded through a link that can only support IP packets up to 2308 bytes. Then, these fragments have been forwarded to the next link that can only support IP packets up to 1500 bytes. Please write down the following IP header fields of all IP fragments of the original 4000 ~~3500~~-byte IP packet after the above two links: "Total length", "Fragment offset" and "More Fragment (MF)". [3]

No. of fragments required = $\frac{4000}{2308-20}$ = 1.75 = 2 fragments

X

	length	Frag offset	M.F
fragment 1 :	2308	0	1
fragment 2 :	1692	286	0

No. of fragments needed for fragment 1 :- $\frac{2308}{1500-20}$ = 1.56 = 2 fragments

— END —