Module - 1 16/07/2023

1) Assume the difference between circuit switching and packet switching. Assume the link's rate is 2 Mbps and users are generating data at a rate of 100 Kbps when busy. Users are busy only %'1 of time.

a) what is the maximum number of users that a circuit switching architecture can support simultaneously?

link rate 2mbps

data rate 100 Kbps

$$\text{Maximum number of users} = \frac{\text{link rate}}{\text{data rate}} = \frac{2,000,000}{100,000} = \underline{\underline{20}}$$

2) With a network with bandwidth of 10 mbps can pass only an average of 12,000 frames per minute with each frame carrying an average of 10,000 bits. what is the throughput of this network?

bandwidth = 10 mbps

frames = 12000 / per minute

each frame carrying an average of 10000 bits

$$\frac{\cancel{1}2000 \times 1000\cancel{0}}{6\cancel{0}} = 2000000$$

$$= \underline{\underline{2\ \text{Mbps}}}$$

Throughput is amount of data moved succesfully from one place to another place.

3) Imagine a signal travels through a transmission medium and its power is reduced to half. This means $P_2 = \left(\frac{1}{2}\right)P_1$. Calculate Attenuation.

$$P_2 = \left(\frac{1}{2}\right)P_1$$

$$\text{Attenuation} = 10 \log_{10} \frac{P_2}{P_1}$$

$$= 10 \log_{10} \frac{0.5\cancel{P_1}}{\cancel{P_1}}$$

$= 10 \log_{10} 0.5$

$= 10(-0.3)$

$= -3 \, dB$

4) Consider a telephone line normally has a bandwidth of 3000 Hz (300 to 3300 Hz) assigned for data communications. The signal-to-noise ratio is usually 3162. Calculate the channel capacity for this channel?

bandwidth = 3000 Hz (300 to 3300 Hz)

signal-to-noise ratio = 3162.

capacity = Bandwidth $\times \log_2 (1+SNR)$

$= 3000 \times \log_2 (1+3162)$

$= 3000 \times \log_2 (3163)$

$= 3000 \times 11.62$

$= 34860$ bps

5) Illustrate for a wavelength in vacuum of 1550 nm, the corresponding frequency is $f = c/\lambda = (3*10^8)/(1550*10^{-9}) = 193.4*10^{12} = 193.4$ THz. for a typical single mode fiber, the velocity of propagation is approximately $v = 2.04*10^8$. Find out wavelength of the fiber optic cable.

wavelength in vaccum = 1550 nm

frequency = 193.4 THz

velocity propagation (v) = $2.04*10^8$

$V = \frac{c}{n} = \frac{3 \times 10^8}{1.5}$ m/s

$= 2 \times 10^8$ m/s

$f = 193.4 \text{ THz}$

$= 194 \times 10^{12} \text{ Hz}$

$\lambda = \frac{v}{f} = \frac{2 \times 10^{8}}{194 \times 10^{12}}$

$= 1.03 \times 10^{-6}$

$= \underline{1030 \text{ nm}}$

Module - II

1) Illustrate a network with one primary and four secondary stations using polling. The size of a data frame is 1000 bytes. The size of the poll, ACK and NAK frames are 32 bytes each. Each station has 5 frames to send. How many bytes are exchanged if there is no limitation on the number of frames a station can send in response to a poll?

Size of a data frame = 1000 bytes
The size of the poll, ACK and NAK frames are 32 bytes each
Each station has 5 frames to send.

polling and Data transfer

station 1 : [poll + 5x (frame + ACK)]
station 2 : [poll + 5x (frame + ACK)]
station 3 : [poll + 5x (frame + ACK)]
Station 4 : [poll + 5x (frame + ACK)]

polling and sending NAKs

station 1 : [poll + NAK]
station 2 : [poll + NAK]
station 3 : [poll + NAK]
station 4 : [poll + NAK]

Total activity

= 8 polls + 20 frames + 20 ACK + 4 NAK
= 8(32) + 20(1000) + 20(32) + 4(32)
= 21024 bytes

2) Find CRC for $P = 110011$ and $M = 11100011$

$P = 110011$ (6 bits)

$M = 11100011$ (8 bits)

· CRC = Cyclic Redundancy check

→ It is an error identifying method.

P = pattern

M = Message

$P = n-1$

n = number of pattern bits

$P = 6-1$

$P = 5$

∴ Appending 5 zero's at the end of the message.

$M = 1110001100000$

3) One hundred stations on a pure ALOHA network share a 1-mbps channel. If frames are 1000 bits long, find the throughput if each station is sending 10 frames/sec?

100 stations

Bandwidth = 1-mbps channel

frames = 1000 bits

Throughput of pure aloha ⇒ $S = G \times e^{-2G}$

G = Number of frames generated

$$\text{Transmission time} = \frac{\text{frame size}}{\text{bandwidth}}$$

$$= \frac{1000}{1 \text{ mbps}} = 1 \text{ ms}$$

$G = 1$

$S = 1 \times e^{-2}$

$S = 0.135$

$S = 135$ Kbps

4) Calculate the hamming distance for each of the following code words

i) $d(10000, 01000)$

ii) $d(10101, 10010)$

iii) $d(1111, 1111)$

iv) $d(0000, 0000)$

i) $d(10000, 01000) = 11000$, so $HD = 2$

ii) $d(10101, 10010) = 00111$, so $HD = 3$

iii) $d(1111, 1111) = 0000$, so $HD = 0$

iv) $d(0000, 0000) = 0000$, so $HD = 0$

5) Exclusive-OR (XOR) is one of the most used operations in the calculation of codewords. Apply the exclusive-OR operation on the following pairs of patterns. Interpret the results

a) (10001), (10001)

b) (11100), (00000)

c) (10011), (11111)

a) (10001), (10001)

codewords are identical so,

00000

b) (11100), (00000)

11100

c) (10011), (11111)

01100

6) Assuming even parity, find the parity bit for each of the following data units.

a) 1001011 = 1001011<u>0</u>

b) 0001100 = 0001100<u>0</u>

c) 1000000 = 1000000<u>1</u>

d) 1110111 = 1110111<u>0</u>

If this scheme makes the total number of 1's even, that is why it is called even parity checking.

<u>In case of even parity -</u>

If number of 1's is even, parity bit value is 0

If number of 1's is odd, parity bit value is 1

<u>In case of odd parity -</u>

If number of 1's is odd, parity bit value is 0

If number of 1's is ~~odd~~ even, parity bit value is 1

7) Given the dataword 101001111 and the divisor 10111, show the generation of the CRC codeword at the sender site (using binary division)

dataword 101001111

divisor 10111 = 5 bits = n

$n-1 = 5-1 = 4$

So, appending 4 zero's at the end of the dataword

10111) 1 0 1 0 0 1 1 1 1 0 0 0 0 (100110111

```
10111) 1010011110000 (100110111
       10111
       -----
        00111
        00000
        -----
         01111
         00000
         -----
          11111
          10111
          -----
           10001
           10111
           -----
            01100
            00000
            -----
             11000
             10111
             -----
              11110
              10111
              -----
               10010
               10111
               -----
               00101
```

⇒ 1010011110101 (code word)

8) A category of error detecting (and correcting) code, called the Hamming code, is a code in which dmin =3. This code can detect up to two errors (or correct one single error). In this code, the values of n, K and r are related as Find the number of bits in the dataword and the codewords if r ≠ is 3

n = codeword bits
r = reductant bits
K = data word

$n = 2^{r} - 1$

$K = n - r$

$r = 3$

$n = 2^{3} - 1$

$n = 7$

$K = n - r$

$K = 7 - 3$

$\underline{\underline{K = 4}}$ ∴ Hence data word bits = 4
codeword bits = 7

9) A slotted ALOHA network transmits 200-bit frames using a shared channel with a 200-Kbps bandwidth. Find the throughput if the system (all stations together) produces

a) 1000 frames per second
b) 500 frames per second
c) 250 frames per second

Slotted ALOHA

$S = G \times e^{-G}$

$G = 1$

a) 1000 frames per second

$S = 1 \times e = 0.368$

Throughput $= 1000 \times 0.0368$

$= 368$ frames

b) 500 frames per second

$S = 1 \times e = 0.368$

Throughput $= 500 \times 0.0368$

$= 184$ frames

c) 250 frames per second

$S = 1 \times e = 0.368$

Throughput $= 250 \times 0.0368$

$= 92$ frames

10) Given a remainder of 000, a data unit of 1001110, a divisor of 1011, using CRC detect check whether there is an error in the data unit?

~~1001110~~

Module-2

10)

1001110

1011 = 4 bits = n

n-1 = 4-1 = 3

```
1011)1001110~~000~~(1010~~000~~
     1011
     ----
      0101
      0000
      ----
      1011
      1011
      ----
       0000
       0000
       ----
        000~~0~~
        ~~0000~~
        ----
         0000
         0000
         ----
          0000
          0000
          ----
             0
```

Uncorrupted codeword $\boxed{1001|110}$

Dataword accepted $\boxed{1001}$

Module-III

1) Define the following MASKS in slash notation (/n).

a) 255.0.0.0

b) 255.255.224.0

c) 255.255.255.0

d) 255.255.240.0

a) 255.0.0.0 (/8)

This mask has the first 8 bits set to 1 and the remaining 24 bits set to 0. It corresponds to a network with a single 8-bit network prefix, allowing for 16,777,216 unique host addresses.

b) This mask has the first 19 bits set to 1 and the remaining 13 bits set to 0. It corresponds to a network with a 19-bit network prefix, allowing for 8,192 unique host addresses.

255.255.224.0 (/19)

c) 255.255.255.0 (/24)

This mask has the first 24 bits set to 1 and the remaining 8 bits set to 0. It corresponds to a network with a 24-bit network prefix, allowing for 256 unique host addresses.

d) 255.255.240.0 (/20)

This mask has the first 20 bits set to 1 and the remaining 12 bits set to ~~20~~ 0. It corresponds to a network with a 20-bit network prefix, allowing for 4,096 unique host addresses.

2) Find the class of the following IP addresses

a) 237.14.2.1

b) 208..35.54.12

c) 129.14.6.8

d) 114.34.2.8

class C addresses have a range of 192.0.0.0 to 223.255.255.255

a) 237.14.2.1 – class D (multicast address range is 224.0.0.0 to 239.255.255.255)

b) 208..35.54.12 – This IP address is not valid because there is a double period (..) present. IP addresses should have four octets separated by periods. Please provide a valid IP address.

c) 129.14.6.8 – class B (private address range is 128.0.0.0 to 191.255.255.255)

d) 114.34.2.8 – class A (public address range is 1.0.0.0 to 126.255.255.255)

3) Design the autonomous system with the following specifications:

a) There are 8 networks (N1 to N8)

b) There are 8 routers (R1 to R8)

c) N1, N2, N3, N4, N5 and N6 are Ethernet LANs

d) N7 and N8 are point to point WANs

e) R1 connects N1 and N2

f) R2 connects N1 and N7

g) R3 connects N2 and N8

Networks :

N1 : Ethernet LAN

N2 : Ethernet LAN

N3 : Ethernet LAN

N4 : Ethernet LAN

N5 : Ethernet LAN

N6 : Ethernet LAN

N7 : Point-to-Point WAN

N8 : Point-to-Point WAN

Routers :

R1 : Connects N1 and N2

R2 : Connects N1 and N7

R3 : Connects N2 and N8

R4 : Unassigned

R5 : Unassigned

R6 : Unassigned

R7 : Unassigned

R8 : Unassigned

4) A router with IPV4 address 123.45.21.12 and Ethernet physical address 23:45:BA:00:67:CD has received a packet for a host destination with IP address 124.10.78.10. Show the entries in the ARP request packet sent by the router. Assume no sub-netting?

In an ARP (Address Resolution Protocol) request packet, the router is trying to find the Ethernet physical address (MAC address) corresponding to a given IPV4 address. The IPV4 address for the destination host is 124.10.78.10

The ARP request packet sent by the router will have the following entries:

1) Sender's IP Address: 123.45.21.12
2) Sender's MAC Address: 23:45:BA:00:67:CD
3) Target IP Address: 124.10.78.10
4) Target MAC Address: This field will be set to all zeros (00:00:00:00:00:00) in the ARP request packet because the router is trying to find the MAC address of the destination host and does not yet know it.

The router sends this ARP request as a broadcast packet, meaning it will be sent to all devices on the local network, and the device with the IP address 124.10.78.10 (the target IP address) will respond with its MAC address so that the router can update its ARP table and send future packets directly to the destination host without the need for ARP requests.

5) Define subnet. Consider a company is granted the site address 201.70.64./16. The company needs six subnets of equal size, accordingly design the subnets.

Subnetting is the process of dividing a single IP network into smaller & more manageable subnetworks. Each subnet has its own unique network address and contains a range of IP addresses.

To create six equal-sized subnets, we need to borrow three bits from the host portion to accommodate the required number of subnets. This results in a subnet mask of /19. (16 network bits + 3 borrowed bits). Each subnet will ~~be~~ have approximately 8190 usable IP addresses.

Design of the six subnets:-

1) Subnet: 201.70.64.0/19
   Usable IP Range: 201.70.64.1 to 201.70.95.254
2) Subnet: 201.70.96.0/19
   Usable IP Range: 201.70.96.1 to 201.70.127.254
3) Subnet: 201.70.128.0/19
   Usable IP Range: 201.70.128.1 to 201.70.159.254
4) Subnet: 201.70.160.0/19
   Usable IP Range: 201.70.160.1 to 201.70.191.254
5) Subnet: 201.70.192.0/19
   Usable IP Range: 201.70.192.1 to 201.70.223.254
6) Subnet: 201.70.224.0/19
   Usable IP Range: 201.70.224.1 to 201.70.255.254

Each subnet has the same number of IP addresses, and they are distinct, allowing the company to manage its network efficiently.

1 to 126 — class A
128 to 191 — class B
192 to 223 — class C
224 to 239 — class D
240 to 254 — class E

6) Change the following IPV4 addresses from binary notation to dotted-decimal notation.

i) 10000001 00001011 00001011 11101111

ii) 11000001 10000011 00011011 11111111

i) 129.11.11.239

ii) 193.131.27.255

i) $2^8 \times$ - $2^7+2^0 = 128+1=129$

$2^3+2^1+2^0 = 8+2+1=11$

$2^7+2^6+2^5+2^3+2^2+2^1+2^0 = 128+64+32+8+4+2+1$

$= 239$

$\therefore$ 129.11.11.239

ii) $2^7+2^6+2^0 = 128+64+1 = 193$

$2^7+2^1+2^0 = 128+2+1 = 131$

$2^4+2^3+2^1+2^0 = 16+8+2+1 = 27$

$2^7+2^6+2^5+2^4+2^3+2^2+2^1+2^0 = 255$

$\therefore$ 193.131.27.255

Module-4

1) Assume an end system sends 50 packets for second using UDP over a full duplex mode 100 mbps Ethernet LAN connection. Each packet consists of 1500 Bytes of the Ethernet frame payload data. what is the throughput when measured at UDP protocol?

~~Frame size = 1500B~~

~~Packet has the following headers:-~~

~~IP header (20 B)~~

~~UDP header (8 B)~~

~~Total header in each packet = 28 B~~

~~Total UDP payload data is therefore 1500-28 = 1472 B~~

~~Total bits sent per second = 1472 X 8 X 50~~

Need to find ~~= 588800 bps or 588 Kbps~~

Ans 1) The number of packets sent per second (packet rate)

2) The size of each packet (payload data size)

3) The bandwidth of the Ethernet connection

Total data transmitted per second = 50 * 1500

= 75000 Bytes/second

Total data transmitted per second in bits = 75000 X 8

$\boxed{1 \text{ Byte} = 8 \text{ bits}}$

= 600000

Throughput = 600000 bits / second

Throughput in mbps = 0.6 mbps

∴ The throughput when measured at the UDP protocol is 0.6 mbps.

2) Assume each packet has typical TCP and IP headers each 20 bytes long. If we have three computers A, B and C. The link between A and B has an MTU of 3000 bytes, while the link between B and C has an MTU of 1000 bytes. Consider the case where a packet needs to be sent from A to C that has a size of 3000 bytes (including headers). How many fragments will we have from B to C, and how much data will be in each fragment (i.e excluding headers). (all connections are assumed to be Ethernet).

MTU – Maximum Transmission Unit

1) Link between A and B:
MTU: 3000 bytes

2) Link between B and C:
MTU: 1000 bytes

3) Packet size (including headers) to be sent from A to C:
3000 bytes

Payload size = Total packet size – TCP header size – IP header size

Payload size = 3000 bytes – 20 bytes – 20 bytes

Payload size = 2960 bytes

Step-1 Sending from A to B

A packet of 3000 bytes will be sent from A to B.

~~step-2~~ Since the MTU on the link between A and B is 3000 bytes, the entire packet can be sent in a single fragment.

Step-2 Sending from B to C.

The packet received at B from A is 3000 bytes, but the MTU on the link between B and C is only 1000 bytes. This means the packet needs to be fragmented before being transmitted from B to C.

Now, we need to split the payload into fragments that fit within the MTU of the link between B and C (1000 bytes)

Number of fragments = Ceiling (payload size/ MTU)

= Ceiling (2960 / 1000)

= Ceiling (2.96) $\approx$ 3 fragments

Now, determining the data size in each fragment

First fragment:

Payload size in the first fragment = MTU - IP header size

= 1000 - 20

= 980 bytes

Second and third fragments:

Payload size in the subsequent fragments =

MTU - IP header size - TCP header size

= 1000 - 20 - 20

= 960 bytes

So the data size in each fragment will be

Fragment 1 : 980 bytes

Fragment 2 : 960 bytes

Fragment 3 : 960 bytes

3) Organise a client that uses UDP to send data to a server. The data are 15 bytes. Calculate the efficiency of this transmission at the UDP level (ratio of useful bytes to total bytes)

Calculating the efficiency of the transmission at the UDP level:-

UDP Header size : UDP has an 8-byte header

Total Bytes Transmitted : Data size + UDP header size

Data size = 15 bytes

UDP header size = 8 bytes

Total Bytes transmitted = 15 + 8 = 23 bytes

Efficiency at the UDP level = $\frac{\text{Data size}}{\text{Total bytes transmitted}} \times 100$

$= \frac{15}{23} \times 100$

$= 0.65 \times 100$

$= 65\%$ (approximately)

Module-5

1) Determine which of the following an FQDN is and which is a PQDN

a) mil
b) Edu
c) xxx.yyy.net
d) iare
e) www.iare.ac.in

An FQDN (Fully Qualified Domain Name) is a domain name that includes the host name and all its parent domain labels up to the root domain.

A PQDN (Partial Qualified Domain Name) only contains a portion of the domain name, typically lacking the complete hierarchy to the root domain.

a) mil – This is a PQDN because it lacks the domain hierarchy and does not provide the complete information for a full domain name.

b) Edu – This is a PQDN for the same reason as mil.

c) xxx.yyy.net – This is an FQDN because it includes the host name ".xxx", the second-level domain "yyy", and the top-level domain (TLD) ".net" providing the complete domain hierarchy.

d) iare – This is a PQDN since it only contains the host name "iare" and lacks the domain hierarchy.

e) www.iare.ac.in – This is an FQDN as it contains the host name "www", the second-level domain "iare", the third-level domain "ac", and the country code top-level domain (ccTLD) "in", providing the complete domain hierarchy.

FQDN's – xxx.yyy.net, www.iare.ac.in

PQDN's – mil, Edu, iare.

2) Interpret the following sequences of characters (In Hexadecimals) received by a TELNET client or server

a) FFFB01   c) FFF4
b) FFFE01   d) FFF9

In the context of Telnet, sequences of characters in hexadecimal format are called Telnet commands or options. These commands are used for negotiating various settings and options between the Telnet client and server.

a) FFFB01 – This sequence represents the "Will" Telnet option negotiation command. It is used by the client to indicate that it wants the server to enable a specific Telnet option. The "01" following FFFB is the code for the Telnet option the client is requesting to enable. The exact meaning of the option depends on the specific code.

a) FFFB01 – FF :- Interpret as a Telnet command
FB :- The option code for "Will" command
01 :- The option code for the option being negotiated.

b) FFFE01 :- FF :- Interpret as a Telnet command
FE :- The option code for "Do" command
01 :- The option code for the option being negotiated

c) FFF4 :- FF :- Interpret as a Telnet command
F4 :- The code for the "Interrupt Process" command.

d) FFF9 :- FF :- Interpret as a Telnet command
F9 :- The code for the "Negotiate About Window Size" command.

3) Show the sequence of bits sent from a client TELNET for the binary transmission of

11110011 00111100 11111111

We need to convert each binary octet (8 bits) to its ASCII representation. TELNET uses ASCII encoding for the data transmission.

Here's the binary data converted to ASCII:

1) Binary: 11110011 → ASCII: 0XF3
2) Binary: 00111100 → ASCII: 0X3C
3) Binary: 11111111 → ASCII: 0XFF

Note:- When representing ASCII characters in hexadecimal format, a prefix "0X" is often used.

So, it would be

0XF3 . 0X3C 0XFF

Each of these hex values represents an ASCII character, and they would be sent one after the other in the binary form over the TELNET connection.