

Lecture Note
on
Data Communication & Computer Network
by
Swagatika Malik
Lecturer (IT)

UNIT-2

Data Transmission & media

Data means Information in digital format and communication means to exchange information between two or many users in forms of audio, video and text over a transmission media like twisted pair cable, coaxial cable, optical fibers, radio waves, satellite microwaves etc.

→ the user are device that sends the data is source / sender

→ the user are device that receives the data is receiver
characteristics

1. Delivery : Data must be delivered to the correct destination and must be received by the intended receiver only.

2. Accuracy : Data delivered must be accurate

3. Timeliness: Data must be delivered within the ideal time else it becomes useless.

4. Jitter: It is the variation in the arrival time of audio or video packets. unevenly delay in the delivery of audio or video packets.

Data Representation:

Information is represented in various forms such as text, images, numbers, audio and video.

Data channel

Channel simply means a path to carry the flow.

Data channel means the flow of data carries the data from one device to another.

These are the some data channel protocols.

SCTP - Stream control transmission protocol

DTLS - Datagram transport layer security

UDP - User datagram protocol.

Band

It is actually a common measurement unit of data transfer / signal.

- It is the rate at which data is transferred from sender to receiver.
BPS (bits per second)

It is the measurement units of speed at which one data is transferred.

Bandwidth

It is the range of frequencies over which a communication system works.

- It measures the amount of data that can be transferred in a given amount of time over a data channel.
- It is the difference between the highest and lowest frequencies of a data channel.

Data

For data transmission, data needs to be changed into signals.

Signals

Signals are the electric or electro-magnetic impulses used to encode and transmit data.

Introduction to Physical Layer:

Communication at the physical layer means exchanging signals.

- ⇒ Data need to be transmitted and received, but media have to change data to signal.
- ⇒ Both data and signal can be either analog or digital.

Analog and Digital Data:

Data can be analog or digital.

- ⇒ Analog data means information that is continuous.

Ex - analog clock

- ⇒ Digital data means information that has discrete state.

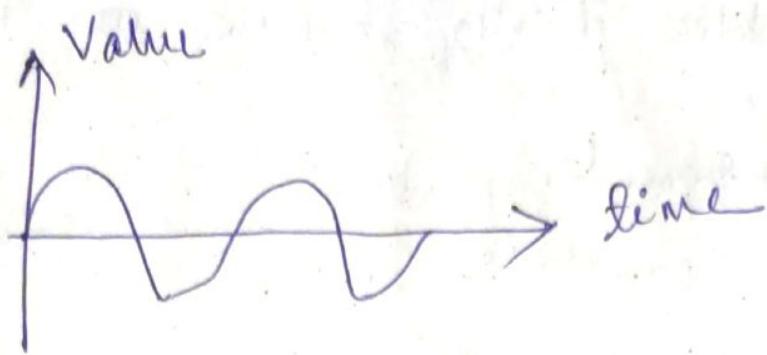
Ex - digital clock.

Analog and Digital Signals:

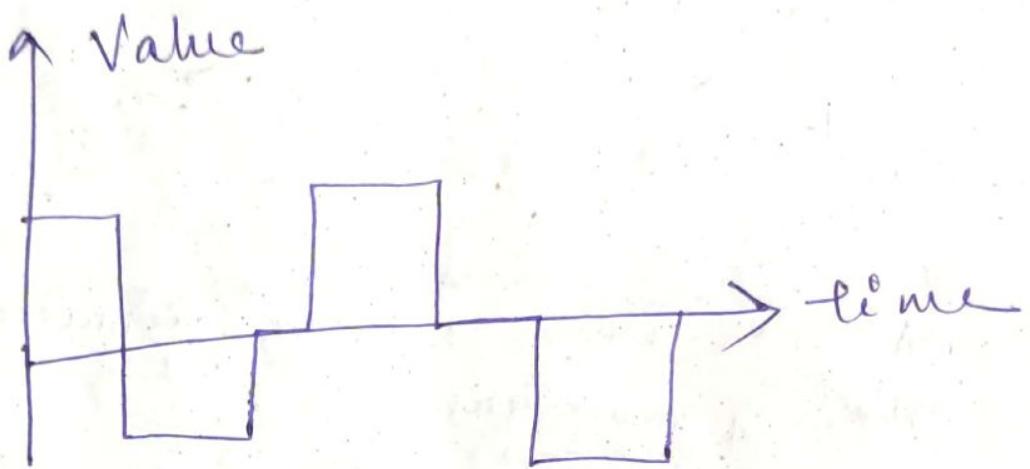
Signals can be analog or digital.

- ⇒ An analog signal has infinitely many levels of intensity over a period of time i.e. wave moves from A to B .
- ⇒ A digital signal, only has a limited number of defined values i.e. 0 and 1.

Analog Signal



Digital signal



Periodic and Non-periodic Signals:

Both analog and digital signals can take one of two forms either periodic or nonperiodic.

Identify

→ A periodic signal exhibits a pattern within a measurable

→ The completion of one full pattern is called a cycle.

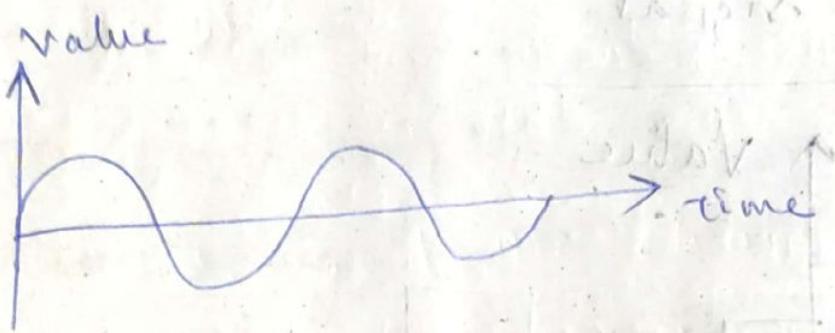
→ A nonperiodic signal changes without exhibiting a pattern etc cycle that repeats over time.

Periodic Analog Signals

periodic analog signals are of two types

- simple
- composite

Rx - Sine wave



Lap. Int. (Laplace Transform)

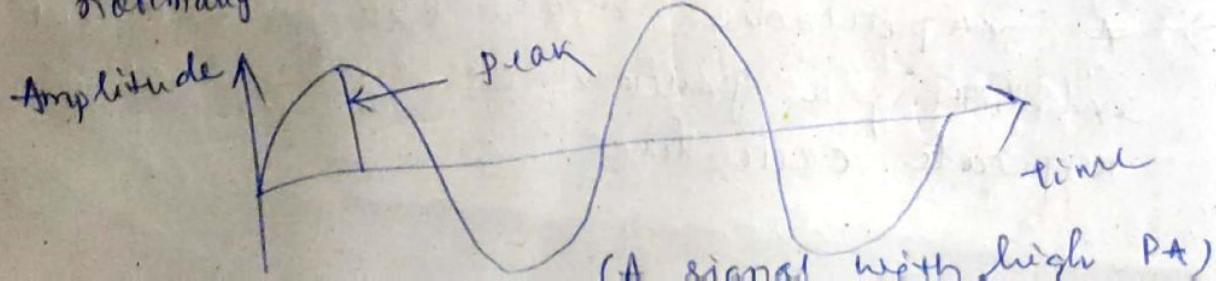
→ a sine wave can be represented by three parameters

- peak amplitude
- frequency
- phase

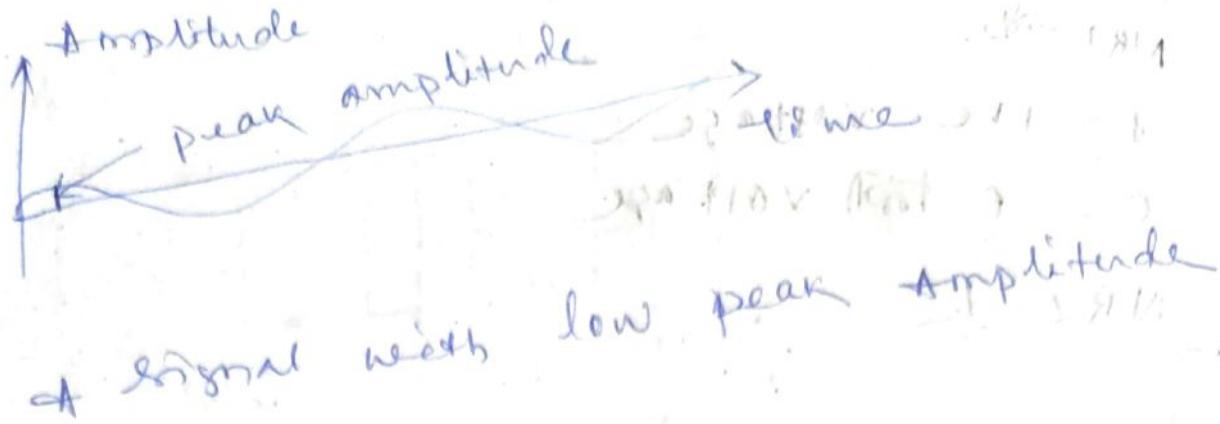
Peak Amplitude

The peak amplitude of a signal is the absolute value of its highest intensity, proportional to the energy it carries.

→ For electrical signals, peak amplitude is normally measured in volts.



(A signal with high PA)



at signal width low peak Amplitude

& signal width

Period

period refers to the duration of time in second, a signal needs to complete 1 cycle

Frequency

frequency referring to the number of

Frequency refers to inverse of

periods ^{see} ~~period~~ to determine frequency

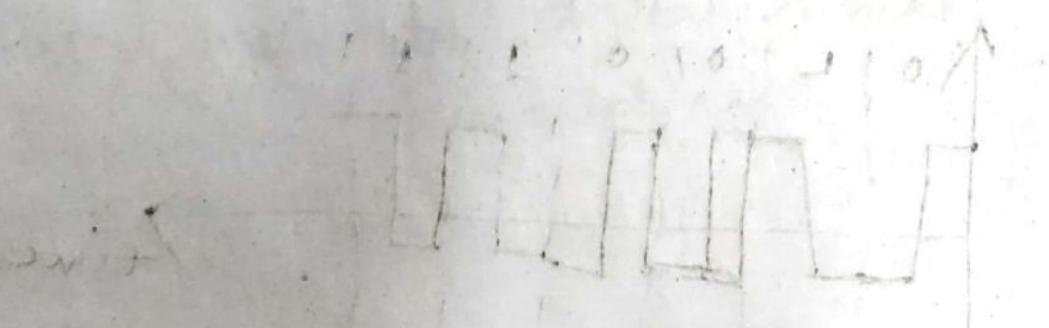
\Rightarrow period is inverse of frequency
and frequency is inverse of period

$$f = \frac{1}{T} \text{ and } T = \frac{1}{f}$$

~~1 sec~~ periods

express period $T = f^{-1}$
~~1 sec~~ periods

$$T = \frac{1}{f}$$



NRZ-~~D~~

0 = +ve voltage

1 = 0 volt voltage

NRZ-L

0 = +ve

1 = negative

NRZ-I

0 = +ve and no change

1 = -ve and transition until it reaches 1

always transitioning at every bit if 1

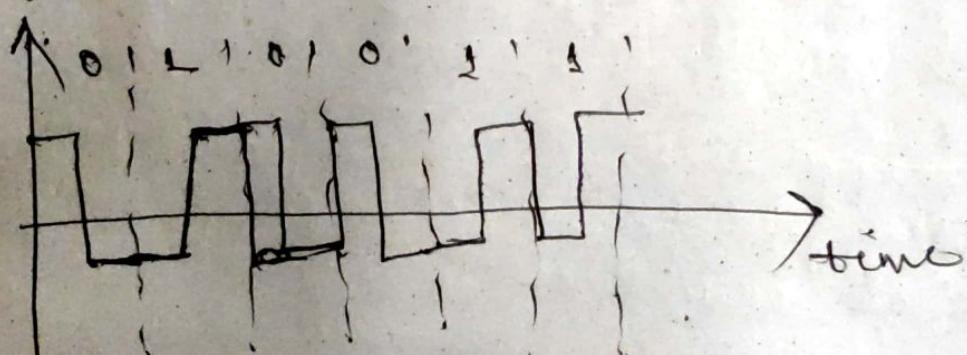
RZ -

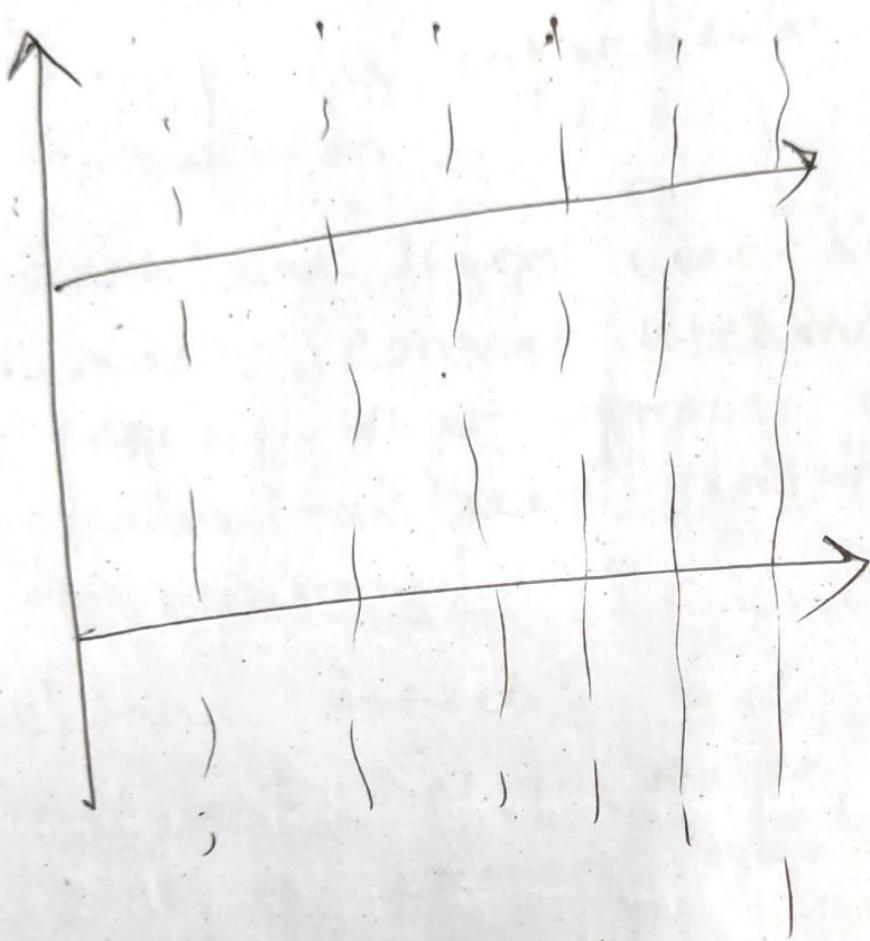
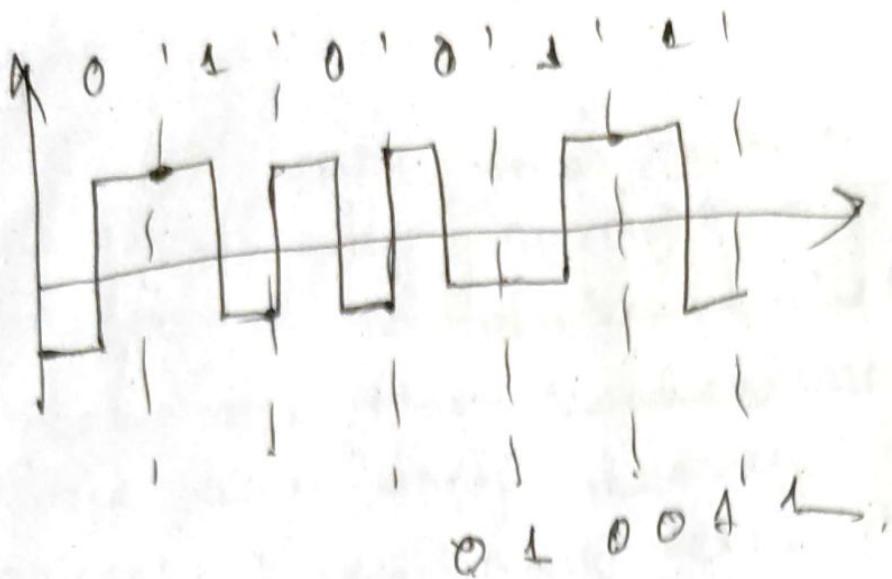
0 = -ve ~~no~~ signal changes during bit

1 = +ve , signal changes during bit

Manchester

RZ + RZ-RZ-I





digital signal to analog signal -
modulation

analog signal to digital signal -
demodulation

Error Detection

During data transmission, the message may corrupt due to many factors. To detect those errors.

These are the mechanisms such as there are many reasons which may noise, cross-talk etc corrupt the information during transmission.

- Data link layer uses some error control mechanism to ensure that frames are transmitted with certain level of accuracy.
- Before detection and correction it is essential to know what types of errors may occur.

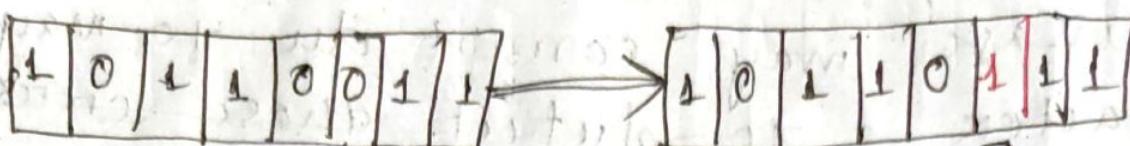
Types of Errors:

There ~~may be~~ are three types of errors.

Single bit error

In this type of errors only 1 bit of given data unit is changed from 1 to 0 or from 0 to 1.

Sent -



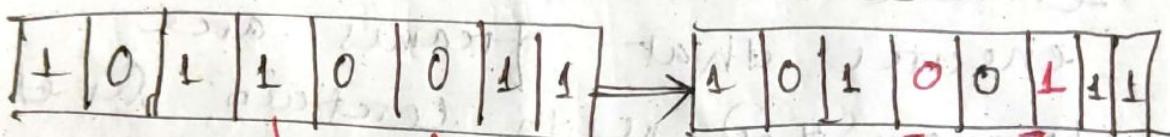
Corrupted bit

Multiple bit error

In this type of error more than one bits are corrupted

Sent

Received



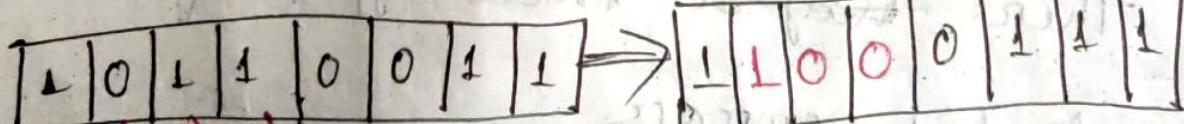
corrupted bits

Burst error

In this type error, the frame contains more than 1 consecutive bits corrupted

Sent

Received



corrupted bits

Data link layer provides error control mechanism such as

Error detection

Error Correction

Error Detection

Detection means to look whether any error has occurred. The errors in the frame are detected by two ways

* parity check

* cyclic Redundancy check (CRC)

Parity check

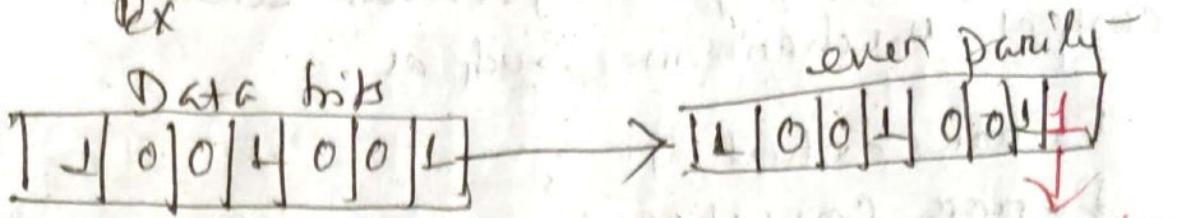
One extra bit is sent along with the original bits to make number of 1s even is called even parity

and to make the number of 1s odd is called odd parity

Even parity

In even parity - in the bit stream if the no. of 1s is even then one extra bit 0 will be added to bit stream.

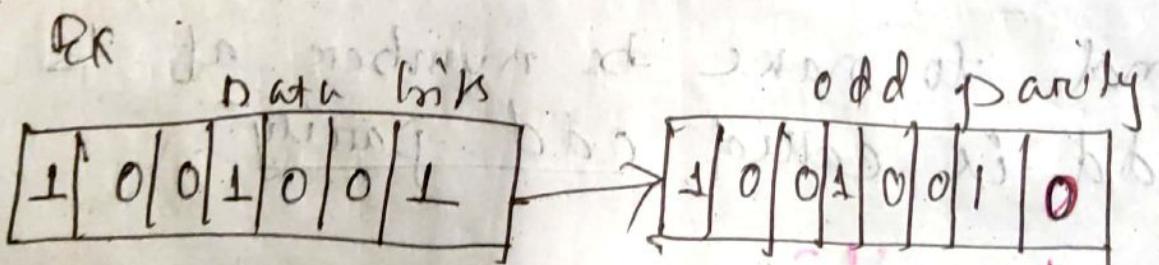
If the no. of 1s is odd then one extra bit 1 will be added to bit stream to make all 1s even.



The receiver will simply count the number of 1s in a frame. If the count of 1s is even and even parity is used, and the frame is considered to be not corrupted and is accepted.

odd parity

In odd parity, if the total no. of 1s is odd then 0 will be added. If total no. of 1s is even, the 1 will be added to make it odd.



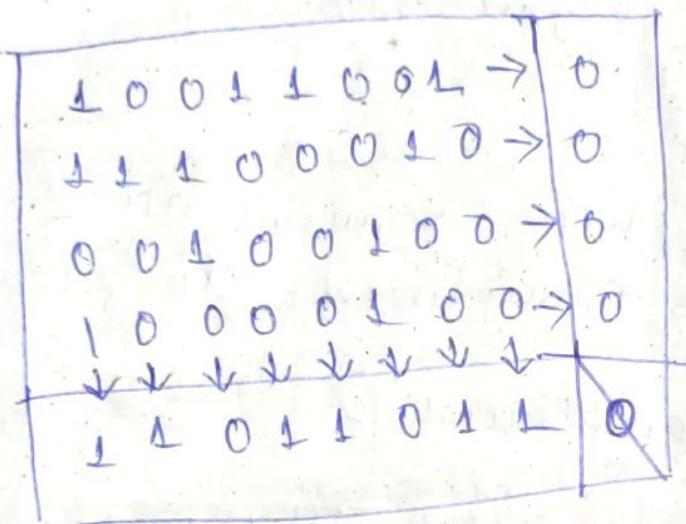
The receiver will simple count the total no. of 1s in the frame. If it is odd, odd parity will be used and the frame is considered to be not corrupted and is accepted. Otherwise it will be rejected.

Two dimensional Parity check:

Bits are calculated for each row and column. Another bit are sent along with the data. At the receiving end, these are compared with the parity bits calculated on the received data.

original data

10011001	11100010	00100100	10000100
----------	----------	----------	----------



data to be send

100110010	111000100	001001000	10000100
110110110	task	length	

Checksum

checksum error detection is a method used to identify errors in transmitted data.

→ All the data are divided into equal sized segments and then using 1's complement, the sum of all the segments calculated.

At Sender's Side

- ⇒ Data is divided into K segments each of m bits
- ⇒ All segments are added using 1's complement to get the sum
- ⇒ the sum is complemented to get the checksum.
- ⇒ the checksum segment is sent along with the data segments.

At Receiver's Side

- ⇒ All the received segments are added using 1's complement to get the sum.
- ⇒ the sum is complemented.
- ⇒ if the result is zero, the received data is accepted otherwise discarded.

Original data

10011001	11100010	00100100	10000100
1	2	3	4

$$R = 4 \quad m = 8$$

4 segments each of 8 bits

Sender

1 10011001
2 11100010

① 01111011
↓
01111100

3 00100100

10100000

4 10000100

① 00100100
↓
sum = 00100101

check word = 11011010

Data accepted as

Receiver

1 10011001
11100010

2 ① 01111011
↓
01111100

3 00100100

10100000

4 10000100

① 00100100
↓
00100101
↓
11011010

sum = 11111111

complement = 00000000

result is zero

Cyclic Redundancy Check (CRC)

→ CRC is based on binary division

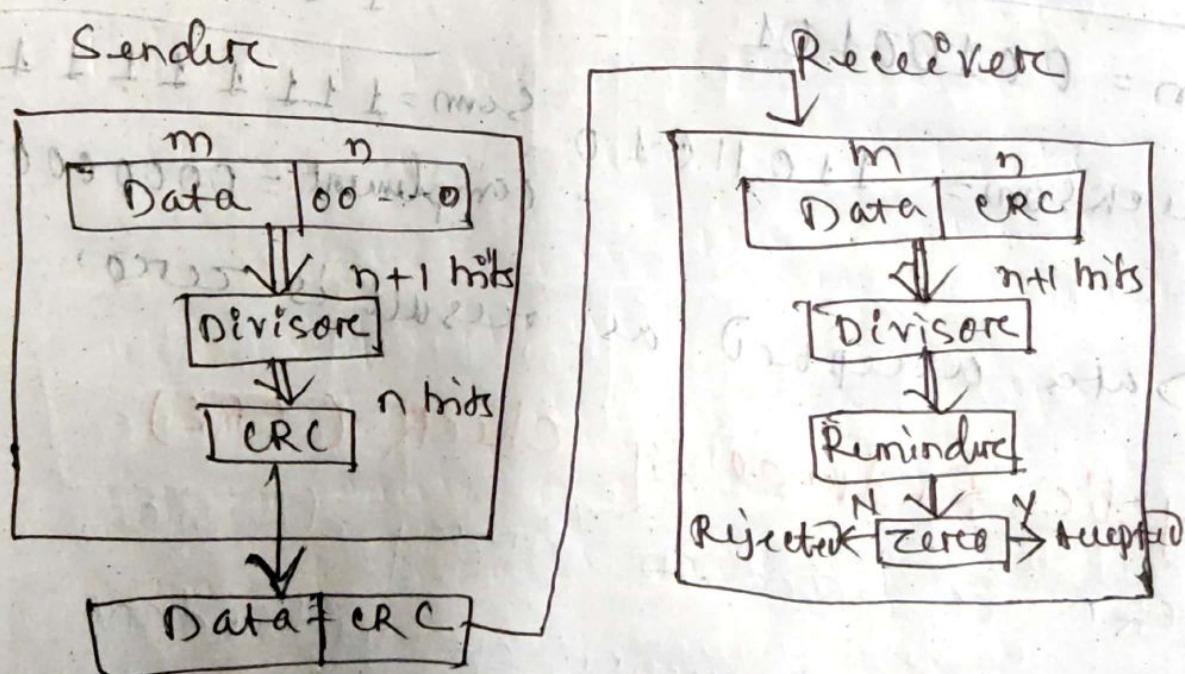
→ In CRC, a sequence of redundant bits called cyclic redundancy check bits are appended to the end of the data unit so that the resulting data unit becomes exactly

divisible by a second predetermined binary number.

→ At the receiver, the incoming data unit is divided by the same number.

→ If there is no remainder the data is correct and hence accepted.

→ If there is a remainder, then the data is corrupted and hence rejected.



original message is

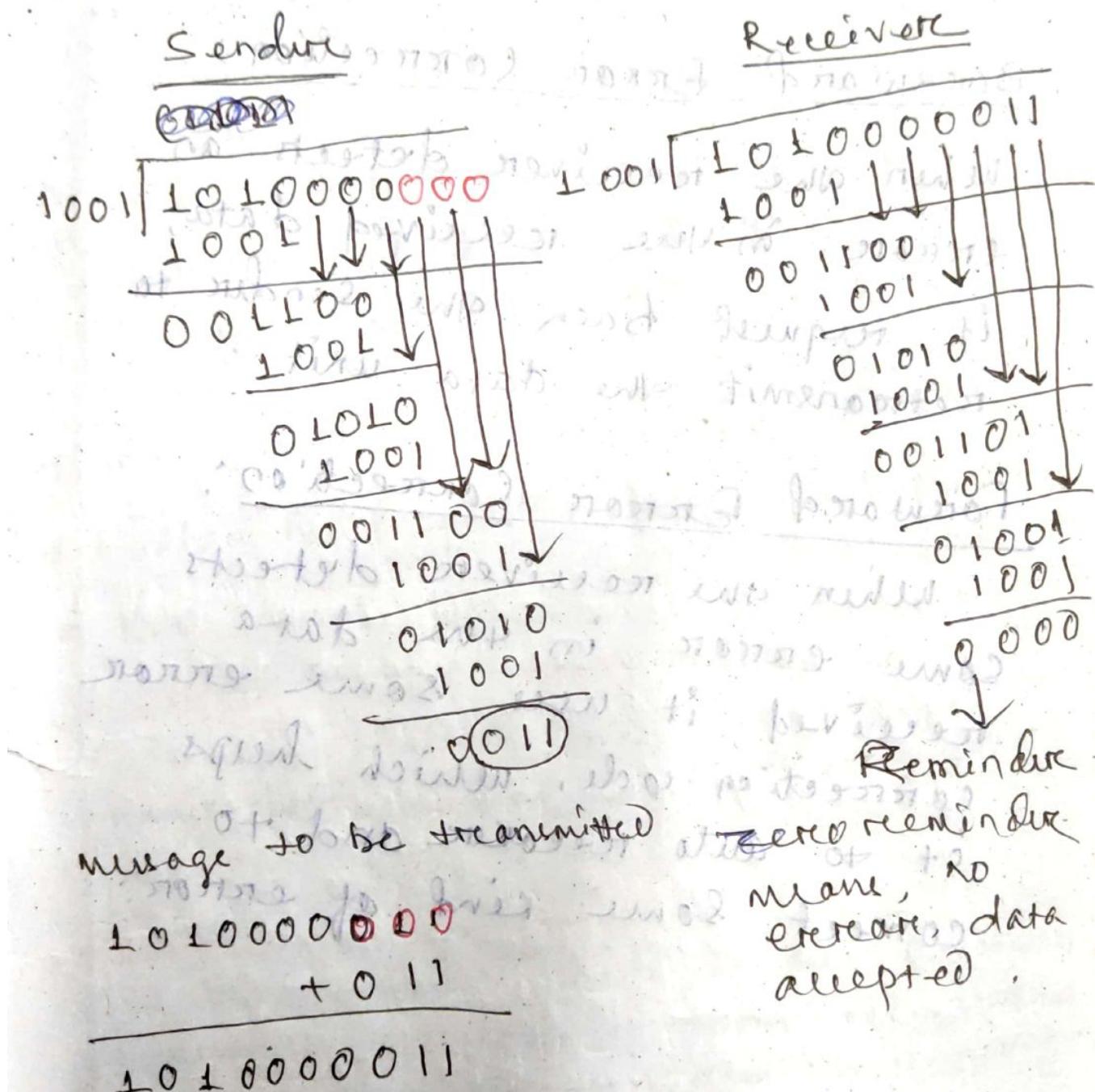
10100000

CRC generator polynomial
 $x^3 + 1$

$$1 \times u^3 + 0 \times u^2 + 0 \times u^1 + 1 \times u^0$$

\Rightarrow 1001 - 4 bit CRC generator

If CRC is n bit then $n+1$ bit
will be appended at the end of
original data.



Error Correction

Error correction can be done in two ways

- * Backward Error correction
- * Forward Error correction

Backward Error Correction

When the receiver detects an error in the received data, it request back the sender to retransmit the data unit.

Forward Error Correction

When the receiver detects some error in the data received, it uses some error correction code, which helps it to auto recover and to correct some kind of error.

Flow Control

Data link layer is responsible for flow control.

- ⇒ Flow control is a technique that allows two stations to communicate data at different speed.
- ⇒ Two stations to transmit data at different speed.
- ⇒ Flow control tells the sender how much data should be sent to the receiver so that it is not lost.
- ⇒ Flow control can be broadly classified

* Feedback based flow control

* Rate based flow control

Feedback based flow control:

In these protocols, the sender sends frames after it has received acknowledgement from the user.

Rate based flow control:

These protocols have built-in mechanism to restrict the rate of transmission without requiring acknowledgement from the receiver.

The flow control uses following technique to control the rate of data transmission.

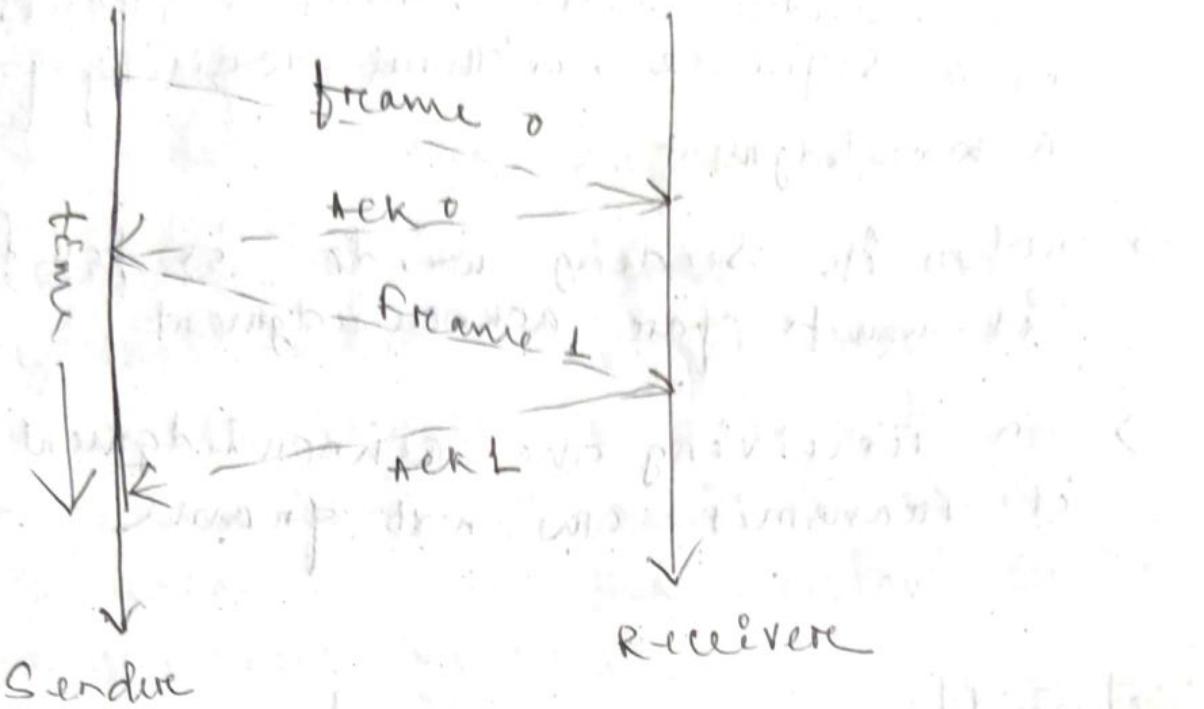
- * Stop and Wait

- * Sliding Window

Stop and wait Protocol

Stop and wait technique is the datalink layer protocol.

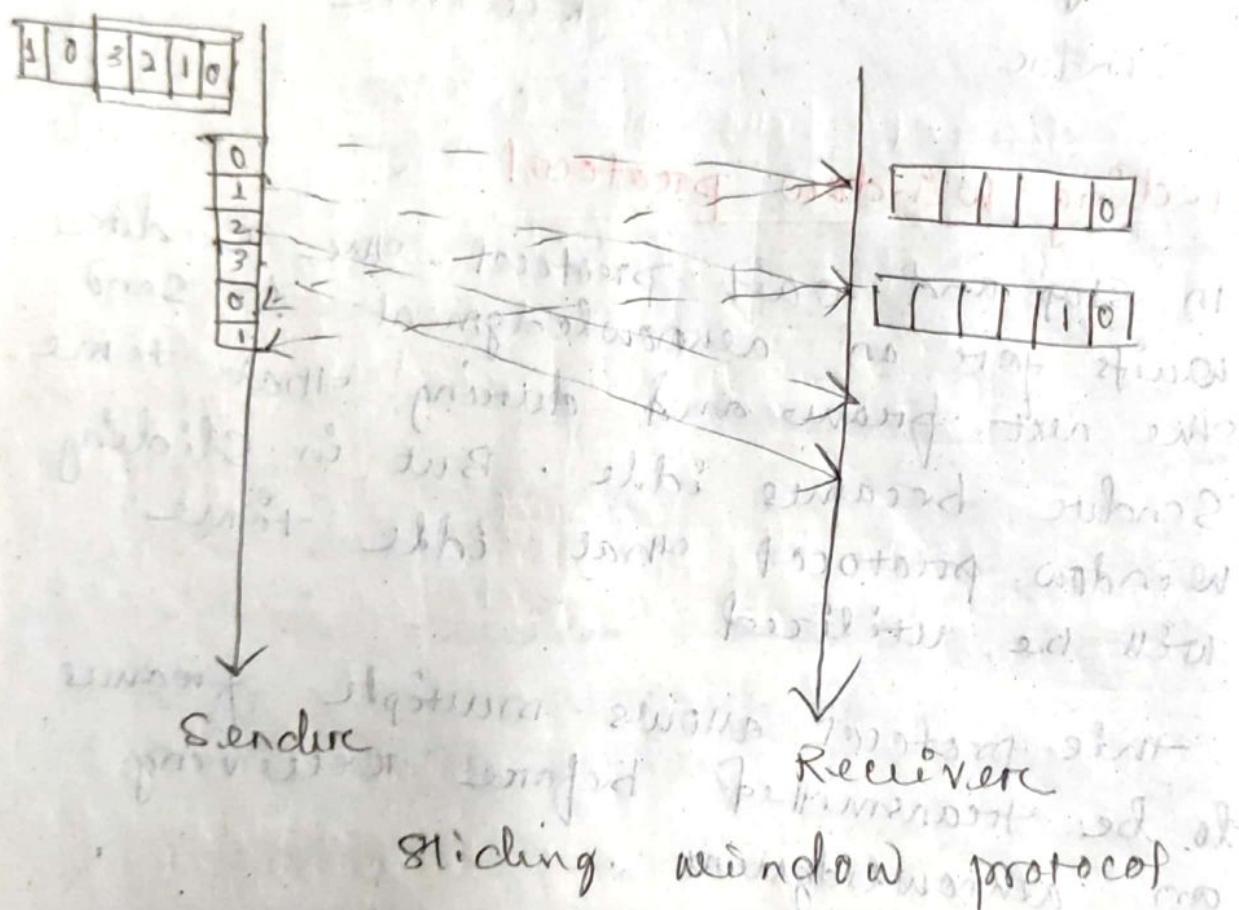
- ⇒ This protocol uses both flow and error control.
- ⇒ In this method, the sender will transmit one frame at a time to the receiver.
- ⇒ the Sender will stop and wait for the acknowledgement from the receiver.
- ⇒ Once the receiver receives the frame it sends an acknowledgement frame back to the sender.
- ⇒ on receiving the acknowledgement frame, the sender understands that the receiver is ready to accept the next frame. So it sends the next frame in the queue.
- ⇒ And the process will continue.



Sliding Window protocol

- In Stop and wait protocol, the sender waits for an acknowledgement to send the next frame and during that time sender becomes idle. But in sliding window protocol that idle time will be utilized.
 - this protocol allows multiple frames to be transmitted before receiving an acknowledgement.
- The working principle of this protocol are as follows:
- Both the sender and receiver has finite sized buffers called windows.
 - the sender and receiver agrees upon the number of frames to be sent based upon the buffer size.

- ⇒ the sender sends multiple frames in a sequence, without waiting for acknowledgment.
- ⇒ when its sending window is filled, it waits for acknowledgment.
- ⇒ on receiving one acknowledgment - it transmit one next frame



- ⇒ Suppose the size of the window is 4, so the frames should be numbered as 0, 1, 2, 3, 0, 1, 2, 3, 0 and so on.
- ⇒ Initially the frames in the window are 0, 1, 2, 3. Now the sender starts transmitting frame 0.

- When the receiver receives the first frame i.e. frame-0, then it sends an acknowledgement.
- When the acknowledgement is received by the sender, then it knows that the first frame is received by the receiver and it need not to keep its record, so the window slides to the next frame.
- In this way, one window slides the frame, that's why the name is sliding window protocol.



Unit-5 Switching & Routing

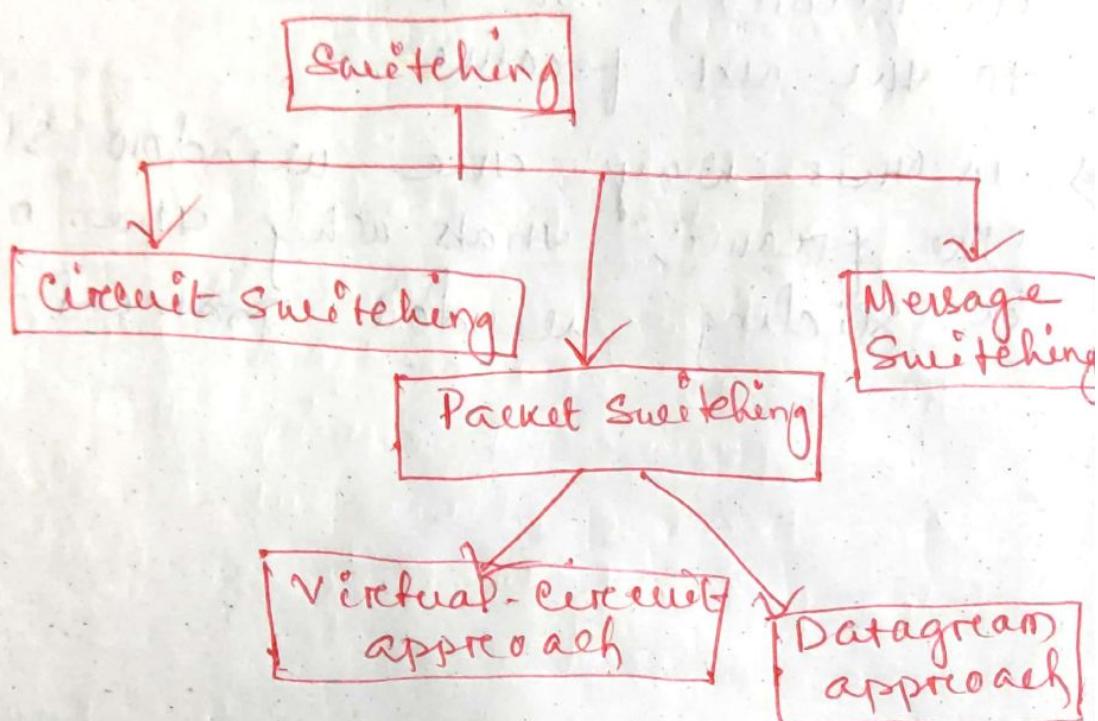
A switched nw consists of a series of interlinked nodes called switches.

There are 03 methods of switching

- * Circuit Switching

- * Packet Switching

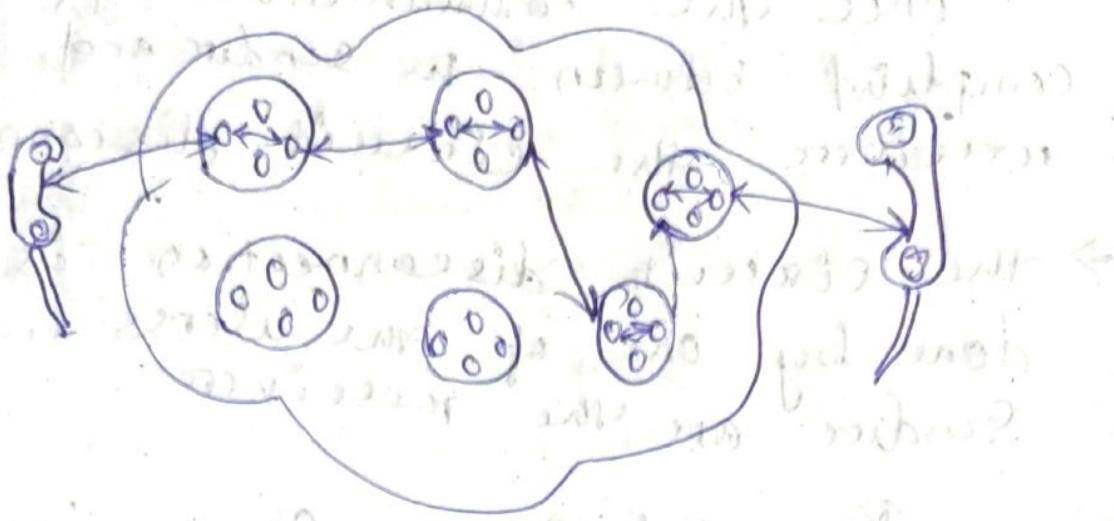
- * Message Switching



Circuit Switching

In circuit switching, a dedicated channel is established for a single connection, where the sender and receiver can communicate.

→ It is a switching technique that uses a prespecified route between the sender and receiver and this route is reserved for both these devices as long as the connection is active.



communication that take place through circuit switching has 3 phases

- * Establish a circuit
- * Transfer the data
- * Disconnect the circuit

Establish a circuit

In the first phase, a circuit is established, means a dedicated link is established between the sender and the receiver through a number of switching centers or nodes.

Transfer the data

Once the circuit is established between sender and receiver, they can communicate with each other.

Disconnect the circuit

Once the communication is completed between the sender and receiver, the circuit disconnects.

- the circuit disconnection is done by one of the users i.e. sender or the receiver.

Ex - Telephone Communication
Advantage

- A dedicated link is established between both devices, which provides guaranteed data transmission.

Disadvantage:

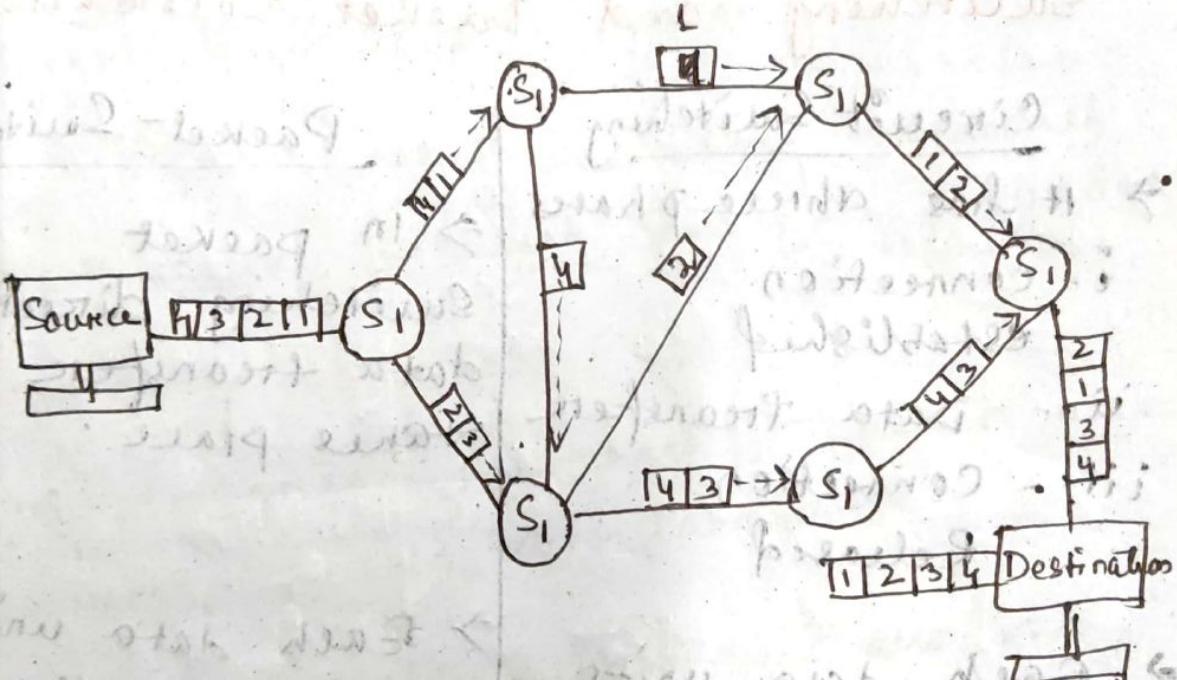
- Once the dedicated path is established between the sender and receiver, the path becomes reserved and other devices cannot use this path.

Packet Switching:

In packet switching, when we send a message, then the whole message is divided into smaller pieces, called packets.

- These packets travel across the network and take the shortest path possible.
- Every packet has a sequence number to identify its order at the receiving end.

- Each packet contains some information including a source address, a destination address, intermediate node address information, sequence number, etc, so that individual packets can be routed through the internetwork independently.
- This method allows for more efficient use of network resources and enable multiple transmission to occur simultaneously.



Advantages of packet switching:

1. Efficiency - Packet switching is a very efficient method of transmitting data.
2. Flexibility - packet switching allows different types of data such as text, voice and video.

3. Robustness - it is highly robust because it allows packets to be sent along different routes to their destination.

4. Scalability : it is highly scalable as it can handle a large no. of users and devices

5. Cost-effectiveness

Difference between Circuit switching and packet switching

Circuit Switching

- It has three phases
 - i. Connection established
 - ii. Data transfer
 - iii. Connection released
- Each data unit knows the entire path address, which is provided by the source
- In circuit switching data is processed at the source system only.

Packet-Switching

- In packet switching direct data transfer takes place.
- Each data unit just knows the final destination address intermediate is decided by the routers.
- In packet switching data is processed at all intermediate nodes including the source systems.

- ⇒ wastage of resources is more
- ⇒ less wastage of resources
- ⇒ it is not a store and forward technique
- ⇒ it is a store and forward technique
- ⇒ call setup is required in circuit switching
- ⇒ no call setup is required in packet switching.

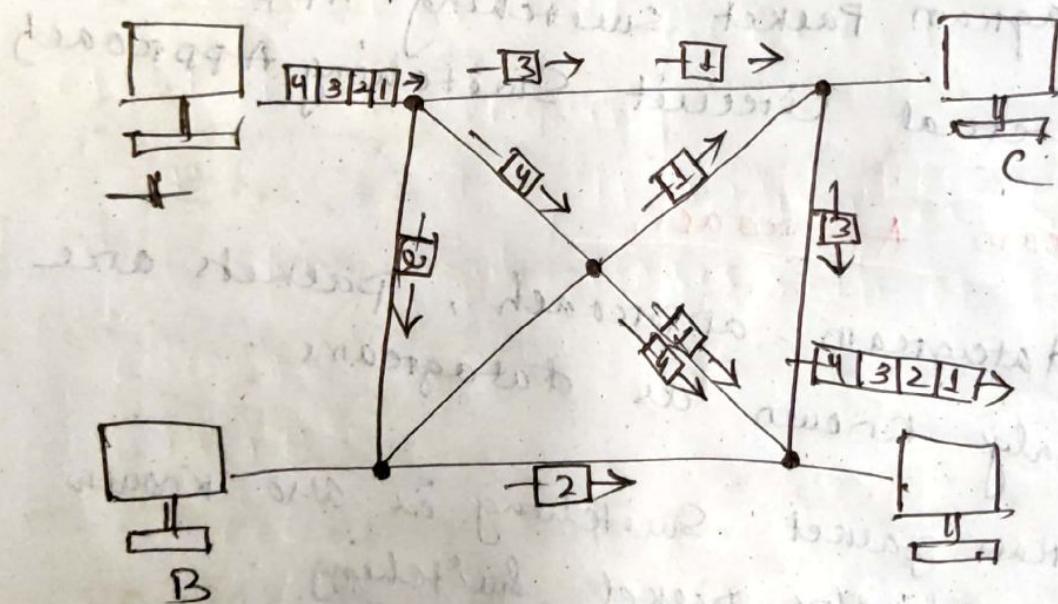
Two different approaches are used for packet switching as follows:

- * Datagram Packet switching Approach
- * Virtual Circuit Switching Approach

Datagram Approach

- ⇒ in datagram approach, packets are commonly known as datagrams.
- ⇒ Datagram packet switching is also known as connectionless packet switching.
- ⇒ In this technique, each packet is treated individually by network devices based on the destination address of each packet.
- ⇒ Datagram approach is connectionless because, the packet does not keep the information about the connection state.
- ⇒ In this approach path is not fixed.

- Routing decisions are taken by intermediate nodes to forward the packets
- so that, all the datagram that belongs to same message may travel through different path in order to reach their destination.
- on the receiving node, all the packets are reassembled to get the message in the original form
- It is the responsibility of the upper layer protocol, to reassemble the datagrams.



Datagram packet

Switching

Virtual circuit Switching approach

Virtual circuit switching is also known as connection-oriented switching.

- this switching contains the characteristic of circuit switching as well as datagram packet switching.
- in this switching approach, data packets are first assembled, and then sequentially numbered. Now they are ready to travel across a predefined route sequentially.
- in this switching process, three phases are there. Set up phase, transfer phase, and tear down phase.
- the resource allocation is done during the Setup phase.
- all the packets in the virtual circuit follows the same path that is established during the connection.
- after transferring all the packets in the data transfer phase, the source will send a special packet to terminate the established connection.

IP Address

An IP address is a 32 bit unique address having an address space of 2^{32} .

Notation

IP address is normally denoted by dotted decimal notation.

Ex:-

128.113.31.1
→ 256 points 10000000 → 128
→ 256 points 00010011 → 113
→ 256 points 00000011 → 1

Classification of Addressing

In the 32 bit IP address is divided into five sub-classes such as

Class A

Class B

Class C

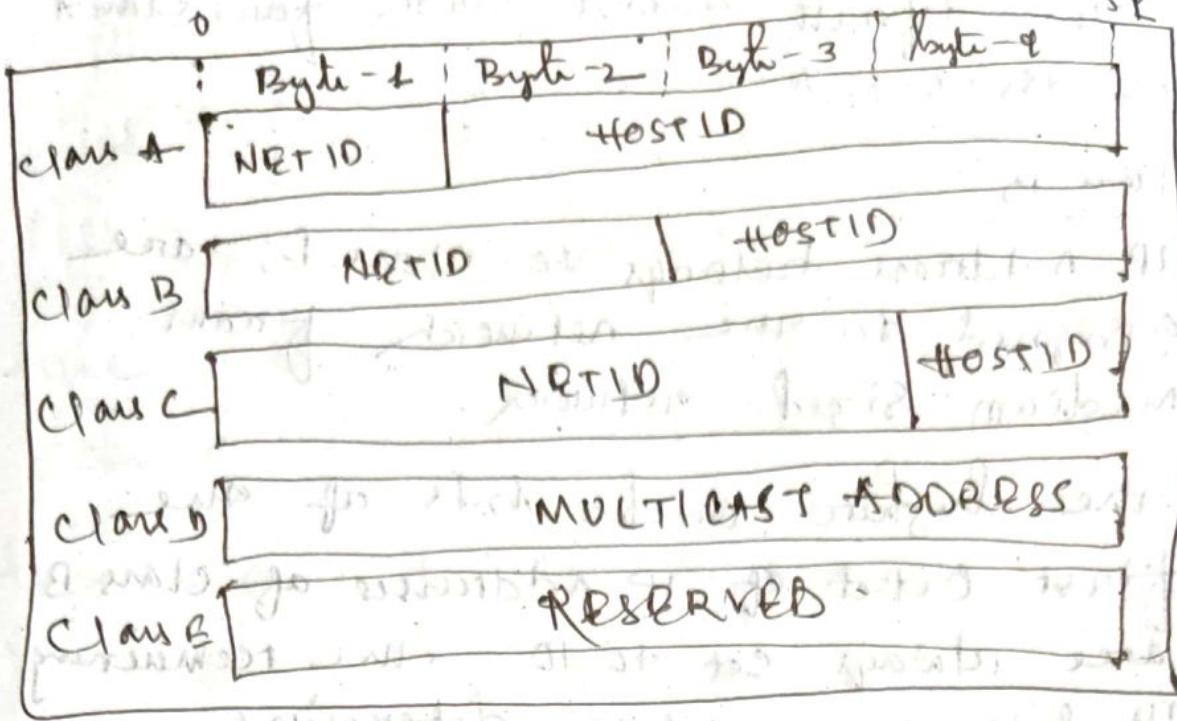
Class D

Class E

IP address is divided into two parts

* Network ID

* Host ID



Class A

If address belongs to class A are assigned to the network, that contain a large no. of host.

- * The network ID is 8 bits long
- * The Host ID is 24 bit long

The highest order bit of first octet in class A is always set to zero, the remaining are used to determine network ID.

→ the 24 bits of Host ID are used to determine the host ID in any network.

So, the class A has total of

$$2^7 - 2 = 126 \text{ Network ID}$$

$$2^{24} - 2 = 16, 777, 214 \text{ host ID}$$

the default subnet mask for class A
is 255.0.0.0

Class B

IP addresses belongs to class B are assigned to the network from medium sized network.

⇒ the higher order bits of the first Octet of IP Addresses of class B are always set to 10. The remaining 14 bits are used to determine network ID.

So class B has a total of

$$2^{14} - 2 = 16384, \text{ network ID}$$

$$2^6 - 2 = 65534, \text{ host ID}$$

the default sub-net mask for class B is 255.255.0.0

Class C

IP addresses belongs to class C are assigned to small sized network.

- ⇒ the network ID is 24 bit long
- ⇒ the host ID is 8 bits long

⇒ the higher order bits of first Octet of IP address of class C are always set to 110 and the remaining ~~of~~ 24 bits are used to determine network id.

so class C has total of

$$2^{2^L} = 2097152 \text{ Network ID}$$

$$2^{8-2} = 256 \text{ host ID}$$

the default subnet mask for class C is $255.255.255.x$

the Range of class A from
 $0.0.0.0$ to $126.x.x.x$

the Range of class B from
 $128.0.x.x - 191.255.x.x$

Range of class C from

$$192.0.0.x - 223.255.255.x$$

Class D

IP address belongs to class D is reserved for multi-casting.

the Range of IP address of class D

from $224.0.0.0$ to $239.255.255.255$

Class E

IP address belongs to class E are reserved.

X-26

X.25 is a protocol suite defined by ITU - T for packet switched communication over X.25 (wide area network).

X.25 has three layers

→ physical layer

→ Datalink Layer

→ Packet Layer

Frame Relay

Frame Relay is a packet switched communication service from LAN to backbone network and WANs.

It operates at two layers

⇒ physical layer

⇒ Datalink layer

Ethernet (CSMA/CD)

Carrier Sense multiple access / collision detection) is a media access control method that was widely used in

early ethernet technology / LANs, where there used to be shared

Bus Topology and each computer were connected by co-axial cable

Consider a scenario, where there are n stations on a link and all are waiting to transfer data through that channel.

→ In this case all n stations would want to access the channel to transfer their own data.

⇒ The problem arises when more than one station transmits data through that channel.

→ In this case there will be collisions in the data frame from different stations.

By using CSMA/CD protocol, different stations agree some terms and collision detection measures for effective transmitting.

⇒ The algorithms of CSMA/CD

→ When a frame is ready, the transmitting station checks whether the channel is idle or busy.

→ If the channel is busy, the station waits until the channel becomes idle.

- ⇒ if the channel is idle, the station starts transmitting and continually monitors the channel to detect collision.
- ⇒ if collision detected, the station starts collision resolution algorithm.
- ⇒ the station reset the retransmission counter and completes frame transmission.

- ① What is ARPANET
- ARPANET Stands for Advanced Research project Agency.
- This is basically beginning of Internet.
- It was introduced by ARPA of US Department of Defense.

- ② Define multiplexing and demultiplexing.

Multiplexing is a technique used to combine and send the multiple data stream over a single channel.

Multiplexing is achieved by Multiplexer:

Multiplexer is also known as a device that combines n input line to generate single line.
it follows Many-to-one

- ③ Line coding:

It is a process of digital data to digital coding.

Analog to Analog conversion:

- 1. Analog to Analog conversion method converts analog information into analog signal.

Example

Radio,

→ Govt. has assigned a narrow bandwidth to radio. Signal produced by various stations lie in the same range. To listen to different stations, these signals need to be shifted to different ranges.

⇒ This can be achieved by using any of these techniques from AM, FM and PM.

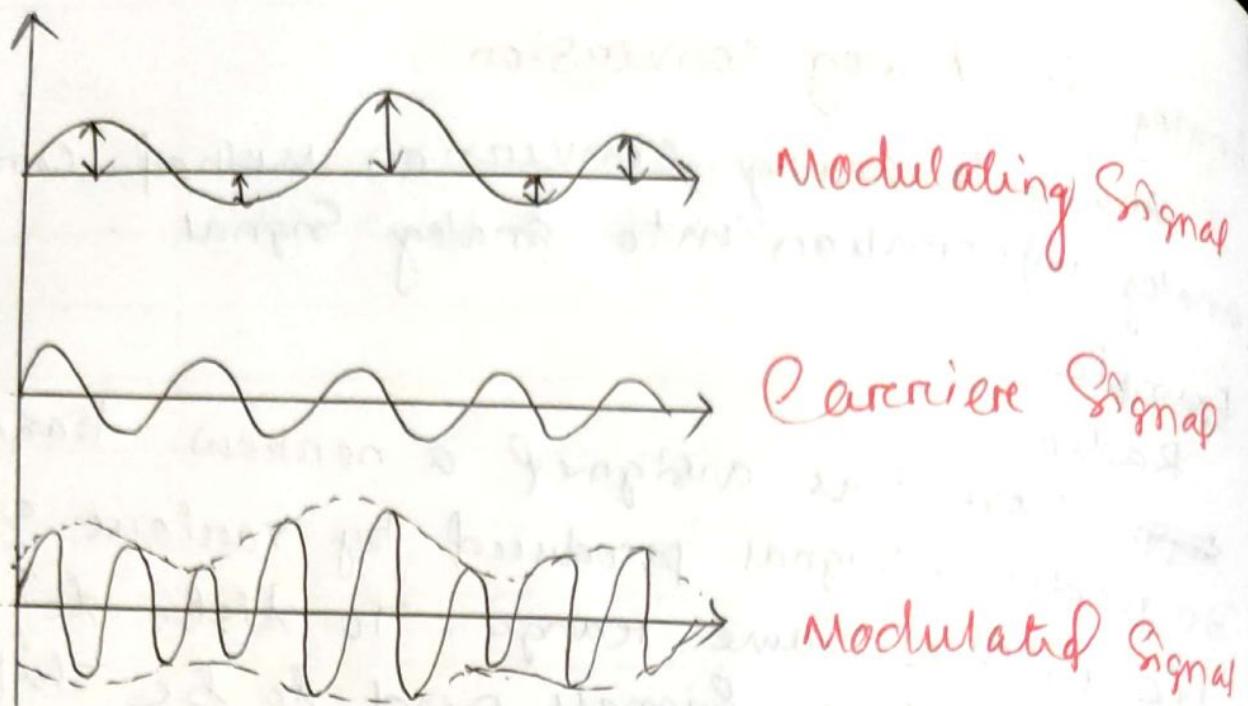
1. Amplitude Modulation

⇒ Amplitude of carrier signal is changed based on the amplitude of modulating signal.

Modulating signal means - Original analog data.

⇒ Carrier signal - It is a signal with steady waveform, that means constant height are amplitude and frequency.

⇒ Frequency and phase of carrier remain constant.



Frequency Modulation:

- Frequency of the carrier signal is changed based on the amplitude of the modulating signal.
- Peak amplitude and phase of carrier remains constant.

