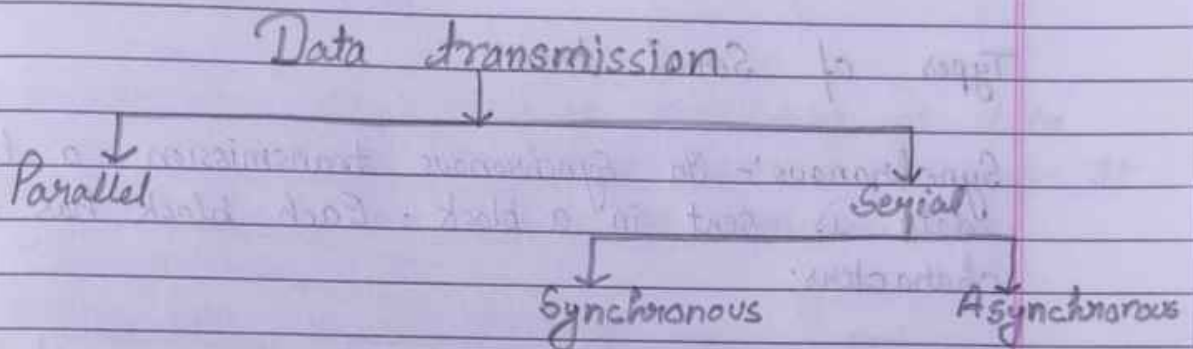


Data transmission

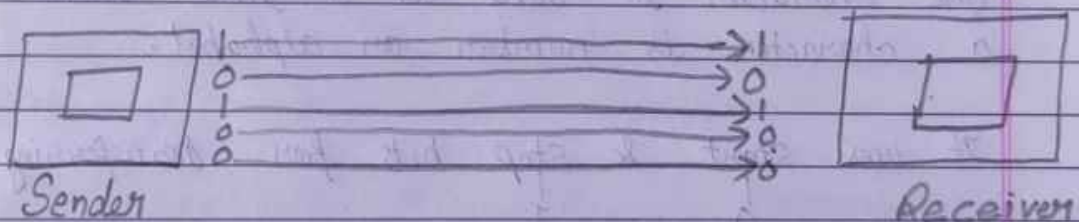
Data transmission refers to the process of transferring the data between two or more digital devices in analog and digital format. This data is transferred in the form of bits.

Types of Data transmission



Parallel data transmission

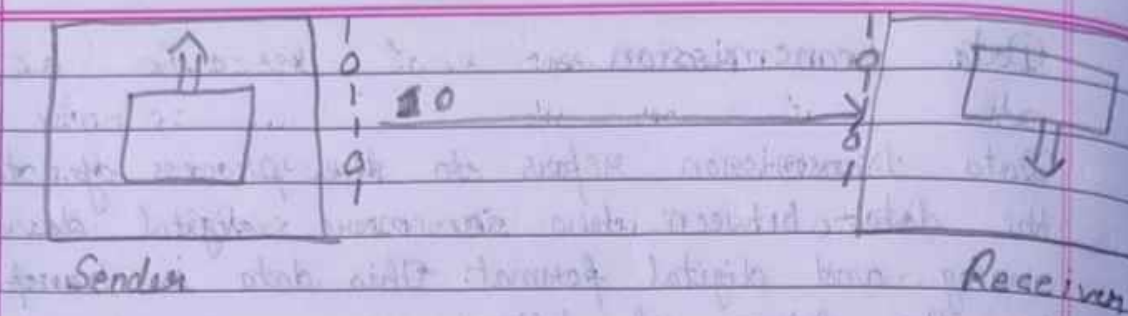
Parallel data transmission sends multiple data bits at the same time over multiple channels.



transferring data in short distance.

Serial data transmission

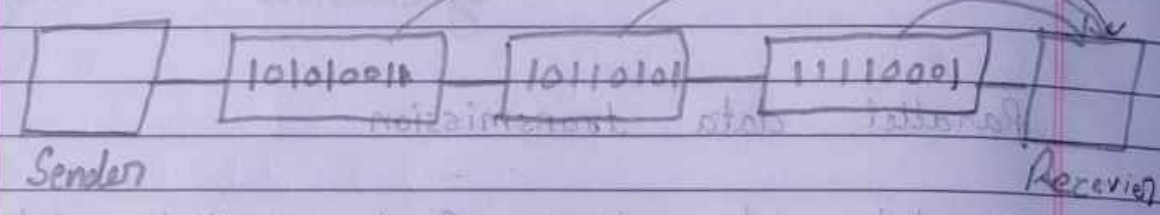
Serial data transmission sends data bits one after another over a single channel.



used for transferring data to the long distance

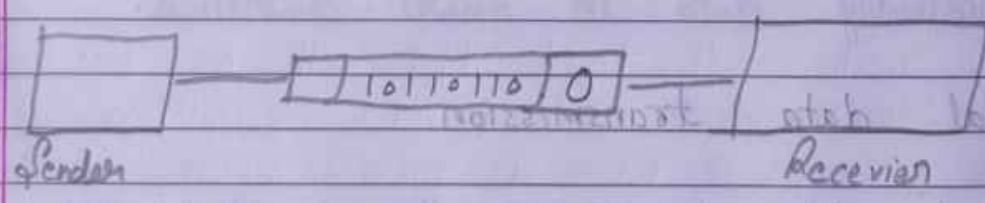
Types of Serial trans.

Synchronous:- In Synchronous transmission, a lot of data is sent in a block. Each block has many characters.



Asynchronous:- In Asynchronous transmission only one character is sent at a time. Whether that a character is number or alphabet.

It uses start & stop bits for transferring data



When Sender want to send data to the receiver first it send the start data which

is a 0. After that receiver get alert that the data is transferring by the sender. So, after receiving data from the sender again sender sends the stop alert to the receiver & hence data get transferred by sender to receiver.

Transmission mode.

Transmission mode means transferring of data b/w two devices connected over a network. It is also known as mode of communication.

Three types of transmission

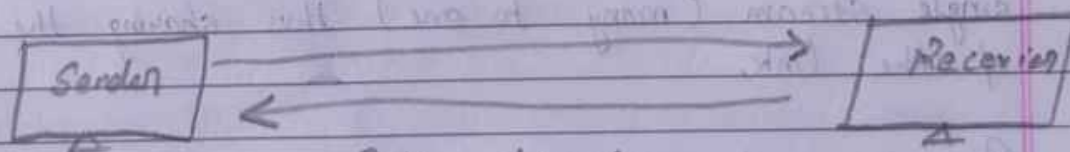
Simplex mode :- In this mode data can be send only one direction (uni-directional)

Ex. Sound loudspeaker, Keyboard, Monitor etc



Half duplex :- In this mode of communication a sender can send the data as well as receiver the data but not at the same time.

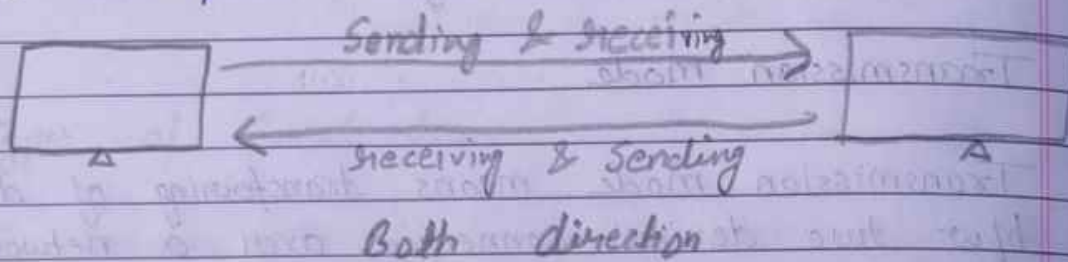
Ex. Walkie-talkie



Both direction

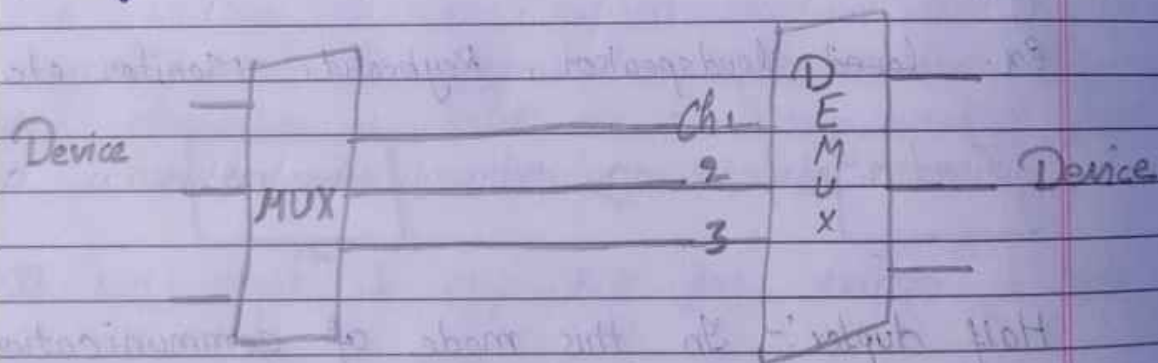
Full Duplex:- In this mode Sender can send data as well as receive data on the other hand the receiver can receive as well as send the data of the at the same time.

Ex:- Telephone Network



Multiplexing

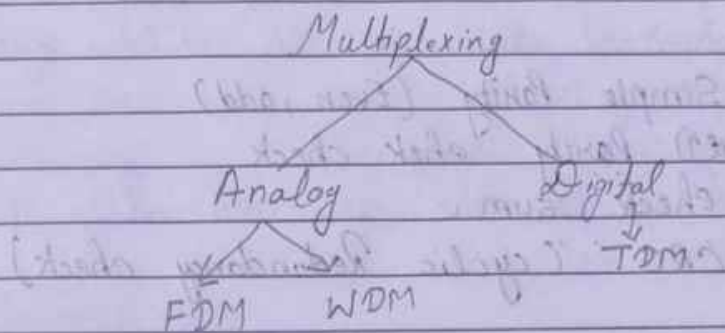
Multiplexing is the set of techniques that allows the simultaneous transmission of multiple signals across a single data link.



Device on the left direct their transmission streams to multiplexer (mux) which combines them into a single stream (many to one) thus sharing the capacity of the link.

Receiving end, demultiplexer (DEMux) separates the

single stream back into its component transmission (one to many) & directs them to their intended receiving devices.



FDM → Frequency Division Multiplexing

WDM → Wavelength Division Multiplexing

TDM → Time Division multiplexing

Spreading → A spreading code is used to map each data bit in the original signal to multiple bits in the transmitted signal.

Encoding & Decoding

In computer, encoding is the process of putting a sequence of characters (letters, numbers, punctuation and certain symbols) into a specialized format for efficient transmission or storage. Decoding is the opposite process-- the conversion of an encoded format back into the original sequence of characters.

Error Detection & Recovery

Error → The data send by the sender and the same data did not received by the receiver then we can

mycompanion

nonermodm

say that there is an error

Single bit Error 103, 105

Burst Error - more than 1 bit error

Detection \rightarrow Simple Parity (Even, odd)
CRC Parity check
check sum
CRC (cyclic Redundancy check)

Correction

Hamming codes

Simple parity check

Blocks of data from the source are subjected to a check bit or parity bit generated from, where a parity of

1 is added to the block if it contains odd number of 1's

0 is added if it contains even number of 1's

Sender

100011

Compute parity bit

100011 | 1

Transmission media

100011 | 1

Reject data

Even

Accept data

RECEIVER

Compute parity bit

2D parity check

Parity check bits are calculated for each row which is equivalent to a simple parity check bit. Parity check bits are also calculated for all columns then both 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
----------	----------	----------	----------

Row parities

Column parities	1	0	0	1	1	0	0	1	0
	1	1	1	0	0	0	1	0	0
	0	0	1	0	0	1	0	0	0
	1	0	0	0	0	1	0	0	0
	1	1	0	1	1	0	1	1	0

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

Data to be sent

Checksum

In this, the data segment is divided into k segments each of m bits.

In the sender's end the segments are added using 1's complement arithmetic to get the sum. The sum is complemented to get the checksum

The checksum segment is sent along with the data segment.

At the Receiver's end, all received segments are added using 1's complement arithmetic to get the sum, the sum is complemented.

if the result is 0, the received data is accepted otherwise discarded.

Original data

10011001 | 11100010 | 00100100 | 10000100

$N=4$ $M=8$

Sender

Receiver

```

10011001
11100010
-----
10111011
      1
-----
01111100
10000100
-----
10100000
10000100
-----
100100100

```

Sum 00100101

C.K Sum 11011010

00100101

11011010

Sum:- 11111111

Compl:- 00000000

Con. Accepted data

CRC (Cyclic Redundancy Check)

This technique is more powerful than parity check & checksum error detection.

Work on binary division. A sequence of redundant bit called as CRC remainder is appended at the end.

This forms a codeword

To form this codeword an agreed upon $g(x)$ [generator polynomial] is used.

At the receiver's end this $g(x)$ is used to divide the sent codeword

Remainder = 0 implies no error

Remainder $\neq 0$ implies error

Undetected Error in CRC

CRC cannot detect all type of error

The probability of error detection & the types of detectable errors depends on the choice of division.

Binary division \oplus - EX-OR operation

x	y	output
0	0	0
0	1	1
1	0	1
1	1	0

Type 1:- Generate the CRC Code for the data word 110010101. divisor is 10101

Data word : 110010101

Divisor : 10101

Size = $m = 5$

Dividend = Data word + 'm' zeros

Dividend = 110010101 00000

Data word Added 5 zeros

```

      1111100111
10101) 11001010100000
      10101
      ---
      011000
       10101
       ---
       0011011
        10101
        ---
        011100
         10101
         ---
         010011
          10101
          ---
          0011000
           10101
           ---
           011010
            10101
            ---
            011110
             10101
             ---
             010110
              10101
              ---
              00101
               10101
               ---
               000110
  
```

Remainder = 000110

Code word.

Dividend + Remainder

$$\begin{array}{r} 11001010100000 \\ 000110 \\ \hline 11001010100110 \end{array}$$

Code word :- 11001010100110

Type 2:- codeword here received as 1100100101011
check whether there are errors in received codeword
if the divisor is 10101. (divisor = $g(x)$ g.P.

The codeword is formed by adding data word & remainder.

This will have a property that it is completely divided by divisor.

After division, if remainder is 0 then codeword is error-free, if not it has errors.

we will divide the codeword with the divisor.

$$\text{Divisor: } 10101$$

$$\begin{array}{r} 10101 \downarrow \\ 011000 \\ \underline{10101} \downarrow \\ 011010 \\ \underline{10101} \downarrow \end{array}$$

0	1	0	0
1	0	1	1

000011011
10101

Remainder $\rightarrow 01110$

Network Topologies

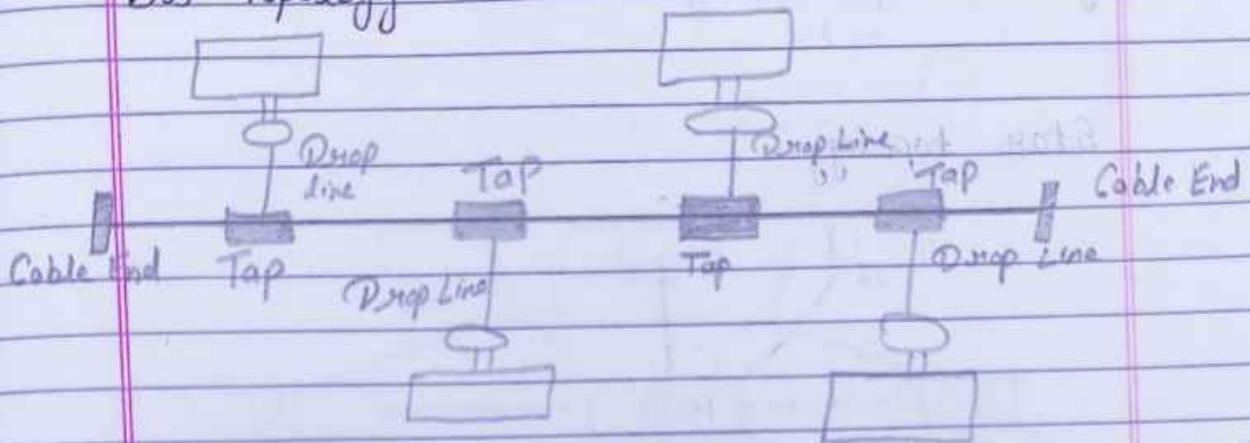
Cables medium
wireless medium

Devices are connected using communication links.

Bus Topology
Ring topology
Star topology
last companion

Mesh topology
Tree topology
Hybrid topology

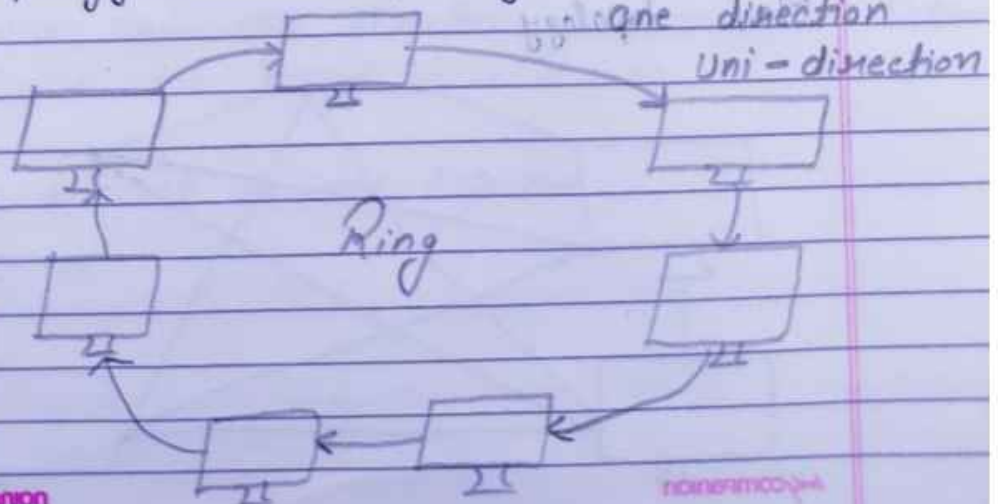
Bus Topology



Bus topology is used & easy to install on small network.

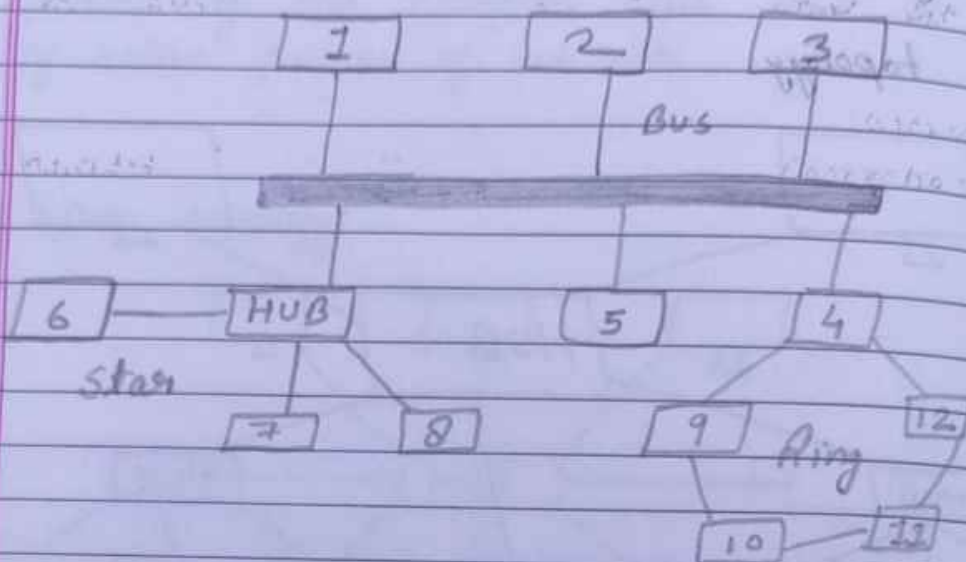
if the no. of devices are less than our bus top. work in an efficient way but when the no. of devices are in higher amount it get slow down.

Ring topology → Token passing → data flow is in



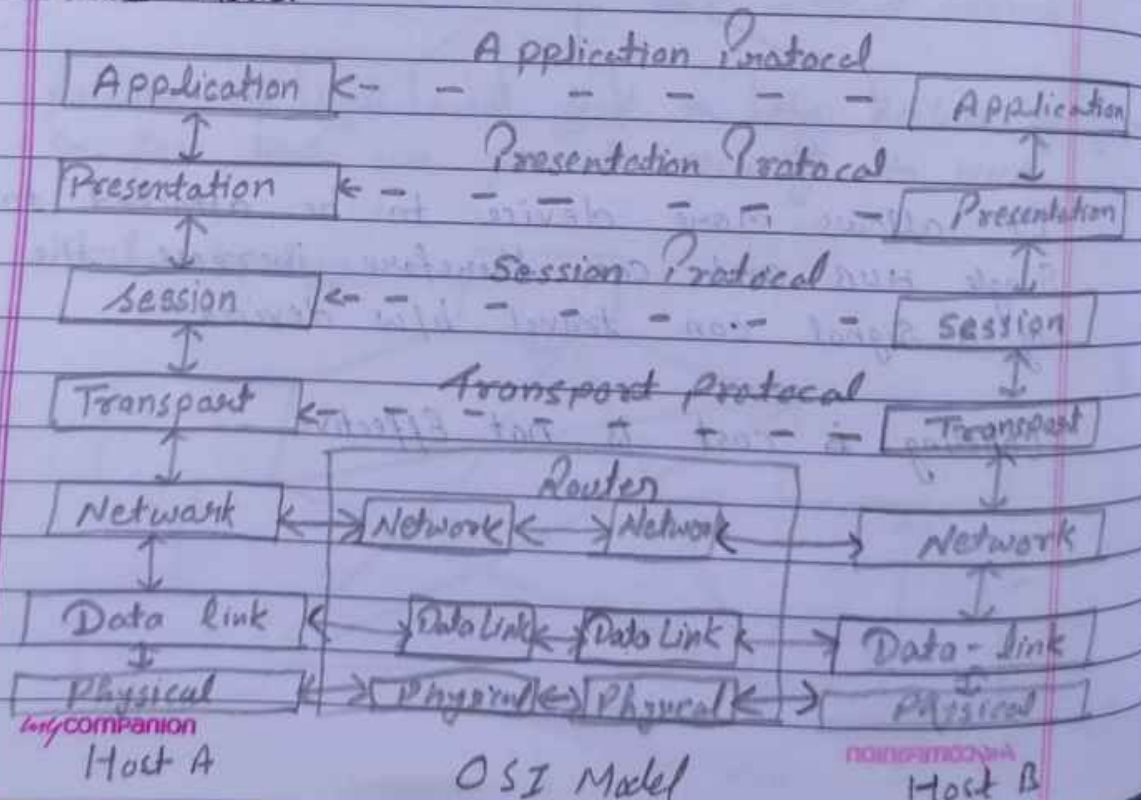
Hybrid topology

Mixture of various topologies is called as Hybrid topology



It provide us flexibility.

OSI Model



TCP/IP Model

OSI Model

Application

Presentation

Session

Transport

Network

Data link

Physical

TCP/IP Model

Application

Transport

Internet

Host to

Network

Diff. b/w. OSI & TCP/IP

OSI

It has 7 layers

Transport layer guarantees the delivery of data

It is less reliable

OSI is a General model

Follows Horizontal approach

TCP/IP

It has 4 layers

Transport (Internet) layer does not guarantee the delivery of data

It is more reliable

TCP/IP cannot use any other application hence it is not general model

Follows vertical approach

TCP/IP Model

OSI Model

Application

Presentation

Session

Transport

Network

Data link

Physical

TCP/IP Model

Application

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Host to

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Diff. b/w. OSI & TCP/IP

OSI

It has 7 layers

Transport layer guarantees the delivery of data

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OSI is a General model

Follows Horizontal approach

TCP/IP

It has 4 layers

Transport (Internet) layer does not guarantee the delivery of data

It is more reliable

TCP/IP cannot use any other application hence it is not general model

Follows vertical approach

It has a separate presentation layer

No separate presentation layer

OSI has problem of fitting the protocol in the model

TCP/IP model does not fit any protocol

Network provide both connection oriented & connectionless service

It provides only Connectionless Service

Communication channels & components

Wired communication refers to the transmission of data over a wire-based communication technology. Ex. telephone network, cable television, internet access & fiber-optic communication.

① TPC (Twisted pair cables)

A commonly used medium because it is cheaper than the co-axial cable or optical fiber cable.

Why to twist wires?

Twisting of wires will reduce the effect of noise or external interference.

The induced emf into the two wires due to interference tends to cancel out each other.

The two commonly used types of twisted pair cables are:

Unshielded Twisted pair (UTP)

Shielded Twisted pair (STP)

Characteristics of STP

Low cost medium

Used only for IBM Computer

The conductors are shielded by a braided mesh to avoid interference.

Characteristics of UTP

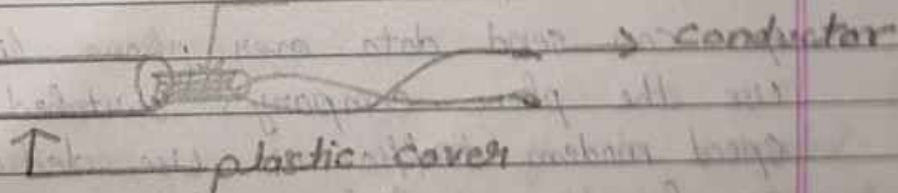
Noise & interference is high

Economical & easy to install

Used in LAN & provides data rate of ~~set~~ several Mbps.

What is STP & How it looks like?

Metal Shield



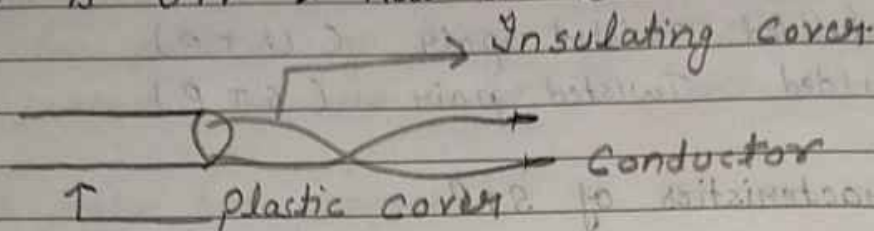
STP cable has a braided mesh included in order to cover each pair of twisted insulating conductors.

Practically UTP is used more than STP.

STP was developed by IBM

IBM Computers use this cable only.

What is UTP & How it looks like



The UTP Cable are cheap & easy to install.

Badly affected by the electromagnetic noise interference.

Telephone Line

Most telephone wire are one or more twisted pairs of copper wire. The most common type is the 4-strand (2 twisted pair). The consist of red and green wires, which makes a pair & yellow & black wires, which makes the other pair. One telephone wire line needs only two wires.

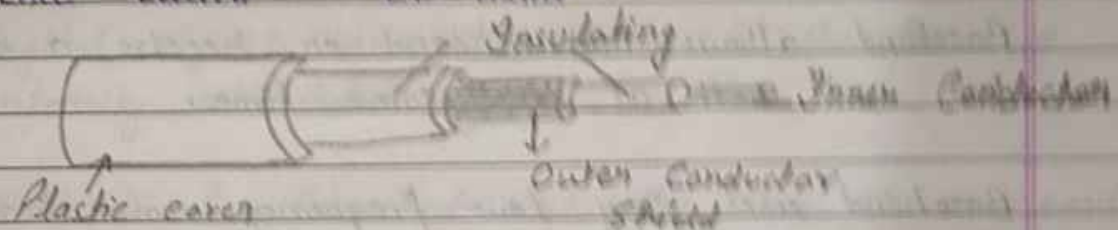
you can send data over phone lines in two ways: Use the phone company's switched network for low-speed modem traffic. or. Use dedicated circuits that can function at high speeds more or less independently of the network switching system.

Co-axial Cable

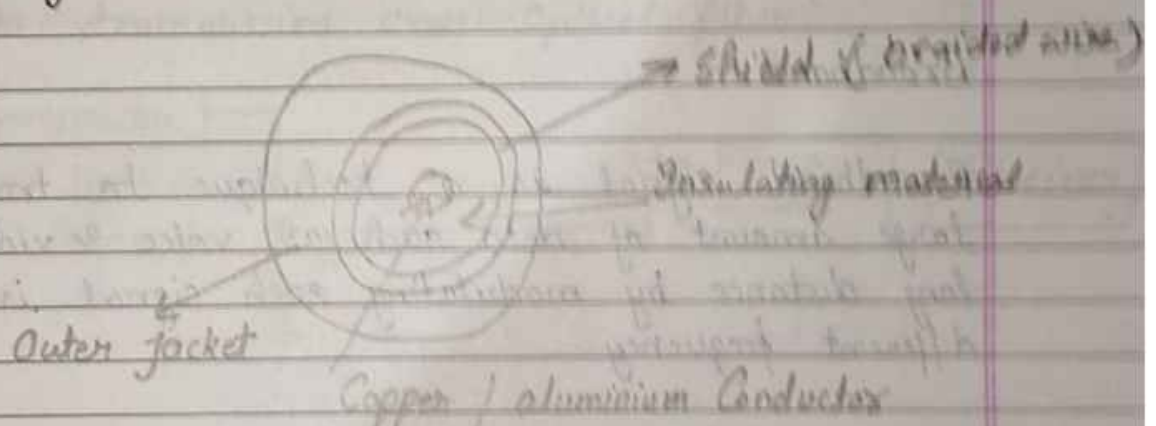
Used for Cable television, LAN & telephone

Has an inner Conductor surrounded by shielded mesh.

Both Conductors share common central axis, hence called "co-axial"



if you cut this cable



Baseband Transmission

Baseband transmission is transmission of the created signal using its own baseband frequencies i.e. without any shift to higher frequency ranges. It is used for short distance.

Baseband is a communication technique in which digital signals are placed on the transmission line without change in modulation.

Digital signals are commonly called baseband signals.

Mainly used in ethernet connection.

In baseband whole bandwidth is used to transmit a signal.

Baseband allows either send or receive a signal but not both at the same time.

Baseband uses very low frequency waves hence they are used for short distance communication i.e LAN or ethernet.

Broadband :-

Broadband signal is a technique to transmit large amount of data such as voice & video over long distance by modulating each signal into a different frequency.

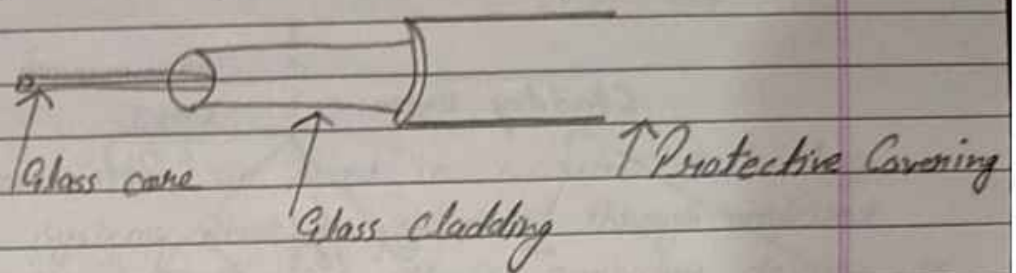
Mainly used in T.V & Radio transmission.

In broadband no. of signal can pass through the whole bandwidth.

Broadband allows send & receive the signal both at the same time.

It uses high frequency wave to transmit the information signal hence such signal can travel very long distance easily.

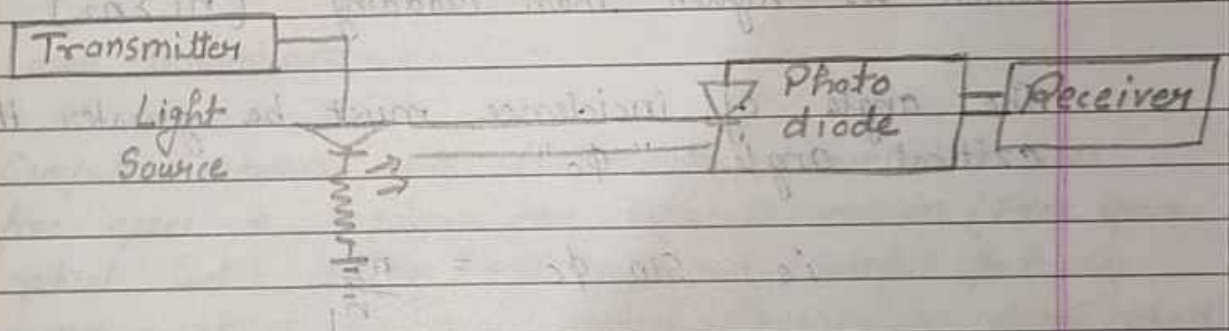
Optical fiber cable



Digital signals are transmitted in the form of intensity modulated signal.

Light is launched into the fiber at one end using a light source such as LED or laser.

Data transmission over optical fiber:



for data transmission, the transmitter must be capable of inducing data bit 0 to 1 into the light source.

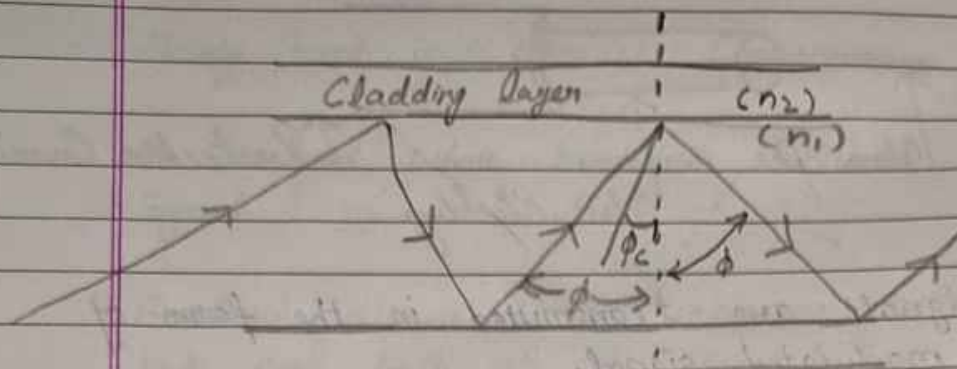
At receiver's end, a photo diode is used to transmit this light back into data bit

Sources

Light emitting diode
LED

Injection Laser diode
ILD

Principle of Light propagation in fiber



Total internal reflection follows these conditions

The glass fiber must have a refractive index which is higher than cladding ($n_1 > n_2$)

The angle of incidence must be greater than critical angle " ϕ_c "

$$\text{ie } \sin \phi_c = \frac{n_2}{n_1}$$

Characteristics

It provides extremely high bandwidth range 100 mbps to 2 Gbps.

The cost of fiber optic cable is more than others.

The installation is difficult & tedious.

Fiber optic is not affected by EMI effects & used

in areas where high voltages are passing by.

Infrared transmission

Infrared transmission is used in wireless technology devices or systems that convey data through infrared radiation. Infrared technology allows computing devices to communicate via short range wireless signals. With infrared transmission, computers can transfer files & other digital data bidirectional.

Infrared have existed for many years & their use having been limited to TV remote controls & wireless slide projector remote controls.

Laser transmission

Computer network with laser data transmission uses free space a medium for data transmission (Free Space optical link). They are especially useful for city communications network, MAN (Metropolitan Area Network). This type of network is an alternative to existing telecommunications network.

Radio transmission

Electrosignal Electromagnetic waves, lying in frequencies between 3 KHz to 10THz are called radio waves.

Omni directional, propagate in all direction.

So sending & receiving antennas do not have to

be aligned & the signals can be received by all the studios within the broadcast area.

Radio waves propagate in the sky mode, can travel long distance making it a good candidate for long distance broadcasting.

Easy to generate

Used for low data rate

App. → Multicasting (1 sender - many receivers)

AM & FM Radio

Television

Cellular phones

Satellite Transmission

A Communication satellite is a microwave repeater station in a space that is used for telecommunication, radio & television signals. A communication satellite processes the data coming from one earth station & it converts the data into another form & send it to the second earth station.

VSAT Network

A very small aperture terminal is a small size earth station used in the transmit / receive of data, voice & video signals over a satellite communication network, excluding broadcast television. The satellite

Sends & receives signals from a ground station computer that acts as a hub for the system.

Switching

When a user accesses the internet or another computer network outside their immediate location, messages are sent through the network of transmission media. This technique of transferring the information from one computer network to another network is known as switching.

Bandwidth:- It is defined as the maximum transfer rate of a cable. It is a very critical & expensive resource. Therefore, switching techniques are used for the effective utilization of the bandwidth of network.

Collision:- Collision is the effect that occurs when more than one device transmits the message over the same signal physical media, & they collide with each other. To overcome this problem, switching technology is implemented so that packets do not collide with each other.

Network

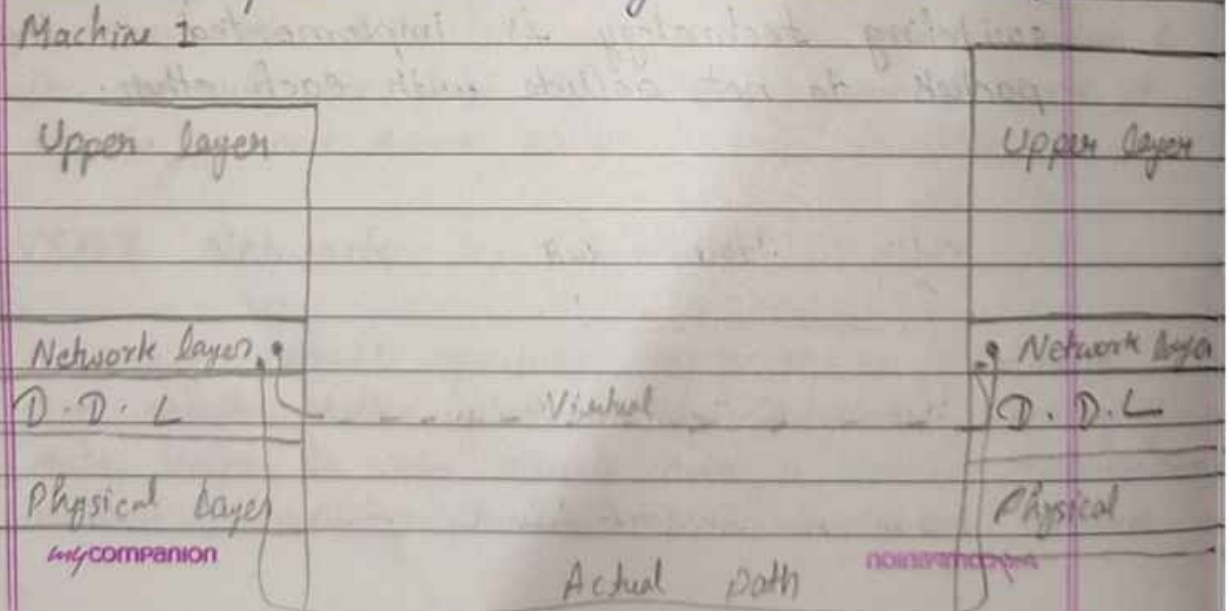
Service provided to data link layer

Data Link Layer is generally representing protocol layer in program that is simply used to handle & control the transmission of data b/w source & destination machines. It is simply responsible for exchange of frames among nodes or machines over physical network media. This layer is often closest & nearest to physical layer (Hardware).

Services Provided to Network layer.

The important & essential function of data link layer is to provide an interface to network layer. Network layer is third layer of 7 OSI reference model & is present just above Data link layer.

The main aim of data link layer is to transmit data frames they have received to destination machine so that these data frames can be handed over to network layer of destination machine. At the Network layer, these data frames are basically addressed & routed.



Actual path: Communication

In this, physical medium is present through which Data link layer simply transmits data frames. The actual path is Network layer \rightarrow Data link layer \rightarrow physical layer on sending machine, then to physical media & after that to physical layer \rightarrow Data link layer \rightarrow Network layer on receiving machine.

Virtual communication

In this, no physical medium is present for data link layer to transmit data. It can be only be visualized & imagined that two data link layers are communicating with each other with the help of or using data link protocol.

Framing

The data link layer needs to pack bits into frames, so that each frame is distinguishable from another. Our postal system practices a type of framing. The simple act of inserting a letter into an envelope separates one piece of information from another; the envelope serves as the delimiter.

Flag Abhi Flag
710 7

Flag A Flag C Flag

Flag A Esc Flag C Flag

Byte stuffing is the process of adding 1 extra byte whenever there is a flag or escape character in the text.

0 1 1 1 1 1 1 → Start frame delimiter

Frame Sent

Flag	Header	00011111110011111101000	Trailer	Flag
------	--------	-------------------------	---------	------

Extra 2 bits

Frame Received

Flag	Header	00011111110011111101000	Trailer	Flag
------	--------	-------------------------	---------	------

Unstuffed

0001111111001111101000

Data to upper layer

Error Control

Sender transmits packets in the form of frame to the receiver. But there is a travel of frame b/w sender to the receiver. So there is chances of error to occur in this travel.

S.M
Packet

R.M
Packet

Frame

H	Payload field	T
---	---------------	---

H	Payload field	T
---	---------------	---

if sender receives a positive acknowledgement about a frame, the frame has received safely.

A negative acknowledgement means that something has gone wrong & the frame must be transmitted again.

what if frame not received by receiver?

Here timer concept is used.

when the sender transmits a frame, it also starts a timer.

Before expiry of this timer acknowledgement from receiver must reach to the sender.

In absent of acknowledgement sender will again transmit the frame.

What is acknowledgement sent by receiver not reached to sender?

In this case may possible sender sent multiple frames.

To prevent from receiving same frames by receiver sender assign a sequence number to the frame.

By seeing sequence number receiver identifies that it's duplicate frame.

Flow Control

D.S 5mb/s

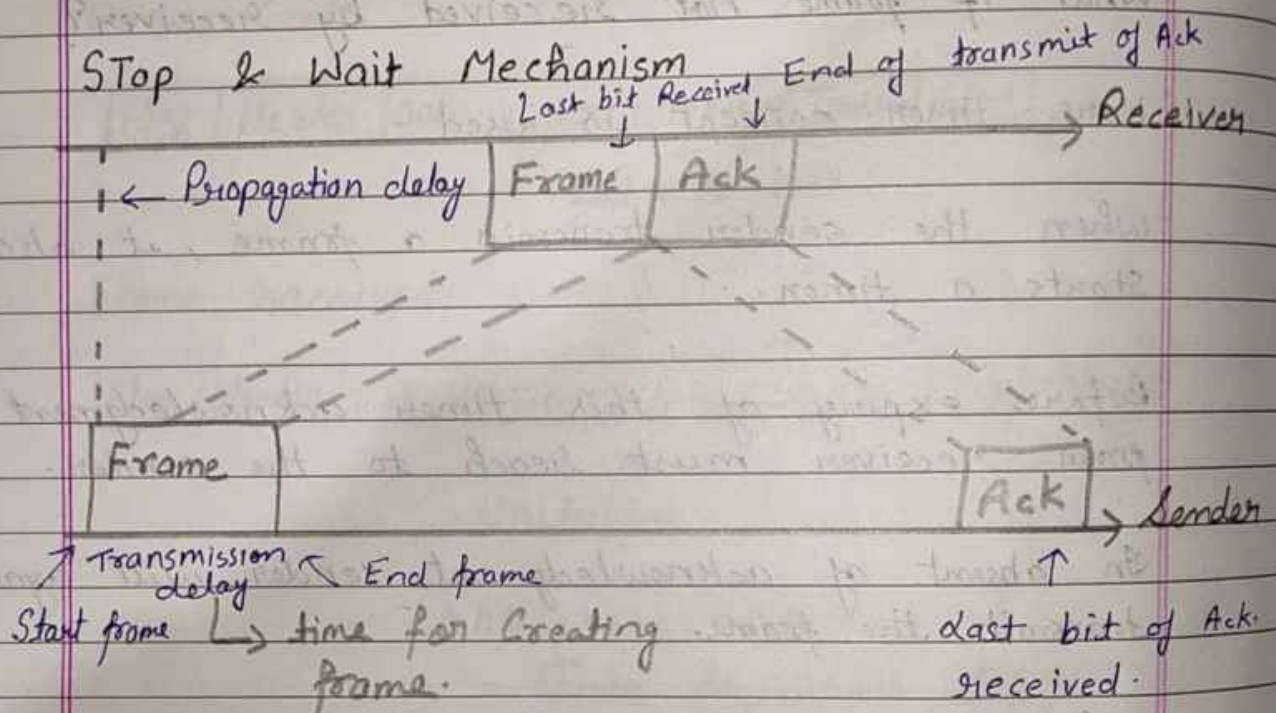
D.R 3mb/s

Sender

Receiver

So, here managing the data rate in specific manner by which receiver can receive data properly is called flow control

Stop & Wait Mechanism



A transmitter transmit the frame

Transmitter wait for the acknowledgement for fixed period of time.

On receiving valid frame, Receiver send back an acknowledgment for next time.

On receiving acknowledgement transmitter transmit next frame

if sender not received any acknowledgement with time duration it re-transmit the same frame.

The rate of transmission depends on the processing power of the receiver.

What if the size of the frame is large?

The transmitter divides large messages into smaller frames.

Then transmit these smaller frames.

Sliding Window protocol

Sender sends a fixed number of frames without acknowledgments.

Each frame is labelled with a sequence number.

On getting acknowledgment from the receiver

Sender sends more frames.

Each acknowledgment is labelled with a respective frames sequence number.

Size
Window is 7

Sender can transmit 7 frames without acknowledgement

Frame no. 1, 2, 3, 4, 5, 6, 7

① ② ③ ④ ⑥ ⑦ 8 9 10 11

Now Sender transmit 4 frames & received an acknowledgment that the first 3 frames are successfully received.

① ② ③ 4 6 7 8 9 10 11

The window will slide forward by 3 frames

1 2 3 ④ ⑤ ⑥ ⑦ ⑧ ⑨ ⑩ 11

Now Sender will cover next 7 frames.

Frame no. 4, 5, 6, 7, 8, 9, 10

which looks like window is sliding from left to right.

High Level Data link Protocol (HDLC)

The high level data link protocol (HDLC) developed by ISO.

HDLC is a bit-oriented data link protocol, and it

is designed to satisfy many of data control requirements.

HDLC protocol has three stations defined

1. Primary Station - Sender \rightarrow responsible \rightarrow more features - more
2. Secondary Station - Receiver \rightarrow " \rightarrow less " \rightarrow less
3. Combined Station \rightarrow Both \rightarrow Can transmit & receive

Following modes of operation are possible in (HDLC)

1. Normal Response mode (NRM)
2. Asynchronous Response mode (ARM)
3. Asynchronous balanced mode (ABM)

1. Normal Response Mode (NRM)

This mode is suitable for point to point as well as point-to-multipoint configuration.

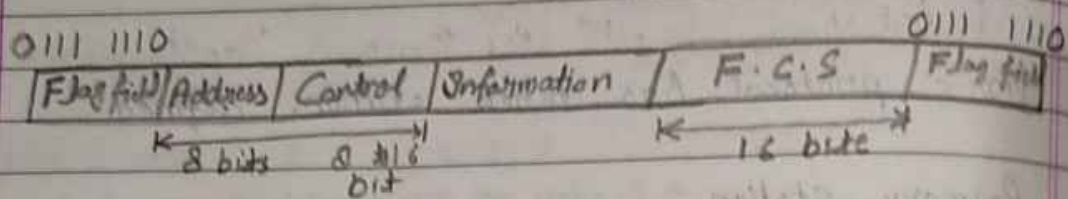
2. Asynchronous Response mode (ARM)

This mode is used for communication b/w primary & secondary stations.

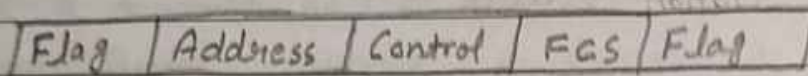
3. Asynchronous Balanced Mode (ABM)

This mode is applicable to point-to-point communication b/w combined station.

Frame Structure in HDLC



Information transfer Frame



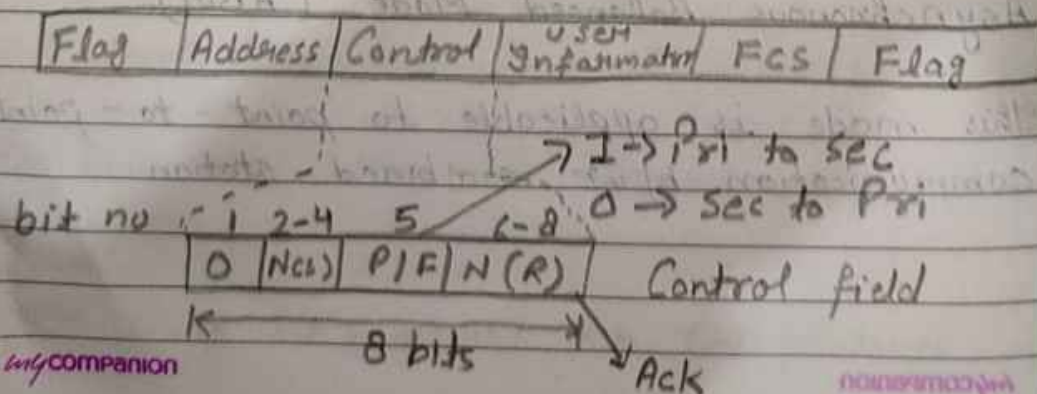
Supervisory frame

1. Flag field
2. Address field \rightarrow Hold the address of Secondary station
3. Control field \rightarrow flow control \rightarrow Ack \rightarrow Frame Sequence
4. Information field
5. FCS field (Frame check Sequence)

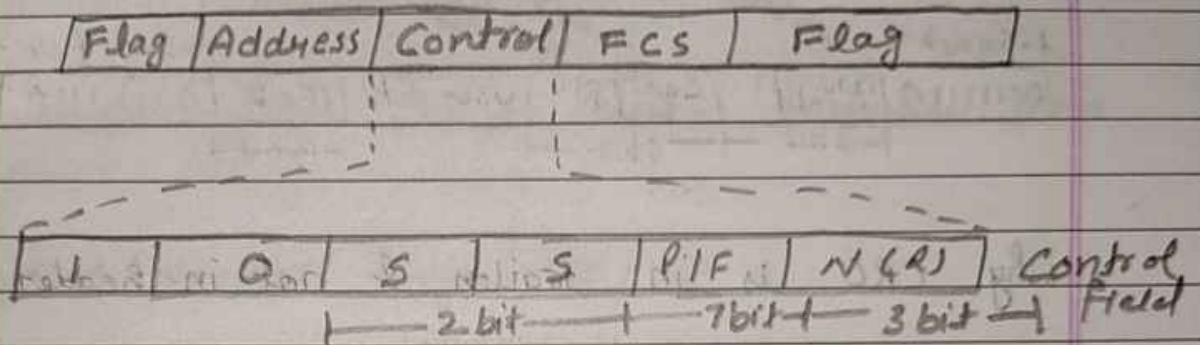
Three types of frame defined in HDLC

1. I-frame
2. S-frame
3. U-frame

The I-Frame



S frame



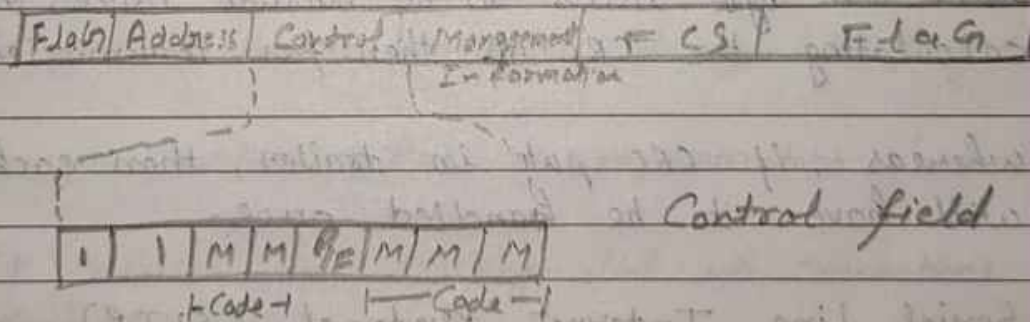
SS = 00 → (RR) - receive ready

SS = 01 → (RJ) - reject frames

SS = 10 → (RNR) - receive not ready

SS = 11 → selective - repeat frame

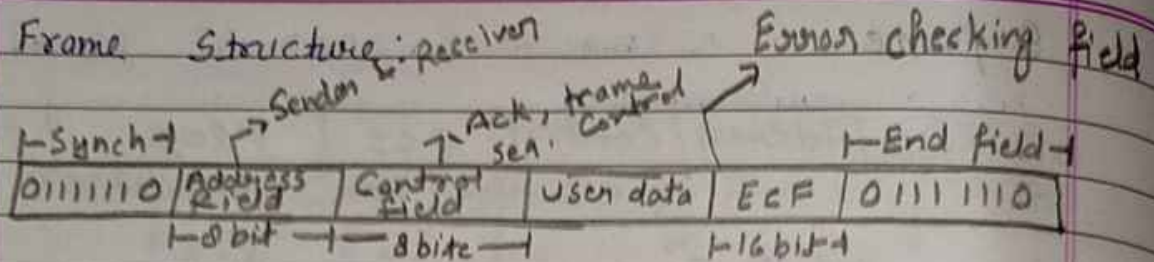
3 U - Frame



SDLC (Synchronous Data Link Control Protocol)

SDLC protocol is used by IBM. This is not a standard but it is a widely used protocol.

SDLC is basically a subset of HDLC but with minor additional features.



Why CRC is in trailer & not in header?

Data link protocols so far, the CRC Field which contains the checksum for error detection & correction always appears in trailer, why so?

The CRC is obtained by adding all the bits being transmitted & appended to outgoing stream.

For each byte needs to be handled twice, once for calculating the CRC & then for transmission.

whereas, if CRC put in trailer, then each byte will have to be handled once.

Serial Line Internet Protocol (SLIP)

It is simple protocol that developed for UNIX environment & works with TCP/IP for communication over serial ports & routers. 1984 - Rick Adams

Communication b/w previously configured for direct communication with each other.

Older serial line protocol that does not support automatic negotiation of network configurations.

It has been replaced by PPP (point-to-point protocol) because of.

windows 2000 can't accept connection from SLIP clients.

SLIP supports only TCP/IP

SLIP requires the user to write script for automating login process.

It requires host's TCP/IP parameters configured manually.

Advantage

Support Internet protocol. deployment easy.

it is suitable for microcontrollers.

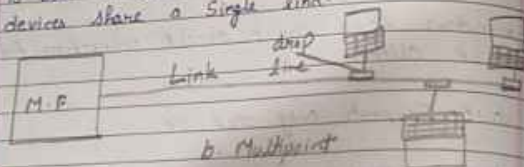
It reuses the existing dial up connections & telephone lines.

Point to Point

A point to point connection provides a dedicated link b/w two devices.

Most point-to-point connections use an actual length of wire or cable to connect the two end but other options, such as microwave / Satellite links, are also possible.

A multipoint (also called multidrop) connection is one in which more than two specific devices share a single link.



Aloha

→ Random Access Protocol

Ack is there

LAN based protocol

Only transmission time

No propagation time

Vulnerable time



$$T_p = \frac{M}{BW} = \frac{1000 \text{ bits}}{10^6 \text{ bps}} = 10^{-3} \text{ s} = 1 \text{ ms}$$

$$V_t = 2 \times T_p$$

$$\text{Efficiency } \eta = G \times e^{-2G}$$

$$\begin{aligned} \frac{d\eta}{dG} &= G \times e^{-2G} (-2) + e^{-2G} (1) = 0 \\ &= e^{-2G} (-2G + 1) = 0 \quad -2G + 1 = 0 \\ &= G = 1/2 \end{aligned}$$

Slotted Aloha



$$V_t = T_p$$



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

$$\begin{aligned} \frac{d\eta}{dG} = 0 &\Rightarrow G \times e^{-G} (-1) + e^{-G} (1) = 0 \\ &\Rightarrow e^{-G} (-G + 1) = 0 \\ &\Rightarrow -G + 1 = 0 \\ &\Rightarrow -G = -1 \\ &\Rightarrow G = 1 \end{aligned}$$

$$\eta_{\text{max}} = \frac{1}{e} = \frac{1}{2.718} = 0.368 = 36.8\%$$