Data Communication and Networking

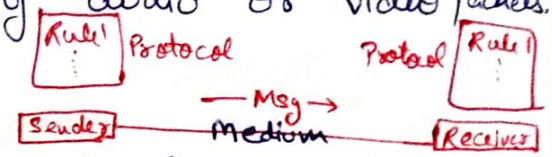
Module 1

Basics of Data Communication – Type of Connection – Physical Topology – Categories of Networks – Protocols & standards – Layered Tasks – OSI Model – TCP/IP Protocol Suit – TCP/IP Addressing

Data Communication

Effectiveness of data communication depends on four fundamentals

1) Delivery — Correct device / user.
2) Accuracy
3) Timeliness — Real time transmission with no significant delay.
4) Jitter — refers to variation in the packet arrival time. It is uneven delay in the delivery of audio or video packets.



Components of data Communication:

1) Message — Includes text, no., pics., audio & video. It's the info" to be communicated.
2) Sender — Eg computer, workstation, telephone handset ....
3) Receiver — Eg " " "
4) Transmission Medium — Physical path by which msg travels. Eg twisted pair wire, coaxial cable, fibre-optic cable, radio waves
5) Protocol — Set of rules that govern data comm. It's an agreement b/w 2 communicating devices.

Data Representation

Text – Represented in bit patterns (0 & 1) called code. Prevalent coding today is Unicode, uses 32 bits.

Numbers – It is also represented by bit patterns (binary)

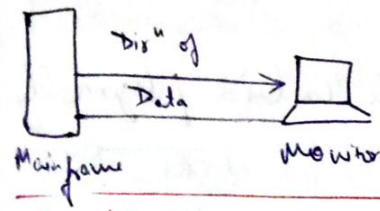
Images – by bit patterns. Image is divided into pixels. No. of pixel depends on resolution. Each pixel is assigned a bit pattern to denote intensity of colour. There are several methods to represent colour images Eg RGB (Red Green Blue) is used make all colours
YCM (Yellow, Cyan & Magenta) " " "

Audio - By nature it diff from text, no. & pics
It is continuous, not discrete.

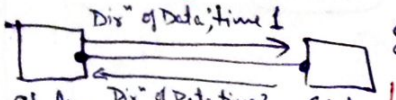
Video - It can be produced as continuous entity, or it can be a combination of images.

Data Flow Communication b/w two devices can be simplex, half-duplex, or full-duplex.

1) Simplex Mode Unidirection comm"; one-way street
Only one of two transmits, the other receives.
It uses entire capacity of channel to send in 1 dir"



2) Half-Duplex Mode Both can transmit & receive but not at same time. Eg Walkie-Talkies
Entire capacity of channel can be used for each dir".



3) Full Duplex Mode Both can send & receive the data simultaneously. Eg Telephone Network

Network - Set of devices (nodes) connected by communicating links.
Distributed processing in which task is divided among multiple comp.

Network Criteria: must be able to meet following —
1) Performance can be measured by transit time, response time etc. Transit time is time for travel of msg from one device to another. Response time is elapsed b/w inquiry & response.
Also performance is good with more throughput and less delay.
2) Reliability is measured by freq. of failure, the time it takes a link to recover from a failure, and the networks' robustness in a catastrophe.
3) Security Protecting data from unauthorised access, breaches, data loss etc.

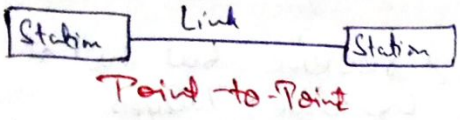
Physical Structures

Type of Connections

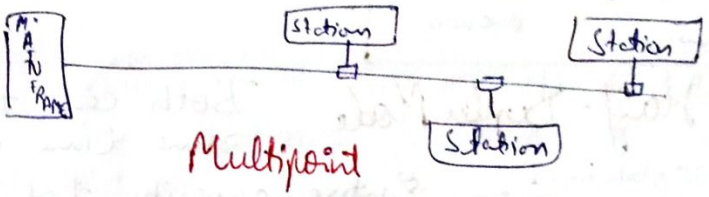
1) **Point-to-Point** Dedicated link; entire capacity reserved; Mostly it includes actual length of wire or cable but microwave & satellite links are also possible.

2) **Multipoint** where more than two specific devices share a single link. Capacity of channel is shared, either spatially or temporally.

Physical Topology is way in which network is laid physically.



Point-to-Point



Multipoint

Categories of Topology

Mesh

- Every device linked to every device, point-to-point.
- $\frac{n(n-1)}{2}$ full-duplex mode links are required.
- Each device should have (n-1) I/p-O/p ports

Advantage:
- Privacy & Security
- Robust System
- No traffic Problems
- P-to-P makes fault-identification & fault isolation easy.

Disadvantage:
- Amt. of Cable & port needed
- Installation & reconnection difficult.
- Costly

Use: As backbone of Hybrid

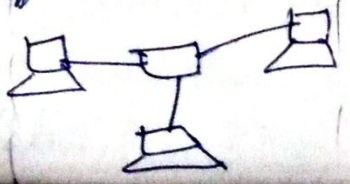
Star

Each device has dedicated p-to-p connection with hub

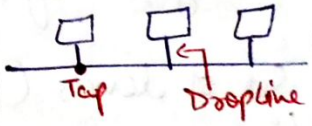
Advantage:
Less costly than mesh
Easy install & configure
Robust
Easy fault identification & fault isolation

Disadvantage:
Whole network depends upon single point: Hub

Use: LAN's use it.



Bus



Long cable is backbone of network

Tap: is a connector that splices into main cable or punctures the sheating of cable.

As signal travels in backbone cable some of it converts into heat, so there is a limit on the no. of taps & dist. b/w taps & length of cable.

Ring

Dedicated connection with adjacent device.

When a devices receives a signal intended for another device, its repeater regenerates the bits & passes them along.

Hybrid Topology Combination of diff. topology.

Categories of NetWork → LAN, WAN, MAN

LAN Privately owned; For few kms;
Commonly use bus, ring or star topology.

WAN Provides long dist. transmission of data overe large geography.
The switched WAN connects end systems, which usually

MAN Size in LAN & WAN.
Designed for high speed connectivity

When two or more of LAN & MAN are connected, they become internetwork or internet.

Protocols and Standards

For communication two entities must agree upon a set of rules called protocol. A protocol defines how, what, and when it is communicated.

Following are the key elements of protocols:—

1) Syntax is structure or format of the data, meaning the order in which they are presented.

2) Semantics refers to meaning of each section of bits.
Eg — does a address identify the route to be taken or the final destination of the message?

3) Timing refers to two characteristics: when data should be sent? & how fast it could be sent?

Standards are essential in creating & maintaing an open & competitive market for equipment manufacturers & in guaranteeing national & international interoperability of data & telecommunications technology & processes.

De facto Standards (by convention) Not adopted by organization but used widespread.

De jure Standards that have been legislated by an official organization.

Layered Tasks

Each layer at the sending site uses services of layer immediately below it. The sender at the higher layers uses the services of the middle layers.

↳ OSI
↳ TCP/IP

OSI

Application Intermediate nodes only involve first three layers.

The process on each machine that communicate at a given layer are called peer-to-peer processes

Interface b/w layers : Each pair of adjacent layers have interface. Each interface defines info" & services a layer must provide for the layer above it. Well defined interfaces & layer fuc" provide modularity to a network.

1 Phy.
2 Data Link
3 Network

} Network support ← layers

They deal with physical aspect of moving data such as electrical specifications, Phy. connections, phy. addressing, & transport timing & reliability.

5 Session
6 Presentation
7 Application.

} User support ← layers

Allow interoperability among unrelated software system.

4 Transport layer Links the above 2 subgroups & ensures that what lower layers have transmitted is in a form that upper layers can use.

The upper OSI layers are almost always implemented in software; lower layers are a combination of hardware & software, except for the phy. layer which is mostly hardware.

Physical Layer Deals with phy. mechanical & electrical specifications of the interface & transmission medium.

Responsible for movement of individual bits from hop to hop.

Also concerned with ⟶

- Physical Characteristics of interfaces & medium.
- Representation of bits Here bits need to be changed to electrical or optical signals (encoding). Phy. layer defines type of encoding.
- Data rate Transmission Rate (Bits sent per second) is defined by PL.
- Synchronization of bits Sender & receiver clocks must be synchronized.
- Line configuration PL is concerned with connection of devices to media. In a point-to-point configuration, two devices are connected through dedicated link.
- Physical Topology
- Transmission Mode Simplex, Halfduplex, Fullduplex

Data Link Layer

It transforms raw transmission facility of PL, to a reliable link.

Responsible for moving frames from hop to hop.

Other responsibilities ⟶

Framing Divides stream of bits into manageable data units frames.

Physical Addressing DLL adds header to frame to define sender/receiver.

Flow Control DLL imposes flow control mechanism to avoid overwhelming the receiver.

Error Control Adds reliability by adding mechanism to detect & retransmit damaged & lost frames.

Access Control

OSI

Open System Interconnection Model

Each layer is package of protocols which are required make these applications work correctly.

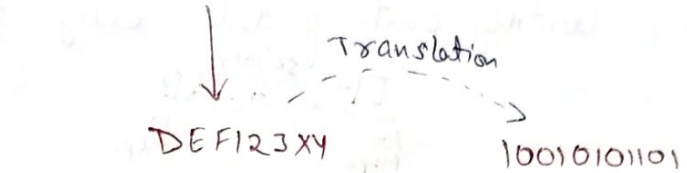
Application Layer is used by network app. (that use internet) like chrome, firefox, skype etc.

Protocols HTTP, HTTPs, TELNET, FTP etc work surfing

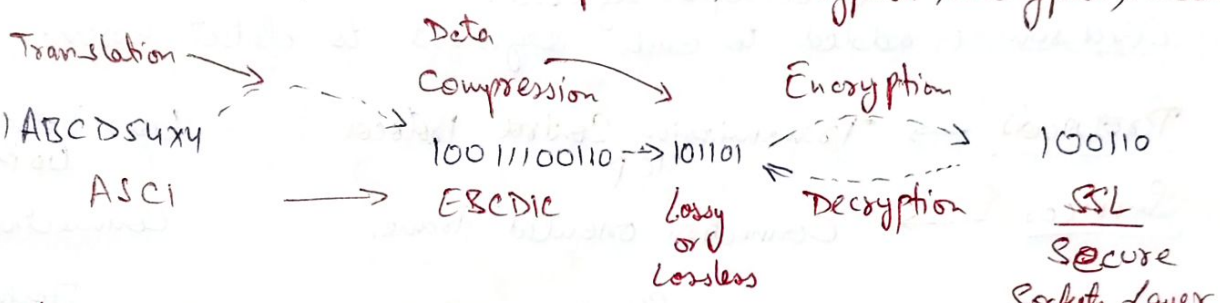
FTP for File Transfer, HTTP/S Web Surfing, SMTP for Emails

TELNET Virtual Terminals

Presentation Layer



Presentation Layer performs data compression, encryption, decryption, translation



Session Layer helps in setting up and managing connections, helps in sending & receiving of data followed by termination of connection.

It has APIs (App. programming interfaces), eg NETBIOS (Network basic I/p O/p Systems) which allows app. on diff. comp. to communicate.

- Authentication Just before establishing connection, network performs authetication, to verify who is the user.

It uses Username - Password to verify, later a session/connection is established b/w comp. & server.

- Authorization It checks what services current user can access.
- Session Management

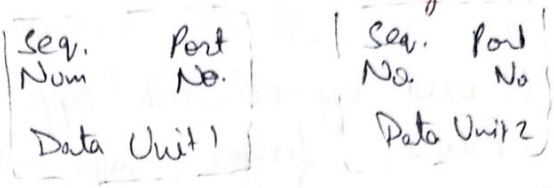
Session Layer also keeps track of file downloaded & uploaded.

Files received in form of data packets are tracked by SL that where they come from & go to.

Transport Layer controls reliability.

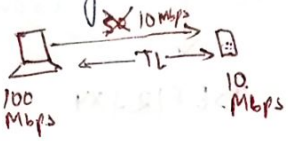
It splits data into segments.

- Segmentation



Each segment has
Dest. Port no. — to send data at correct dest.
Sequence no. — to arrange segments in sequence at receivers end.

- Flow Control — Controls amt. of data being transmitted.



- Error Control — by Automatic Repeat Request scheme for missing packet or corrupted segment.

Checksum is added to each segment to detect error.

Protocols → Transmission Control Protocol (TCP) | User Datagram Protocol (UDP)

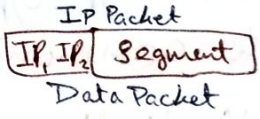
Services → Connection oriented Trans.n | Connectionless Trans.n

	Slow	Faster
	Feedback	No Feedback
Eg	WWW, email FTP	Games, Movie

Network Layer

Transmits recieved data-segments from one comp. to another, in diff. network.

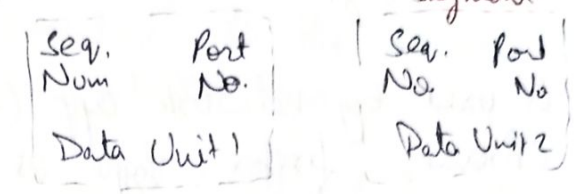
Routers are present in this layer.



- Logical Addressing — IP addressing done here is logical add.n
  IP address of sender & receiver is attached to segment
- Routing — Based on IP address & mask, routing decision are made.
  Its a method of moving data packet.
- Path Determination — Chossing best path from sender to receiver using protocols —
  OSPF - Open Shortest Path First
  IS-IS Intermediate System – Intermediate System
  BGP – Border Gateway Protocol

Transport Layer controls reliability.

- Segmentation — It splits data into segments.



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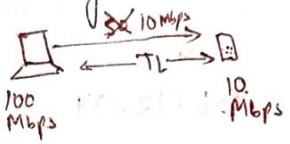

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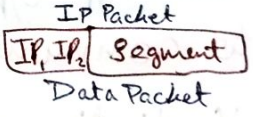

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↓ Data Packets / IP packet

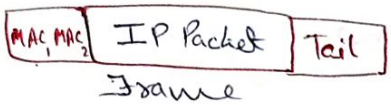
Data Link Layer

Physical Addressing — MAC address of sender & receiver is added to data packet to make it a frame.

- MAC add. is a 12 digit alphanumeric no. embeded in the network interface card (NIC) of comp.
- DLL is embeded in NIC of comp. as software & provide means to transfer data via local media.

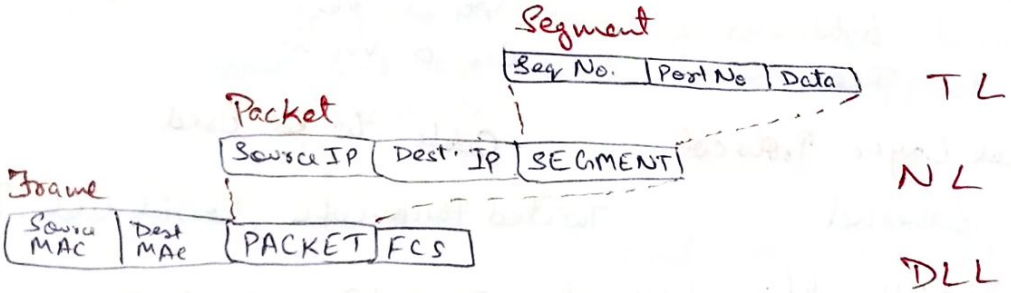
Local Media → Copper wire, optical fibre, air signals

Framing — DLL allows upper layers to access media using Framing. Controls how data is placed & received from the media using techniques Media Access Control, Error Detection

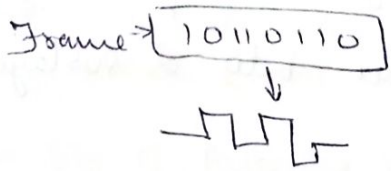


← Tail is for error detection

Using Media Access Control, DLL gets frame on & off the media. Many devices may be connected to one media, which may cause collision of their data, so DLL checks when media is free to transmit, this is called Carrier-sense multiple access (CSMA)



Physical Layer



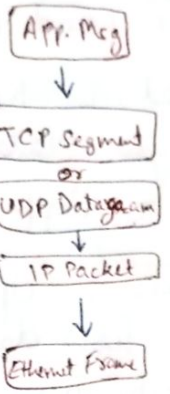
PL converts bits of frame into signals to transmit through media.

TCP/IP

Transmission Control Protocol / Internet Protocol

OSI is used for research and TCP/IP is practical model developed to meet the needs of original internet design.

	PROTOCOLS			
Application	HTTP	FTP	DNS	POP3
Transport	TCP UDP			
Network	IP	ICMP	ARP	
Data Link	Ethernet			
Physical	Ethernet			



Physical Layer is where actual commun. takes place. It convert bits into signal & transmits over media.

Signal	Local Media
Electrical	Copper Cable / LAN Cable
Light	Optical Fiber
Radio	Air or Vaccum

Physical Layer Protocol	Cable to be used
Ethernet	Twisted Pair cable, Coaxial Cable, Fiber Optic Cable
Fast Ethernet / Gigabit Ethernet	Twisted PC, Fiber OC

Data Link Layer is divided into 2 sublayers

Medium Access Control
MAC Sub Layer

- **Data Encapsulation** MAC Sub layer adds a header & trailer to IP packet received from Network layer.

- **Accessing the media** MAC Sub layers uses the Access method CSMA/CD Carrier Sense Multiple Access / Collision Detection

Logical Link Control
LLC Sub Layer

- Flow Control
- Error Control → Detection → Retransmission

LLC Sub layer re-size the IP packets received from the network layer to fit them in the DLL frame

Transport Layer provides most of services of LLC Sub layer including flow control, error control, sizing of packet, therefore the services of LLC are usually bypassed.

Network Layer, Transport Layer, Network Layer are in software app.

Network Layer — Transport Layer passes TCP segment or UDP Datagram to NL. NL adds Logical /IP add. to form IP packet & then they are sent using routers.
Logical Addressing, Path Determination, Routing
Protocol :- IP

Transport Layer — can use either TCP or UDP.
TCP uses segmentation but UDP does not

Application Layer

Protocols

(DNS) Translates IP address to Domainame & vice-Versa
Domain Name System

Dynamic Host Configuration Protocol (DHCP) Auto assigns IP addresses

FTP	Transfers File
HTTP	send & receive webpages
SNMP	Simple Network Management Protocol, managing devices using TCP/IP
TELNET	Terminal Network, Establish connection b/w local comp. & remote comp. such that local terminal appears to be a terminal at remote sys.

Protocol in Internet / Network Layer

- Address Resolution Protocol (ARP) Finds physical address from IP add.
- Internet Control Message Protocol (ICMP) Used by Host/Routers to send notification regarding datagram problem but it doesn't fixes the problem.
- Internet Group Management Protocol (IGMP) Used to create & send msg. to a group of units.

Ping It tests the reachability of particular node.

Data & Signals

Analog & Digital Data

Analog Data — continuous info" Eg: Clock with hr, min, & sec hands gives continuous info" as movement of hands is continuous.

Digital Data — discrete states Eg Digital Clock reporting hrs:min will change suddenly from 8:00 to 8:01

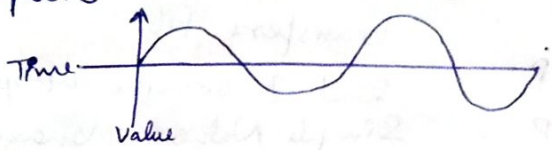
Analog Signal has infinitely many levels of intensity over a period of time.

Digital Signal can have a limited number of defined values.

Both digital & analog signals can be periodic and non-periodic.

In data comm". we commonly use **periodic analog signals** & **non-periodic digital signals**.
bcoz it needs less bandwidth
bcoz it can show variation

Periodic Analog Signals → Simple / Composite



Simple PAS is a **sine wave**.
Smooth, consistent, rolling flow
It can be represented by 3 parameters **peak amplitude**, **frequence**, **phase**.

Peak Amplitude: Absolute value of its highest intensity, proportional to energy it carries.

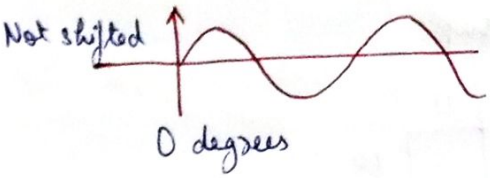
Period Amt. of time in sec. to complete one cycle $T = 1/f$ seconds

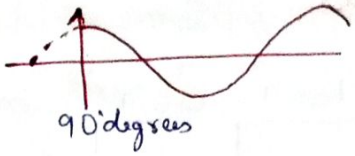
Frequency No. of periods per seconds $f = 1/T$ hertz

Unit	Equivalent	Unit	Equivalent
s	1 s	Hertz	1 Hz
Millisecond (ms)	10^{-3} s	kHz	10^3 Hz
Microsec (μs)	10^{-6} s	Megahz (MHz)	10^6 Hz
Nanosec (ns)	10^{-9} s	Giga Hz (GHz)	10^9 Hz
Picosec (ps)	10^{-12} s	Tera Hz (THz)	10^{12} Hz

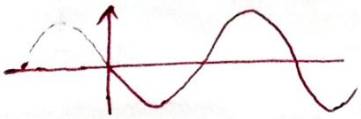
Phase describes the pos^n of waveform relative to time 0.
Measured in degrees or radians.

Three sine waves with same amplitude & freq. but diff. phases.





Shifted left by 1/4 cycle.



Shifted left by 1/2 cycle.

Phase can be seen in terms of shift/offset also.

Q A sine wave of offset 1/6 cycle. What is its phase in radian.

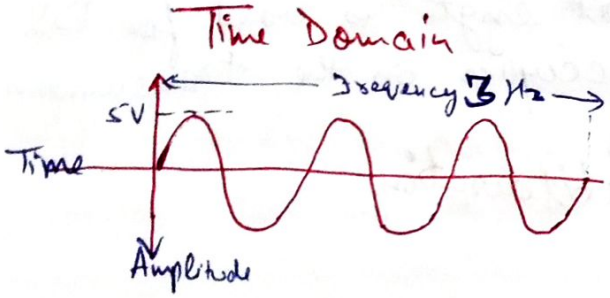
$\frac{1}{6} \times 360^\circ = 60^\circ = 60 \times \frac{2\pi}{360}$ rad $= \frac{\pi}{3}$ rad $= 1.046$ rad

Wavelength λ (micrometers μm)

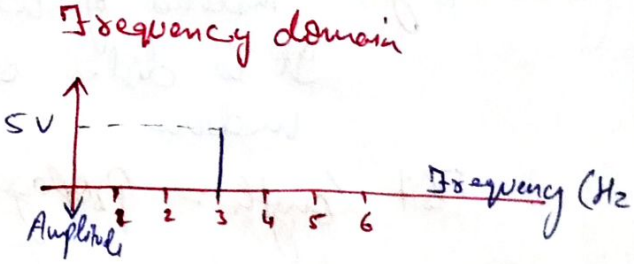
Dist. single signal can travel in one period.

$\lambda = c/f$ $\quad$ c = propagation speed.

$\lambda = c \times \text{period} = \frac{c}{f}$



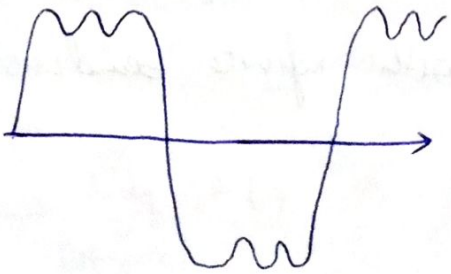
Same wave in diff. domain

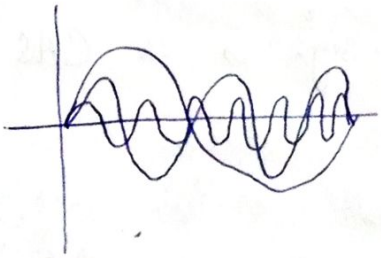


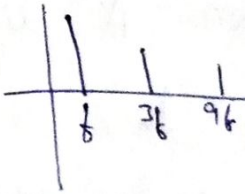
A complete sine wave in time domain can be represented by one single spike in the frequency domain.

Composite Signal

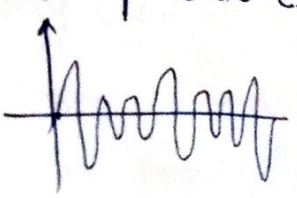
Periodic CS

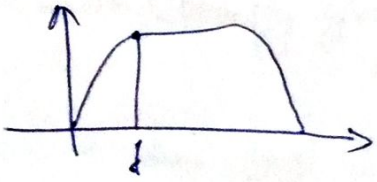






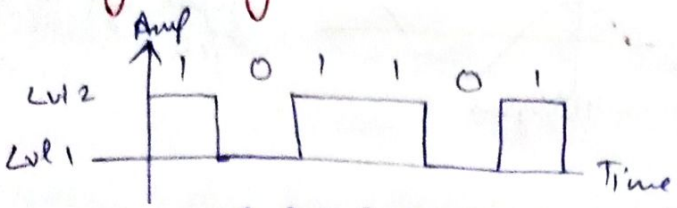
Non-periodic CS



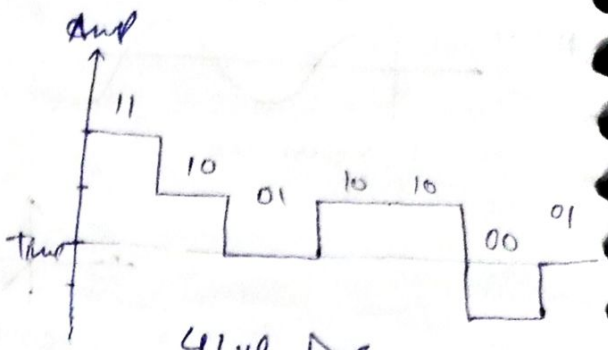


Bandwidth $B = f_h - f_l$ = Bandwidth of CS.

Digital Signals



2 level DS



4Lvl DS

No. of bits/level = $\log_2 L$ (L = no. of levels)

Bit Rate instead of 'freq.' is used to describe Non-periodic DS.
unit – bits/sec (bps)

Bit Length instead of 'wavelength' bit length is used for DS.
It is dist. one bit occupies on the transmission medium

Bit Length = Propagation speed × bit duration

Baseband Transmission means sending a DS over a channel without changing the DS into AS.

A dig. sig. is a CAS with infinite bandwidth.

In

Transmission Impairment

① **Attenuation** — loss of energy; weakening of signal. Amplifier are used to amplify.

Unit → Decibel (dB) to measure relative strength. -ve for attenuation, +ve for amplification

$$dB = 10 \log_{10} \frac{P_2}{P_1}$$

② **Distortion** — Signal changes its form or shape. Due to diff. delay in diff. signals of composite signal distortion is caused.

③ **Noise**

Thermal Noise is random motion of e^- in a wire creating extra signal.
Induced Noise comes from source like motors/appliances
Crosstalk is effect of one wire on another.
Impulse Noise is a spike (signal with high energy in a very short time) coming from power line, lightning etc.

Signal to Noise Ration (SNR)

$$SNR = \frac{\text{avg. signal power}}{\text{avg. noise power}} \qquad SNR_{dB} = 10 \log_{10} SNR$$

Data Rate Limits

How fast we can send data.

depends on:
- Bandwidth
- Level of signals
- Quality of Channel (lvl of noise)

Noiseless Channel: Nyquist bit rate formula defines theoretical max bit rate.

$$\text{Bit rate} = 2 \times B \times \log_2 L$$

Noisy Channel: Shannon Capacity gives theoretical highest data rate

$$C, \text{Capacity} = B \times \log_2 (1 + SNR)$$

For practical purpose when SNR is very high then, $C = B \times \frac{SNR_{dB}}{3}$

Performance

① Bandwidth — { in Hz / in bps }

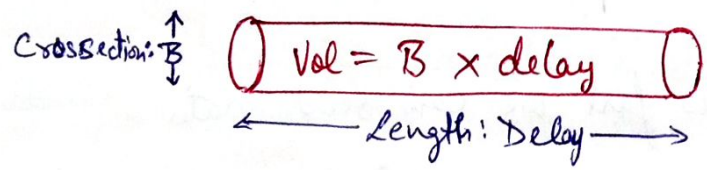
② Throughput — how fast we can actually send data through a network.

Throughput = Bits sent / sec. bps

③ Latency (Delay) = propagation time + transmission time + queuing time + processing time

- **propagation time** — time req. to travel from src to dest. by a bit.
  $= \frac{\text{Dist}}{\text{Prop. speed}}$
- **transmission time** — time req. to send complete msg.
  $= \frac{\text{Msg size (bits)}}{\text{Bandwidth}}$
- **queuing time** — time needed by intermediate or end device to hold the msg. before processing
  not fixed
  depends on traffic
- **processing time**

Bandwidth - Delay Product defines the no. of bits that can fill the link



Jitter is a problem if diff. packets of data encounter diff. delays & the app. using data at receiver's end is time sensitive. (Audio & Video)

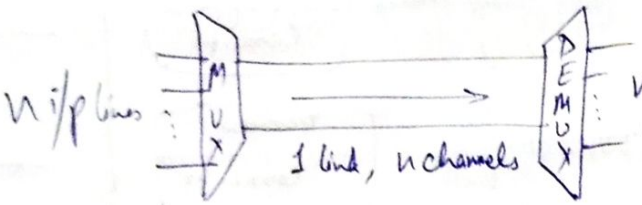
Digital Transmission

Bandwidth Utilization : Multiplexing & Spreading

Bandwidth utilization is wise use of avail. B to achieve specific goals.

Efficiency can be achieved by multiplexing ; i.e. sharing B b/w users.

Privacy & antijamming can be achieved by spreading



Multiplexing →
- Freq-division mul.ⁿ Analog
- Wavelength-division mul.ⁿ Analog
- Time-division mul.ⁿ Digital

① Freq. division Multiplexing FDM

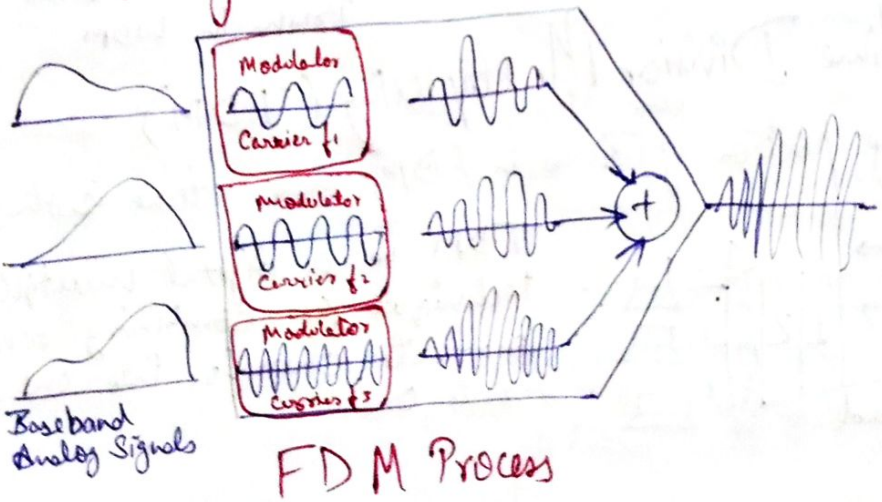
can be applied when B of link (in Hz) is greater than B of signals to transmit together.

Carrier freq. are seperated by sufficient B to accomodate the modulated signal.

Channels are seperated by unused B called guard bands – prevents overlapping of signals.

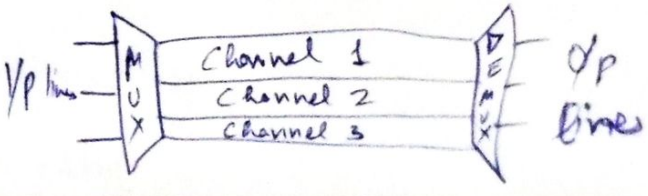
* Signals generated by each device (shift) modulate diff. carrier freq., these are combined into composite signal

Multiplexing Process →



FDM Process

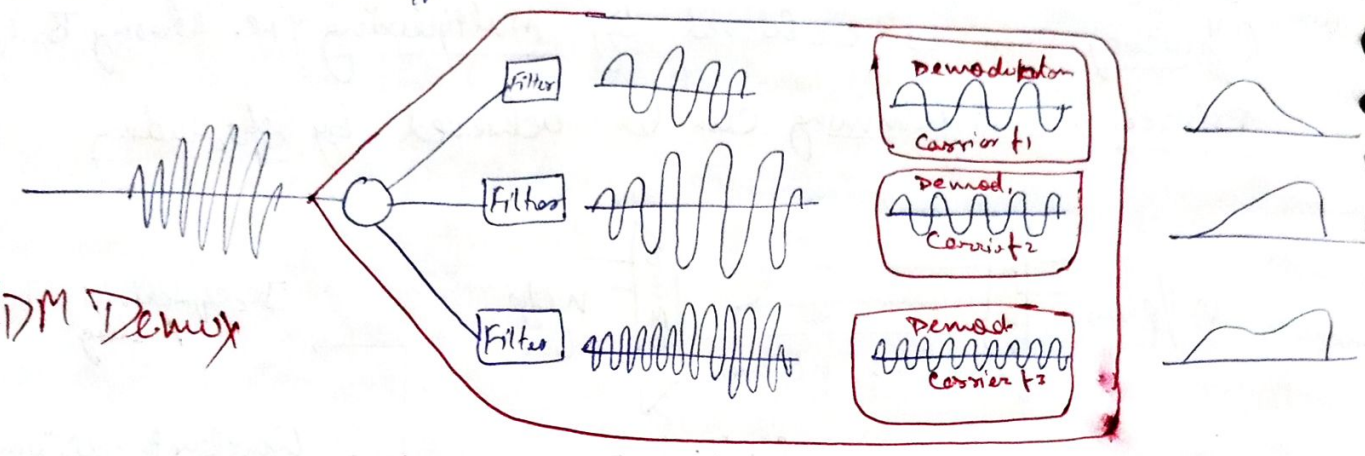
FDM is an analog multiplexing technique that combines analog signals.



Demultiplexing Process

Demultiplexer uses a series of filters to decompose the multiplexed signal into its constituent signals.

Individual signals are passed into demodulator that separates carriers & passes o/p lines



FDM Demux

② Wavelength Division Mux

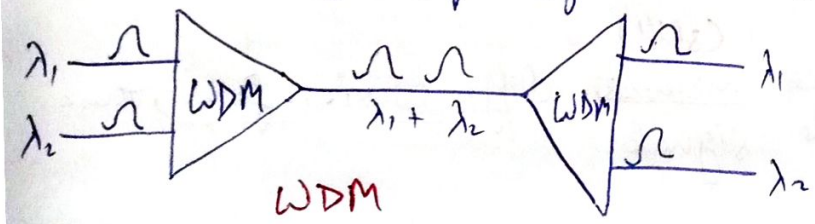
designed to use high data rate capability of fibre-optic cable.

Conceptually same as FDM.

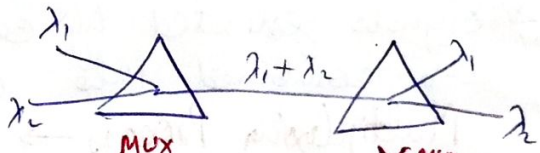
Here freq. are very high.

* WDM is analog multiplexing technique to combine optical signals.

We combine multiple light sources into one at mux & opp. at demux.



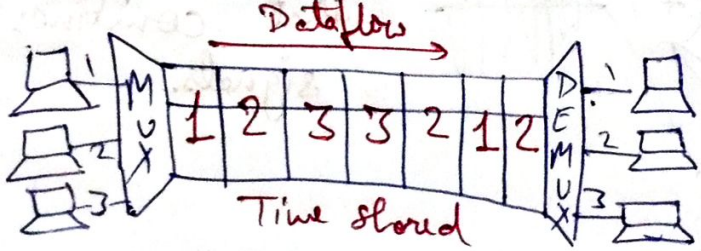
WDM



Prism in WDM

③ Synchronous Time Division Multiplexing (TDM)

Instead of sharing portion of B as in FDM, here time is shared

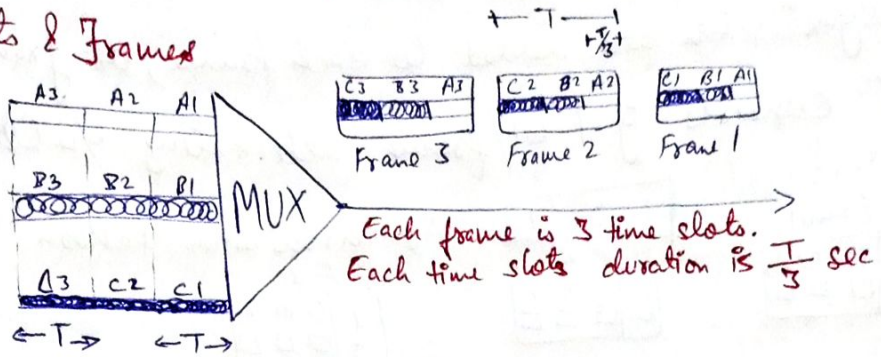


TDM

TDM is a digital multiplexing technique for combining several low-rate channels into one high-rate one.

In Synchronous TDM, each i/p connection has an allotment in the o/p even if it is not sending data.

Time Slots & Frames



Data taken from each line every T sec.

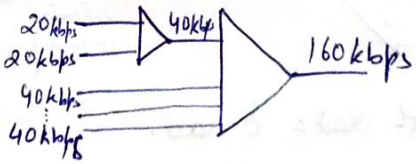
If we have n connection, each frame is divided into n slots
If i/p unit is T sec, each slot is T/n sec.

* In Synchronous TDM, the data rate of the link is n time faster, & the unit duration is n times shorter.

Empty Slots When a source does not has data to send, its slot in o/p frame is empty.

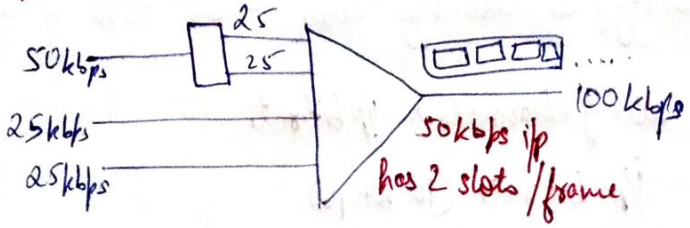
Data Rate Management (TDM) To handle a disparity in the i/p data rates — 3 strategies Multilevel multiplexing, multiple-slot allocation and pulse stuffing.

① Multilevel Mux

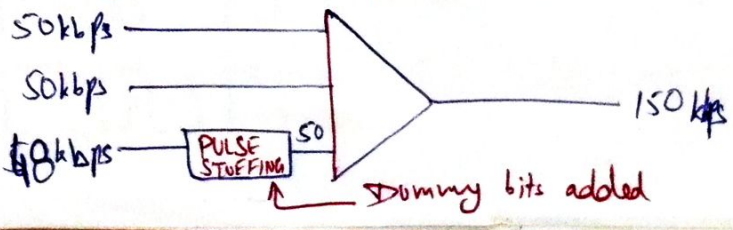


② Multiple Slot Allocation

Allocating more than one slot in a frame to a single i/p line.



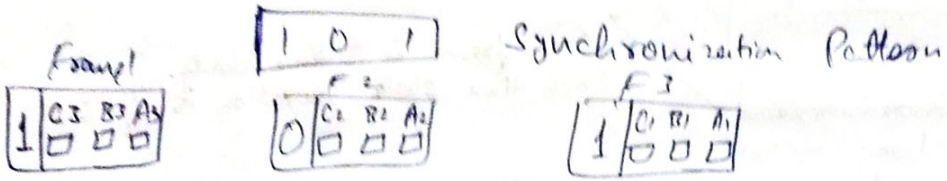
③ Pulse Stuffing / Bit padding / Bit stuffing



Frame Synchronization In TDM synchronization of mux & demux is very imp. & is a major issue.

For this, "sync" bit are added to each frame, it's **framing bit**

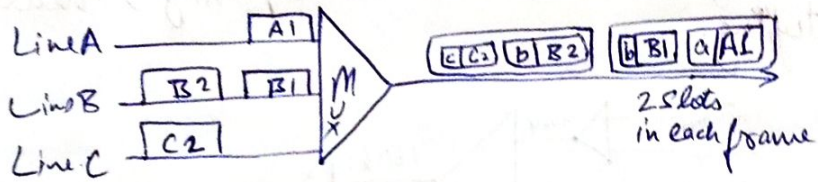
Sync" info" consists of 1 bit/frame alternating 1/0 or 0&1.



Statistical Time-Division Multiplexing

No fixed slot for senders. Slots are dynamically allocated acc. to requirement.

Each slot has add. of receiver attached.



Each slot carries both data & add.

No Synchronous bit is added with Frame

Bandwidth capacity of link is usually less than sum of capacity of each channel.

* bit rate = no. of channels × i/p bit rate

frame rate = $\frac{\text{i/p bit rate (in bits ps)}}{\text{Time slot}}$

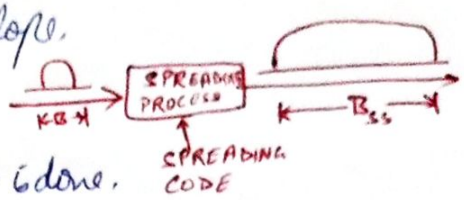
Frame duration = bit duration = $\frac{1}{\text{data rate}}$

Spread Spectrum (SS) designed to be used in wireless app. (LAN & WAN)

Stations must share medium (air or vaccum) without being subject to jamming, for this SS techniques add redundancy. They spread required bandwidth B, to B_{ss} such that $B_{ss} >> B$

This allows to wrap msg in protective envelope.

B_{ss} is far larges than B.



When signal to be sent is created, the spreding is done.

2 techniques for SS →

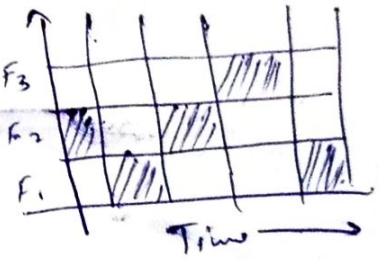
① Freq. Hoping Spread Spectrum (FHSS)

To avoid — Interference Spying

It has predifined hopping sequence eg: $\{F_2, F_3, F_1, F_3, F_2, \ldots\}$

(i) Slow freq. hopping: Less hopping & multiple symbol transmission

(ii) Fast freq. hopping: Each symbol transmit in several freq. hopping

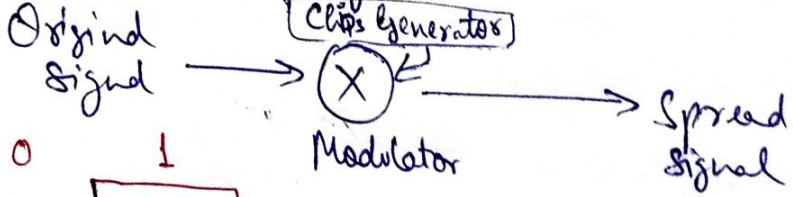


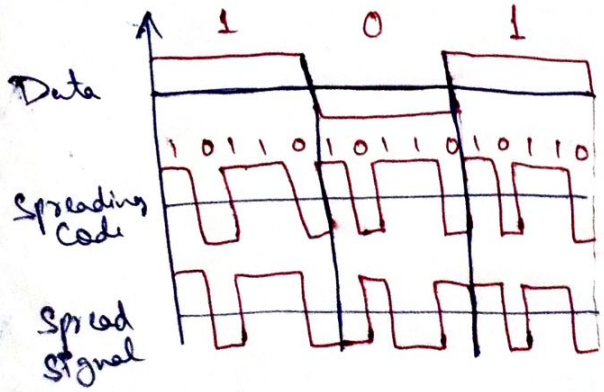
② Direct Sequence Spread Spectrum

Here we have a spreading code (binary)

Each data bit is spread (replaced) by n-bit called chips.

Chips rate is n times that of data rate.

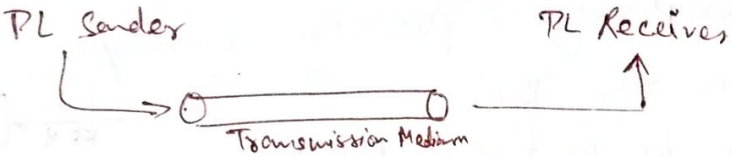




Transmission Media

Guided | Unguided

Twisted Pair | Coaxial | Fibre-Optic | Radiowave | Microwave | Infrared



Guided Media

Wired / Bounded Media.

Signals transmitted are directed & confined in narrow pathway

Features: High Speed, Secure, Used for comparatively shorter distance

① Twisted Pair Cable

2 seperate insulated wires ; most widely used

- **Unshielded TP**

2 insulated copper wires twisted around each other.

Can block interference

Used for telephonic applications

Advantage

Least Expensive

Easy to install

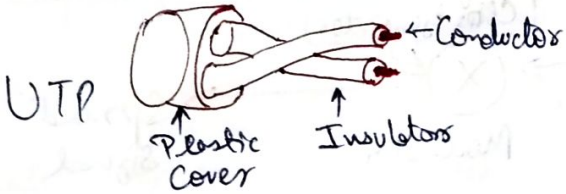
High-speed capacity

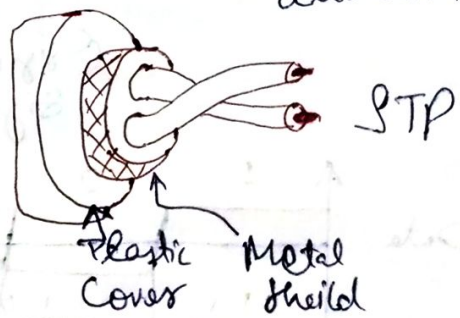
Disadvantage

Susceptible to external interference

Lower capacity & performance than STP

Short dist. transmission due to attenuation.





2) Shielded TP

Consists of special jacket (copper braid covering or foil shield to block external interference.

Used in fast-data-rate Ethernet; in voice & data channels of telephone lines

Advantages

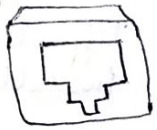
Better performance in high data rate
Eliminates crosstalk
Comparatively faster

Disadvantage

Difficult to install & manufacture
Expensive
Bulky

Connectors

UTP connector RJ45 (Registered Jack 45)
Its keyed connector, means can be inserted in one way only


RJ45 female

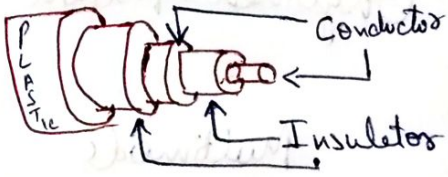

Male

Performance

Performance of TP cable can be measured by comparing attenuation versus freq. & dist.

Coaxial Cable

Has plastic covering containing an insulation layer made of PVC or Teflon and 2 parallel conductors with each seperate insulation.



Transmits in 2 modes :—

Baseband Mode delicate cable bandwidth
Broadband Mode cable bandwidth is split into sperate ranges

Use : Cable TVs, Analog TV network

Advantage

Easy Instalation
Better cut-through resistance so more reliable & durable
Less affect of noise, crosstalk or electromagnetic interference
Support multiple channels

Disadvantage

Expensive
Must be grounded to prevent crosstalk
Bulky due to multiple layers.
Chance of breaking & attacking t-join by hackers

Connectors of Coaxial Cable

BNC connector

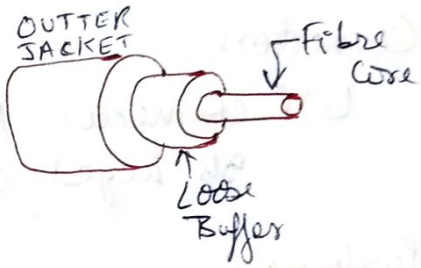
Optical Fibre Cable

Uses concept of refraction of light through a core made up of glass or plastic. Used in backbone of network due to wide B.

Core is surrounded by less dense glass/plastic covering Cladding

Transmits large volume of data.

Can be unidirectional or bidirectional



Advantage

Increased Capacity & Bandwidth
Lightweight
Less attenuation
Immunity to electromagnetic interference
Resistance to corrosive materials

Disadvantage

Difficult to install & maintain
High Cost
Fragile

Application Medical Purpose, Defence & Industrial Purpose

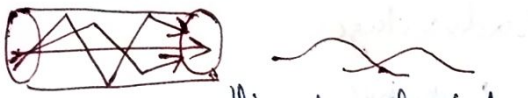
Connector Subscriber channel (SC) connector
Straight tip connector

~~Unguided Media~~

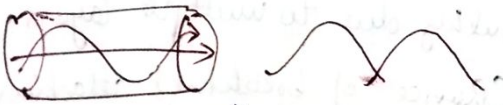
Mode

Multimode

Multiple beam of light source move through core in diffrent paths



multimode step index



multimod graded

Single Mode

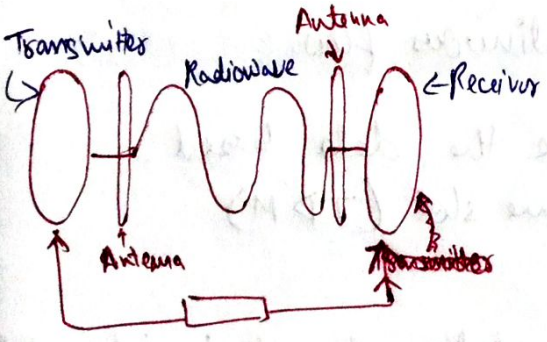
Highly focused beam source of light that limits beams to a small range of angles.

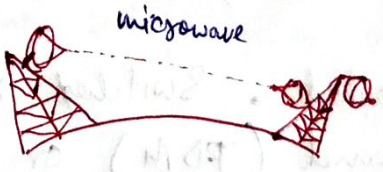
Unguided Media

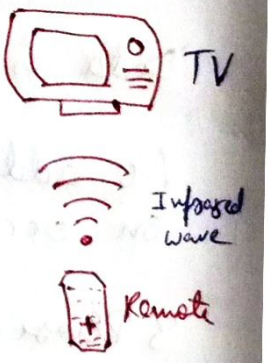
Wireless / Unbounded TM

Features
Signal broadcast through air , Less Secure, Used for long dist.

	Radiowave	Microwave	Infrared Wave
Dir^n	Omnidirectional	Unidir^n	Unidir^n
Penetration	At low freq: penetrate through solid obj. & wall At high freq: Bounce off the obstacle	← Same Cannot penetrate	Cannot penetrate through any solid & walls
Freq. Range	3kHz — 1GHz	1GHz – 300GHz	300GHz – 400THz
Security	Poor	Medium	High
Attenuation	High	Variable	Low
Usage Cost	Moderate	High	Less
Communication	Long Dist.	Long Dist.	Short Dist.

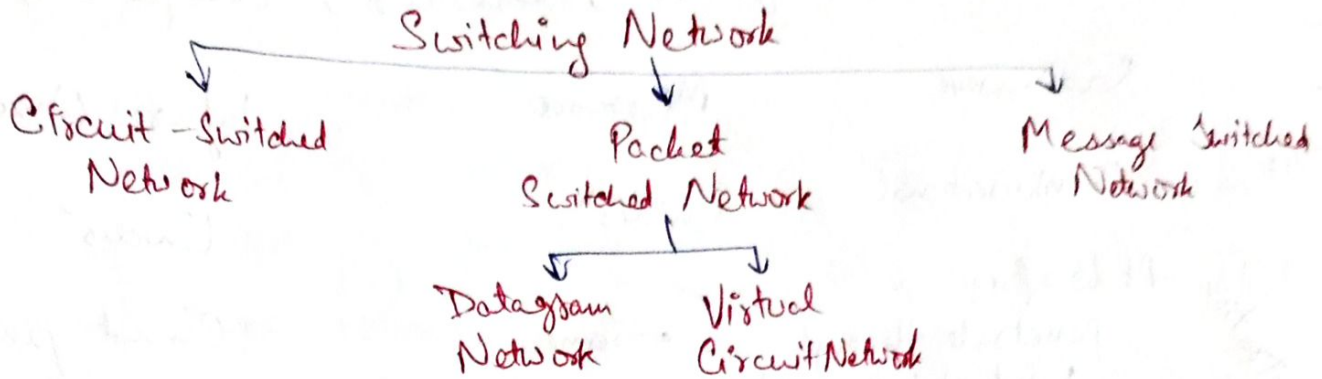






Switching

Solution to increasing no. of ports & connection in various topologies is switching



Circuit Switched Network

Switches connected by physical links.

Connection b/w 2 station is made using one or more link

Each connection uses only one dedicated link.

Each link is divided into n-channels using FDM or TDM

Circuit Switching takes place at Physical Layer

Resorces are reserved during the setup phase & remain dedicated for the entire duration until teardown phase

Data is not packetized, it is in continuous flow.

No addressing needed. Switches route the data based on occupied band (FDM) or time slot (TDM)

3 Phase →

① Setup Request is sent by a station, passed by intermediate switches to end station. Acknowledgement sent back. Resources are reserved.

② Data Transfer phase

③ Teardown phase When 1 needs to disconnect, signal is sent to each switch to release resources.

Efficiency is low but delay is minimal.

Switching at the physical layer in the traditional telephone network uses the CS approach.

Datagram Network

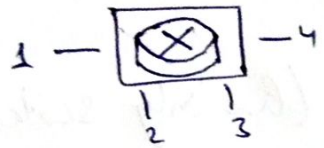
At network layer — Data is packetized (called datagram)

No fixed route or dedicated resources (connectionless network)

Resource allocation on demand (FCFS)

Routing Table — Each switch has routing table

Its dynamic & updated periodically



Dest. Add.	O/p Port
1230	1
4150	2
⋮	⋮
9130	3

Each packet has destination address header, remains same during entire journey

Efficiency is better than CS.

Delay is greater than virtual-circuit network

Delay is non-uniform as packets take diff. paths.

Switching in Internet is done using this approach

Virtual Circuit Network

Cross b/w CSN & DatagramN

Some characteristics of both →

Setup & teardown phase

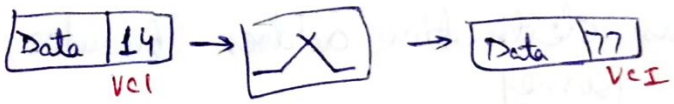
Resource can be allocated both in setup & on-demand

Data is packetized and header contains add. to immediate next destination.

All packet follow same path established during connection

Implemented in Data link Layer

Virtual Circuit Identifier VCI is a small no. (has only switch scope) it used by frame b/w 2 switches.



Switching in DLL in a switched WAN is implemented using Virtual Circuit Network