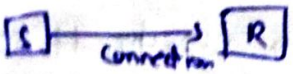
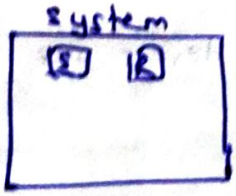
COMPUTER NETWORKS



Protocol is both on sender and receiver's side. It is a set of instructions.



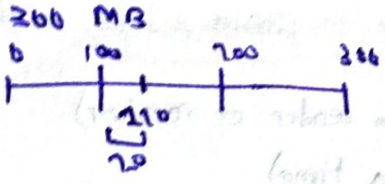
Within a system, when one process interacts with others, it is known as interprocess communication. It is not used wrt computer networks.

CN is used between different devices.

Functionalities ⟹ Mandatory
↳ Error Control ↳ Flow control ↳ MUX, DEMUX (manage multiple processes)
↳ Stop & Wait
↳ Selective Repeat
↳ Go Back N

optional
↳ Encryption / Decryption (used in banking)
↳ Checkpointing (used in downloading)

Say 200 MB

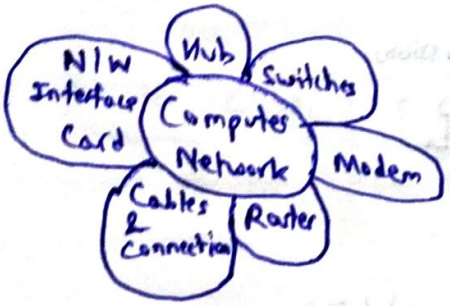


(If download stalls at 120, it'll restart from 100)

Computer Network is a group of computers connected with each other through wire, optical fibre or optical link so that various devices can interact with each other through a network.

The aim of computer network is the sharing of resources among various devices.

Components of CN



Hub is a central device that split the network connection into multiple devices. When computer requests for information for a computer, it sends it to the hub. Hub distributes this request to all the interconnected networks.

Switch is a networking device that groups all the devices over the network, to transfer the data to another device.

Switch is better than hub as it does not broadcast the message over the network.

Various devices in CN

↳ Cables ↳ Repeaters ↳ Hubs ↳ Bridges ↳ Switch ↳ Router

Hardware (used in physical layer) — Hardware and software (DLL) ↳ Data link layer

↳ Gateway ↳ Intrition Detection System (IDS) ↳ Firewalls

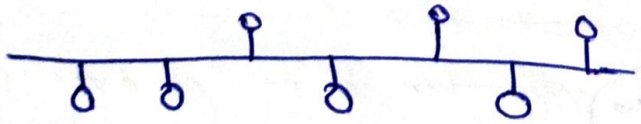
Used in memory

Band ↳ Base (1 signal at a time, from sender or receiver)
↳ Broadband (multiple signals at a time)

Cables

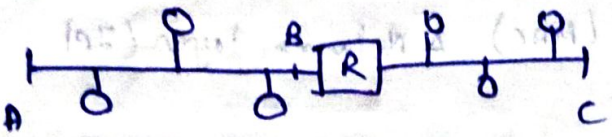
- Unshield
  - 10 Base T [10 → speed in MBPS] [T → range]
  - 100 Base T
- Co-axial
  - 10 Base 2 (2 ≡ 200m)
  - 10 Base 5 (5 ≡ 500m)
- Fiber optics → 100 Base Fx [100 Mbps] [Fx → fiber generation]

For n devices, there are n collisions



There is no use of IP/MAC address.

Repeater



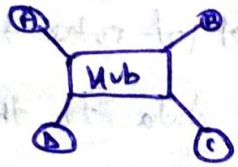
Assume cable to be 10 Base 2

After reaching R, signal will not get stuck, rather, it would forward with the same speed.

If signal is to be sent from A to B, we don't need repeater, but repeater doesn't understand this, and it will forward regardless.

Repeater ↳ 2 port device ↳ Forwarding ↳ No filtering ↳ Collision domain

Hub



↳ Multiport repeater ↳ Forwarding ↳ Collision Domain

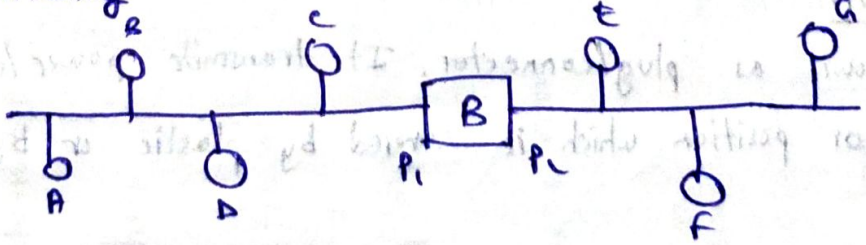
Bridges

Used in physical as well as data link layer (MAC address)

↳ Connect (two different LANs)

↳ Forwarding

↳ Filtering

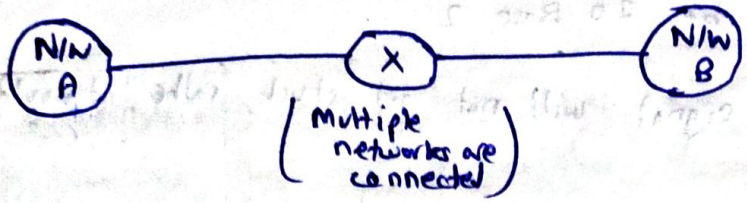


MAC	A	B	C	D	E	F	G
Port		P1			R		

Router

Used in physical, data link layer (MAC) & Network layer (IP)

Symbol: (X)



Packet → Sending a message
Flooding → Flowing in all directions (spreading)

A router determines a packet's future path examining the destination IP address of the router and comparing it to the routing database. The list of routing table outlines how the sender sends the data to a specific network location. They use a set of rules to determine the most effective way to transmit the data to the specified IP location.

Types of routers

↳ Broadband router ↳ Wireless router ↳ Wired router ↳ Edge router
↳ Core router ↳ Virtual router ↳ Portable router

Cables (left out part)

It is also known as plug/connector. It transmits power/data between devices or position which is covered by plastic or by one or more wires.

Unshielded: Copper cables that are commonly used to transmit data in ethernet n/w.

Coaxial: Made of plastic and copper wires which transmit the signal in electrical form

Fibre optics: Used to transmit data signal as light. They are faster and cheaper than traditional electrical cables and can travel 100s of miles.

	PAN	LAN	CAN	MAN	WAN
Full form	Personal Area Network	Local Area Network	Campus Area Network	Metropolitan Area Network	Wide Area Network
Technology	Bluetooth	Ethernet, Wi-Fi	Ethernet	FDDI, CDDI, ATM	Dial-Up, Lease Line
Range	1-100m	Upto 2km	1-5 km	5-50 km	>50 km
Transmission Speed	Very High	Very High	High	Low	Low
Area	Within a room	Within an office	College	City (eg: Mumbai)	Countries
Maintenance	Low	Low	Moderate	High	High
Error Rate & Cost	Very low	Very low	Moderate	High	Very High

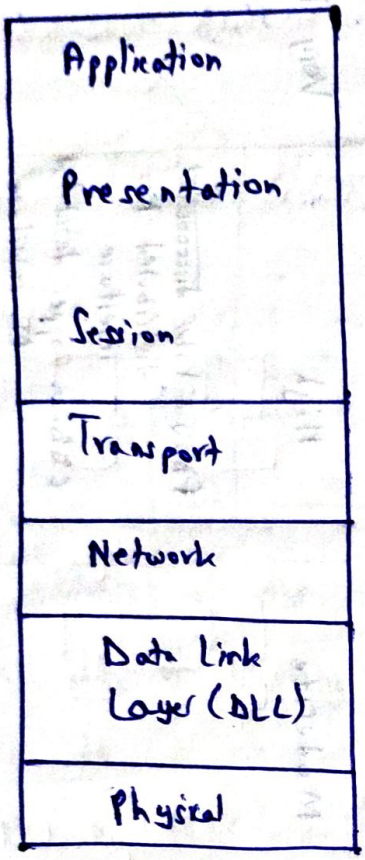
FDDI - Fiber ~~disconnected~~ distributed DB interface

CDDI - Copper distributed DB interface

ATM - Asynchronous Transfer Machine

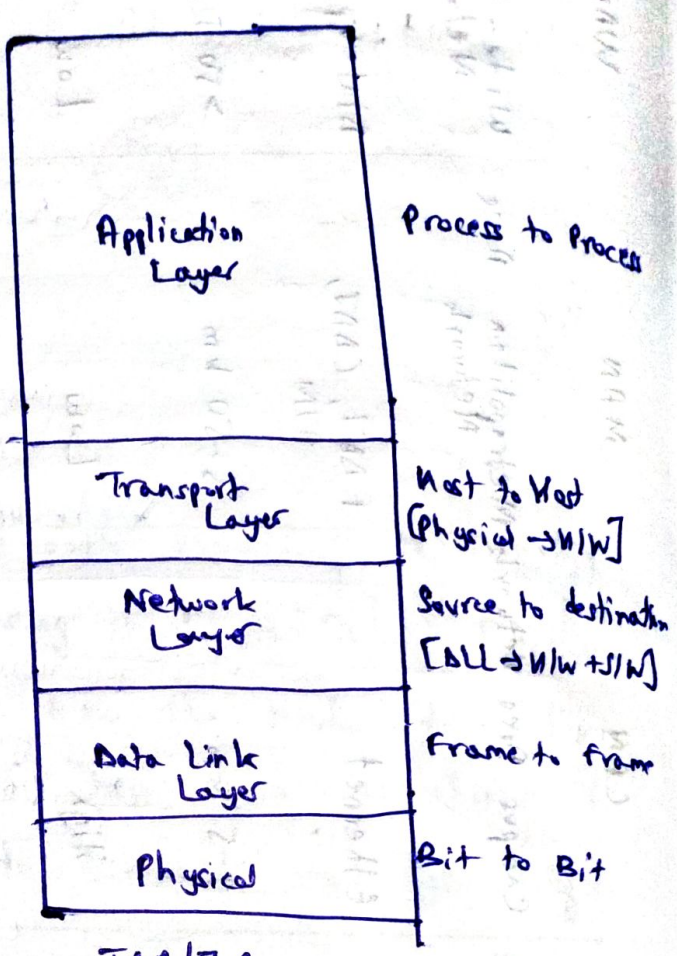
TCP / IP Suite

Theoretical Model



OSI

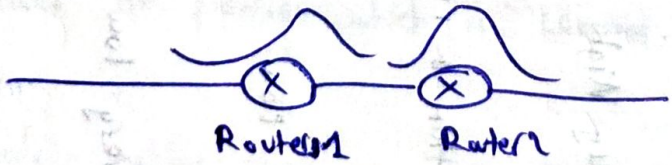
Implemented Model



TCP/IP

Flow of Data

User
↓
Application
↓
Transportation
↓
N/W (Node to Node)
↓
DLL



Router has 3 layers
- N/W
- DLL
- Physical

Receiver
↑
Application
↑
Transportation
↑
Data Link Layer (DLL)
↑
Physical

Application Layer: This layer provides service to user

Presentation Layer: It is responsible for translation, compression & encryption.

Session Layer: It is used to establish, manage and terminate the session.

Transport Layer: It provides reliable message delivery from process to process.

Network Layer: It is responsible for moving the packet from source to destination.

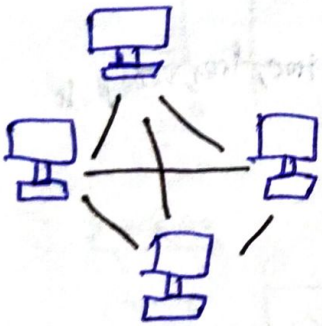
Data Link Layer: It is used for error-free transfer of data frame.

Physical Layer: It provides a physical medium through which bits are transferred.

Computer Network Architecture

↳ Peer to Peer ↳ Client /Server

Peer To Pear



Disadvantage

↳ No privacy

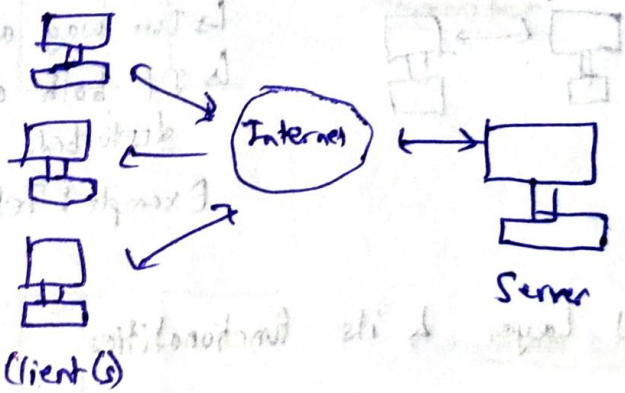
Advantage

↳ Less costly

↳ Less burden on each system

↳ Even if a system crashes, work doesn't stop.

Client /Server



Disadvantage

↳ If server fails, entire system is down.

↳ Server should have high memory, because it has to store data of all clients.

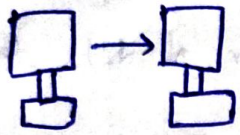
Features of CN

↳ Communication speed ↳ File sharing ↳ Easy backup & rollback
↳ Software & Hardware sharing ↳ Security ↳ Scalability ↳ Reliability

Transmission

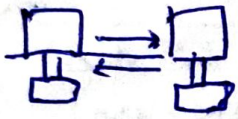
Data transfer from one device to another.

↳ Simplex



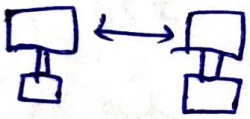
↳ One way transmission
↳ No collission
Example : Radio / TV

↳ Half Duplex



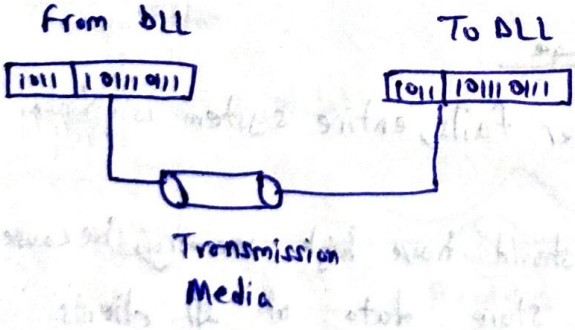
↳ One way transmission at a time
↳ Time Taking
Example : Walkie-Talkie

↳ Full Duplex



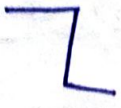
↳ Two way at a time
↳ If both are used at same time, frequency is disturbed.
Example : Telephone

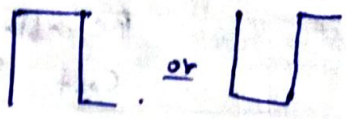
Physical Layer & its functionalities



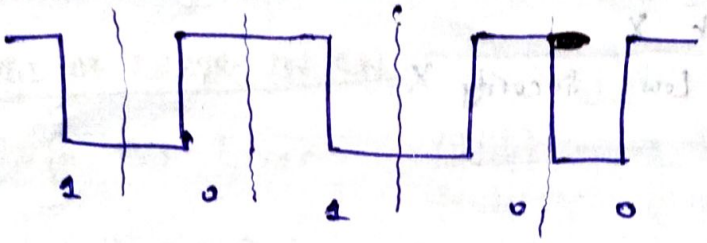
↳ Cables and connectors
↳ Physical Topology
↳ Hardware (Repeaters & Hubs)
↳ Transmission Mode
↳ MUX
↳ Encoding
(Digital to Analog, Analog to Digital, Analog to Analog, Digital to Digital)

Digital to Digital Encoding
(Manchester vs Diff. Manchester)

Manchester 1  0 

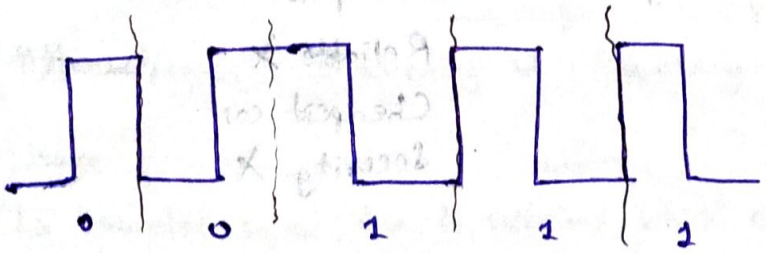
Diff. Manchester 1  or 0 

1 0 1 0 0



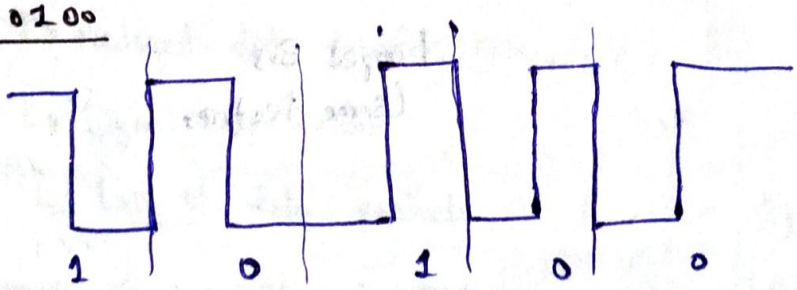
Manchester

0 0 1 1 1



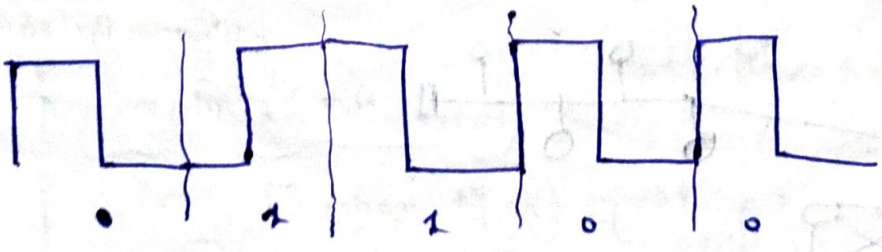
Manchester

1 0 1 0 0



Manchester Diff

0 1 1 0 0

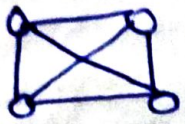


Manchester Diff

NETWORK TOPOLOGIES

↳ Mesh ↳ Star ↳ Bus ↳ Ring ↳ Hybrid

Mesh



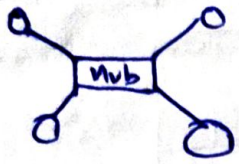
Cables = $\frac{n(n-1)}{2}$

No. of ports = n-1

Reliable

Cost ↑ Security ↑

Star



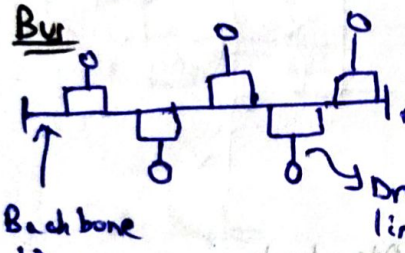
Cables = n

No of ports = 1 × n

Reliable X

Cost Low Security X

Bus



Cables = n+1

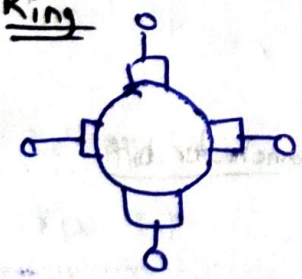
No of ports = 1 × n

Reliable X

Cheapest cost

Security X

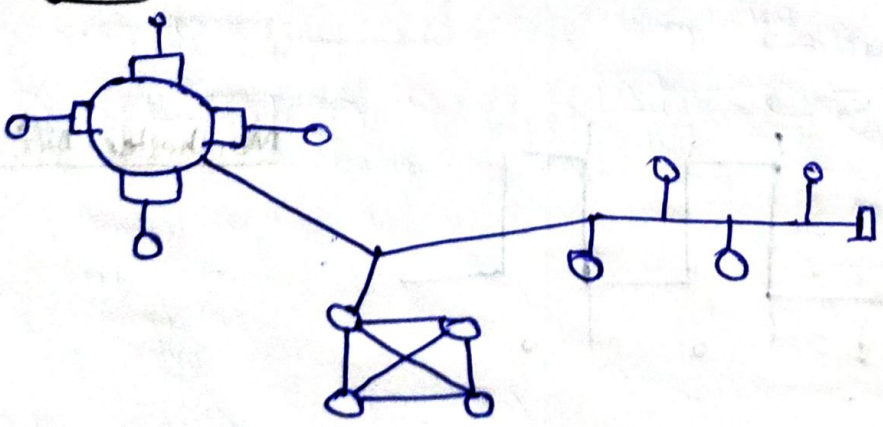
Ring



Looped Bus

(Some features

Hybrid



Reliable: If one part of the network fails, the rest of the network is not generally affected.

Scalable: Nodes can be easily added / removed without disruption of entire network.

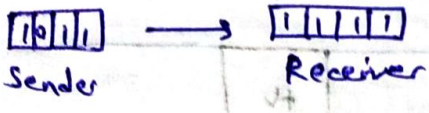
Flexibility: The network can be designed to meet specific needs.

Fault Tolerance: The network can maintain integrity even when individual component fails.

Load Distribution: Data loads are evenly distributed to avoid any part of the network.

TYPES OF ERROR IN CN

↳ Single Bit Error



↳ Multiple Bit Error

↳ Attenuation — Weakening of frequency of network

↳ Noise

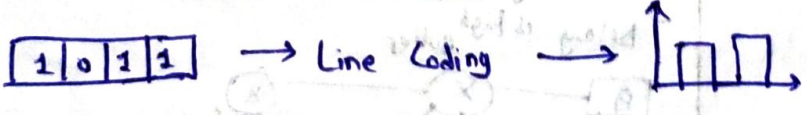
↳ Unwanted signal, due to collisions, which can disrupt the normal flow of data signal

↳ Reduced data transfer rate

↳ Signal attenuation

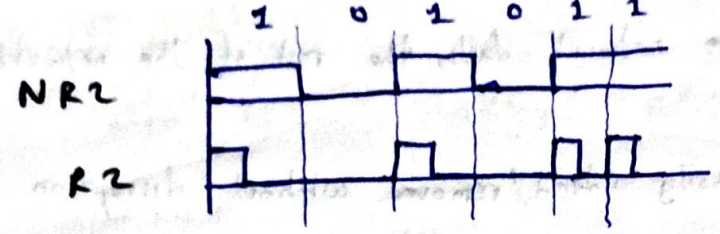
↳ Loss of data packets

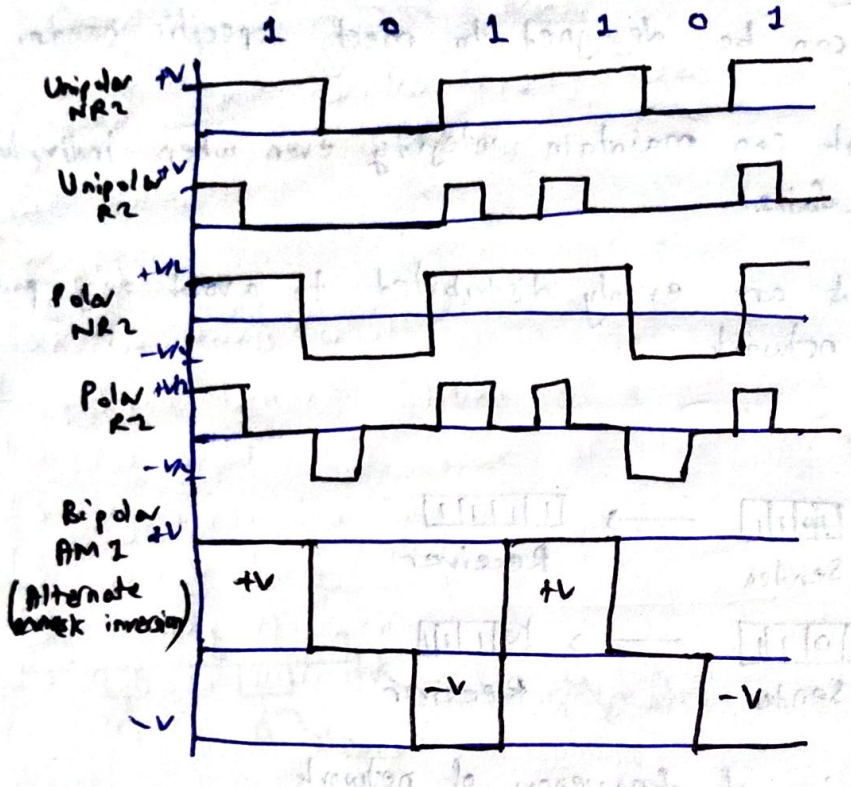
DIGITAL TO DIGITAL CONVERSION



D to D encoding

- Unipolar (1 Voltage, +A) → RZ (Return to zero), NRZ (Non-return to zero)
- Bipolar (2 Voltages, $+\frac{V}{2}, -\frac{V}{2}$) → Polar RZ, Polar NRZ
- Bipolar (3 voltages: +ve +V, -ve -V, 0 0) → AMI (Alternate Mark Inversion)



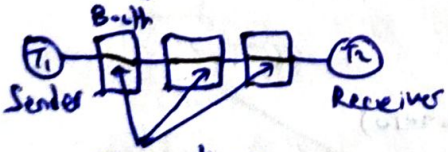


Switching Technology

- Circuit
- Message
- Packet
  - Datagram
  - Virtual Circuit

Circuit

- Physical
- Contigious flow
- No header
- Efficiency Less
- Delay Less
- No storage
- Dedicated path



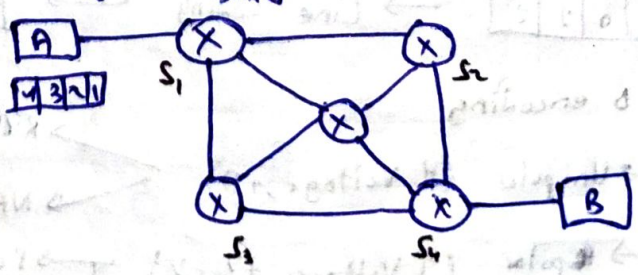
These lines need to be joined for setup

Total time = Setup + T_t (Transmission Time) + T_p + Teardown

$T_t = \frac{M}{BW}$ $T_p = \frac{D}{V}$

Packet

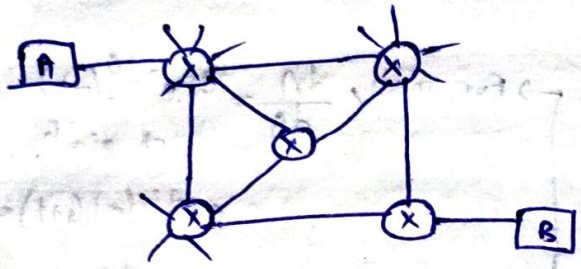
- DLL & Network layer (DLL → Virtual, N/W → Datagram)
- Store & Forward
- Pipelining
- Efficiency is high
- Delay is high



Transmit → B/W
Store → Buffer
Process → CPU utilisation

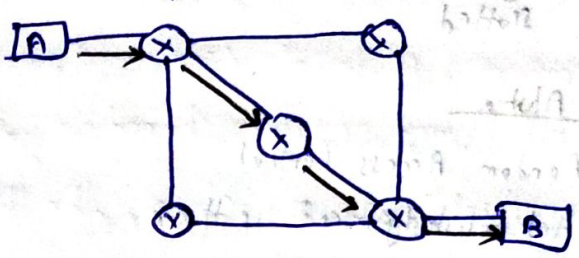
Datagram

- Connectionless
- No Reservation
- Out of order
- High overhead
- Packet loss (due to random path because no reservation)
- Used in internet



Virtual Circuit

- Connection Oriented
- Reservation
- Same order
- Less overhead
- Packet loss is absent.
- X 25, ATM



UNIT-2

DLL → Logical Link Control
DLL → Media Access Control
(2 parts)

MAC → Random Access Control
MAC → Control Access
MAC → Channelization Prob

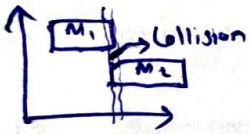
Random Access Control → ALOHA (Pure, Slotted), CSMA, CSMA/CD, CSMA/CA

Control Access → Polling, Token Ring

Channelization Prob → FDMA, TDMA, CDMA

Pure Aloha

- Random Access Control
- Acknowledgement is there
- LAN Based
- Only transmission time
- Vulnerable Time = 2 × Transmission Time = $2 \times \frac{M}{B/W}$
- Efficiency $\eta = G \times e^{-2G}$
  - It is also denoted by S.
- Collision occurs



For max, $\frac{d\eta}{dG} = G.e^{-2G}.(-2) + e^{-2G}.$

$e^{-2G}(-2G+1) = 0$

$-2G+1 = 0$

$G = \frac{1}{2}$

Avg no. of frame generated by system

$\eta = \left(\frac{1}{2}\right)(e)^{-2.\frac{1}{2}}$

$\eta_{max} = 0.184 = 18.4\%$

Due to low efficiency, pure Aloha is not considered very good.

Slotted Aloha

- Random Access Control
- Acknowledgement is there
- LAN Based
- Only transmission time
- Vulnerable Time = Transmission Time
- Efficiency $\eta/S = G.e^{-G}$
- Throughput = Efficiency . No. of frames

Although better than

For max, $\frac{d\eta}{dS} = G.(e^{-G})(-1) + (e^{-G})$

$-G.e^{-G} + e^{-G} = 0$

$G = 1$

$\therefore \eta = G.e^{-G}$

$= 1.e^{-1}$

$= \frac{1}{e} = 0.368$

$\eta_{max} = 36.8\%$

Q A Pure ALOHA network transmits 200 bit frame on a shared channel of 200 Kbps. What is the thruput if the system all station, together produce 1000 frame/second.

$M = 200$ bits ; $B/W = 200000$ bps

$T_t = \frac{M}{B/W} = \frac{200}{200000} = \frac{1}{1000}$ s

Q A pure ALOHA network transmits . . . . 200 Kbps. What is the if the system all station, together produce 500 frame/second?

Q A slotted Aloha network transmits 200 bits using a shared channel with a 200 KBPS. Find the throughput, if system produces 250 frames/s.

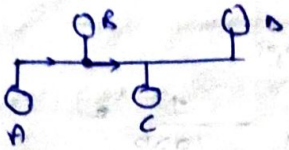
$M = 200$ bits. ;

CSMA (Carrier Sense Multiple Access)

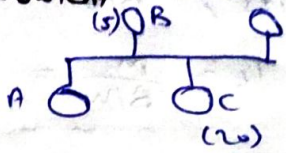
↳ 1 persistent ↳ 0 persistent ↳ p persistent

During collision, throughput ↓ Bandwidth waste occurs

1 persistent



0 persistent Doesn't check continuously



p persistent (probability $\in [0,1]$)

1 persistent : Mode of CSMA that define each node first sense of shared channel and if the channel is idle, it immediately sends the data.

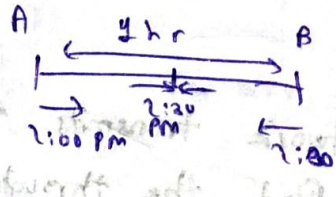
0 persistent : It defines the supereiority of the state before the transmission of the frame on the shared channel.

p persistent: It is a combination of 1 persistent and 0 persistent modes. The p persistent mode defines that each node sense the channel and if the channel is inactive, it sends a frame with a p probability.

CSMA/CD (CD → collission detection) [Works for wired]

There is no acknowledgement.

$T_t > P_D$ (Propagation delay)



For no collision,

$$T_t \geq 2.P_D$$

$$\frac{M}{BW} \geq 2.P_D \Rightarrow \boxed{M \geq 2.P_D.BW}$$

Q Consider CSMA/CD network that transmits data at a rate of 100 Mbps ($\sim 10^8$ bps) over 1 km cable with no repeater. If the minimum frame size required is 1750 bytes. What is the signal speed in km/s in the cable.

$$T_T = 2.P_D \Rightarrow \frac{M}{BW} = 2.\frac{D}{V} \Rightarrow V = \frac{2.D.BW}{M}$$

$$= \frac{2.1.10^8}{1750.8}$$

$\therefore V = 2 \times 10^4$ km/s

Efficiency Efficiency $= \frac{1}{1+6.44a}$

$$= \frac{1}{1+6.44\frac{P_D}{T_T}}$$

We know $\Rightarrow T_T = 2.P_D \rightarrow \frac{P_D}{T_T} = \frac{1}{2}$

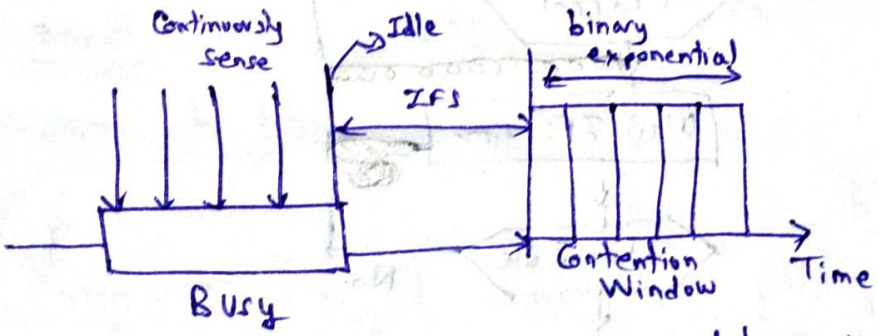
$$\therefore \text{Efficiency} = \frac{1}{1+6.44/2}$$

$$= \frac{1}{1+3.22} = \frac{1}{4.22} = 0.2369$$

$\therefore$ **Efficiency = 23.69 %**

CSMA/CA (CA → Collision avoidance)

↳ Meant for wireless network (wireless LAN)



↳ Higher the priority, smaller is the sensing time. (For higher priority, time is in ~ns order) ∴ hence waiting

↳ Interframe space ↳ Contention Window ↳ Acknowledgement

In case of collision, next signal is sent in form 2^k ($k \leq 15$)

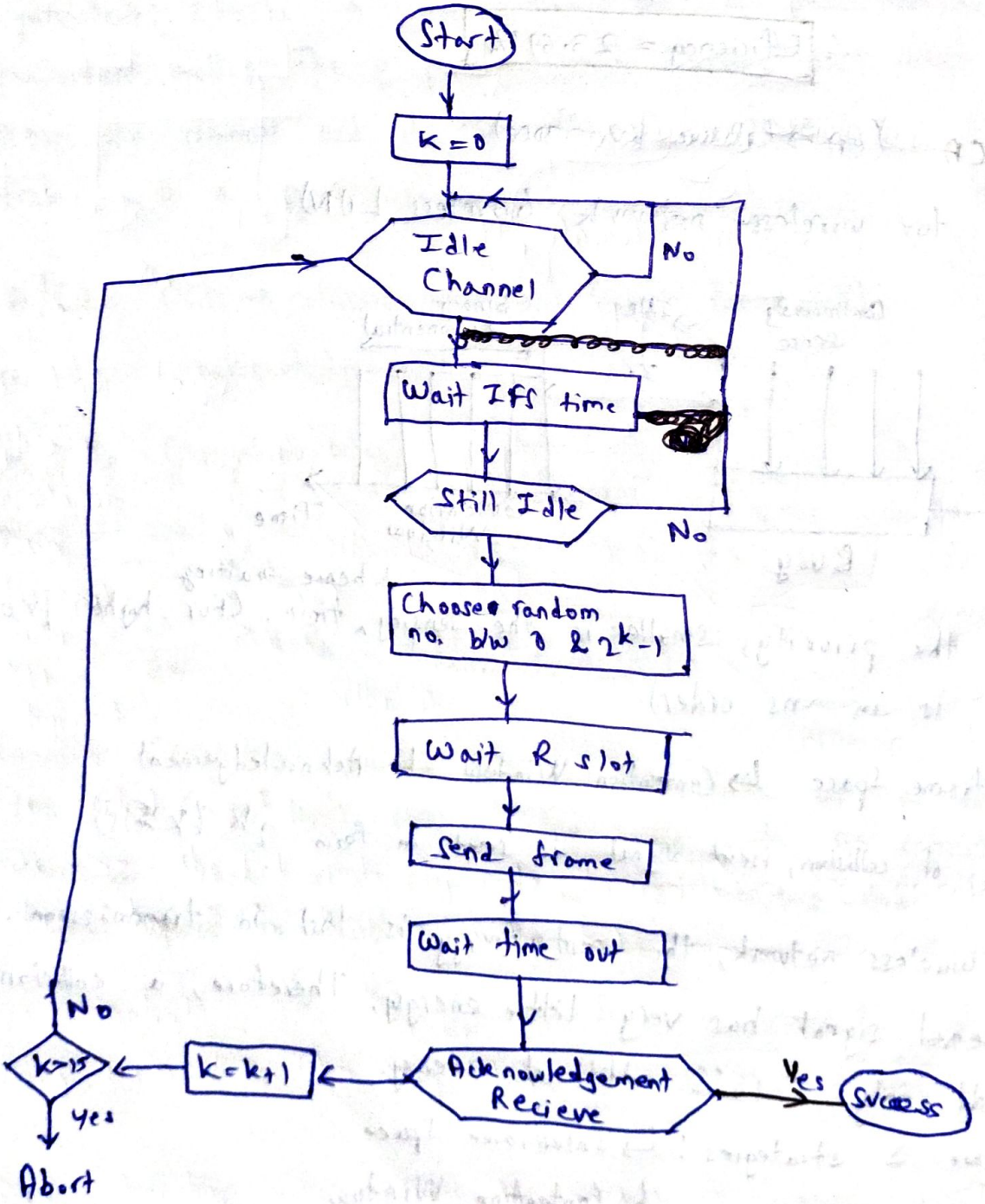
In a wireless network, the sent energy is lost in transmission. The received signal has very little energy. Therefore, a collision may add only 5-10% additional energy.

These are 3 strategies : ↳ Interframe space
↳ Contention Window
↳ Acknowledgement

Interframe Space: First collision are avoided by transmission even if the channel is found idle. When an idle channel is found, the station does not send immediately. It waits for a period of time, called interframe space.

Contention Window: The contention window is a amount of time divided into sluts. A station that is ready to send chooses a random number of slots as its wait time.

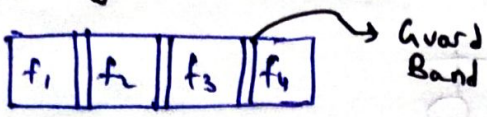
Acknowledgement: The positive acknowledgement and the time out timer can help gvarantee that the receiver has received the frame.

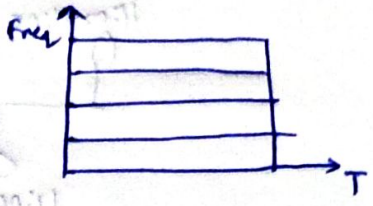


CHANNELISATION

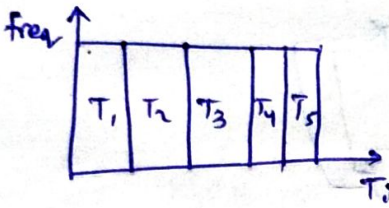
↳ FDMA ↳ TDMA ↳ CDMA

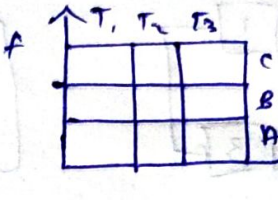
FDMA (Frequency Division Multiple Access)





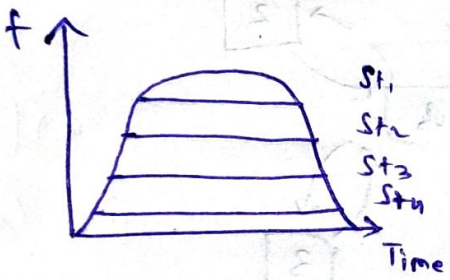
TDMA (Time Division Multiple Access)





↖ Both time & frequency are divided.

CDMA (Code Division Multiple Access)



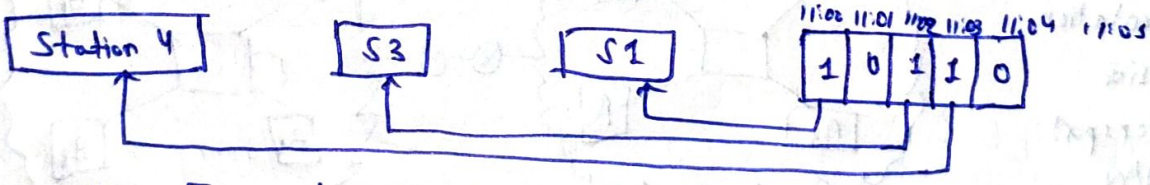
$x_1 \rightarrow x_2$
$y_1 \rightarrow y_2$

C_1 (code)	d_1 (data)	$C_1 d_1$	$(C_1 \times d_1) +$
C_2	d_2	$C_2 d_2$	$(C_2 \times d_2)$
C_3	d_3	$C_3 d_3$	$+(C_3 \times d_3)$
C_4	d_4	$C_4 d_3$	$+ (C_4 \times d_4)$

Controlled Access

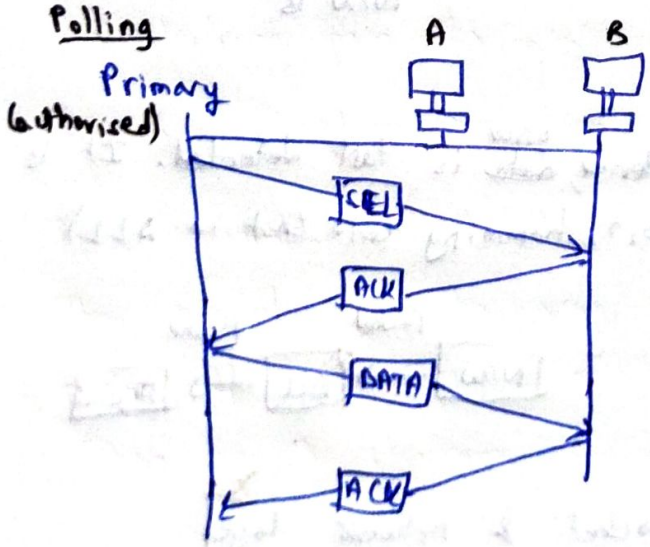
↳ Reservation ↳ Polling ↳ Token Ring

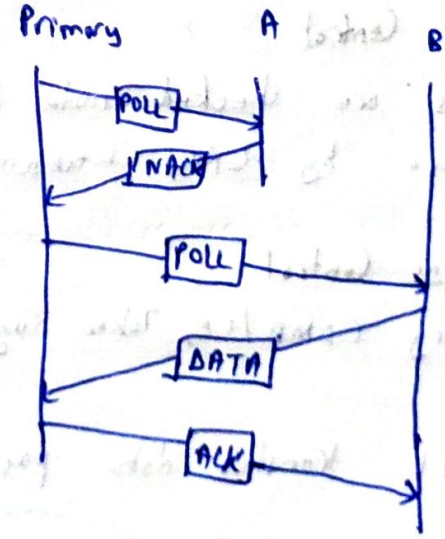
Reservation



↳ Reservation Time ↳ Data transmission

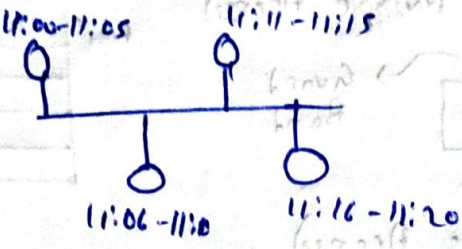
Polling

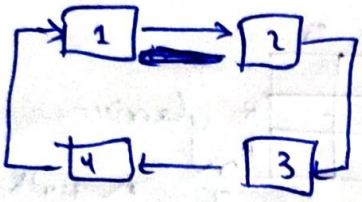




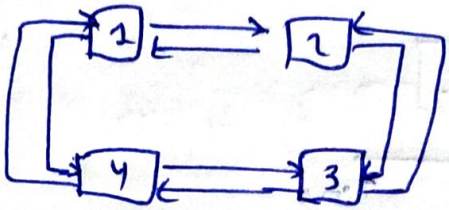
Token Ring

Each device gets a token for some time & only it can transmit for that time

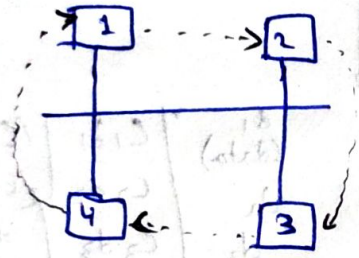




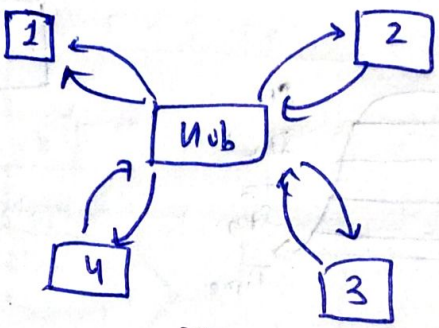
Physical Link



Dual Link



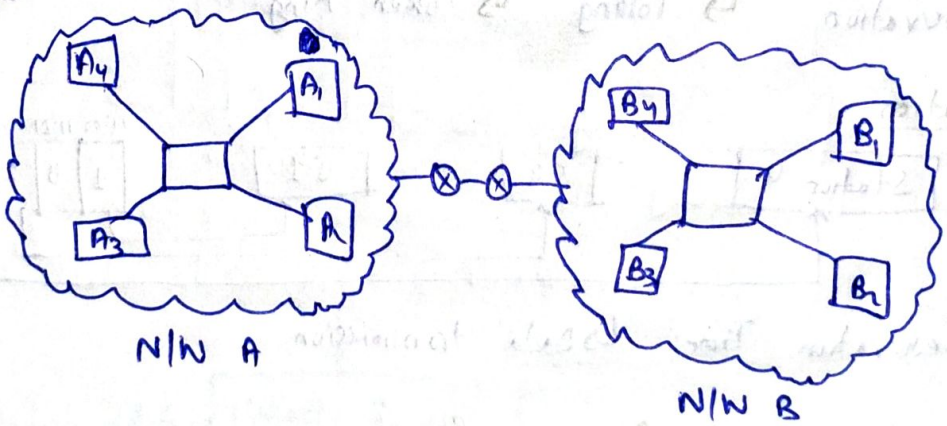
Bus



Star

Data Link Layer

Application
Presentation
Session
Transport
N/W
DLL
Physical



N/W A

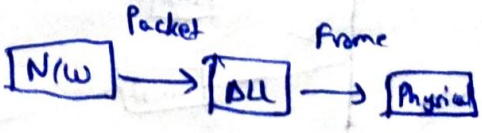
N/W B

Error Control

Bits are checked node by node. Hence, error ~~data~~ is fast detected. It is done by CRC, checksum, parity bit, hamming code (not in DLL)

Access Control

Using CSMA/CD, Token Ring, Aloha



DLL transfers data packed by packet & network layer