N/w Performance

estimating the performance of n/w

(4)

- Bandwidth
- Throughput
- Latency (Delay)
- Bandwidth delay pro -

(2) way high freq - low freq

1st Hz, refers to the range frequencies in a composite signal
or

2nd range of frequency that a channel can pass
high - low

2nd bps, refers to the speed of bit transmission in a channel or link

Throughout

measures how many packet arrived their destination successful

tells you how much data was

transferred from source at any given time

in contrast bandwidth

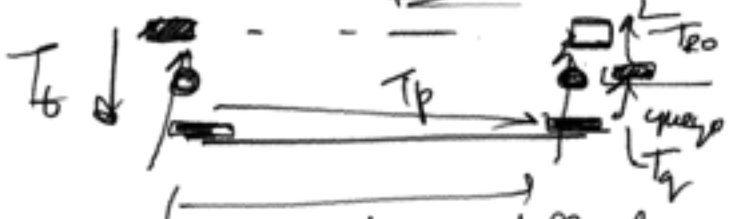
tells you how much data could theoretically be transferred

Unit bandwidth & throughout

bps

3) Delay

means the time for which the processing of a particular packet takes place in transmission



total time it takes for the packet to be ready for transmission & processed at the destination

$$T_{total} = T_t + T_p + T_q + T_{PRO}$$

total delay; Transmission delay; Propagation; queue delay; processing delay

$$T_{total} = \underline{T_t} + \underline{T_p}$$

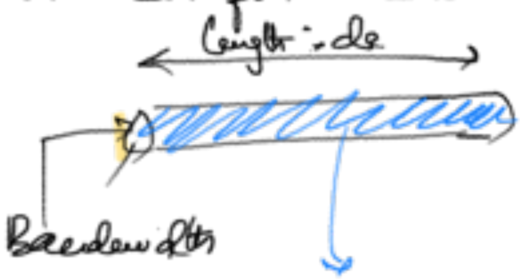
$$\{T_q + T_{PRO} = 0\}$$

$T_t = L/B$ — message length — Bandwidth

T_p = Distance / velocity

4) Bandwidth - delay product

defines the number of bits that can fill the link



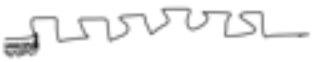
volume of

Bandwidth × delay

Bandwidth delay product

Digital transmission

→ transmission of digital signal through a link



2

↳ Digital data, Digital Signal
  ↳ encode by design
    ↳ one voltage for binary 1 &
       " " " binary 0
  ↳ Complex encoding scheme
     synchronisation scheme
↳ Analog data, Digital Signal

→ convert the data to digital by digitization

PCM

Delta Modulation

Digital Transmission

$g(t)$ → Encoder → $x(t)$ → Decoder → $g(t)$

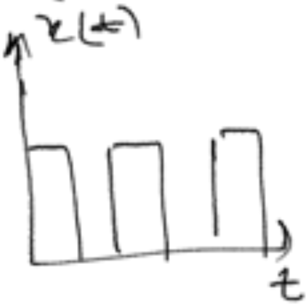
Digital & Analog data

digital signal

Digital signal

data back

$x(t)$



NRZ-L

Non Return to zero level

0 → high level

1 → Low level

NRZI

Non Return to Zero Inverted

0 → no transition at beginning of interval

1 → transition at beginning of interval

transit: high ↑ low, high ↓ low

Bipolar AMI

0 → no line signal

1 → positive & negative level, alternative for successive ones

Pseudoternary ✓

✓0 → positive & negative level, alternative for successive 0s

1 → no line signal

Manchester ✓

✓0 → transition from high to low in middle of interval

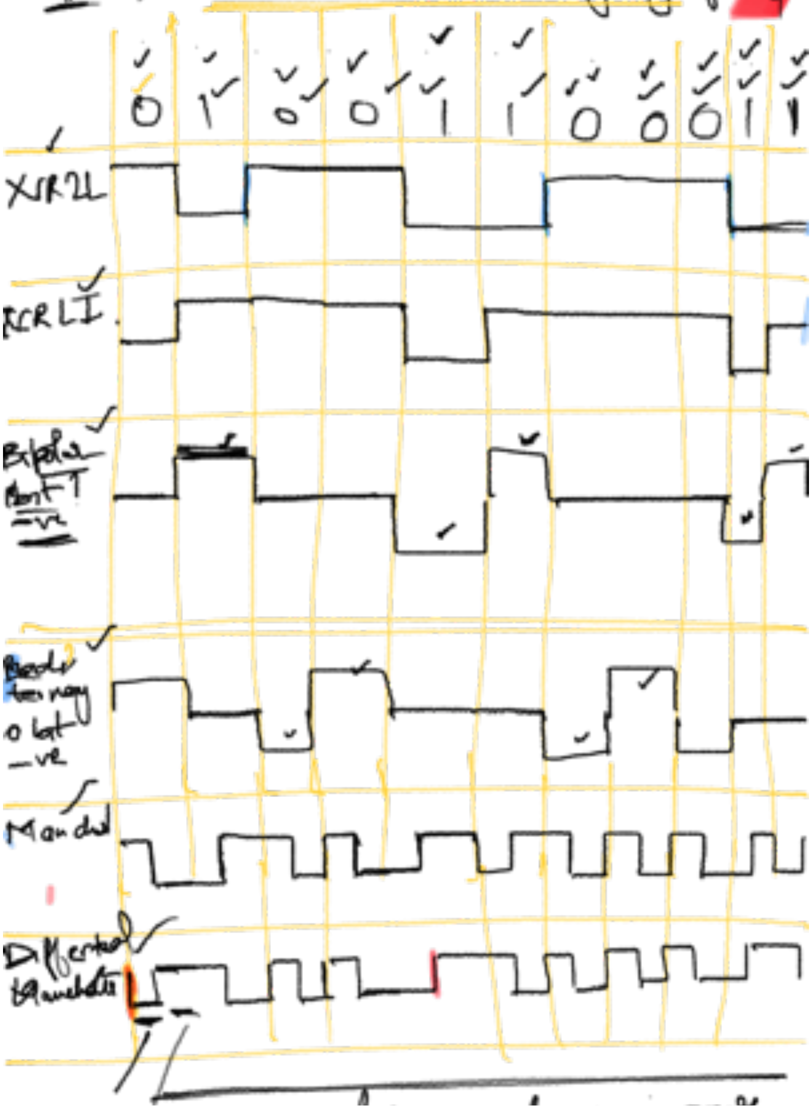
1 → transition from low to high in middle of interval

Differential Manchester

Always a transition in middle of interval

0 → transition at beginning of interval

1 → no transition at beginning of interval



frequency line junction alots

Key data transmission term

① data element → A single binary one or zero
Bits

② data rate → Rate at which data element are transmission
bps

③ Signal element ↳ Part of signal that occupies the shortest interval
→ bits, pulse

④ Signaling rate / Modulation rate → rate at which signal element are transmitted
→ baud

Eg
Consider a follow stream of binary 1's at 1 Mbps

Sample of 5 element

1 bit = 1 μs
1 signal element = 1 μs

1 signal element = μs

1 bit = 1 μs / 2

1 signal element = 0.5 μs

Modulation rate / Baud Rate

$$D = \frac{R}{L} = \frac{R}{\log_2 M} \qquad M = 2^L$$

↳ data rate, bps

↳ no of different signal elements $= 2^L$

→ number of bits per signal element

NRZI $D = \frac{1 \text{ mbps}}{1} = 1 \text{ Mbps}$

$R = D$

data rate — modulation rate

Manchester $D = \frac{1 \text{ Mbps}}{\frac{1}{2}} = 2 \text{ Mbps}$

$D = 2R$

DT
↳ DD, DS
↳ AD / DS

→ first we want to convert AD to DD is called Digitization

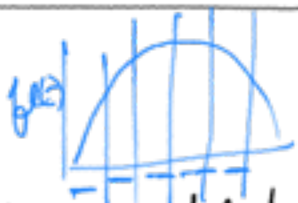
Digitization

→ PCM (Pulse Code Modulation)

→ Delta Modulation

PCM & Delta Modulation

Sampling

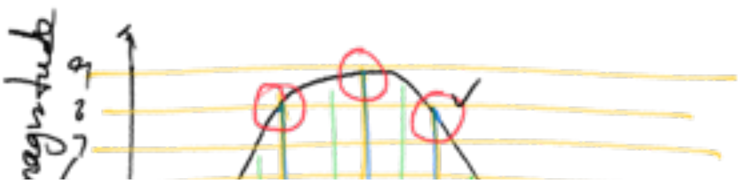


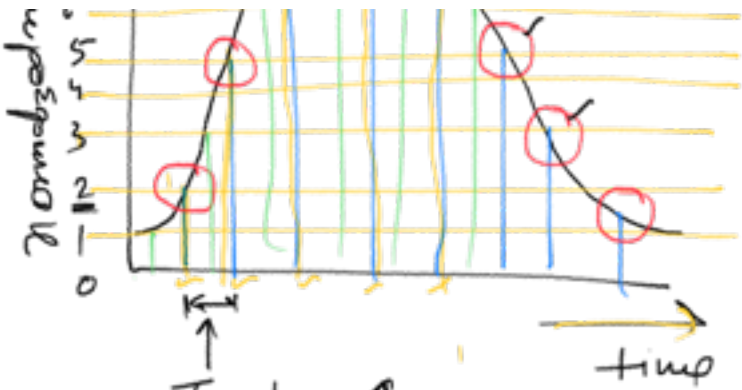
If a signal f(t) is sampled at regular intervals of time and at a rate higher than twice the highest signal frequency, then the sample contain all the information of the original signal.

by using PCM / delta modulation

→ Sampling of signal at rate higher than twice highest frequency of signal

PCM Pulse Code Modulation





$T_s = \frac{1}{2B}$

↑ increase ~~the~~ data but will also increase

PAM value	2.1	5.0	8.1	7.9	7.8	6.2	3.1	1.5
QLM	2	5	8	8	7	6	3	1
PCM Code	0010	0101	1000	1000	0111	0110	0011	0001

Quantized Code Number

transfer the bit stream as data data

2.1 to lowest integer value (2.1) to a digital value

8 4 2 1
(8) → 1000 4 bit

→ PAM Sampler → Quantizer → Encoder →

Analog: Continuous-time Continuous-amplitude

Discrete-time Continuous-amplitude (PAM pulse)

Discrete-time Discrete-amplitude (PCM pulses)

Digital bit stream & output signal

block diagram of PCM

Delta modulation

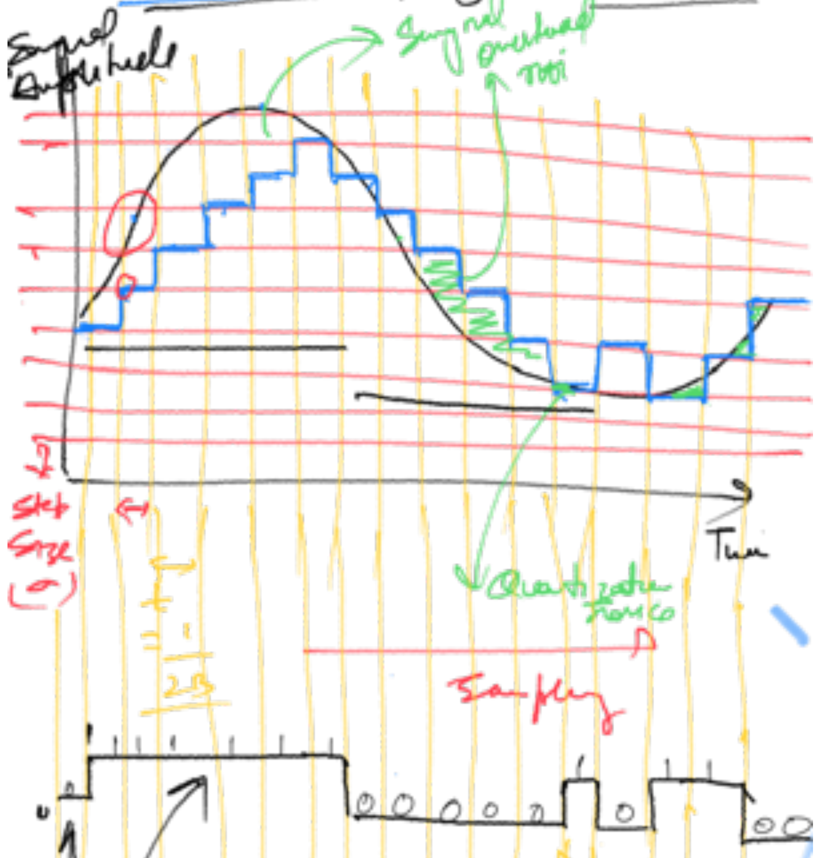
↳ a sample by only one bit

a sample is represented by multiple bits

× multiple

Unit 1

An analog input is approximated by a staircase function that move up & down by one Quantized level (σ) at each sampling interval (Ts)



Delta Modulation output (Digital)

Sample is convert to only 1 bit

Transmission
- D
  - DD, DS ✓
  - AD, DS ✓
- A
  - DD, AS
  - AD, AS

Analogy transmission

→ Analogy signal

↳ Transmission technique

↳ optical fiber

↳ unguided media

$f_c(t)$ carrier

$m(t)$ → Modulator → $s(t)$ → Demodulator → $m(t)$

Digital

Analog

Modulating

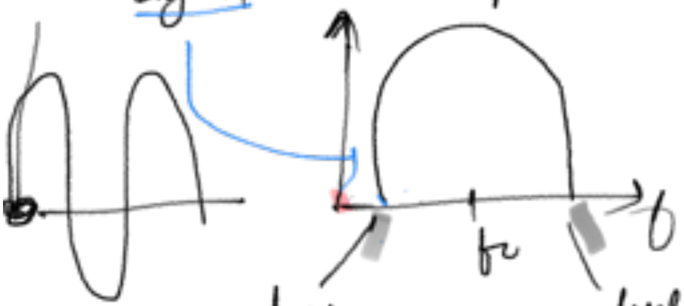
Baseband signal

Analog Signal

TM

Modulated signal

↳ Band-pass



low frequency

high frequency

Analog Transmission

- Digital data, Analog Signal
- Analog data, Analog Signal

3

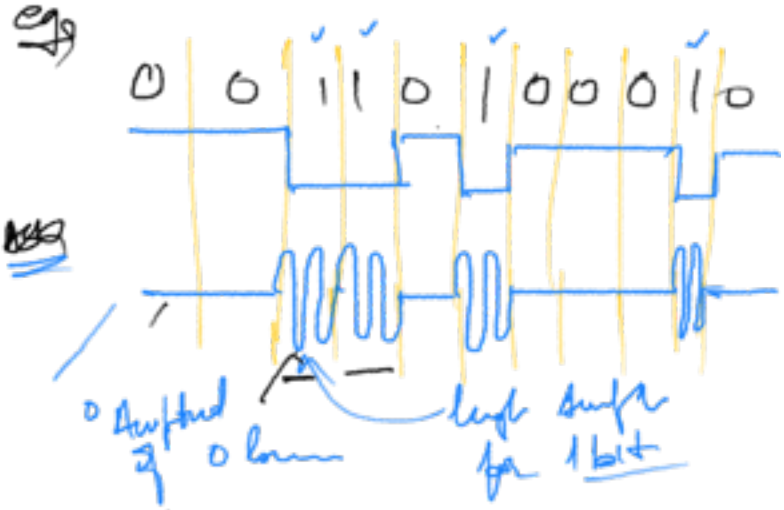
- ASK (Amplitude shift keying)
- FSK (Frequency shift keying)
- PSK (Phase shift keying)
  - ↳ QAM (Quadrature Amplitude

modulation)

ASK (Amplitude Shift Keying)

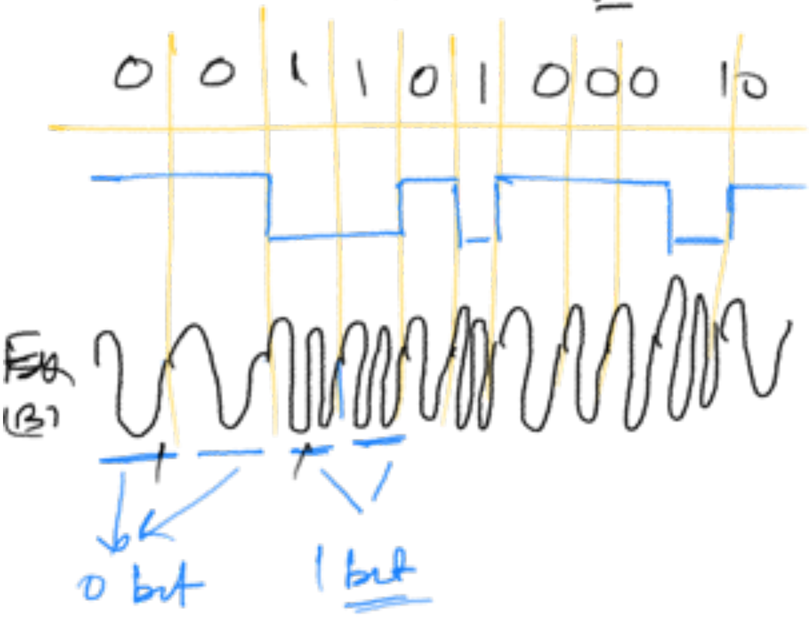
ASK $s(t) = \begin{cases} A\cos(2\pi f_c t) \to \text{binary } 1 \\ 0 \to \text{binary } 0 \end{cases}$

eg



FSK (Frequency Shift Keying)

FSK $s(t) = \begin{cases} A\cos(2\pi f_1 t) \to 1 \\ A\cos(2\pi f_2 t) \to 0 \end{cases}$



B FSK

Binary Frequency Shift Keying

↳ 0

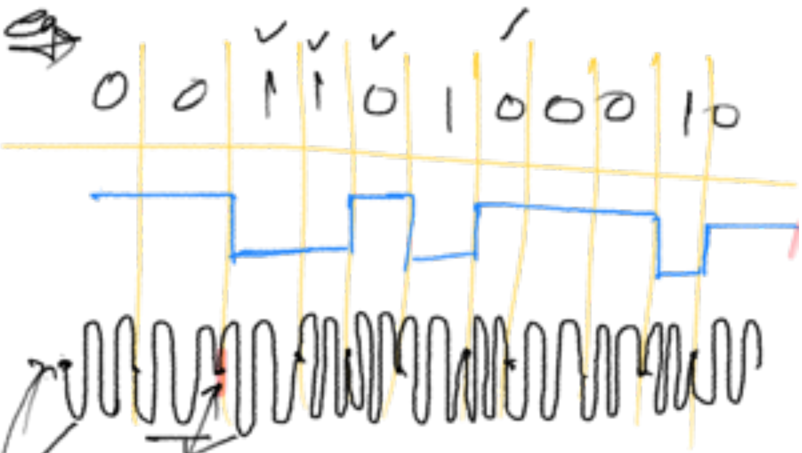
↳ 1

PSK (Phase shift Keying)

PSK $s(t) = \begin{cases} A\cos(2\pi f_c t) \rightarrow 1 \\ A\cos(2\pi f_c t + \pi) \rightarrow 0 \end{cases}$

Same Same $t + 180°$

$= A\cos(2\pi f_c t)$



amplitude frequency is same

Phase are different

PSK < 0, 1

2 level signal it is called

B PSK

Binary Phase Shift Keying

QPSK — ASK, FSK

represent 1 bit

ASK, PSK, FSK — 2 level

to make efficient use of bandwidth a new technique has been proposed in which you can represent multiple bits in single signal element — QPSK

QPSK $s(t) = \begin{cases} A\cos(2\pi f_c t + \frac{\pi}{4}) \to 11 \\ A\cos(2\pi f_c t + \frac{3\pi}{4}) \to 01 \\ A\cos(2\pi f_c t - \frac{4\pi}{4}) \to 00 \\ A\cos(2\pi f_c t - \frac{\pi}{4}) \to 10 \end{cases}$

$90°$ phase cap

$\frac{\pi}{2}$ multiple of

one signal element is now represent 2 bits in contrast to one bit in upper SK encoding

---

Analog data, Analog Signal

TM

Baseband $\longrightarrow$ Band pass

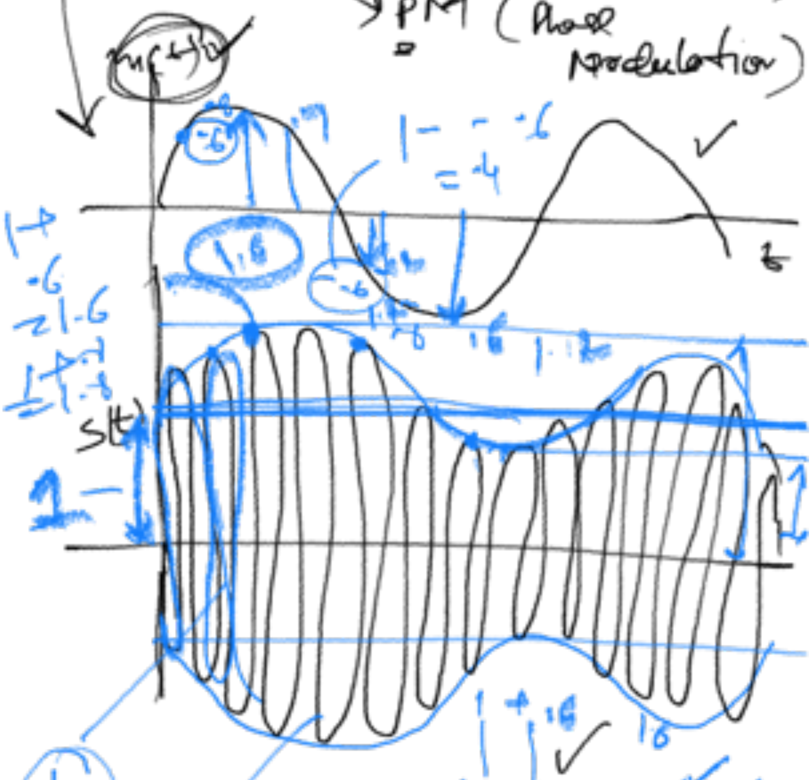
Band pass → Band pass

Modulate Analog data to Analog signal

3 → AM (Amplitude Modulation)

FM (Frequency Modulation)

PM (Phase Modulation)



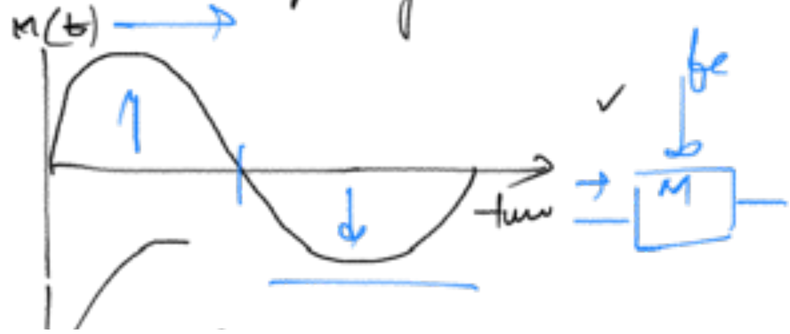
$(1+m)\cos 2\pi f_c t$

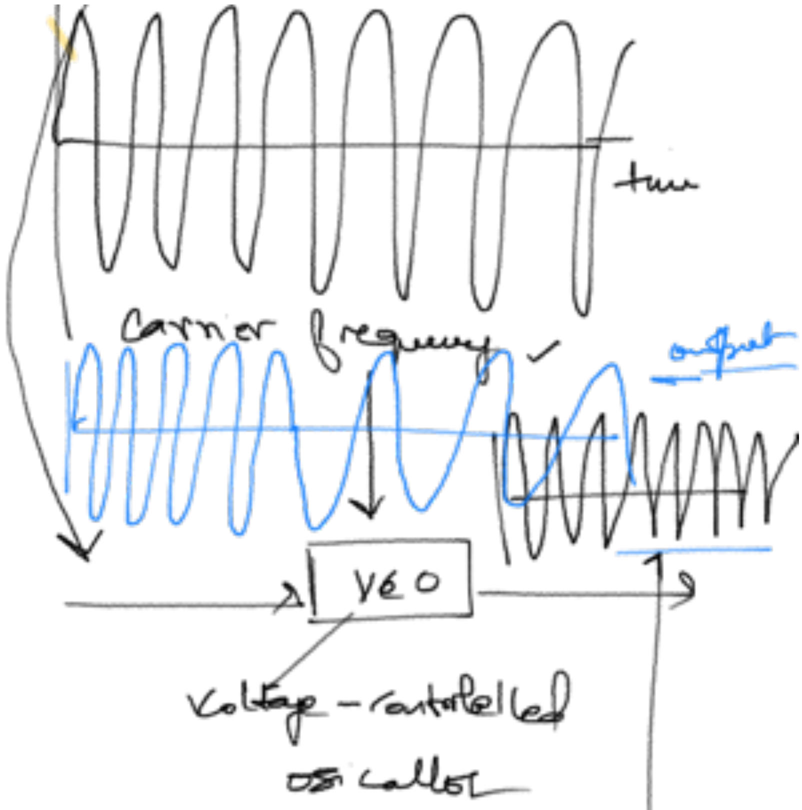
AM

$$s(t) = [1 + m(t)]\cos 2\pi f_c t$$

energy

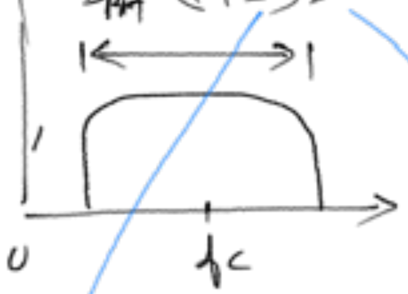
Frequency Modulation





output
analog
signal

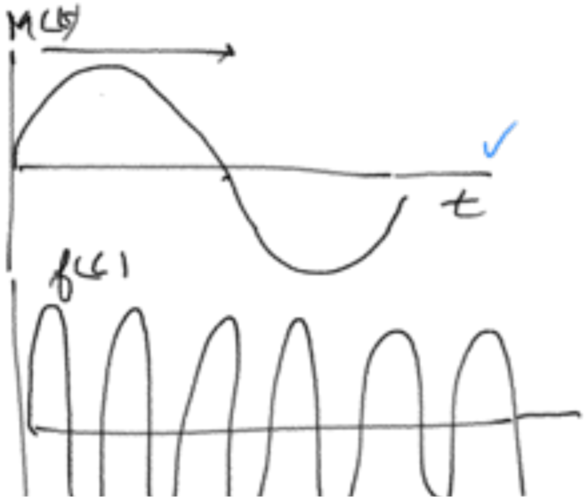
$B_{PM} = (2+b)B$

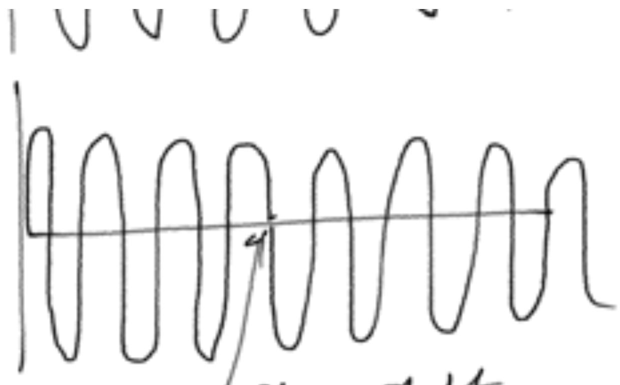


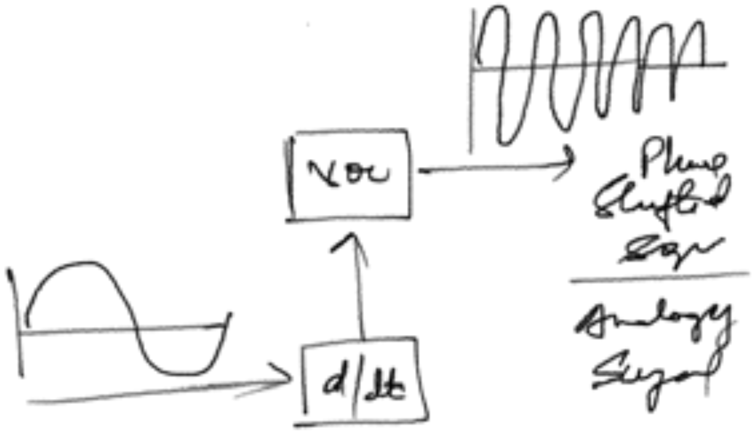
Bandwidth

b is a factor which depends on the modulation technique

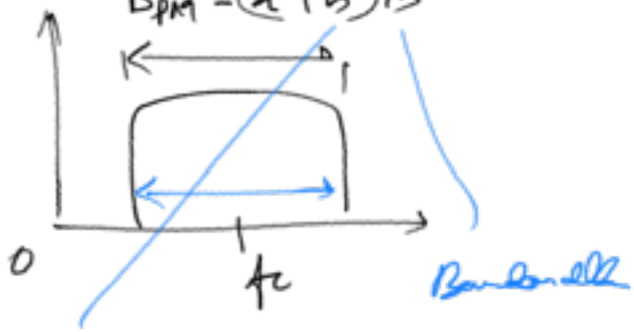
Phase Modulation





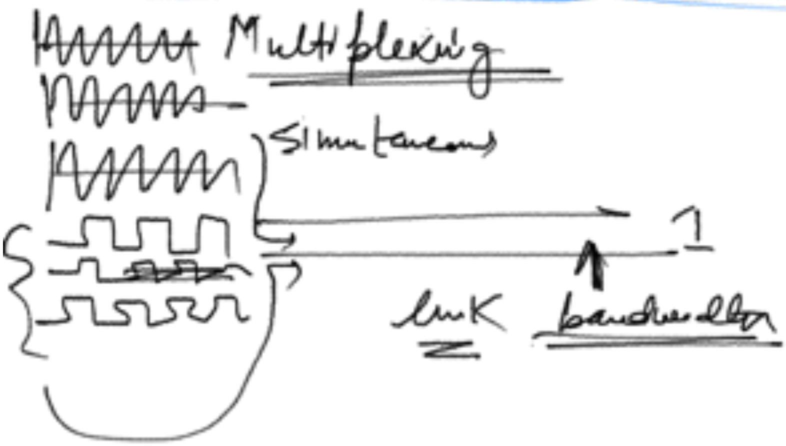


$B_{PM} = (2+b)B$



b is a factor which depends on the modulation technique

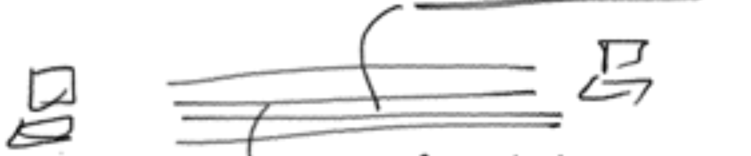
Multiplexing



the set of technique that allow us to do this is called Multiplexing technique

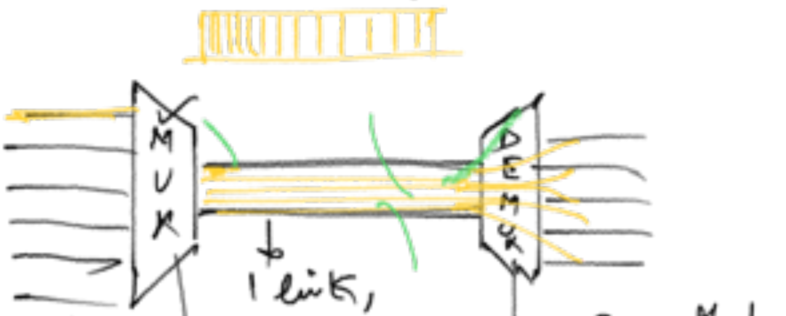
Multiplexing technique

or multiple channel



bandwidth of link is much greater than the bandwidth of device

Multiplex → converting a single link into multiple channels is also called Multiplexing



1 link, n channels

n input lines

n output line

multiplexing

Demultiplexing

Multiplexing

Analogy signal

Digital Signal

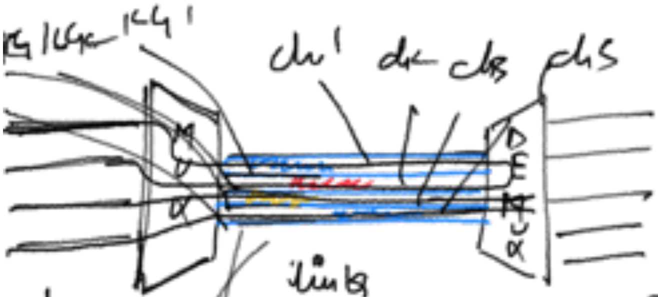
FDM — Frequency Division

WDM — Wavelength Division

TDM — Time Division

- Synchronous TDM
- Statistical TDM

FDM



link

i/p line

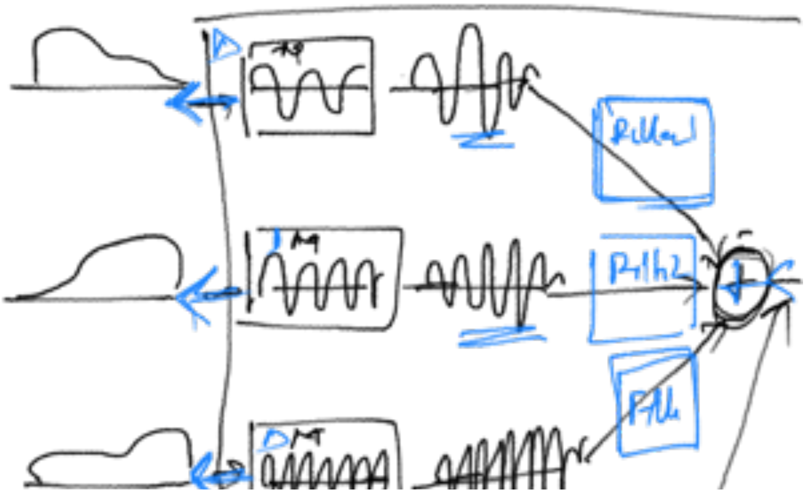
4 channel

o/p line

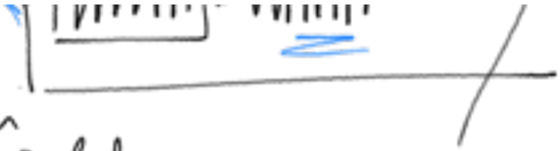
inter channel gap

Bandwidth of the link is the multiple of bandwidth of the device who want transmit from the link

---



Baseband
analogy sign



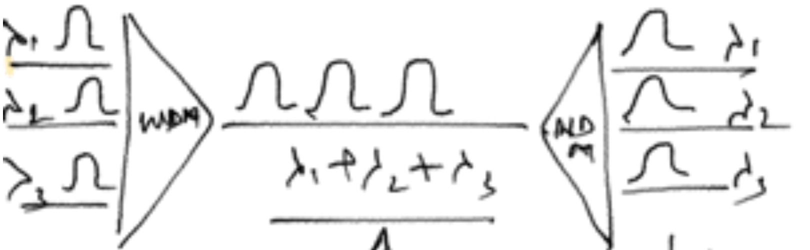
M-Modulator
DM – Demodulator

Sender Receiver

WDM

Wavelength Division Multiplexing

→ to utilize the high data rate capability of fiber-optic cable,

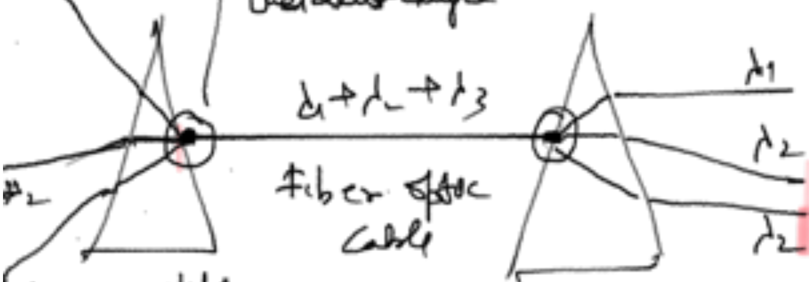


I/P

Single signal

o/p
wavelength of light

we try to put wavelength at different incident angle

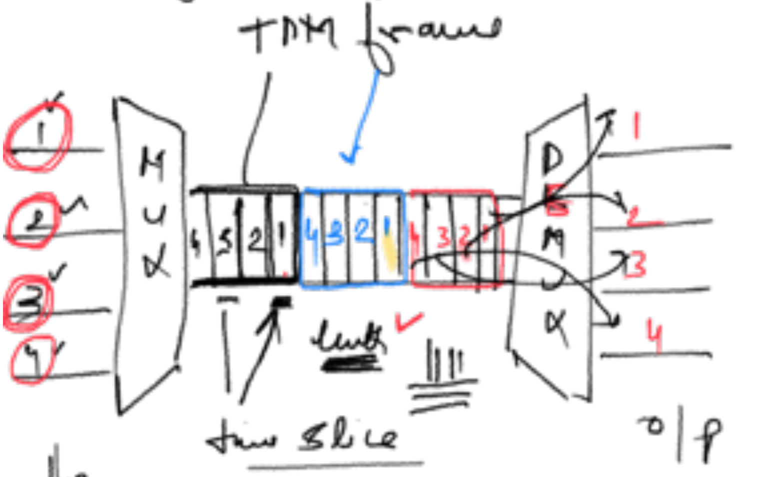


λ_2 multiplexer Demultiplexer

TDM time division multiplexing

→ digital transmission

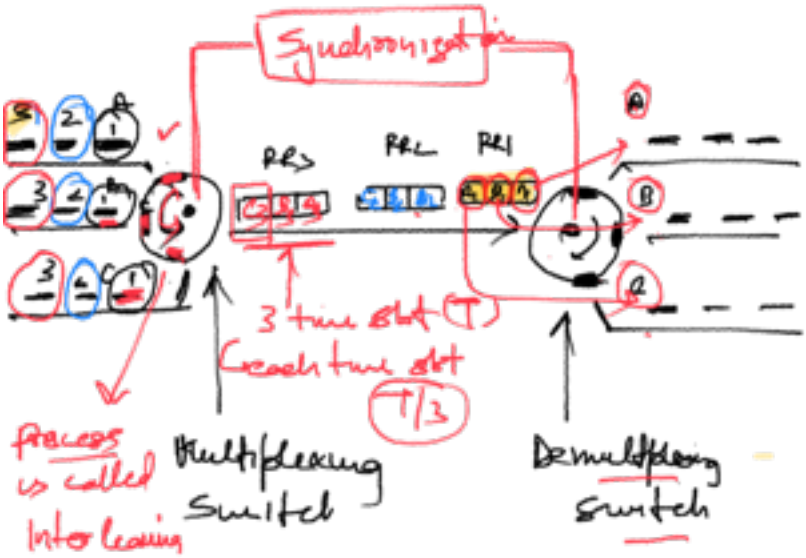
Digital signal



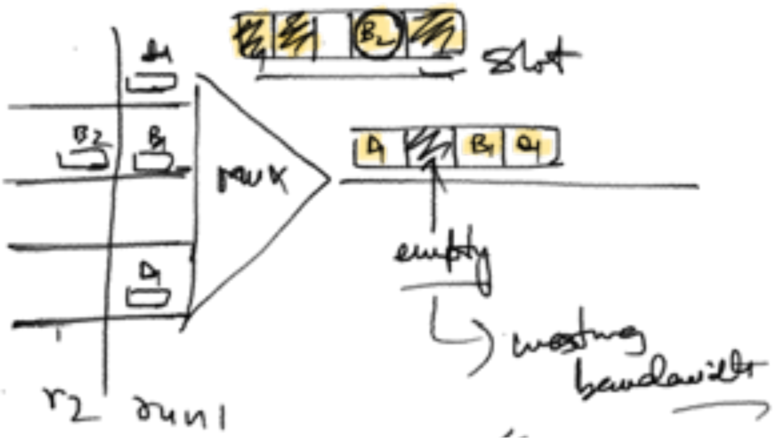
time slice is used by a input device to transmit its digital signal for that time slice

1/18

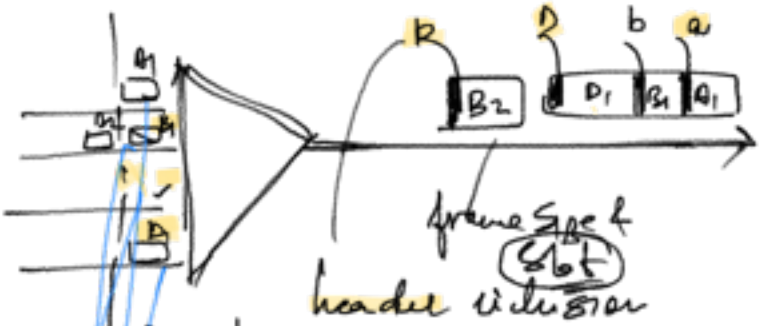
↳ Synchronous TDM (Clock)



not synchronized receiver will receive a Frame



Statistical TDM



now I can create frame that don't have empty slot

Assumption same data rate

TDM has a problem of not handling different data rate & transmission device

Disparity in the i/p lines

Data Rate Management in TDM

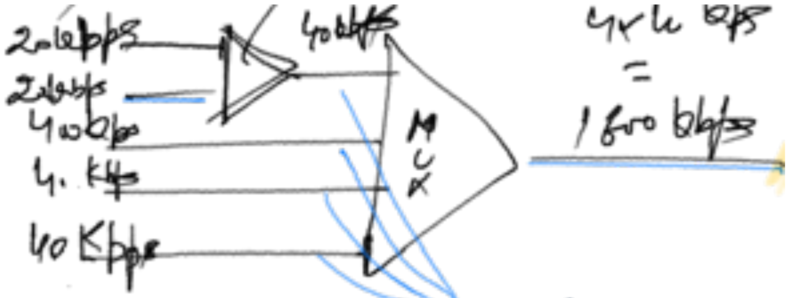
Data rate which are multiple of data

- Multilevel Multiplexing
- Multi-slot Allocation

Data that is not a multiple of other data rate

- pulse stuffing

MUX

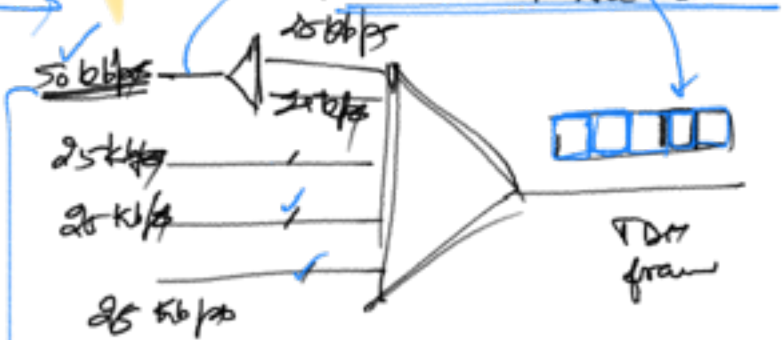


all data rate are not same

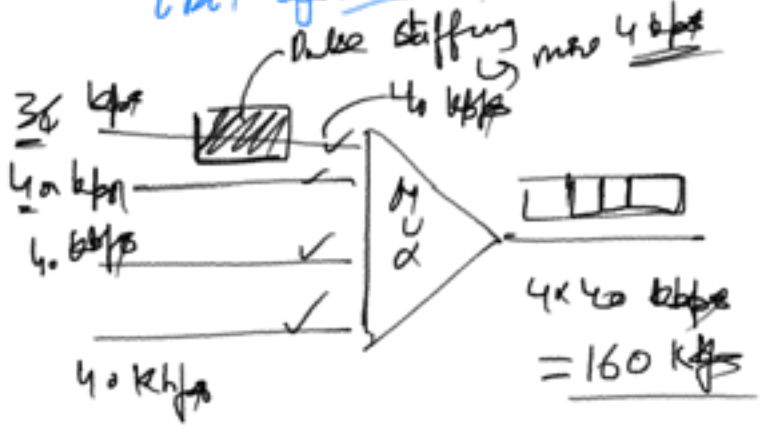
But they are integer multiple of other data

Now have same data rate

Multi-Slot Allocation



2 time slots allocated to 50 kbps data rate in TDM frame



Switching

Switching N/W

Switched Communication n/w, (N)

data entering the n/w from a

station ... routed to the

station are routed to destination by being switched from node to node

Switched n/w

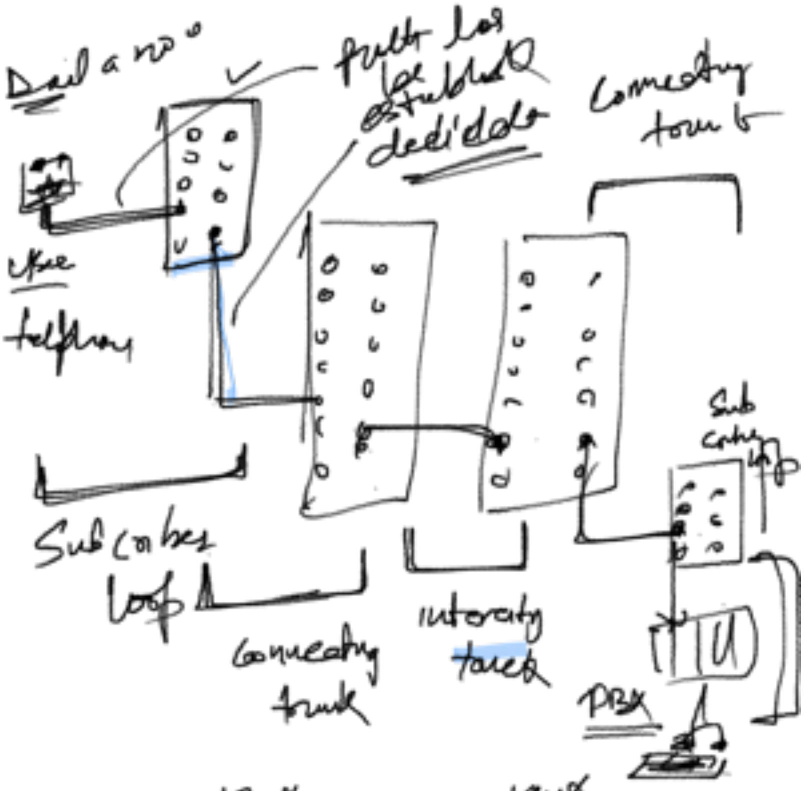
- Circuit Switched n/w
- Packet switched n/w
  - Datagram n/w
  - Virtual Circuit n/w
- Message switched n/w

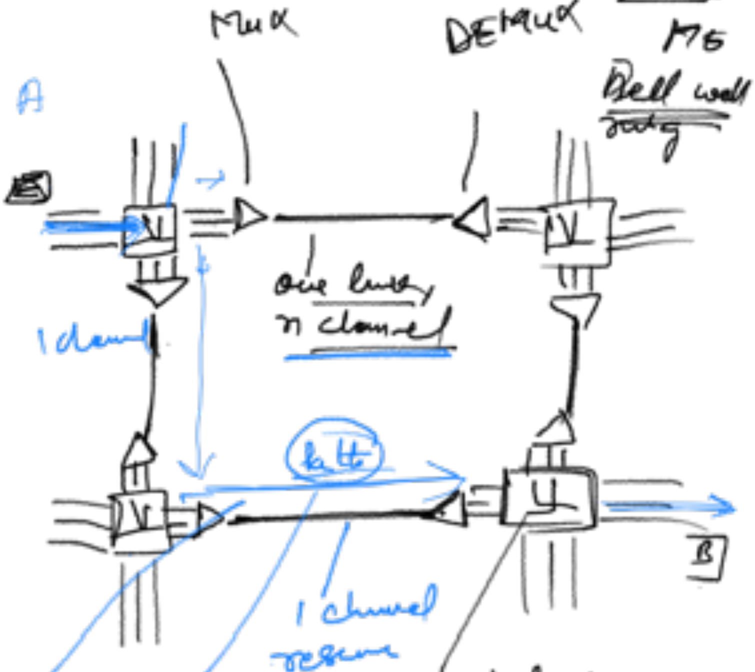
Circuit Switched n/w

A connection b/w 2 stations is a dedicated path made of one or more links.

However, each connection uses only one dedicated channel on each link (FDM, TDM)

eg) Telephone n/w
PCSN n/w
Public Circuit Switching

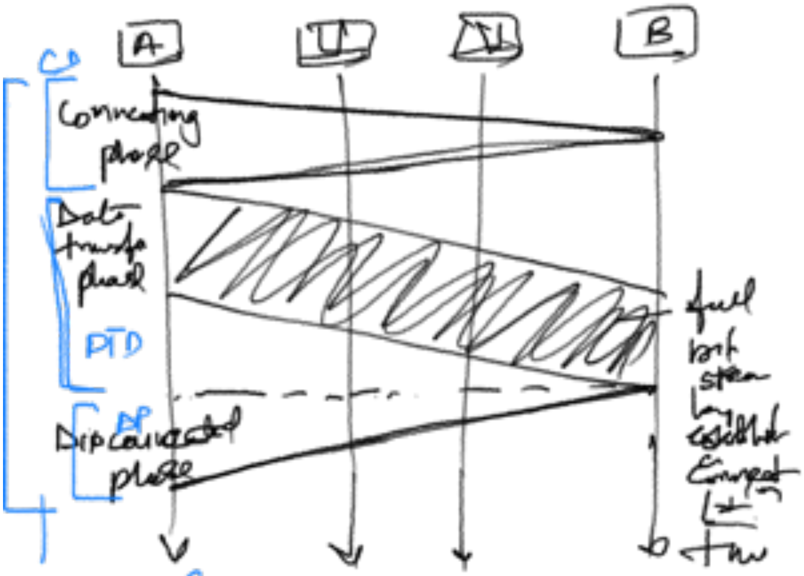




Switching

path that will consist of multiple nodes to node link/channel

Circuit established



Total Delay
↳ setup phase ✓
↳ Data transfer ✓
↳ tear down phase ✓

Total Delay = $C_D + DT_D + D_D$

Packet Switched n/w

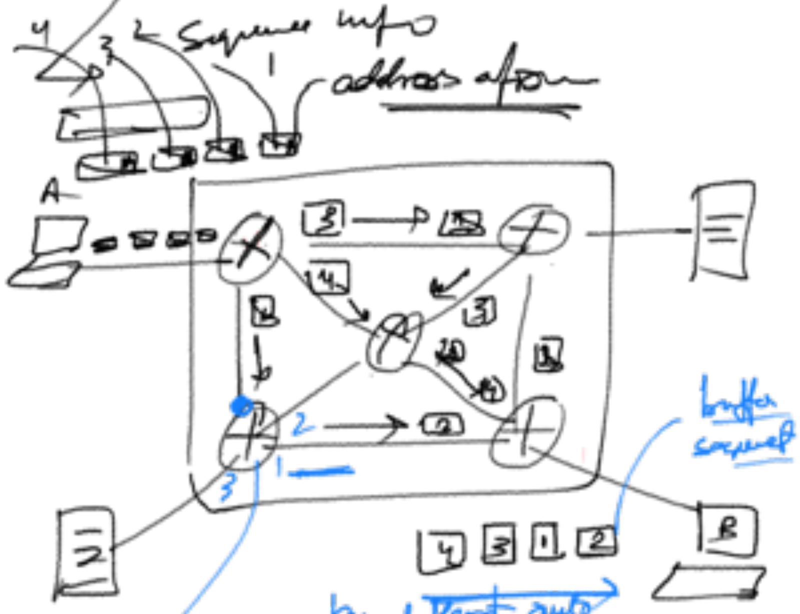
Packet

will be switched from node to node

So that I can reach destination

source/destination address

↳ that are going to help them reach destination without establish connect before hand datagram   Virtual Circuit

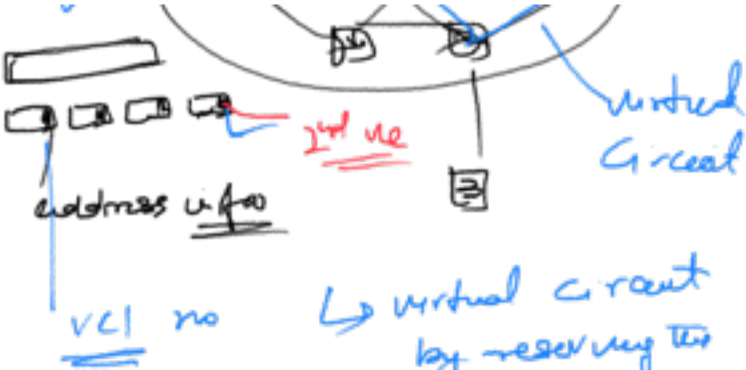


we don't establish circuit
only packet have address info
with which switch node
decide where to find Route

D. add	output port L
1234	1
4150	2
1	
9130	3

Virtual - Circuit N/W

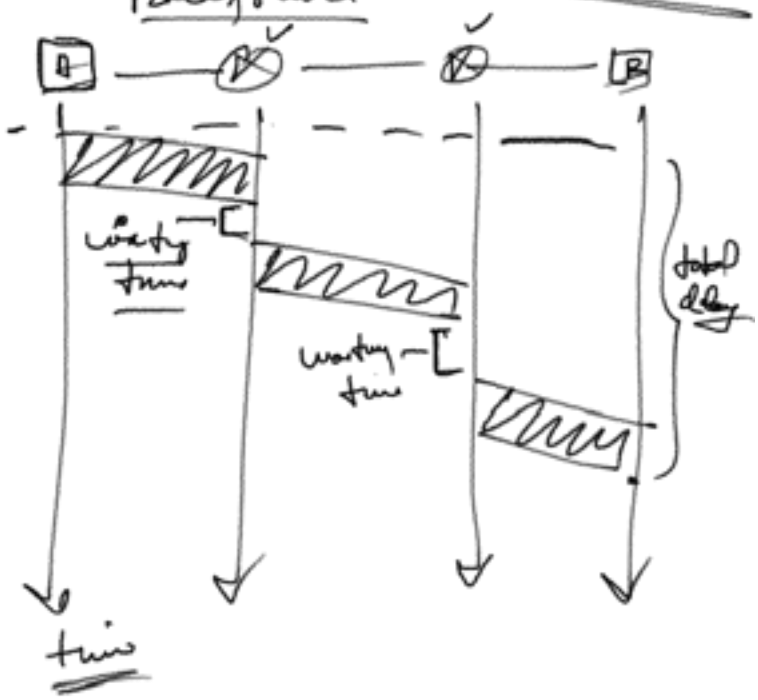
↳ a combination of
packet switch and
Circuit switch



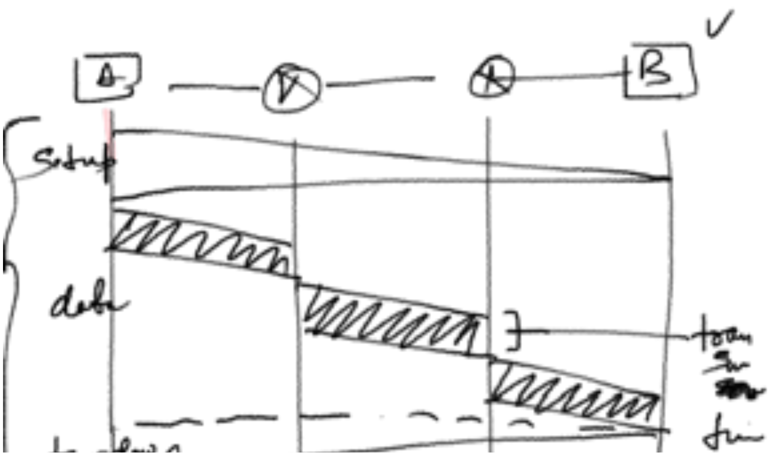
↳ virtual circuit by reserving the bandwidth & channel on demand

↳ then we pass the packet with address info of VC to the

Datagram



VC Packet Switching



total delay =

$setup_D + data_D + forwarder_D$

Message switch

CS 1950

100MB can be of any len — MS 1970

PS 1985

Circuit

Store & forward

buffer

buffer of memory

It can handle & buffer all data

1970 — RAM high mem

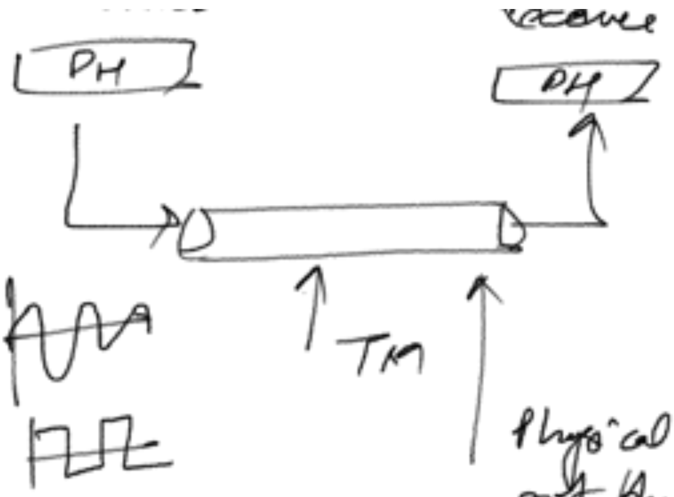
HDD store & forward

α

Transmission media

medium

sender



Physical &
not physical

→ transmit data from
source to receiver

Transmission
Media

- Guided ✓
  - ↓ Wire/Cables
    - Twisted pair Cable
    - Coaxial cable
    - Fiber optic Cable glass / PVC
- Unguided media ✗
  - ↓ Air
    - Radio
    - microwave
    - IR

electr
telephone
Internet

Tv
Cable
DTH

analogy &
digital
Signal

Analogy
Single

Remote

✓
Design Factor (TM) (LAN, MAN, WAN)

↳ Bandwidth :

↳ Impairment ;

↳ Interference ;

↳ Number of Receiver :

P to P , ~~broad~~ broadcast

Guided Media

① Twisted Pair cable

twisted
are been made to
protect signal from crosstalk and interference

plastic protective shield
Insulator

no of twist / inch

- more the twist
good cable in CRI

TPC

↳ UTP
Unshielded Twisted Pair

↳ STP

Shielded Twisted Pair

Carry signal two work like a gather of crosstalk

Collected signal of crosstalk is grounded by earth signal

ground or earthing

9 fig

Cable

8 wires

4 → tx

4 — RX

UTP cable model

Internet

2 → tx

2 → Rx

4 → POE

Power or Ethernet

Industry Research

electronic

Telecommunication

EIA/TIA 568 cable UTP

1 2 3 6 wire are use of tx & RX

Connect dissimilar device

Straigh cable → EIA 568A on both ends

Cross cable → EIA 568A at one end EIA 568B at other end

Rollover cable ↳ EIA 568A on one end and roll the wire on other end

configuration cable

Connect similar device

EIA 568

↳ cat 3
- cable
- connector
- upto 16 MHz

↳ cat 4
- cable
- connector
- upto 20 MHz

↳ cat 5
- cable
- connector
- upto 100 MHz

LAN current

↳ cat 6
- cable
- connector
- upto 1 GHz

future LAN

category

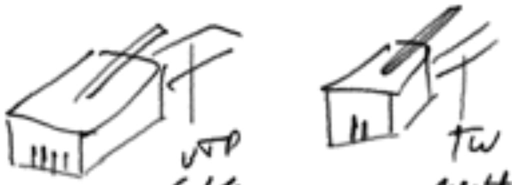
UTP/STP

four pair

Registered jack

one one

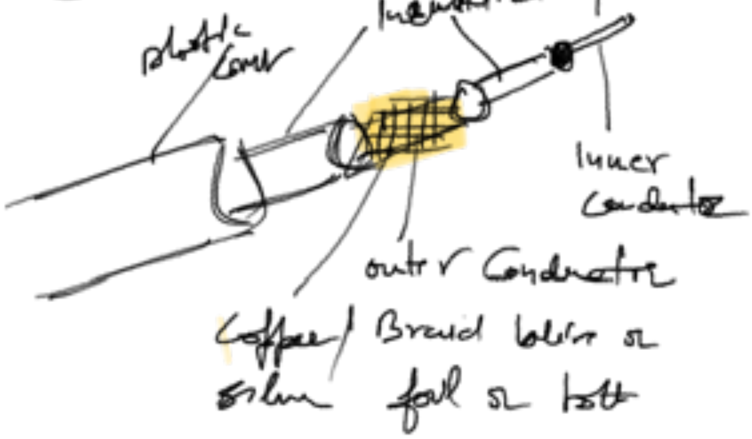
RJ45 RJ11



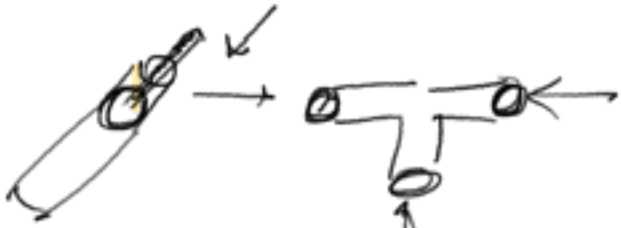
UTP cable with 8 pair

TW with one pair

② Coaxial Cable



Connect BNC

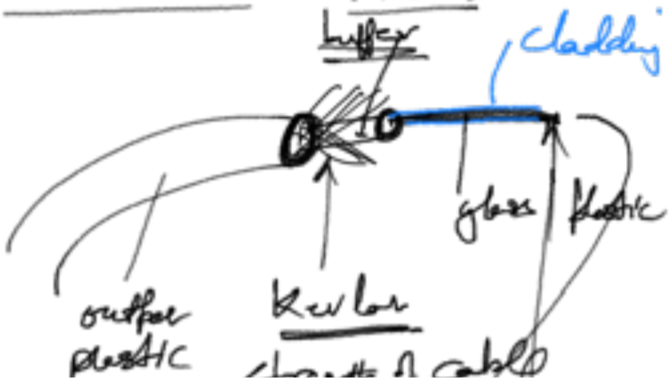


system

T connector
↳ Drop cable connects from line to system/node

Application
→ TV distribution
→ long-distance telephone transmission
→ Short-run Computer (BUS)
→ LAN

Optical Fiber



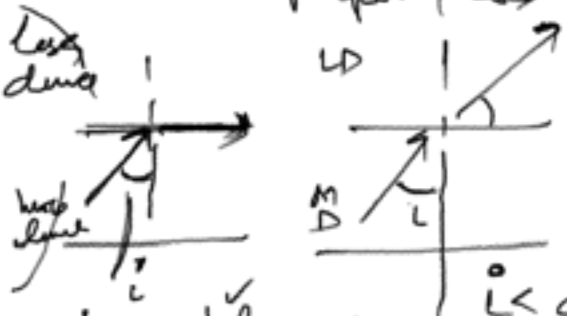
jacket strength

refraction and reflection of optica to transmitt data

glass

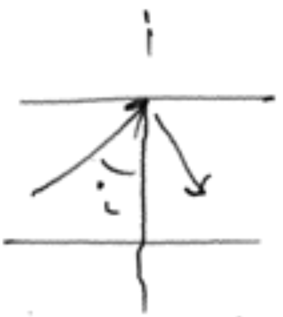
8 µm to 50 µm

To transmitt signal it use Refraction & Reflection of ~~optical~~



i = critical angle

i < critical angle
refraction

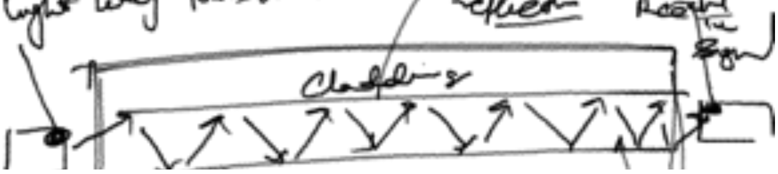


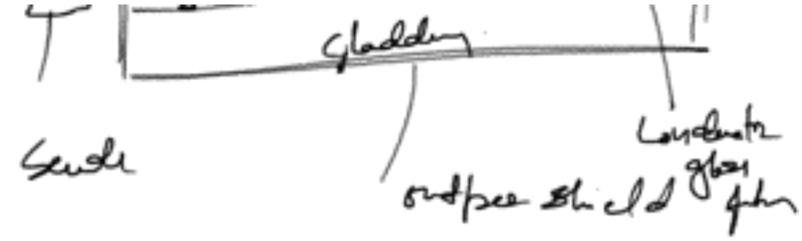
i > critical angle
reflection

light way transmit

because of diffraction of direction of light to reflect

diode Receive the signal





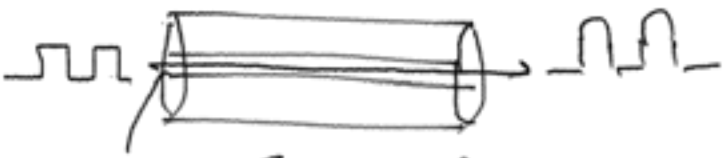
optics

↓

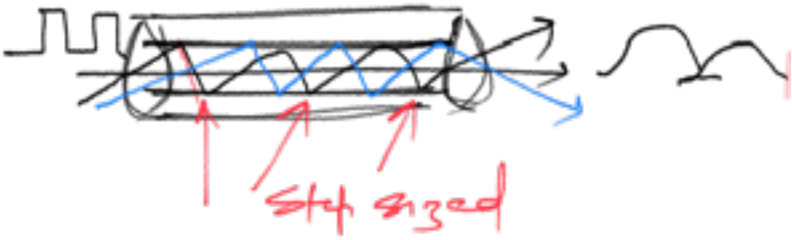
propagation modes

Single Mode ✓ | Multimode ✓

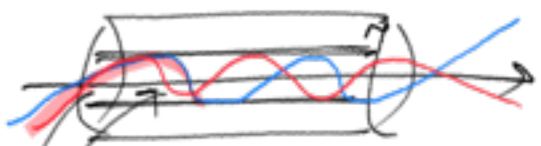
Multimode → step index | graded index



Single Mode



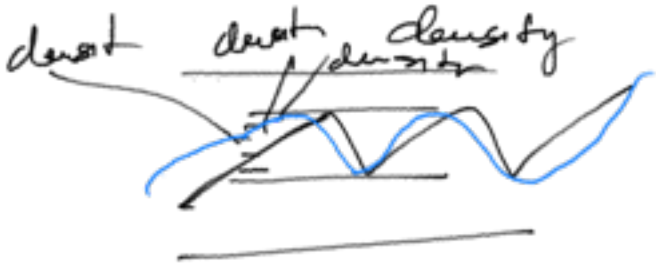
Multimode, step index



Multimode, graded index

round due to the fast

\ years core → dont have constant



SC ST connector

Unguided Media

↓

Wireless transmission

Radio	Microwave	Infrared
30 MHz to 1 GHz	1 GHz to 40 GHz	3×10^{11} to 2×10^{14} THz
Omnidirection	Unicast, unidirection	Unicast, unidirection, line of sight
eg FM radio	eg cellular n/w	eg Remote controlling

Radio wave & microwave	Infrared	light wave

3 MHz — 300 GHz — 400 THz — 900 THz

d. electromagnetic spectrum

→ to transmit data through
- ↳ atmosphere
- ↳ air
- ↳ sky

Antennas

↳ electrical conductor or system of conductors used either for radiating electromagnetic energy & for collecting electromagnetic energy

↓ transmission

↓ Reception

radio frequency electrical energy

to ↓

electromagnetic

↓ to

↓ two way antenna

→ isotropic or omnidirectional antenna

Cross section of parabolic antenna

Antenna gain

is a measure of the directionality of an antenna

$$G = \frac{4\pi A_e}{\lambda^2}$$

antenna gain

effective area

carrier wavelength

$$= \frac{4\pi f^2 A_e}{c^2}$$

carrier frequency

speed of light

($\approx 3\times10^8$ m/s)

Microwave transmission

- ↳ Unicast
- ↳ cellular n/w
- ↳ satellite n/w
- ↳ wireless LAN

⟶ 2 categorized

Terrestrial

Microwave

air as a media

they transmit & receive

Satellite

Microwave

↳ ground / earth station

↳ satellite

Eg long-haul telecommunication

↳ replacement coaxial cable & optical cable

↳ point to point

↳ closed-circuit TV

Loss & Attenuation

$$L = 10 \log \left(\frac{4\pi d}{\lambda} \right)^2 dB$$

loss & attenuation

distance

wavelength

in same unit

Satellite Microwaves

Point to point link

Broadcast link

Radio | Broadcast Radio

↳ radio

↳ television

↳ Paging system

↳ omnidirection

antenna are not required to be precisely in line of sight

30 MHz to 1 GHz

$\boxed{\text{FM, VHF, UHF}}$

Radio   TV

Loss

$$L = 10 \log \left(\frac{4\pi d}{\lambda}\right)^2 dB$$

d distance λ wave length

same unit

Infrared Transmission (Remote Control)

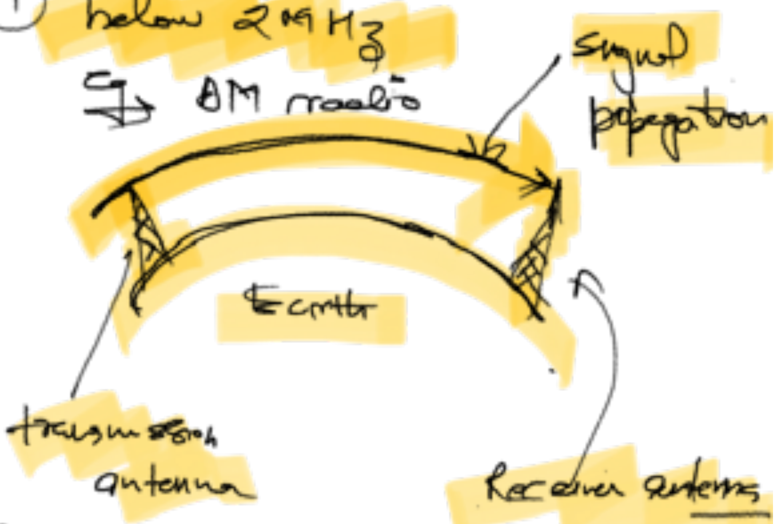
↳ short-range signal

↳ line of sight
↳ It can not penetrate through build
↳ signal should travel by Reflection (light coloured surface)
↳ licensing (not required)

Wireless Propogation

① Ground Wave Propogation
② Sky Wave Propogation
③ Line of Sight propogation

① below 2 MHz
⇒ AM radio



② 2 MHz → 30 MHz
Signal