Data Communication

- Data communication are the exchange of data between two devices via some form of tranmsformation medium.

- For ~~data~~ data communication two parts / the communication devices must be part of a common system.
  made of software and hardware

-

OR, DC is the exchange of ~~d~~ information from one entity (which is able to send and recieve) to the other using a transmission medium.

Data Unorganized	Information Organized

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- The effectiveness of data depends on,
  1. Delivery → The system must deliver the data to the desired destination. + security.
  2. Accuracy → must deliver the data accurately. Alter in incorrect data are unusable
  3. Timeliness → must deliver in time. Late delivered data are useless.
  4. Jitter → uneven delay in the delivery of audio or vedio packets.

Called as → real-time transmission.
Video, audio, delivering data as they produced

Element of Components

Device

Sender | Reciever

Has some Rules / Protocals.

Transmission medium

Rules/Protocal

Agreement between devices.

Messages

Data

Data flow

Simplex

keyboard, monitor,

Simplex mode can use the whole capacity of the channel.

Half - duplex

walkie-talkies

Full - duplex

Data Representation.

Text * Represanted in bit Pattern.

→ A sequence of 0s and 1s.

Different set of bit pattern have been designed ~~designes~~ to Represant text Symbols.

→ Each Set is called Code.

And the Process is called as coding.

- Unicode → 32 bits
- ASCII →

Numbers Numbers are also represented by bit Patterns

→ Directly Converted to Binary & Mathmatetical Calculations.

Audio : This is continuous, not discrete.

Data Representation.

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Audio: This is continuous, not discrete.

Video

Images → Represented by bit patterns.
→ Composed of a matrix of Pixels.
→

a small dot

size depends on the resolution.

image
↓
Pixel
↓
bit pattern
↓
Black & white 1-bit = 1 Pixel

Networks

A network is a set of devices (often referred to as nodes) connected by links.

→ A node can be a computer, printer – any device can send and/or recieve data by another nodes on the network.

☐ network types/criteria:
- Performance
- Reliability
- Security

Perfomane

↓

transit time	Response time	throughput	delay
time required for a message to travel one device to another	elapsed time between an inquiry and a response		

Reliability

→ measured by (i) the frequency of failure

→ (ii) Recover from failure

→ (iii) Network's Robustness in a Catastrophe.

The capacity of the network to maintain functionality when a sequencial node removal strategy is performed.

Security

* Protecting from,
  - unauthorized access
  - damage & development
  - data losses

Physical Structure: Types of connections:

Point to Point

S S

dedicated Line

One -- One

Multipoint

S S

Main

S

Shared Link

time share

Station Priority time.

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Bandwidth share

Topology → Geometric Representation of the relationship of all the links & linking devices to one another.

nodes.

Network types

Criteria
- size.
- Geographical.
- ownership.

PAN	LAN	MAN	WAN
50m	50-300m	50KM	
		wimax	

LAN

Privately owned

A single office, building, Campus

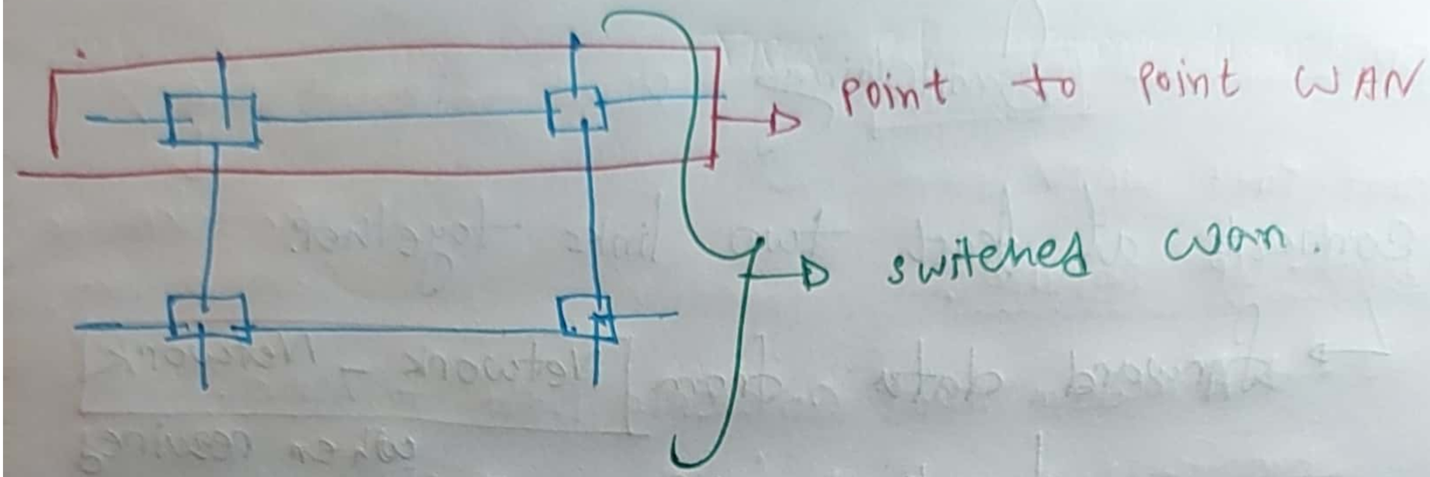
- Someone's home PC- Printer
- Host has unique identifier, address
- A packet
  - Sender Host → Code.
  - Receiver's host → Code.
- Connection among hosts

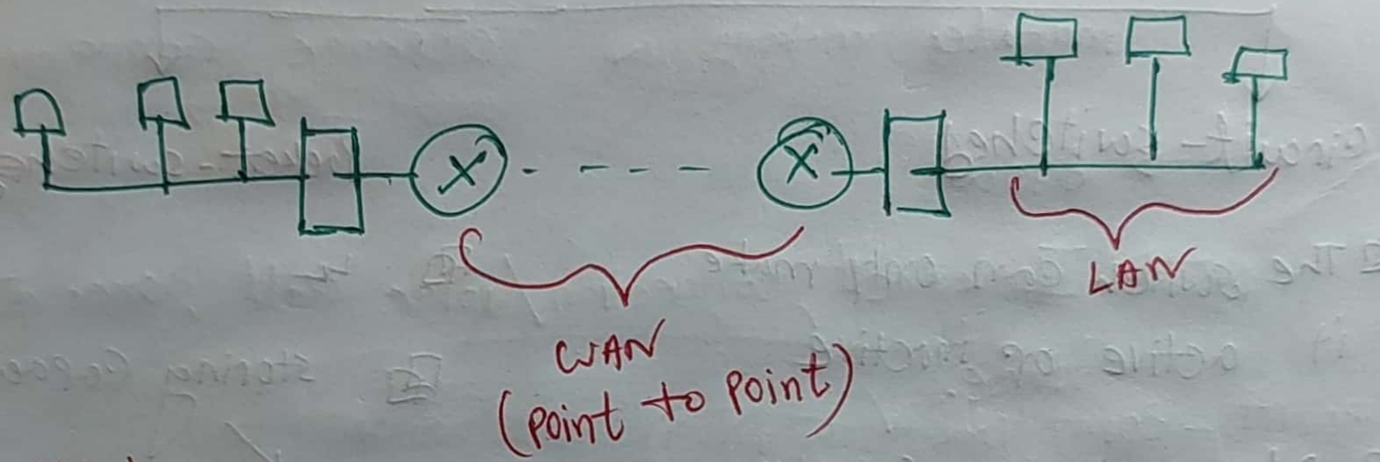
WAN

- wide geographical span
- owned by organization, companies
- connection among switch, routers, modems

- point to point
  = connects two Communicating devices through transmission media (cable / air)

- Switched WAN
  = Has more than two connection. A combination of several point to point WANs that are connected by switch.





NOW/ when two networks are connected, they make INTERNETWORK /internet.

Switching

- Connects at least two links together.
  - ↳ forward data from $\boxed{\text{Network - Network}}$ when required

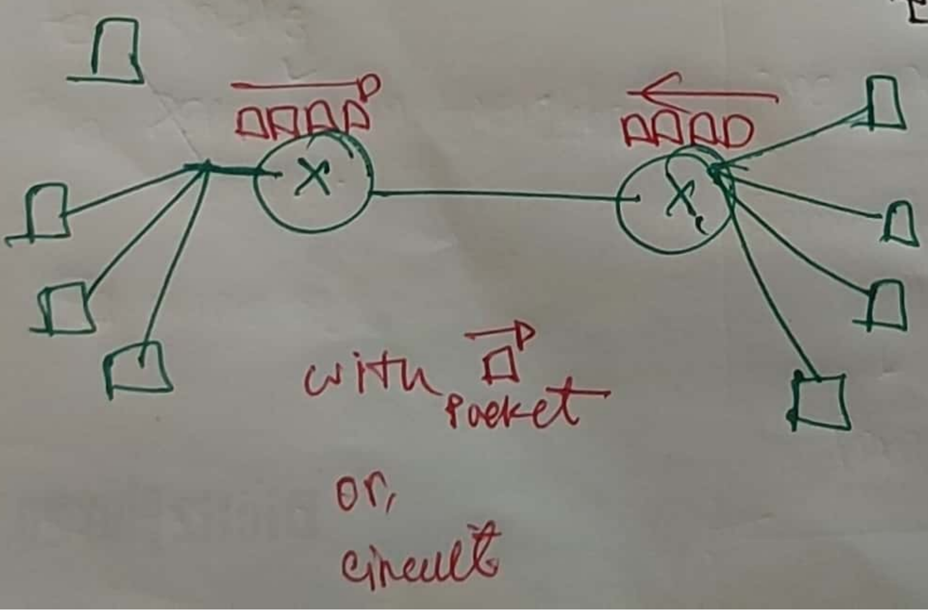
most common

circuit-switched

- The switch can only make it active or inactive
- No storing capacity
- efficient when all at full capacity

Packet-switched

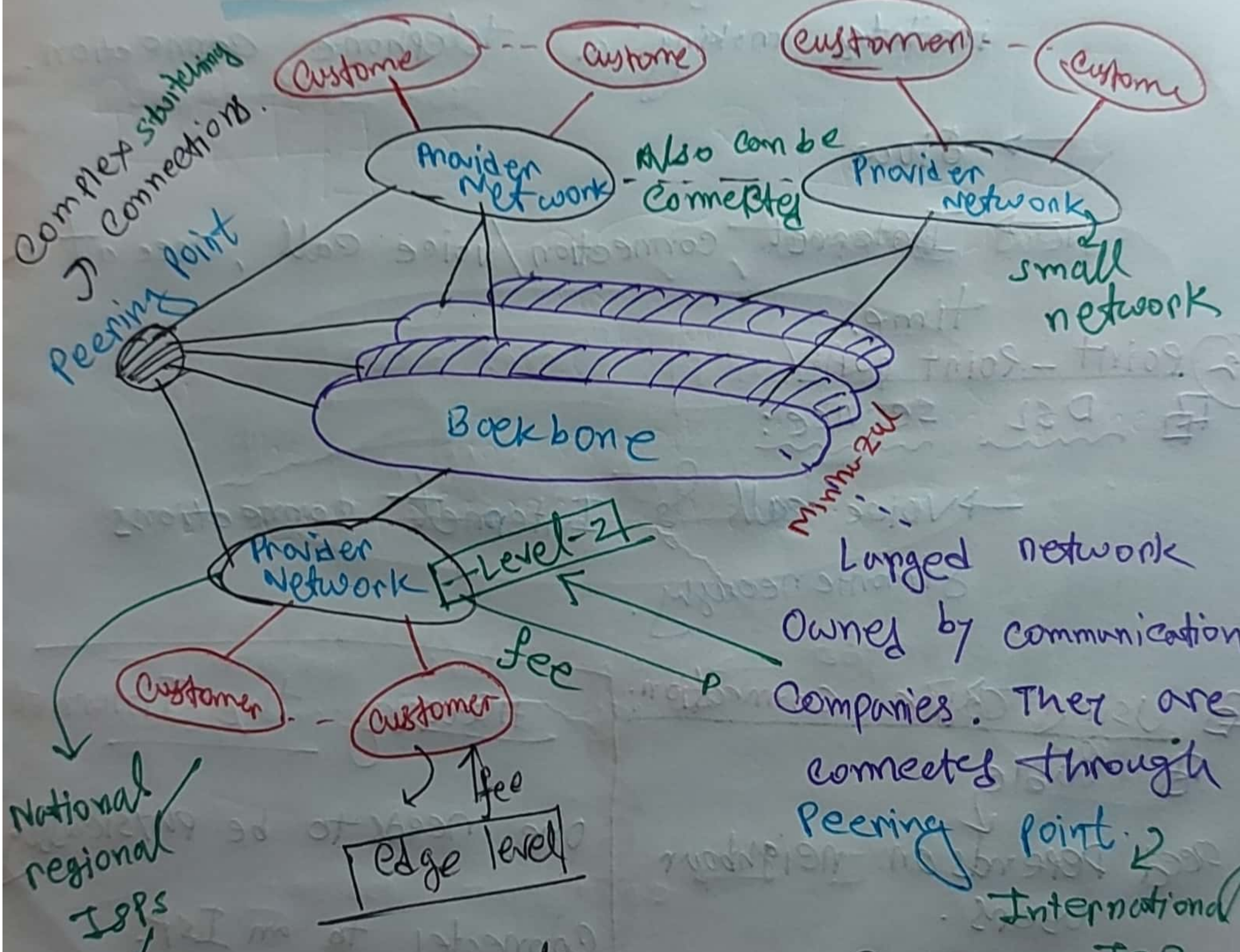
-
- storing capacity
- Can ~~store~~ data later. [uses queue]
-
- Time delay but more efficient



The Internet

The internet we read before is i. But

(I) Internet is Composed of thousands of interconnected networks.



Larged network Owned by communication Companies. They are connected through Peering point.

ISPs → Internet service Providers.

Backbones & Provider networks.

18

User ——— Provider Network → Point to Point WAN → The telephone Center also,

② Point-Point WAN

Dial-Up service:

→ A modem that converts Data to Voice.

→ Software dials the ISP and imitates making a telephone connection.

→ Slow

→ Internet connection/voice call, once at a time.

② Point-Point WAN

DSL service:

→ Voice call & Internet connections simonteneously.

Using ~~Cable~~ Cable connection:

Cable → speed Depends on neighbour users.

wireless

Direct.

Accessing the Internet

One needs to be physically connected to an ISP.

→ Point-Point WAN

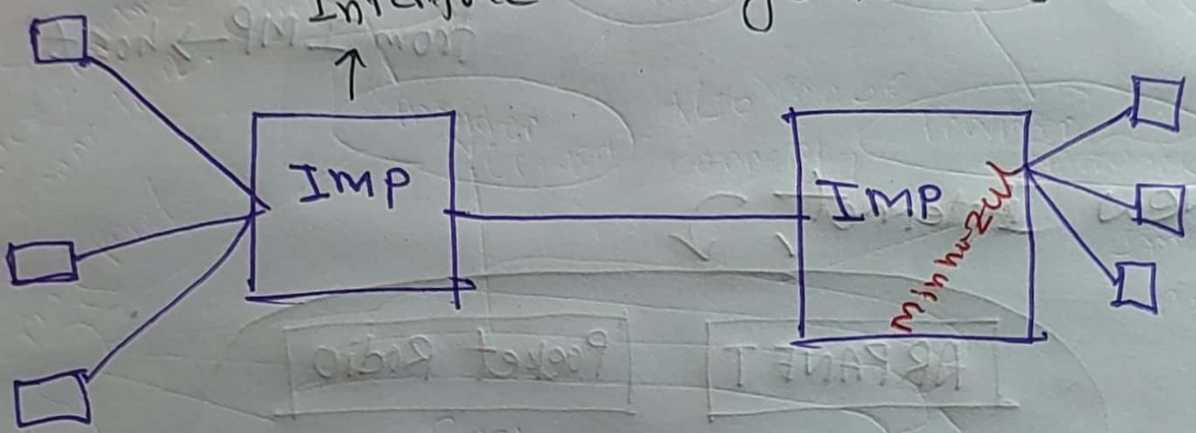
ARPANET by ARPA

Association for computing machinery.

Advanced Research Project Agency

→ At ACM ARPA Presented the idea that they need a connection among researchers.

Interface Message Processors



Software → NCP

Network Control Protocol

Reformed to TCP

transmission

TCP/IP

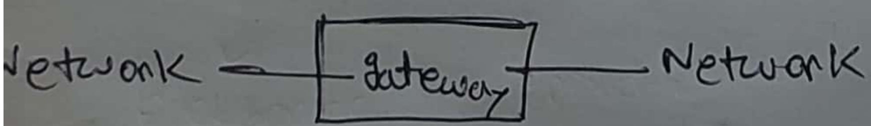
How to link two network!

→ diverse packet size.

→ interface

→ transmission rate.

→ reliability



TCP → Encapsulation

→ datagram

→ gateway function.

Idea → error correction, from IMP → host

New Internet,

ARPANET

Packet Radio

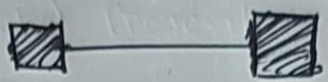
Packet satellite

TCP → TCP → Higher level function
segmation, reassembly, error

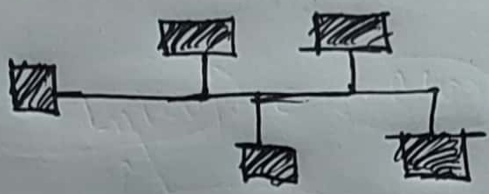
→ IP → datagram routing

Types of connection

- Point to point



- Multipoint



Router

connects devices from different networks.

switch connect all the devices from a network.

PROTOCOLs

↓

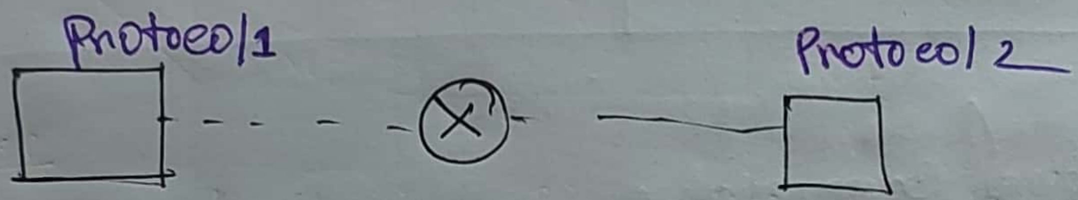
Rules

A set of predetermined rules that govern communication.

Defines

↓

What
How to communicate.
When



Protocol 1 == Protocol 2

Chapter-2

Protocol Layering

- Defines the rules followed by the Sender and reciever.

→ Simple communication.
↳ one protocol.

→ Complex communication
↳ Protocol Layering

at each task we need protocol that's why we use it.

- It enables us to divide a complex task into several smaller and simpler tasks.

Advantages

- A layer can be replaced by human or Robot, the implimentation will not be hampered.

- we always do not need the whole system. Rather than only few layers. saves time

Disadvantages

-

- Find fault easily
- Change in one layer do not affect another.
- Have defined information that they act upon.

Principales of Protocol Layering

Bidirectional Communication

↓

have to make each layer so that it is able to perform two opposite tasks.

→ one in each direction.

Two objects under each layer at both sites should be identical.

Standards

→ organization

→ IEEE, ANSI, TIA, IETF, ITU-T

→ Endorsed by the networking industry and approved by a standards organization.

↓ Benefits.

- Open and Competitive market
- Ensured greater Compatibility and interoperability

Categories

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- De facto
  ↓
  Have been adopted as standards through widespread use
  ↓
  বাপ দাদা দিয়ে আসছে হাটি
  ↓
  TCP/IP

- De jure
  ↓
  Ligislated by an officially recognized body.
  ↓
  OSI

7 layers of OSI

ISO

1. Physical → Binary

2. Data link → Mac Address

3. Network → Hop to hop, IP

4. Transport → TCP, UDP, segments

5. Session → Synchronization

6. Presentation → Encription

7. Application → Http

7. Application Layer

- works as a medium to prepare, by using the application Layer protocols.

  from human readable.

- Gives the access to use the internet.

End - to - End connection.

Application Layer protocol

↓

HTTP, HTTPS, → browser

SMPT → sending } mail

POP 3 → receiving } mail

TELENET → Term viewer

FTP → download.

↓

File transfer Protocol.

Access to end user.

- User end use

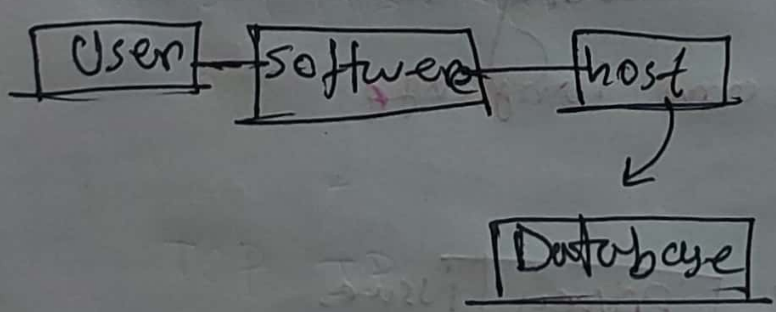
→ File transfer

→ remote access

→ shared data-base management

→ mail service

- Log on to a remote host.



* Are not associated with a particular Protocol stack.

6. Presentation Layer

Syntax Semantics

System ⟷ System

translate	Compression	Encription
from data to machine language → bit	SSL → reduces the bits of the information	

* Syntax and Semantics of information exchanges between two systems.

Translation.

information → bit

* this layer is interprets between these encoding - decoding mathodes for machine and language

Encryption

Encrypting for privacy issue

Security

6. Session Layer

→ synchronization
→ dialog controll.

→ The session layer is the network dialog Controller.

who will communicate first & the amount of data will be sent

→ keep active

→ establishes, → maintains, → synchronizes, the interaction among communicating systems

work-1 Dialogue Controll

mono-zul

→ two system Enters into a dialog.

→ allows communication between two processes to take place

half-duplex   full duplex.

work-2 Synchronization

ensures get full data

→ Add check points ~~[illegible]~~
→ USIS → Reload, Youtube bar.
→ restart sessions that are disrupted or idle for long time.

Transport Layer

End to End delivery of the ~~message~~ entire message

The delivery of a message from one process to another.

→ segmentation & Reassembly

→ ~~Adds~~ Port Address & sequence

→ Connection Control

→ Flow and error control

→ multiplexing

It does not recognize packets ? network layer

Transport Layer Protocol data unit is

PDU = Segments

Ensures that the whole message arrives intact and in order.

— overseeing both error and flow controll at the source to destination level divide into small segments. & treat them independently.

□ □ □ □ □ □ □ □ □

$\boxed{1}$ $\boxed{2}$ $\boxed{3}$ $\boxed{4}$ $\boxed{5}$ $\boxed{6}$ $\boxed{7}$ $\boxed{8}$

in header

(i) Code number (port ~~address~~) + (ii) sequence number.

$\boxed{\text{16 bit number}}$

port	port
source	destination

destination = server
fixed code for
popular protocols.

→ Port number by automatic Operating system

$\boxed{\text{Source} \rightarrow \text{Random value}}$

$\boxed{\text{Destination} \rightarrow \text{Fixed on Protocol}}$

HTML, Email, chat, all together Running.

(a) Data does not follow sequence while transfering after that they all get together and combine with serial.

Reassembling

(b) finds the missing segment and ask the sender to send the segment again.

Dicliz plus 20

Connection Controll

Sender — Reciever

S → R

Asks if Ready!

Yes deliver

terminat

TCP = 3 way handshake.

UDT = Data direct send to the destination

end-end

across a single link.

Flow control ≈ Data link layer

deff →

10 mbps → 6Mbps

buffer 6Mbps

tells to send slow

This is performed end to end rather than across a single link.

Error control:

→ Makes sure that the entire message arrives at the recieving transport layer without error.

Function multiplexing:

1. divinding message into managable segments.

2. reassembling it at the destination.

3. flow and error control.

2. Network Layer

Delivery of individual Packets from the source host to the destination host.

PDU = Packet

Source - destination → Across multiple networks.

Header

Source IP

Destination IP

Data —— Router —— Host

Routing table → IP address friendly

Routing table → works as a team → Network Number

Member → PC & server → IP addresses.

Routing = which Path.

Router is a level 3 device.

IP	MAC
Changes based on Location	Never changes.

Logical addressing

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→ Adds a header to the packet coming from the upper layer that, among other things, includes the logical addresses of the sender and receiver.

- Sender and reciever's IP address.

2. Data Link Layer

Responsible for moving frames from one hop(node) to the next node.

PUD = Frame

Source	Destination	Data

Now

immidiate next.

Hop - Hop

- makes the physical layer error-free to upper layer.
- Shows the relationship of the data link layer to the network & physical layer.

→ Framing

→ Physical Addressing

→ Flow control / data rate

→ Error control

→ Access Control

→ deetion and correction of damage and lost frames.

Framing:

→ divides the steam of bits received from the network layer into managable data units called frames.

Flow Control:

$\boxed{10\ \text{mbps}}$ - - - → $\boxed{5\ \text{mbps}}$

flow controll mechanism.

Error control:

→ detect & retrasmit damages or lost frames.

→ recognize duplicate frames.

→ Aehieved through a trailer added to the end of the frame.

Access Control:

multiple devices are connected

→ Determine which device has control over the link at any given time

1. Physical Layer

→ Responsible for movements of individual bits from one hop (node) to the next.

→ Physical characteristics of interfaces and medium

MAC Address

→ Representation of bits.

→ Data Rate → bps

→ Synchronization of bits.

- Convert to signal
- Data speed rate.

→ Type of encoding

→ transmission rate and mode.

→ The way devices are connected with each other and to the links.

Lack of OSI model:

1. it is costly.

2. some layers are not fully described. Corresponding solfware was not fully developed.

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3. when it is implimented by other organization it did not show enough level of performance.

IP Address

70.59.19.179

0 – 255

$\boxed{32 \text{ bits}}$

128.11.3.31

- No leading Zeros 111.56.045.78
- Not more than 4 numbers 221.34.7.8.20
- Range 0-255 75.45.301.14
- no binary mixed up 1110010.23.14.67

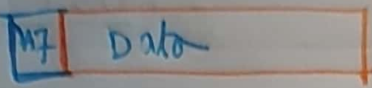
MAC Address

- Standard for media ~~Controll~~ Access controll.
- Every node in the LAN is identified with MAC address.
- physical, hardware address
- Globally unique
- can not be altered
- Provided by manufacturer
- Represented in hexadecimal, 48 bit long
- 00: 1B: 44: 11: 3A: B7
- separators can be, $\boxed{- \, , \, : \, , \, .}$

IP – Location

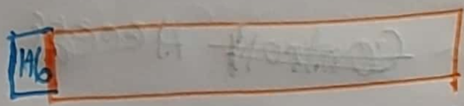
MAC – Name

↓



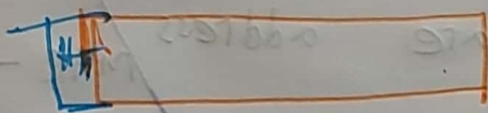
Layer 7, Data is encapsulated

Hi



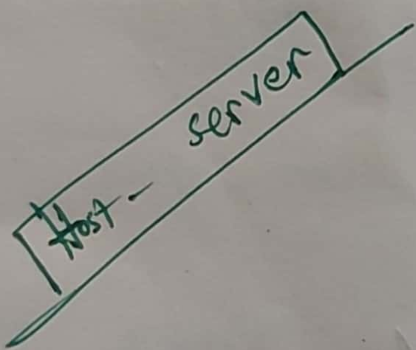
010101 Data → binary.

→ reduce data size



→ dialogue

→ setting, managing Connection



Add check point,

if not,

Large data is lost then have to send the whole data.

delivary

ensure

Host → Host

send, ennon

Data = Segments

Data divides into transmitable segments.

1 2 3 4 5

each data containting segments number

Connection control

Port numbers → source, destination

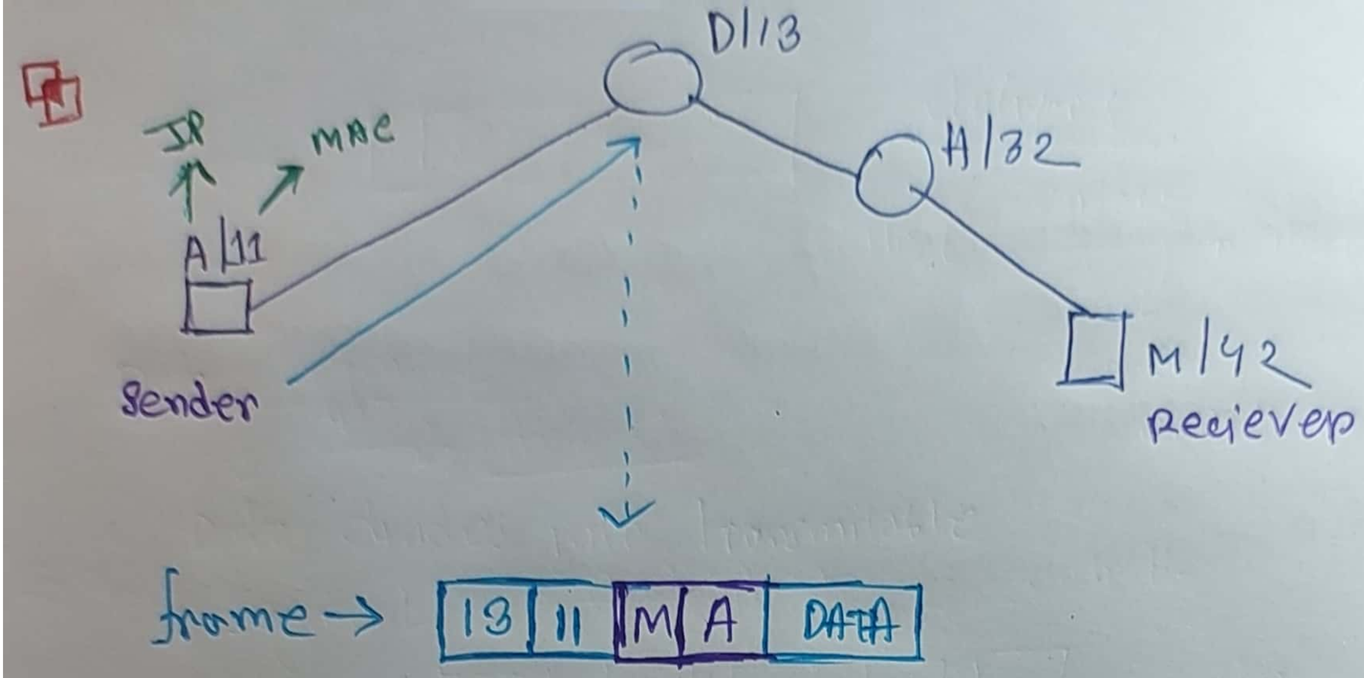
identify the application

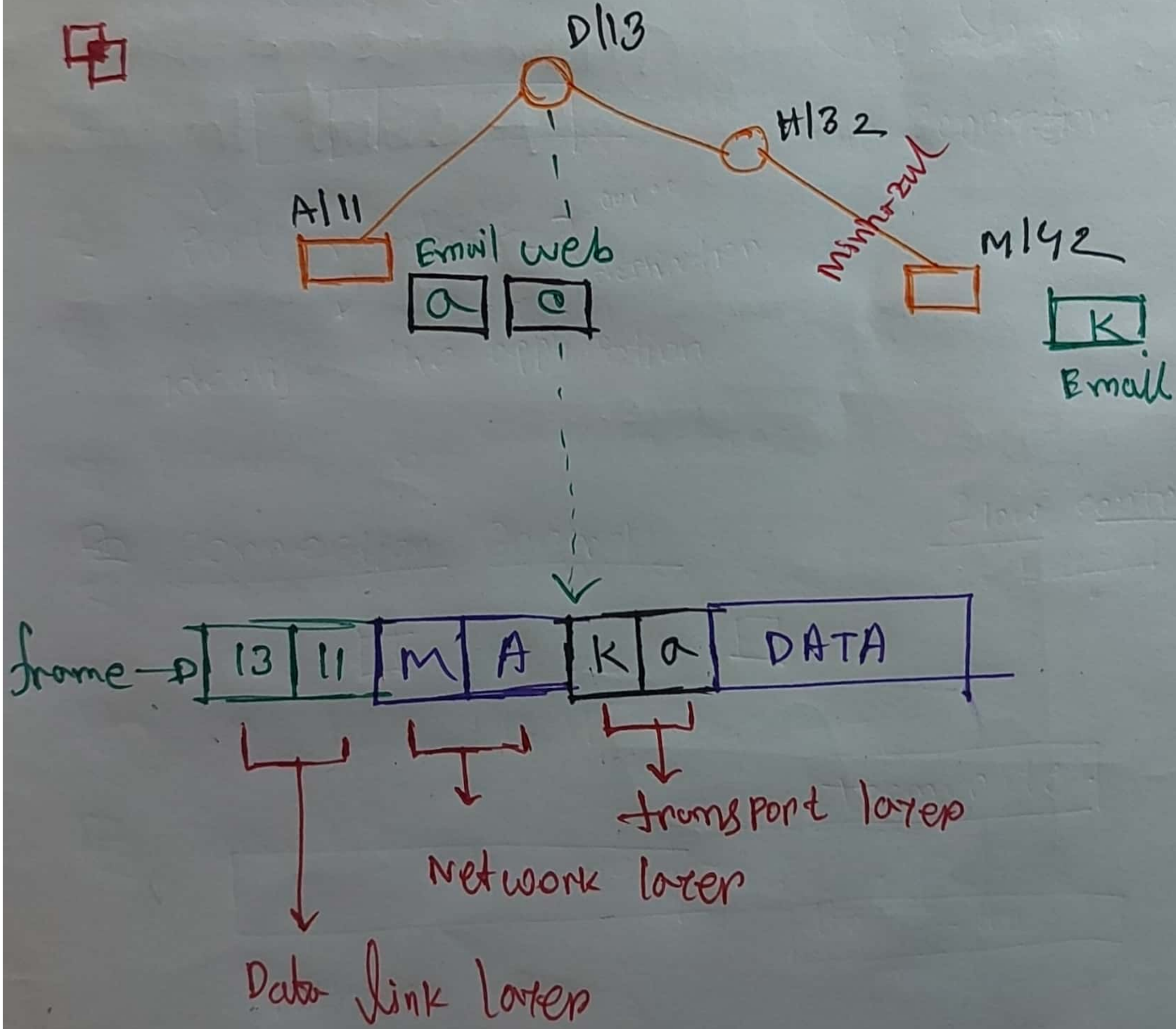
Connection Controll , flow controll

Terminate

Host - Host

Package → IP, logical address.


D/13
IP
MAC
A/11
Sender
H/32
M/42
Reciever
frame →
13
11
M
A
DATA


D/13
H/32
A/11
Email
web
a
@
Minhazul
M/42
K
Email
frame →
13
11
M
A
K
a
DATA
transport layer
Network layer
Data link layer

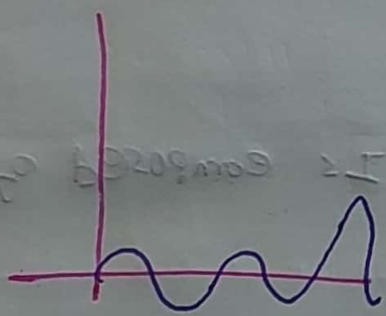
Capter ~ iii

Analog data : Contineous. → we can see clock turning

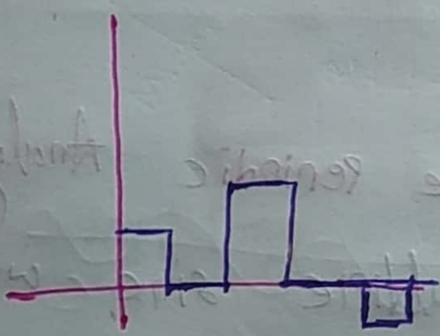
Digital data : Discrete values. → Clock time changes suddenly

Analog signal: Infinitely many levels of intensity over a period of time.

Digital signal: A limited number of defined values.



Analog



Digital

Periodic signal: completes a pattern within a measureable time frame.

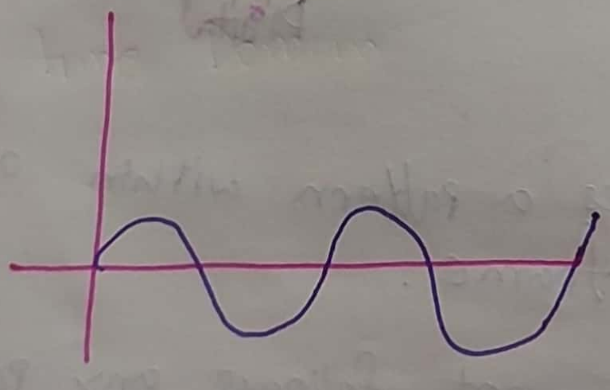
Non-periodic signal: Does not follows any pattern.

Both Analog & Digital can be Periodic or non periodic.

cycle: completation of one period of time is called as cycle. A periodic function follows some term.

Simple periodic Analog signal: A sine wave can not be decomposed into simpler signals.

Composite periodic Analog signal: Is composed of multiple sine wave.



sine wave

Amplitude: Most distance of / height of wave.
A

Frequency: Completation of Periods in 1 second.
F
Unit = HZ

Time Period: Time to make one period.
T
Unit = S

High frequency: change in short span of time.

Low frequency: change over long span of time.

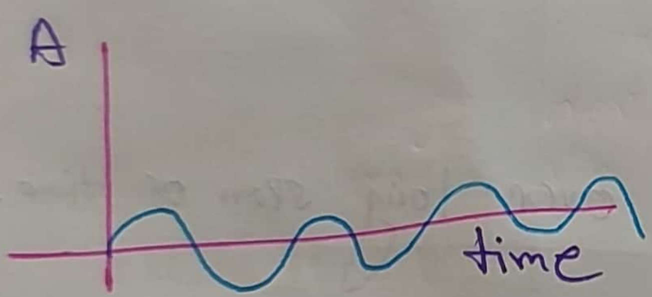
Zero frequency: A signal does not change.

Infinite frequency: So fast change.

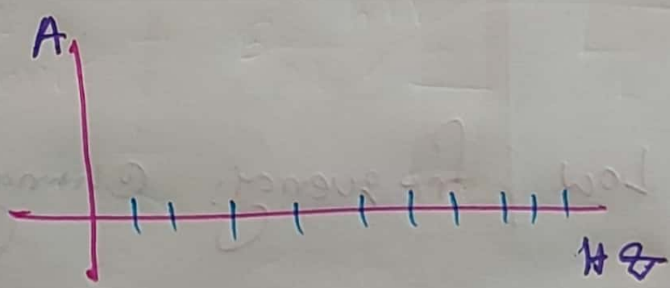
Phase: change of position of a wave with respect to the origin.

Time Domain:

Frewency Domain:



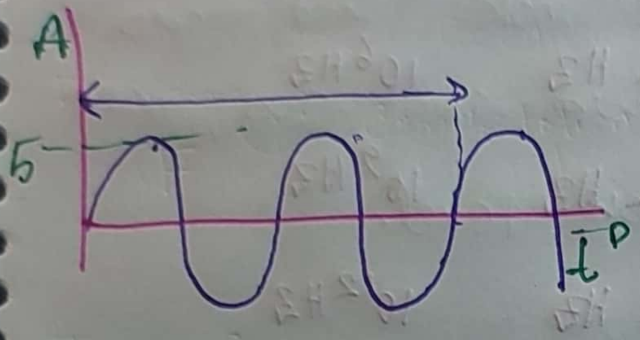
time Domain

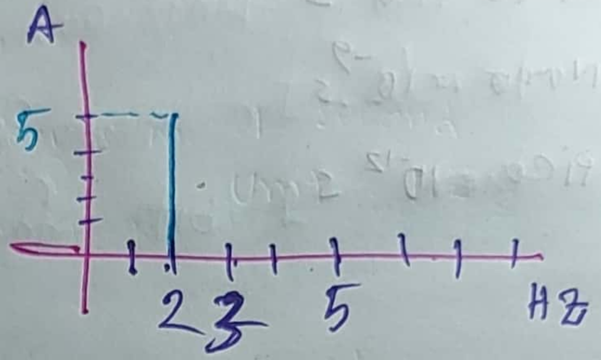


Frewecny Domain

Clear, Compact

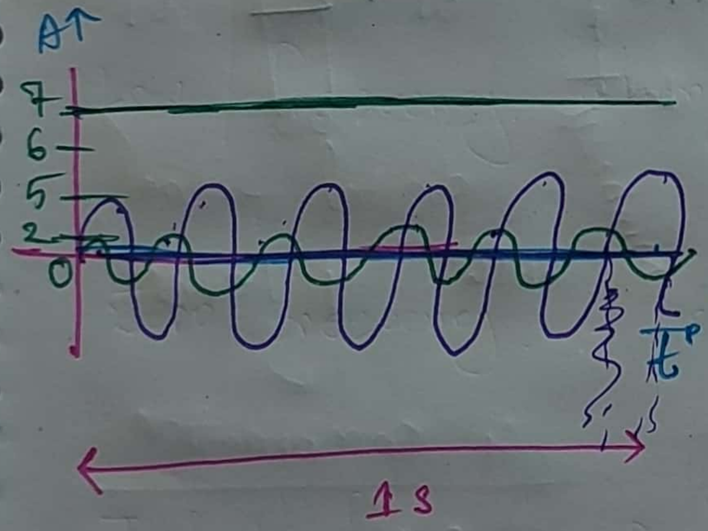
A sine wave

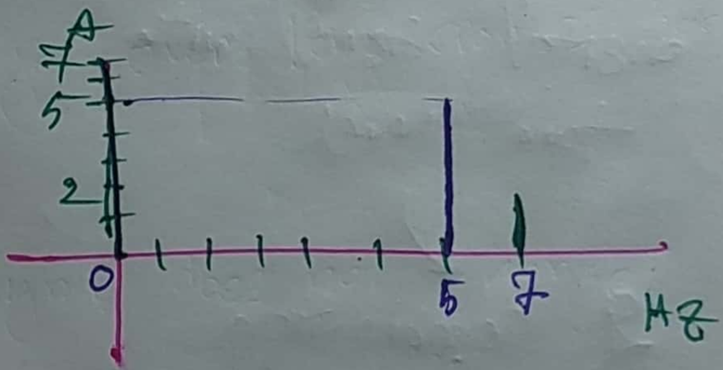




frequency = 2 HZ

Three sine wave





HZ = 6

HZ = 7

HZ = 0

Mili	$= 10^{-3}$ s
Micro	$= 10^{-6}$ s
Nano	$= 10^{-9}$ s
Pico	$= 10^{-12}$ s

Hertz	1 HZ
Kilo HZ	10^{3} HZ
mega HZ	10^{6} HZ
Giga HZ	10^{9} HZ
Tera HZ	10^{12} HZ

For one harmonic $B = \lambda/2$

2 harmonic $B = 3\lambda/2$

3 harmonic $B = 5\lambda/2$

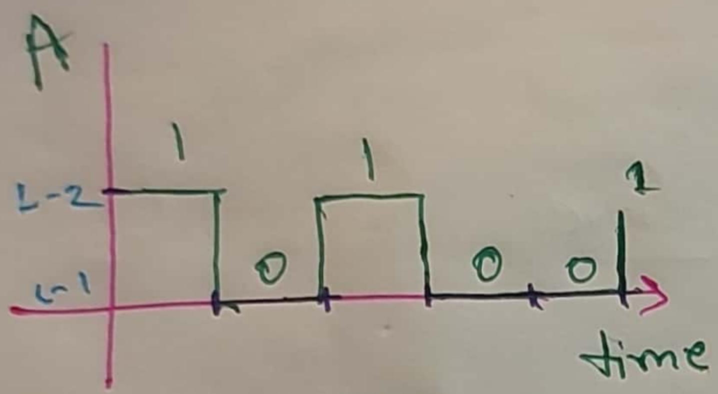
Bandwidth:

Bit per second / Hz

Bandwidth → (highest frequency – lowest frequency) of Composite Periodic analog signal. on non-periodic.

Digital Signals.

- A digital signal can have more than two levels. In this case we can send more than 1 bit for each level.



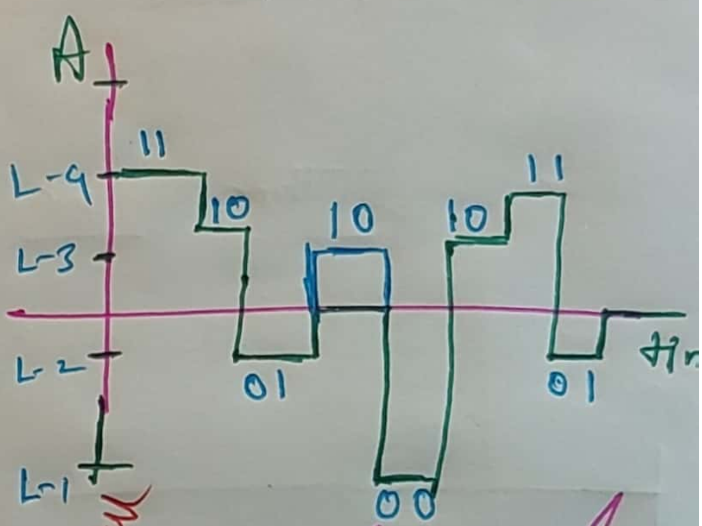
digital signal with two level

↓

2 combination

0
1

$\boxed{1 \text{ bit}}$



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digital signal with 4 level

↓

4 combination

00
01
10
11

$\boxed{2 \text{ bit}}$

$\therefore$ 3 bit = 8 combination
= 8 level

$\therefore \text{Level} = 2^{\text{no of bits}}$

No of bits = $\log_2(\text{levels})$

Q A digital signal has 8 levels. How many bits are required.

$$\text{bits} = \log_2 8 = 3$$

we can divide 8 3 times by 2.

Bit Rate

Q The number of bits sent in 1s.

→ Expressed in (bps).

Example we need to download at rate of 100 pages per second. What is the required bit rate of the channel?

= A Page wit avg 24 lines with 80 Characters.

1 character requires 8 bit.

$\therefore$ $100 \times 24 \times 80 \times 8 = 1536000$ bps

$= 1.536$ Mbps

$\boxed{\text{Bit Length}}$ = The distance one bit occupies on the transmission medium.

= Propagation speed × bit duration.

Transmission Impairment

- The imperfection causes impairment.
  - → The data sent by sender does not match with the data recieved by the reciever.

Attenuation

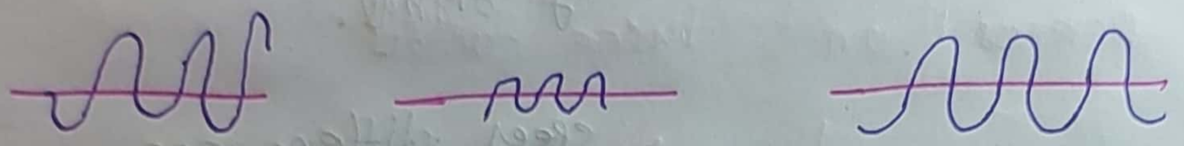
Loss of signal energy.
by,
heat/Ressistance/
Cause amplifier to
get rid of it.

Distortion

Change in the shape of the signal

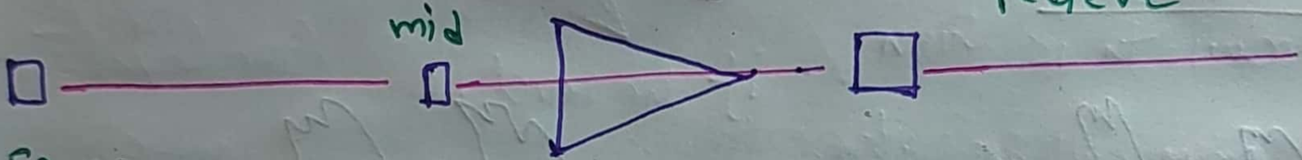
Noise.

Attenuation - Loss of Power



Source mid Recieve

Loss of energy



\# Measured in decibel.

$$\boxed{10 \log_{10} \frac{P_2}{P_1}} \rightarrow$$ minimal Amplified

Example: A signal travel through a transmission medium and it's power is reduces to one-half. This means that P_2 is $(1/2)P$. In this case, the attenuation (loss of power) can be calculated as,

$$10 \log_{10} \frac{P_2}{P_1} = 10 \log_{10} \frac{0.5 P_1}{P_1} = 10 \log_{10} 0.5$$

$$= 10 \times (-0.3)$$

$$= -3 dB$$

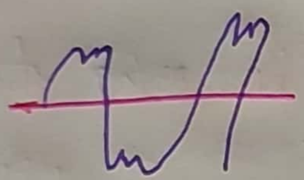
A loss of 3dB is equivalent to losing one-half the power.

$\boxed{\text{Distortion}}$

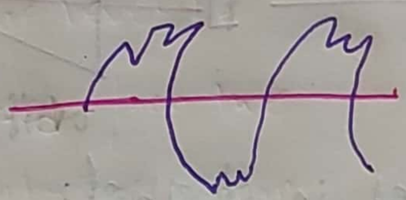
→ changes in the form of signal.

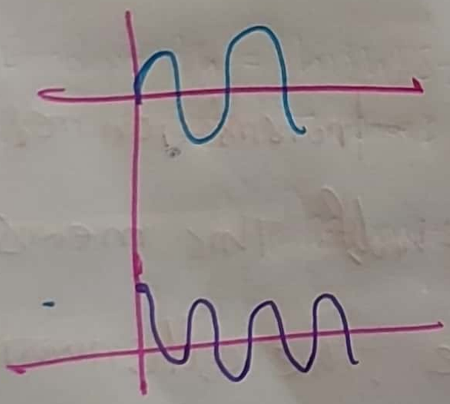
→ speed differences among medium.

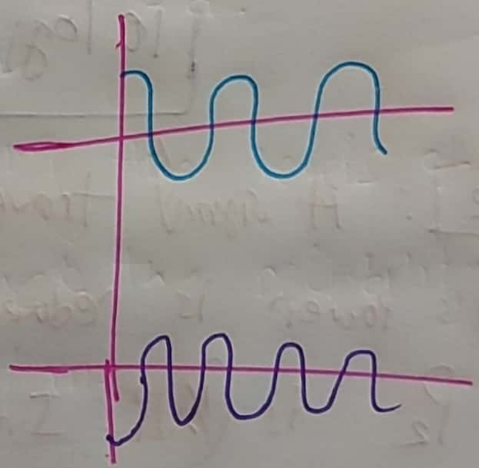
Sender



Reciever





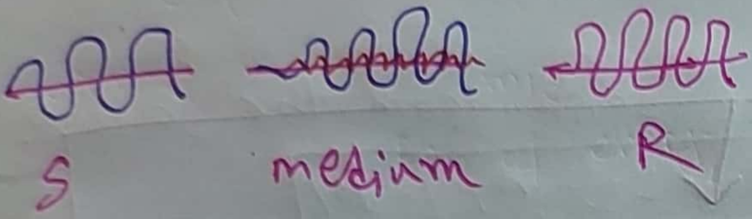


due to the transmission medium.

Noise

→ From other

→ Telephone.



→ one wire affects the others wire.

Signal to Noise Ration (SNR):

$$SNR = \frac{P_{signal}}{P_{noise}}$$

P_{signal} → wanted

P_{noise} → unwanted

Noise ↓ = ∞

signal power ∝ signal

noise ∝ $(noise)^2$

Example The power of a signal of 10mW and the power of noise is 1 μW. What are the values of SNR and SNR_{dB}?

Sol^n:

$$SNR = \frac{10 \times 10^3\ \mu W}{1\ \mu W} = 10{,}000\ \mu W$$

$$\boxed{SNR_{dB} = 10 \log_{10}(SNR)}$$

$$\therefore SNR_{dB} = 10 \log_{10} 10{,}000$$

$$= 10 \log_{10} 10^4 = 4 \times 10$$

$= 4$ dB

Dicliz plus 20

Data Rate Limits

Depends on three factors

The Bandwidth

if bandwidth is high, data rates will be also high.

Level of signal

if the level is increased then the possibility of error is also increased.

Increasing the levels of signal may reduce the reliability of the system.

The quality of the channel (The level of noise)

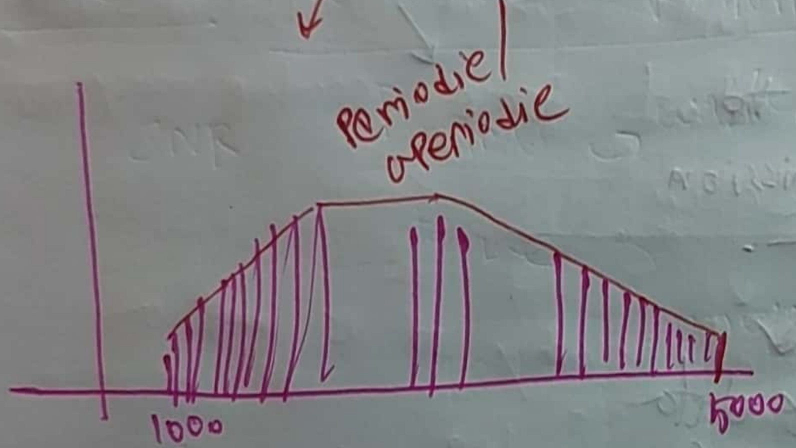
Recape

Bandwidth = (highest − lowest) frequency

Bandwidth

HZ → Capacity/range of frequencies can pass through a channel.

BPS → the speed of bit transmission in channel or link. → Number of bits can pass through the channel



$\therefore = 5000 - 1000 = 4000\ HZ$

we can pass the whole system with 4000HZ bandwidth.

minimal

Increase in Bandwidth

&

Increase in speed.

For noiseless channel,

Level

$$\boxed{\text{Bit Rate} = 2 \times \text{Bandwidth} \times \log_2 L}$$

Latency → Delay

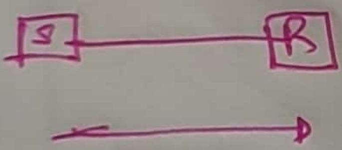
How long it takes to reach at reciever point from 1st bit is sent from the Sender.

$\boxed{\sum \text{all} = \text{Latency / delay}}$

- Propagation time
- Transmission time
- Queuing time
- Processing time

Propagation time

Time required for a bit to travel from source to destination



speed = of signal

Distance

$t_p = \frac{\text{Distance}}{\text{speed}}$

Transmission time

Source to transmission media → whole data → depends → size of data, bandwidth

$t_T = \frac{\text{message size}}{\text{bandwidth}}$

Example

message size = 2.5 kbyte

network bandwidth = 1 Gbps

Distance = 12,000 km

speed of light = $2.4 \times 10^8 \ ms^{-1}$

for km ⟺ m

solution

$$t_p = \frac{12000 \times 1000}{2.4 \times 10^8} = 50 \ ms$$

kbyte ⟺ byte

byte ⟺ bit

$$t_t = \frac{2.5 \times 1000 \times 8}{10^9} = 0.020 \ ms$$

Queuing time

- The time needed for each intermediate or end device to hold the message before it can be Processed.

- Not a fixed factor.

- If we have more than One router, we will sum up all router's delay it is possible that some router may not have any delay.

that is why it is not a fixed factor.

Processing Delay

↳ The time an intermediary devices take to process.

Routers to process the header.

$\boxed{\text{Example}}$ Data = 5 million bits

Router = 10 , queuing time 2 μs

processing time 1 μs

Distance = 2000 km

speed = $2 \times 10^8 \, ms^{-1}$

bandwidth = 5 Mbps.

$\boxed{\text{Solution:}}$

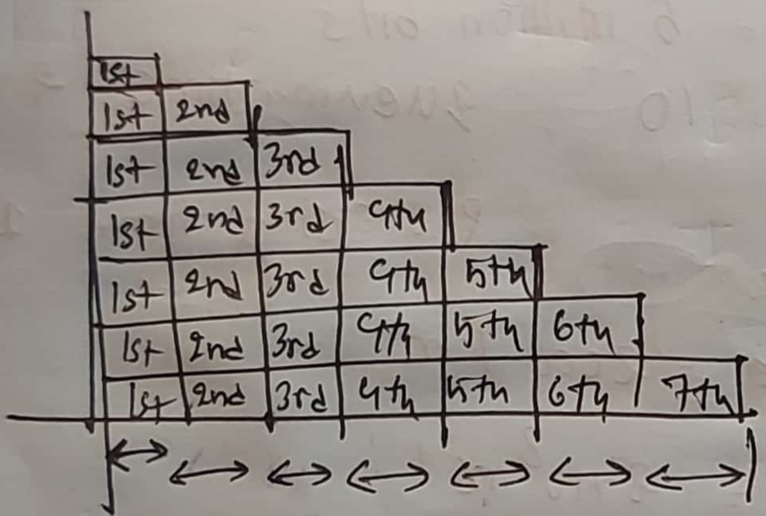
$$\text{delay} = \frac{2000 \times 10^3}{2 \times 10^8} + \frac{5 \times 10^6}{5 \times 10^6} + 10 \times 10^{-6} + 10 \times 10^{-6}$$

$= 1s.$

Performance of a network

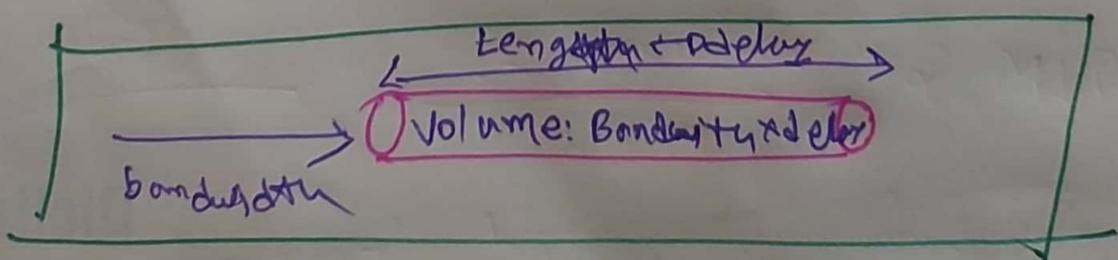
Bandwidth-Delay Product.

Two performance matrices of a link.



for a 7 bit data we will have a 7s of delay.

It defines the number of bits that can fill the link.

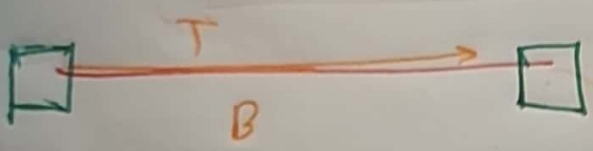


Jitter

- Different Packets of Data encounter different delays and the application using the data at the reciever site is time sensitive.

Network Throughput

Measures how fast we can actually send the data through a network



B = Bandwidth

T = Throughput

$\boxed{T < B}$

Example A network with Bandwidth of 10 Mbps can pass only an average of 12,000 frames per minute with each frame carrying an average of 10,000 bits. What is the throughput of this network?

Sol^n:

$$\frac{12\,000 \times 1000}{60} = 2 \text{ Mbps}$$

∴ throughput 1/5 of the Bandwidth.

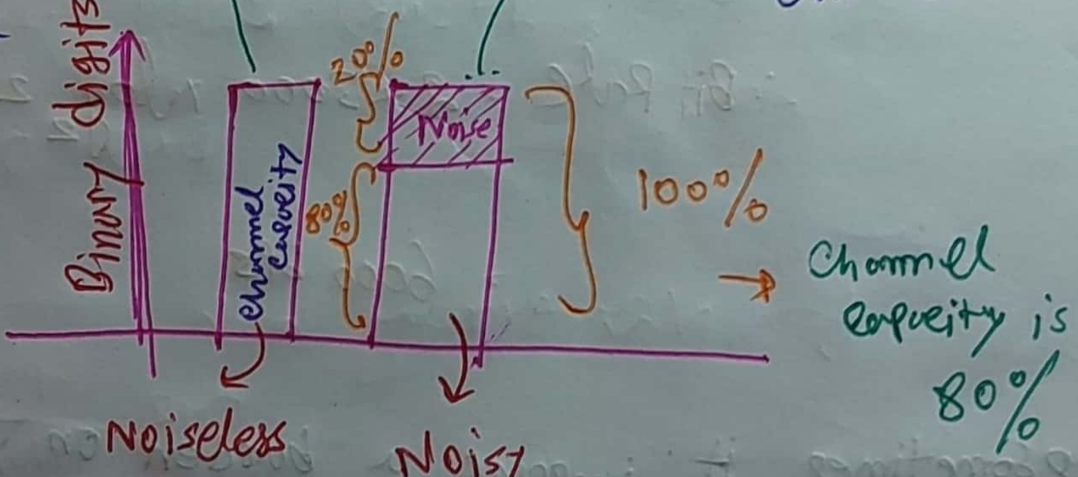
Data Rate Limit

The rate we can pass the data from sender to the reciever.

Two theoritical formulas were developed to calculate the data rate

Nyquist → for noiseless channel

Shannon → for noisy channel.



Noiseless Channel : Nyquist Rate

→ Defines the theoritical maximum rate.

$$\boxed{\text{Bit Rate} = 2 \times \text{bandwidth} \times \log_2 L}$$

Example

bandwidth = 3000 Hz
two signal levels.

∴ Bit Rate = $2 \times 3000 \times \log_2 2$

= 6000 bps

→ Sometimes, it imposes a burden on the reciever.

→ If the level of a signal is 64, the reciever must be very sophisticated to distinguish between 64 different levels.

Example: we need to send 265 kbps over a noiseless channel with a bandwidth of 20 KHZ. How many signal levels do we need?

Soln:

265 is not a power of 2.

~~so~~ we need to increase the

we need 512

or

~~it~~ reduce the bit rate.

$$265000 = 2 \times 20{,}000 \times \log_2 L$$

$$L = 98.7$$

128 levels → 280 kbps

64 levels → 240 kps

Noisy Channel: Shannon Capacity

Shannon Capacity

$$\boxed{SNR = \frac{Signal}{Noise}}$$

$$Capacity = bandwidth \times \log_2 (1 + SNR)$$

- **Extremely noisy channel:**

$$C = B \log_2 (1 + SNR) = B \log_2 (1+0)$$

$$= B \times 0 = 0$$

if $N \approx$ extremy high

$$SNR = \frac{Signal}{Noise} = \frac{S}{\infty} = 0$$

$$\boxed{SNR = 10^{SNR_{dB}/10}}$$

when, SNR is very high.

$$C = B \times \log_2(1+SNR)$$

$$= B \log_2(SNR)$$

$\boxed{\text{Example}}$ bandwidth = 1 M-Hz

SNR = 63

what is bit Rate and signal level?

$$C = 10^6 \times \log_2(63+1) = 10^6 \log_2(64)$$

$$= 6 \text{ MBPS}$$

Shannon gives → higher limit.

Let take, 4 MBPS, Lower

Now, Nyquist formula

$$B_r = 2 \times B \times \log_2 L$$

$$4 = 2 \times 10^6 \times \log_2 L$$

$$\therefore L = 4$$

Chapter – 4

(i) Digital-to-Digital conversion techniwes

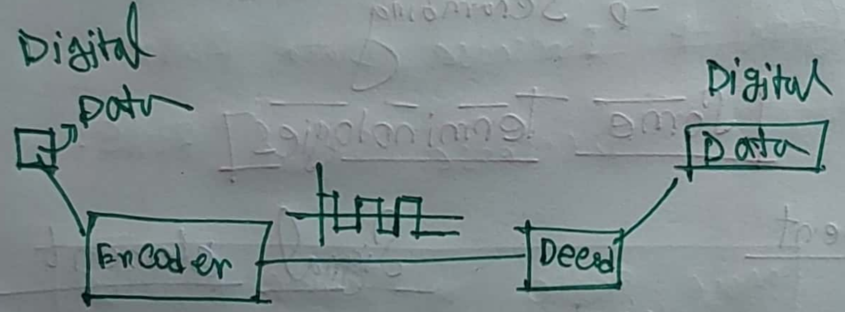
(ii) Analog-to-digital conversion techniwes

(iii) Transmission mode

CHAPTER-IV

Analog Data — Digital Data

Analog signal — Digital signal



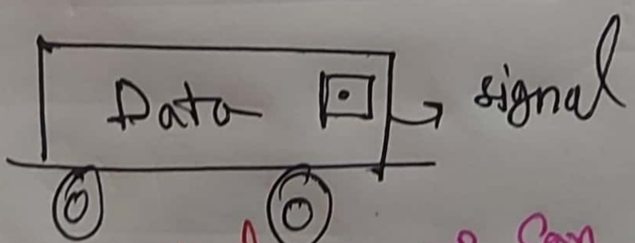
our target is:
Represent digital data by using digital signals.

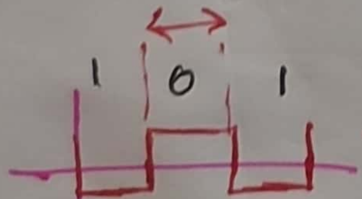
Conversion involves three techniques,
- → Line Coding → always needed
- → block coding
- → Scrambling

[Some Terminologies]

Data element
what we need to send
010101

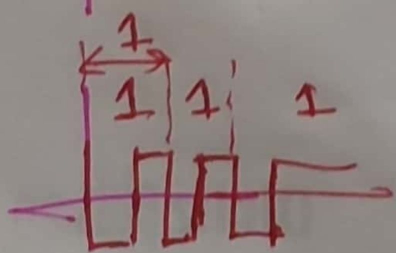
Signal element
what we can send





→ 1 signal
1 data

→ Can carry one signal or more.



2 signal
1 data → 2 vehicle carried by 1 driver.

$$r = \frac{\text{data element}}{\text{signal element}}$$

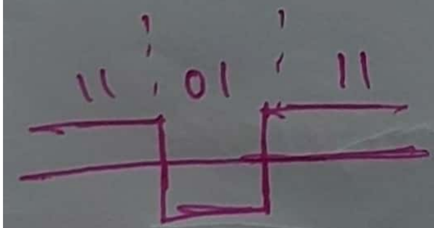
Line Coding

→ Line Coding is the process of converting digital data to digital signal.

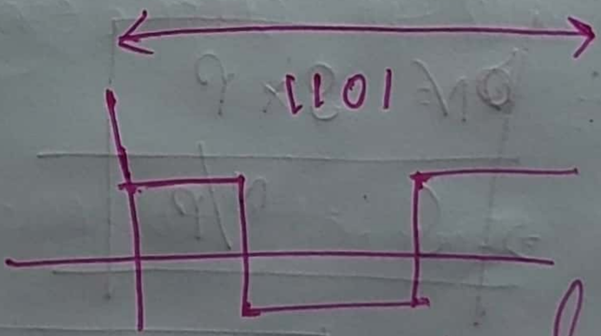
→ Converts a sequence of bits to a digital signal.

Sender - - - - - - - - - - - - - Reciever

Encoding   Decoding



1 signal
2 data



3 signal
4 data

Data Rate

The number of Data Elements (bits) sent in 1 s

Signal Rate

The number of signal element send in 1s.

Bound	modulation	pulse

Rate

Our Goal → Increase Data Rate
Decrease Signal Rate.

More People in Fewer vehicles

Data Rate = $\boxed{\text{Signal Rate} \times r}$ = Signal Rate × $\frac{\text{data element}}{\text{signal elem}}$

∴ $N = S \times r$

⇒ $S = N/r$

Bit Rate = Pulse Rate × $\log_2 L$ → Levels

Example 9 vehicles are sent in 1s. Each of the vehicle is carrying 5 data element.

Solⁿ:

$S = 9$ $r = \frac{5}{1}$

$\therefore N = 9 \times 5 = 20$

Digital Data → Digital Signal

Reciever Needs to know:

Timing of bits   Signal Levels

Factors affecting successful interpretation of Signals:

(a) Baseline woondering

(b) DC Components

(c) self - synchronization

(d) Built-in error detection

(e) Immunity to noise and Interference

(f) Complexity.

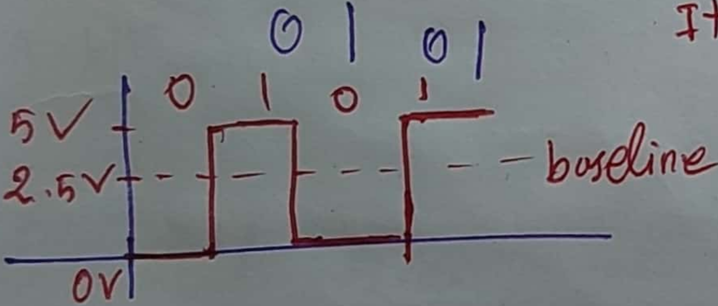
@ Baseline Wandering:

⊙ Reciever Calculates the running average of recieved signal power.

that is baseline then.

when a lot of 0's and 1's are there we face problem.

↳ a drift in the baseline.

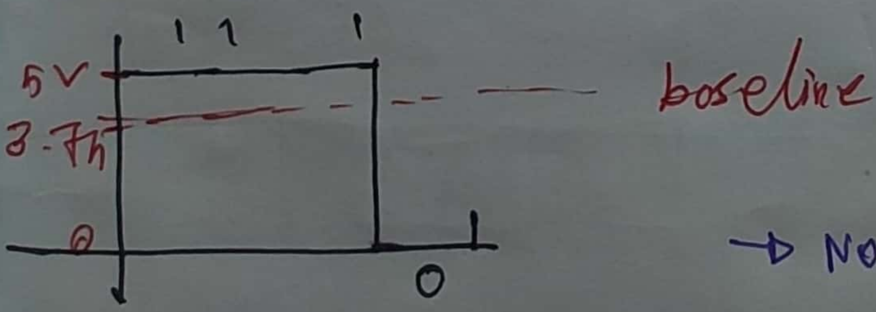


It says,

if it is more than 2.5V we call 1

else, we call 0.

1110 $= \dfrac{5+5+5+0}{4} = 3.75$



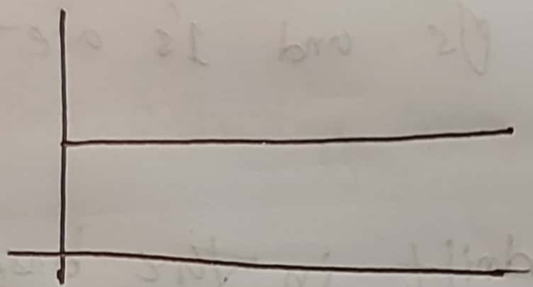
if more than 3.75 V 1

else, 0.

→ Not a good approximation as it is not in avg

(b) DC components: ■ The voltage level is constant for a while. The spectrum creates very low frequencies.
■ when low frequencies are around zero

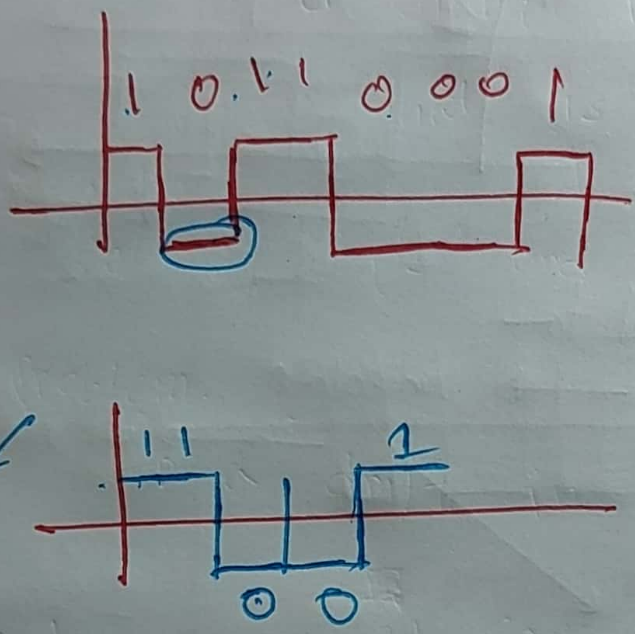
Example



0/1 Parity that can cause base-line wondering.

~~⓪ Self sy~~

⓪ Lack of synchronization: → sleep



between sender & reciever

missing 1 byte

if the sender is Sending a data after 1s.

The reciever should also recieve the data after 1s.

④ Self synchronization:

→ A self synchronizing digital signal includes timing information in the data being transmitted.

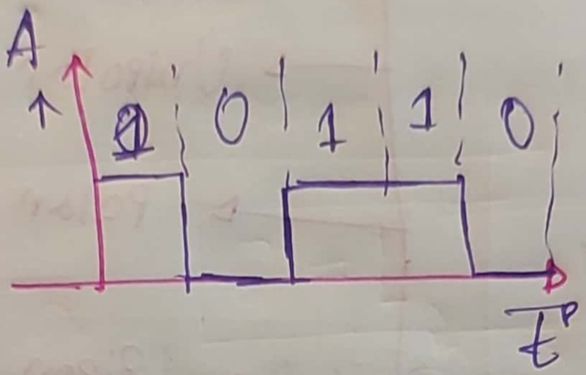
⊡ If we use transition, the reciever will get alerts.

Line Encoding Schemes

- Unipolar → NRZ
- Polar → NRZ, RZ, biphase,
- Bipolar → AMI, Pseudoternary
- multilevel → 2B/1Q, 8B/6T
- multitransition → MLT-3

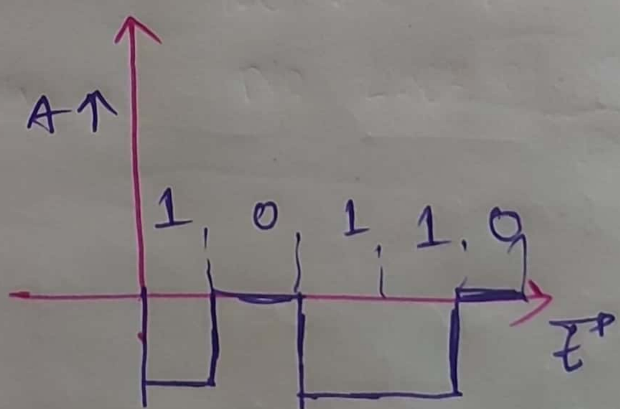
Dicliz plus 20

Unipolar — Line Coding Schemes



- Digital data → unipolar → digital signal

way
↓
Signals will on only one side.
→ Either positive or negative.



Example

NRZ

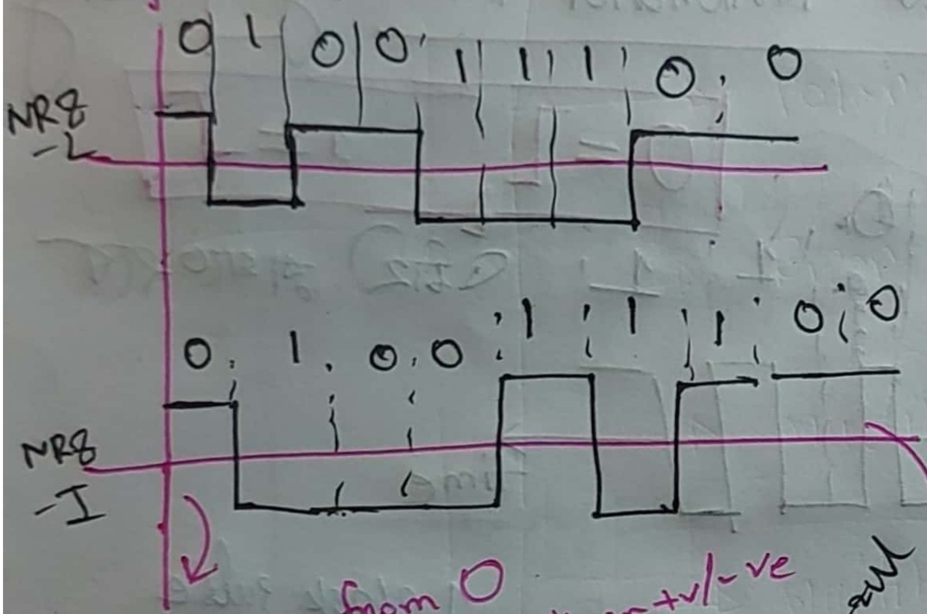
NRZ-L

NRZ-I

Bipolar → NRZ-L & NRZ-I

Line coding

if starts with 0 must be +V



0 → +V

1 → -V

1 → Inverse

0 → No change

if starts from 0 we can take either +v/-ve

Minhazul

Contineous -1 no problem but contineous -0 is a cons

Pros

→ Easy to engineer

→ Make good use of bandwidth

Cons

→ Contineous zeros
↓
same state
↓
① Baseline wondering,
② DC component,
③ self synchronization.

NRZ-L, contineous 0/1 both problem

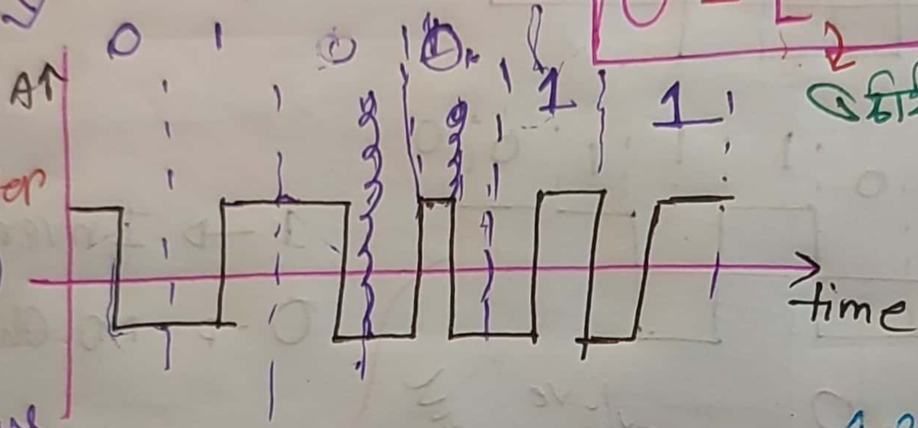
To solve Cons.

Manchester Encoding & Differential Manchester Encoding — Line Coding

0 =   1 =

একটাই রাখতে হবে

Manchester follows NRZ-L



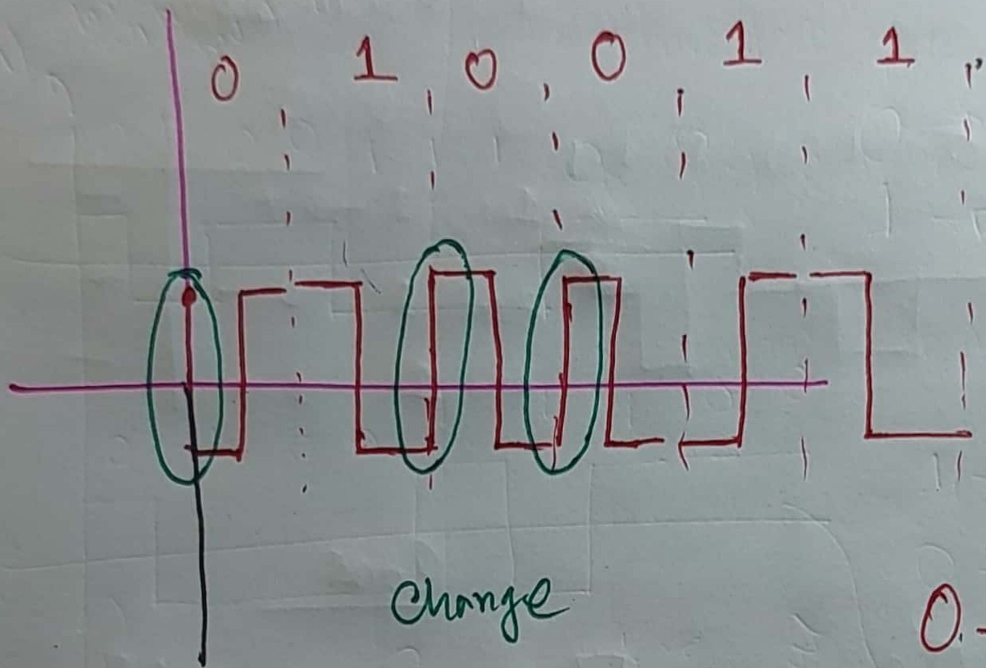
1 clock pulse 2 signals

<u>Cons</u> → Contineous transition
↓
No baseline wondering
No DC Problem
No Lack of self syncronization.

→ Bandwidth is not Optimized

→ need more bandwidth

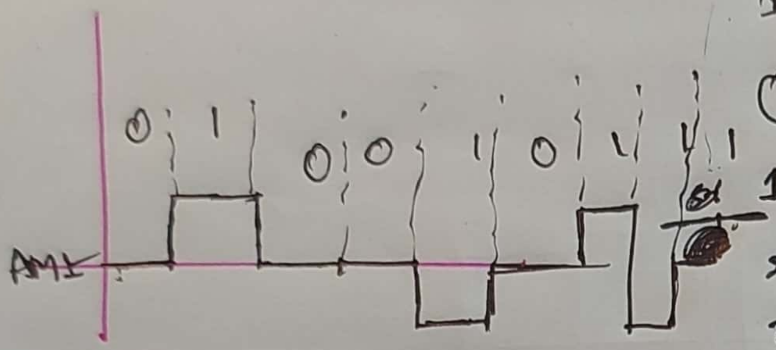
Demon



0 → change

1 → NO change

Bipor - AMI



$1 \to$ Non-Zero

0		$\to$ 0	
1st	1	$\to$ +	−
2nd	1	$\to$ −	+
3rd	1	$\to$ +	−

Pros

→ Conteneous 0's

$\boxed{\text{DC} \to 0 = 0V}$

is not a DC

Component Problem

NO baseline wonder

altime base = 0V

Cons

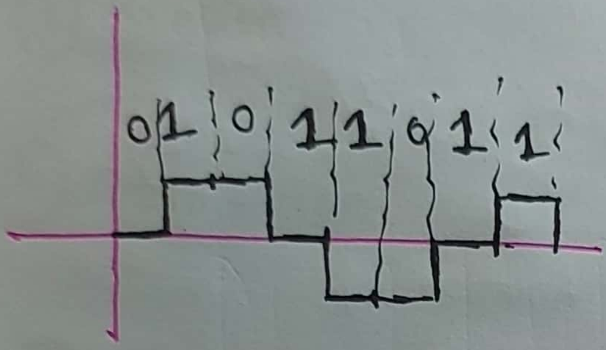
Lake of self Synchonization

when contineous 0's.

minhazul

Bandwidth Synchonization

MLT-3

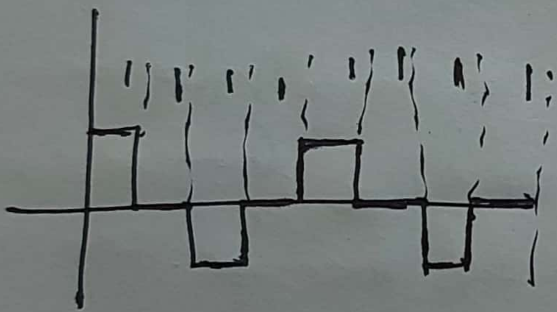


0 → 0 No Change

1 → if at 0 chang

if at non-zero goto 0.

if · at zero - reverse.



Block Coding

① division

② substitution

③ Line Coding / Combination.

mB/nB

Subtitute from table

if

16 bit

m = 4

4B/5B

2^4 2^5

0000 ← 01001

mae as if there is no Consecutive three 0's.

বাকী গুলো Control Sequence.

Scrambling

- → No data change.
- → draw signal as if does not remain in same state.

Block coding এর সমস্যার সমাধান Scrambling

Goals

1. No DC component
2. No long sequences of zero level
3. No reduction in data rate.
4. Error detection capability.

Two ways of

- B8ZS → US → Bipolar with 8 Zeros substitution
- HDB3 → Europe & Japan → High density Bipolar 3 zeros substitution
  - → Based on Bipolar AMI

Based on Bipolar-AMI

$\boxed{B8ZS}$

8 zeroes

If we find $\overbrace{0000\ 0000}^{8\text{ zeroes}}$

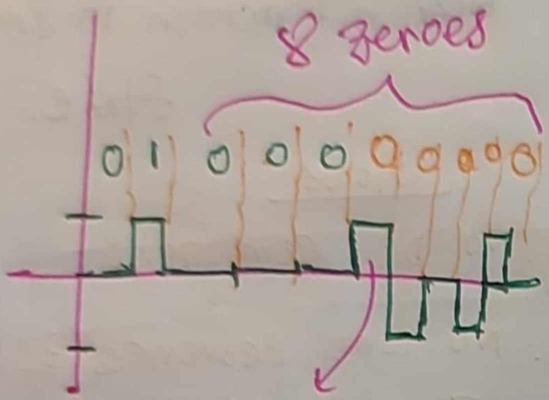
By the rule

000 VB 0 VB

violation of Rule

nonzero element

8 zeroes



if we consider this as (+1)

it should have been in negentive portion. which is the rule. But here we see the violation of Rules.

following (+1), maintains the Rule.

$\boxed{\text{HDB3}}$

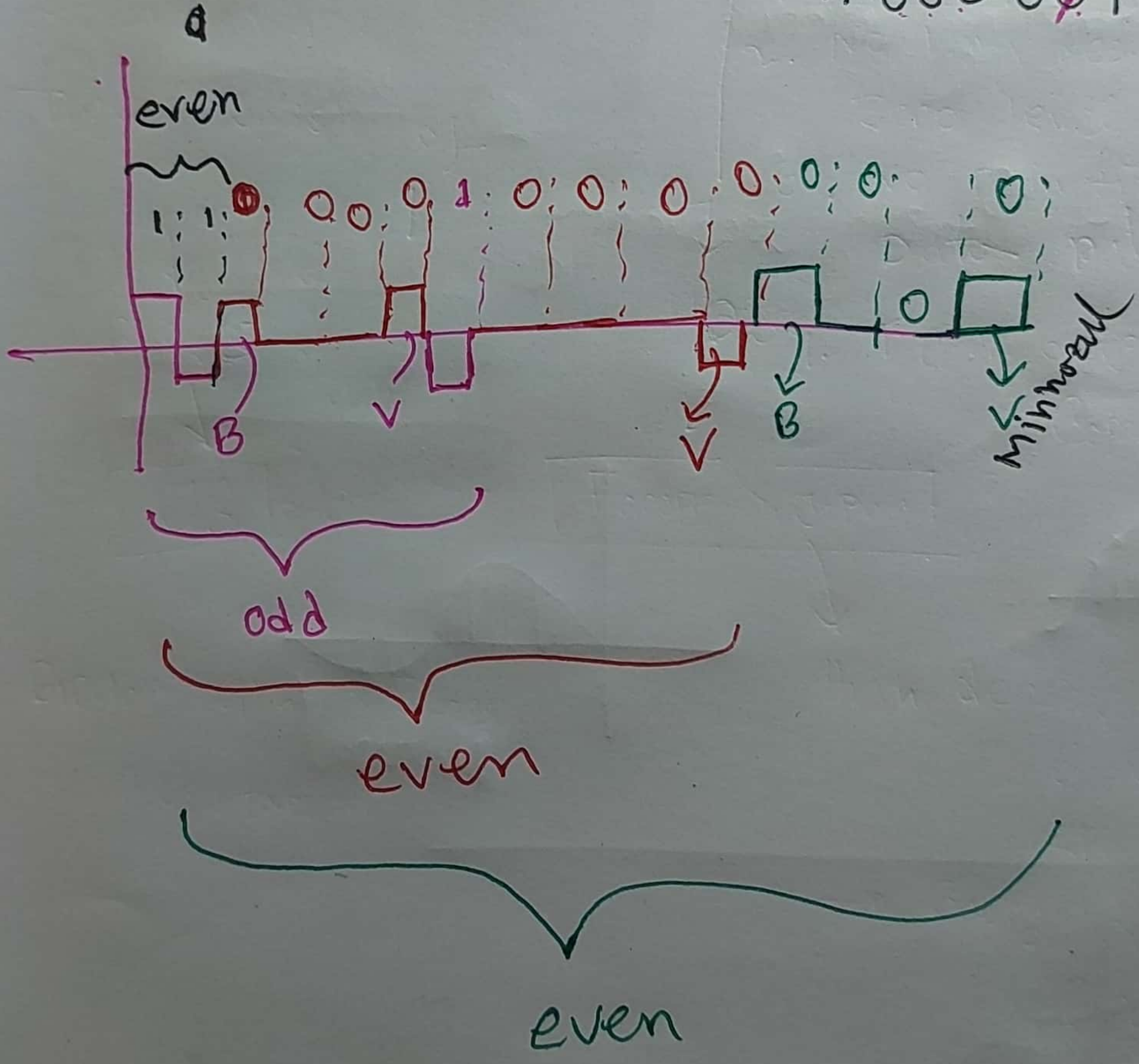
4 zeroes.

$\overbrace{0000}$

$\boxed{\begin{matrix}000V \\ B00V\end{matrix}}$ → Main thing is,

We get even numbers of non zero elements.

11 0000 0~~0~~ | 0000 0000



PCM

Analog - to - Digital

PCM

DM

① Sampling →

② Quatization →

③ Binary encoding →

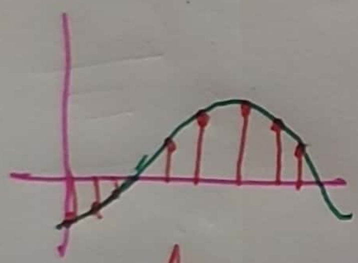
Sampling

we take Sample after sometimes,

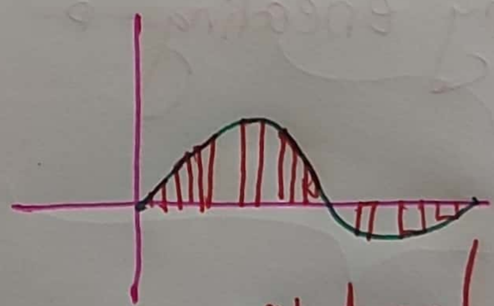
we get instaneetenious changes.

T_s - Sampling interval

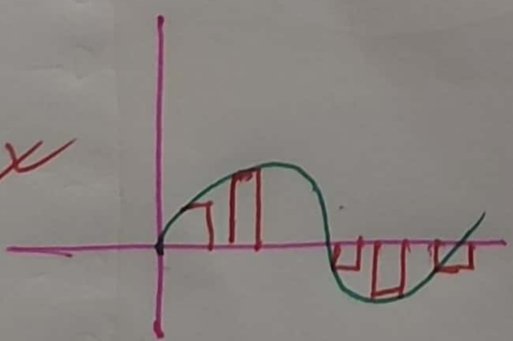
$f_s = 1/T_s$ - Sampling frequency



ideal



Natural



Flat top

→ mostly used

Nyquist theorem: The Sampling rate must be at least 2 times the highest frequency contained in the signal.

→ more than 2 times is not a problem.

→ we can not take less than 2 times.

∴ $\boxed{\text{Nyquist Rate} = 2 \times f_{max}}$

Qunatization

Assum

$$\Delta = \frac{max - min}{L}$$

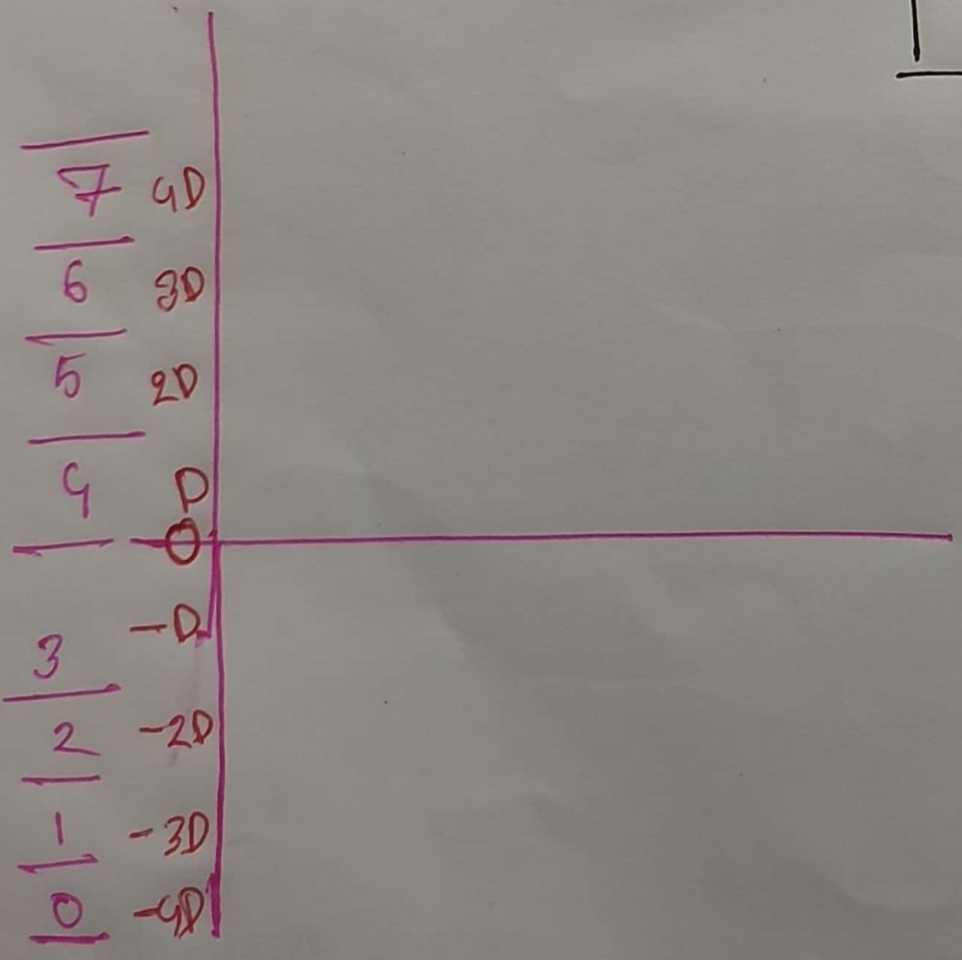
$V_{max} = +20V$

$V_{min} = -20V$

Level = 8

$$\therefore \Delta = \frac{20-(-20)}{8} = 5$$

$$\boxed{n_b = \log_2 L}$$



Steps

1. Determine $\Delta = \frac{max - min}{L}$

2. Give levels in left from $\{0 - (L-1)\}$
   Give D.

3. Plot the values.

4. Normalized PAM value,
   $= \frac{\text{Sampled Pulse vale}}{\text{Zone width}} = \frac{\text{value}}{\Delta}$

5. Normalized quatized value
   $\boxed{= X\Delta}$ $\boxed{X - 0.5}$ → ans,
   ↓
   Co-efficient of D

Minhazul

6. Normalized error = Normalized PAM values − Normalized quantized values.

7. Quantized Code = Left side levels.
   ↓ convert

8. Encode = Binary