

(1)

* Why need networking?

- World without boundaries
- Global communities
- Human network.

* Networking: Networking refers to the practice of connecting multiple devices and systems together to enable communication, resource sharing and collaboration.

④ Host: Every computer ^{device} on a network

④ End device: An end device specifically refers to the devices at the edge of a network that interact directly with users.

Ex:
Router
switch
host
but not
end device

All end device → host

[not] all host → end device

- Data originate
- Flows through network
- Data receive

④ Server: Computers that provide info to end devices.

- 3 types:
- 1) Email
 - 2) Web
 - 3) Server File



Server type

What server uses

what client use

Access what

Email

email serven
s/w

client
s/w

Email

Web

web serven
s/w

browsen
s/w

web pages

File

stores corporate
and user file

corporate
and user
file

files

Clients: computers that send requests to the servers to retrieve information.

P2P Network: P2P network is a

(P2P) distributed network architecture in which

participants (often referred to as peers)

communicate and share resources directly with each other without the need for a centralized server or authority.

Pros:

- Easy to set up
- Less complex
- Lower cost
- used for simple tasks
 - transfer files
 - share prints

Cons:

- no centralized administration
- not secured
- not scalable
- slower performance

Intermediary Device: interconnects end devices.

- regenerate and retransmit data signals
- maintain info about existing pathways
- notify other device about errors / communication failures.

Ex: Router, LAN switch, multilayer switch,

firewall appliance, Router

⑥ ↴

Network media:

- allows message to travel from source to destination
- carries communication

IISOC - Internet Society

IETF - Internet Research Task Force

IANA - Internet Assigned Numbers Authority

IP Address
Domain Name
TCP/ UDP
Port Number

③ types:

of Cables (Copper) — Electrical
Network media → metal wire impulses

fibre

fiber optic cable — light

wireless — specific frequencies
of electromagnetic waves



Wireless



LAN

WAN

Network / Topology Diagram: use symbols to represent devices within network.

NIC (Network Interface Card): hardware component that enables a computer to connect to a network.

- provide necessary interface between computer and network medium

- establish and maintain network communication

Physical port: physical connection on a device

Interface: connection point between device and network / another device

Networks types (based on size) - ④

- 1) small home - few computers and internet
- 2) SOHO - [small office/Home office] - remote office - corporate network
- 3) medium to Large - 100 to 1000 interconnected devices - many locations
- 4) World Wide - hundreds of millions of devices

* Network infrastructure depends on /
vary in terms of:

- 1) size of the area covered
- 2) No. of connected users
- 3) No. and types of available services
- 4) Area of responsibility.

JETF - Internet Engineering Task Force
ICANN - Internet Corporation for Assigned Names and Numbers
IAB - Internet Architecture Board

EIA - Electronic Industries Alliance

TIA - Telecommunications Industry Association

* Types of Networks (based on area) - (2)

LAN → Network Infrastructure WAN

Local Area Network

Wide Area Network

- spans a small geographical area
 - interconnect end devices in a limited area
 - administrated by a single org. / individuals
 - provide high-speed bandwidth to internal devices
- spans a wide geographical area
 - interconnect LANs over wide geo. areas
 - administrated by one or more service providers.
 - provide slower speed links between LANs

Internet: worldwide collection of interconnected LANs and WANs.

LANs use WANs

WANs use copper wires / Fiber optic cable
wireless transmission

to connect with each other.

maintain structure of internet

Intranet: private networks accessible only to authorized individuals within an org. (only company)

Extranet: accessible to

company
suppliers
collaborations
customers
can access

- authorized individuals within an org.
- external users outside org.
↳ Limited permission of access

(SOHO)
Home and Small Office Internet Connections

1) Cable: - high bandwidth

- always on
- provided by cable tv service providers

2) DSL - high bandwidth

- (broadband digital subscriber line)
- always on
 - runs over a telephone line

3) cellular - use cell phone network

- no internet service providers needed

4) satellite - rural areas

~~ITU-T~~ International Telecommunications Union Telecommunication Standardization Sector

5) Dial-up telephone - low bandwidth
(modem) - not expensive

■ Business Internet connections

1) Dedicated Leased Line

2) Ethernet WAN

3) DSL (Ex: SDSL)
(symmetric)

4) Satellite

- higher bandwidth
- dedicated connection
- managed services
needed

■ Converged networks:

deliver data / voice / video over the same network infrastructure
- uses same set of rules and standards

■ Network Architecture: refers to the technologies that support the infrastructure that moves data across the network.

- * characteristics of reliable network (4)
 - 1) Fault tolerance
 - 2) Scalability
 - 3) QoS (quality of service)
 - 4) Security

i) Fault tolerance: refers to the network's ability to limit the impact of a failure by limiting the number of affected devices.

how works? - multiple paths needed

- provide redundancy by implementing a packet switched network

splits traffic
into packets
routed over a net

each packet
takes diff. path

not possible in
circuit switching network

why redundancy needed?

- when a link/device fails
- allow alternative path
- unaffected network

- 2) Scalability: - expand networks quickly
- support additional devices to be connected to network
- doesn't affect performance of services
- follow accepted standards/protocols

- 3) QoS: priority mechanism used to ensure reliable delivery of content for all users
- managed by routers
 - set priorities
 - web page - lower priority
 - voice over call - higher priority
 - need smooth/uninterrupted service

Ex! Live video - pause and break continuously

- bandwidth demand > available
- QoS not configured

4) Network security : (2 types)

Network infrastructure security

Information security

- security of network devices
- prevent unauthorized access to device

3 goals

1 Confidentiality

2 Integrity

3 Availability

* Network Trends (4)

1) BYOD - Bringing Your Own Device

allows end users to use their own devices which give them more opportunities and greater flexibility to access information.

2) Online Collaboration: work with others over network

Tool: Cisco WebEx Teams

- joint project



2) Video communication: also used in video conferencing

Tool: Cisco TelePresence Powers

4) Cloud Computing:

- store personal files / backup data on servers over internet
- smaller companies
 - not afford own data center
 - lease server and storage from larger data centers

(4) types

1) Public: available to public

- paid or free

2) Private: for specific org

3) Hybrid: combo of 2 or more types of clouds

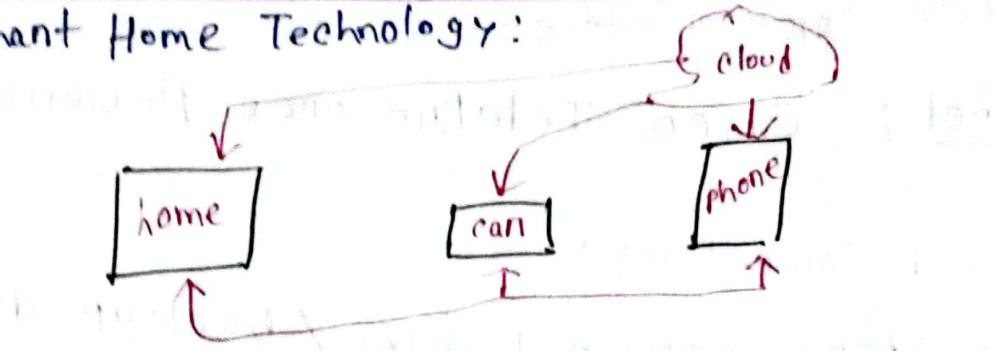
→ some part custom

→ " " " public

Each part ~~separate~~, but connected using the same architecture

4) Custom: built for specific org.

Smart Home Technology:



Powerline Networking:

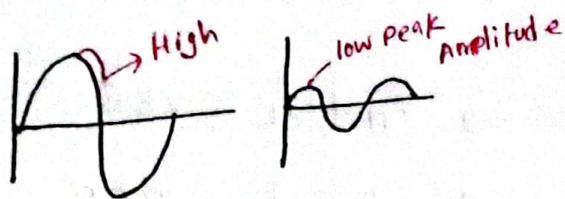
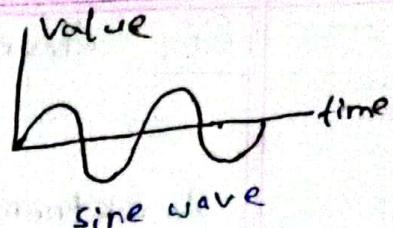
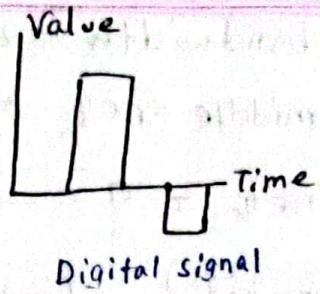
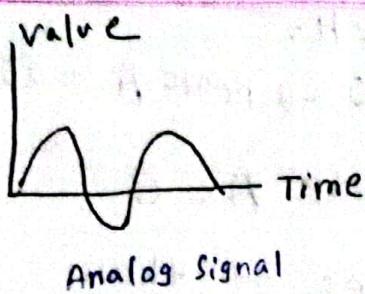
- when wireless communication not possible
- device connect to LAN
- use standard powerline adapter.

Wireless Broadband: home / small business use

- antenna is installed
- WISP — wireless Internet service provider
 - is an ISP that connects user to designated access points on hotspots.

1 character - 8 bit

Chap - 3

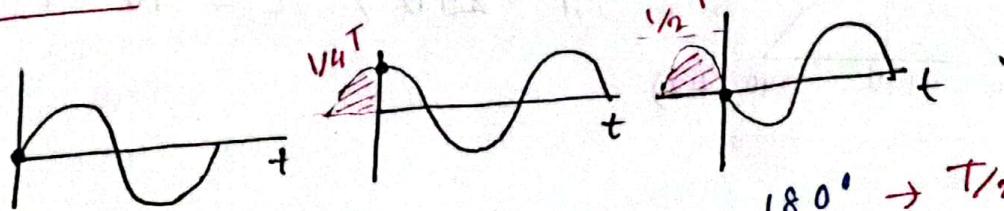


$$\text{period, } T = \frac{1}{f} \rightarrow \text{Frequency (Hz)}$$

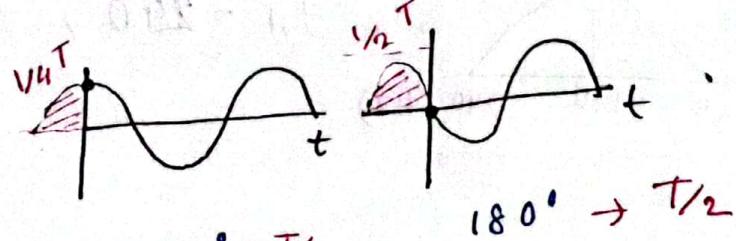
Phase: with (same amplitude and f)

$$\text{wavelength, } \lambda = \frac{v}{f}$$

$v \rightarrow \text{propagation speed}$



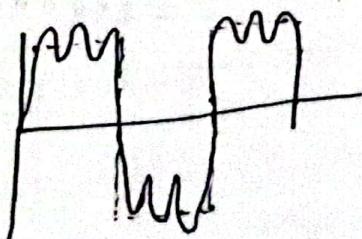
0 amplitude
↓ increase
not shifted



0 amplitude
↓ decrease
shifted to left by $\frac{1}{2}$ cycle

$180^\circ \rightarrow \frac{T}{2}$

Composite signal.



* Bandwidth, $B = f_H - f_L$

* Medium frequency, $f_0 = \frac{f_H + f_L}{2}$

* No. of bits per level

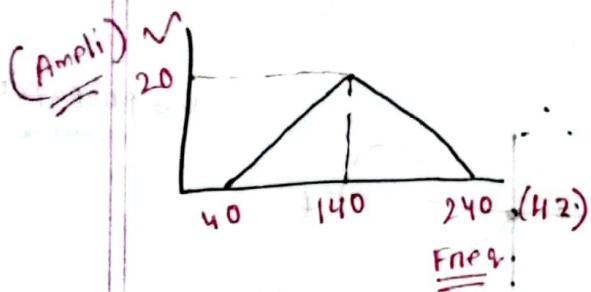
$$= \log_2 (\text{no. of levels})$$

* Bit rate = amount of data / time

Ex: Given, bandwidth = 200 kHz
 middle freq = 140 \rightarrow peak A = 20 V
 2 extreme freq. = ? \rightarrow peak A = 0.
 (both low and high) Find freq. of them.

$$\text{Sol}^n: \frac{f_H + f_L}{2} = 140 \rightarrow f_H + f_L = 280$$

$$\text{Again, } f_H - f_L = 200$$



$$\therefore f_H = 240, f_L = 40 \text{ Hz}$$

Ex: download text document at the rate of 100 pages per minute, where
 1 page \rightarrow 24 line
 1 line \rightarrow 80 chars.

Solⁿ:

$$\begin{aligned}\text{bit rate} &= (100 \times 24 \times 80 \times 8) \\ &= 1536000 \text{ bps} \\ &= 1.536 \text{ Mbps}\end{aligned}$$

For noiseless channel,

* Bit rate = $2 \times$ bandwidth $\times \log_2$ (level) \rightarrow Nyquist theorem

* Bit length = propagation speed \times bit duration

* Bandwidth, $B = \frac{f}{2}$ (Harmonic)

(Hz on

bps)

$B = \frac{3f}{2}$ (3rd harmonic)

$B = \frac{5f}{2}$ (5th)

* decibel, $dB = 10 \log_{10} \frac{P_2}{P_1}$

* Signal to Noise $SNR = \frac{\text{avg. signal power}}{\text{avg. noise power}}$

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

when, noiseless \rightarrow ideal / not possible / in real

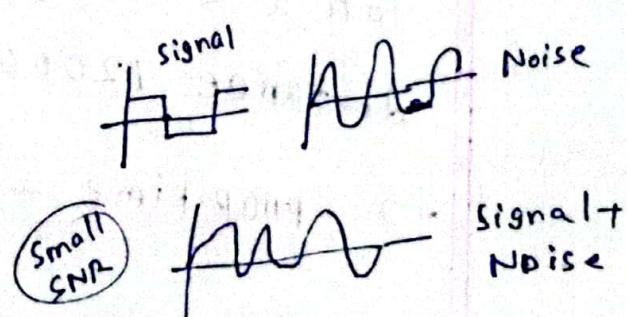
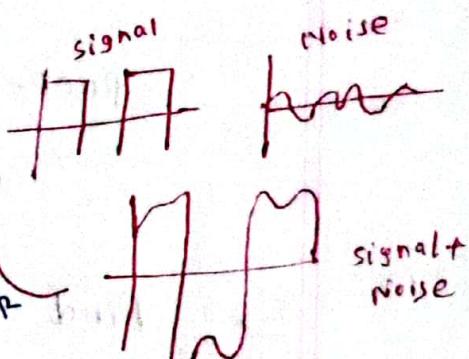
$$SNR = \frac{\text{signal power}}{0} = \infty$$

$$SNR_{dB} = 10 \log_{10} (\infty) = \infty$$

* For noisy channel (Shannon capacity)

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

$$= B \times \frac{SNR_{dB}}{3}$$



- * Transmission time = $\frac{\text{message size}}{\text{packet length (bits)}} \times \text{Bandwidth (bps)}$
- * Latency = processing time + queuing time + transmission time + propagation time
 $t = \frac{s}{v} = \frac{\text{dist.}}{\text{prop. speed}}$
- * Throughput = amt. of data / time
- * bit length = $s \times \text{bit duration}$
 $= \frac{s}{\text{distance}} \times \text{bit duration}$
 $\therefore \text{prop. time} = \frac{s \times \text{bit duration}}{\text{bit length}}$

Ex: Find propagation time and transmission time for a 2.5 kbyte message, bandwidth = 1 Gbps, distance 12000 km, speed = $2.4 \times 10^8 \text{ m/s}$

$$\rightarrow \text{prop. time} = \frac{\text{dist.}}{\text{prop. speed}} = \frac{12000 \times 10^3}{2.4 \times 10^8} = \text{S}$$

$$\text{trans. time} = \frac{\text{message size}}{\text{B}} = \frac{2.5 \times 10^3 \times 8 \text{ bits}}{1 \times 10^9 \text{ bps}} = \text{S}$$

Analog signal: continuous waveforms where the signal's amplitude, frequency and phase can take on any value within a given range.

Digital signal: a signal that represents data as a sequence of discrete values.

Periodic signal: a signal that repeats its waveform over time at regular intervals. (T fixed)

Non-periodic signal: a signal that doesn't repeat its waveform over time in a regular interval.

Peak amplitude: the peak amplitude of a signal is the absolute value of its highest intensity, proportional to the energy it carries.

Period: refers to the amount of time, a signal needs to complete 1 cycle.

needs to complete 1 cycle.

frequency: refers to the no. of periods in 1 s.

describes the position of the waveform relative to time 0.

wavelength: refers to the distance between two consecutive points of the same phase on a wave.

Single frequency sine wave \rightarrow make sound
 \rightarrow not send data

Composite signal: A signal made of many
periodic/non periodic simple sine waves with
different f, A and phases.

The same or
different

periodic composite signal $\xrightarrow{\text{decomposition}}$ discrete frequency
(series of signals)

non-periodic \rightarrow continuous frequency
(combo of sine waves)

Bandwidth: range of frequencies contained in a
composite signal.

Bit rate: no. of bits sent in 1 s.

Bit length: distance one bit occupies on the
transmission medium.

Broadband Transmission/ modulation: digital \rightarrow analog
signal

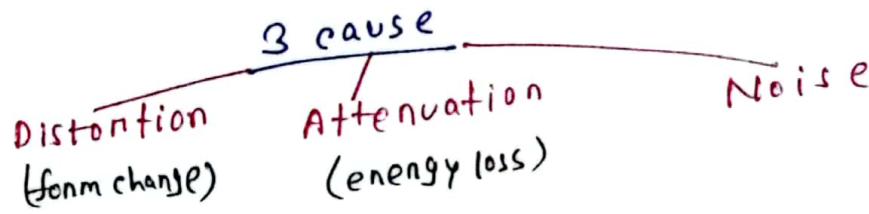
Decibel: measures the relative strengths of 2 signals on 1 signal at 2 different points.

→ ~~energy loss~~
negative → signal decreases (attenuated)
positive → " amplified → energy gain

Distortion: means that the signal changes its form/shape.

condition
[
— composite signal
— different f

Impairment: the signal beginning of medium ≠ " end "



Throughput: how fast send data (bps)

Delay: refers to the time it takes for a packet to travel from source to destination

Transmission time: time to transmit a data packet over a network link.

Propagation time: refers to time it takes for a signal to propagate through a physical medium.

Queuing/waiting time: time a packet spends in a queue before it can be transmitted.

Processing time: time needed by network devices to process and handle packets.

Communication Elements: [3]

- 1) sender
- 2) receiver
- 3) media

Protocols: rules that communication follows.

↳ requirements:
(A)

- 1) own function
- 2) " format
- 3) " rules

- 1) An identified sender and receiver
- 2) Common language and grammar
- 3) Speed and timing of delivery
- 4) Confirmation or acknowledgement

Common computer protocols agreement's requirements:

1) message encoding

2) message formatting and encapsulation

3) " size

4) " timing

5) " delivery options

Unicast - 1 to 1 | Multicast - 1 to many | Broadcast - 1 to all

Message has
specific format
depends on
- type of msg
- delivery channel

message $\xrightarrow{\text{converted}}$ bits $\xrightarrow{\text{encoded}}$

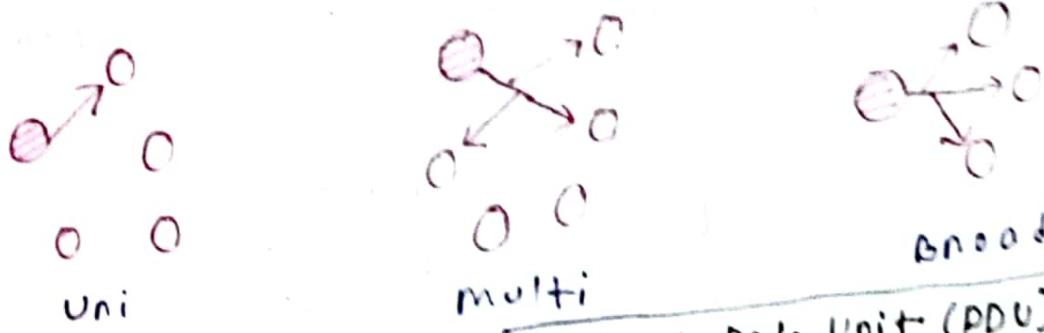
light/
sound/
electrical/
impulse

$\xrightarrow{\text{decode signals}}$
destination
host
interpret msg

Collision: more than one device send traffic at the same time
message corrupted

Encoding: process of converting information into another acceptable form for submission.

Decoding: process of interpreting and extracting meaningful information from encoded data.



More about protocols:

Types: (4)

- 1) Network communication: how many devices communicate
- 2) Security: secure data, authentication, integrity, encryption
- 3) Routing: exchange route info → compare path info → select best path
- 4) Service Discovery: auto detect service

6 functions:

- 1) Addressing - identify sender and receiver
- 2) Reliability - guaranteed delivery
- 3) Flow Control - ensure data flow at efficient rate
- 4) Sequencing - uniquely labels each transmitted segment of data

- 5) Error Detection - determines if data corrupted
- 6) Application Interface - p2p communication
process to process

of TCP/
IP

6 Layens

- different protocols: (message delivery format)
- * HTTP - web server → web client → App layer
 - * TCP - individually handle → Transport layer
 - * IP - sender → receiver (globally) → Internet layer
 - * Ethernet - NIC → NIC (same LAN) → Network Access Layer

2 layens:

- Higher
- Lower → move data
→ provide service to higher layers

Protocol Suite: set of ~~protocols~~ protocols that work together to provide network communication and services.

- * TCP/IP - most common
- maintained by IETF
- * OSI - developed by ISO and ITU
- * AppleTalk - developed by Apple Inc.
released
- * Novell Netware - developed by Novell Inc.

↗ middle ↗

OSI Model Layer: TCP/IP ; TCP/IP Model
 (7) | Protocol suit | Layer (5)

Right side

7. Application - contains protocols used for p2p communication

6. Presentation | HTTP/DNS/ | Application

5. session |

4. Transport | TCP/UDP | Transport

TCP - connection oriented
UDP - connectionless

3. Network | IPv4/IPv6/
| ICMPv4/ICMPv6/ | Internet / Network

2. Data Link - exchange data
frame method

1. physical | Ethernet / WLAN / | Network Access

Physical
Data Link

* Segmenting: process of breaking up messages into smaller units

2 pros

1) speed increase

2) Efficiency "

* multiplexing: process of taking multiple streams of segmented data and interleaving them together.

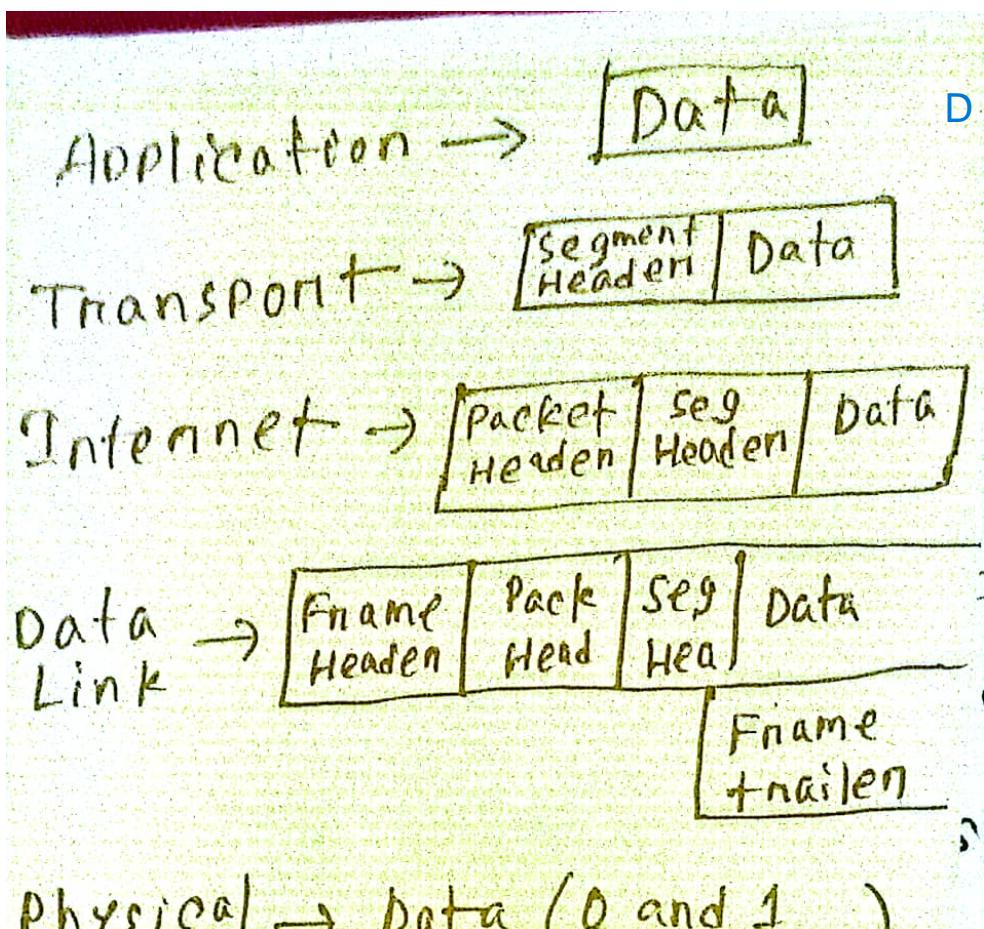
* Sequencing: process of numbering the segments so that the message may be reassembled at the destination.

TCP does this

Sequence number

* 6 benefits of using layered model:

- 1) modular design
- 2) Interoperability
- 3) Abstraction
- 4) Easy troubleshooting
- 5) standardization and compatibility
- 6) Easy implementation



Left ↗ TCP / IP

Right ↗ Data Encapsulate
and De-encapsulate

From TCP to IP → Encapsulate

From IP to Data → De-encapsulate