30.01.2024

UNIT - 1

BASICS OF NETWORK & PHYSICAL LAYER

Data Communication:

Communication is defined as a process in which more than one computer transfers information, instructions to each other and for sharing resources.

A NETWORK of computers is defined as an interconnected collection of ~~autonomous~~ computers, which communicate with each other.

Autonomous computers means, no computer can start, stop or control another computer.

Components of Data Communication:

1. **Message**: piece of information that is to be transmitted from one person to another.
   Ex: text file, audio file, video file etc.

2. **Sender**: device that sends data or messages, and it can be a computer, mobile, video camera or workstation.

3. **Receiver**: device that receives messages. It can be a computer, mobile etc.

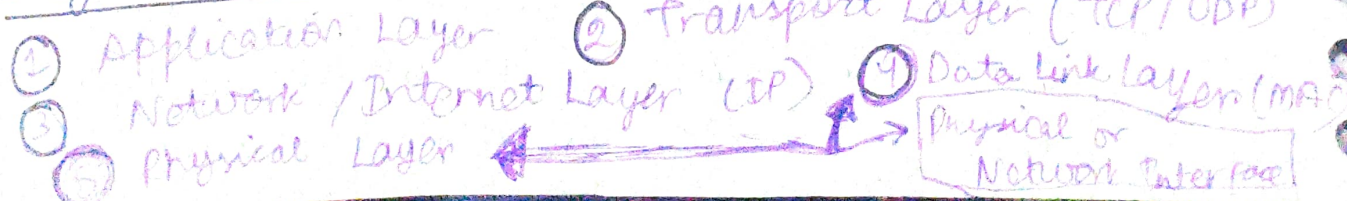
4. **Transmission Medium / Communication Channel**: medium that connects two or more workstations. It can be wired media or wireless media.

5. Set of Rules (Protocols): When someone sends data, it should be understandable to the receiver also, otherwise it is meaningless.
Protocols are followed by every computer connected to the internet :

- TCP/IP: (Transmission Control Protocol / Internet Protocol):
  → designed & developed by Department of Defense (DoD) in the 1960s (different protocols of Comp Netwk)
  → TCP/IP model is a concise version of OSI & has 4 layers.
  → Work: transfer the data of a computer from one device to another.
  → helps in making data reliable and accurate so that the receiver will receive the same info which is sent by the sender.
  → divides the data into packets & combines them at the other end.

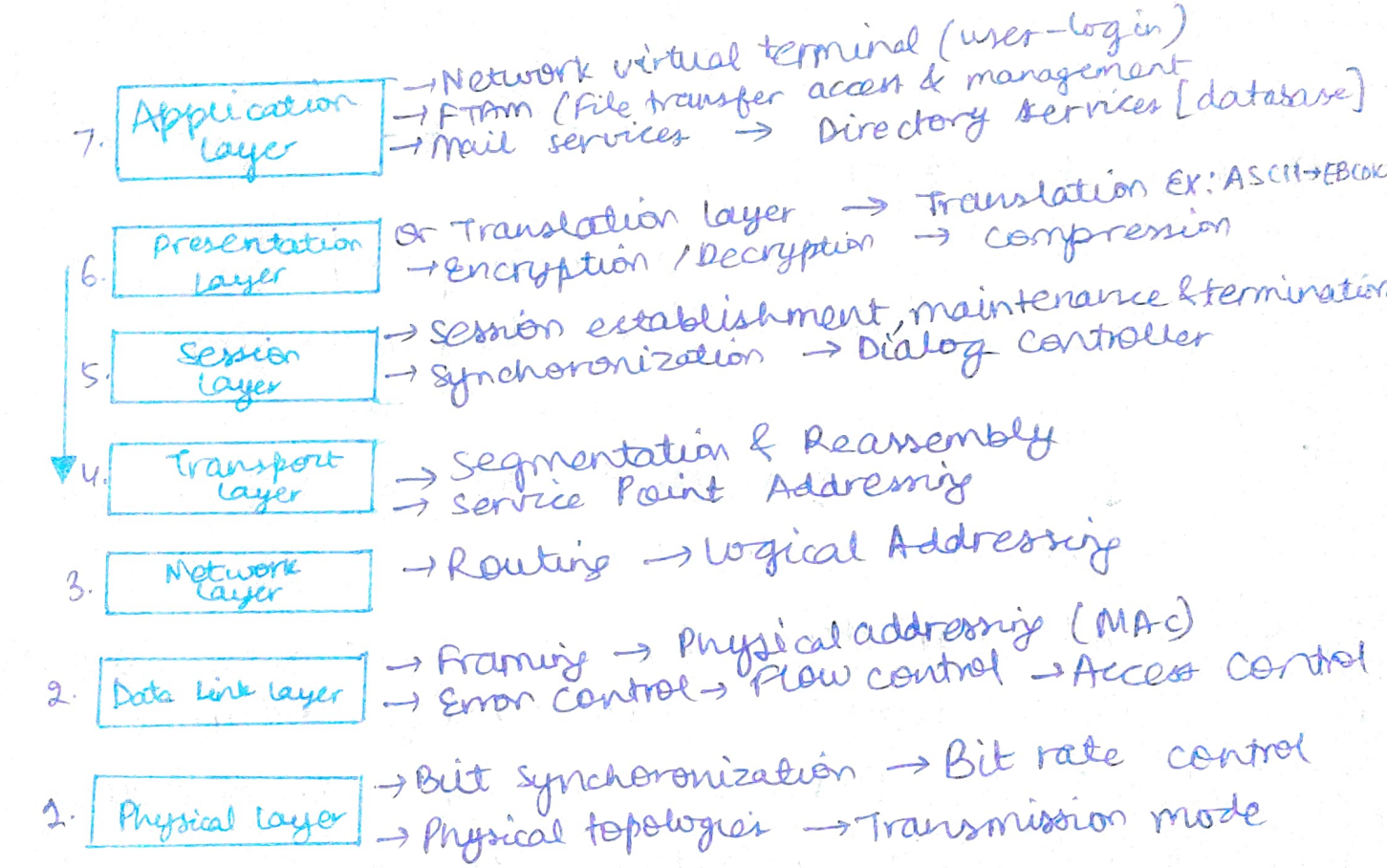
- IP finds the destination of the mail &
- TCP has the work to send and receive the mail.
- UDP (User Datagram Protocol), connectionless protocol used in comp networking. Unlike TCP, UDP does not establish a connection before sending data & does not guarantee delivery.

Layers of TCP/IP Model:



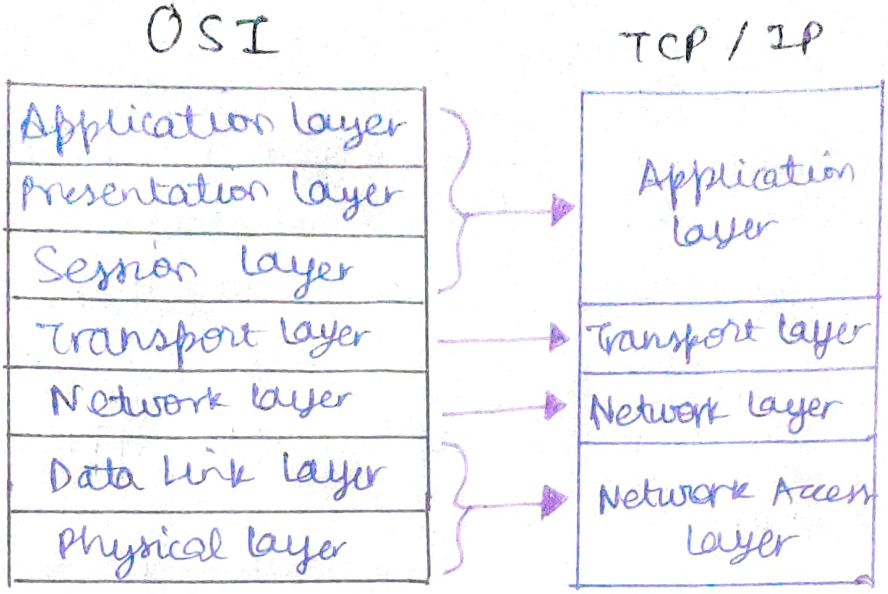
OSI Model:

→ created in 1984 by ISO
→ reference framework that explains the process of transmitting data b/w computers.
→ divided into 7 layers that work together to carry out specialized network functions, allowing for a more systematic approach to networking.



Why TCP/IP over OSI model?

→ OSI has 7 layers, making it more complex, while 4 layers of TCP/IP simplifies networking concepts.
→ TCP/IP was used in ARPANET, the precursor to the modern internet, OSI faced challenges in adoption partly due to its late introduction & the already established presence of TCP/IP.
→ OSI is theoretical framework, not in practice.



ASCII: (128)

A: 65 – Z: 90

a: 97 – z: 122

0: 48 – 9: 57

! : 33	% : 37
" : 34	& : 38
# : 35	' : 39
$: 36	(: 40
	) : 41

- **DATA REPRESENTATION:**

(1.) **Text:** represented as a bit pattern, sequence of bits (0's & 1's). Characters can be represented in Unicode by using the American standard Code for Information Interchange (ASCII)

→ **Control characters:** first 32 ASCII codes (0 to 31) represent newline, tab, carriage return etc.

→ **Printable characters:** 32 – 126, digits, letters, punctuation marks & special symbols.

→ **Extended characters:** 127 – 255

(2.) **Numbers-** Also represented by bit patterns. To simplify mathematical operations the no. is directly converted to a binary no.

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③ Images: represented by bit patterns. Composed of matrix of pixels, where resolution determines the size of the pixel

- PIXEL: "Picture element" Smallest controllable element of a digital image or display device
- Color: determined by pixel's color/bit depth. color depths can be:
  - monochrome (1-bit) → $2^1 = 2$ Black/white or Black/transparent
  - 256 colors (8-bit) → 256
  - true color (24-bit) → RGB 8 8 8 bit : $2^8 \times 2^8 \times 2^8 = 256^3$
  - true color with alpha channel (32 bit) RGB 8 8 8 + alpha channel 8

effects: fading / transparency / layering

④ AUDIO: An audio signal is a representation of sound, typically using either a changing level of electrical voltage for analog signals, or a series of binary numbers for digital signals.

Audio signals may be characterized by parameters such as their bandwidth, nominal level, power level in decibels (dB) and voltage level.

Audio File formats: MP3, M4A audio file type, FLAC, WAV, WMA, AAC etc.

⑤ VIDEO:

A video file format is a type of file format for storing digital video data on a computer system.

A video file normally consists of a container containing visual data in a video coding format, alongside audio data in an audio coding format.

The coded video and audio inside a video file container, is called ESSENCE.

A program or hardware which can decode compressed video or audio is called CODEC.

Formats:

- AVI (audio video interleaved)
- WebM (.webm)
- Windows media Video (.WMV)
- Flash video (.flv)
- Ogg video (.ogv)
- mp4
- mov: Quicktime multimedia file format (developed by APPLE)

GIF: Graphics Interchange Format ← Image format (series of imgs or a soundless video that is in loop & doesn't require anyone to press PLAY.

PERFORMANCE OF A NETWORK:

Measure of service quality of a network as perceived by the user. Depends on both quality & quantity of the network.

Parameters for measuring performance:

1. BAND WIDTH:

- Bandwidth is characterized as the measure of data or information that can be transmitted in a fixed measure of time.
  - In digital devices - measured in bits per sec (bps) or bytes
  - In analog devices - measured in cycles per second or Hertz (Hz)
- Bandwidth determines how rapidly the webserver is able to upload the requested information.

- **Internet speed**: Amount of data you receive every second (has to do with latency also)
- **Bandwidth**: Capacity, (like pipe's diameter) how much data the network connection can handle at once.

BANDWIDTH: CAPACITY	SPEED: transfer Rate
maximum width of a road, indicating how many cars (data) can travel at once.	Speed of your car on that road, determining how quickly you can reach your destination.

2. LATENCY: (delay)

- Total time taken for a complete message to arrive at the destination.
  (Starting with first bit of msg sent out from source to last bit of msg delivered at destinatio

- Network connections with
  small delay occur → Low Latency network
  long delay occur → High Latency network

- Also known as PING RATE, measured in miliseconds (ms)

- **Bottle neck** - refers to a point in the network where the flow of data is constrained or limited

- High latency leads to creation of bottlenecks, stoping the data from taking full advantage of network pipe & conclusively decreases the bandwidth.

Latency = Propogation Time + Transmission Time + Queuing Time + Processing Delay

3. PROPAGATION TIME:

Time required for a bit to travel from the source to the destination.

$$\text{Propagation Time} = \frac{\text{Link Length (Distance)}}{\text{Propagation Speed}}$$

4. TRANSMISSION TIME:

Refers to the time it takes to transmit a packet of data from the sender to the receiver over a network.

$$\text{Transmission Time} = \frac{\text{Packet Size}}{\text{Bandwidth}}$$

5. QUEUING TIME: (Queuing Delay)

Amount of time a packet spends waiting in a queue, before it can be transmitted over a network

6. PROCESSING DELAY: (Processing Time)

Time it takes for a networking device to process a packet of data before forwarding it to its destination. (device performs various tasks related to packet handling & routing or finding the destination)

7. THROUGHPUT:

Rate at which data is succesfully transmitted between source & destination over a network within a specified time, taking into account factors like latency, packet loss, & network congestion.

$$\text{Throughput} = \frac{\text{Amount of data transfered}}{\text{Time taken to transfer data}}$$

[Bandwidth: potential capacity
Throughput: actual rate of data transfer.]

8. JITTER: "packet delay variance"

→ Different packets of data face different delays in a network and the data at the receiver application is time-sensitive, i.e. audio or video.

→ Interference in the normal order of sending data packets.

→ Jitter causes:

- congestion - All the packets come to a junction at the same time, nothing can get loaded.
- Packet loss - packets arriving at different intervals, receiving system is not able to process information, leading to missing information or packet loss.

Solution: jitter buffer & route trafic to most stable paths