CHAPTER - 2

The OSI Model.

M T W T F S S
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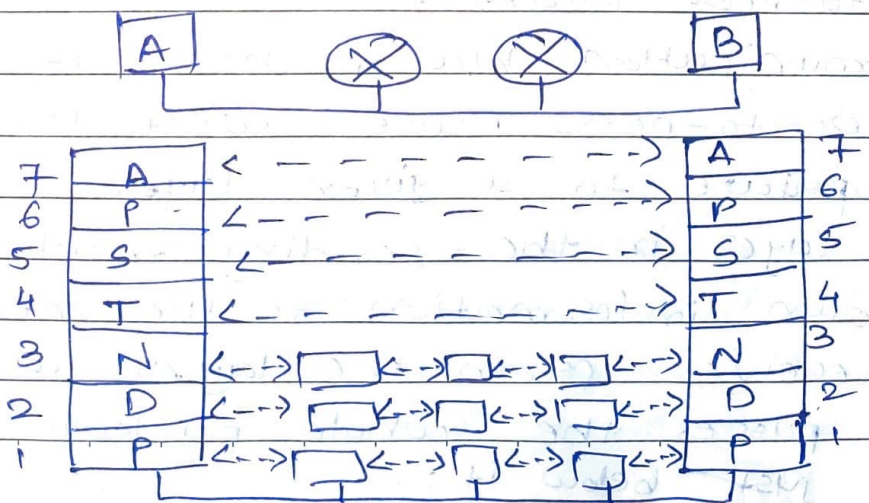
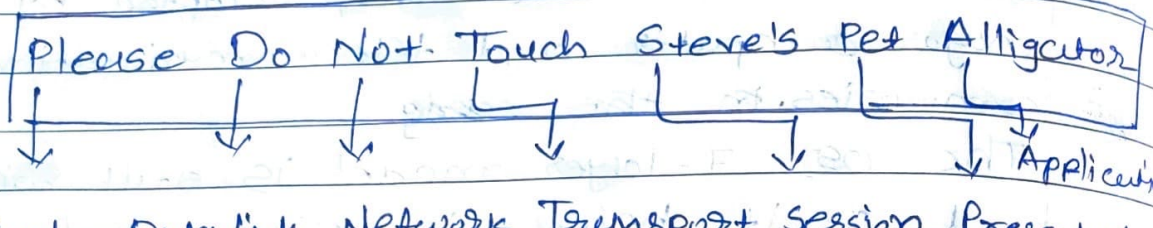
- Established in 1947.
- The Open System Interconnection (OSI) model describes seven layers that computer systems use to communicate over a network.
- It was the first standard model for network communications, adopted by all major computer and telecommunication companies.
- The OSI 7-layer model is still widely used, as it helps visualize and communicate how networks operate, and helps isolate and troubleshoot networking problems.
- As a Software Engineer and Software tester, it is important to understand this OSI model as each of the software applications works based on one of the layers in this model.

*) Layered Architecture:

- The OSI model is built of seven ordered layers: Physical (L-1), Data-Link (L-2), Network (L-3), Transport (L-4), Session (L-5), Presentation (L-6), Application (L-7).



- Fig, shows the layers involved when a message is sent from device A to device B.
- As the message travels from A to B, it may pass through many intermediate nodes.
- These intermediate nodes usually involve only the first three layers of the OSI model.



⟹ Peer-to-Peer Process.

- Within a single machine, each layer calls upon the services of the layer just below it. For eg, Layer 3 uses the services provided by layer 2 and provides services for layer 4.
- Between machines, layer x on one machine communicates with layer x on another machine. This communication is governed by an agreed-upon series of rules and conventions called protocols.
- The process on each machine that communicate at a given layer are called peer-to-peer processes.
- Communication b/w machines is therefore a peer-to-peer process using the protocols appropriate to a given layer.
- Each layer in the sending machine adds its own information to the message it receives from the layer just above it and passes the whole package to the layer just below it.

- This information is added in the form of headers or trailers.
- Headers are added to the message at layers 6, 5, 4, 3, 2 and trailer is added at layer 2.
- At layer 1 the entire package is converted to a form that can be transferred to the receiving machine. At the receiving machine the message is unwrapped layer by layer,
- with each process receiving and removing the data meant for it.
- For eg, layer 2 removes the data meant for it, then passes the rest to layer 3. Layer 3 removes the data meant for it and passes the rest to layer 4 and so on.

⇒ Interfaces b/w layers.

- The passing of the data and network information down through the layers of the receiving machine is made possible by an interface b/w each pair of adjacent layers.
- Each interface defines what information and services a layer must provide for the layer above it.

⇒ Organization of the layers.

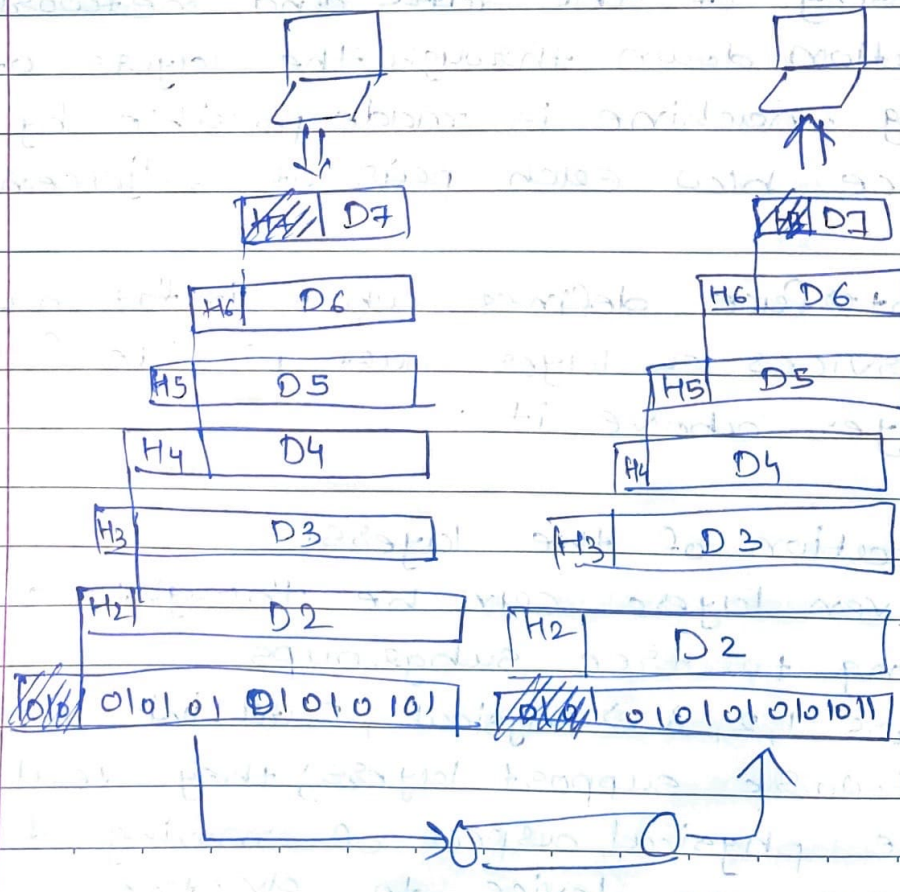
- The seven layers can be thought of as belonging to three subgroups.
  - → Layers 1, 2, 3 ⇒ physical, Data Link, Network
    - Network support layers; they deal with the physical aspect of moving data from one device to another.

→ Layer 5, 6, 7 - session, presentation and application ⇒ User support layers:- they allow interoperability among unrelated software systems.

→ Layer 4 - Transport; ensures end-to-end reliable data transmission while layer 2 ensures ~~implemented~~ ensures reliable transmission on a single link.

- The upper layers are almost always implemented in software and lower layers are a combination of hardware and software.
- Lower layers are a combination of hardware and software, except for the physical layer, which is mostly hardware.

⇒ Data Exchange using the OSI model.



→ D7 data means the data unit at layer 7.
D6 data means the data unit at layer 6.
- The process starts out at layer 7, then moves from layer to layer in descending sequential order.
- At each layer (except layer 7 and 1), a header is added to the data unit.
- At layer 2, a trailer is added as well.
- When the formatted data unit passes through the physical layer (L1), it is changed into an electromagnetic signal and transported along a physical link.
- Upon it's destination, the signal passes into layer 1 and is transformed back into bits.
- The data units then move back up through the OSI layers. As each block of data reaches the next higher layer, the headers and trailers attached to it at the corresponding sending layer are removed, and action appropriate to that layer are taken.
- By the time it reaches layer 7, the message is again in a form appropriate to the application and is made available to the recipient.

⇒ The layered architecture's major goal is to split the design into tiny parts.
- Each lower layer contributes its services to the top layer.
- The number of levels, functions and contents of each layer will differ from one network to the next. However, the objective of each

layer is to offer the service from a lower to a higher layer.

* Fundamental Components of layered Architecture :-

(1) Service :- A collection of activities provided by a layer to a higher layer.

(2) Protocol :- It is a collection of rules that a layer employs to share data with a peer entity.
- These rules primarily address the contents and order of the messages used.

(3) Interface :- The interface is the means through which a message is transmitted from one layer to another.

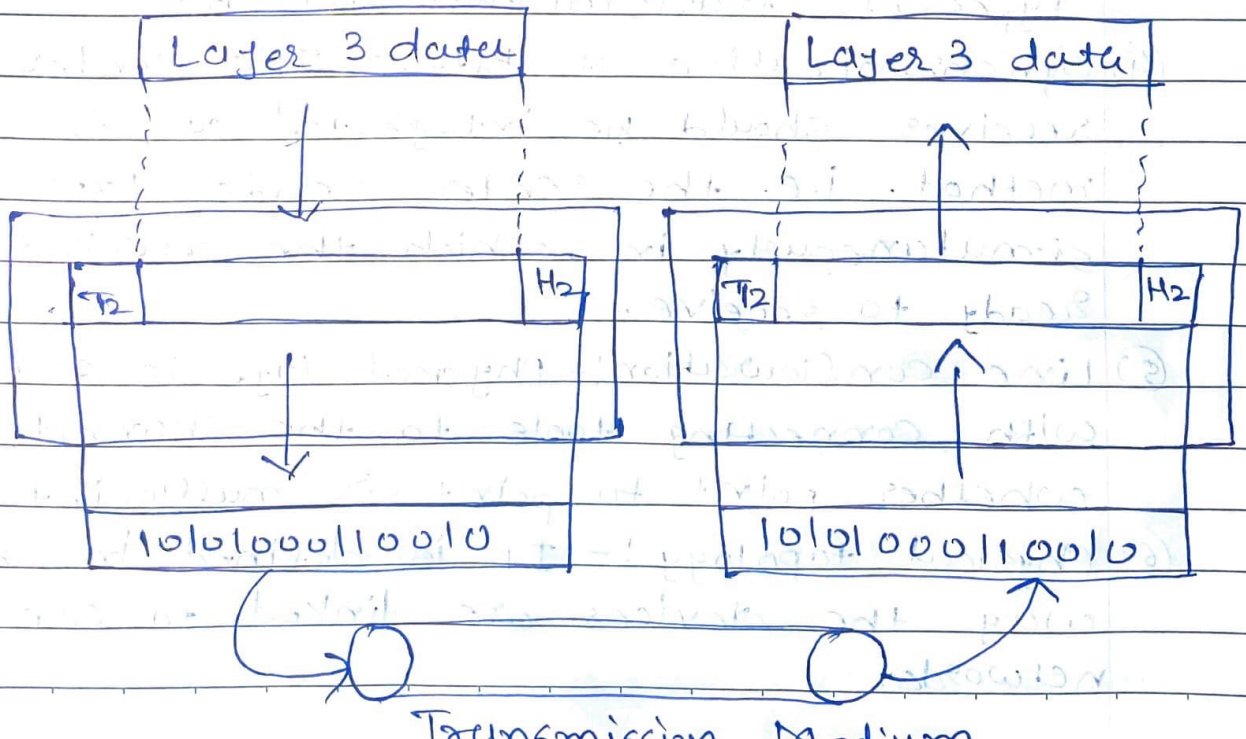
* Why OSI model?
- Helps you to understand communication over a network.
- Troubleshooting is easier by separating functions into different network layers.
- Helps you to understand new technologies as they are developed.
- Allows you to compare primary functional relationship on various network layers.

S/w
Upper layers
- Application → To allow access to network resources
- Presentation → To translate, encrypt and compress data.
- session → To establish, manage and terminate session.

Heart of OSI
- Transport → To provide reliable process to process message delivery and error delivery.

H/w
Lower layers
- Network → To move packets from source to destination.
  → To provide internetworking
- Data link → To organize bits into frames
  → To provide hop-to hop delivery.
- Physical → To transmit bits over a medium.
  → To provide mechanical and electrical specifications

① Physical layer.



- Physical layer defines electrical and physical specification for devices.
- The physical layer defines the relationship b/w a device and a transmission medium, such as a coppor or optical cable.
- this includes the layout of pins, voltages, cable specifications, hubs, repeaters, network adapters, host bus adapters and more.
- the physical layer is not concerned with protocols or other such higher-layer items.

⇒ Services of Physical Layers

① Representation of Bits:- The physical layer data includes a flow of bits. It represents the encoding (how 0's and 1's is modified to signals).

② Data Rate:- It represents the transmission route; i.e. the several bits communicated per second.

③ Transmission Medium:- It represents the types of transmission medium.

④ Synchronization of Bits:- The sender and receiver should be integrated at the bit method. i.e. the sender sends data simultaneously in which the receiver is ready to receive.

⑤ Line configuration:- physical layer is concerned with connecting tools to the channel, whether point to point or multipoint.

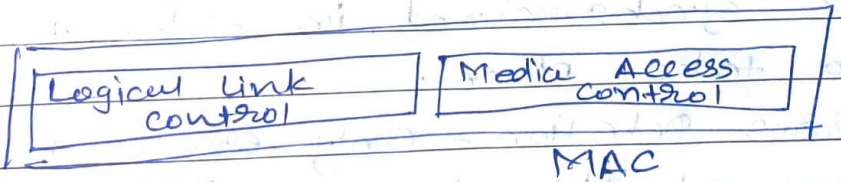
⑥ Physical topology:- It is defined in what way the devices are linked to create a network.

⑦ Transmission mode: It also defines the mode of transmission, i.e., the services of a message b/w the two computers. In half duplex or full duplex or simplex.

2) Data-Link layer

- Data link layer is the second layer from the bottom of the OSI reference model.
- The main function of the data-link layer is to perform error detection and combine the data bits into frames.
- It combines the raw data into bytes and bytes to frames and transmit the data packet to the network layer of the desired destination host.
- At the destination end, the data-link layer receives the signal, decodes it into frames and delivers it to the hardware.
- At receiving end, Data Link layer picks up data from h/w which are in the form of electric signals, assembles them in a recognizable frame format, and hands over to upper layer.

⇒ Data link layer has 2 sub layers.



LLC - deals with protocols, flow-control and error control

MAC - deals with actual control of media.

⇒ MAC Address = Data-Link layer supervises the physical addressing system called the MAC address for the network and handles the access of the network components to the physical medium.

- A MAC address is a unique device address and each device or component in a network has a MAC address on the basis of which we can uniquely identify a device of the network. It is a 12 digit unique address.

⇒ Functionalities of Data link layer.

① Framing :- DLL takes packets from Network layer and encapsulates them into frames.

- Then, it sends each frame bit-by-bit on the hardware. At receiver's end, DLL picks up signals from hlw and assembles them into frames.

② Addressing :- DLL provides layer-2 hlw addressing mechanism. Hlw address is assumed to be unique on the link. It is encoded into hlw at the time of manufacturing.

③ Synchronization :- When data frames are sent on the link, both machines must be synchronized in order to transfer to take place.

④ Error Detection :- Only error detection is done at this layer, not error correction. Error correction is done at the Transport Layer.

- Sometimes data signals encounter some

Unwanted signals known as error bits.
This layer performs error detection.
- CRC and checksum are few efficient methods of error checking.

(5) Flow control - Data which is sent in the form of a frame b/w the sender and a receiver over a transmission media at this layer, should transmit and receive at the same pace.
- When a frame is sent over a medium at a faster speed than the receiver's working speed, then the data to be received at receiving node will be lost due to mismatch in speed.
- In order to overcome these type of issues, the layer performs flow control mechanism.

⇒ 2 types of flow control process.
① Stop and wait flow control
② Sliding window:- Both sender and receiver will decide the number of frames after which the ack. should be exchanged.

3. Network layer:

- The network layer is the third layer of the OSI model.
- It acts as a network controller.
- It handles the service requests from the transport layer and further forwards the service request to the data link layer.
- The network layer translates the logical addresses into physical addresses.

- It determines the route from the source to the destination and also manages the traffic problems such as switching, routing and controls the congestion of data packets.
- The main role of the network layer is to move the packet from sending host to the receiving host.
- Transferring of variable data from one node to another, connected in a network, takes place at this layer.
- The data is sent in the form of packets which are then connected to each other once the processing is done.

⟹ Functions

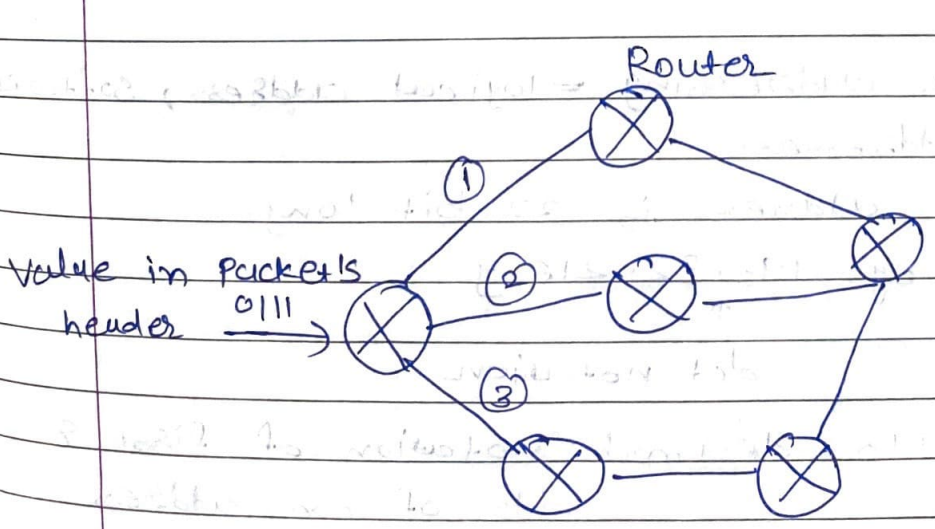
① Routing:- When a packet reaches the router's ip input link, the router will move the packets to the router's output link.

② Logical Addressing:- The data link layer implements the physical addressing and network layer implements the logical addressing.
- Logical addressing is also used to distinguish b/w source and destination system.
- The network layer adds a header to the packet ~~coit~~ which includes the logical addresses of both the sender and the receiver.

③ Internetworking:- This is the main role of the network layer that it provides the logical connection b/w different types of networks.

⇒ Forwarding and Routing

- In network layer, a router is used to forward the packets.
- Every router has a forwarding table.
- A router forwards a packet by examining a packet's header field and then using the header field value to index into the forwarding table.
- The value stored in the forwarding table corresponding to the header field value indicates the router's outgoing interface link to which the packet is to be forwarded.
- For eg; the router with a header field value of 0111 arrives at a router, and then router indexes this header value into the forwarding table that determines the output link interface is 2.
- The router forwards the packet to the interface 2. The routing algorithm determines the values that are inserted in the forwarding table.
- The routing algorithm can be centralized or decentralized.



Routing Algo

Forwarding Table

Header value	Output link
0100	3
0101	2
0111	2
1001	1

⇒ Services

① Guaranteed delivery :- This layer provides the service which guarantees that the packet will arrive at its destination.

② In-order packets :- this service ensures that the packet arrives at the destination in the order in which they are sent.

③ Gaurenteed max jitter :- this service ensures that the amount of time taken b/w two successive transmissions at the sender is equal to the time b/w their receipt at the destination.

④ Security services :- the network layer provides security by using a session key b/w the source and destination host.

- The network layer in the source host encrypts the payloads of datagrams being sent to the destination host.
- The network layer in the destination host would then decrypt the payload. In such a way, the network layer maintains the data integrity and source authentication services.

⇒ Network addressing = logical address, software-based addresses.

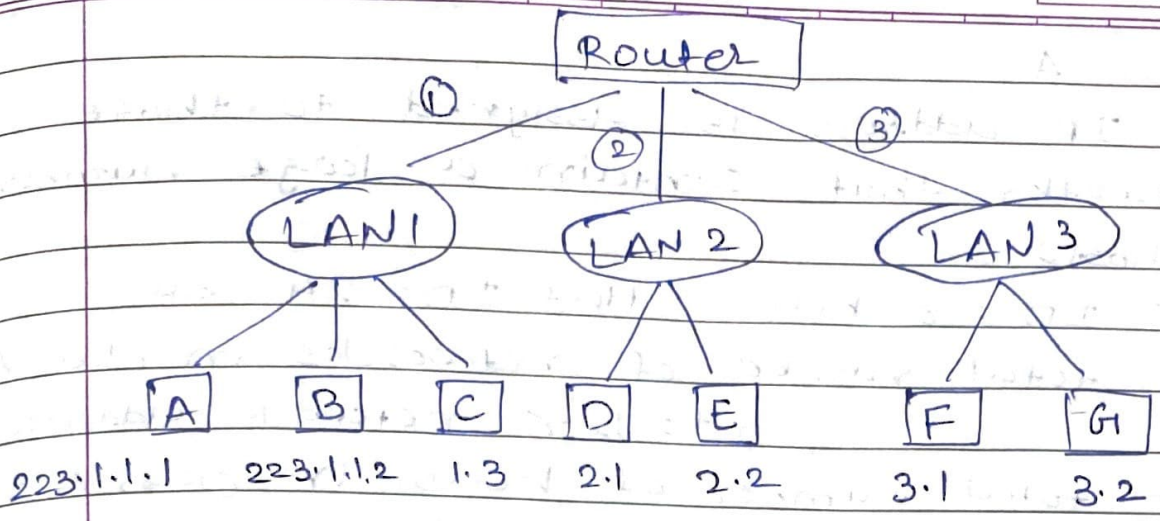
- Each IP address is 32 bit long.

eg: 193.32.216.9

dot notation

193 = decimal notation of first 8 bits of an address.

32 = decimal notation of second 8 bits of an address.



- In the above fig, a router has three interfaces labeled as 1, 2 & 3 and each router interface contains its own IP address.
- Each host contains its own interface and IP address.
- Each IP address consists of two parts. The first part (first 3 bytes) specifies the network and second part (last byte) specifies the host.

⇒ Classful Addressing

IP add = | Network ID | Host IP |

Represents the number of networks

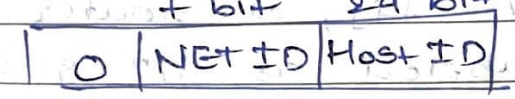
Represent the number of hosts.

	Byte 1	Byte 2	Byte 3	Byte 4	
Class A	NET ID	Host ID			8 + 24
Class B	NET ID		Host ID		16 + 16
Class C	NET ID			Host ID	24 + 8
Class D	MULTICAST ADDRESS				
Class E	RESERVED				

⇒ Class A

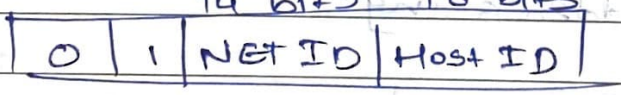
- An IP address is assigned to those networks that contain a large number of hosts.
- NET ID = 8 bits Host ID = 24 bits
- The total number of networks in class A = $2^7 = 128$ network address
- The total number of hosts in class A = $2^{24} - 2 = 16777214$ host add

Range = 0-127



⇒ Class B

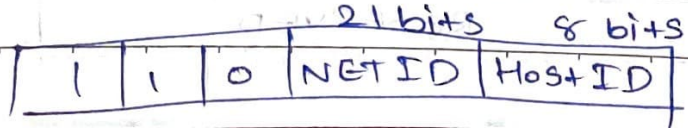
- An IP address is assigned to those networks that range from small-sized to large-sized networks.
  → Network ID = 16 bits.
  Host ID = 16 bits
- total network = $2^{14} = 16384$
  total host = $2^{16} - 2 = 65534$



Range = 128-191

⇒ Class C

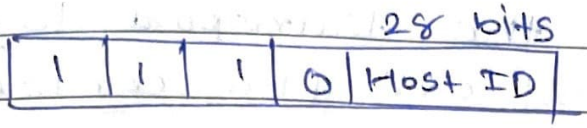
- An IP address is assigned to only small-sized networks.
  → Network ID = 24 bits
  Host ID = 8 bits.
- total network = $2^{21} = 2097152$
  total host = $2^8 - 2 = 254$



Range = 192-223

⇒ Class D

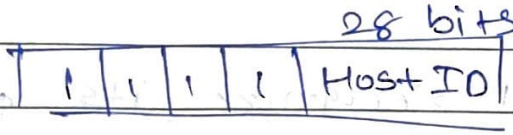
- An IP address is reserved for multicast address.
- It does not process subnetting.



Range:- 224 - ~~255~~ 239

⇒ Class E

- An IP address is used for the future use or for the research and development purposes.



Range = 240 - 255

4) Transport layer.

- The transport layer builds on the network layer to provide data transport from a process on a source machine to a process on a destination machine.
- This layer is responsible for end-to-end communication b/w the two devices.
- This includes taking data from the session layer and breaking up into chunks called segments before sending it to layer 3.
- The transport layer on the receiving device is responsible for reassembling the segments into data the session layer can consume.

- The transport layer deals with the coordination of the data transfer b/w end systems and hosts. How much data to send, at what rate, where it goes, etc.
- In addition, the transport layer handles error control and flow control. On the receiving end, the transport layer performs error control by ensuring the data is complete and it isn't, requesting a retransmission.
- The transport layer also ensures that the data received at host end will be in the same order in which it was transmitted.
- A host will recognize its peer host at the remote network by its port number.
- Transport layer offers peer-to-peer and end-to-end connection b/w two processes on remote hosts.

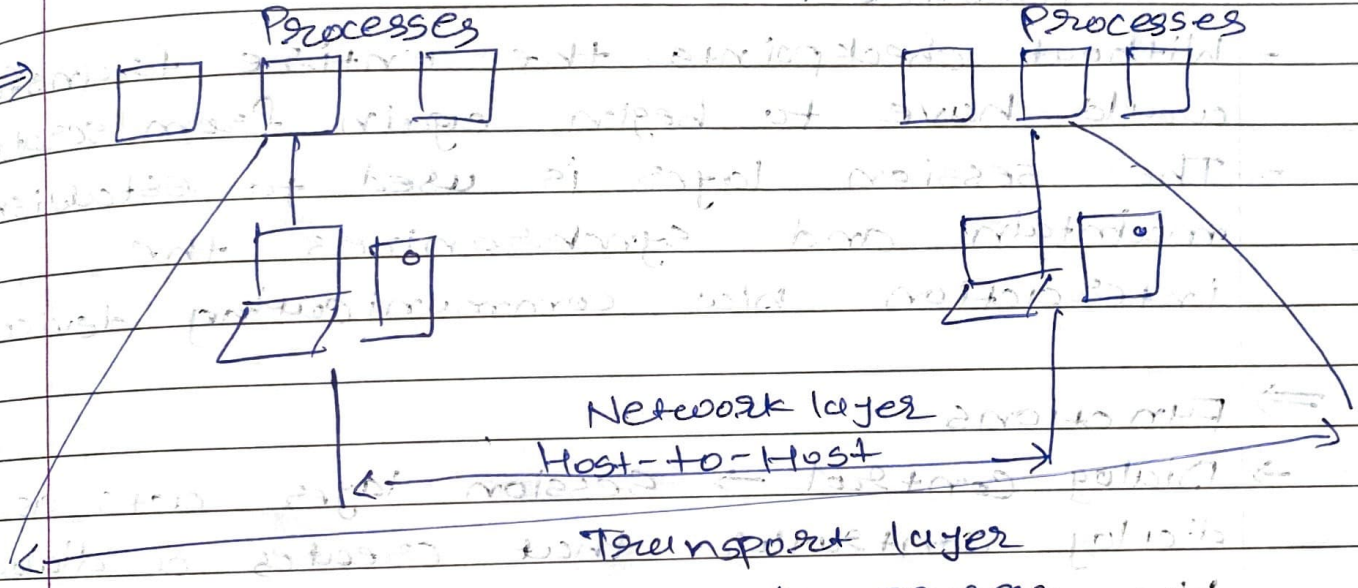
⟹ Functions.

- This layer is the first one which breaks the information data, supplied by Application layer in to smaller units called segments. It numbers every byte in the segment and maintains their accounting.
- This layer ensures that data must be received in the same sequence in which it was sent.
- This layer provides end-to-end delivery of data between hosts which may or may not belong to the same subnet.
- Transport layer header includes service point address which is the port address. This

layer gets the message to the correct process on the computer unlike Network layer, which gets each packet to the correct computer.

- Connection Control :- It includes 2 types:
- Connectionless Transport layer: Each segment is considered as an independent packet and delivered to the transport layer at the destination machine.
- Connection-oriented Transport layer: Before delivering packets, the connection is made with the transport layer at the destination machine.

⇒



5) Session Layer

- The session layer responsible for opening and closing communication between the two devices.
- The time b/w when the communication is opened and closed is known as the session.
- It is responsible for opening sessions, ensuring they remain open and functional

while data is being transferred, and closing them when communication ends.

- The session layer also synchronizes data transfer with checkpoints.
- For eg:- if a 100 megabytes file is being transferred, the session layer could set a checkpoint every 5 megabytes. In the case of a disconnect or a crash after 52 megabytes have been transferred, the session could be resumed from the last checkpoint, meaning only 50 more megabytes of data need to be transferred.
- Without checkpoints, the entire transfer would have to begin again from scratch.
- The session layer is used to establish, maintain and synchronizes the interaction b/w communicating devices.

⇒ Functions

→ Dialog control → session layer acts as a dialog controller that creates a dialog b/w two processes or we can say that it allows the communication b/w two processes which can be either half-duplex or full-duplex.

→ Synchronization → session layer adds some checkpoints when transmitting the data in a sequence. If some error occurs in the middle of the transmission of data, then the transmission will take place again, from the checkpoint.

- This process is known as synchronization and recovery.
- Common examples include HTTPS sessions that allow internet users to visit and browse websites for a specific time period.
- The session layer is responsible for a range of functions including, opening, closing, and re-establishing session activities, authentication and authorization of communication b/w specific apps and servers, identifying full-duplex or half-duplex operations, and synchronizing data streams.

6) Presentation layer
- This layer is primarily responsible for preparing data, so that it can be used by the application layer.
- In other words, layer 6 makes the data presentable for applications to consume.
- The presentation layer is responsible for translation, encryption and compression of data.
- Two communicating devices communicating may be using different encoding methods, so layer 6 is responsible for translating incoming data into a syntax that the application layer of the receiving device can understand.
- If the devices are communicating over an encrypted connection, layer 6 is responsible for adding the encryption on the sender's end as well as

decoding the encryption on the receiver's end, so that it can present the application layer with unencrypted, readable data.

- The presentation layer is also responsible for compressing data, it receives from the application layer before delivering it to layer 5. this helps to improve the speed and efficiency of communication by minimizing the amount of data that will be transferred.
- It acts as a data translator for a network.
- This layer is a part of the operating system that converts the data from one presentation format to another format.
- This layer is also known as the syntax layer.

⇒ Functions

⇒ Translation - The processes in two systems exchange the information in the form of character strings, numbers and so on. Different computers use different encoding methods, the presentation layer handles the interoperability btw the different encoding methods. It converts the data from sender-dependent format into a common format and changes the common format into receiver-dependent format at the receiving end.

→ Encryption - Encryption is needed to maintain privacy. encryption is a process of converting the sender-transmitted information into another form and sends the resulting message over the network.

→ Compression - this is the process of compressing the data. i.e, it reduces the number of bits to be transmitted.
- Data compression is very important in multimedia such as text, audio, video.