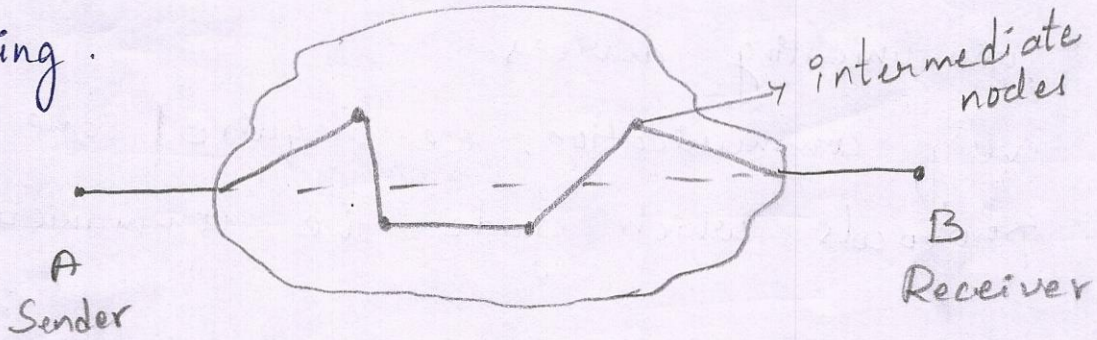
UNIT - I

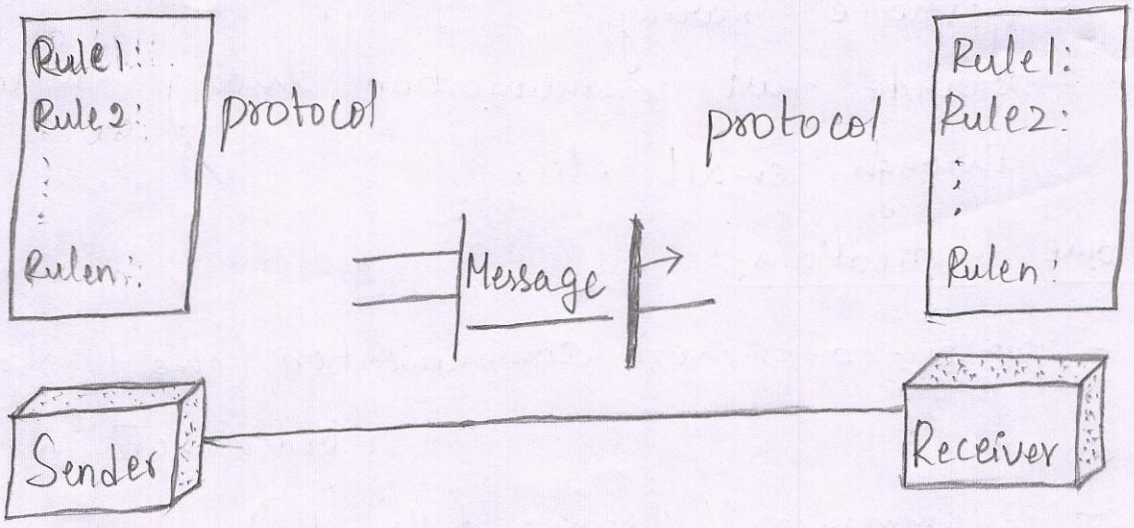
Introduction

Network: A network is a collection of computers or Hardware devices that are connected together either physically or logically using special Hardware or Software to allow them to exchange informations and cooperate.

- Network provides data communication b/w systems
- The purpose of data communication is information sharing.



Data Communication Components:



(1) Message : It is the information (data) to be communicated.

(2) Sender : Sender is a device that sends data.

(3) Receiver : Receiver is a device that receives data.

(4) Transmission medium : It is a physical path by which a message the travels from sender to receiver. Eg :- wire, wireless.

(5) Protocol : It is a set of rules that guide the data communication. It is an agreement between the communicating devices.

- For every communication, we require some rules called protocols which guide the communication.

Applications of Computer Networks :

(1) Business Applications :

- resource sharing
- provide fast communication among employees through email etc.

(2) Home Applications :

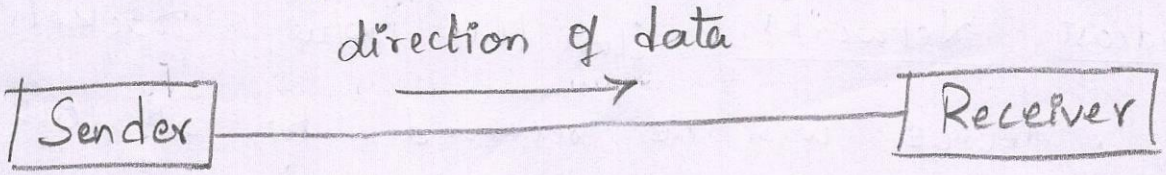
- person-to-person communication (email, chatting, video chat, audio chat).
- e-commerce (shopping, bills etc).

③ Mobile users : connecting to the Internet
M-commerce (M-tickets)

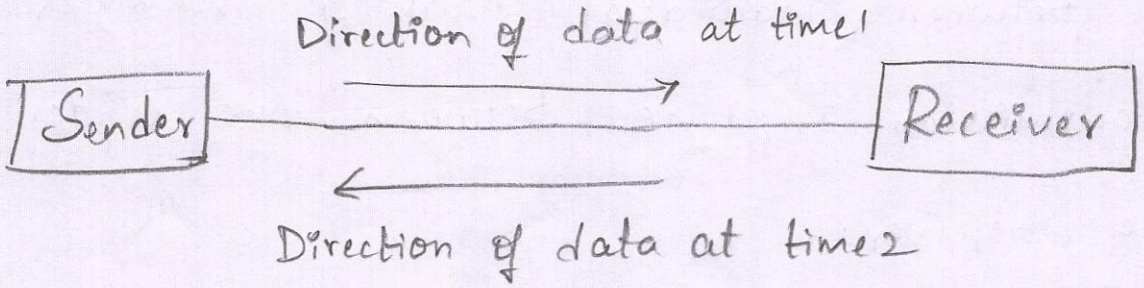
④ Social Issues :- In Social Networking websites.

Transmission modes : There are three transmission modes for data communication.

① Simplex mode (SX) : In this, communication is unidirectional.
- one of the two devices can transmit, the other can only receive. Eg :- Radio.
- Simplex lines are also called receive-only, transmit only.

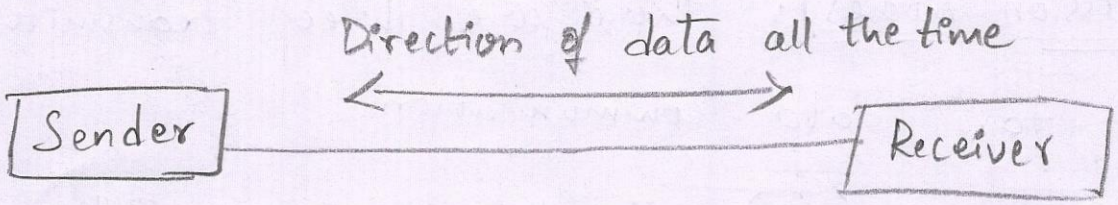


② Half-duplex mode (HDX) : Each device can both transmit and receive, but not at the same time.
- When one device is sending, the other can only receive and vice versa. Eg :- Walkie-Talkie.



③ Full-Duplex mode (FDX) : In this, both devices can transmit and receive simultaneously.

Eg:- Telephone



Network Categories (based on transmission mode):

- Based on mode of transmission, computer networks are divided into: Broadcast Networks
  Multicast Networks
  Unicast Networks

① Broadcast Networks : In this n/w, packets sent by a device will be received by all other computers on the Network.

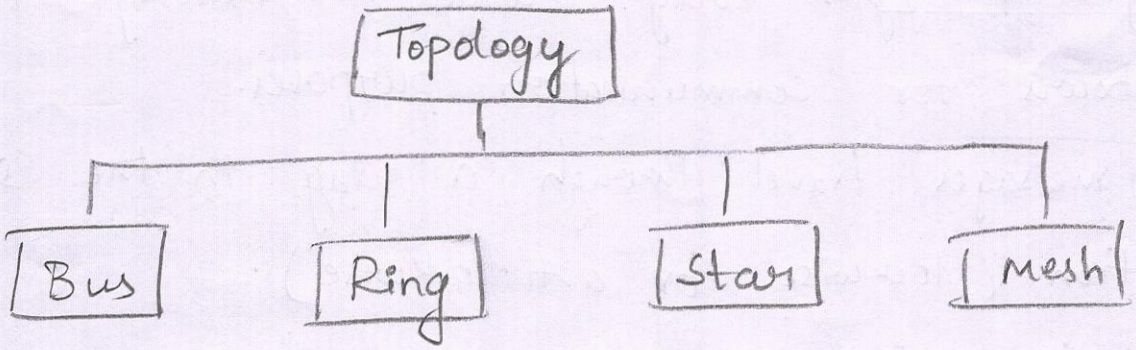
② Multicast Networks : In this n/w, transmission is done ~~between~~ to a subset of devices. (group of devices).

③ Unicast Networks : In this N/w, transmission is done between individual pairs of machines.

- Transmission is done between one sender and one receiver.

Network Topology : It refers to the way a n/w is laid out physically.

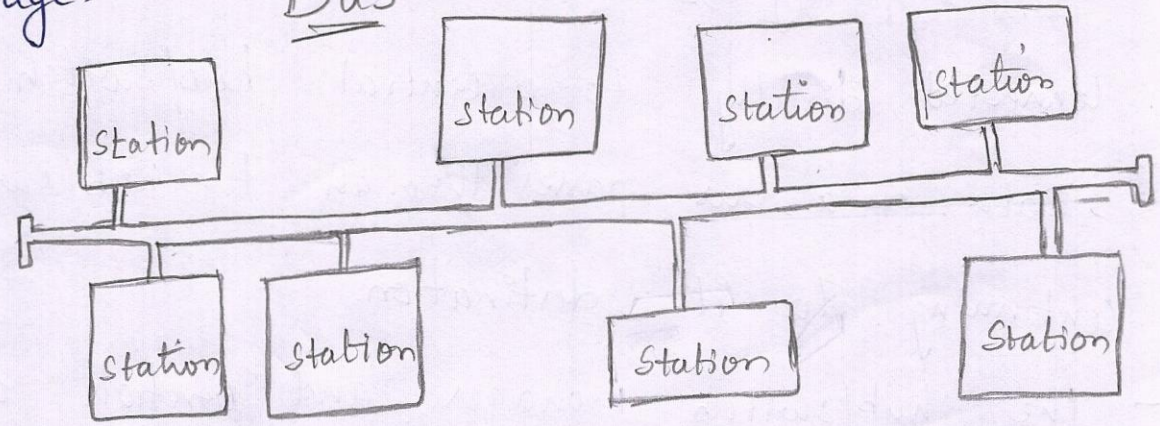
- there are five basic topologies :-



① **Bus topology** : A single cable functions as a shared communication medium.

- A device wanting to communicate with other device on the n/w sends a broadcast message onto the wire that all other devices can see, but only the intended recipient actually accepts and processes the message.

Bus



Adv :- cheap and easy to implement
Require less cable
Doesn't use specialized n/w equipment.

Disadv : n/w interrupts when computers are added or removed.

- A break in the cable will prevent all systems from accessing the n/w.

② Ring topology: Every device has exactly two neighbours for communication purposes.

- All messages travel through a ring in the same direction (clockwise or anticlockwise).
- All the devices are interconnected to form a circle.
- Transmissions are unidirectional and must propogate through all the stations in the circle.

Adv:- Easy to install

Disadv: Expansion to the n/w can cause n/w interruption
- A single break in the cable can destroy the entire n/w

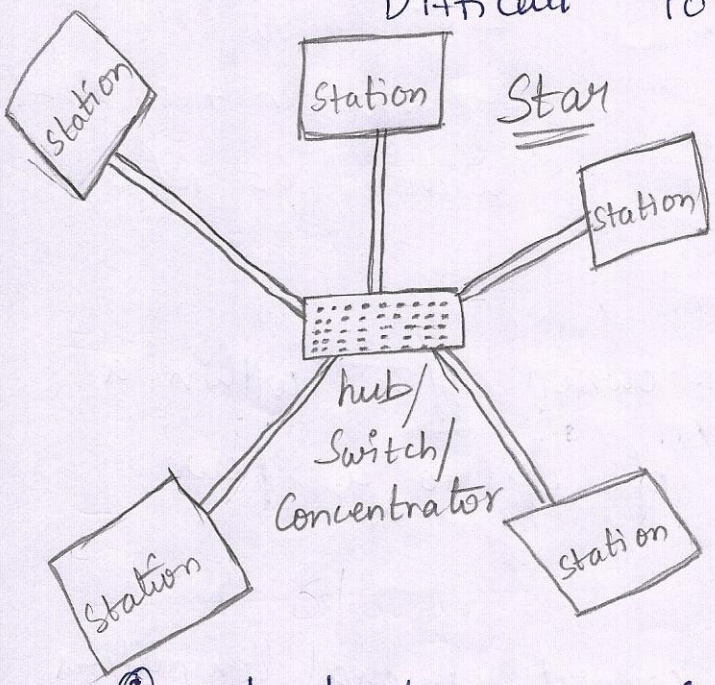
③ Star topology: It is designed with each node connected directly to a central hub/switch.

- Data on a bus passes through the hub/switch before continuing to its destination.
- the hub/switch manages and controls all functions of the n/w.

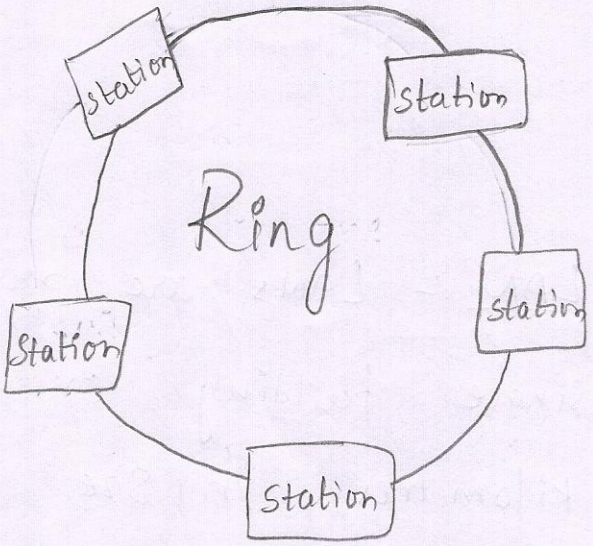
Adv:- Easily expanded without interruption to the n/w.
- Cable failure affects only a single user.

Disadv :- Requires more cable

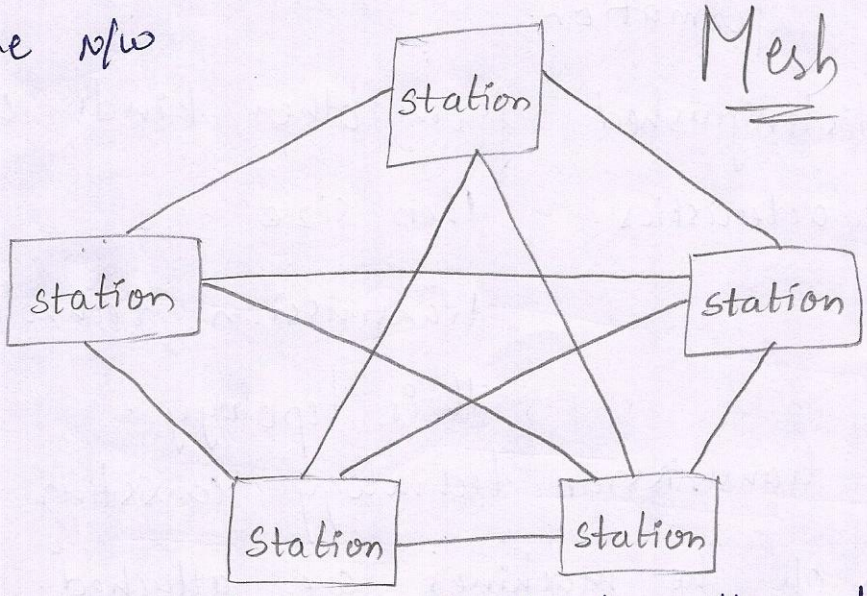
Difficult to implement



Star



④ Mesh topology : It is a design in which each computer on the n/w connects to every other on the n/w



Mesh

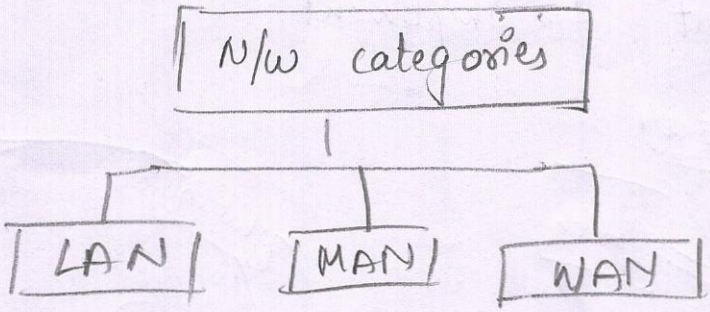
Adv :- provides redundant paths b/w devices.

- n/w can be expanded without interruption to current users.

Disadv : Requires more cable than other LAN topologies.

- Complemented implementation.

Network Categories (Based on Scale)



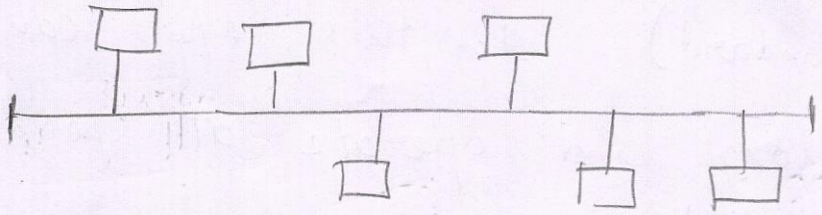
Local Area N/w
Metropolitan Area N/w
Wide Area N/w

(1) LAN :- LANs are privately-owned n/ws within a single building or campus of up to a few kilometres in size.

- They are widely used to connect personal computers in company offices and factories to share resources and exchange information.
- LANs are distinguished from other kinds of n/ws by three characteristics: their size
  transmission technology
  their topology.
- LANs use a transmission technology consisting of a cable to which all the machines are attached.
- LANs run at speeds of 10 Mbps to 100 Mbps.
- Topologies for broadcast LANs are :-

(a) Bus topology: At any instant, atmost one machine is the master and is allowed to transmit. All other machines are required to refrain from sending.

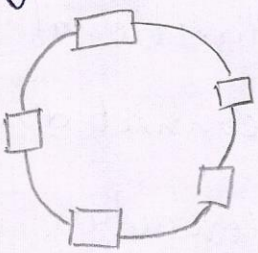
Ex :- Ethernet (IEEE 802.3 standard)



In Ethernet, computers can transmit whenever they want to, if two or more packets collide, each computer just waits a random ~~ti~~ amount of time and tries again later.

(b) Ring topology : In a ring, each data packet propagates the entire ring.

Ex :- Token ring (IEEE 802.5 standard).

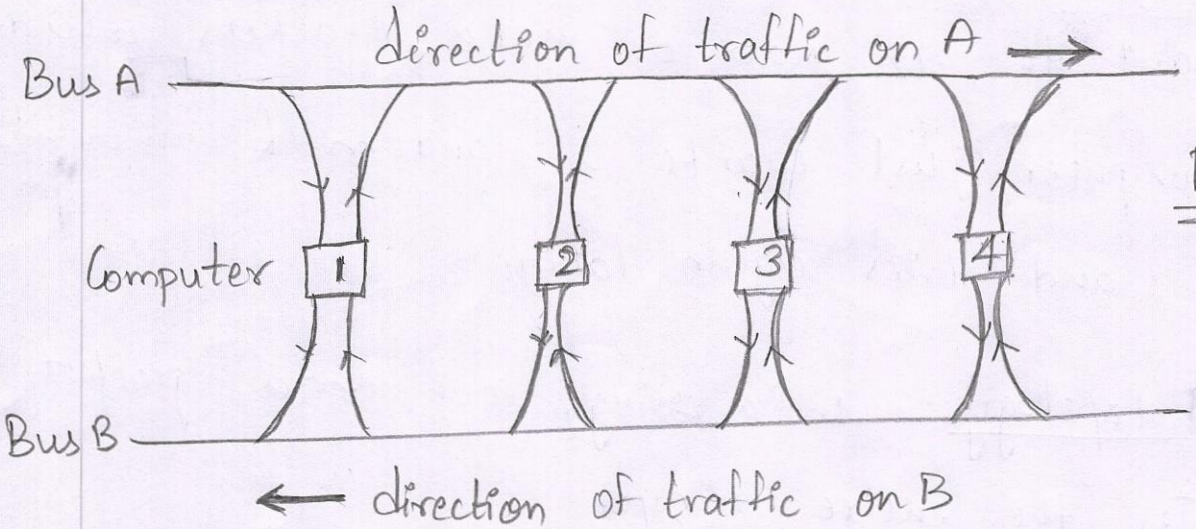


(3) MAN :- MAN covers a city.

Ex :- cable television n/w available in many cities

- It covers a larger geographical area than a LAN ranging from several blocks of buildings to entire cities.
- Its geographic scope falls b/w a WAN & LAN.
- MANs typically operate at speeds of 1.5 Mbps to 10 Mbps and range from 5 miles to a few hundred miles in length.

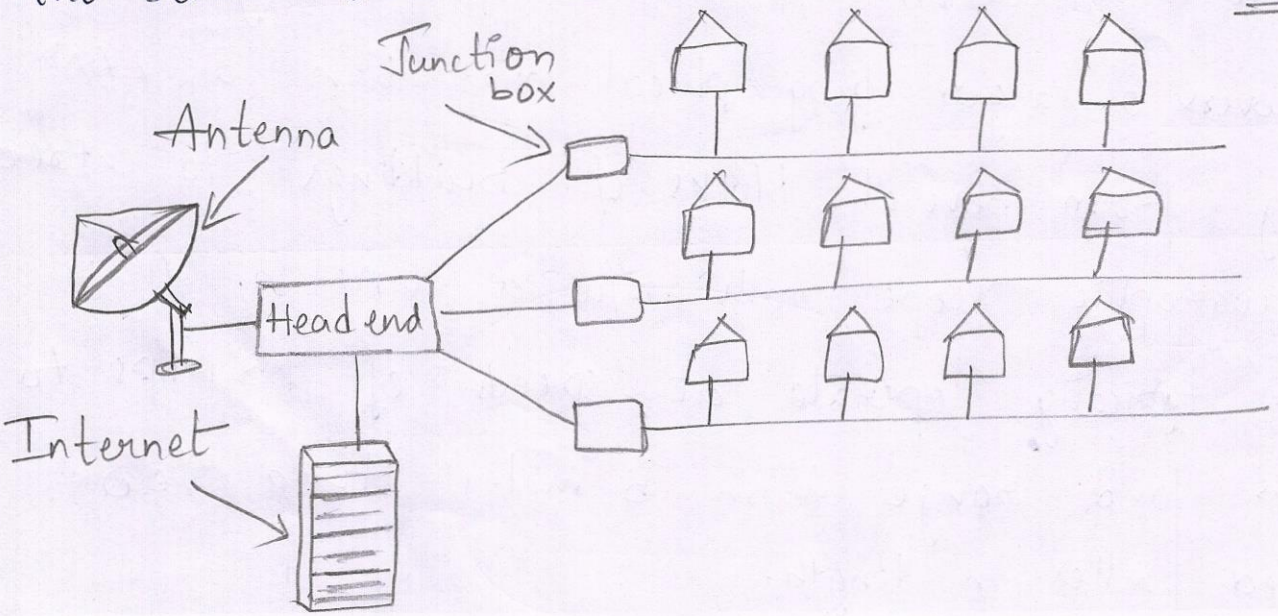
Ex :- Distributed Queue Dual Bus (DQDB) (IEEE 802.6 standard) - In this, N/ws can be upto 20 miles long and operate at speeds of 34 to 155 Mbit/s.



DQDB

- It consists of two bidirectional buses to which all the computers are connected.
- Traffic destined for a computer to the right of the sender uses the upper bus, to the left of the sender uses the lower bus.

MAN



WAN :- WAN covers large geographical areas such as countries or entire continent.

- WAN contains collection of machines (hosts).
- hosts are connected by a communication subnet.
- hosts are owned by customers. Subnet is owned by telephone company / Internet Service Provider.
- The job of the subnet is to carry messages from host to host.
- In WAN, subnet consists of transmission lines and switching elements.

Transmission lines: These are used to move data b/w machines, made up of copper wire / optical fiber.

Switching elements: they connect three or more transmission lines.

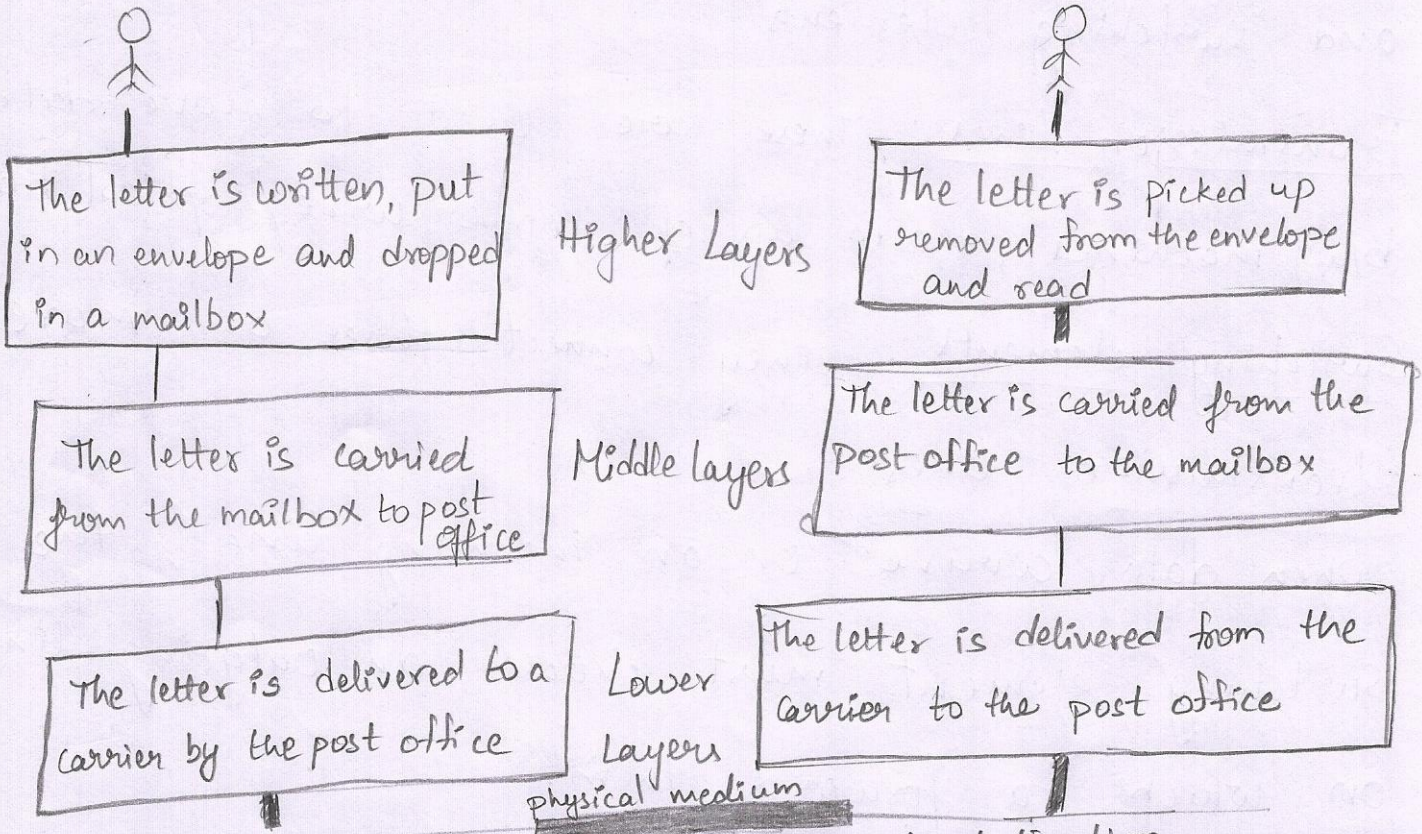
- When data arrive on an incoming line, the switching element must choose an outgoing line on which to forward them.
- Router is used as a switching element.

Store-and-forward subnet: when a process ~~on~~ A process divides the message into packets, each one having its own sequence number.

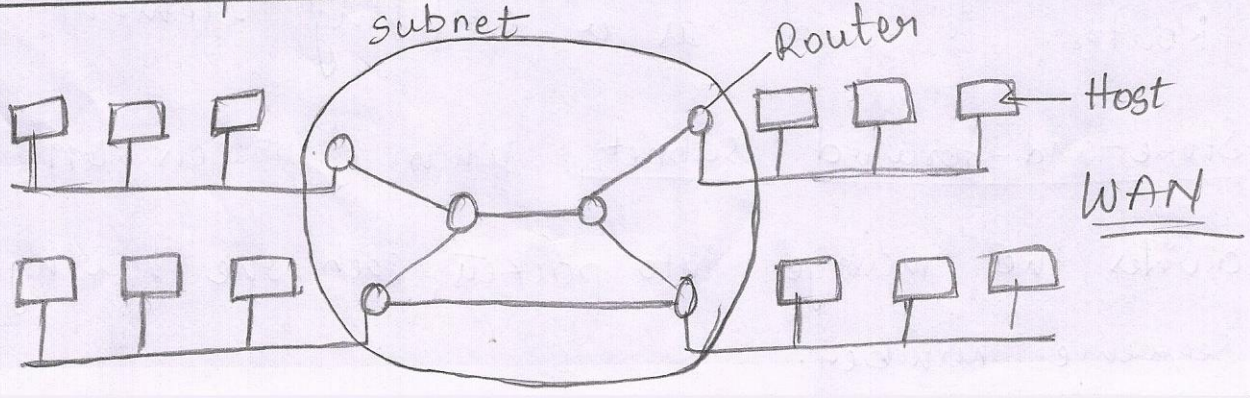
- These packets are transfered to the destination, where they are reassembled into the original message and delivered to the receiving process.
- Routing decisions are made locally according to a routing algorithm.

Layered Architecture:

- Ex:- Let us consider two friends who communicate through postal mail.



The parcel is carried from source to destination



At the sender site: the post is moved from the higher layer to the lower layer, then transmitted through a source of transport.

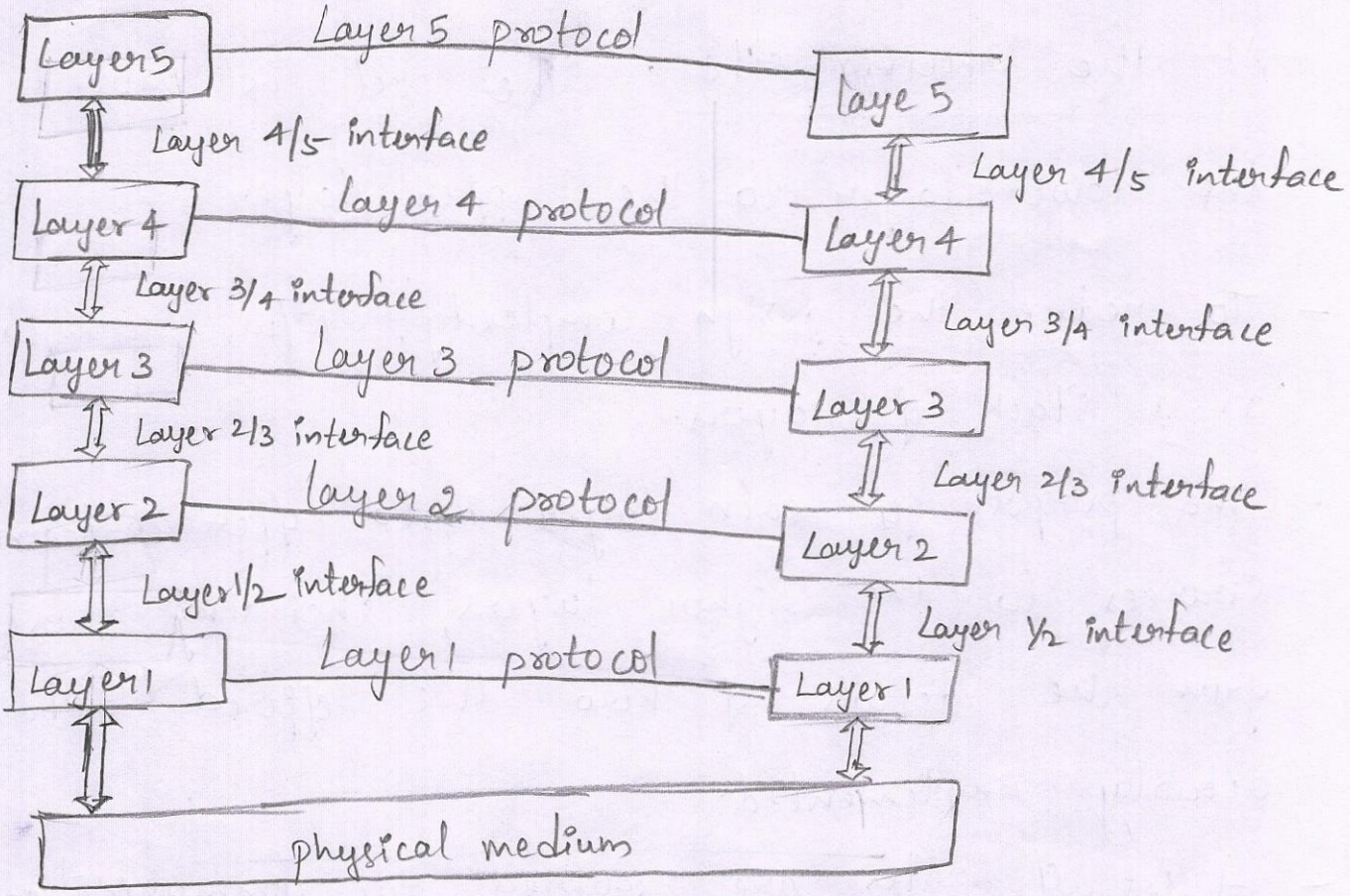
At the receiver site: The post is moved from the lower layer to the upper layer.

- To reduce the design complexity, N/ws are organized as a stack of layers.
- The purpose of each layer is to offer certain services to the higher layers, sheilding those layers from the details of how the offered services are actually implemented.
- A set of rules are required for communication b/w a layer on one machine with a layer on other machine.
- these rules are called as a protocol.
- A protocol is an agreement b/w the communicating parties on how ~~to~~ communication is to proceed.
- A communicating protocol is a set of rules allowing end users and N/w devices to send & receive data in an orderly and structured manner.
- A protocol consists of three key rules :-

  Syntax (format of data)

Semantics (interpretation of data)

timing (when to send & when to respond with what speed).



- The entities with layers on different machines are called peers.
- Peers communicate using protocols.
- No data are directly transferred from layer on one machine to layer on another machine.
- Each layer panes data to the layer below it, until the lowest layer is reached.
- Below layer1 is physical medium through which actual communication occurs.

- Between each pair of adjacent layers is an interface
- the interface defines operations and services to the lower layer makes available to the upper one.
- A set of layers and protocols is called a n/w architecture.
- A list of protocols used by certain system is called a protocol stack.

Reference model

- A reference model is a layout that describes how communication b/w devices should occur.

OSI Reference Model: (ISO-OSI reference model)

- OSI means Open System Interconnection because this reference model deals with connecting open systems ie., systems that are open for communication with other systems.
- OSI model has seven layers.

lower 4 layers (TL, NL, DLL, PL) - responsible with the flow of data from end-to-end through n/w.

upper 3 layers (SL, PL, AL) - responsible for services to the applications.

① Physical layer :- It deals with the transmission of raw bits (individual bits) over the communication channel.

- It should make sure that when one side sends as '1' bit, it is received by the other side as a '1' bit, not as a '0' bit.

Design issues : Responsibilities :

- how the bit is represented?
- what is the transmission type?
  (whether connection-oriented or connectionless)
  Ex:- metallic cable, optical fiber cable, wireless radio-wave propagation.
- what is the transmission mode? (SX, HDX, FDX)
- how to establish the connection.

② Data Link Layer : To organize bits into frames.

- Responsible for transmitting frames from Source to Dest.

Responsibilities :

ⓐ Error Control : It makes sure that the entire message arrives at the receiving end without any error.
(data with no damage, loss or duplication.)

ⓑ Flow Control : If the rate at which the data is absorbed by the receiver is less than the rate at

which data is transferred by the sender, the DLL uses a flow control ~~mechanism~~ protocols to maintain same data transfer rate b/w sender and receiver.

(c) Framing: The DLL divides the bits into frames and vice versa.

(d) Access Control: When two or more devices are connected to the same link, data link layer protocols are necessary to determine which device has to send the data at any given time. Otherwise there is a chance of collision. For this purpose a special sub layer in the DLL known as Medium Access Sub Layer is added.

(3) Network Layer:- It is responsible for delivery of individual packets from source to destination.

Responsibilities:

(a) Routing: The connecting devices (called routers) route or switch the packets to the final destination.

(b) Congestion Control: If there is traffic in one way of N/w, for transferring the data, it is called as congestion. Then we should find another path for transferring the data by use of congestion control protocols.

④ Transport layer : It performs process-to-process delivery.

- It is responsible for delivery of message from one process to another.

Responsibilities :

ⓐ Segmentation and Reassembly : A message is divided into Segments at the sender, with each segment having a sequence number which is called as segmentation.

- At the receiver, all the segments are again combined according to the sequence number called as Reassembly.

ⓑ Connection Control :- A transport layer can be either connectionless or connection-oriented.

- A connectionless transport layer treats each segment as an independent packet and delivers it to the destination.
- A connection-oriented transport layer will set up a pre-defined path before delivering the packets.

ⓒ Flow Control : If the rate at which the data is absorbed by the receiver is less than the rate at which data is transferred by the sender, a flow control protocol is used to maintain same data transfer rate between sender and receiver.

(d) Error Control : It makes sure that the entire message arrives at the receiver without any error. (No damage, loss or duplication). Error correction is achieved through re-transmission.

(5) Session Layer : To establish, manage and terminate the session.

Responsibilities :

(a) Dialog Control : If more than one system want to perform the operation, on that case, which system will have the priority is the service provided by the session layer.

(b) Token management :- preventing two parties from attempting the same operation simultaneously.

(c) Synchronization : Create checkpoints while downloading If we are transferring a file which may take 2 hours between 2 hours. b/w two machines. After the completion of 1 hour, if the system crashes, automatically already transferred data will be lost. For that purpose such a huge data will be divided into checkpoints.

(6) Presentation layer : It translates, encrypt and compress the data.

- It is concerned with the syntax and semantics of the information transmitted

Responsibilities :-

(a) Data Translation: This layer changes the sender-dependent format into common format. At the receiving end, it changes the common format into receiver-dependent format.

(b) Encryption: It is done to ensure privacy. At the sender side, encryption is done ie, the original message is transformed into un-readable form. At the receiver side, decryption is done., the un-readable form is again transformed back to its original form.

(c) Compression: Data compression reduces the number of bits contained in the information. Data compression becomes particularly important in the transmission of multimedia such as text, audio & video.

(7) Application Layer: It is responsible for providing services to the user. It allows access to n/w resources. (N/w Applications)

Responsibilities :-

(a) File transfer, access and management. This application

allows a user to access files in a remote host to retrieve files from a remote computer for use in the local computer and to manage or control files in a remote computer locally. (uses FTP protocol)

(b) Mail Services :- This application provides the basis for e-mail forwarding and storage. (SMTP protocol)

(c) Web Surfing :- This application allows browsing of various web services. (uses HTTP protocol).

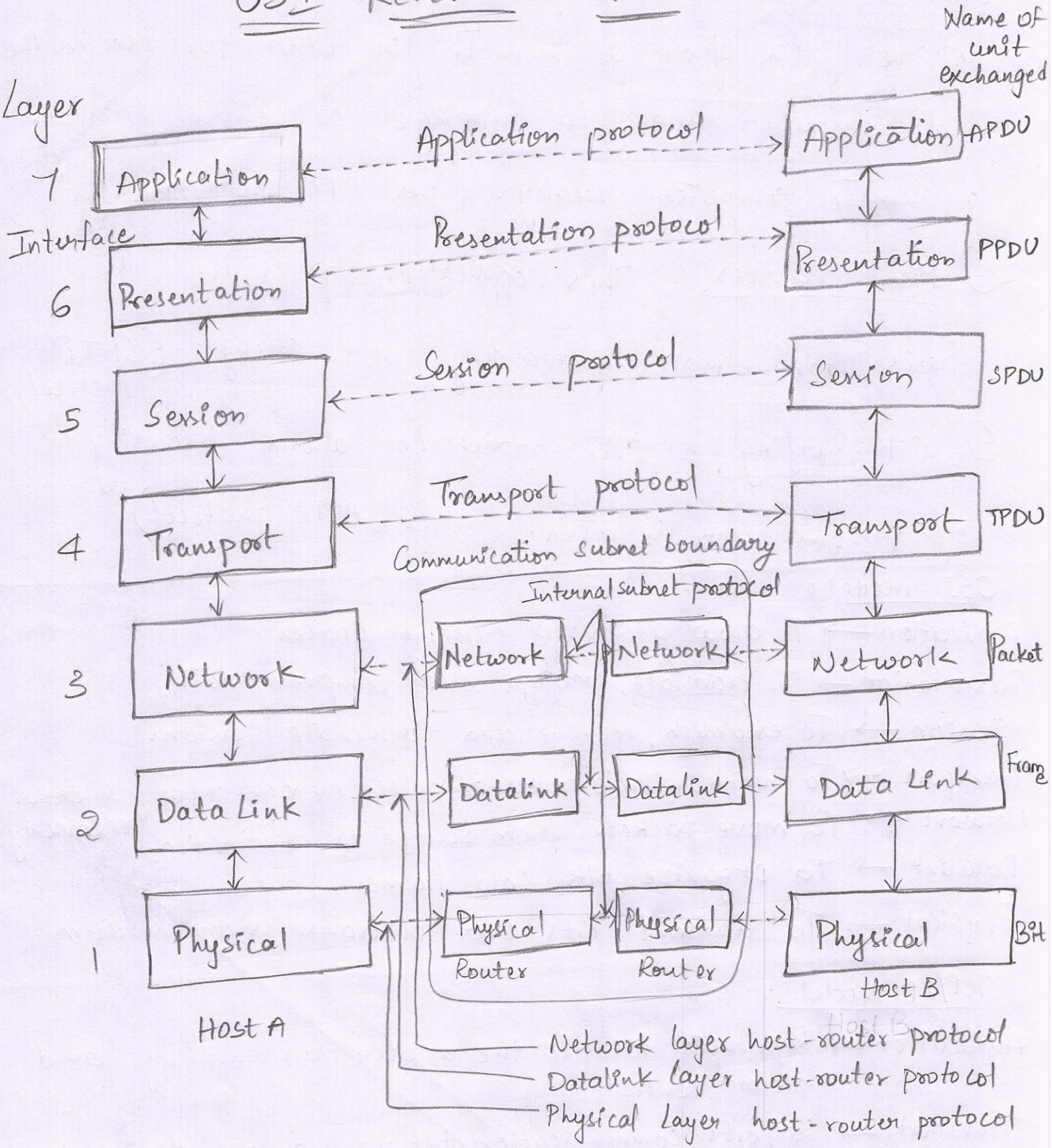
OSI model :

Application → To allow access to n/w resources
Presentation → To translate, encrypt and compress data
Session → To establish, manage and terminate sessions
Transport → To provide reliable process-to-process message delivery & error recovery
Network → To move packets from source to destination.
Datalink → To organize bits into frames.
Physical → To transmit bits over a transmission medium.

TCP/IP model :-

Application → Represents data to the user plus encoding and dialog control
Transport → Supports communication between diverse devices across diverse networks.
Internet → Determines the best path through the n/w.
Host-to-n/w → Controls the h/w devices and media that make up the n/w.

OSI Reference Model



TCP/IP Reference Model :

- The ARPANET was a research n/w used to connect hundreds of universities and government installations using leased telephone lines.
- When satellite and radio n/ws were added later, the existing protocols had trouble interworking with them. So, a new reference architecture was developed which is known as the TCP/IP Reference Model.
- Since TCP (Transmission Control Protocol) and IP (Internet protocol) are the most important protocols used in this model. So, the reference model is given the name TCP/IP.
- TCP/IP has 4 layers. They are:-

Host-to-n/w Layer
Internet ~~Network~~ Layer
Transport Layer
Application Layer.

① **Host-to-n/w Layer :-** It acts as an interface to the actual Network Hardware.

- It is an interface b/w hosts and transmission links.

(2) Internet Layer :-

- Its job is to permit hosts to inject packets into any n/w and they travel independently to the destination.
- Internet Protocol (IP) is the most important protocol in this layer.

IP :- It is a connectionless protocol.

- It does not provide reliability, flow control or error recovery.
- It provides a routing function that delivers transmitted messages to their destination.
- A message unit in an IP n/w is called an IP datagram.
- Other internet layer protocols are:

  ICMP (Internet Control Message Protocol)
  IGMP (Internet Group Management Protocol)
  ARP (Address Resolution Protocol)
  RARP (Reverse ARP).

(3) Transport layer :

- Transport layer in TCP/IP works as OSI transport layer.

- Two transport protocols are:-

  TCP (Transmission Control Protocol)

  UDP (User Datagram Protocol).

TCP :- It is a connection-oriented protocol.

- It allows a byte stream on one machine to be delivered without errors on any other machine in the internet.
- It divides the incoming byte stream into discrete messages and sent to the destination.
- At the dest, the receiver reassembles the received messages into output stream.
- TCP also handles flow control.

UDP :- It is a unrealiable, connectionless protocol.

- It is widely used in client-server type. and in applications such as transmitting speech or video.

④ Application Layer :-

- The TCP/IP model does not have session or presentation layers.
- Some of the Application layer protocols are:-

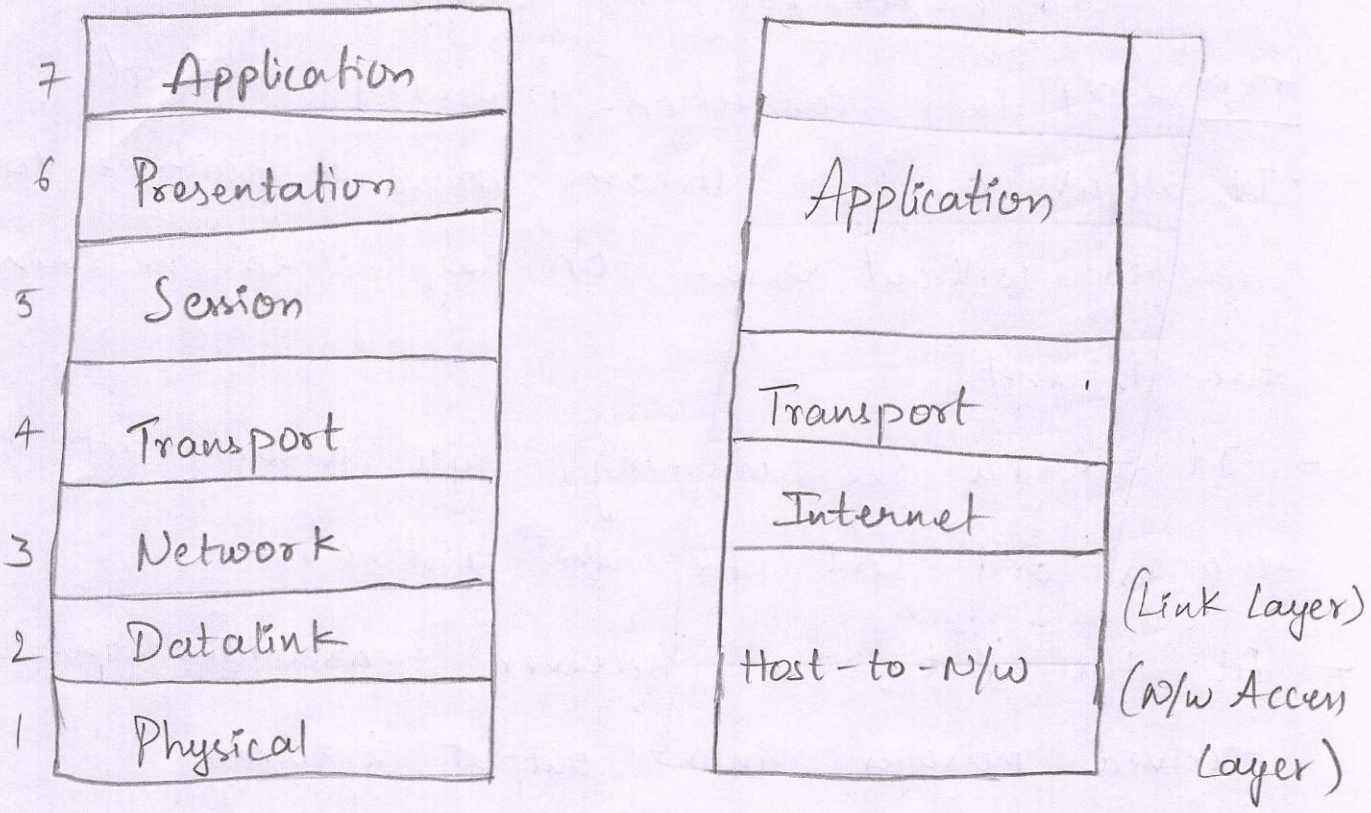
  TELNET

  FTP (File Transfer Protocol)

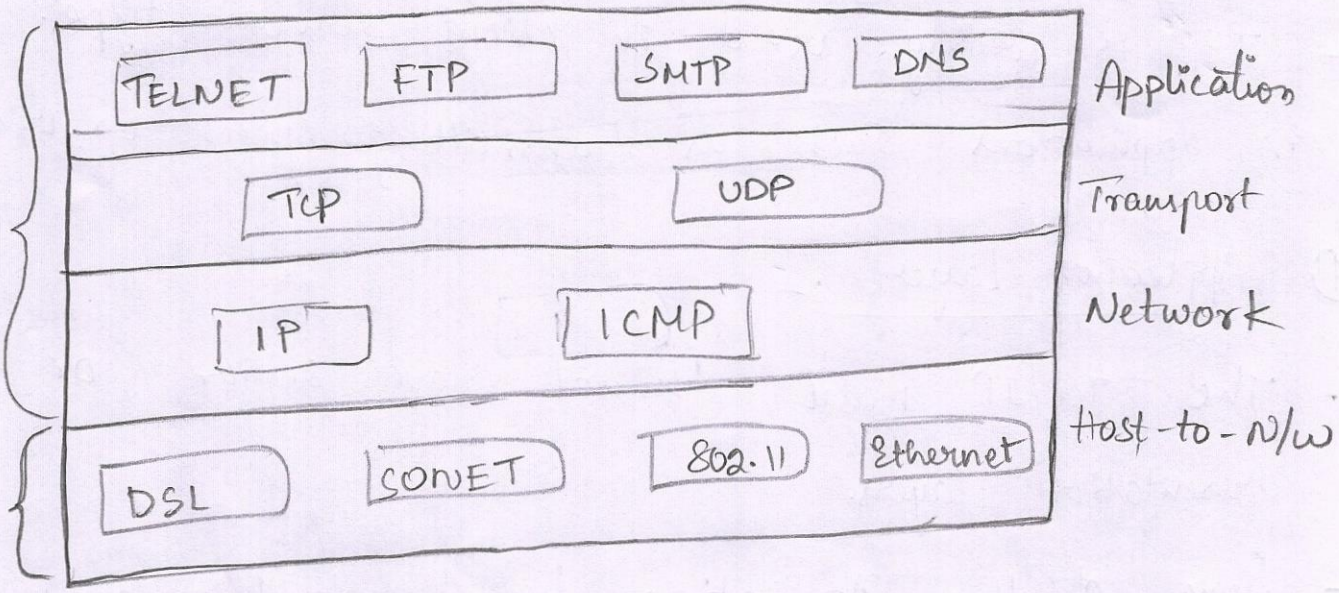
  SMTP (Simple Mail Transfer protocol) for e-mail.

  HTTP (Hyper Text Transfer Protocol)

TCP/IP model :



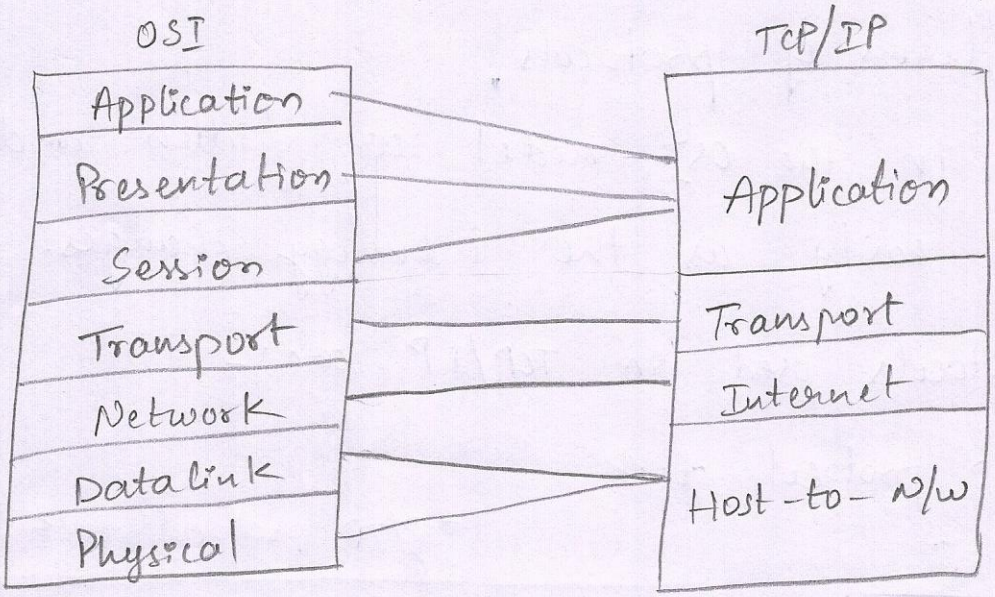
TCP/IP protocol stack : (protocol suite)



Comparison of OSI and TCP/IP reference model :

In terms of layers,

(1) The main difference between OSI & TCP/IP is that OSI model has 7 layers & TCP/IP has 4 layers.



In terms of Services, Interfaces & Protocols,

(2) OSI clearly distinguishes b/w services, Interfaces & Protocols

Services :- Every lower layer provides some services to the upper layer. It tells what the layer does;

Interfaces :- It provides communication between layers on the same machine.

Protocol :- It provides communication b/w layers on different machines.

- Protocols used in a layer are the layer's own business. Layer can use any protocol it wants to, as long as it gets the job done. It can also change them

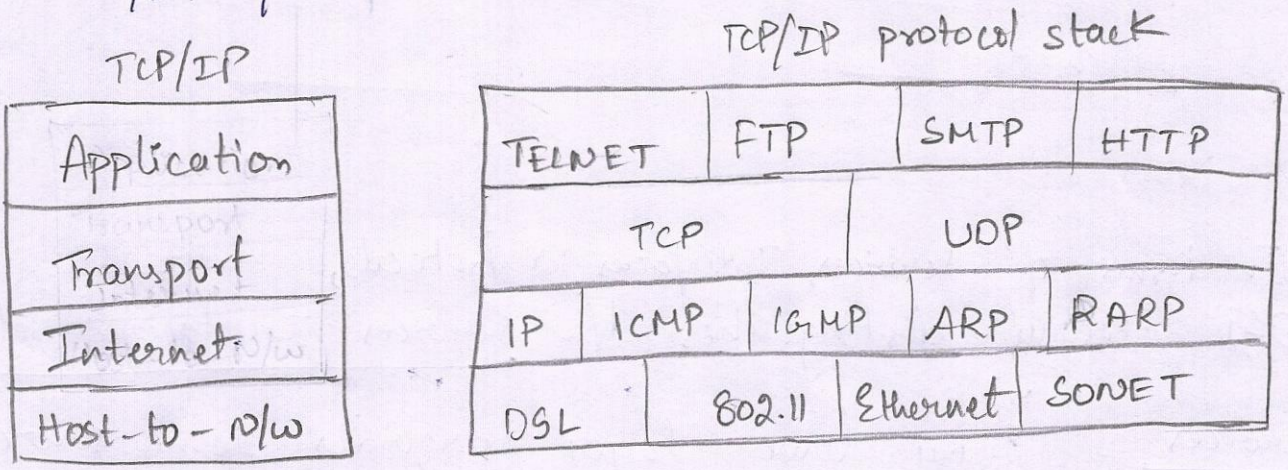
without affecting s/w in higher layers.

- TCP/IP did not clearly distinguish b/w service, interface and protocol.

(3) In terms of protocols,

- Protocols in the OSI model are hidden and can be replaced easily as the technology changes.
- The protocols used in TCP/IP are:-

TCP/IP protocol stack



(4) Connection-oriented vs connectionless communication.

OSI model:

N/w layer	Transport layer
Supports both connection-oriented and connectionless	Supports only connection-oriented.

TCP/IP :

N/w Layer	Transport Layer
Supports only connectionless	Supports both connection-oriented & connectionless.

(5) Interms of data units,

OSI model :

OSI
Application
Presentation
Session
Transport
Network
Data link
Physical

data unit
data
data
data
Segment
Packet
Frame
Bits

TCP/IP model :

TCP/IP
Application
Transport
Network
Host-to- N/w

data unit
data
byte stream/ messages
packets/ datagrams
frames / bits