Government Arts and Science College (Women), Sathankulam – 628704

Class : III B.Sc. (Computer Science)

Semester : V

Subject : Data Communication and Computer Network

Topic : Unit – I

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Data Communications

- Exchange of data between two devices via some transmission medium
- The communication system made up of combination of hardware and software
- Fundamental characteristics of data communication
    - Delivery – must deliver data to the correct destination.
    - Accuracy – must deliver data accurately.
    - Timeliness – must deliver data in a timely manner. Late delivery of data are useless.
    - Jitter – refers to the variation in the packet arrival time.

Components of Data Communication

It has five components

- Message

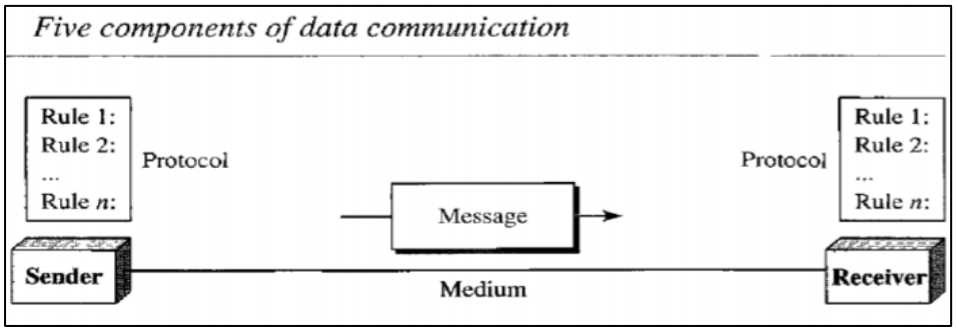
  It is the information to be communicated. It includes text, numbers, pictures, audio and video
- Sender

  Device that sends the message. Computer, workstation, telephone headset, video camera
- Receiver

  Device that receives the message. Computer, workstation, telephone headset, television
- Transmission medium

  By which message travels from sender to receiver. Ex. Twisted-pair wire, coaxial cable, fiber-optic cable, radio waves.
- Protocol

  Set of rules that govern data communications. Without it two devices may be connected but not communicate



Data Representation

Text

- Is represented in a bit pattern. Different set of patterns represent text symbols
- Each set is a code and the process of representing symbols is called coding.
- Coding system used is Unicode which uses 32 bits

Numbers

- Represented by bit patterns
- It is directly converted to a binary number

Images

- Represented by bit patterns
- Image is composed of a matrix of pixels
- Size of pixels depends on the resolution
- For image made of black and white dots a 1 bit-pattern is used
- For grayscale we use 2 bit-patterns
- To represent color images we use RGB combination of red, green and blue and YCM combination of yellow, cyan and magenta

Audio

- Refers to the recording or broadcasting of sound or music. It is continuous

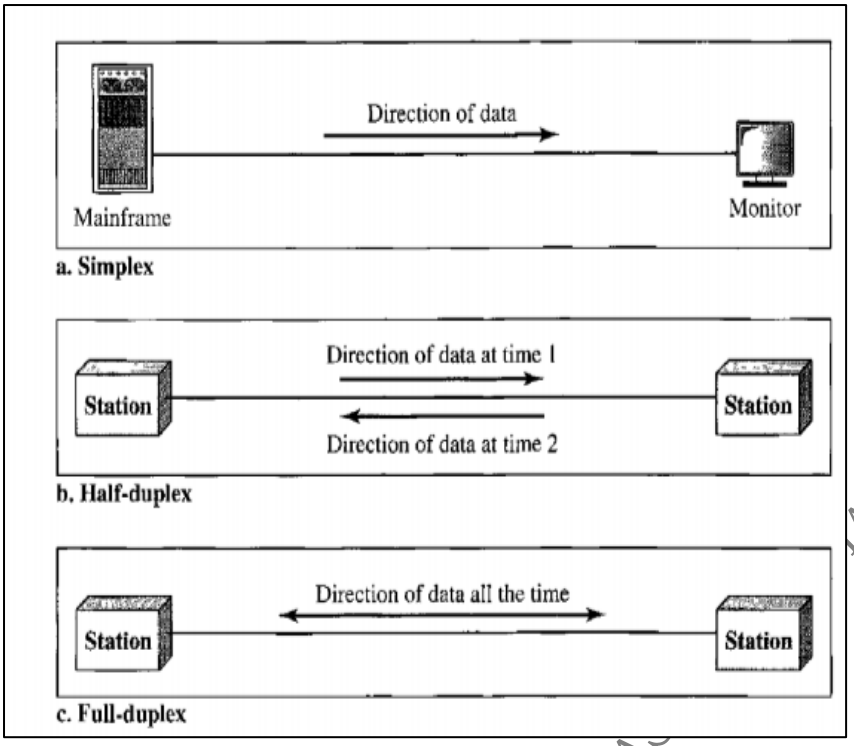
Video

- Refers to the recording or broadcasting of a picture or movie
- It can be continuous or a combination of images arranged in motion

Data Flow

Communication between two devices may be

- Simplex
- Half-duplex
- Full-duplex



Simplex

- The communication is unidirectional
- Only one device can transmit, the other can only receive
- Ex. Keyboard and monitors. Keyboard produce only input; monitor accept only output.

Half-Duplex

- Each station can both transmit and receive but not at the same time.
- It is like a one-lane road with traffic allowed in both directions
- Used when there is no need for communications in both directions at the same time.

Full – Duplex

- Also called duplex, both stations can transmit receive simultaneously
- Its like two way street with traffic flowing in both directions
- Signals going in one direction share the capacity of the link with signals going in the other direction.
- Sharing is done in two ways:
    - The link must contain two separate transmission paths
    - The capacity of the channel is divided between signals travelling in both directions
- Ex: telephone network. When communicating both can talk and listen at the same time

Networks

- A network is a set of devices connected by communication links
- A node can be printer, computer, or any device capable of sending and / or receiving data generated by other nodes
- Most network use distributed processing in which a task is divided among multiple computers.

Network Criteria

Performance

- Measured by including transit time and response time
    - Transit time – time required for a message to travel from one device to another
    - Response time – elapsed time between an inquiry and a response
- Depends on number of users, type of transmission medium, connected hardware and efficiency of software
- Evaluated by throughput and delay

Reliability

- Measured by the frequency of failures, time taken to recover from failure, network's robustness in a disaster

Security

- Protecting data from unauthorized access, from damage and development, and implementing policies, procedures for recovery from breaches and data losses

Physical Structures

A network is two or more devices connected through links. A link is pathway that transfers data from one device to another.

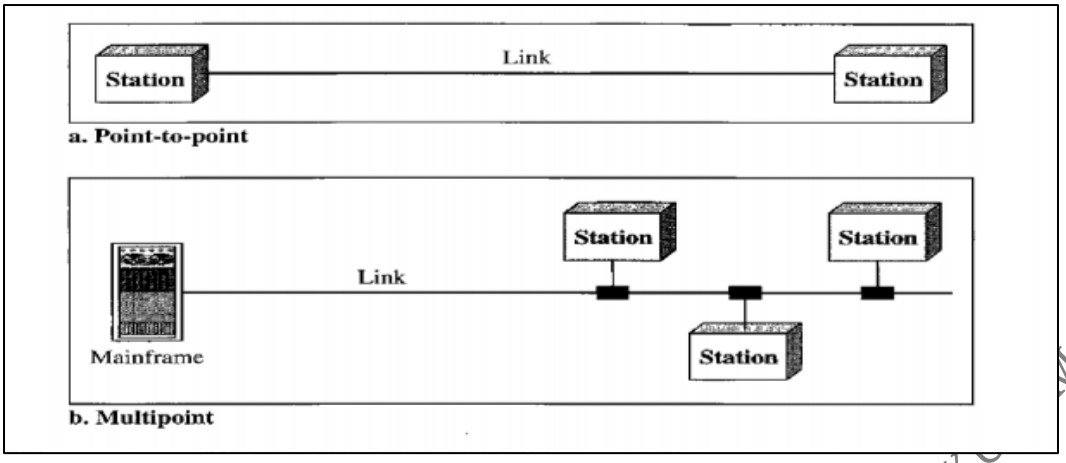
Types of connection

Point-to-Point

- It provides a dedicated link between two devices.
- They use an actual length of wire or cable to connect two ends
- Ex. Infrared remote control.

Multipoint

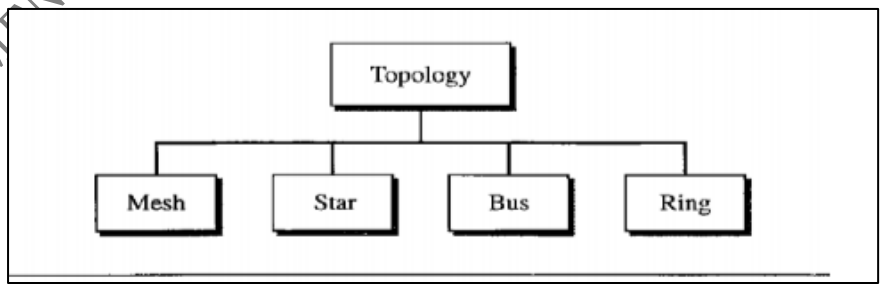
- It is in which more than two devices share a single link
- The capacity of channel is shared spatially or temporally
- If several devices use the same link simultaneously, it is spatially shared connection, if users take turns, it is timeshared connection



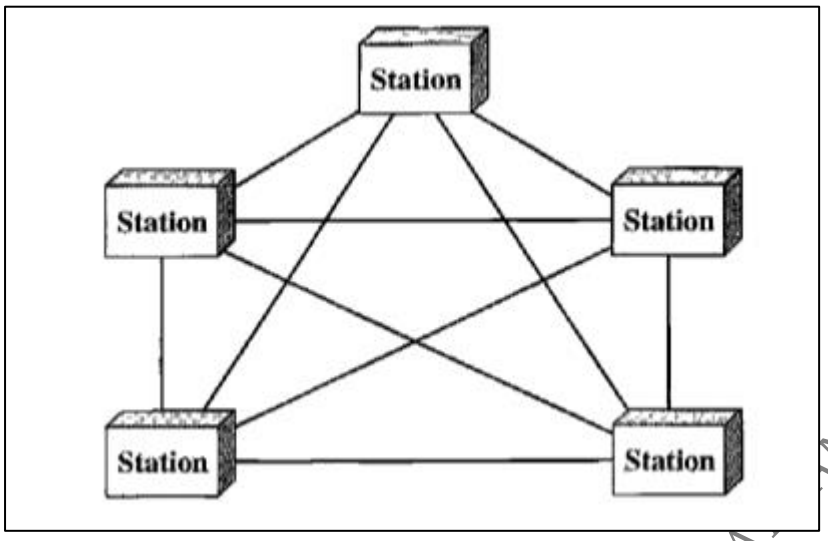
Physical Topology

- This term refers to the way in which a network is laid out physically
- Two or more devices connect to a link
- Two or more links form a topology
- Topology of a network is the geometric representation of the relationship of all the links and linking devices to one another
- Four basic topologies:
    - Mesh
    - Star
    - Bus
    - Ring

Categories of topology



Mesh topology



- Every device has a dedicated point-to-point link to every other device.
- Dedicated means the link carries traffic only between the two device it connects.
- To find number of physical links connected to a mesh network with n nodes, each node must be connected to every other node.
- We need n(n-1) physical links
- If each physical link allows communication in both direction, we divide the number of links by 2. we need

  n(n-1)/2 duplex-mode links

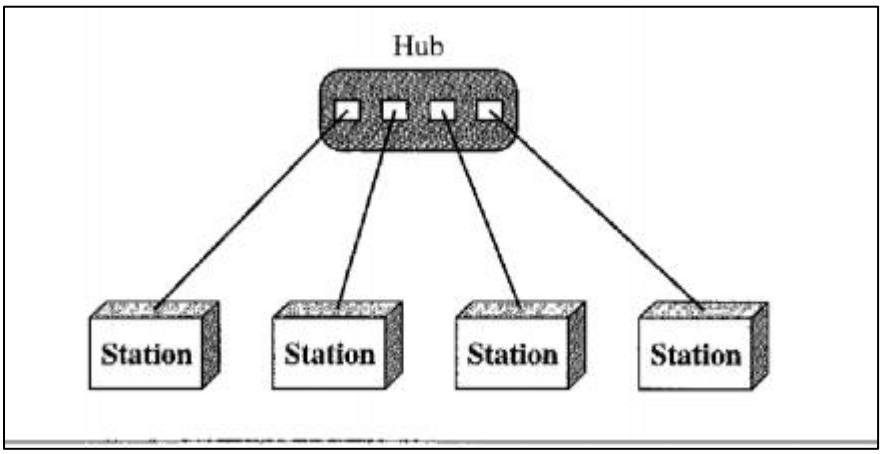
Advantages of mesh

- Use dedicated links.
- It is robust.
- Privacy or security.
- Identify fault and isolate it easily

Disadvantages

- Installation and reconnection are difficult
- Complete bulk of wiring can be greater than available space
- Hardware required to connect each link can be expensive
- Ex. Telephone regional office

Star topology



- It has dedicated point-to-point link to a central controller called a hub
- If one sends data to another, it sends to the data to the controller, which relays the data to another connected device

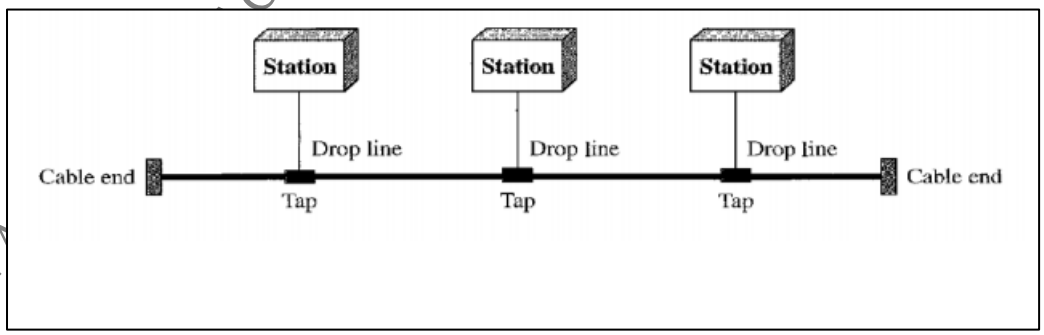
Advantages of star topology

- It is less expensive
- It is easy to install and reconfigure
- Less cabling
- Robustness
- Easily identify fault and isolate fault

Disadvantage

- If the hub goes down, whole system is dead
- Ex. LAN (Local Area Network)

Bus topology



- It is multipoint
- One long cable acts as backbone to link all the devices in a network.
- Nodes are connected by drop lines and taps.
- A drop line is a connection running between the device and main cable
- A tap is a connector create contact with the metallic core

- Some of its energy is transformed into heat. So it becomes weaker as it travels farther and farther.

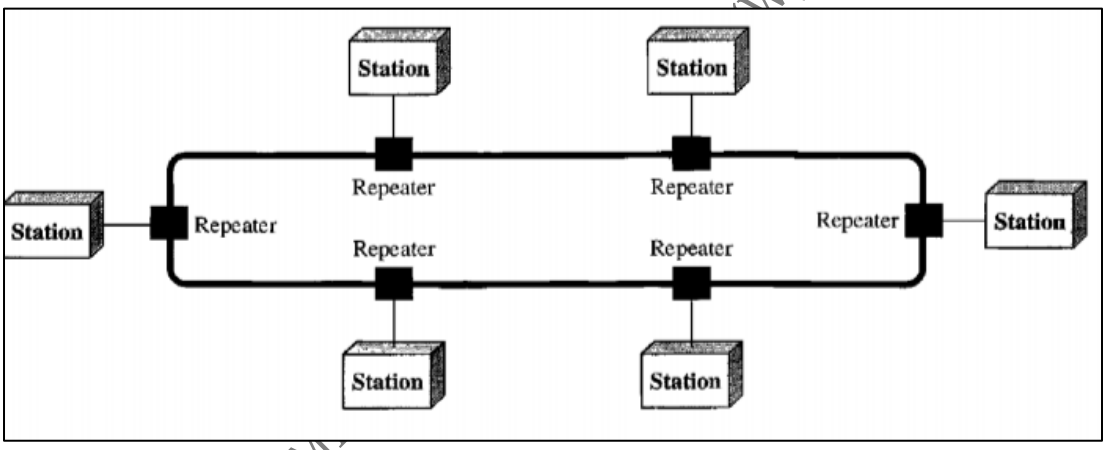
Advantages

- Ease of installation
- Uses less cabling
- Redundancy is eliminated
- Only backbone cable stretches

Disadvantages

- Difficult reconnection and fault isolation
- Signal reflection at the taps cause degradation in quality
- Adding new devices need modification or replacement of backbone
- A fault or break in the bus cable stops al transmission

Ring Topology



- Each device has a dedicated point-to-point connection with only the two devices on either side of it.
- Signal passes along the ring in one direction from device to device until it reaches its destination.
- Each device has a repeater to receive signal from the device and pass it on

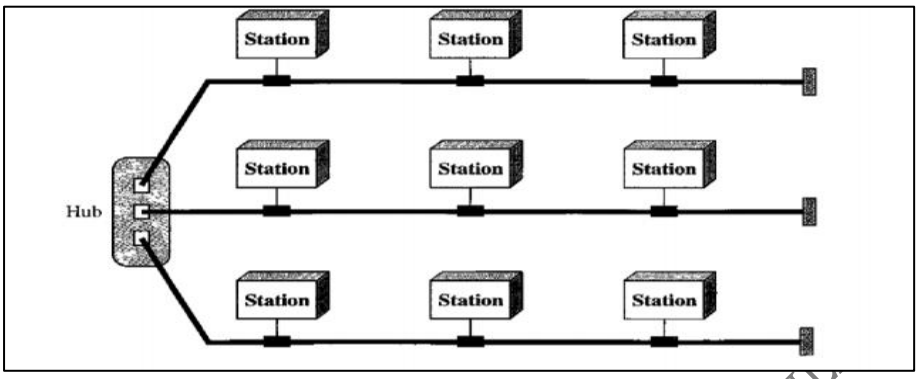
Advantages

- Easy to install and reconfigure
- Fault isolation is simplified

Disadvantages

- Unidirectional traffic
- A break in the ring disable entire network

Hybrid topology



Categories of Networks

The category is defined by its size.

- Local Area Network

  Normally covers an area less than 3 kilometers

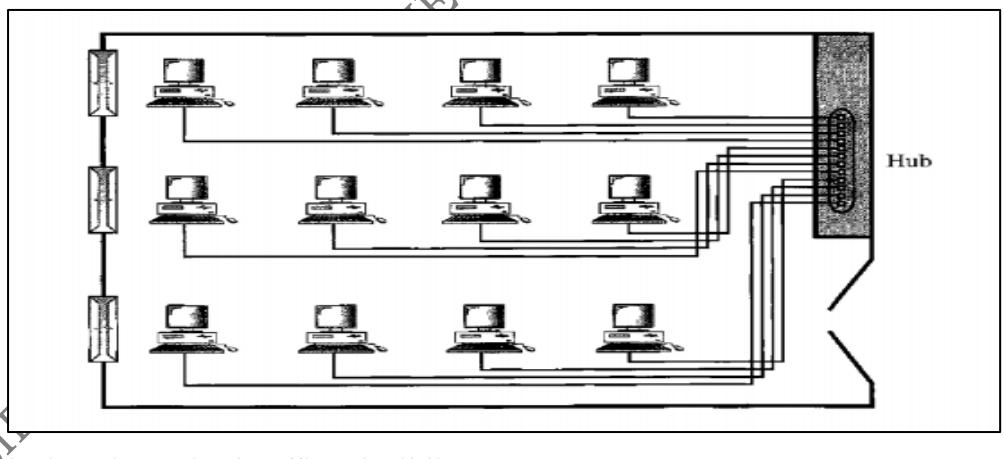
- Wide Area Network

  Can be worldwide

- Metropolitan Area Network

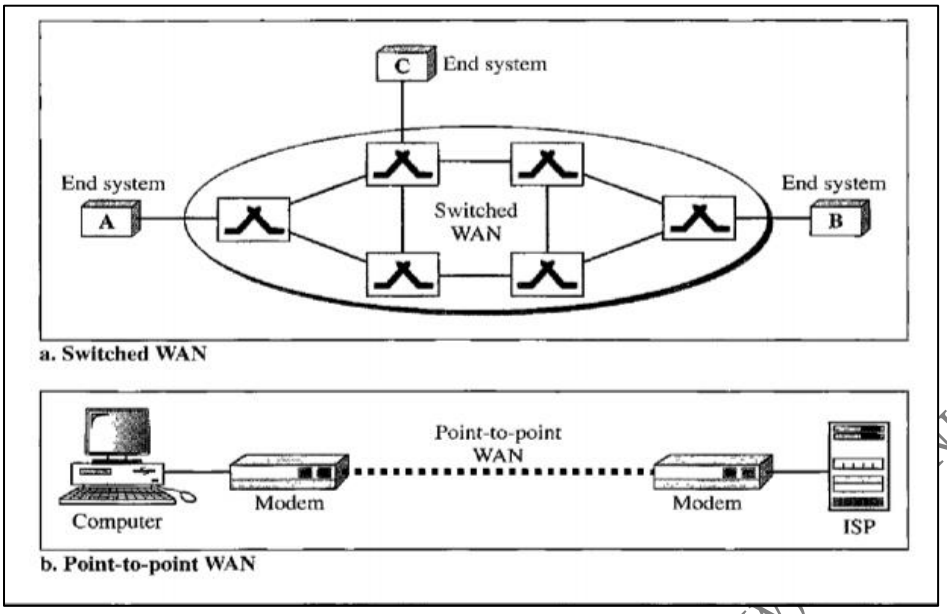
  span 5 to 50 kilometers

Local Area Network (LAN)



- Links devices in a single office, building or campus
- It may be as simple as two PCs and a printer in home office or may extend throughout a company and include audio and video
- It is limited to few kilometers
- It allow resources to be shared between personal computers or workstations.
- The resources can include hardware, software or data.
- LAN use only one type of transmission media.
- Most common topologies : bus, ring and star
- Early LANs data rates 4 to 16 megabits per second (Mbps)
- Now speed are normally 100 to 1000 Mbps

Wide Area Network (WAN)

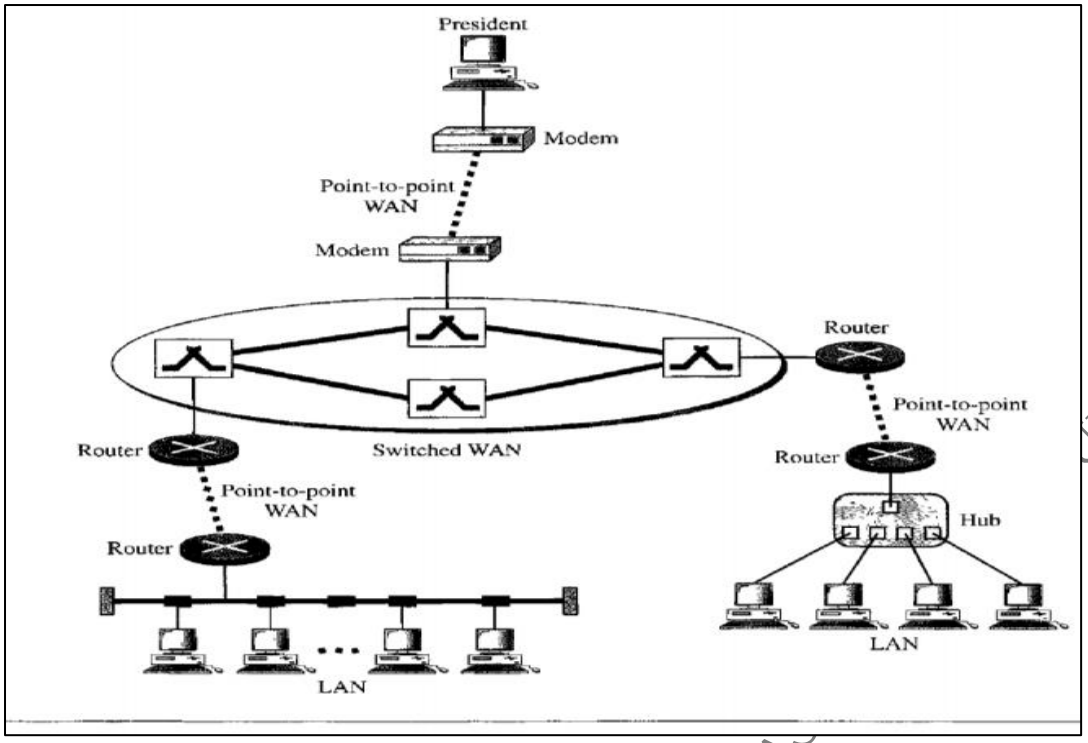


- Provides long-distance transmission of data, image, audio and video over large geographical area may be a country, a continent or whole world.
- Switched WAN
  - connects the end systems which include a router that connects to another LAN or WAN.
  - Ex. WAN X.25.
- Point-to-point WAN
  - is a line leased from a telephone or cable TV that connects small LAN to an ISP.
  - This type is used to provide Internet access.

Metropolitan Area Networks(MAN)

- It is a size between a LAN and a WAN.
- It covers the area inside a town or city.
- Designed for customers who need high-speed connectivity and have endpoints over a city or part of city.
- Ex. Part of telephone company network that provide high-speed DSL , Cable TV network also used for high-speed data connection to the Internet

Interconnection of Networks: Internetwork



- When two or more networks are connected, they become an internetwork or internet.
- Ex. An organization has two offices one on east coast with LAN topology, another on west coast with star topology. The president of the company lives somewhere in the middle and want to control over the company from her home. To create a backbone WAN for connecting these three entities, a switched WAN has been leased. To connect the LAN we need three point-to-point WAN. These point-to-point WANs can be a high-speed DSL line offered by a telephone company or a cable modem line offered by a cable TV provider

Internet

- An internet is two or more networks that can communicate with each other.
- Internet is more than hundreds of thousands of interconnected networks.

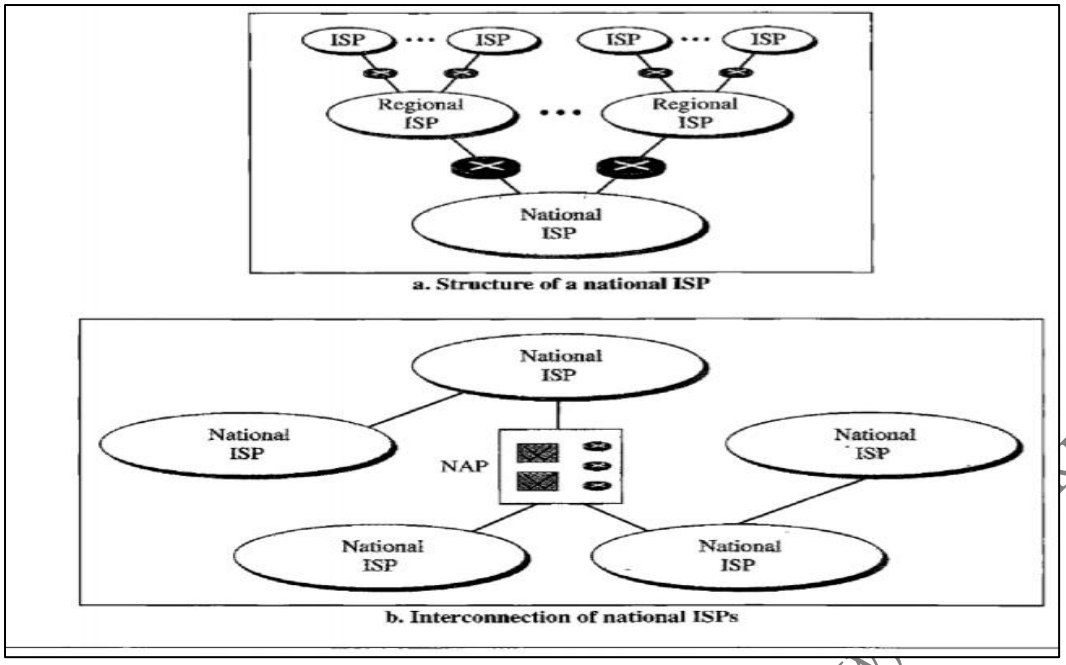
History

- In 1960s Advanced Research Projects Agency (ARPA) in the Department of Defense (DoD) found a way to connect computers so that the researchers can share their findings, reducing costs and eliminating duplication of effort.
- In 1967 ARPA presented ARPANET, a small network for connected computers.
- Each host computer attached to a specialized computer, called interface message processor (IMP).

- IMP was able to communicate with other IMPs as well as with its own attached host.
- In 1969 Four nodes at University of California at Los Angeles (UCLA), University of California at Santa Barbara (UCSB), Stanford Research Institute (SRI) and the University of Utah were connected via IMPs to form a network.
- Network Control Protocol (NCP) provided communication.
- In 1972 Vint Cerf and Bob Kahn outlined the protocols to achieve end-to-end delivery of packets called TCP.
- TCP was split into two protocols Transmission Control Protocol(TCP) and Internetworking Protocol(IP).
- IP handle datagram routing while TCP responsible for segmentation, reassembly and error detection.
- The internetworking protocol known as TCP/IP

The Internet today

- Internet is made up of many wide- and local- area networks joined by connecting devices and switching stations.
- Internet connections use the services of Internet Service Providers (ISPs).
    - International Internet Service Providers
        - The top level hierarchy that connect nations together
    - National Internet Service Providers
        - Backbone networks created and maintained by specialized companies.
        - To provide connectivity between the end users, these backbones are connected by switching stations called Network Access Points (NAPs)
    - Regional Internet Service Providers
        - Connected to one or more national ISPs. Third level in hierarchy with smaller data rate.
    - Local Internet Service Providers
        - Provide direct services to end users. Local ISPs can be connected to regional ISPs or directly to national ISPs.



a. Structure of a national ISP

b. Interconnection of national ISPs

PROTOCOLS AND STANDARDS

Protocols

- A protocol is a set of rules that govern data communications.
- It defines what is communicated, how it is communicated and when it is communicated.
- Key elements:
  - Syntax:

    Structure or format of the data that order in which they are presented.
  - Semantics

    Meaning of each section of bits.
  - Timing

    When data should be sent and how fast they can be sent.

Standards

Standards provide guidelines to manufacturers, vendors, government agencies and other service providers.

- Two categories
  - De facto (by fact or by convention)
    - Standards that have not been approved by an organized body but adopted through widespread use
  - De jure (by law or by regulation)

- Standards that have been legislated by an officially recognized body

Standard Organizations

Standard Creation Committee

- International Organization for Standardization (ISO)

  In the areas of scientific, technological and economic activity
- International Telecommunication Union – Telecommunication Sector (ITU-T)

  Devoted to research and establishment of standard for telecommunications and for phone and data systems
- American National Standards Institute (ANSI)

  Welfare of the United States and its citizens
- Institute of Electrical and Electronics Engineers (IEEE)

  It aims to advance theory, creativity and product quality in the fields of electrical engineering, electronics and radio. Also adoption of international standard for computing and communications
- Electronic Industries Association (EIA)

  In the field of information technology EIA made Significant contributions by defining physical connection interfaces and electronic signaling specifications for data communications.

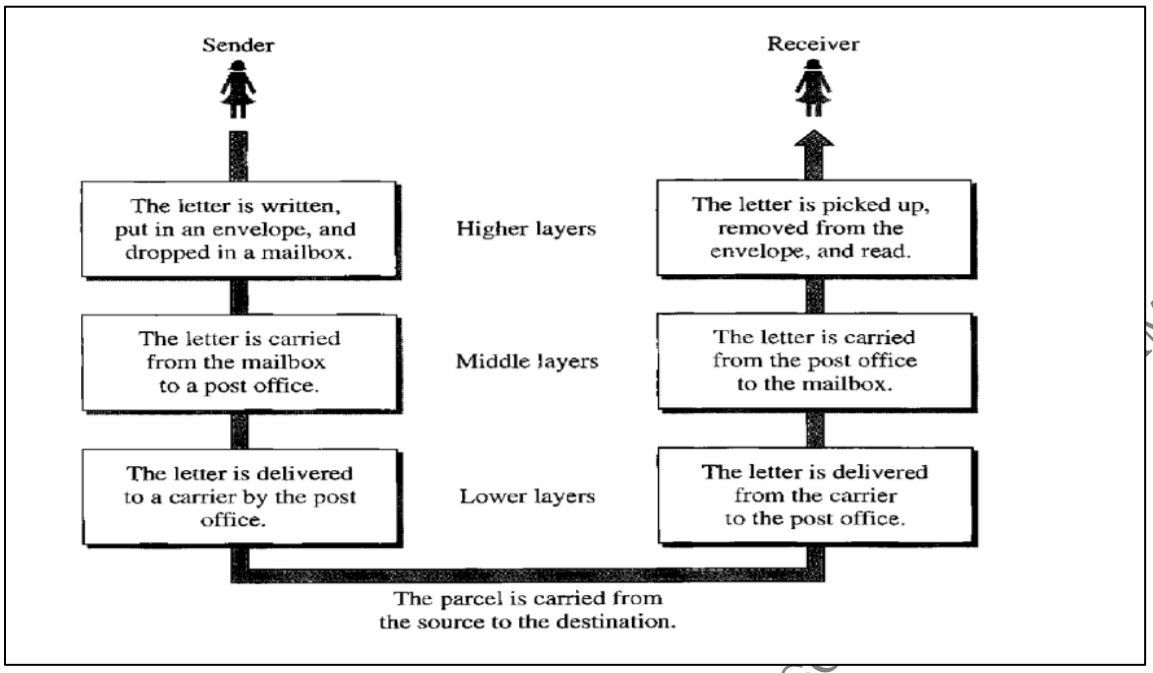
Forums

- To accommodate the need for working models and agreements and to facilitate the standardization process forums were formed
- They work with universities and users to test, evaluate and standardize new technologies
- The forums present their conclusions to the standard bodies.

Regulatory agencies

- Their purpose is to protect the public interest by regulating radio, television, and wire/cable communications.

LAYERED TASKS



Sender, Receiver and Carrier

Hierarchy of Tasks

At the sender site

- Higher layer – sender writes letter, inserts letter, writes address and drops the letter in a mailbox
- Middle layer – letter picked by letter carrier and delivered to post office
- Lower layer – letter sorted at post office, a carrier transports letter

On the way

- Letter go through central office, transported by truck, train, airplane or a combination of these

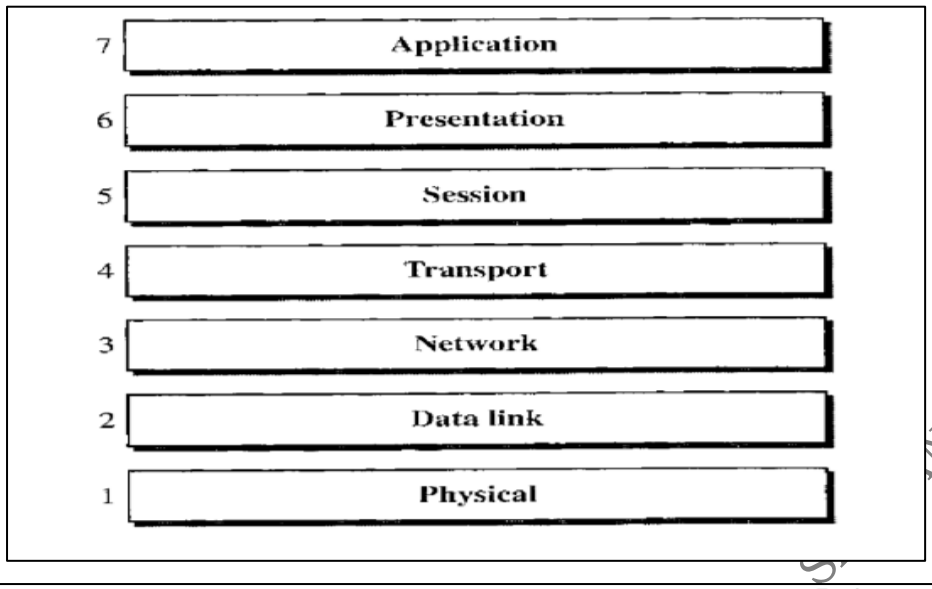
At the receiver site

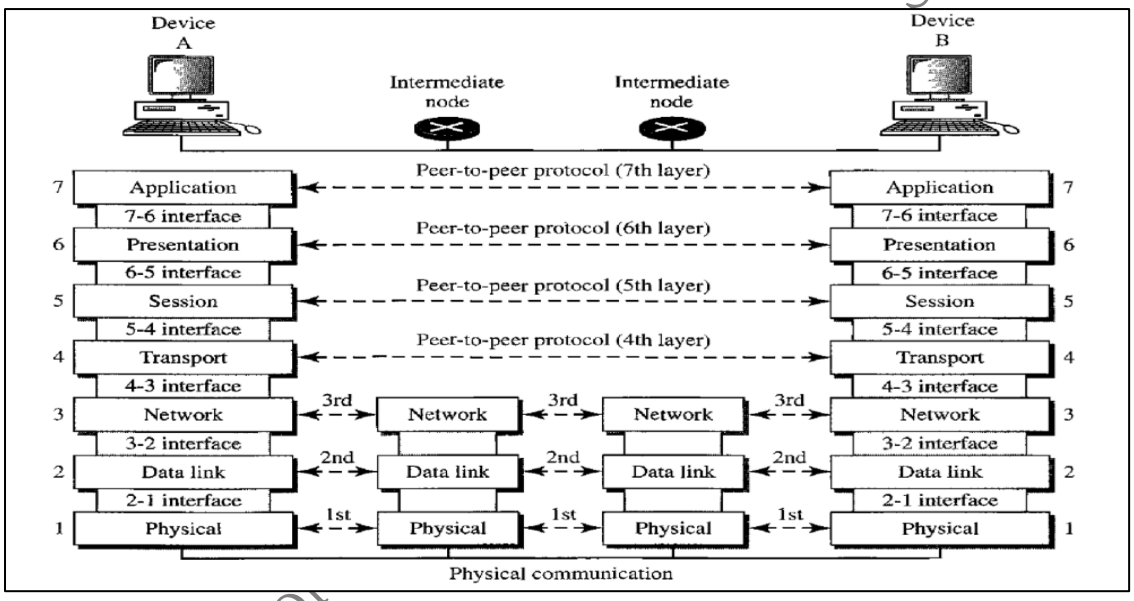
- Lower layer – transports letter to the post office
- Middle layer – letter sorted and delivered to the recipients mailbox
- Lower layer – receiver picks up the letter, opens the envelope and reads it

OSI MODEL

- An ISO (International Standards Organization) standard covers all aspects of network communications is the Open System Interconnection model.
- Purpose of OSI model is how to help communication between different systems without changing the logic of hardware and software
- It is a model of understanding and designing a network architecture.

Seven layers of OSI model





Layered Architecture

- Message is sent from Device A to Device B.
- It pass through many intermediate nodes.
- Intermediate nodes involve only first three layers of the OSI model.
- Each layer has function distinct from other layers
- Within a single machine, each layer calls upon the services of the layer just below it.
- For example 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.
- Communication is governed by protocols

- The processes on each machine that communicate at a given layer are called peer-to-peer processes

Peer-to-Peer Processes

- At physical layer communication is direct.
- Device A sends a stream of bits to device B.
- Communication must move down through the layers on device A over to device B and back up through the layers
- Each layer add its own information to the message it receives from the layer above it and passes to the layer below it
- At layer 1 entire package is converted to a form and transmitted.
- At the receiving machine the message is unwrapped layer by layer and remove the data meant for it.

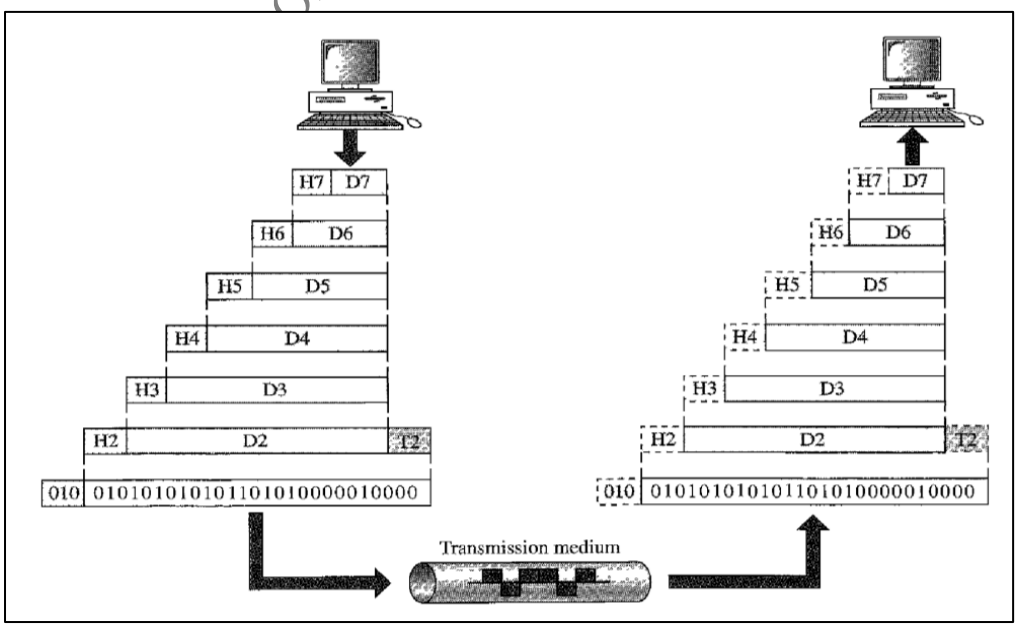
Interfaces between layers

- Passing of data and network information through sending device and back up through receiving device is made by interface.
- Each interface defines information and services a layer must provide for the layer above it.

Organization of layers

- Layers 1, 2 and 3 are the network support layers. They deal with moving data from one device to another.
- Layers 5, 6 and 7 are the user support layers.
- Layer 4 transport layer links two subgroups and ensures what the lower layers have transmitted is in the form the upper layers can use.

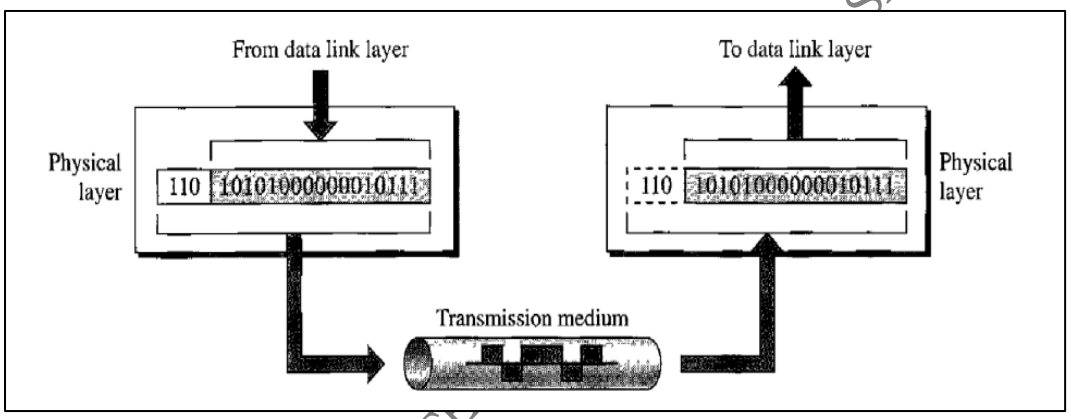
Overall view of OSI layers



- D7 means data unit at layer 7.
- Process starts at layer 7 and moves in descending order.
- At each layer a header or trailer can be added. Trailer added at layer 2
- When data passes layer 1 it is changed into an electromagnetic signal and transported along physical link and at destination it is transformed into digital form.
- As each block reaches the next higher layer the headers and trailers are removed.
- When it reaches layer 7 the form appropriate to the application is made available

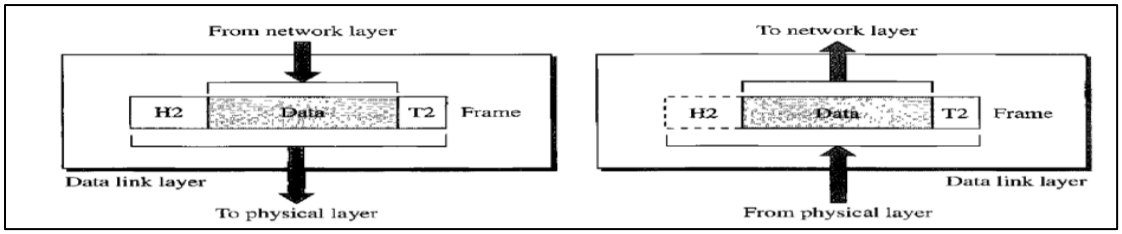
LAYERS IN THE OSI MODEL

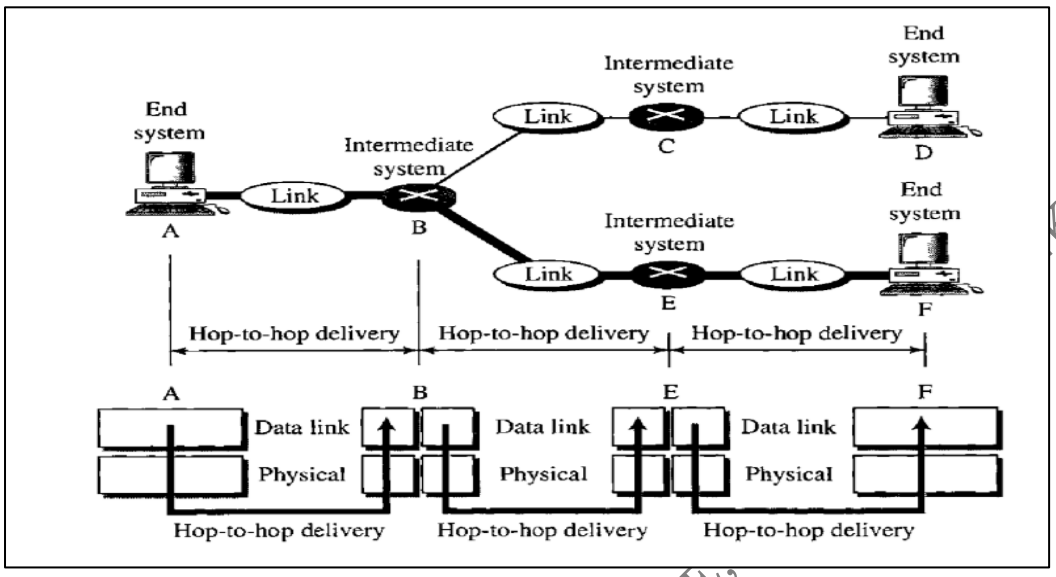
Physical Layer



- Physical characteristics of interfaces and medium
  also defines type of transmission medium
- Representation of bits
  defines type of encoding
- Data rate
  transmission rate – number of bits sent each second
- Synchronization of bits
  clock must be synchronized
- Line configuration
  connection of devices. Point-to-point or multipoint
- Physical topology
  how devices are connected
- Transmission mode
  direction of transmission between two devices: simplex, half-duplex, full-duplex

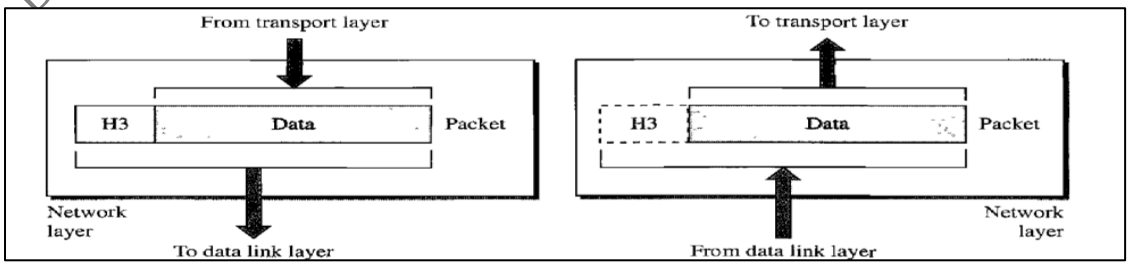
Data Link Layer

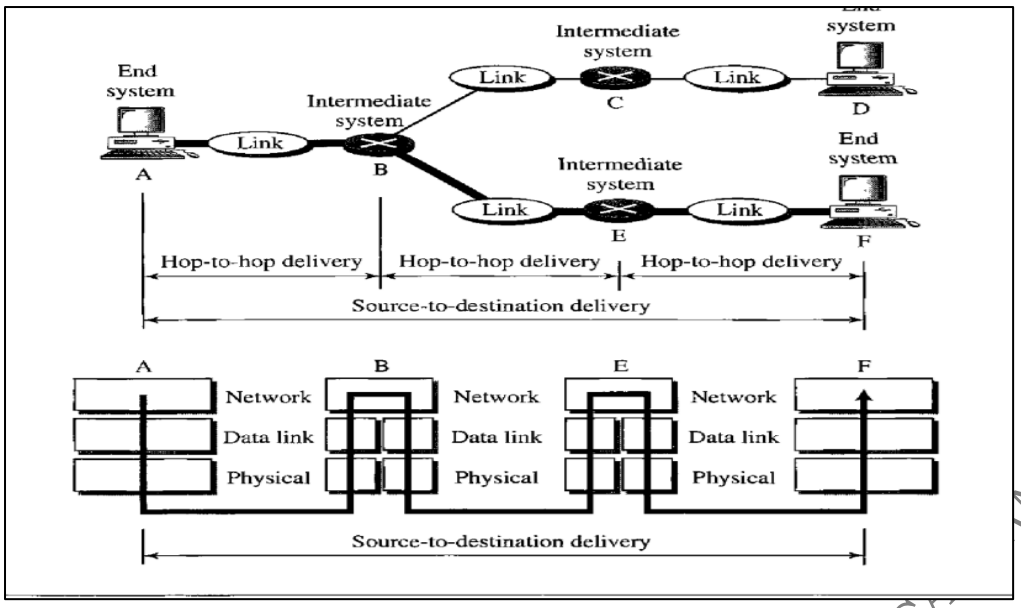




- Data link layer is responsible for moving frames from one hop(node) to the next
- Other responsibilities
  - Framing - divides stream of bits from network layer into data units called frames
  - Physical addressing - Adds a header to frame to define sender and/or receiver
  - Flow control - to avoid overwhelming the receiver
  - Error control - adds reliability by adding mechanisms to detect and transmit damaged or lost frames
  - Access control - when connected to the same link to determine which device has control over the link at any given time

Network Layer



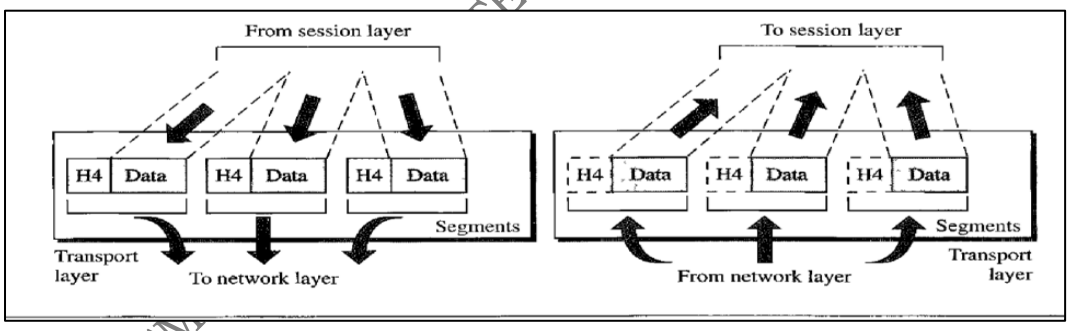


Network layer is responsible for delivery of individual packets from source host to destination host

Other responsibilities

- Logical addressing - Network layer adds a header that include logical addresses if a packet passes the network boundary
- Routing - when connected to large networks, routers route or switch the packet to their destination

Transport Layer



- Transport layer is responsible for the delivery of message from one process to another
- A process is an application program running on a host

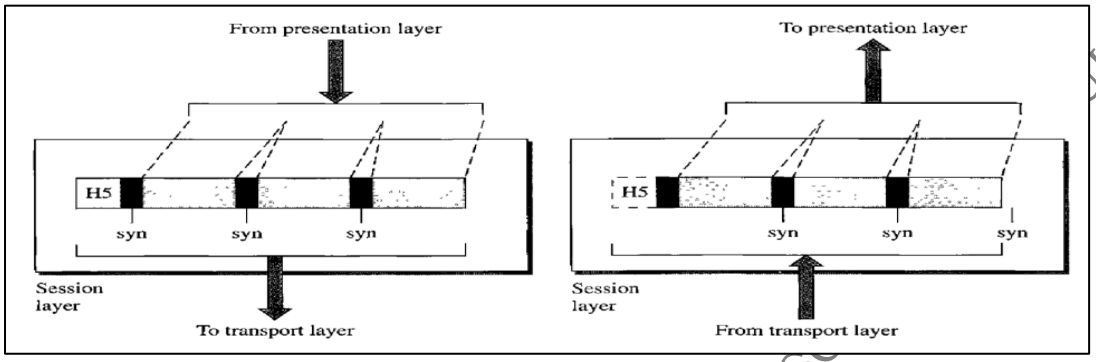
Responsibilities of transport layer

- Service-point addressing – Header includes service-point address or port address
- Segmentation and reassembly - Message divided into segments and has a sequence number to reassemble the message correctly
- Connection control - establishing connection and terminating it

- Flow control - Flow across a single link
- Error control - message arrives without error

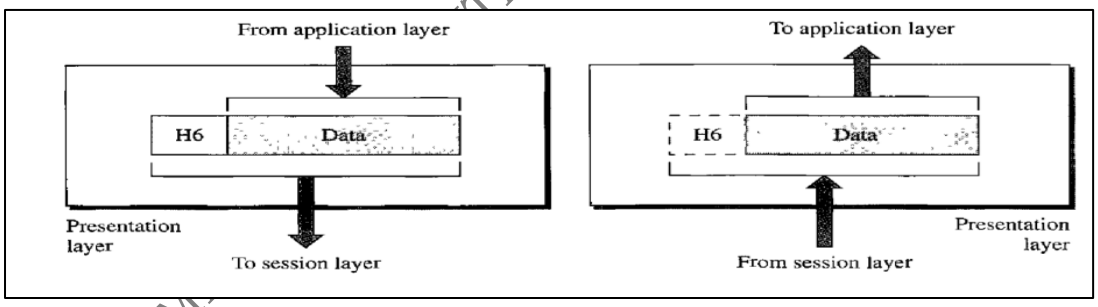
Session layer

- It is the network dialog controller.
- It establishes, maintains and synchronizes interaction among systems
- Dialog control - Allows communication between two processes
- Synchronization - Add Check points



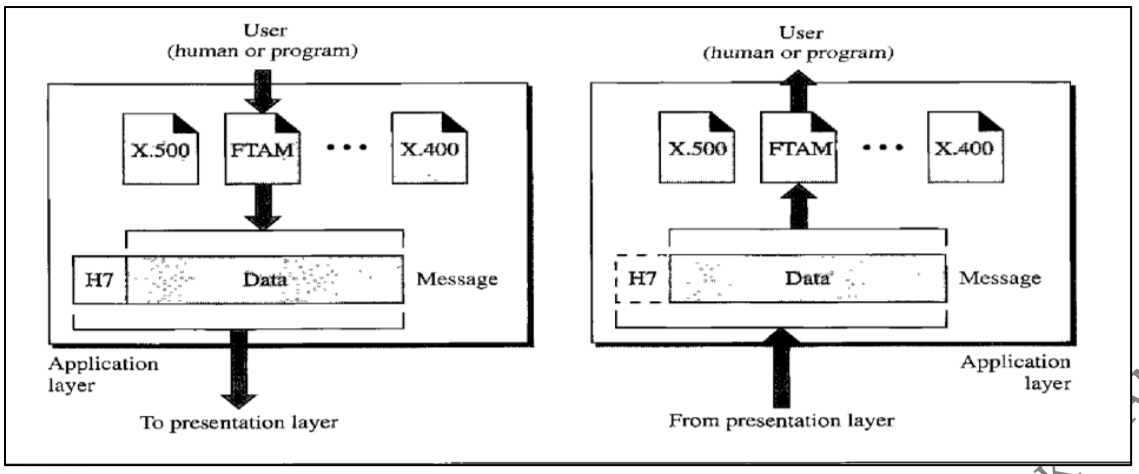
Presentation layer

- Concerned with the syntax and semantics of the information exchanged
- Translation - Changed into bit streams
- Encryption - Sender transforms original message to another form and send the message
- Compression- Reduces the number of bits contained in the information



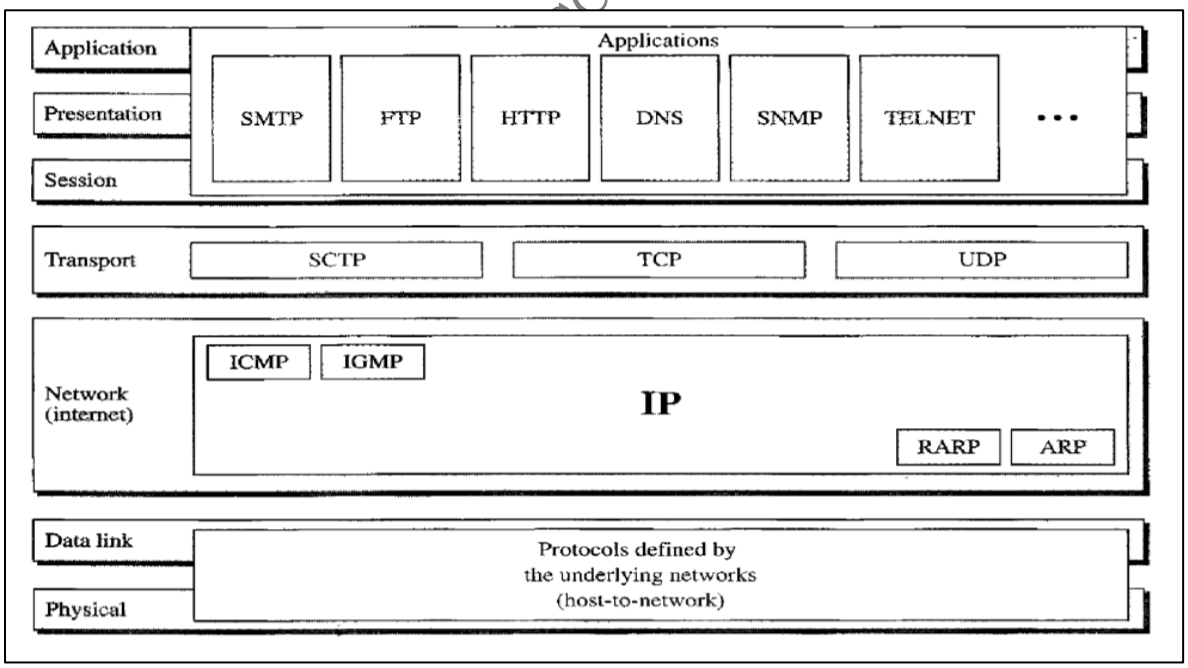
Application layer

- Enables the user to access the network.
- Provides user interfaces and support
- Network virtual terminal - Software which allows user to logon to a remote host
- File transfer, access and management - Allows user to access files in a remote host, retrieve and control files
- Mail services - E-mail forwarding and storage
- Directory services - Provides distributed database sources and access for global information



TCP/IP PROTOCOL SUITE

- TCP/IP protocol suite has four layers: host-to-network, internet, transport and application
- First four layers provide physical standards, network interfaces, internetworking and transport functions that corresponds to first four layers of OSI model
- The three topmost layers in the OSI are represented by a single layer called the application layer in TCP/IP



Physical and data link layer

- It supports all standard and proprietary protocols
- A network in a TCP/IP internetwork can be a LAN or WAN

Network layer

Internetworking Protocol (IP)

- It is an unreliable and connectionless protocol.
- It provides no error checking or tracking
- Transports data in packets called datagrams
- Datagrams can travel along different routes and arrive out of sequence or duplicated
- It does not keep track of routes and no facility for reordering datagrams

Address Resolution Protocol

- It is used to associate logical address with a physical address.
- Each device on a link is identified by a physical address on the Network Interface Card(NIC)
- Used to find the physical address of the node when its Internet address is not known

Reverse Address Resolution Protocol

- It allows a host to discover Internet address when it knows only physical address

Internet Control Message Protocol

- It is a mechanism used by hosts to send notification of datagram problems to the sender
- It sends query and error reporting messages

Internet Group Message Protocol

- Facilitate the simultaneous transmission of a message to a group of recipients

Transport Layer

Transmission Control Protocol (TCP)

- It is a reliable connection-oriented protocol
- Connection must be established before either can transmit data
- It divides stream of data into segments. Each segment has a sequence number and an acknowledgement number
- Segments are carried across the internet inside of IP datagrams
- At the receiving end TCP collects each datagram and reorders based on sequence number

User Datagram Protocol (UDP)

- It adds only port addresses, checksum error control and length information of the data

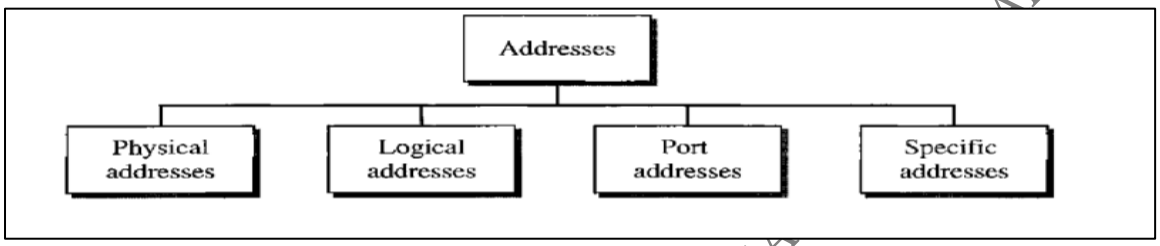
Stream Control Transmission Protocol (SCTP)

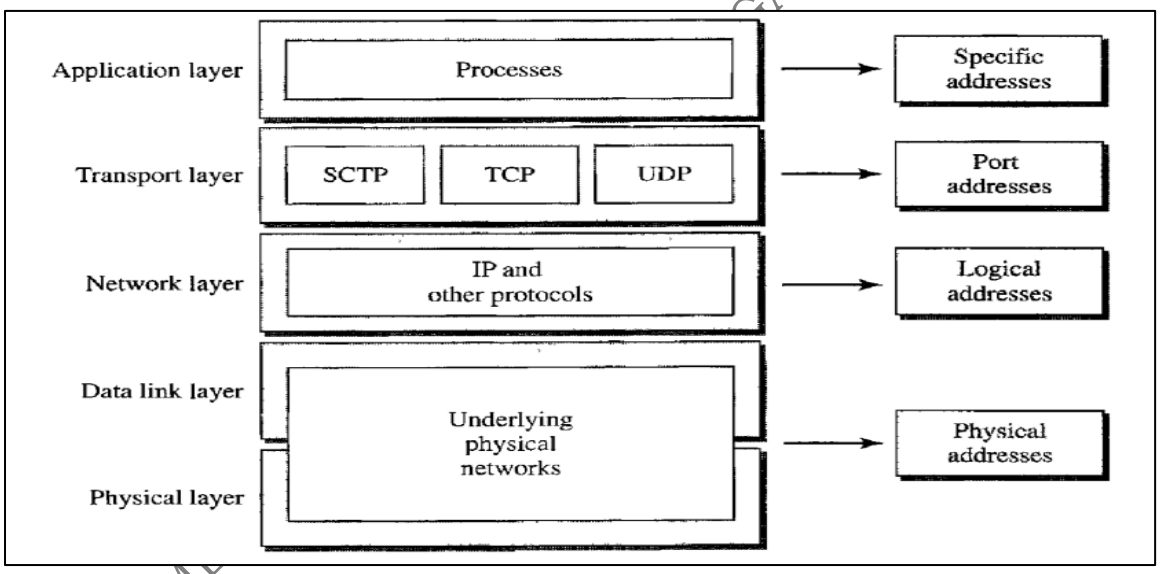
- Provides support for newer application such as voice over the internet.
- It combines the feature of UDP and TCP

Application Layer

- It is equivalent to the combined session, presentation and application layers in the OSI model
- It includes Simple Mail Transfer Protocol(SMTP), File Transfer Protocol(FTP), Hyper Text Transfer Protocol(HTTP), Domain Name Server(DNS), Simple Network Management Protocol(SNMP), Terminal Network(TELNET) etc.

ADDRESSING

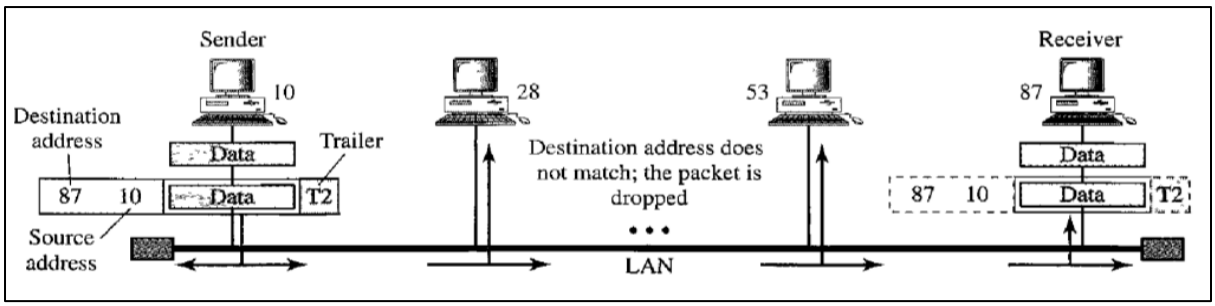




Physical Addresses

- It is also known as link address, address of a node defined by its LAN or WAN
- It is included in the frame used by the data link layer
- It is the lowest level address

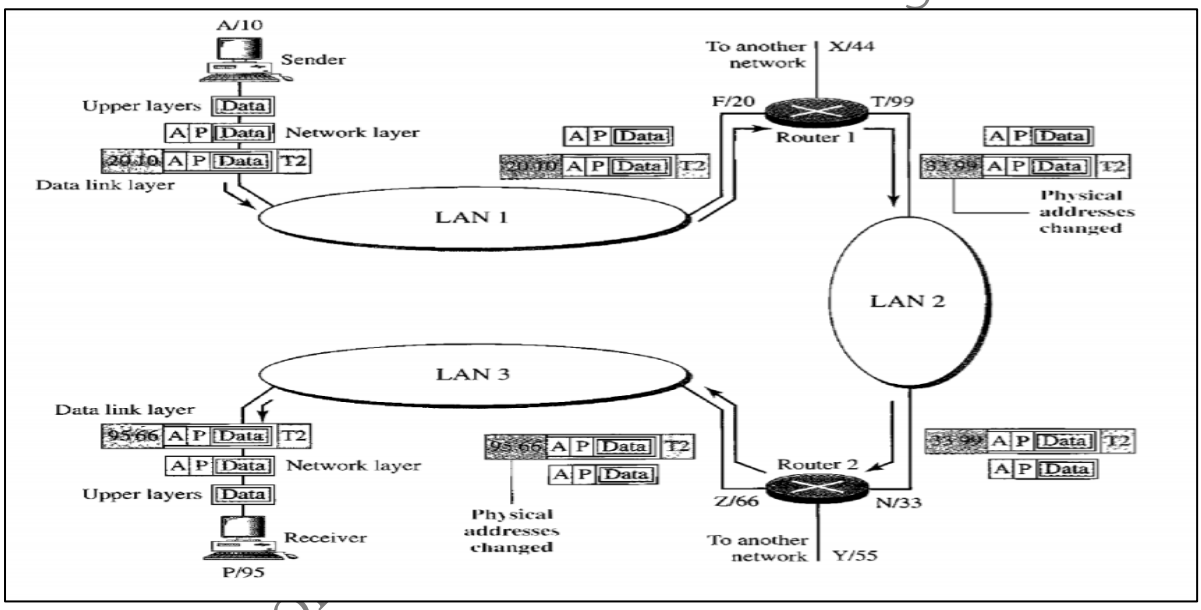
Ex.



Logical Addresses

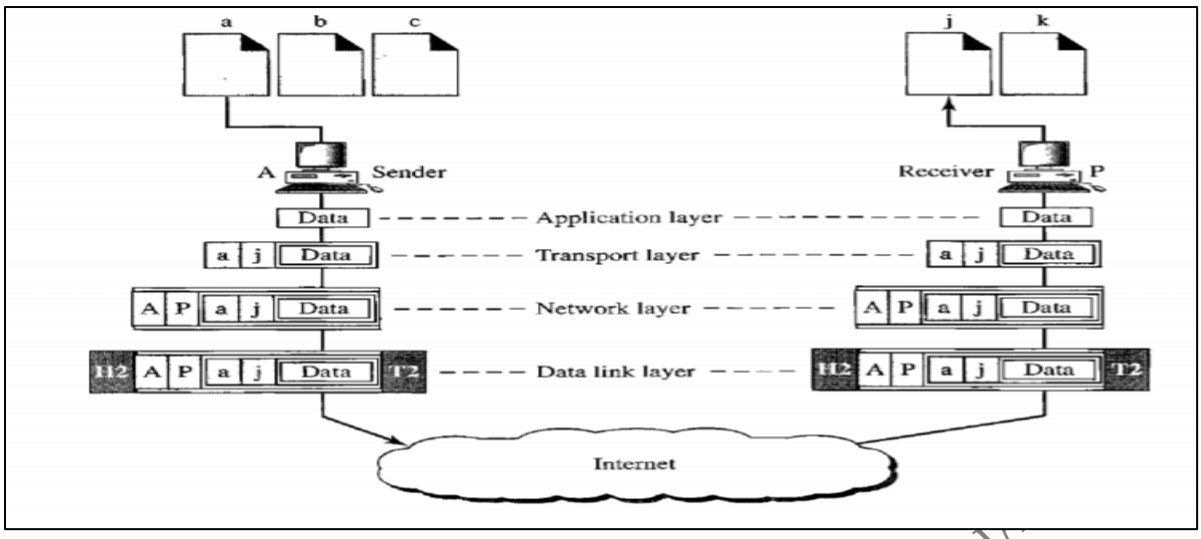
- It is necessary for universal communications that are independent of underlying physical network
- It is 32-bit address that uniquely define a host connected to the Internet.

Ex.



Port Addresses

- Computers can run multiple processes at the same time.
- Internet communication is a process communicating with another process
- For processes to receive data simultaneously, we need a method to label different processes.
- The label assigned to a process is called a port address
- Port address is 16 bits in length



Specific addresses

- Some application user-friendly addresses that are designed for that specific address
- Examples: e-mail address, Uniform Resource Locator(URL)