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LECTURE NOTES

ON

IT305 DATA COMMUNICATION AND NETWORKING

MODULE 1

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M E S COLLEGE OF ENGINEERING, KUTTIPPURAM

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SYLLABUS

Module 1

Introduction: - Types of Computer Networks, Network Software - Protocol Hierarchies, Connection oriented and Connection less hierarchies, Reference Models - ISO-OSI Reference Model, TCP/IP Reference Model – Comparison of OSI and TCP/IP reference models.

Physical Layer: - Guided Transmission Media– Twisted Pair, Coaxial and Fiber Optics, Wireless Transmission- Radio and Microwave transmission, Communication Satellites – GEO, MEO, LEO.

Comparison of Network hardware - Repeaters, Routers, Bridges, Gateways, Hub and Cable Modem.

Introduction

What is a computer network?

A computer network is a group of two or more computers connected with each other for sharing resources and information. A simple computer network can be built only from two computers while a complex computer network can be built from several thousand computers.

Computer Network: A set of communication elements connected by communication links.

- Communication elements
  - Computers, printers, mobile phones,⋯
  - Routers, switches, ...
- Communication links
  - optic fiber
  - coaxial cable
  - twisted pair
  - wireless (radio, microwave, satellite)

Uses of Computer Networks

- Business Applications
- Home Applications
- Mobile Users

1.1 Types of Computer Networks

Network Hardware

Two dimensions

-Transmission technology (Broadcast links, point-to-point links)

-Scale(PAN,LAN,MAN,WAN)

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Interprocessor distance	Processors located in same	Example
1 m	Square meter	Personal area network
10 m	Room	Local area network
100 m	Building	
1 km	Campus	
10 km	City	Metropolitan area network
100 km	Country	Wide area network
1000 km	Continent	
10,000 km	Planet	The Internet

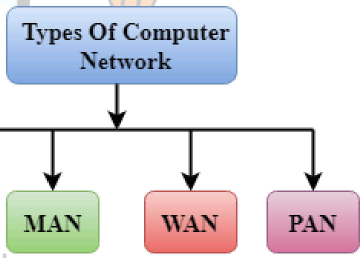
A computer network can be categorized by their size. A computer network is mainly of four types:

PAN(Personal Area Network)

LAN(Local Area Network)

MAN(Metropolitan Area Network)

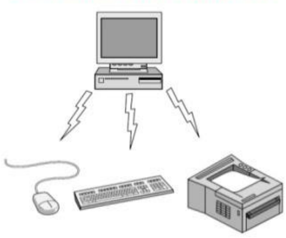
WAN(Wide Area Network)



PAN (Personal Area Network)

- PANs (Personal Area Networks) let devices communicate over the range of a person.
- A common example is a wireless network that connects a computer with its peripherals.
- Connection using Bluetooth

Personal Area Network



Bluetooth PAN configuration

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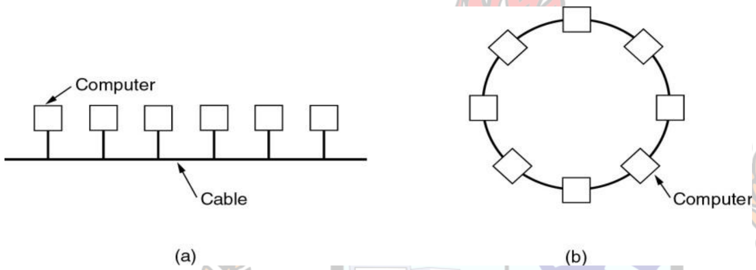
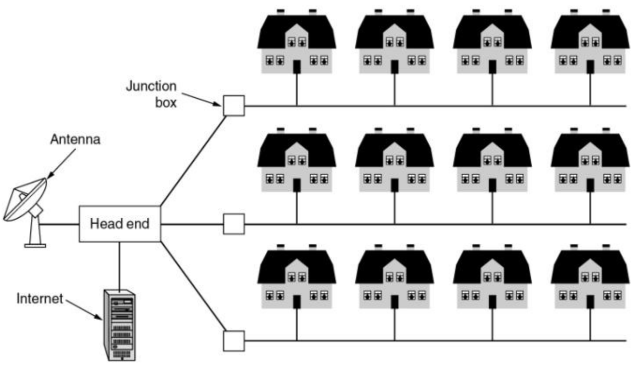
LAN (Local Area Network)

- Local area networks, generally called LANs, are privately-owned networks within a single building or campus of up to a few kilometers in size.
- They are widely used to connect personal computers and workstations in company offices and factories to share resources (e.g., printers) and exchange information.
- LANs are distinguished from other kinds of networks by three characteristics: (1) their size, (2) their transmission technology, and (3) their topology.
- LANs are restricted in size
- LANs may use a transmission technology consisting of a cable to which all the machines are attached(twisted pair, coaxial cable, etc.)
- Traditional LANs run at speeds of 10 Mbps to 100 Mbps, have low delay (microseconds or nanoseconds), and make very few errors.
- Newer LANs operate at up to 10 Gbps.
- Various topologies are possible for broadcast LANs (eg: a)bus, b)ring)



MAN(Metropolitan Area Network)

- A metropolitan area network is a network that covers a larger geographic area by interconnecting a different LAN to form a larger network.
- Government agencies use MAN to connect to the citizens and private industries.
- In MAN, various LANs are connected to each other through a telephone exchange line.
- The most widely used protocols in MAN are RS-232, Frame Relay, ATM, ISDN, OC-3, ADSL, etc.
- It has a higher range than Local Area Network(LAN).
- The best-known example of a MAN is the cable television network available in many cities



WAN (Wide Area Network)

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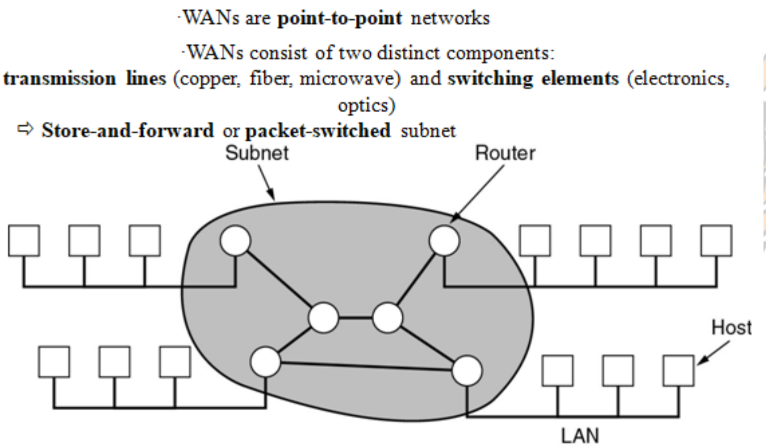
- A wide area network, or WAN, spans a large geographical area, often a country or continent.
- It contains a collection of machines (Hosts) intended for running user (i.e., application) programs.
- The hosts are connected by a communication subnet
- The hosts are owned by the customers (e.g., people's personal computers), whereas the communication subnet is typically owned and operated by a telephone company or Internet service provider.
- The job of the subnet is to carry messages from host to host.
- In most wide area networks, the subnet consists of two distinct components: transmission lines and switching elements.
- Transmission lines move bits between machines.
- They can be made of copper wire, optical fiber, or even radio links.
- Switching elements are specialized computers that 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. (Routers)



Relation between hosts on LANs and the subnet.

Wireless Networks

Categories of wireless networks:

- System interconnection
  (short-range radio, e.g. Bluetooth)
- Wireless LANs
  (IEEE 802: 802.11a, 802.11b, 802.11g)
- Wireless WANs
  (802.16, Cellular telephones, Satellites)
- Wireless sensor networks

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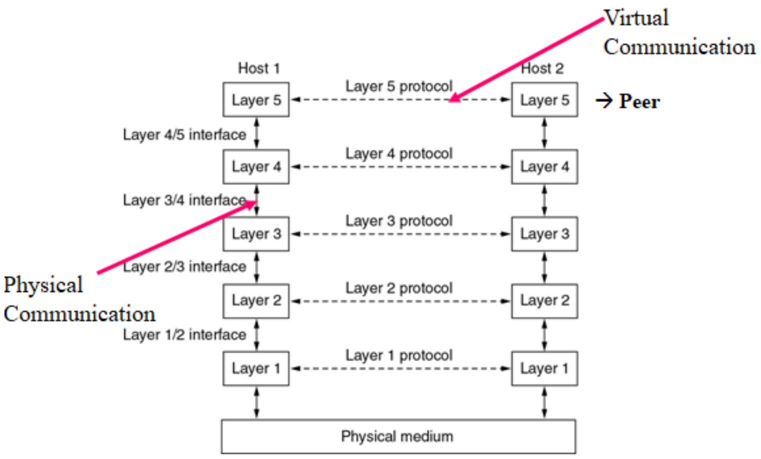
1.2 Network Software

The first computer networks were designed with the hardware as the main concern and the software as an afterthought. This strategy no longer works. Network software is now highly structured.

1.2.1 Protocol Hierarchies

- To reduce design complexity, most networks are organized as a stack of layers or levels, each one built upon the one below it.
- The number of layers, the name of each layer, the contents of each layer, and the function of each layer differ from network to network.
- The purpose of each layer is to offer certain services to the higher layers, shielding those layers from the details of how the offered services are actually implemented.



Layers, protocols, and interfaces.

- Layer n on one machine carries on a conversation with layer n on another machine.
- The rules and conventions used in this conversation are collectively known as the layer n protocol.
- Basically, a protocol is an agreement between the communicating parties on how communication is to proceed.
- no data are directly transferred from layer n on one machine to layer n on another machine.
- each layer passes data and control information to the layer immediately below it, until the lowest layer is reached. Below layer 1 is the physical medium through which actual communication occurs
- Between each pair of adjacent layers is an interface.

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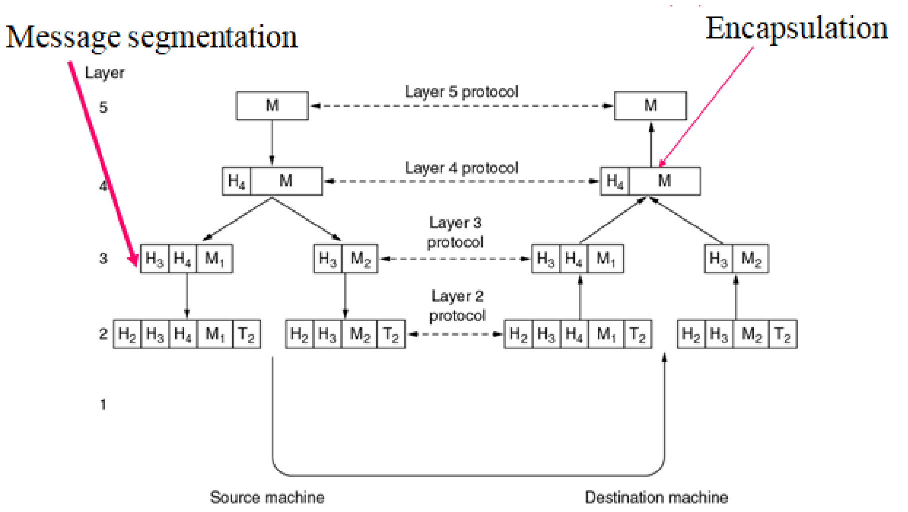
- The interface defines which primitive operations and services the lower layer makes available to the upper one.
- A set of layers and protocols is called network architecture.

Layering

- To make things simple: modularization
- Different layer has different functions
- Create layer boundary such that
  - **description of services can be small**
  - **number of interactions across boundary are minimized**
  - **potential for interface standardized**
- Different level of abstraction in the handling of data (e.g., syntax, semantics)
- Provide appropriate services to upper layer
- Use service primitives of lower layer



Example information flow supporting virtual communication in layer 5.

Design Issues for the Layers

- Addressing (telephone number, e-mail address, IP address,…)
- Error Control (error correction codes, ARQ, HARQ,…)
- Flow Control (feedback-based, rate-based)
- Multiplexing (gathering several small messages with the same destination into a single large message or vice versa à Demultiplexing)
- Routing (directing traffic to the destination)

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1.2.2 Connection oriented and Connection less hierarchies

	Service	Example
Connection-oriented	Reliable message stream	Sequence of pages
	Reliable byte stream	Remote login
	Unreliable connection	Digitized voice
Connection-less	Unreliable datagram	Electronic junk mail
	Acknowledged datagram	Registered mail
	Request-reply	Database query

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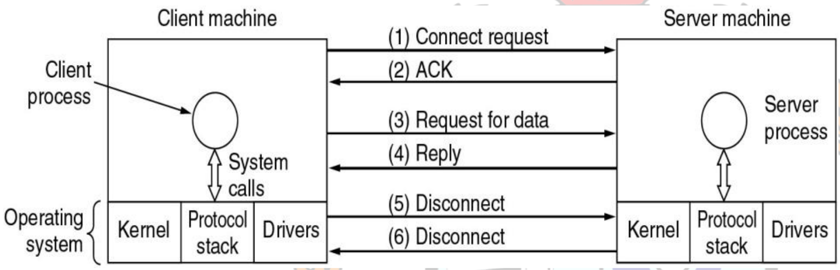
Service Primitives (Operations)

A service is formally defined by a set of primitives (operations) available to a user process to access the services. If the protocol stack is located in the operating system, the primitives are normally system calls. Table shows five service primitives for implementing a simple connection-oriented service.

Primitive	Meaning
LISTEN	Block waiting for an incoming connection
CONNECT	Establish a connection with a waiting peer
RECEIVE	Block waiting for an incoming message
SEND	Send a message to the peer
DISCONNECT	Terminate a connection

Figure shows packets sent in a simple client-server interaction on a connection-oriented network.

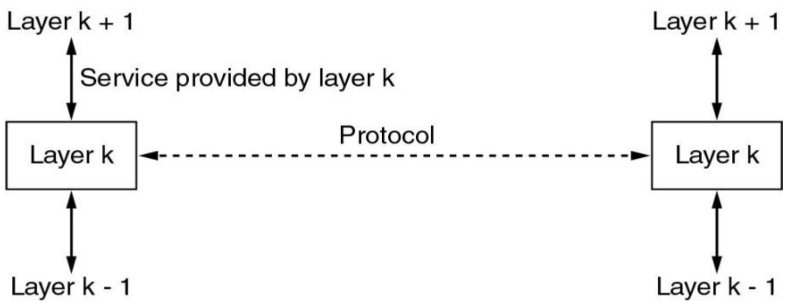


Services to Protocols Relationship

The service defines what operations the layer is prepared to perform on behalf of its users. A service is a set of primitives that a layer provides to the layer above it. A protocol is a set of rules governing the format and meaning of the packets which are exchanged by the peer entities in the same layer.

Services related to the interfaces between layers. Protocols related to the packets sent between peer entities on different machine.

Figure shows the relationship between a service and a protocol.



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Connection-Oriented service:

The user first establishes a connection then uses the connection and then releases the connection. The sender transmits bits of information and the receiver takes them out in the same order as they were originally sent.

Connectionless:

Each packet of information carries the full destination address and is routed independently from the others from the source to destination. Packets may take different routes to the destination and it is possible for two packets sent to the same destination the first one to sent can be delayed and the second one arrives first. So, care must be taken in order for the all the bits arrive correctly and in the same order they were sent.

1.3 Reference Models

1. OSI Reference Model
2. The TCP/IP reference model.

1.3.1 OSI Reference Model

The design principle of the OSI reference model

- A layer should be created where a different abstraction is needed
- Each layer should perform a well defined function
- The function of each layer can be chosen as an international standard
- The layer boundaries should be chosen to minimize the information flow across the interfaces
- The number of layers should be not too large or not too small

OSI Reference Model

This model employs hierarchical structure of seven layers.

OSI stands for Open Systems Interconnection. It has 7-layers and attempts to abstract common features common to all approaches to data communications, and organize them into layers so that each layer only worries about the one above it and the one directly below it. Before getting into details explaining the functions and responsibilities of each layer let me clear one important statement. Although the actual data transmission is vertical, starting from the Application layer of the client’s computer all the way to the Application layer of the destination computer, each layer is programmed as though the data transmission were horizontal.

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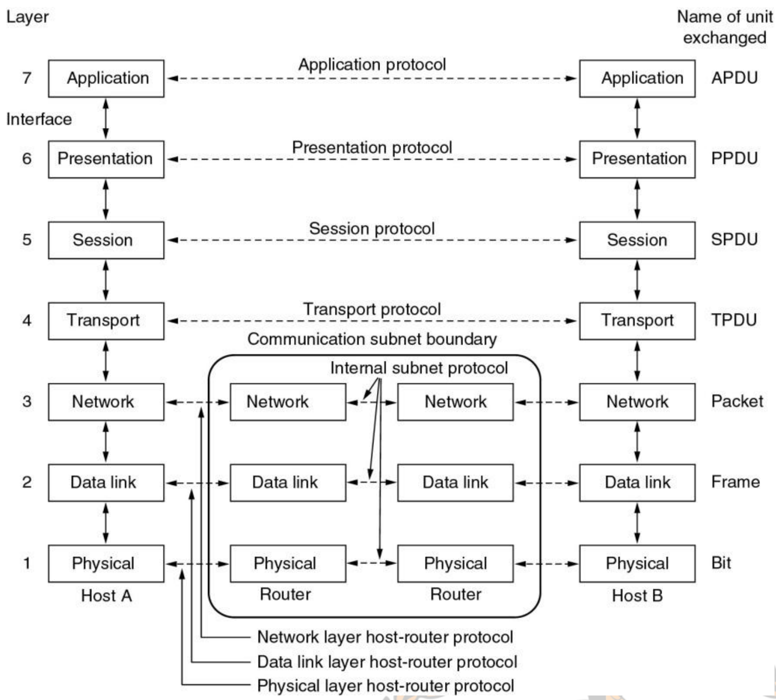

Data Link Layer

Data link layer provides means to transfer data between network entities. At the source machine it takes the bit streams of data from the Network Layer breaks into frames and passes them to the physical layer. At the receiving end data link layer detects and possibly corrects the errors that may occur during the transmission and passes the correct stream to the network layer. It's also concerned with flow control techniques.

Network Layer

This layer performs network routing, flow control and error control functions. Network routing simply means the way packets are routed from source to destination and flow control, prevents the possibility of congestion between packets which are present in the subnet simultaneously and form bottlenecks.

Transport Layer

The Transport Layer has as a main task to accept data from the Session layer, split them up into smaller units and passes them to the Network layer making sure that all the pieces arrive correctly to the destination. It is the first end-to-end layer all the way from source machine to destination machine unlike the first three layers which are chained having their protocols between each machine.

Session Layer

Session layer is responsible for controlling exchange information and for synchronization.

Presentation Layer

It is responsible to translate different data formats from the representation used inside the computer (ASCII) to the network standard representation and back. Computers use different codes for representing character strings so a standard encoding must be used and

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is handled by the presentation layer. Generally, in a few words this layer is concerned with the syntax and semantics of the information transmitted.

Application layer

The upper layer of this model performs common application service for the application processes meaning that software programs are written in the application layer to handle the many different terminal types that exist and map the virtual terminal software onto the real terminal. It contains a variety of protocols and is concerned with file transfer as well as electronic mail, remote job entry and various other services of general interest.

The functions of the seven layers

- The physical layer is concerned with transmitting raw bits over a communication channel
- The data link layer performs flow control and also transforms a raw transmission facility into a line that appears error free (ARQ)-Framing
- The network layer controls the operation of the subnet, e.g. routing, flow control, internetworking,…
- The transport layer performs assembling and disassembling, isolates the upper layers from the changes in the network hardware, and determines the type of services
- The session layer establishes sessions (dialog control, …)
- The presentation layer is concerned with the syntax and semantics
- The application layer contains a variety of commonly used protocols (e.g. Hyper Text Transfer Protocol for WWW, file transfer, e-mail, network news,…)

1.3.2 TCP/IP Reference Model

Figure below shows the OSI and TCP/IP network architectures illustrating the layers of the OSI model and introducing the corresponding layers on TCP/IP model.

	OSI	TCP/IP
7	Application	Application
6	Presentation	
5	Session	
4	Transport	Transport
3	Network	Internet
2	Data link	Host-to-network
1	Physical	

Not present

In the modal

TCP/IP reference model was named after its two main protocols: TCP (Transmission Control Protocol) and IP (Internet Protocol). This model has the ability to connect multiple networks together in a way so that data transferred from a program in one computer are delivered safely to a similar program on another computer.

Unlike the architecture of OSI model TCP/IP has 4 main layers as indicated in the table above.

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Host-to-Network Layer: It translates data and addresses information into format appropriate for an Ethernet Network or Token Ring Network. It uses a protocol (not specified due to lack of information concerned with this layer) in order for the host to connect to the network. Through this layer communication is achieved with physical links such as twisted pair or fiber optics carrying 1's and 0's.

Internet Layer: This layer is a connectionless internetwork layer and defines a connectionless protocol called IP. It is concerned with delivering packets from source to destination. These packets travel independently each taking a different route so may arrive in a different order than they were sending. Internet layer does not care about the order the packets arrive at the destination as this job belongs to higher layers.

Transport Layer: It contains two end-to-end protocols. TCP is a connection oriented protocol and is responsible for keeping track of the order in which packets are sent and reassemble arriving packets in the correct order. It also ensures that a byte stream originating on one machine to be delivered without error on any other machine on the internet. The incoming byte stream is fragmented into discrete messages and is passed to the internet layer. With an inverse process, at the destination, an output stream is produced by reassembling the received massage.

UDP is the second protocol in this layer and it stands for User Datagram Protocol. In contrast to TCP, UDP is a connectionless protocol used for applications operating on its own flow control independently from TCP. It is also an unreliable protocol and is widely used for applications where prompt delivery is more important than accurate delivery, such as transmitting speech or video.

Application Layer: Is the upper layer of the model and contains different kinds of protocols used for many applications. It includes virtual terminal TELNET for remote accessing on a distance machine, File Transfer Protocol FTP and e-mail (SMTP). It also contains protocols like HTTP for fetching pages on the www and others.

1.3.3 Comparison of OSI and TCP/IP reference models

Similarities between the OSI and TCP/IP model

The following are the similarities between the OSI and TCP/IP model:

- Share common architecture: Both the models are the logical models and having similar architectures as both the models are constructed with the layers.
- Define standards: Both the layers have defined standards, and they also provide the framework used for implementing the standards and devices.
- Simplified troubleshooting process: Both models have simplified the troubleshooting process by breaking the complex function into simpler components.
- Pre-defined standards: The standards and protocols which are already pre-defined; these models do not redefine them; they just reference or use them. For example, the Ethernet standards were already defined by the IEEE before the development of these models; instead of recreating them, models have used these pre-defined standards.

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- Both have similar functionality of 'transport' and 'network' layers: The function which is performed between the 'presentation' and the 'network' layer is similar to the function performed at the transport layer.

Differences between the OSI and TCP/IP model

OSI Model	TCP/IP Model
It is developed by ISO (International Standard Organization)	It is developed by ARPANET (Advanced Research Project Agency Network).
OSI model provides a clear distinction between interfaces, services, and protocols.	TCP/IP doesn't have any clear distinguishing points between services, interfaces, and protocols.
OSI refers to Open Systems Interconnection.	TCP refers to Transmission Control Protocol.
OSI uses the network layer to define routing standards and protocols.	TCP/IP uses only the Internet layer.
OSI follows a vertical approach.	TCP/IP follows a horizontal approach.
OSI layers have seven layers.	TCP/IP has four layers.
In the OSI model, the transport layer is only connection-oriented.	A layer of the TCP/IP model is both connection-oriented and connectionless.
In the OSI model, the data link layer and physical are separate layers.	In TCP, physical and data link are both combined as a single host-to-network layer.
Session and presentation layers are a part of the OSI model.	There is no session and presentation layer in the TCP model.
It is defined after the advent of the Internet.	It is defined before the advent of the internet.
The minimum size of the OSI header is 5 bytes.	The minimum header size is 20 bytes.

Despite all these differences the two models have much in common. They are both based on the concept of a stack of independent protocols and the functionality of each layer is roughly similar.

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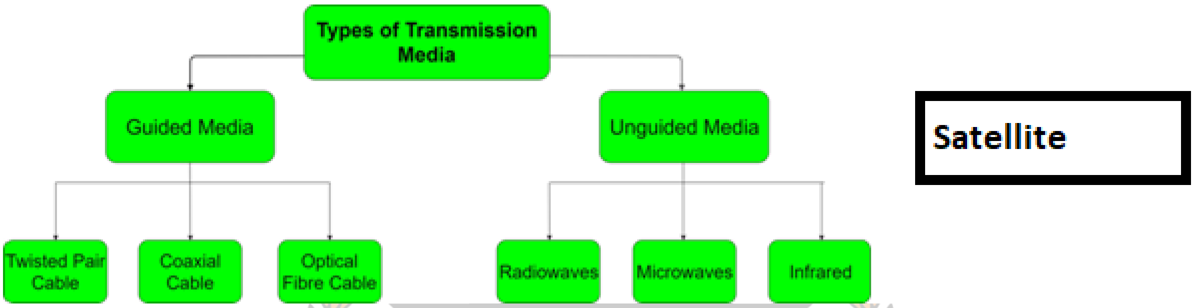
1.4 Physical Layer

The purpose of the physical layer is to transport a raw bit stream from one machine to another. Various physical media can be used for the actual transmission. Each one has its own niche in terms of bandwidth, delay, cost, and ease of installation and maintenance.

- The properties of different kinds of physical channel determine the performance – throughput, latency, and error rate.

Types of Transmission Media

In data communication terminology, a transmission medium is a physical path between the transmitter and the receiver i.e it is the channel through which data is sent from one place to another. Transmission Media is broadly classified into the following types:



1.4.1. Guided Transmission Media:

It is also referred to as Wired or Bounded transmission media. Signals being transmitted are directed and confined in a narrow pathway by using physical links.

Features:

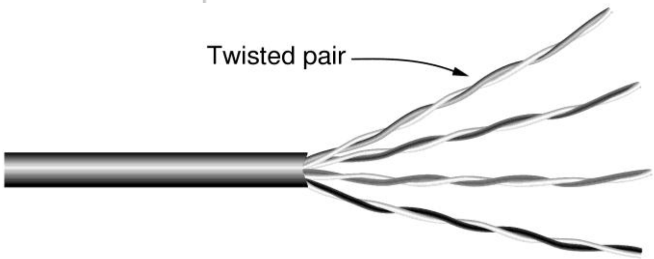
High Speed

Secure

Used for comparatively shorter distances

There are 3 major types of Guided Media:

1.4.1.1 Twisted Pair Cable



It consists of 2 separately insulated conductor wires wound about each other. Generally, several such pairs are bundled together in a protective sheath. They are the most widely used Transmission Media. Twisted Pair is of two types:

Unshielded Twisted Pair (UTP):

This type of cable has the ability to block interference and does not depend on a physical shield for this purpose. It is used for telephonic applications.

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Advantages:

- Least expensive
- Easy to install
- High speed capacity

Disadvantages:

- Susceptible to external interference
- Lower capacity and performance in comparison to STP
- Short distance transmission due to attenuation

Shielded Twisted Pair (STP):

This type of cable consists of a special jacket to block external interference. It is used in fast-data-rate Ethernet and in voice and data channels of telephone lines.

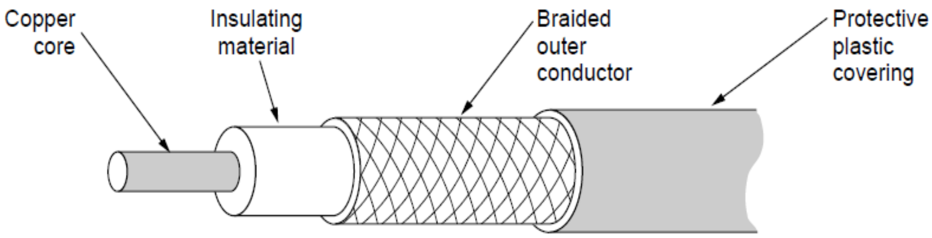
Advantages:

- Better performance at a higher data rate in comparison to UTP
- Eliminates crosstalk
- Comparatively faster

Disadvantages:

- Comparatively difficult to install and manufacture
- More expensive
- Bulky

<u>1.4.1.2 Coaxial Cable</u>



It has an outer plastic covering containing 2 parallel conductors each having a separate insulated protection cover. Coaxial cable transmits information in two modes: Baseband mode (dedicated cable bandwidth) and Broadband mode(cable bandwidth is split into separate ranges). Cable TVs and analog television networks widely use Coaxial cables.

Advantages:

- High Bandwidth
- Better noise Immunity
- Easy to install and expand
- Inexpensive

Disadvantages:

- Single cable failure can disrupt the entire network

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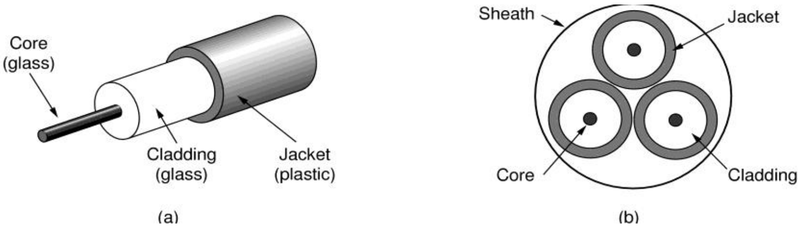
1.4.1.3 Optical Fiber Cable



It uses the concept of reflection of light through a core made up of glass or plastic. The core is surrounded by a less dense glass or plastic covering called the cladding. It is used for transmission of large volumes of data.

Advantages:

- Increased capacity and bandwidth
- Light weight
- Less signal attenuation
- Immunity to electromagnetic interference
- Resistance to corrosive materials

Disadvantages:

- Difficult to install and maintain
- High cost
- Fragile
- unidirectional, ie, will need another fibre, if we need bidirectional communication.

1.4.2 Wireless Transmission (Unguided Media)

It is also referred to as unbounded transmission media. No physical medium is required for the transmission of electromagnetic signals.

Features:

Signal is broadcasted through air
Less Secure
Used for larger distances

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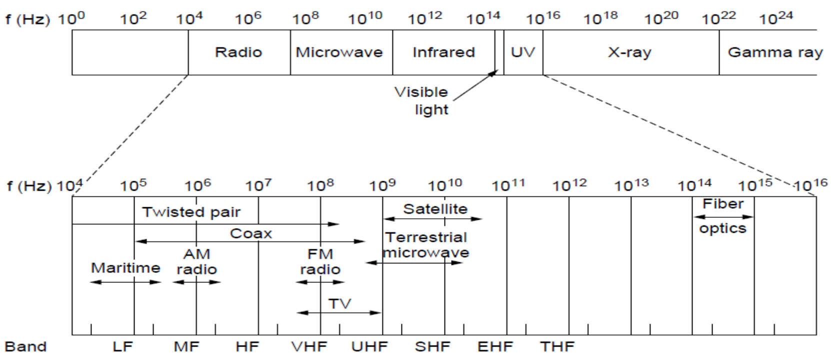
The electromagnetic spectrum and its uses for communication



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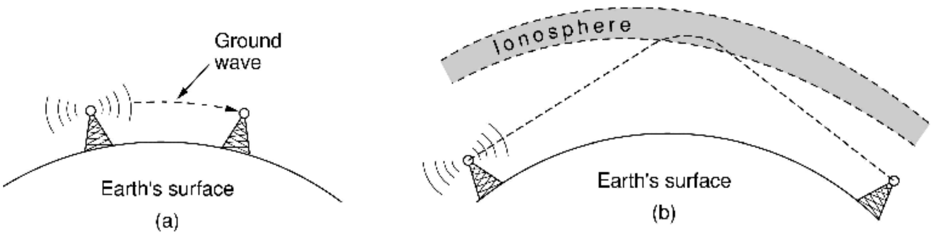
There are 3 major types of Unguided Media:

1.4.2.1 Radio waves

These are easy to generate and can penetrate through buildings. The sending and receiving antennas need not be aligned. Frequency Range:3KHz – 1GHz. AM and FM radios and cordless phones use Radio waves for transmission.

Further Categorized as (i) Terrestrial and (ii) Satellite.



In the VLF, LF, and MF bands, radio waves follow the curvature of the earth

In the HF band, they bounce off the ionosphere

1.4.2.2 Microwaves

It is a line of sight transmission i.e. the sending and receiving antennas need to be properly aligned with each other. The distance covered by the signal is directly proportional to the height of the antenna. Frequency Range:1GHz – 300GHz. These are majorly used for mobile phone communication and television distribution.

1.4.2.3 Infrared

Infrared waves are used for very short distance communication. They cannot penetrate through obstacles. This prevents interference between systems. Frequency Range:300GHz – 400THz. It is used in TV remotes, wireless mouse, keyboard, printer, etc.

1.5 Communication Satellites

A communication satellite is a microwave repeater station in a space that is used for telecommunication, radio and television signals. A communication satellite processes the data coming from one earth station and it converts the data into another form and send it to the second earth station.

How a Satellite Works

Two stations on earth want to communicate through radio broadcast but are too far away to use conventional means. The two stations can use a relay station for their communication. One earth station transmits the signal to the satellite.

Uplink frequency is the frequency at which ground station is communicating with satellite. The satellite transponder converts the signal and sends it down to the second earth station, and this is called ***Downlink frequency***. The second earth station also communicates with the first one in the same way.

Four different types of satellites orbits have been identified. These are:

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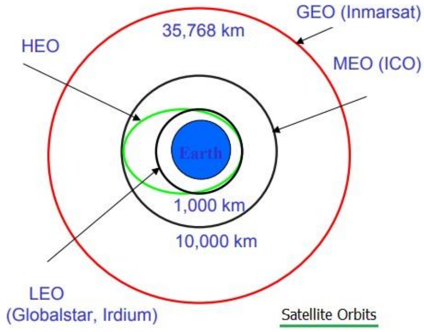

Satellite Orbits

- GEO (Geostationary Earth Orbit) at about 36,000km above the earth's surface.
- LEO (Low Earth Orbit) at about 500-1500km above the earth's surface.
- MEO (Medium Earth Orbit) or ICO (Intermediate Circular Orbit) at about 6000-20,000 km above the earth's surface.
- HEO (Highly Elliptical Orbit)

1.5.1 GEO (Geostationary Earth Orbit)

- If a satellite should appear in fixed in the sky, it requires a period of 24 hours. Using the equation of distance earth and satellite, r = (g.r2 /2.r.f)2)1/3 and the period of 24 hours f = 1/24 h. the resulting distance is 35,786 km. the orbit must have an inclination of 0 degree.
- Geostationary satellites have a distance of almost 36,000 km to the earth. Examples are almost all TV and radio broadcast satellites, any weather satellites and satellites operating as backbones for the telephone network.
- Objects in GEO moves around the earth at the same speed as the earth rotates. This means geostationary satellites remain in the same position relative to the surface of earth.

Advantages of GEO satellite

- Three Geostationary satellites are enough for a complete coverage of almost any spot on earth.
- Receivers and senders can use fixed antenna positions, no adjusting is needed.
- GEOs are ideal for TV and radio broadcasting.
- Lifetime expectations for GEOs are rather high, at about 15 years.
- Geostationary satellites have a 24-hour view of a particular area.
- GEOs typically do not need handover due to the large footprints.
- GEOs don't exhibit any Doppler shift because the relative movement is zero.

Disadvantages of GEO satellite

- Northern or southern regions of the earth have more problems receiving these satellites due to the low elevation above latitude of 60 degree, i.e. larger antennas are needed in this case.
- Shading of the signals in cities due to high buildings and the low elevation further away from the equator limits transmission quality.
- The transmit power needed is relatively high (about 10 W) which causes problems for battery powered devices.
- These satellites can't be used for small mobile phones.
- The biggest problem for voice and also data communication is high latency of over 0.25s one way-retransmission schemes which are known from fixed networks fail.
- Transferring a GEO into orbit is very expensive.

1.5.2 LEO (Low Earth Orbit)

- As LEOs circulate on a lower orbit, it is obvious that they exhibit a much shorter period (the typical duration of LEO periods are 95 to 120 minutes). Additionally, LEO systems

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try to ensure a high elevation for every spot on earth to provide a high quality communication link.

- Each LEO satellite will only be visible from the earth for about ten minutes.
- A further classification of LEOs into little LEOs with low bandwidth services (some 100 bit/s), big LEOs (some 1,000 bit/s) and broadband LEOs with plans reaching into the Mbits/s range can be found in Comparetto (1997).
- LEO satellites are much closer to earth than GEO satellites, ranging from 500 to 1,500 km above the surface. LEO satellites do not stay in fixed position relative to the surface, and are only visible for 15 to 20 minutes each pass.

Advantages of LEO satellite

- Using advanced compression schemes, transmission rates of about 2,400 bit/s can be enough for voice communication.
- LEOs even provide this bandwidth for mobile terminals with omni-directional antennas using low transmit power in the range of 1 W.
- A LEO satellite smaller area of coverage is less of a waste of bandwidth.
- Using advanced compression schemes, transmission rates of about 2,400 bit/s can be enough for voice communication.
- A LEO satellite's proximity to earth compared to a Geostationary satellite gives it a better signal strength and less of a time delay, which makes it better for point to point communication.
- Smaller footprints of LEOs allow for better frequency reuse, similar to the concepts used for cellular networks.

Disadvantages of LEO satellite

- The biggest problem of the LEO concept is the need for many satellites if global coverage is to be reached.
- The high number of satellites combined with the fast movement's results in a high complexity of the whole satellite system.
- The short time of visibility with a high elevation requires additional mechanism for connection handover between different satellites.
- One general problem of LEO is the short lifetime of about five to eight years due to atmospheric drag and radiation from the inner Van Allen belt.
- The low latency via a single LEO is only half of the story.
- Other factors are the need for routing of data packets from satellite to satellite (or several times from base stations to satellites and back) if a user wants to communicate around the world.
- A GEO typically does not need this type of routing, as senders and receivers are most likely in the same footprints.

1.5.3 MEO (Medium Earth Orbit)

- A MEO satellite situates in orbit somewhere between 6,000 km to 20,000 km above the earth's surface.
- MEO satellites are similar to LEO satellites in the context of functionality.
- MEO satellites are similar to LEO satellite in functionality.
- Medium earth orbit satellites are visible for much longer periods of time than LEO satellites usually between 2 to 8 hours.
- MEO satellites have a larger coverage area than Low Earth Orbit satellites.

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- MEOs can be positioned somewhere between LEOs and GEOs, both in terms of their orbit and due to their advantages and disadvantages.

Advantages of MEO

- Using orbits around 10,000km, the system only requires a dozen satellites which is more than a GEO system, but much less than a LEO system.
- These satellites move more slowly relative to the earth's rotation allowing a simpler system design (satellite periods are about six hours).
- Depending on the inclination, a MEO can cover larger populations, so requiring fewer handovers.
- A MEO satellite's longer duration of visibility and wider footprint means fewer satellites are needed in a MEO network than a LEO network.

Disadvantages of MEO

- Again due to the larger distance to the earth, delay increases to about 70-80 ms.
- The satellites need higher transmit power and special antennas for smaller footprints.
- A MEO satellite's distance gives it a longer time delay and weaker signal than LEO satellite.

HEO (High Earth Orbit)

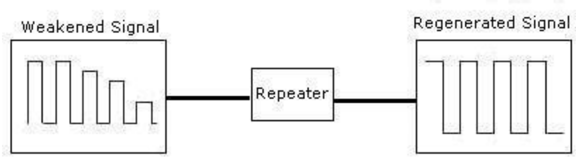
- The High Earth orbit satellite is the only non-circular orbit of the four types.
- HEO satellite operates with an elliptical orbit, with a maximum altitude (apogee) similar to GEO, and a minimum altitude (perigee) similar to the LEO.
- The HEO satellites used for the special applications where coverage of high latitude locations is required.

1.6 Comparison of Network hardware - Repeaters, Routers, Bridges, Gateways, Hub and Cable Modem

1.6.1 Repeaters:

As signals travel along a network cable (or any other medium of transmission), they degrade and become distorted in a process that is called attenuation. If a cable is long enough, the attenuation will finally make a signal unrecognizable by the receiver.

A Repeater enables signals to travel longer distances over a network. Repeaters work at the OSI's Physical layer. A repeater regenerates the received signals and then retransmits the regenerated (or conditioned) signals on other segments.



To pass data through the repeater in a usable fashion from one segment to the next, the packets and the Logical Link Control (LLC) protocols must be the same on the each segment. This means that a repeater will not enable communication, for example, between an 802.3 segment (Ethernet) and an 802.5 segment (Token Ring). That is, they cannot translate an Ethernet packet into a Token Ring packet. In other words, repeaters do not translate anything.

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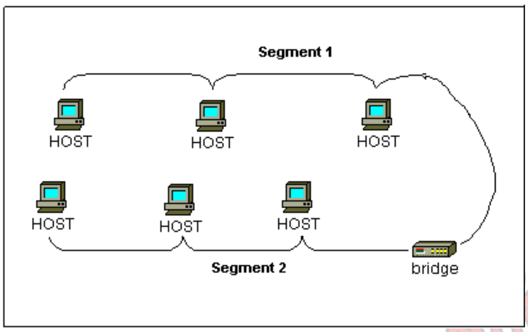
1.6.2 Bridges:

Like a repeater, a bridge can join segments or workgroup LANs. However, a bridge can also divide a network to isolate traffic or problems. For example, if the volume of traffic from one or two computers or a single department is flooding the network with data and slowing down entire operation, a bridge can isolate those computers or that department.

In the following figure, a bridge is used to connect two segment 1 and segment 2.



Bridges can be used to:

i. Expand the distance of a segment.

ii. Provide for an increased number of computers on the network.

iii. Reduce traffic bottlenecks resulting from an excessive number of attached computers.

Bridges work at the Data Link Layer of the OSI model. Because they work at this layer, all information contained in the higher levels of the OSI model is unavailable to them. Therefore, they do not distinguish between one protocol and another.

Bridges simply pass all protocols along the network. Because all protocols pass across the bridges, it is up to the individual computers to determine which protocols they can recognize.

A bridge works on the principle that each network node has its own address. A bridge forwards the packets based on the address of the particular destination node.

As traffic passes through the bridge, information about the computer addresses is then stored in the bridge's RAM. The bridge will then use this RAM to build a routing table based on source addresses.

1.6.3 Routers:

In an environment consisting of several network segments with different protocols and architecture, a bridge may not be adequate for ensuring fast communication among all of the segments. A complex network needs a device, which not only knows the address of each segment, but also can determine the best path for sending data and filtering broadcast traffic to the local segment. Such device is called a Router.

Routers work at the Network layer of the OSI model meaning that the Routers can switch and route packets across multiple networks. They do this by exchanging protocol-specific information between separate networks. Routers have access to more information in packets than bridges, and use this information to improve packet deliveries. Routers are usually used in a complex network situation because they provide better traffic management than bridges and do not pass broadcast traffic.

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Routers can share status and routing information with one another and use this information to bypass slow or malfunctioning connections.

Routers do not look at the destination node address; they only look at the network address. Routers will only pass the information if the network address is known. This ability to control the data passing through the router reduces the amount of traffic between networks and allows

1.6.4 Gateways:

Gateways make communication possible between different architectures and environments. They repackage and convert data going from one environment to another so that each environment can understand the other's environment data. A gateway repackages information to match the requirements of the destination system. Gateways can change the format of a message so that it will conform to the application program at the receiving end of the transfer.

A gateway links two systems that do not use the same:

i. Communication protocols

ii. Data formatting structures

iii. Languages

iv. Architecture

For example, electronic mail gateways, such as X.400 gateway, receive messages in one format, and then translate it, and forward in X.400 format used by the receiver, and vice versa.

To process the data, the gateway: Decapsulates incoming data through the networks complete protocol stack and encapsulates the outgoing data in the complete protocol stack of the other network to allow transmission.

1.6.5 Hub

A hub is basically a multiport repeater. A hub connects multiple wires coming from different branches, for example, the connector in star topology which connects different stations. Hubs cannot filter data, so data packets are sent to all connected devices. In other words, collision domain of all hosts connected through Hub remains one. Also, they do not have intelligence to find out best path for data packets which leads to inefficiencies and wastage.

Types of Hub

- **Active Hub:-** These are the hubs which have their own power supply and can clean, boost and relay the signal along with the network. It serves both as a repeater as well as wiring centre. These are used to extend the maximum distance between nodes.
- **Passive Hub :-** These are the hubs which collect wiring from nodes and power supply from active hub. These hubs relay signals onto the network without cleaning and boosting them and can’t be used to extend the distance between nodes.

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1.6.6 Cable Modem

A cable modem is a peripheral device used to connect to the Internet. It operates over coax cable TV lines and provides high-speed Internet access. Since cable modems offer an always-on connection and fast data transfer rates, they are considered broadband devices.

Early cable modems provided download and upload speeds of 1 to 3 Mbps, 20 to 60 times faster than the fastest dial-up modems. Today, standard cable Internet access speeds range from 25 to 50 Mbps. On the high end, Comcast offers an "Xfinity Extreme" service with speeds up to 505 Mbps.

Most cable modems include a standard RJ45 port that connects to the Ethernet port on your computer or router. Since most homes now have several Internet-enabled devices, cable modems are typically connected to a home router, allowing multiple devices to access the Internet. Some cable modems even include a built-in wireless router, eliminating the need for a second device.

While "cable modem" includes the word "modem," it does not function as a traditional modem (which is short for "modulator/demodulator"). Cable modems send and receive information digitally, so there is no need to modulate an analog signal.

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Question Bank Module 1

1. Classify Network types based on its size and explain each.
2. Compare OSI model with TCP/IP reference model.
3. Explain the use of networking devices used in physical layer and data link layer.
4. Describe any three Data Link Layer Design issues in detail. How are they solved?
5. Classify computer network based on Scale, topology and transmission technology.
6. For 20 devices in a network, what is the number of cable links required for a mesh and ring topology. How many ports are needed for each device?
7. List the different types of services provided under connection-oriented and Connection-less services with lucid example.
8. State three main differences between ISO-OSI model and TCP/IP Model.
9. What are the characteristics of GEO, MEO & LEO communication satellites?
10. Differentiate Switches and Routers.
11. Distinguish between routers, switches, gateways, hubs, bridges and modems.
12. How is data transmitted through an optic fiber?
13. Show how TCP/IP reference Model incorporates the functions of all seven layers of the OSI Model.
14. Classify different types of Computer Networks.
15. Write short notes on Fiber Optics technology.
16. Explain the characteristics and need of communication satellites.
17. Compare between repeaters, hubs and switches.

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