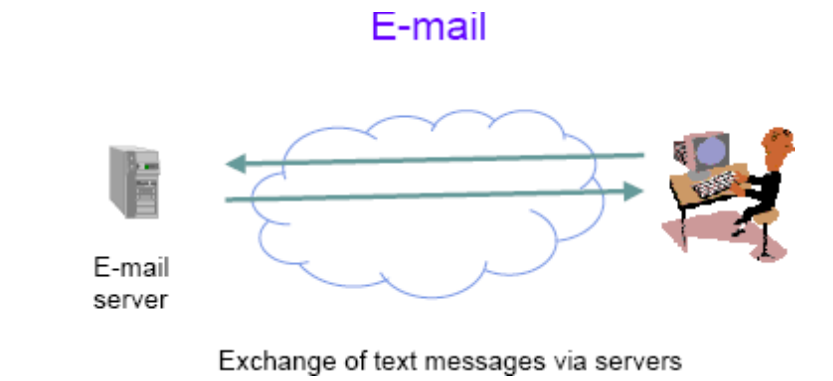
Unit - IV

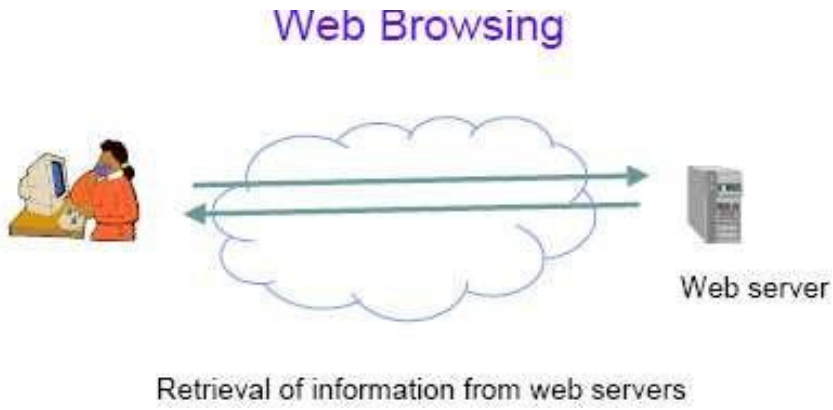
Overview of Data Communication & Networking:

Data Communication:

The information is shared when we communicate. This sharing can be local or over long distance. Data refers to information presented in whatever form is agreed upon by the parties creating and using it. Data communications are the exchange of data between two devices via some form of transmission medium such as a wire cable. A communication service enables the exchange of information between users at different locations. The communicating devices must be a part of a communication system made up of a combination of hardware (physical equipment) and software (programs).

Communication services & applications are everywhere. Some examples are given below:





Characteristics of data Communication:

The effectiveness of a data communication system depends on Four fundamental characteristics:

1. Delivery
2. Accuracy

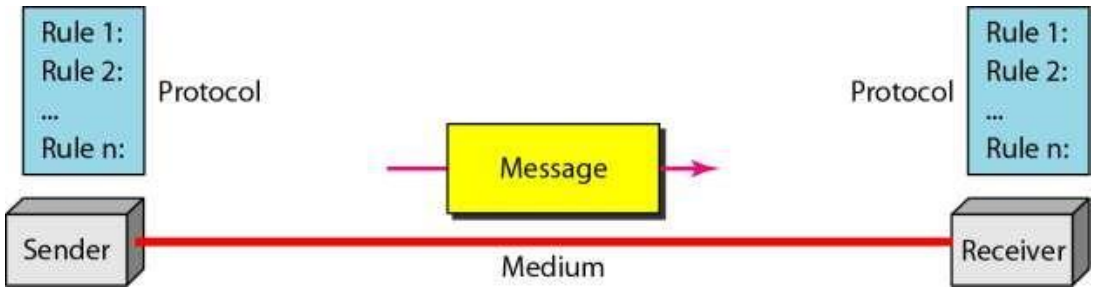
3. Timeliness
4. Jitter

Delivery: The system must deliver data to correct destination.
Accuracy: The system must deliver data accurately.
Timeliness: The system must deliver data in a timely manner. Timely delivery means delivering data as they are produced, in the same order that they are produced and without significant delay. This kind of delivery is called real –time transmission.
Jitter: Jitter refers to the variation in the packet arrival time.

Simply we can say that a data communication system must deliver data to the correct destination in anaccurate and timely manner.

Components:
The essential components of a data communication system are:

- Message
- Sender
- Receiver
- Medium
- Protocol



Message: The information to be communicated. It can consist of text, pictures, numbers, sound, videoor audio.
Sender: The sender is the device that sends the data message. It can be a computer or workstation telephone handset, video camera and so on.
Receiver: The receiver is the device that receives the message. It can be a computer or workstation telephone handset, video camera and so on.
Medium: The transmission medium is the physical path connecting both the sender as well as the receiver by which a message travels from sender to receiver. It could be a twisted pair wire, coaxial cable, fiber optic cable, or radio waves.
Protocol: A protocol is a set of rules that governs data communications. It represents an agreement between the communicating devices.

Data representation:
Information can be in any form such as text, numbers, images, audio and video.

Text

Text is represented as a bit pattern

The number of bits in a pattern depends on the number of symbols in that language. Code is the set of bit patterns designed to represent text symbols.

ASCII

The American National Standards Institute developed a code called the American Standard code for Information Interchange (ASCII) .This code uses 7 bits for each symbol.

Extended ASCII

To make the size of each pattern 1 byte (8 bits), an extra 0 is augmented at the left the ASCII bit patternswhich doesn't change the value of the pattern.

Unicode

To represent a symbol or code in any language Unicode is used. It uses 32 bits to represent.

ISO

The international organization for standardization known as ISO has designed a code using a 32 – bit pattern. This code can represent up to 4,294,967,296 symbols.

Numbers

Numbers are also represented by using bit patterns. Instead of using ASCII to represent numbers, the number is directly converted to a binary number.

Images

Images are also represented by bit patterns. An image is divided into a matrix of pixels (The smallest element of an image) where each pixel is a small dot having dimension. Each pixel is assigned a bit pattern. The size and value of the pattern depends on the image.

Audio

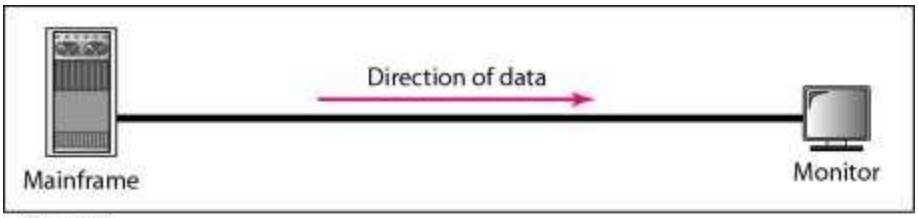
Audio is the recording or broadcasting of sound or music. Audio is by nature different from text, numbersor images. It is continuous not discrete.

Video

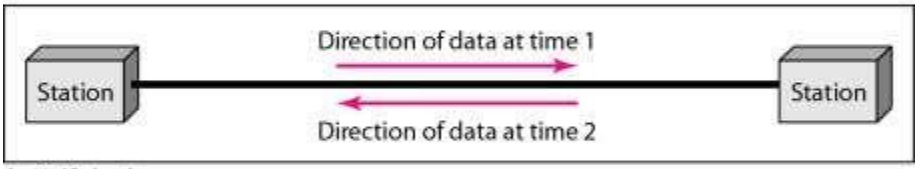
Video is the recording or broadcasting of picture or movie. Video can be produced either a continuous entity or it can be a combination of images.

Direction of data flow

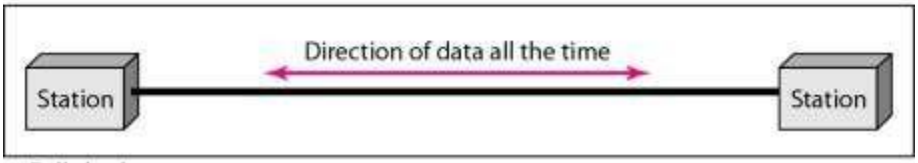
Two devices can communicate in simplex, half-duplex or full-duplex mode.



a. Simplex



b. Half-duplex



c. Full-duplex

Simplex:
In simplex mode, the communication is unidirectional. Only one of the devices on a link can transmit; the other can only receive.
Ex. Keyboard and monitor

Half-duplex
In half-duplex mode, each station can both transmit and receive but not at the same time. When one device is sending, the other can only receive.
Ex. Walkie-talkies and CB (citizen band radios)

Full-duplex
In full-duplex mode, both stations can transmit and receive simultaneously.Ex. Telephone network
When two people are communicating by a telephone line, both can listen and talk at the same time.

Network definition:

- A network is set of devices (nodes) connected by communication links (media)
- A node can be a computer, printer or other device capable of sending and/or receiving data
- Link connecting the devices are often called communication channels
- Most network use distributed processing.

Distributed Processing
Networks use distributed processing in which a task divided among multiple computers. Separate computers handle a subset instead of a single machine responsible for all aspects of a process.

Performance

Performance can be measured in terms of transit time, response time, number of users, type of transmission medium, and capabilities of the connected hardware and the efficiency of the software.

Transit time

The time required for a message to travel from one device to another.

Response time

The time spent between an inquiry and a response

Reliability

It is measured by the frequency of failure and time required to recover from a failure.

Security

Network security is protecting data from unauthorized access.

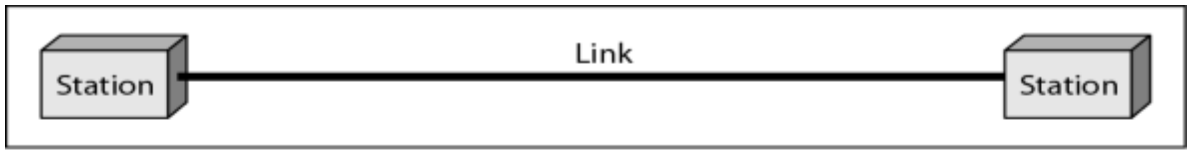
Type of connection

Two types of connections

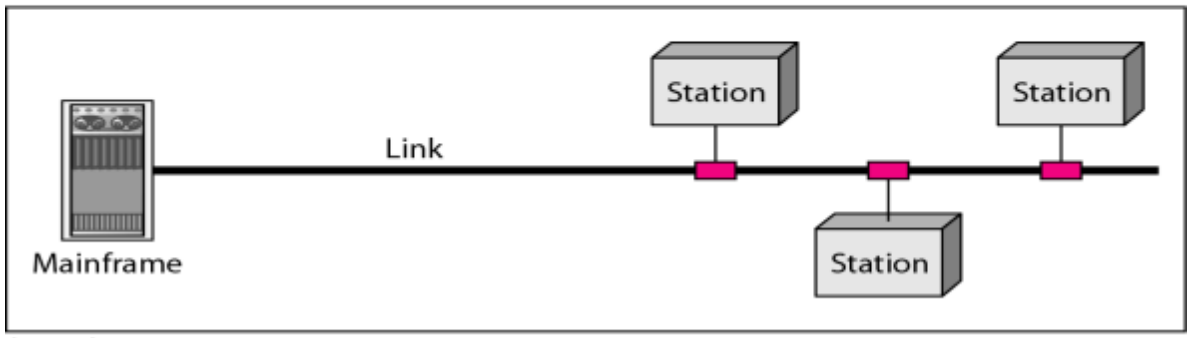
a. Point-to-point
b. Multipoint

In point-to-point connection the two devices are connected by a dedicated link. The entire capacity of the link is reserved for transmission between those two devices.

A multipoint (also known as multidrop) connection is one in which more than two specific devices share a single link. The capacity of the channel is shared either spatially or temporally.



a. Point-to-point



b. Multipoint

What is Network Topology?

The network topology defines how the different nodes, devices, and connections in the network are physically or logically organized with each other.

when we build a network for organization, home, building etc. we need to build a map and that

map is called network topology.

Types of Network Topology

Basically, there are two types of topologies in a computer network which are discussed below:

Physical Network Topology

The physical network topology deals with the actual connections like wires, cables, etc. and the arrangement of networking devices. you can say that it is the physical layout of devices, computers, and cables in the network.

Logical Network Topology

The logical network topology tells about how the network is setup, lt defines the routng path, from where data flow from one computer to another. Virtual and Cloud resources are a good example of Logical network topology

Point to Point

Point-to-point networks are a very basic and simple type of networks containing exactly two hosts that can be computer, switches, routers, servers which directly connected end to end using a single piece of cable. In simple the receiving end of one node (Destination) is connected to the sending end of other host.

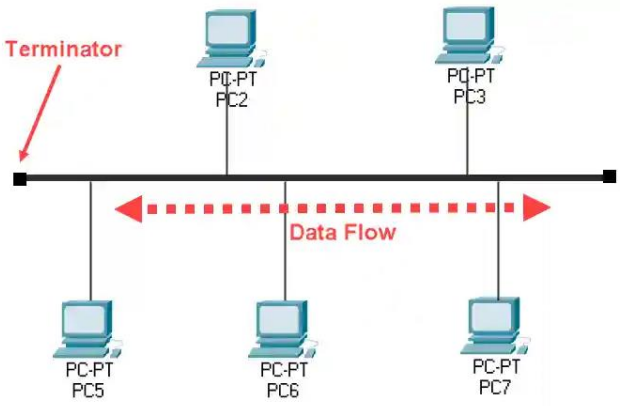
Bus Network Topology

In a Bus topology, a common bus or medium is used for communication in the network i.e, It uses a single cable that work like a backbone of the entire network, but it can link more than two hosts.

Its working is simple so when a sender sends a message, all other computers that are connected to the network can hear it, but only the receiver accepts that message and others rejects it. Here the failure of one device does not affect other devices. However, the failure of the common communication line can affect all other devices that result in to stop working of the network.

In the below picture you can see both ends of the cable have a line terminator. The terminator removes the data from the line. Bus technology as soon as it reaches the extreme end. Data flow in Bust topology is one-directional and this topology is mainly used for small networks like

LAN, etc.



Advantages of Bus Network Topology:

1. Easy to install and use.
2. If one node stop functioning, it will not affect other connected nodes.
3. Less cabling is required because it's used in short areas.
4. It is in the budget of every administrator.

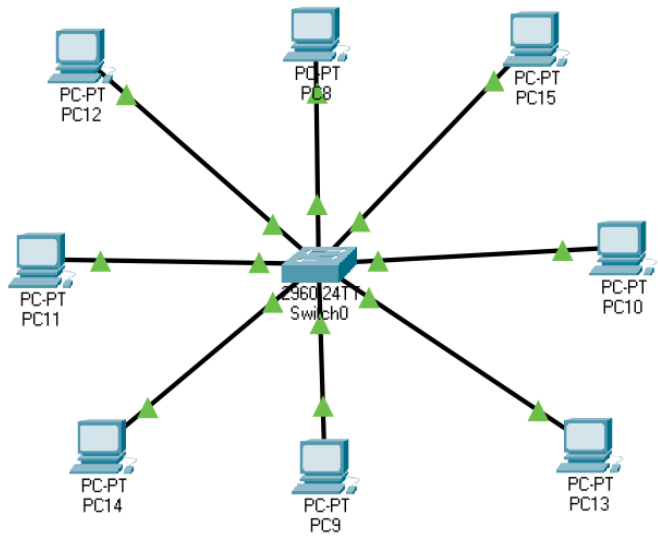
Disadvantages of Bus Network Topology:

1. Efficiency will reduce when you expand the network.
2. If the bus fails, the whole network will fail.
3. Messages are reaching all to nodes that lead to security concerns.
4. Higher chances of congestion and traffic on the bus because of its single source of communication.

Star Network Topology

In Star topology all hosts are directly connected to a centralized device that can be a hub or switch, Here the relation between the node and the central device is point-to-point. Any host requesting for service or providing service, first contact the switch or hub for communication.

This topology is also mostly used in small areas like LAN's (Local Area Network) and it provides security and speed.



Star Topology

Advantages of Star Network Topology:

1. Because of centralized control, it is easy to troubleshoot network
2. It is also less expensive and easy to expand by adding nodes.
3. If one node stop functioning, it will not affect other connected nodes.
4. Easy to reconfigure and upgrade

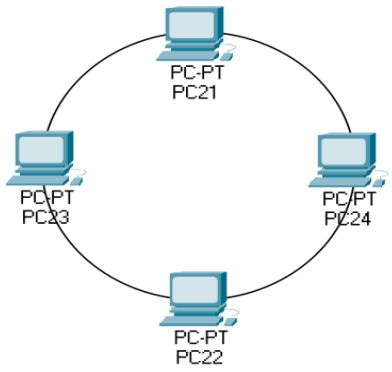
Disadvantages of Star Network Topology:

1. If the centralized device fails, the full network will fail.
2. It is limited when expanding due to the number of ports in a centralized device.

Ring Network Topology

In-ring topology, each node connects to exactly two other nodes, like a ring. When a host tries to send a message to a non-adjoining host, the data will transmit across all intermediate hosts. You need only one cable to expand this network.

Failure of any one host will stop the working of the whole ring. Here all the machines are connected with each other in a closed-loop. This topology mainly used on token-based systems where the token travel in a loop in a particular direction.



Ring Topology

Advantages of Ring Network Topology:

1. Easy to install due to low requirements of cables.
2. Reduces data collision.
3. Easy to troubleshoot as the token will not pass through the faulty nodes.
4. Each node gets the same time interval.

Disadvantages of Ring Network Topology:

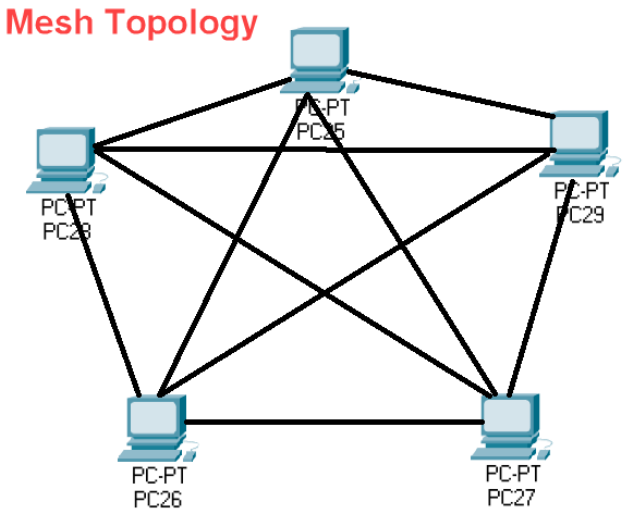
1. If any one node fails, the whole network stops communication.
2. Slow data travelling speed as every message has to go through the ring path
3. Hard to reconfigure which always lead to the breakage of the ring.

Mesh Network Topology

In Mesh network topology hosts are interconnected with each other. This is the topology where every host that is present in the network are directly connected with each other without any centralized device.

Mesh network topology further has two types::

1. **Full Mesh:** In this network each node connected with every host that reconnected to the network.
2. **Partial Mesh:** As its name here some nodes are not connected to every node.



Advantages of Mesh Network Topology:

1. Dedicated connection to every host that provides fast communication.
2. No congestion or traffic problems.
3. No broadcasting maintains privacy and security issues because of the presence of a separate channel for communication.
4. If one node fails, the other will be alternatively available in the network.

Disadvantages of Mesh Network Topology:

1. Lots of cables required to build this topology.
2. Very Expensive.
3. As it looks in the diagram it is also complex to implement.
4. Difficult to maintain.

Tree Network Topology

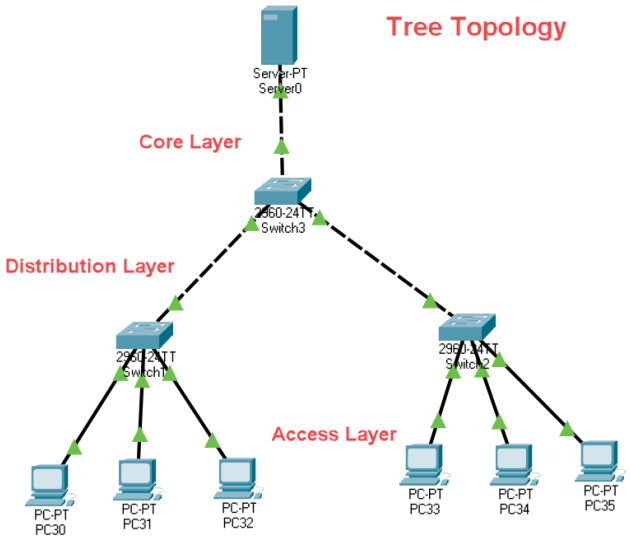
In Tree network topology all nodes are connected to the same cable and those connections can be directly and indirectly. You can also say that this topology is a mix of bus and star topology..

This topology is a hierarchy i.e, The entire network is divided into parts, so that can be easily managed and maintained. Here a root hub and all the other sub-hubs are connected to each other.

This topology is multiple layers of the network where three are main layers that responsible to build Tree network topology:

1. **Access Layer:** It is the lowermost layer that connects all nodes with it
2. **Distribution Layer:** This is the layer that works in the middle of both the core layer and access layer.

3. **Core Layer:** The main core layer is the root layer and works on the upper part of the network.



4.

Advantages of Tree Network Topology:

1. Hierarchy structure makes it easy to troubleshoot.
2. Almost no data loss while transmitting.
3. A very scalable topology.
4. Other networks will not be affected if one of them fails.

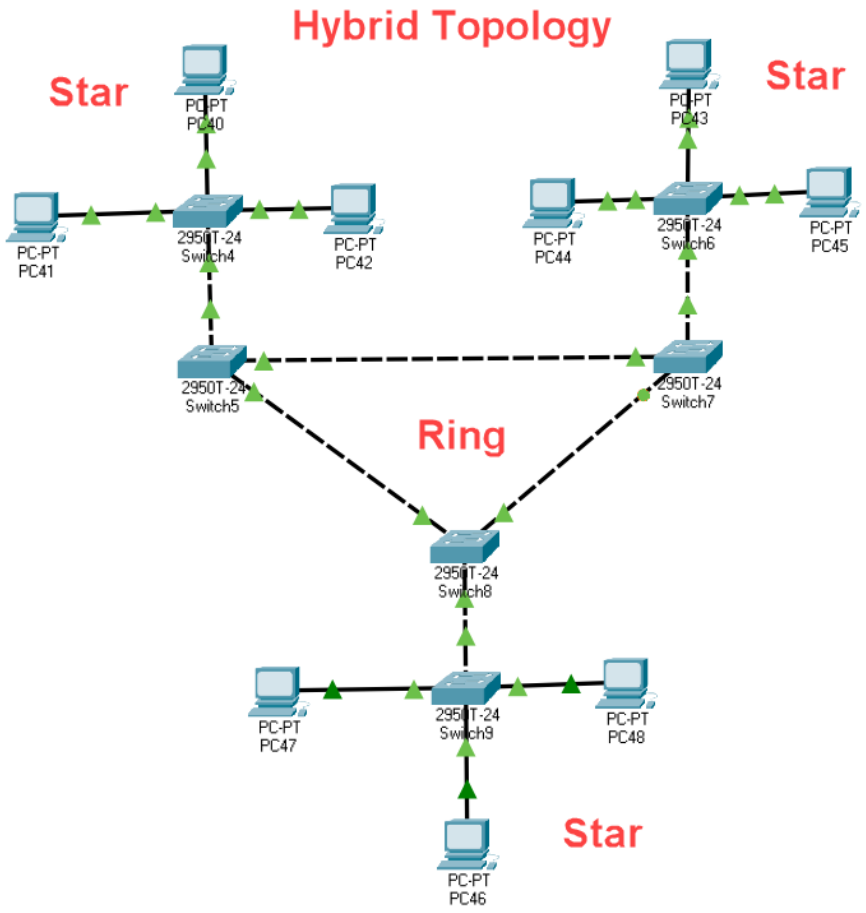
Disadvantages of Tree Network Topology:

1. Lots of hardware and cables required that makes it expensive.
2. Difficult to implement.
3. It is very hard to maintain
4. It requires high maintenance.

Hybrid Network Topology

A network is said to be Hybrid if it including two or more topologies i.e, a combination of other topologies. As you can see in the below image there are two different topologies start and ring that making a Hybrid network topology.

It is a very smart type of topology that inherits all benefits of other topologies to make an efficient hybrid topology. Internet is the most common example of the largest Hybrid topology



Advantages of Hybrid Network Topology:

1. It is capable to manage a large number of nodes.
2. It is a very flexible topology that can be modified according to the requirements.
3. Very Reliable and Secure
4. If one node fails it will not affect others or an entire network

Disadvantages of Hybrid Network Topology:

1. Very Complex design.
2. Expensive to implement because of multiple topologies.

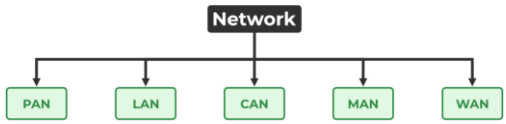
Protocols

- A protocol is a set of rules that governs data communication; the key elements of aprotocol are
- Syntax – data formats and Signal levels
- Semantics – control information and error handling
- Timing – speed matching and sequencing

Types of Computer Networks

There are mainly five types of Computer Networks

1. Personal Area Network (PAN)
2. Local Area Network (LAN)
3. Campus Area Network (CAN)
4. Metropolitan Area Network (MAN)
5. Wide Area Network (WAN)

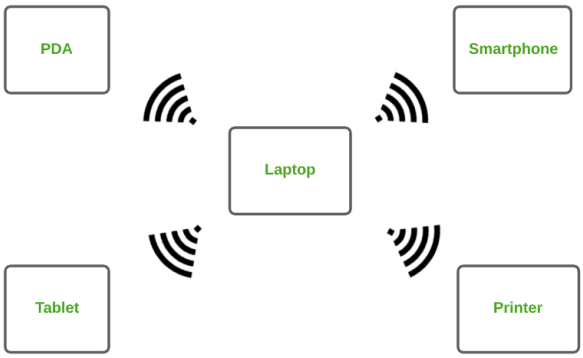


1. Personal Area Network (PAN)

PAN is the most basic type of computer network. This network is restrained to a single person, that is, communication between the computer devices is centered only on an individual's workspace. PAN offers a network range of 1 to 100 meters from person to device providing communication. Its transmission speed is very high with very easy maintenance and very low cost.

This uses Bluetooth**,** IrDA**,** and Zigbee as technology.

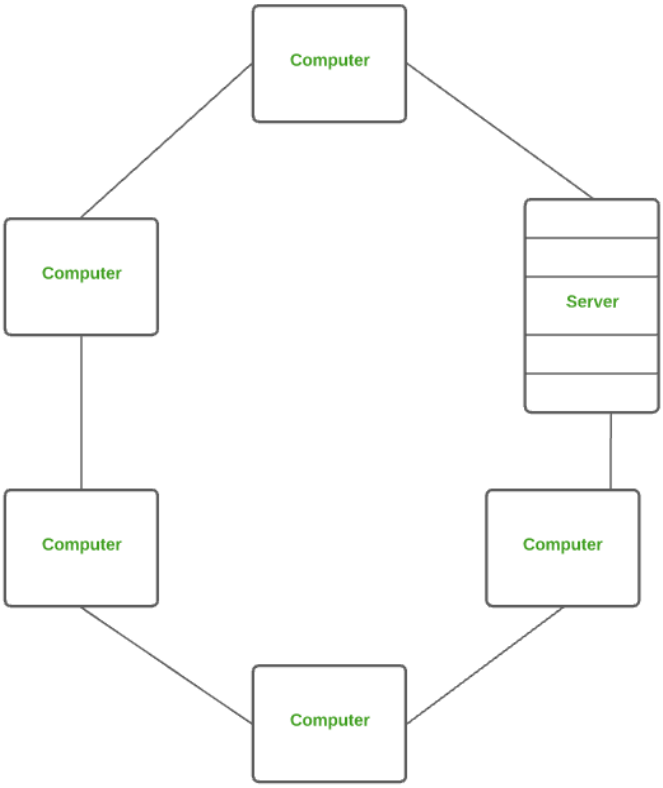
Examples of PAN are USB, computer, phone, tablet, printer, PDA, etc.



2. Local Area Network (LAN)

LAN is the most frequently used network. A LAN is a computer network that connects computers through a common communication path, contained within a limited area, that is, locally. A LAN encompasses two or more computers connected over a server. The two important technologies involved in this network are Ethernet and Wi-fi. It ranges up to 2km & transmission speed is very high with easy maintenance and low cost.

Examples of LAN are networking in a home, school, library, laboratory, college, office, etc.

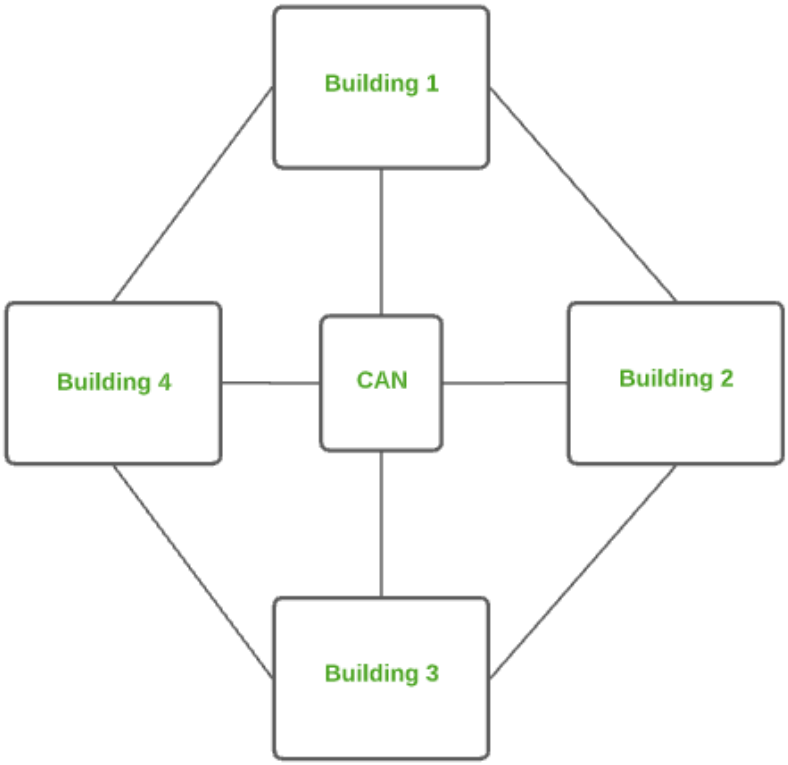


3. Campus Area Network (CAN)

CAN is bigger than a LAN but smaller than a MAN. This is a type of computer network that is usually used in places like a school or colleges. This network covers a limited geographical area that is, it spreads across several buildings within the campus. CAN mainly use Ethernet technology with a range from 1km to 5km.

Its transmission speed is very high with a moderate maintenance cost and moderate cost.

Examples of CAN are networks that cover schools, colleges, buildings, etc.

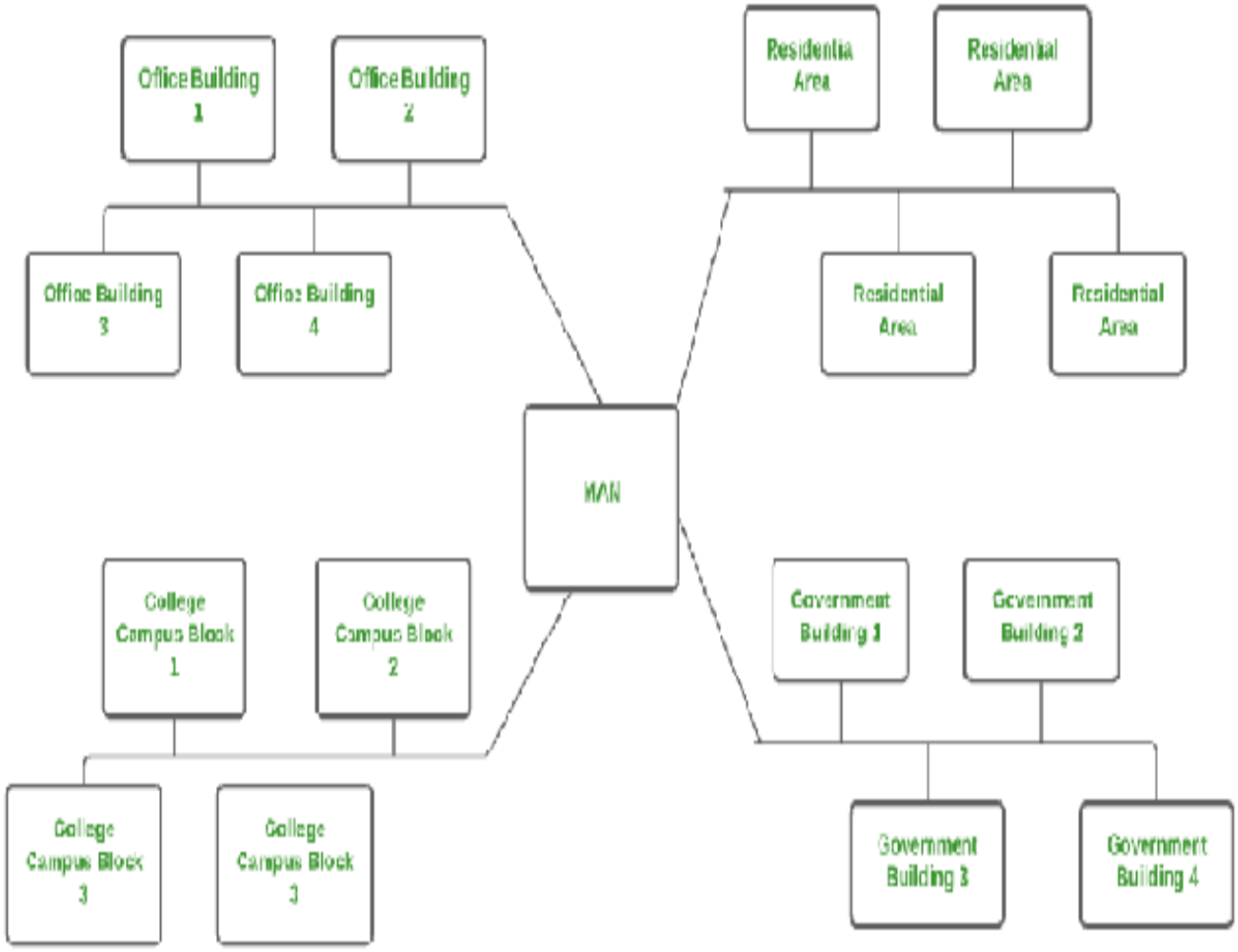


Campus Area Network (CAN)

4. Metropolitan Area Network (MAN)

A MAN is larger than a LAN but smaller than a WAN. This is the type of computer network that connects computers over a geographical distance through a shared communication path over a city, town, or metropolitan area. This network mainly uses FDDI, CDDI, and ATM as the technology with a range from 5km to 50km. Its transmission speed is average. It is difficult to maintain and it comes with a high cost.

Examples of MAN are networking in towns, cities, a single large city, a large area within multiple buildings, etc.

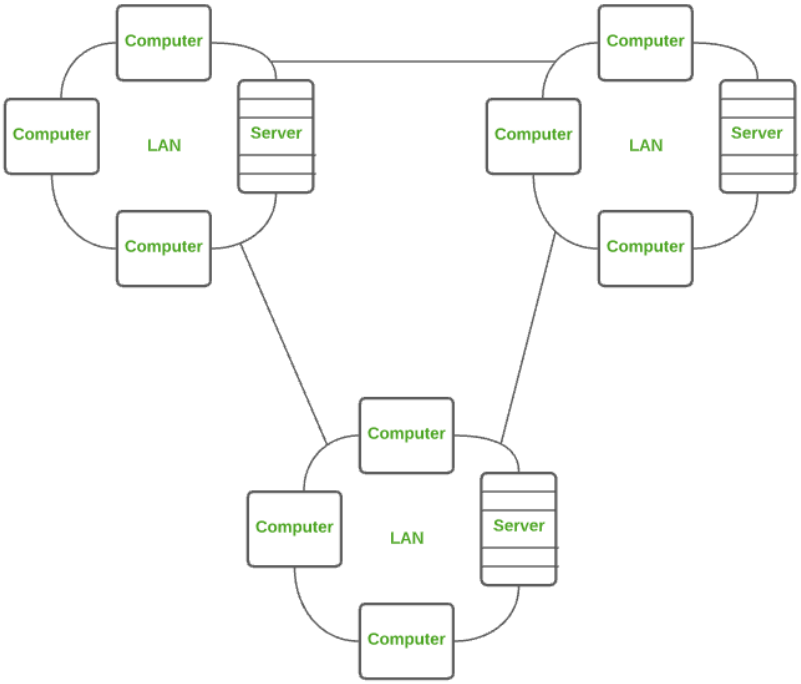


5. Wide Area Network (WAN)

WAN is a type of computer network that connects computers over a large geographical distance through a shared communication path. It is not restrained to a single location but extends over many locations. WAN can also be defined as a group of local area networks that communicate with each other with a range above 50km.

Here we use Leased-Line & Dial-up technology. Its transmission speed is very low and it comes with very high maintenance and very high cost.

The most common example of WAN is the Internet.



Wide Area Network (WAN)

Comparison between Different Computer Networks

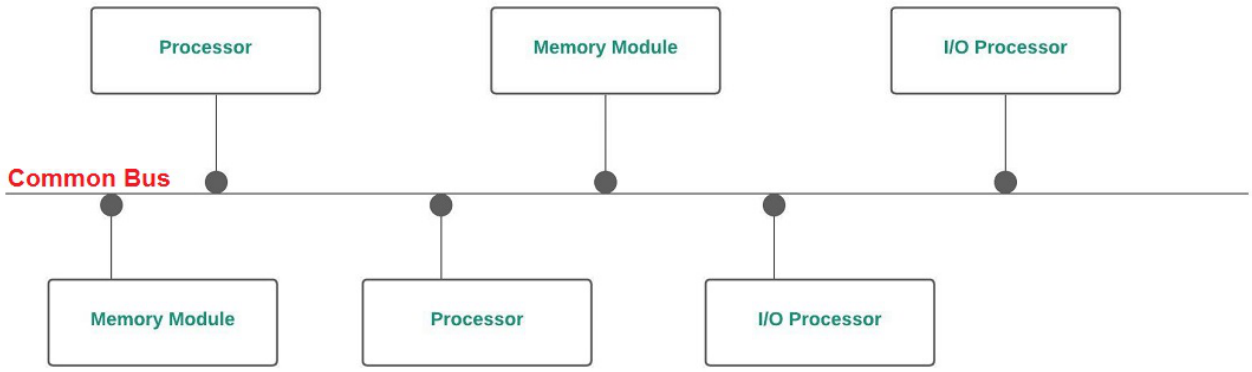
parameters	**PAN**	**LAN**	**CAN**	**MAN**	**WAN**
Full Name	Personal Area Network	Local Area Network	Campus Area Network	Metropolitan Area Network	Wide Area Network
Technology	Bluetooth, IrDA,Zigbee	Ethernet & Wifi	Ethernet	FDDI, CDDi. ATM	Leased Line, Dial-Up
Range	1-100 m	Upto 2km	1 – 5 km	5-50 km	Above 50 km
Transmission Speed	Very High	Very High	High	Average	Low

Ownership	Private	Private	Private	Private or Public	Private or Public
Maintenance	Very Easy	Easy	Moderate	Difficult	Very Difficult
Cost	Very Low	Low	Moderate	High	Very High

Interconnection structures :
The processors must be able to share a set of main memory modules & I/O devices in a multiprocessor system. This sharing capability can be provided through interconnection structures. The interconnection structure that are commonly used can be given as follows –

1. Time-shared / Common Bus
2. Cross bar Switch
3. Multiport Memory
4. Hypercube System
5. Multistage Switching Network

1. Time-shared / Common Bus (Interconnection structure in Multiprocessor System) :
In a multiprocessor system, the time shared bus interconnection provides a common communication path connecting all the functional units like processor, I/O processor, memory unit etc. The figure below shows the multiple processors with common communication path (single bus).



Single-Bus Multiprocessor Organization

Advantages –

- Inexpensive as no extra hardware is required such as switch.
- Simple & easy to configure as the functional units are directly connected to the bus .

Disadvantages –

- Major fight with this kind of configuration is that if malfunctioning occurs in any of the bus interface circuits, complete system will fail.

2. Crossbar Switch :

A point is reached at which there is a separate path available for each memory module, if the number of buses in common bus system is increased. Crossbar Switch (for multiprocessors) provides separate path for each module.

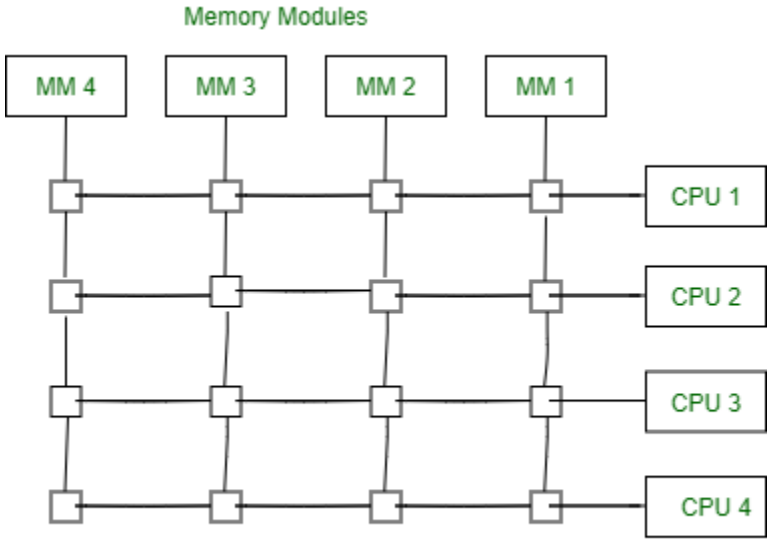


Figure - Crossbar Switch System

3.Multiport Memory :

In Multiport Memory system, the control, switching & priority arbitration logic are distributed throughout the crossbar switch matrix which is distributed at the interfaces to the memory modules.

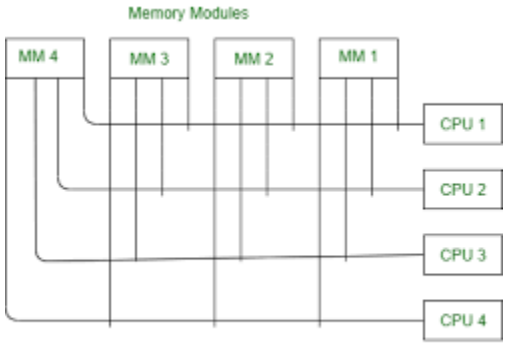


Figure - Multiport Memory System

4.Hypercube Interconnection :

This is a binary n-cube architecture. Here we can connect 2n processors and each of the processor here forms a node of the cube. A node can be memory module, I/O interface also, not necessarily processor. The processor at a node has communication path that is direct goes to n other nodes (total 2n nodes). There are total 2n distinct n-bit binary addresses.

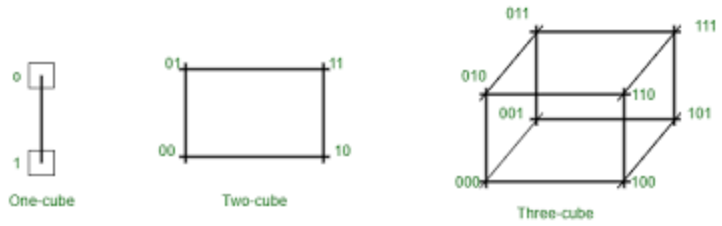
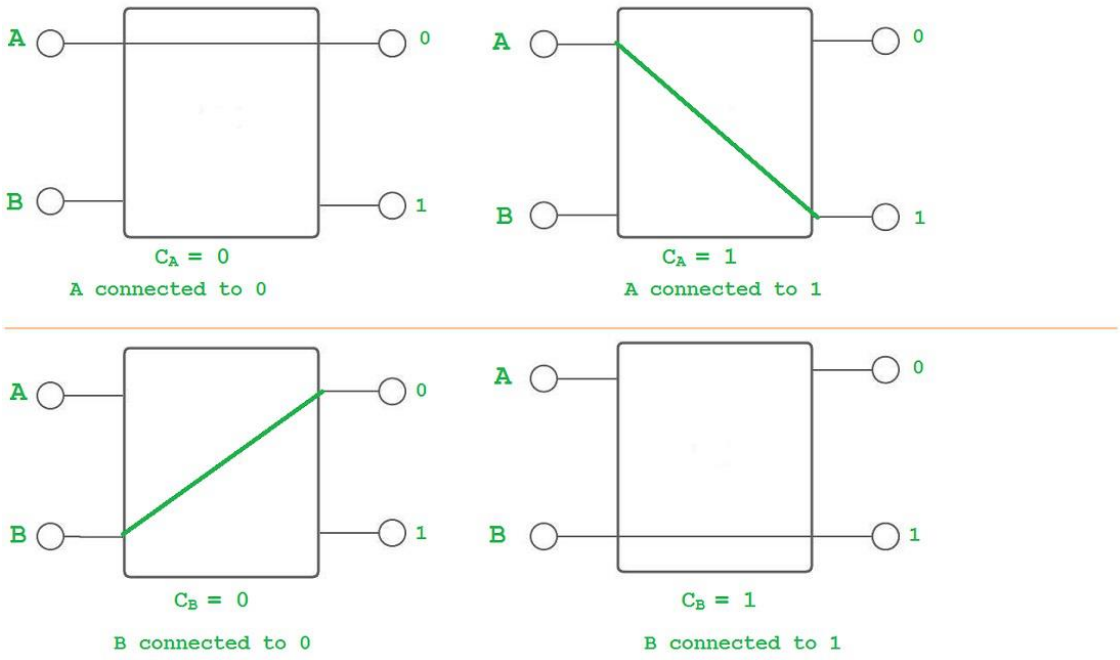


Figure - Hypercube Structures For n = 1,2,3

5.Multistage Switching Network :

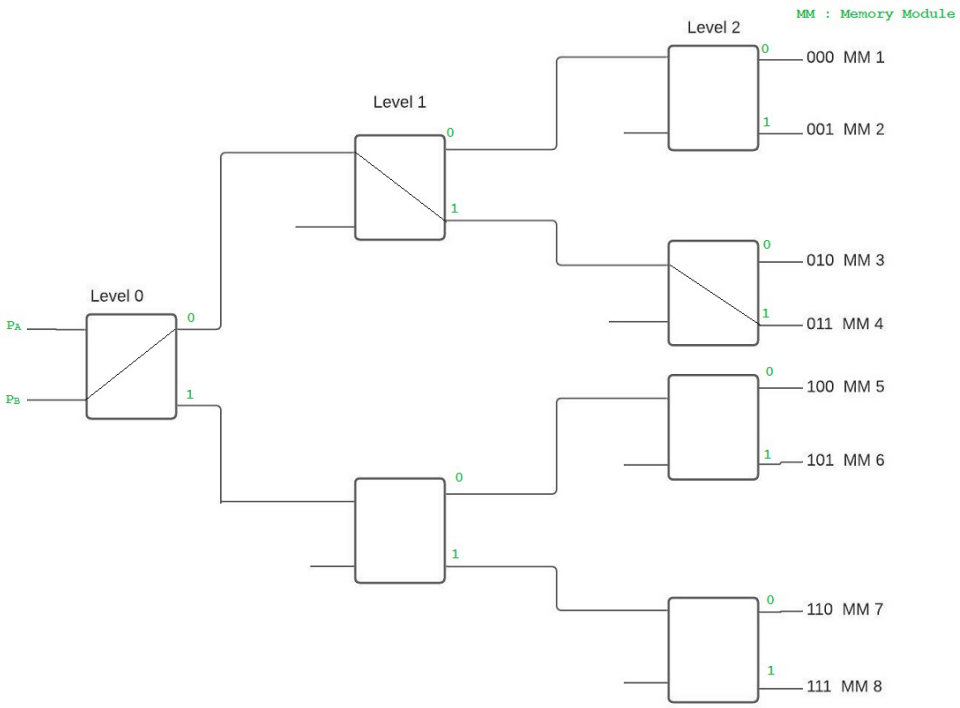
- The 2×2 crossbar switch is used in the multistage network. It has 2 inputs (A & B) and 2 outputs (0 & 1). To establish the connection between the input & output terminals, the control inputs C_A & C_B are associated.



*2 * 2 Crossbar Switch*

- The input is connected to 0 output if the control input is 0 & the input is connected to 1 output if the control input is 1. This switch can arbitrate between conflicting requests. Only 1 will be connected if both A & B require the same output terminal, the other will be blocked/ rejected.

We can construct a multistage network using 2×2 switches, in order to control the communication between a number of sources & destinations. Creating a binary tree of cross-bar switches accomplishes the connections to connect the input to one of the 8 possible destinations.



Network Standards

Network Standards are necessary to ensure that products from different manufacturers can worktogether as expected.

Why do we need standards?

- To create and maintain an open and competitive market for equipment manufacturers
- To guarantee national and international interoperability of data, telecommunication technology andprocess
- To give a fixed quality and product to the customer
- To allow the same product to be re used again elsewhere
- To aid the design and implementation of ideas
- To provide guidelines to manufacturers, vendors, government agencies and other service providersto ensure kind of interconnectivity.

Data communication standards are divided into two types

De facto (from the fact):

- Standards that have not been approved by an organized body.
- It has been adopted as standards through widespread use.
- This is often established originally by manufacturers to define the functionality of a new product ortechnology.

De jure (by law):

- Those that have been legislated by an officially recognized body.

Standards organizations

Standards are developed through the cooperation of standards creation committees,

forums, andgovernment regulatory agencies.

Standards Creation Committees

ITU, International Telecommunications Union formerly the (CCITT):

- It a standard for telecommunication in general and data systems in particular.

ISO, International Standards Organization:

- It is active in developing cooperation in the realms of scientific, technological and economic activity.

ANSI, American National Standards Institute:

- It is a private nonprofit corporation and affiliated with the U.S federal government.

IEEE, Institute of Electrical and Electronics Engineers:

- It aims to advance theory, creativity, and product quality in the fields of electrical engineering, electronics radio and in all related branches of Engineering.
- It oversees the development and adoption of international standards for computing and communications.

EIA, Electronic Industries Association:

- It is a nonprofit organization devoted to the promotion of electronics manufacturing concerns.
- Its activities include public awareness education and lobbying efforts in addition to standardsdevelopment.
- It also made significant contributions by defining physical connection interfaces and electronicsignaling specifications for data communication.