

## Fundamentals of Networking Course

### **What is a Computer Network?**

A network is any collection of independent computers that communicate with one another over a shared network medium. A computer network is a collection of two or more connected computers.

The computers on a network may be linked through cables, telephone lines, radio waves, satellites, or infrared light beams.

When these computers are joined in a network, people can share files and peripherals such as modems, printers, tape backup drives, or CD-ROM drives. When networks at multiple locations are connected using services available from phone companies, people can send e-mail, share links to the global Internet, or conduct video conferences in real time with other remote users.

### **Every network includes:**

- At least two computers Server or Client workstation.
- Networking Interface Card's (NIC)
- A connection medium, usually a wire or cable, although wireless communication between networked computers and peripherals is also possible.
- Network Operating system software, such as Microsoft Windows NT or 2000, Novell NetWare, Unix and Linux.

### **Benefits of Computer Networks**

- Sharing hardware or software
- Centralize administration and support
- Increased speed
- Reduced cost
- Improved security
- Centralized software managements
- Electronic mail
- Flexible access

### **Disadvantages of Computer Networks**

- High cost of installation
- Requires time for administration
- Failure of server & cables

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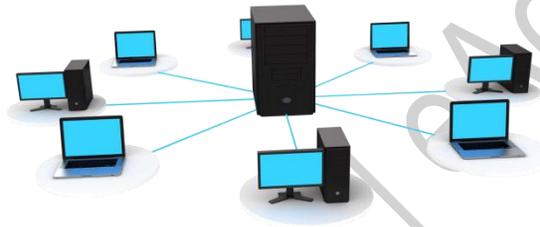
## Types of Networks

Depending upon the geographical area covered by a network, it is classified as,

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

### Local Area Network (LAN)

A LAN is a network that is used for communicating among computer devices, usually within an office building or home. LANs can be a single network installed in a home or small office, the definition of LAN has evolved to include interconnected local networks consisting of many hundreds of hosts, installed in multiple buildings and locations.



LAN's enable the sharing of resources such as files or hardware devices that may be needed by multiple users. LAN is limited in size, typically spanning a few hundred meters, and no more than a mile it is fast, with speeds from 10 Mbps.

LAN's can be either wired or wireless. Twisted pair, coaxial cable or fiber optic cable can be used in wired LAN's. Every LAN uses a protocol which means a set of rules that governs how packets are configured and transmitted.

LANs consist of the following components :

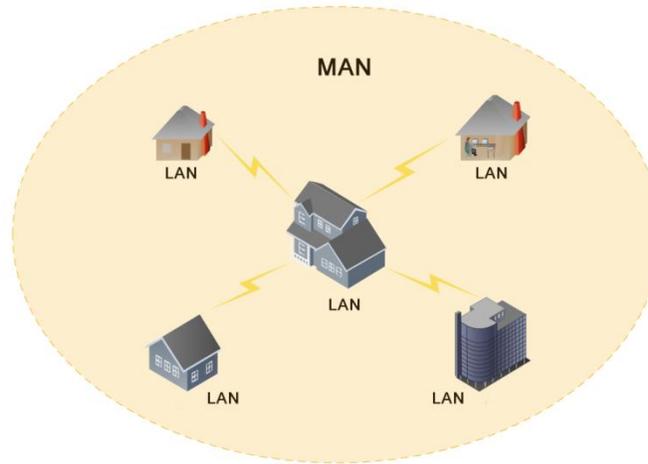
- Computers
- Network interface cards
- Peripheral devices
- Networking media
- Network devices

LAN include following technologies :

- Ethernet
- Token Ring
- FDDI

## Metropolitan Area Network (MAN)

A metropolitan area network (MAN) is a large computer network that usually spans a city or a large campus. A MAN is optimized for a larger geographical area than a LAN, ranging from several blocks of buildings to entire cities.

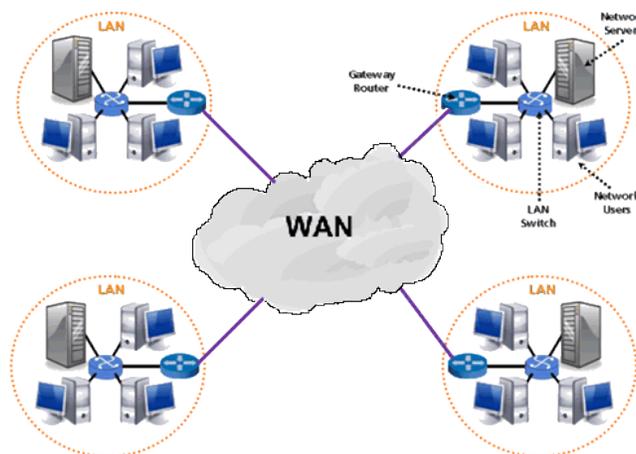


A MAN might be owned and operated by a single organization, but it usually will be used by many individuals and organizations. The network consists of various buildings interconnected via either wireless or fiber optics backbones. A MAN often acts as a high speed network to allow sharing of regional resources. A MAN typically covers an area of between 5 and 50 km diameter.

## Wide Area Network (WAN)

A network that spans broader geographical area than a local area network over public communication network. WANs interconnect LANs, which then provide access to computers or file servers in other locations. Multiple LANs can be connected together using devices such as bridges, routers, or gateways, which enable them to share data. To cover great distances, WANs may transmit data over leased high-speed phone lines or wireless links such as satellites.

The world's most popular WAN is the Internet.



WANs connect user networks over a large geographical area, they make it possible for businesses to communicate across great distances. WANs allow computers, printers, and other devices on a LAN to be shared with distant locations. WANs provide instant communications across large geographic areas.

WANs are designed to do the following:

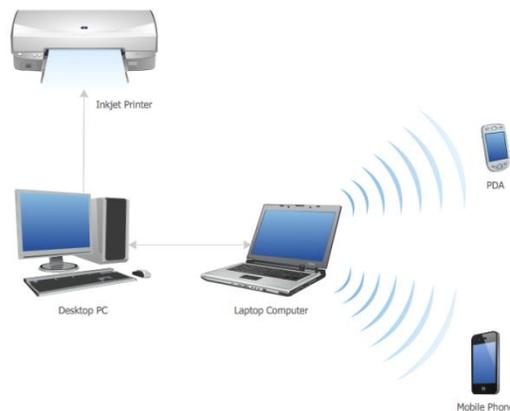
- Operate over a large and geographically separated area
- Allow users to have real-time communication capabilities with other users
- Provide full-time remote resources connected to local services
- Provide e-mail, Internet, file transfer, and e-commerce services

WAN include following technologies :

- Modems
- Integrated Services Digital Network (ISDN)
- Digital subscriber line (DSL)
- Synchronous Optical Network (SONET)

### Personal Area Network (PAN)

A PAN is a network that is used for communicating among computers and computer devices (including telephones) in close proximity of around a few meters within a room. It generally consists of a mobile computer, a cell phone or personal digital assistant. PAN enables the communication among these devices.



It can be used for communicating between the devices themselves, or for connecting to a larger network such as the internet. PAN's can be wired or wireless. The reach of a PAN is typically a few meters.

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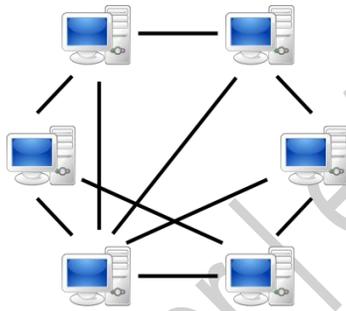
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## Network Classification by their Component Role

1. Peer To Peer Network
2. Client Server Network

### *Peer to Peer Network –*

In peer to peer network each computer is responsible for making its own resources available to other computers on the network. Each computer is responsible for setting up and maintaining its own security for these resources and each computer is responsible for accessing the required network resources from peer to peer relationships. Peer to peer network is useful for a small network containing less than 10 computers on a single LAN. Peer to peer networks do not have a central control system. There are no servers in peer networks.



### Advantages & Disadvantages of Peer To Peer Network

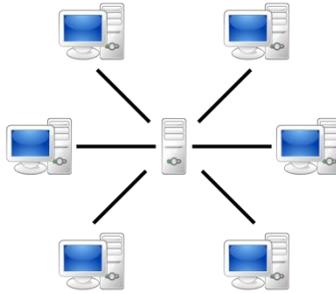
Advantages	Disadvantages
Use less expensive computer hardware	Not very secure
Easy to administer	No central point of storage or file archiving
No NOS required	Additional load on computer because of resource sharing
More built in redundancy	Hard to maintain version control
Easy setup & low cost	

### *Client Server Network –*

In client-server network relationships, certain computers act as server and other act as clients. A server is simply a computer, that available the network resources and provides service to other computers when they request it. A client is the computer running a program that requests the service from a server.

A client-server network is one in which all available network resources such as files, directories, applications and shared devices, are centrally managed and hosted and then are accessed by client.

Client server network are defined by the presence of servers on a network that provide security and administration of the network.



### Advantages And Disadvantages of Client-Server Network

Advantages	Disadvantages
Very secure	Requires professional administration
Better performance	More hardware intensive
Centralized backup	More software intensive
Very reliable	Expensive dedicated software

### Types of Servers

1. **File Server:** These servers provide the services for storing, retrieving and moving the data. A user can read, write, exchange and manage the files with the help of file servers.
2. **Application Server:** The expensive software and additional computing power can be shared by the computers in a network with the help of application servers. Application server Hosts web apps (computer programs that run inside a web browser) allowing users in the network to run and use them, without having to install a copy on their own computers.
3. **Web Server:** Hosts web pages. A web server is what makes the World Wide Web possible. Each website has one or more web servers. The entire exchange is mediated by the browser and server talking to each other using HTTP.
4. **Mail Server:** Almost as ubiquitous and crucial as Web servers, mail servers move and store mail over corporate networks (via LANs and WANs) and across the Internet.
5. **Database server:** It is a type of application server. It allows the use to access the centralized strong database.

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## Computer Network Topologies

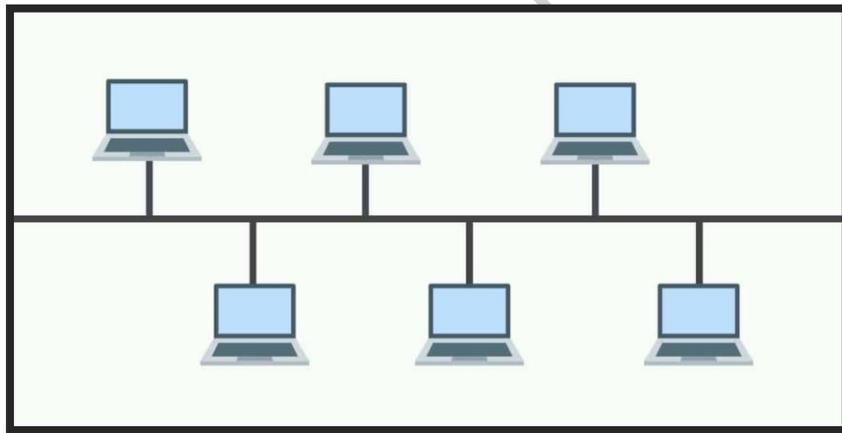
Network topologies describe the ways in which the elements of a network are mapped. They describe the physical and logical arrangement of the network nodes. The physical topology of a network refers to the configuration of cables, computers, and other peripherals.

### Different Types of Topologies

- 1) Bus Topology
- 2) Star Topology
- 3) Ring Topology
- 4) Mesh Topology
- 5) Tree Topology
- 6) Hybrid Topology

#### 1. Bus Topology

All the nodes (file server, workstations, and peripherals) on a bus topology are connected by one single cable. A bus topology consists of a main run of cable with a terminator at each end. All nodes (file server, workstations, and peripherals) are connected to the linear cable. Popular on LANs because they are inexpensive and easy to install.



#### *Advantages of Bus Topology*

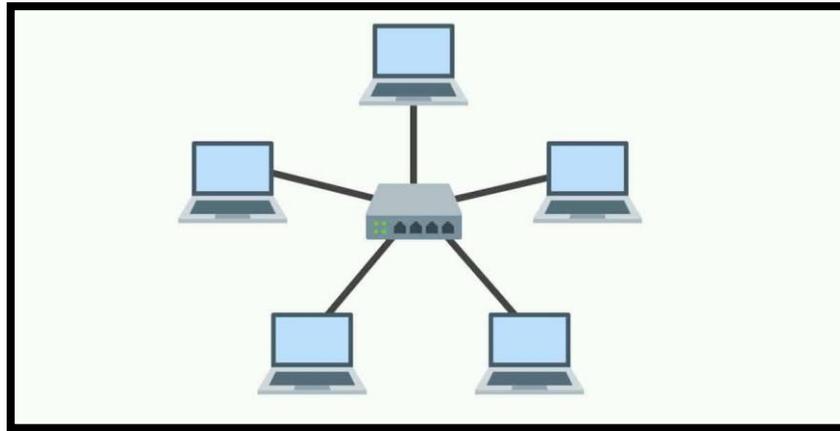
- It is Cheap, easy to handle and implement.
- Require less cable
- It is best suited for small networks.

#### *Disadvantages of Bus Topology*

- The cable length is limited. This limits the number of stations that can be connected.
- This network topology can perform well only for a limited number of nodes.

## 2. Star Topology

In a star network, each node (file server, workstations, and peripherals) is connected to a central device called a hub. The hub takes a signal that comes from any node and passes it along to all the other nodes in the network. Data on a star network passes through the hub, switch, or concentrator before continuing to its destination. The hub, switch, or concentrator manages and controls all functions of the network. The star topology reduces the chance of network failure by connecting all of the systems to a central node.



### *Advantages of Star Topology*

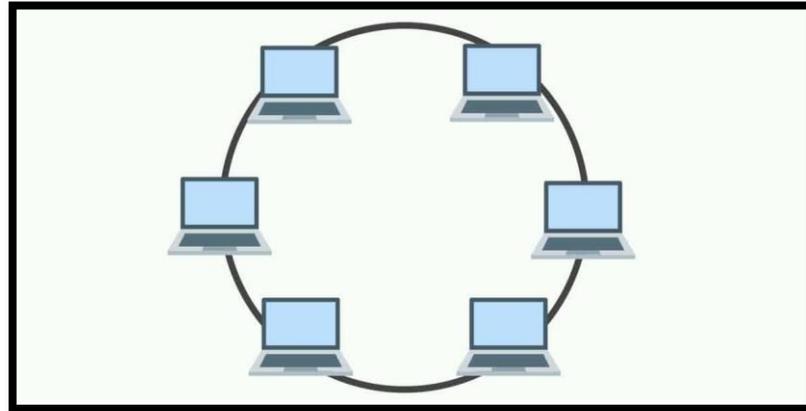
- Easy to manage
- Easy to locate problems (cable/workstations)
- Easier to expand than a bus or ring topology.
- Easy to install and wire.
- Easy to detect faults and to remove parts.

### *Disadvantages of Star Topology*

- Requires more cable length than a linear topology.
- If the hub or concentrator fails, nodes attached are disabled.
- More expensive because of the cost of the concentrators.

## 3. Ring Topology

In a ring network, every device has exactly two neighbors for communication purposes. All messages travel through a ring in the same direction. A failure in any cable or device breaks the loop and can take down the entire network. To implement a ring network we use the Token Ring technology. A token, or small data packet, is continuously passed around the network. When a device needs to transmit, it reserves the token for the next trip around, then attaches its data packet to it.



### ***Advantages of Ring Topology***

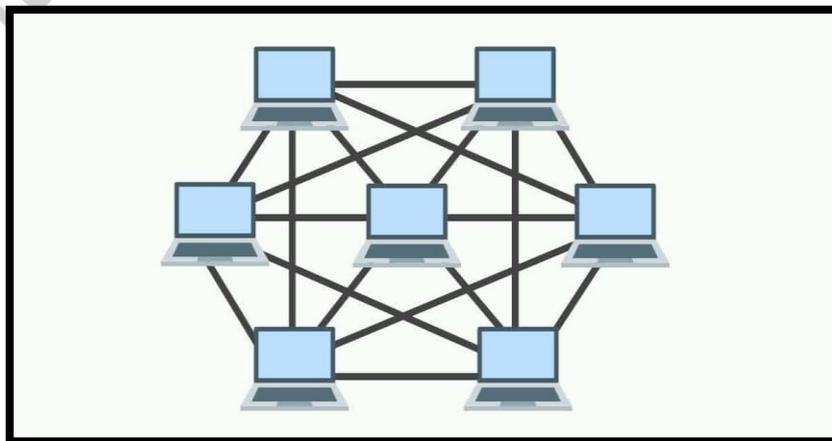
- Very orderly network where every device has access to the token and the opportunity to transmit.
- Easier to Manage than a Bus Network
- Good Communication over long distances
- Handles high volume of traffic

### ***Disadvantages of Ring Topology***

- The failure of a single node of the network can cause the entire network to fail.
- The movement or changes made to network nodes affects the performance of the entire network.

## **4. Mesh Topology**

In this topology, each node is connected to every other node in them network. Implementing the mesh topology is expensive and difficult. In this type of network, each node may send message to destination through multiple paths. While the data is travelling on the Mesh Network it is automatically configured to reach the destination by taking the shortest route which means the least number of hops.



### ***Advantages of Mesh Topology***

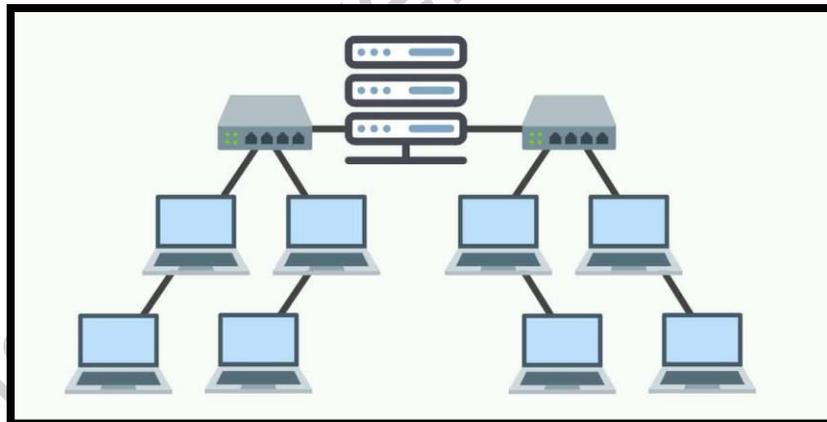
- No traffic problem as there are dedicated links.
- It has multiple links, so if one route is blocked then other routes can be used for data communication.
- Points to point links make fault identification easy.

### ***Disadvantages of Mesh Topology***

- There is mesh of wiring which can be difficult to manage.
- Installation is complex as each node is connected to every node.
- Cabling cost is high.

## **5. Tree Topology**

A tree topology (hierarchical topology) can be viewed as a collection of star networks arranged in a hierarchy. This tree has individual peripheral nodes which are required to transmit to and receive from one other only and are not required to act as repeaters or regenerators. The tree topology arranges links and nodes into distinct hierarchies in order to allow greater control and easier troubleshooting. This is particularly helpful for colleges, universities and schools so that each of the connect to the big network in some way.



### ***Advantages of Tree Topology***

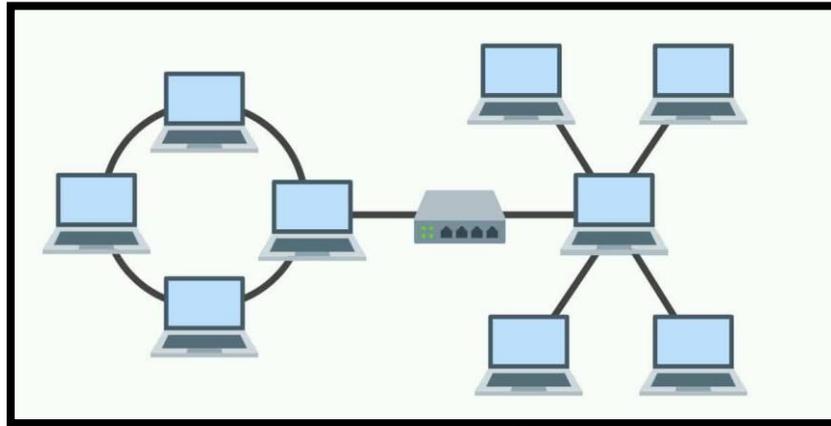
- Point-to-point wiring for individual segments.
- Supported by several hardware and software vendors.
- All the computers have access to the larger and their immediate networks.

### ***Disadvantages of Tree Topology***

- Overall length of each segment is limited by the type of cabling used.
- If the backbone line breaks, the entire segment goes down.
- More difficult to configure and wire than other topologies.

## 6. Hybrid Topology

A combination of any two or more network topologies. A hybrid topology always accrues when two different basic network topologies are connected. It is a mixture of above mentioned topologies. Usually, a central computer is attached with sub-controllers which in turn participate in a variety of topologies.



### *Advantages of Hybrid Topology*

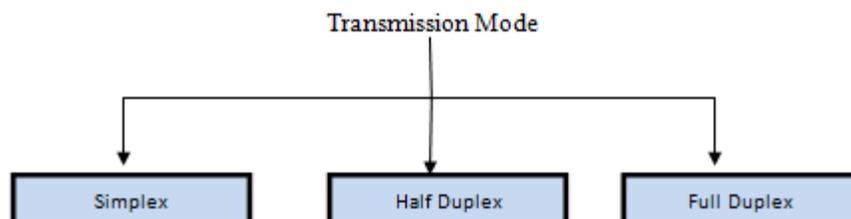
- It is extremely flexible.
- It is very reliable.

### *Disadvantages of Hybrid Topology*

- Expensive to develop & maintain

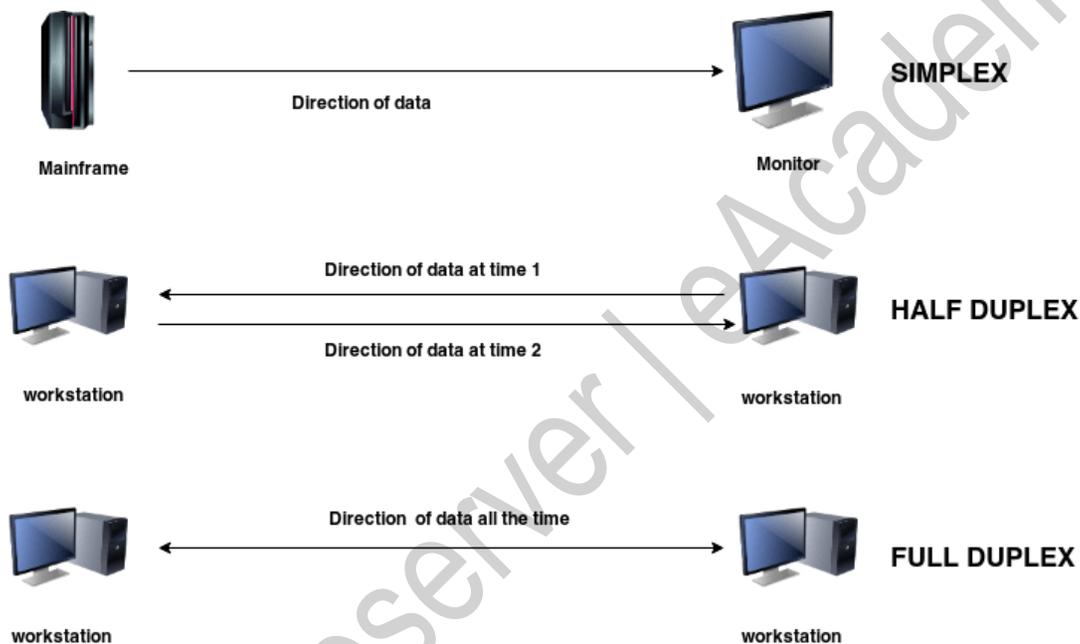
## Data Transmission Modes

Data communication is concerned specifically with the issues that must be considered when communicating data between two devices, generally computers. There are basically 3 modes of data communication.



1. Simplex
2. Half-Duplex
3. Full Duplex

- 1. Simplex** - In simplex data transmission, data is directed one way. There is no any space for data transmission to be directed the other way. The best examples which can be mentioned here are television and radio transmission.
- 2. Half-Duplex** - In Half-Duplex data transmission, data can be directed one way at a time. Though data can be transmitted both ways here, till the data transmission to one direction is ended, data cannot be transmitted to the other direction. The best example which can be shown here is Walkie-talkie.
- 3. Full Duplex** - In duplex data transmission, data can be transmitted both ways at a time. The best example which can be shown here is the telephone.

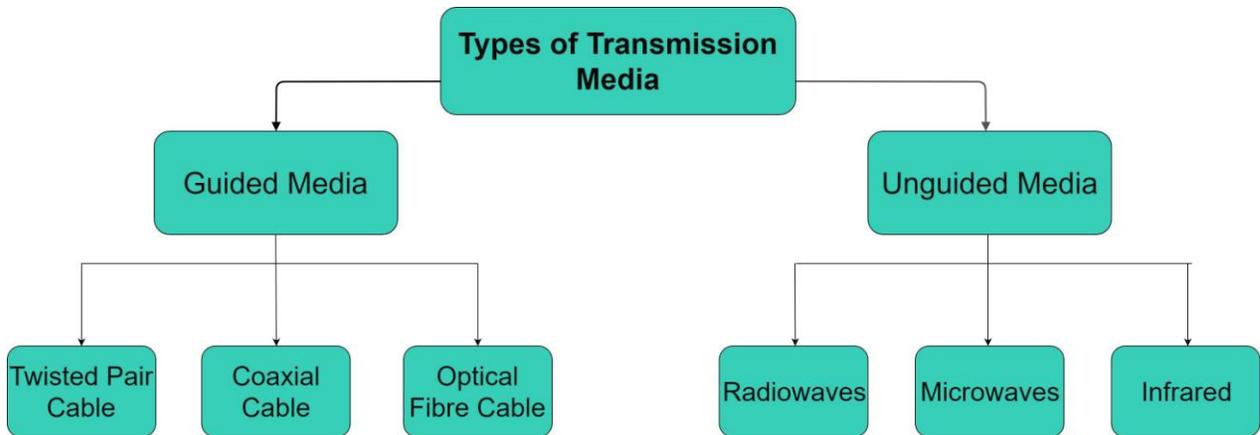


## Data Transmission Media

Transmission media can be defined as physical path between transmitter and receiver in a data transmission system. And it may be classified into two types as shown.

- 1. Guided Media:** Transmission capacity depends critically on the medium, the length, and whether the medium is point-to-point or multipoint (e.g. LAN). Examples are coaxial cable, twisted pair, and optical fiber. Example wired transmission.
- 2. Unguided Media:** provides a means for transmitting electro-magnetic signals but do not guide them. Example wireless transmission.

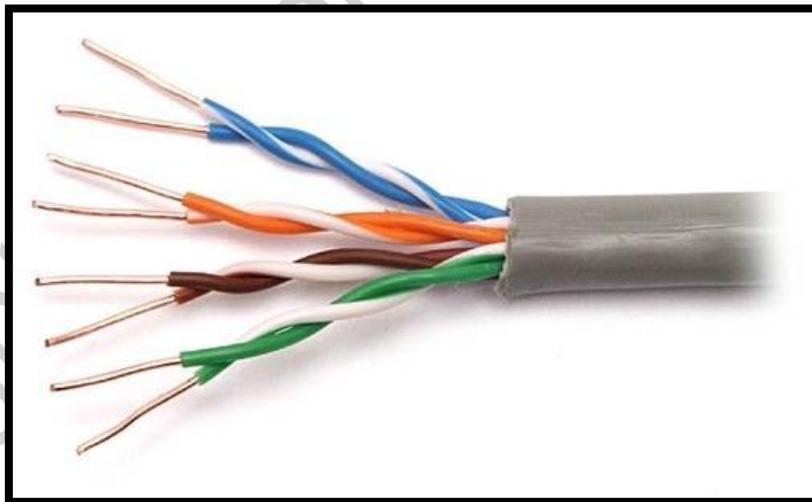
Characteristics and quality of data transmission are determined by medium and signal characteristics. For guided media, the medium is more important in determining the limitations of transmission. While in case of unguided media, the bandwidth of the signal produced by the transmitting antenna and the size of the antenna is more important than the medium.



## Guided Media Transmission

### **Twisted Pair Cable**

In twisted pair technology, two copper wires are strung between two points. The two wires are typically "twisted" together in a helix to reduce interference between the two conductors. Twisting decreases the crosstalk interference between adjacent pairs in a cable. Typically, a number of pairs are bundled together into a cable by wrapping them in a tough protective sheath. Can carry both analog and digital signals. Actually, they carry only analog signals. However, the "analog" signals can very closely correspond to the square waves representing bits, so we often think of them as carrying digital data.

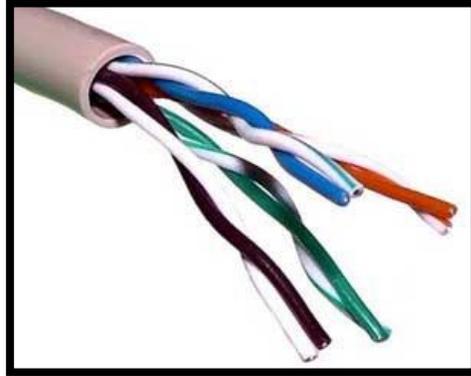


Use: The oldest and the most popular use of twisted pair are in telephony. In LAN it is commonly used for point-to-point short distance communication (say, 100m) within a building or a room.

There are two types of Twisted Pair cables. These are the Unshielded Twisted Pair and Shielded Twisted Pair.

### *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.



### 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
- ✓ Comparitively faster

**Disadvantages:**

- ✓ Comparitively difficult to install and manufacture
- ✓ More expensive
- ✓ Bulky

**Coaxial Cable**

With ``coax'', the medium consists of a copper core surrounded by insulating material and a braided outer conductor. Co-axial cable has superior frequency characteristics compared to twisted-pair and can be used for both analog and digital signaling. Coaxial cables are used both for baseband and broadband communication. One of the most popular use of co-axial cable is in cable TV (CATV) for the distribution of TV signals. Another importance use of co-axial cable is in LAN.

**Advantages:**

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

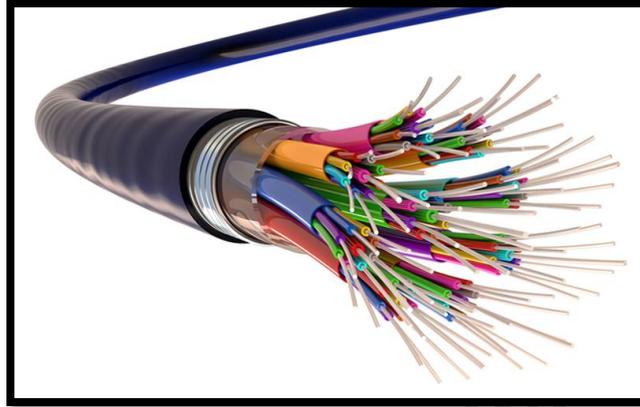
**Disadvantages:**

- ✓ Single cable failure can disrupt the entire network

## Fiber Optics

In fiber optic technology, the medium consists of a hair-width strand of silicon or glass, and the signal consists of pulses of light. For instance, a pulse of light means ``1", lack of pulse means ``0". It has a cylindrical shape and consists of three concentric sections: the core, the cladding, and the jacket.

Optical fiber cables are finding widespread use in long-distance telecommunications. Fiber optic cables are also used in high-speed LAN applications.



### 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

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## Unguided Media Transmission

### **Radiowaves**

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 Radiowaves for transmission.

### **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.

### **Infrared**

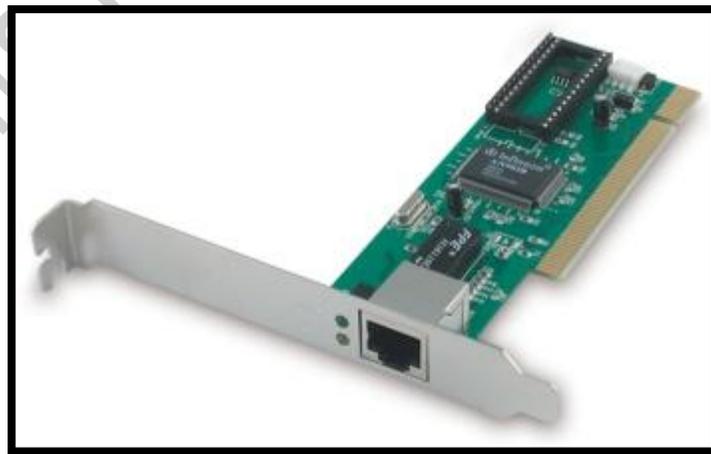
Infrared waves are used for very short distance communication. They cannot penetrate through obstacles. This prevents interference between systems. Frequency Range:300GHz – 400THz. It is used in TV remotes, wireless mouse, keyboard, printer, etc.

## Networking Hardware

Computers need networking hardware in order to connect to each other.

### ❖ Network Interface Card (NIC)

Any computer that is to be connected to a network, needs to have a network interface card (NIC). Most modern computers have these devices built into the motherboard, but in some computers you have to add an extra expansion card (small circuit board)



### ❖ Network Cable

To connect together different devices to make up a network, you need cables. Cables are still used in most networks, rather than using only wireless, because they can carry much more data per second, and are more secure.



### ❖ Router

A router can form a LAN by connecting devices within a building. It also makes it possible to connect different networks together. Homes and businesses use a router to connect to the internet. A router can often incorporate a modem within the hardware.



### ❖ Modem

A modem enables a computer to connect to the internet over a telephone line. A modem converts digital signals from a computer to analogue signals that are then sent down the telephone line. A modem on the other end converts the analogue signal back to a digital signal which another computer can understand.

Hubs, bridges and switches allow multiple devices to connect to the router and they transfer data to all devices on a network. A router is a more complex device that usually includes the capability of hubs, bridges and switches.



#### ❖ Hub

A hub broadcasts data to all devices on a network. This can use a lot of bandwidth as it results in unnecessary data being sent - not all computers might need to receive the data. A hub would be useful to link up a few games consoles for a local multiplayer game using a wired LAN.



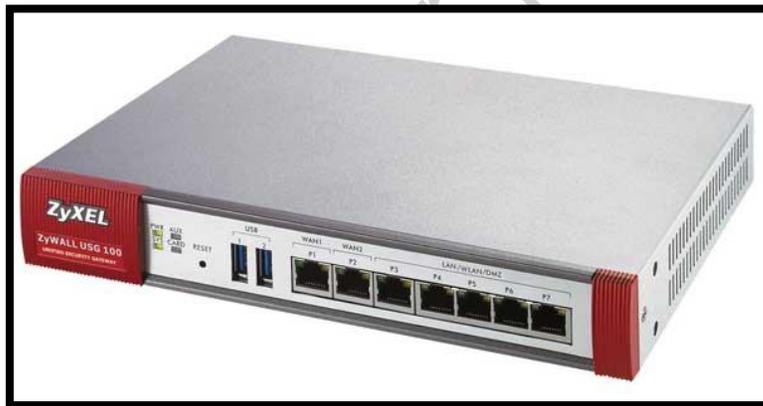
#### ❖ Bridge

A bridge is used to connect two separate LAN networks. A computer can act as a bridge through the operating system. A bridge looks for the receiving device before it sends the message. This means that it will not send a message if the receiving computer is not there. It will check to see if the receiver has already had the message. This can help save unnecessary data transfers, which improves the performance of a network.



### ❖ Firewall

A firewall is a device, or a piece of software that is placed between your computer and the rest of the network. If you wish to protect your whole LAN from hackers out on the Internet, you would place a firewall between the LAN and the Internet connection. A firewall blocks unauthorised connections being made to your computer or LAN. Normal data is allowed through the firewall (e.g. e-mails or web pages) but all other data is blocked.



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