# Computer Communication Networks

## MCOMP – 305 – MCA: Computer Communication Networks

**Introduction to Computer Network :**

Advantages of networks, structure of the communications network, point to-point and Multidrop circuits, data flow and physical circuits, network topologies, topologies and design goals. Hierarchical topology, horizontal topology (Bus), Star topology, ring topology, mesh topology, The telephone network, switched and nonswitched options, fundaments of communications theory, channel speed and bit rate, voice communications and analog waveforms, band width and the frequency spectrum, Connecting the analog and digital worlds, digital world, digital signals, the modem, asynchronous and synchronous transmission.

# CH 1 : Introduction to Computer Network

## 1. What is network?

A *network* can be anything from a simple collection of computers (two connected computers qualify as a network) at one location that have been tied together using a particular connectivity medium (such as network cabling or wireless technology) to a giant global network, such as the Internet, that uses a number of different connectivity media, including microwave and satellite technology. The network can then be used to transmit data, voice, and even video between users on the network.

Networks consist of the computers, the connectivity medium (such as copper wire or fiber optic cables), and other devices, such as hubs, switches, and routers, that make up the network infrastructure. Some devices, such as network interface cards, serve as the computer's connection to the network. Devices such as switches and routers provide traffic-control strategies for the network. All sorts of different technologies can actually be employed to move data from one place to another, including network cabling (copper or fiber optics), radio waves, and even microwave technology.

Networks are not networks just because they contain highly complex connectivity strategies. Two computers running the Windows Me operating system can be joined together by their COM ports (also known as *serial ports*) by a single serial cable. Is this a network? Sure, it allows you to share resources between the two computers and therefore meets the basic definition of what a network is.

In our discussion of computer networks, we will be looking at two distinct entities: LANs and WANs. A *local area network (LAN)* is a collection of personal computers and other peripheral devices connected at one location. A *wide area network (WAN)* is a collection of LANs at different locations connected together using various WAN technologies.

## 2. Advantages of Networks :

Networks can be used for simple tasks, such as sharing a printer, or they can be used for more advanced applications, such as a complex point-of-sale system and worldwide video conferencing.

All networks, whether big or small, are typically created so that users on the network can share resources and communicate. The following list breaks down some of the reasons for networking computers:

***File sharing*** **:** Networking computers makes it very easy for the users on the network to share data files. Files on a particular user's computer can be shared on the network or files can be placed on a file server, which provides a central location for all files needed by the users on the network.

***Hardware sharing*** : Users can share devices such as printers, CD-ROM drives, and hard drives (users can be assigned space on network server drives). Once networked, computers can share their own local devices, such as CD-ROM and hard drives, or take

advantage of high-speed printers or other devices that are provided by a particular server on the network.

***Program sharing*** **:** Applications such as spreadsheets and word processors can be run over the network. You keep most of the files that make up the application on a special application server on the network. This makes installing the software on a computer easier (because it can be done over the network). It also makes upgrading an application easier because the upgrade only has to be performed on the server itself.

***User communication*** **:** Networks allow users to take advantage of communication media such as electronic mail, newsgroups, and video conferencing. Because voice, pictures, and video can be moved across the network as data, network communication is certainly not limited to just text messages. A number of communication platforms exist for PC networks such as Lotus Notes and Microsoft Exchange. Internet e-mail and chatting both audio and video means are also examples.

***Multiplayer gaming*** **:** While this certainly isn't a reason for networking computers in a business environment, individuals who set up home-based peer-to-peer networks can take advantage of a large number of computer games that provide support for multiple players on a network.

***Backup*** : Networking also supports the critical function of backup. In the event a computer fails, its counterpart can assume its functions and workload. Backup capability is especially important in systems such as those used for air traffic control. In the event a computer malfunctions, backup computers rapidly take over and assume control of operations without endangering air travelers. Similarly backup is also essential in financial transactions.

***Flexible working Environment*** **:** The use of networking allows a very flexible working environment. Employees can work at home by using terminals tied through networks into the computer at the office. Many employees now carry terminals or portable personal computers on trips and connect into their networks through hotel room telephones. Other employees travel to remote offices and use telephones and networks to transmit and receive critical sales, administrative, and research data from computers at company headquarters.

In networks that consist of more than just a few computers, one can find two different types of computers operating on the network: clients and servers. *Client computers* supply users with a connection to the network. *Servers* actually serve up the resources that are available on the network—everything from files to electronic mail post offices.

Not only does a network provide the ability to share resources found locally on the network (such as a printer shared by several users in a small office), but the fact that the network exists means that the local network can be connected to other networks. Most networks, big and small, are also now connected to the Internet, meaning that the potential for sharing resources and communication is almost endless. One of the most compelling reasons for a company to decide to network its computers is to have all its users "plugged in to" the global network that is the Internet.

**3. Structure of the Communications Network :**

Following Figure 1 illustrates a simple data communications system. The *application process* (AP) is the end-user application. It usually consists of software such as a computer program. Typical examples are an accounts receivable program, a payroll program, an airline reservation system, an inventory control package, or a personnel system. The application resides in the *data terminal equipment,* or DTE which is a computer of any type.
The function of a communications network is to interconnect DTEs so they can share resources, exchange data, provide backup for each other, and allow employees and individuals to perform their work from any location.

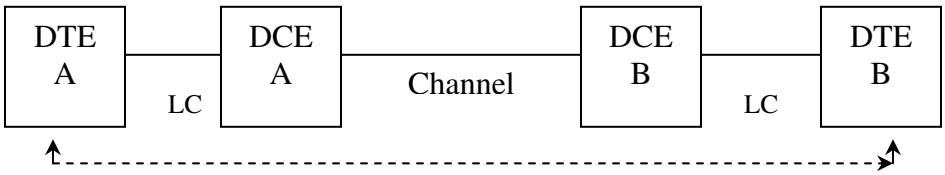



Figure 1.1 : A Communication System

The Figure 1 shows that a network provides *logical* and *physical* communications for the computers and terminals to be connected. The applications and files use the physical channel to effect logical communications. Logical, in this context, means the DTEs are not concerned with the physical aspects of the communications process.
Application in DTE A need only issue a logical *Read* request with an identification of the data. In turn, the communications system is responsible for sending the *Read* request across the physical channels to application DTE B.

Figure 1 also shows the *data circuit-terminating equipment,* or DCE (also called data communications equipment). Its function is to connect the DTEs into the communication line or channel. The primary function of the DCE remains to provide an *interface* of the DTE into the communications network. The familiar modem is an example of a DCE.

The interfaces are specified and established through *protocols.* Protocols are agreements on how communications components and DTEs are to communicate with each other.

**Types of Data Communication Networks :**

**(a) Peer-to-Peer Networking :**
*Peer-to-peer networking* provides a simple, low-cost method for connecting personal computers in situations where you want to share files and other resources such as a printer. Peer-to-peer networking does not require a server, meaning the added expense of a powerful computer to act as a server and a network operating system for the server is avoided in this approach to creating small networks.

In a peer-to-peer network, the computers on the network function as peers. A *peer* computer basically acts as both a client and a server computer. Peer computers can access resources on the network, and they can supply resources to other peer computers (the same as a server does on a server-based network).

A peer-to-peer network is also commonly referred to as a *workgroup*. This is because the term *workgroup* connotes collaboration without central control, differentiating the peer-to-peer network from the larger-scale server-based network.

With Microsoft Windows dominating today's personal computing market (because of availability, usability, and acceptance as standards in the business world), peer-to-peer networking is certainly an easy-to-configure, low-cost avenue for sharing files and printers at home or a small business. Once the computers and printers in the peer-to-peer network have been physically connected, actually setting up the sharing of files and printers is a very straightforward matter.

Linux distributions also provide workgroup capabilities with other Linux clients or with Microsoft Windows clients.

### *Pros of Peer-to-Peer Networking*

The pros related to peer-to-peer networking revolve around cost and ease of installation. Depending on the operating system you are running on your computers, peer-to-peer networking does not require the purchase of additional software or a computer to act as a dedicated network server. Most operating systems that support peer-to-peer networking also make it very easy for you to configure your computers so that they will communicate in a workgroup.

In a nutshell, here are the overall advantages of peer-to-peer networks:

- They are relatively cheap as far as hardware outlay goes. You don't have to buy any additional computers, such as a server.
- They are pretty easy to set up.
- All the software that you need is typically included in your operating system.
- Centralized administration is not required and individual users can configure the sharing of resources.
- The peer computers don't depend on a central server machine for their resources or to log in to the network; therefore, they can operate even when other peer computers are not available.

Even though peer-to-peer networking is cheap and fairly simple to set up and configure, it is not scalable, meaning that around 10 computers at the most can live together in a peer-to-peer situation. What's more, you will still have to outfit the computers with network interface cards and connect them. If you use twisted-pair cabling, you will need

a hub. If you go with coaxial cable, you will need T-connectors and terminators. Other connection strategies, such as wireless communication, will require the appropriate hardware.

### *Cons of Peer-to-Peer Networking*

Although peer-to-peer networking appears to be the perfect networking solution in situations where you don't want to go to the trouble to install and configure a network server (or can't afford a server and the network operating system software), it does have a number of limitations. First of all, it is extremely limited as far as the number of computers you can connect together. This type of networking is really reserved for very small installations of 10 computers or less. Many experts recommend that a peer-to-peer network not include more than five peer computers; this limit is recommended because the greater the number of peers accessing information, the greater the performance hit on the peers that are providing that information. Since peer networking distributes resources across the network, having many peer shares (which each potentially require a different password) can make accessing files confusing.

Peer-to-peer networking also does not provide any centralized security on the network. Users don't have to be authenticated by a network server to actually view and potentially use the resources on the network. This is related to how resources are shared in a workgroup.

Each resource that is shared (such as a drive, folder, or printer) can potentially require a different password for access. If a lot of resources are shared across the network, you will have to remember the password for each resource. This type of security is referred to as *share-level security*; each drive, folder, or printer that is shared is referred to as a *share*.

A summary list of peer-to-peer network shortcomings follows:

- There's an increased performance hit on computers because of resource sharing. If users access your printer, your computer's processing resources are used as they print.
- No centralized location of shared files makes it difficult to back up data.
- Security must be handled on a resource-by-resource basis.
- Decentralization of resources makes it difficult for users to locate particular resources.
- Users might have to keep track of numerous passwords.

**(b) Server-Based Networks :**

*Server-based networking* provides you with the ability to build large networks that offer a greater range of resources to users (when compared to peer-to-peer networks). This is

because a number of different, specialized server types (such as mail and database servers) can be included on the network.

Server-based networks also provide you with greater centralized control of resources and make it easier to add additional computers, users, and resources (again, when compared to peer-to-peer networks). Server-based networks are *scalable networks*, meaning they are easily expandable.

One requirement for a server-based network is a computer running a network operating system; this computer is known as the *server*. A server computer is basically a special-purpose machine that logs in users and "serves" up resources, such as files and printers, to the users. Because the server verifies users and determines the level of access the users will have to the various network resources, server-based networks provide a more secure environment than peer-to-peer networks.

Actually accessing resources on a server-based network is also easier than in the peer-to-peer environment because one username and one password gets a user onto the network and provides that user access to any resource he or she has the appropriate permissions for. This is in sharp contrast to a peer-to-peer network, which may have a different password for every resource on the network.

### *Pros and Cons of Server-Based Networking*

As is the case with peer-to-peer networking, server-based networking has its pros and cons. The upside of server-based networking revolves around the fact that this type of network provides central control of resources and makes it easier for users to actually find resources. For example, the network operating system (NOS) Microsoft Windows Server 2003 manages resources such as shared folders and drives, printers, and even users in a tool called the Active Directory,.

Active Directory is used to add and remove users from the network and can even be used to place users who access the same resources into groups. Management tools such as Active Directory provide the administrator with the ability to control network access and the different levels of access that are given to users or groups of users.

This ability to manage network users and resources centrally comes with a high price tag, however, and one of the major cons of server-based networking is the cost of the dedicated server computer and the NOS that you must run on it. Server-based networks also require a network administrator—someone who is well versed in the NOS being used. This usually means an additional employee on the company's payroll, which is another cost associated with server-based networks.

However, the overall cost of network operating system software and computer hardware is lower today than it ever has been, and the server-based network has become the standard for networking in even relatively small companies. Security features built in to the NOS allow the network administrator to protect the company's data from outside the

network, and they also provide a great deal of control over sensitive data and its access from inside the network.

**The pros server-based networks :**

- Users log on using one username and password to access network resources.
- The network security is centrally controlled, as are the network resources.
- Resources such as folders and files can easily be backed up because they are centrally located.
- Dedicated, high-powered servers allow users faster access to resources.
- Server-based networks can be easily expanded.

**The cons server-based networks :**

- For small companies, the cost of the server equipment, the network operating system, and the appropriate client licenses can be a con.
- Although not a con if you are the network administrator, someone must be charge in setting up and controlling the resources on the network. This typically means a dedicated network administrator's position.
- If the main server goes down, so goes the access to network resources.

The local area network (LAN)—another name for a server-based network in one location—is really the rule rather than the exception in today's business world. Even small LANs can use different types of servers to provide users with the resources they need. Let's take a look at the possibilities.

**(c) Hybrid Networks :**
Hybrid networks have all three types of computers (server, peer, & clients) on them. This means that while most shared resources are located on servers, network users still have access to' any resource being shared by peers in your workgroup.

**How do you decide which type of network to use?**

Use Peer-to-peer if
- ☛ There are fewer than 10 people in your organization.
- ☛ The people in your organization are sophisticated computer users.
- ☛ Security is not an issue or if users can be trusted to maintain good security.
- ☛ The cost of an additional computer just to serve files exceeds available funds.
- ☛ Users can be relied upon to back up their own data.
- ☛ Users are physically close together and there are no plans for expansion of the network.

Use A Server-based Network if
- ☛ There are more than 10 people in your organization.
- ☛ Many of the people are not sophisticated computer users.
- ☛ Your organization maintains information that must be centrally controlled.

- ☛ You have enough users that central file servers and applications are cost-effective.
- ☛ A central administrator will administer the network and set network policies.

## 4. Types of Network Servers :

We've already discussed the fact that a LAN uses a server to validate users as they log on to the network. If a user's login name and password don't match up, the server doesn't let him or her on the network. In large networks, this "central computer" (for lack of a better name) can be kept quite busy logging users on to the network as they fire up their client PCs. Rather than over-burden this server with additional duties, it's not uncommon to distribute the workload among other specialized servers.

### File Servers

A file server's job is to serve as a home for the files that are needed by users on the network. This can include files that a number of users share. These files are typically held in what is called a *public folder*, which can include private folders that are specific for a particular user. The great thing about using a file server is that important files reside in one place, making it very easy to back up the data periodically. The downside is that if the file server goes down, users can't get at their files.

### Print Servers

A print server is used to host a network printer. It is basically the control conduit for the printer. Because print jobs need to be spooled (placed on the computer before they are sent to the printer) before they are printed, the print server supplies the hard drive space needed. The print server also queues up all the print jobs being directed to the printer. The network administrator can also delete print jobs and change the queue order of print jobs by accessing the print server.

### Communication Servers

A communication server runs specialized software that allows users on the network to communicate. It provides services such as electronic mail and discussion groups to allow users to share information. Two of the most popular communication packages for a LAN (and each need to be set up on a server on a LAN) are Microsoft Exchange and Lotus Notes.

### Application Servers

Application servers host various applications such as specialized databases. Even typical desktop applications such as word processors and spreadsheet software can also be stored on an application server. This makes updating software applications much easier because the software doesn't actually reside on every client workstation; users start these applications from their local computers, but the application software is actually stored on the server.

**Web Servers**

Web servers provide you with the ability to create a Web site that can be accessed internally by your employees (this is called an *intranet*) or by folks surfing the Internet. Web servers aren't for everyone, and many companies still use Web-hosting companies to get their Web sites up and running on the Internet. A number of different software packages can be used to set up a Web server, and they vary in ease of use and stability. Microsoft Windows Server 2003 ships with Internet Information Server 6.0 (IIS6), a Web server software package.

**Other Specialized Servers**

There are also other types of servers that can reside on the network that don't actually provide any resources to the LAN users, but they are needed to make the network run properly or more efficiently. For example, on larger networks that use the TCP/IP network protocol, each computer must be configured with a unique Internet Protocol (IP) address (which is much like a person's Social Security number) to communicate on the network. This means that the network administrator might have to configure hundreds of computers, one at a time. However, a server running the Dynamic Host Configuration Protocol (DHCP) can actually automatically assign IP addresses to computers as they are started up on the network.

**5. Point to-point and Multi-drop Circuits :**

DCEs and DTEs are connected in one of two ways. As illustrated in Figure 1.2, they are connected in a point-to-point configuration in which only two DTE devices are on the line or channel.

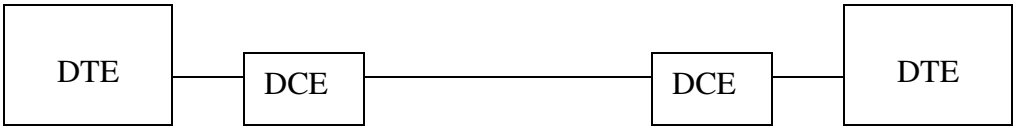



Figure 1.2 : Multi-drop circuit

A point-to-point link is a direct connection between two devices (nodes). One example of this is a PC connected to a printer. A more common example is a mainframe terminal connected to a mainframe front-end processor.

Illustrated in Figure 1-3 is another approach called a multidrop configuration. In this configuration, more than two devices are connected to the same channel.

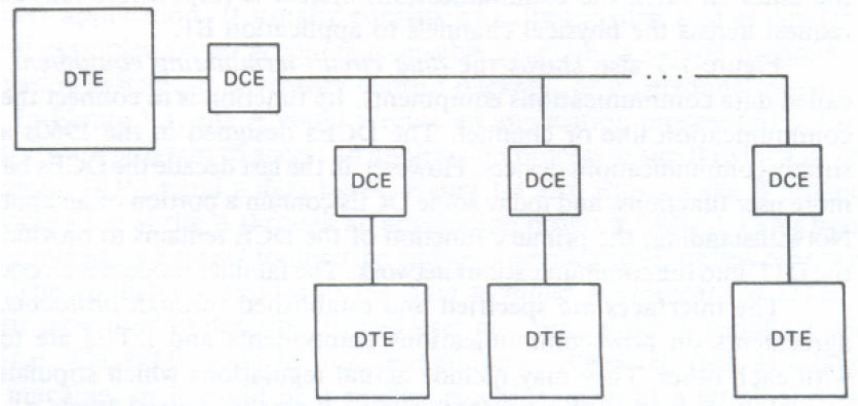



Figure 1.3 : Multi-drop circuit

**6. Data flow and Physical Circuits :**

The DTEs and DCEs send communications traffic to each other in one of three methods :
**Simplex :** Transmission in one direction only
**Half-Duplex :** Transmission in both directions, but only one direction at a time (also called two-way alternate )
**Full-Duplex (or Duplex):** Transmission simultaneously in both directions (also called two-way simultaneous).

Simplex transmission is common in television and commercial radio. It is not as common in data communications because of the one-way nature of the process, but simplex systems are found in some applications, such as telemetry. Half-duplex transmission is found in many systems, such as inquiry/response applications wherein a DTE sends a query to another DTE and waits for the applications process to access and/or compute the answer and transmit the response back. Terminal based systems (keyboard terminals and terminals with CRT screens) often use half-duplex techniques. Full-duplex (or simply duplex) provides for simultaneous two-way transmission, without the intervening stop-and-wait aspect of half-duplex. Full-duplex is widely used in applications requiring continuous channel usage, high throughput, and fast response time.
Thus far, the terms *half-duplex and full-duplex* (duplex) have been used to describe how data move across the circuit. Figure 1-4 shows the physical circuit itself, without regard to how data moves.

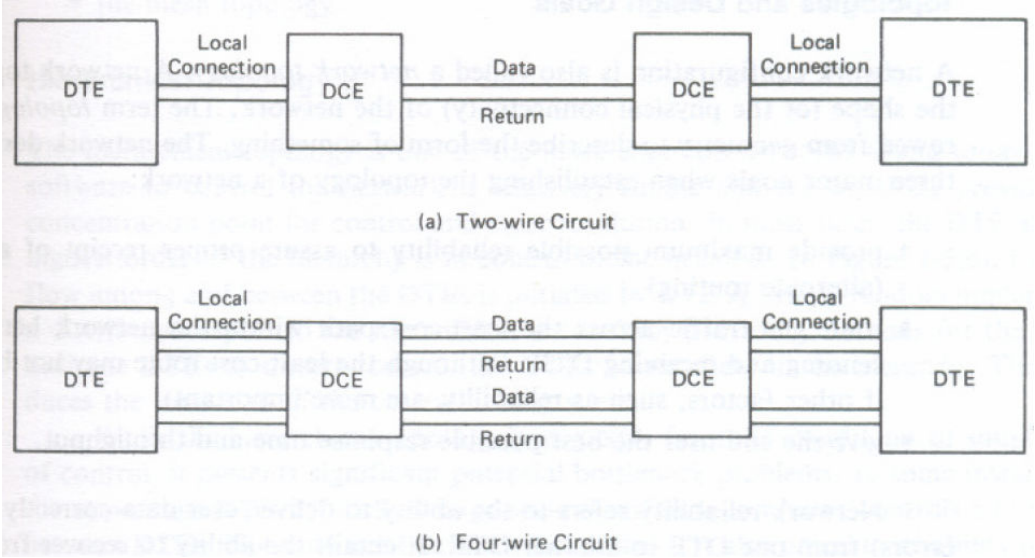



Figure 1.4 : Two wire & Four wire circuits

**7. Network topologies, topologies and design goals :**

A network configuration is also called a *network topology.* A network topology is the shape (or the physical connectivity) of the network. The term *topology* is borrowed from geometry to describe the form of something. The network designer has three major goals when establishing the topology of a network :

The first major gole is to :

☛ provide maximum possible reliability to assure proper receipt of all traffic (alternate routing)

☛ route the traffic across the least-cost path within the network between the sending and receiving DTEs (although the least-cost route may not be chosen if other factors, such as reliability, are more important)

☛ give the end user the best possible response time and throughput.

Network reliability refers to the ability to deliver user data correctly (without errors) from one DTE to another DTE. It entails the ability to recover from errors or lost data in the network, including channel, DTE, DCE, or DSE failure.

The second major goal in establishing a topology for the network is to provide the least-cost path between the application processes residing on the DTEs. This involves:

☛ minimizing the actual length of the channel between the components, which usually entails routing the traffic through the fewest number of intermediate components;

☛ providing the least expensive channel option for a particular application; for instance, transmitting low-priority data over a relatively inexpensive dial-up, low-speed telephone line, in contrast to transmitting the same data over an expensive high-speed satellite channel.

The third major goal in establishing a topology is to provide the best possible response time and throughput. Short response time entails minimizing delay between the transmission and the receipt of the data between the DTEs, and is especially important for

interactive sessions between user applications. Throughput entails the transmission of the maximum amount of end-user data in a given period.

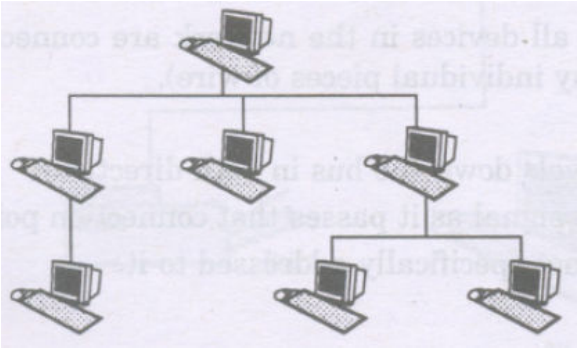
The more common network topologies are :
1. Hierarchical topology (tree)
2. Horizontal topology (bus)
3. Star topology
4. Ring topology (hub)
5. Mesh topology.

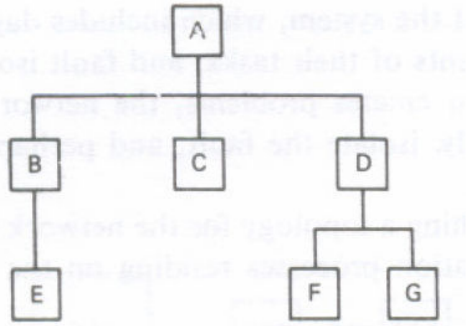
### 7.1 Hierarchical topology : (Tree)

Hierarchical topology', the tree topology is a combination of bus and star topologies. It consists of groups of star-configured workstations connected to a linear bus backbone cable. Tree topologies allow for the expansion of an existing network and enable schools to configure a network to meet their needs. They are very common in larger networks.
A typical scenario is : A file server is connected to a 24-port switch. A cable goes from the switch to a computer room where it connects to another switch. Many cables pass from this switch to the computers in the computer room. The node at the highest point in the hierarchy usually a file server-controls the network.

**Advantages of a Tree Topology**
1. Point-to-point wiring for individual segments.
2. Supported by several hardware and software vendors.

**Disadvantages of a Tree Topology**
1. Overall length of each segment is limited by the type of cabling used.
2. If the backbone line breaks, the entire segment goes down.
3. More difficult to configure and wire than other topologies.






(a) Hierarchical or Tree Topology

### 7.2 Horizontal topology (Bus) :

A *bus topology* is characterized by a main trunk or backbone line with the networked computers attached at intervals along the trunk line, as shown in Figure. This topology type is considered a *passive* topology because the computers on a bus just sit and listen. When they "hear" data on the wire that belongs to them, they accept that data (they actually listen using their network interface cards). When they are ready to transmit, they

make sure no one else on the bus is transmitting and then send their packets of information.

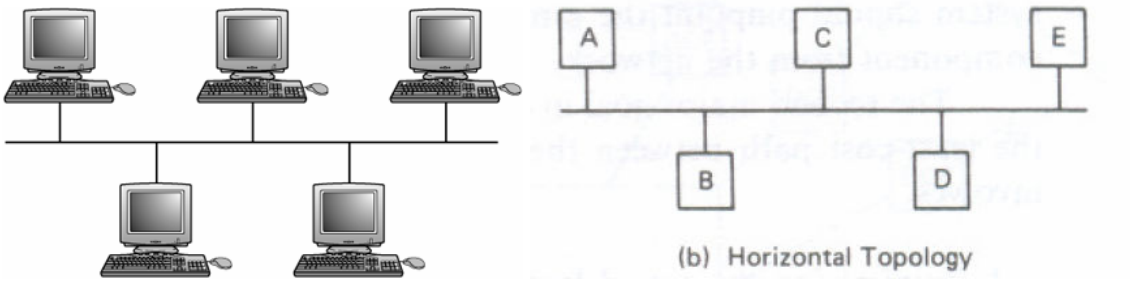



**FIGURE** A bus topology provides one of the simplest ways to connect a group of computers.

Bus networks typically use coaxial networking cable (it looks like the same coaxial cable used for cable television, but it is actually slightly different) hooked to each computer using a T-connector. Each end of the network is terminated using a terminator specific to the cable type (if you use 50-Ohm cable, you use 50-Ohm terminators). Because the bus network is really just a collection of cable, connectors, and terminators, there is no amplification of the signal as it travels on the wire. This means that the size of the network will be limited by the maximum distance the cable type can actually move the signal that holds the data.

Bus networks are easy to assemble and are easy to extend. They require a fairly limited amount of cabling when compared to other topologies. Bus networks are prone to cable breaks, loose connectors, and cable shorts that can be very difficult to troubleshoot. One physical problem on the network, such as a detached connector, can actually bring down the entire bus network. Although at one time a bus network would have been the cheapest and easiest way to connect a small group of computers for peer-to-peer networking, the drop in the price of hubs (discussed in the next section on star networks) and the ease of using twisted-pair wire have really pushed the coaxial cable bus network to the edge of extinction.

The main reason for knowing about bus networks is that there are still bus installations found in small and medium-size companies. Remember that troubleshooting this type of network will typically require an inspection of all the cabling and their connections.

**Features of Bus Network**

- A bus is a single electrical circuit to which all devices in the network are connected (although the bus might be made up of many individual pieces of wire).
- A bus topology is a broadcast network.
- When a node transmits data, the signal travels down the bUs in both directions.
- Each node connected to the bus receives the signal as it passes that connection point.
- However, a node ignores any signal that is not specifically addressed to it.
- The cable is terminated at each end.
- The wiring is normally done point to point.

☛ A faulty cable will take the entire LAN down.

**Advantages of Bus Topology**
1. Bus topologies are relatively easy to install and don't require much cabling compared to other topologies.
2. Easy to connect a computer or peripheral to a linear bus.
3. Requires less cable length than a star topology, as you only need to chain the stations together.
4. There is no central point of failure on a bus because there is no hub.
5. Simple and easy to implement and extend.
6. Well suited for temporary networks that must be set up in hurry.
7. Failure of one station does not affect others.

**Disadvantages of a Linear Bus Topology**
1. Entire network shuts down if there is a break in the main cable.
2. Terminators are required at both ends of the backbone cable.
3. Difficult to identify the problem if the entire network shuts down.
4. Not meant to be used as a stand-alone solution in a large building.
5. Maintenance costs may be higher in the long run.
6. *More expensive cabling:* Because the line must be shared the cable has to have a high bandwidth.
7. *Not very fast:* Addition of nodes negatively affects the performance of the whole network, and if there is a lot of traffic throughput decreases rapidly.
8. *Higher error probability:* The more components work on a signal the more probable errors become. As the signal has to be multiplexed and de-multiplexed and as every connected device is examining them errors can more easily occur.

## 7.3 Star topology :

In a *star topology*, the computers on the network connect to a centralized connectivity device called a *hub*. Each computer is connected with its own cable (typically twisted-pair cable) to a port on the hub, as shown in Figure. Star LANs also use the same type of wait-and-listen strategy to access data or send data as characterized by the bus topology.

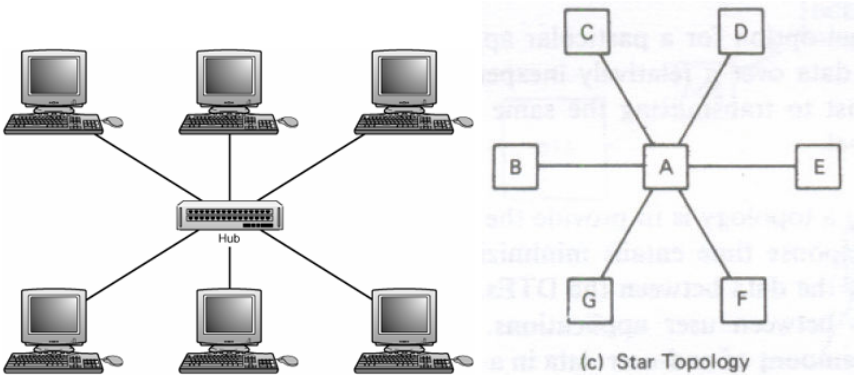



**FIGURE** The star topology uses a hub as the central connection point for the computers on the LAN.

Because the star topology uses a separate cable connection for each computer on the network, star networks are easily expandable, with the main limiting factor being the number of ports available on the hub (although hubs can easily be daisy-chained together to increase the number of ports available). Expanding a star topology network is also very unobtrusive: Adding a computer to the network is just a matter of running a wire between the computer and the hub. Users on the network will be pretty much unaware that the expansion is taking place.

Disadvantages of the star topology revolve around cabling needs and the hub itself. Because each computer on the network requires a separate cable, cable costs will be higher than a bus topology network (although twisted-pair, the cable type used for star networks, is the least expensive cable type). Having to purchase a hub or hubs for your network does add additional costs when you are building a network based on the star topology, but considering the benefits of this type of topology in terms of managing the physical aspects of your network, it is probably well worth it.

The greatest benefit of using the star topology is that you can easily add new computers to the network without disrupting service to the computers already on the network. Also, if one computer goes down on the network, it does not negate the ability of the other computers on the star to communicate with each other. Obviously, the most crucial failure point on a star network would be the central hub.

**Features of Star Network**

☛ In a star network each node is connected by a point-to-point link to a central point.
☛ These central points are called hubs, concentrators or multipoint repeaters.
☛ These central points can be passive or active.
☛ If passive these hubs simply connect the points of the star.
☛ If active, these hubs regenerate (repeat) the electrical signals they receive.
☛ A hub-centered star topology is a broadcast network, because the hub copies each signal to all other computers attached to it. The hub may have extra features like LEDs that indicate activity and errors on each port, making it even easier to isolate problems.
☛ With the introduction of switches, you can dramatically increase network performance by replacing the hub with a switch. .

**Advantages of a Star Topology**

1. Easy to install and wire.
2. Easy to add new stations as each station has its own direct cable connection to the hub. If a cable is cut, it only affects the computer that was attached to it.
3. It can accommodate different wiring. It can be installed using twisted pair, coaxial cable or fiber optic cable.
4. Since all information in a star topology goes through a central point star, topologies are easy to troubleshoot. A star can simplify troubleshooting because stations can be disconnected from the hub one at a time until the problem is isolated.
5. The main advantage is that one malfunctioning node does not affect the rest of the network.

**Disadvantages of a Star Topology**

1. Depending on where the hubs are located, star networks can require more cable length than a linear topology.
2. If the hub or concentrator fails, nodes attached are disabled.
3. More expensive than linear bus topologies because of the cost of the hub or concentrators.

**7.4 Ring topology :**

A *ring topology* connects the LAN computers one after the other on the wire in a physical circle, as shown in Figure. The ring topology moves information on the wire in one direction and is considered an *active* topology. Computers on the network actually retransmit the packets (*packet* is a generic term for the chunks of data that are being moved along the network) they receive and then send them on to the next computer in the ring.

The ring topology is considered an active topology because the computers in the ring actually pass a *token* around the circle. The token is a special packet of data, sort of like your ATM card, that gives the computer with the token special abilities. If a computer wants to send data onto the network, it has to wait until it has possession of the token.

True ring topologies can be difficult to troubleshoot, and the failure of one computer on the ring can disrupt the data flow (because data circulates around the ring in one direction). Also, adding or removing computers from this type of topology can disrupt the operation of the network. On most small LANs, you won't run into the ring topology because IBM Token Ring and some other high-speed network technologies that use a ring are more typical of larger networks.

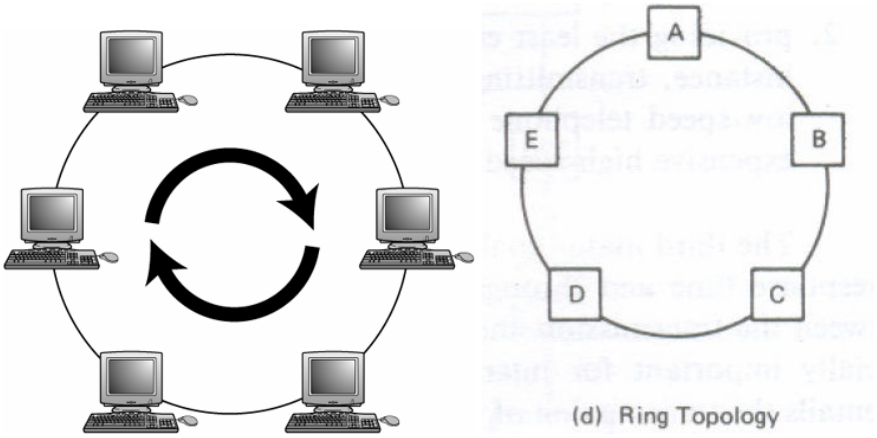



**FIGURE** The ring topology connects the computers in a circle, where a token is used to permit the transmission of data.

**Features of Ring Network**

☛ A"pure" ring topology is a collection of separate point-to-point links, arranged to make a ring.

☛ Each node's network interface card (NIC) has one input and one output connection, so each node is connected to two links.
☛ When a node receives a signal on its input connection, its repeater circuitry retransmits that signal, immediately and without buffering, to its output connection. Thus, in many rings, data flows only in one direction.
☛ To send a message, a node transmits new bits onto the ring.
☛ If a message is addressed to a node, that node copies bits off the ring as they go by.
☛ If a node receives a message that is not addressed to it, it repeats the message without copying it.

**Advantages of Ring Topology**

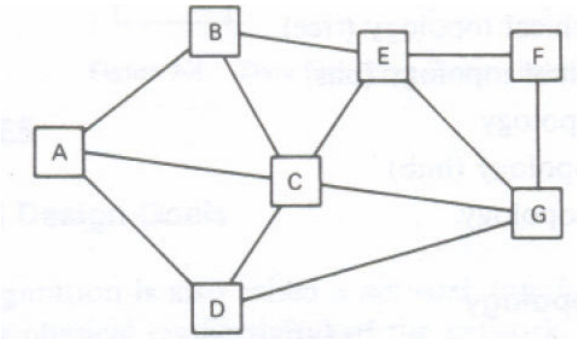
1. Growth of system has minimal impact on performance. The ring networks can be larger than bus or star because each node regenerates the signal.
2. Degrade nicely under high utilization. Everybody gets to talk...
3. Fault tolerance builds into the design (can bypass damaged nodes).
4. All stations have equal access.
5. Data packets travel at a greater speed.

**Disadvantages of Ring Topology**

1. Expensive topology.
2. Failure of one computer may impact others. A failure in any cable or device breaks the loop and will take down the entire segment.
3. It is complex to implement and to extend the network; you must break the ring (which brings the network down). If any device is added to or removed from the ring, the ring is broken and the segment fails.
4. Data clashes can also occur if two machines send messages at the same time. Tokens or electronic signals that travel around the ring were invented to solve this problem. In a Token Ring Network, a computer can only send a message when the token is with it at the time.

### 7.5 Mesh topology :

In the topologies shown above, there is only one possible path from one node to another node. If any cable in that path is broken, the nodes cannot communicate. In a mesh topology, every device has a dedicated point-to point link to every other device. Such a network is called *complete* because between any two devices there is a special link; one could not add any non-redundant additional links.
Mesh topology uses *lots* of cables to connect every node with every other node. It is very expensive to wire up, but if any cable fails, there are many other ways for two' nodes to communicate. Some WANs, like the Internet, employ mesh routing. In fact the Internet was deliberately designed like this to allow sites to communicate even during a nuclear war.



(e) Mesh Topology

**Features of Mesh Network**

☛ In a mesh *topology;* point-to-point links directly connect every site to every other site.

☛ Mesh networks are usually built over time as new sites are added to the overall networks.

☛ A mesh topology is often used for MAN or WAN networks.

☛ The number of point-to-point links increases sharply with the number of locations. Thus, if a network must connect more than a few sites, a mesh topology is usually too expensive.

**Advantages of Mesh Topology :**

1. Redundant links between devices
2. Good security : If the line is not tapped only the intended recipient can see the data.
3. Reliability : Increasing network traffic does not affect the speed of other connections.
4. Easy fault identification and isolation, an unusable link does not incapacitate the entire system.

**Disadvantages of Mesh Topology :**

1. Each node must have an interface for every other device.
2. Large amounts of cable for many devices to be connected in a mesh environment. A mesh topology for n devices needs n (n – 1) / 2 connections. It is therefore, hard to install and expensive because of the extensive cabling.
3. Unless each station sends to every other station frequently, bandwidth is wasted.
4. There is only limited amount of I/O ports in a computer, but every connection one up.

**8. The Telephone Network :**

Since many DCEs, DTEs, and DSEs are connected by a telephone channel, it should prove useful to examine the telephone system. **Figure 1-5** illustrates the telephone network structure. The components are arranged in a hierarchy starting with the customer location at the bottom of the hierarchy. The customers, either in homes or offices, connect through the telephone system into the *central office* (CO), local exchange, or end office. Thousands of these offices may be installed around a country. Connection is provided to the CO through a pair of wires (or four wires) called the *local loop* or *subscriber loop.*

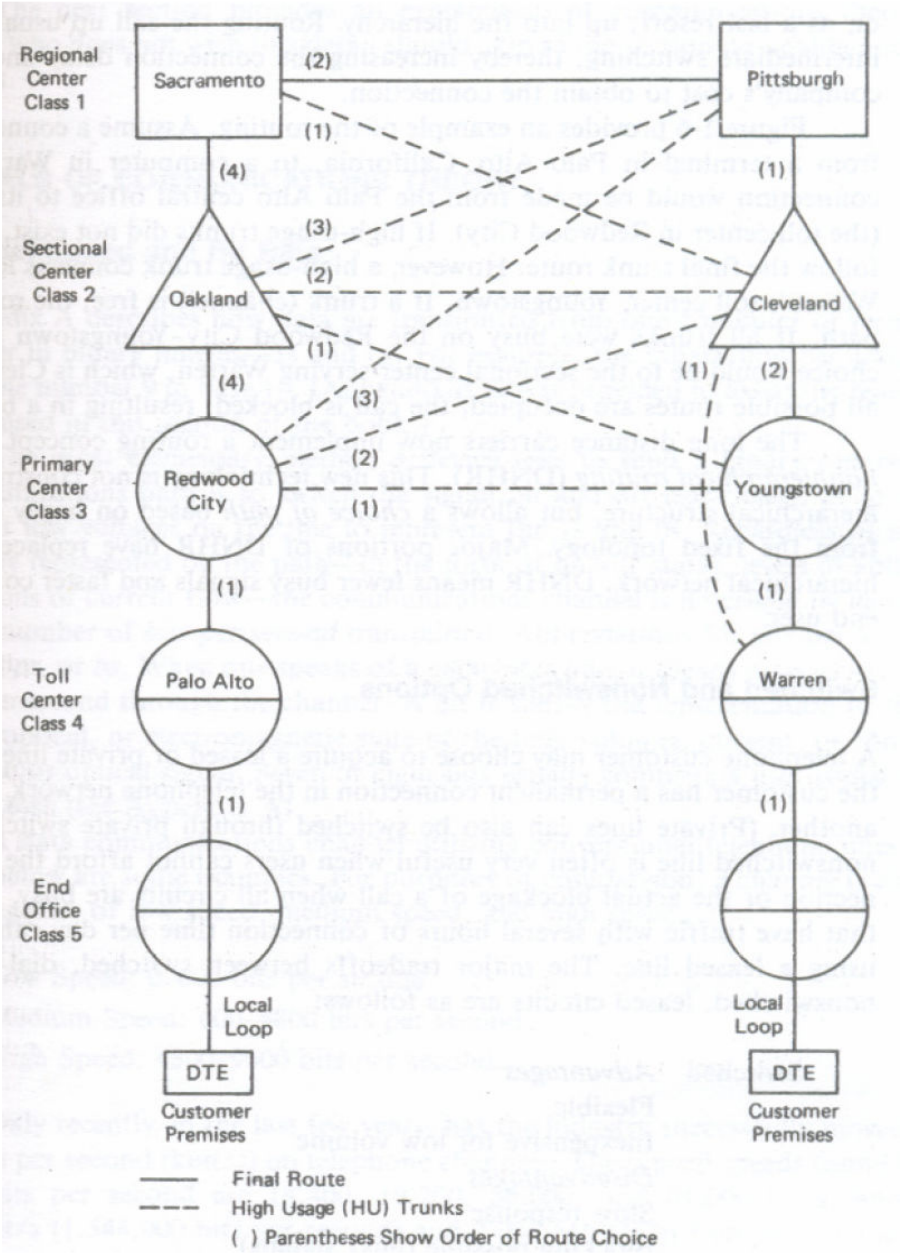



Figure 1.5 : General Telephone Network

Connections between COs are also provided by a facility called a *tandem center* (also called a tandem switch or toll center). The tandem center interconnects COs that do not have direct connections with each other.

The system is designed for each switching center to be connected to an office of a higher level, except at the highest level. The top-level offices are completely interconnected. The structure ensures that a path exists from each switch in the network to any other switch.

The CO is responsible for relaying a dialed telephone number to a local loop, across *to* another CO or tandem office. The design philosophy is to route the call through the most economical path, which is usually the shortest path and/or the fewest number of switches. This design approach reduces the delay of establishing the connection with the other DTE, and the fewer number of intermediate switches reduces the expense to the telephone company. As the tandem path becomes longer, it must go through more components, incurring more delay and additional expense.

**9. Switched and Non-switched Options :**

A telephone customer may choose to acquire a leased or private line, through which the customer has a permanent connection in the telephone network from one site to another. (Private lines can also be switched through private switches.) A private, non-switched line is often very useful when users cannot afford the delay of a connection or the actual blockage of a call when all circuits are busy. Moreover, users that have traffic with several hours of connection time per day can save money by using a leased line. The major tradeoffs between switched, dial-up circuits and non-switched, leased circuits are as follows:

**Switched :**
***Advantages***
Flexible
Inexpensive for low volume
***Disadvantages***
Slow response
Blocking possible (busy signals)
Low quality
Expensive for high volume

**Non-switched :**
***Advantages***
Supports higher volume
Higher quality possible
No blockage (busy signals)
***Disadvantages***
Expensive for low volume
Lack of flexibility when line is inoperable

**10. Fundaments of Communications Theory :**

In data communication, data are transmitted from one computer or terminal to another in binary images-1s and 0s. For example, the binary number 1001 represents the number 9 in base 10.

In the most elementary method of data communication, a device uses to send a binary number on a communications path is to switch the signal on and off electrically, or to

provide high or low voltages on the line to represent the 1s and 0s. Regardless of how the data are represented on the path-in the form of on/off states, levels of voltage, or directions of current flow-the communications channel is described by its capacity in the number of *bits per second* transmitted. Abbreviations for bits per second are *bit/s, bps,* or *bs.* When one speaks of a 4800 bit/s line, it means a device sends 4800 bits per second through the channel. A bit is simply the representation of the electrical, optical, or electromagnetic state of the line: voltages, current, or some form of radio or optical signal. Seven or eight bits usually comprise a user-coded character, or byte.

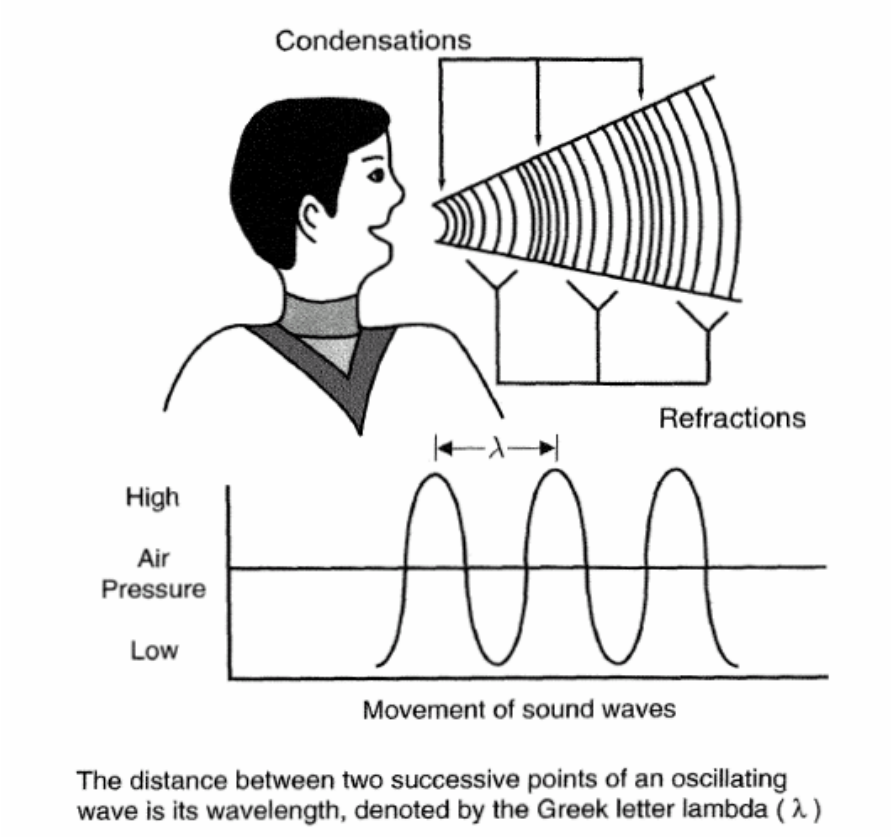



Fig : Generation of Sound Wave

**11. Channel speed and bit rate,**

A data communications channel utilizing conventional telephone lines is very slow. Below are some examples. For purposes of comparison, a channel is classified by categories of low speed, medium speed, and high speed :

Low Speed: 0-600 bits per second

Medium Speed: 600-4800 bits per second

High Speed: 4800-9600 bits per second.

Only recently, in the last few years, has the industry successfully moved to 9.6 kilobits per second (kbit/s) on telephone channels. The typical speeds found beyond 9600 bits per second are 14,400, 19,200, 56,000, and 64,000 bit/s, and 1.544 megabit/s (1,544,000 bits per second) and 2.048 Mbit/s in Europe.

The 1.544 megabits per second channel is the well-known TI carrier. This offering is prevalent in transmissions such as high-speed digital channels and digital switches.

The idea of a high-speed channel operating at 9.6 kbit/s is rapidly changing. With the proliferation of optical fiber technology, megabit speeds are becoming commonplace.

**12. Voice communications and analog waveforms,**

Voice communications generate acoustical waveforms which propagate through the air. In effect, voice communications are physical energy. When one speaks, oscillating waveforms of high and low air pressure are created. These waveforms are called *analog* waveforms. They are so named because they exhibit a continuous, repeating occurrence and they are non-discrete, gradually changing from high to low pressure. Of course, one cannot see waveforms in the air because the voice transmissions are air pressure variations. The frequency of human voice is between 200 Hz to 15 KHz and the human ear can detect frequencies between 40 Hz to 18 KHz. The range of frequencies is called bandwidth. (Bandwidth of a signal = Its Highest frequency – lowest frequency).

The telephone handset translates the physical oscillations of the air (sound wave) to electrical energy with similar waveform characteristics. The waveform exhibits three primary characteristics that are very important to data communications: *amplitude, frequency,* and *phase.*

**13. Band width and the frequency spectrum,**

The voice frequency transmitted in telephone channel is usually between 300 Hz to 3,300 Hz with a bandwidth of 3 KHz. More than one voice signals can be transmitted to larger distance by means of telephone channel by modulating the amplitude, frequency or phase of a high frequency carrier wave.

For example, two voice-grade channels serving two DTEs can be placed onto higher band channels of coaxial cable as follows:

| | | |
|---|---|---|
| | 300 | 10,030,300 |
| voice grade channel 1: | ↕ | ↕ |
| | 3300 | 10,033,300 |
| | 300 | 10,034,300 |
| voice grade channel 2: | ↕ | ↕ |
| | 3300 | 10,037,300 |

Since the DTEs' two voice-grade channels now occupy different frequency spectra, the signals can use the same physical media, because they are *linear* in that they behave as if they are independent of each other. The signals are said to occupy or use *subchanne/s.*

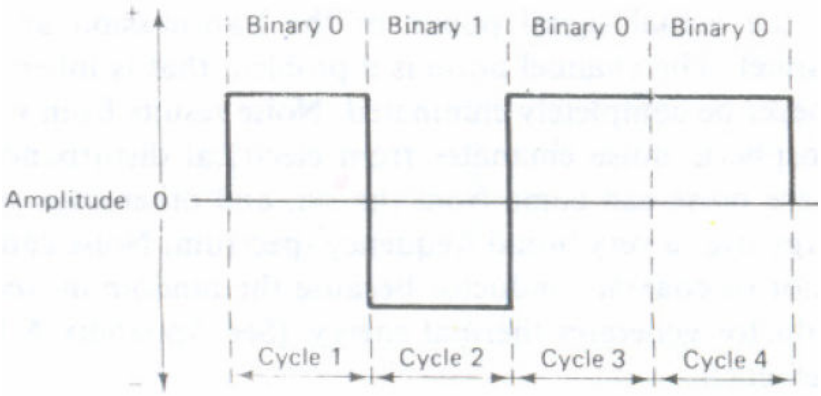
**14. Connecting the analog and digital worlds :**

**Digital world :**

Computers process and store information in digital, binary form because the semiconductor transistors are basically two state discrete devices. These digital signals

can be transmitted from one place to another by means of telephone cable by converting them into analog signals.

**Digital signals:**




## 15. The Modem :

The *modem* provides this digital/analog interface. It alters either the amplitude, the frequency, or the phase to represent the binary digital signal as an analog signal.
The modem is an example of a DCE. It provides the interface between the digital and analog worlds, as well as the capability to transmit from a digital DTE across the analog channel to a receiving digital DTE. The word "modem" is shortened term for modulation/demodulation. The process modulates the signal by means of the **transmitting modem** and demodulates the transmission at the **receiving modem**.

The digital binary signal is called baseband signal and the modem modulates a high frequency carrier signal (either its amplitude, frequency or phase) to carry the baseband signal. Thus a device which converts digital binary signal to analog signal to carry it over telephone cable is called **transmitting modem**. A device which converts analog signal back to digital binary form after transmitting it in a telephone cable is called **receiving modem**.
A modem which varies the amplitude of a carrier signal according to the variation in binary base band signal then the modem is called **AM modem**. A modem which varies the frequency of a carrier signal according to the variation in binary base band signal then the modem is called **FM modem**. On other hand, if a modem which varies the phase of a carrier signal according to the variation in binary base band signal then the modem is called **PM modem**.

Based on the connection, there are two types of modems : Internal Modem & External Modem. An internal modem is a plug-in circuit board and is resides in computer and they are less expensive. An External modem resides in a self –contained box outside the computer system and has a cable to connect to the serial port of the computer.

## 16. SYNCHRONIZING NETWORK COMPONENTS :

In order for computers and terminals to communicate, they first need to notify each other that they are able and wish to communicate. Second, once they are communicating, they must provide a method which keeps both devices aware of the ongoing transmissions. A transmitter, such as a terminal or a computer, must transmit its signal so that the receiving device knows when to search for and recognize the data as they arrive. In essence, the receiver must know the exact time that each binary 1 and 0 is coming across the communications channel. This requirement means that a mutual time base or a "common clock" is necessary between the receiving and transmitting devices.

This process is part of a communication protocol and is generally referred to as *synchronization.* Short connections between machines often use a separate channel, or line, to provide the synchronization. This line transmits a signal that is turned on and off or varied in accordance with pre-established conventions. As the clocking signal coming across this line changes, it notifies the receiving device that it is to examine the data line at a specific time. It may also resynchronize the receiver's clock so that the receiver stays very accurately aligned on each incoming data bit. Thus, clocking signals perform two valuable functions: (1) they synchronize the receiver into the transmission before the data actually arrive, and (2) they keep the receiver synchronized with the incoming data bits.

## 17. Asynchronous and Synchronous transmission :

Data can be transmitted either asynchronously or synchronously. Asynchronous transmission is commonly referred to as a start-stop transmission where one character at a time is transmitted or received. Start and stop bits are used to separate characters and synchronize the receiver with the transmitter, thus providing a method of reducing the possibility that data becomes garbled.
Most devices designed for human-machine interaction that are teletype compatible transmit data asynchronously. By teletype compatible, we refer to terminals and personal computers that operate similar to the TeletypeTM terminal manufactured by Western Electric, a subsidiary of AT&T, Various versions of this once popular terminal were manufactured for over 30 years and at one time it had an installed base of approximately one million such terminals in operation worldwide. As characters are depressed on the device’s keyboard they are transmitted to the computer, with idle time occurring between the transmission of characters.

**Asynchronous Transmission :**
**In** asynchronous transmission, each character to be transmitted is encoded into a series of pulses. The transmission of the character is started by a start pulse equal in length to a code pulse. The encoded character (series of pulses) is followed by a stop pulse that may be equal to or longer than the code pulse, depending upon the transmission code used.

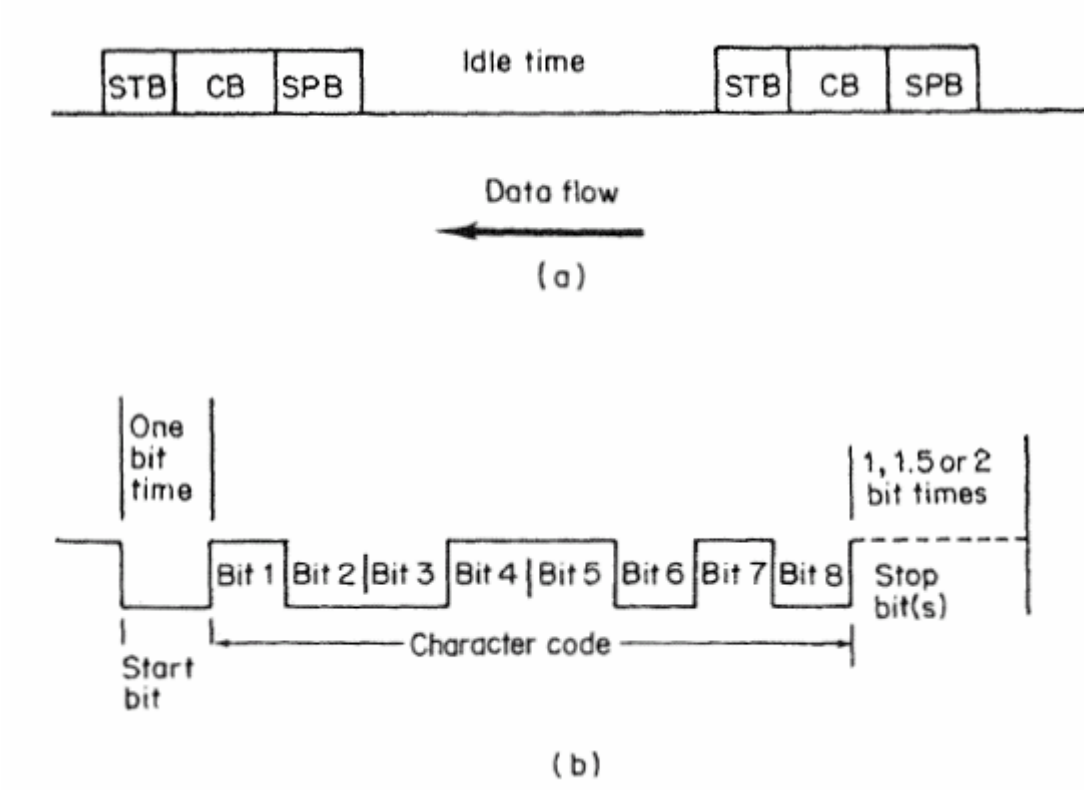



Fig.2 : Asynchronous (start-stop) transmission. (a1 Transmission of many characters. ST6 = start bit; CB = character bits; SPB =stop bit(s); idle time is between character transmission. (b) Transmission of one 8-bit character.

The start bit represented a transition from a mark to a space. Since in an idle condition when no data are transmitted the line is held in a marking condition, the start bit serves as an indicator to the receiving device that a character of data follows. Similarly, the stop bit causes the line to be placed back into its previous 'marking' condition, signifying to the receiver that the data character is complete as well as enabling a start bit to provide a marking to spacing line transition.

As illustrated in the lower portion of Figure 2, on of an 8-bit character requires either 10 or 11 bits, depending upon the length of the stop bit. In actuality the eighth bit may be used as a parity bit for error detection and correction purposes. The use of the parity bit is described in detail in Chapter 10. In the start-stop mode of transmission, transmission starts anew on each character and stops after each character. This is indicated in the upper portion of Figure 2. Since Synchronization starts anew with each character, any timing discrepancy is cleared at the end of each character, and synchrollization is maintained on a character-by-character basis.

Asynchronous transmission is normally used for transmission at speeds up to 56 000 bps over the switched telephone network, and data rates up to 64 kbps or

higher are possible over a direct connect cable whose distance is limited to 50 feet. The term 'asynchronous PITY' or 'TTY compatible' refers to the asynchronous start-stop protocol employed originally by Teletype' terminals and is the protocol in which data are transmitted on a line-by-line basis between a terminal device and a mainframe computer. In comparison, more modern terminals and personal computers with cathode ray tube (CRT) displays are usually designed to transfer data on a full screen basis.

Personal computer users only require an asynchronous communications adapter and a software program that transmits and receives data on a line-byline basis to connect to a mainframe that supports asynchronous TTY compatible terminals. Here the software program that transmits and receives data on a line-by-line basis is normally referred to as a TTY emulator program and it is the most common type of communications program written for use with personal computers. Since a personal computer includes a video display onto which characters and graphics can be positioned, the PC can be used to emulate a full screen addressable terminal. Thus, with appropriate software or a combination **of** hardware and software you can use a personal computes as a replacement for proprietary terminals manufactured to operate with a specific type of mainframe computer as well as to perform such local processing as spreadsheet analysis and word processing functions.

**Synchronous Transmission :**

A second type of transmission involves sending a grouping of characters in a continuous bit stream. This type of transmission is referred to as synchronous or bit-stream synchronization.
In the synchronous mode of transmission, modems or other communications devices located at each end of the transmission medium normally provide a timing signal or clock that is used to establish the data transmission rate and enable the devices attached to the modems to identify the appropriate bits in each character as they are being transmitted or received. In some instances, timing may be provided by the terminal device itself or a communication component, such as a multiplexer or front-end processor channel. No matter what timing source is used, prior to beginning the transmission of data the transmitting and receiving devices must establish synchronization among themselves. In order to keep the receiving clock in step with the transmitting clock for the duration of a stream of bits that may represent a large number of consecutive characters, the transmission of the data is preceded by the transmission of one or more special characters. These special synchronization or 'syn' characters are at the same code level (number of bits per character) as the coded information to be transmitted. They have a unique configuration of zero and one bits which are, however, interpreted as the syn character. Once a group of syn characters is transmitted, the receiver recognizes and synchronizes itself onto a stream of those syn characters.
After synchronization has been achieved, then actual data transmission can proceed. Synchronous transmission is illustrated in Figure 4.22. In synchronous transmission,

characters are grouped or blocked into groups of characters, requiring a buffer or memory area so characters can be grouped together. In addition to having a buffer area, more complex circuitry is required for synchronous transmission since the receiving device must remain in phase with the transmitter for the duration of the transmitted block of information, Synchronous transmission is normally used for data transmission rates in excess of 2000 bps. The major characteristics of asynchronous and synchronous transmission are denoted in Table 4.8.

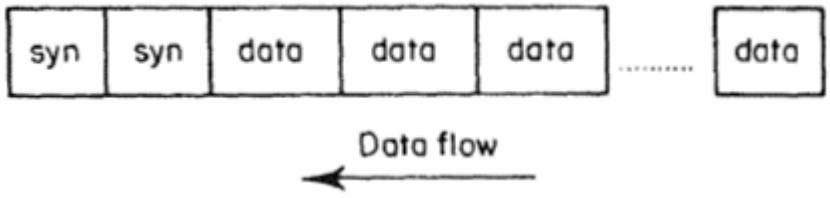



Figure 3 : Synchronous transmission. In synchronous transmission, one or more syn characters are transmitted to establish clocking prior to the transmission of data.

**Table : Transmission technique characteristics**

***Asynchronous***

1. Each character is prefixed by a start bit and followed by one or more stop bits.
2. Idle time (period of inactivity) can exist between transmitted characters.
3. Bits within a character are transmitted at prescribed time intervals.
4. Timing is established independently in the computer and terminal.
5. Transmission speeds normally do not exceed 56000 bps over analog switched facilities.

***Synchronous***

1. Syn characters prefix transmitted data.
2. Syn characters are transmitted between blocks of data to maintain line
3. No gaps exist between characters.
4. Timing is established and maintained by the transmitting and receiving modems, the terminal, or other devices.
5. Terminals must have buffers.
6. Transmission speeds are normally in excess of 2000 bps.

In examining the entries in Table note that the ability to transmit data at 56000 bps over analog switched network facilities is based upon only one end of a point-to-point communications facility having an analog to digital conversion. This means that the other end of the transmission facility has a direct digital interface to a communications carrier's digital network, reducing the potential errors associated with analog to digital conversion as an analog waveform that can have an infinite number of heights is converted into a digital signal and vice versa. A special type of modem referred to as a V.90 modem must be used to achieve 56 kbps transmission. By enhancing the signal to noise ratio, the use of a V.90 modern provides users with the ability to overcome Shannon's Law which restricts communications over a conventional analog telephone channel to approximately 30 000 bps.