Unit 16 □ Networks and their Classsification

Structure

16.0 Objectives

The objectives of the Unit are to :

- Classify networks by various characteristics within the knowledge domain of library and information services.
- Understand role of telecommunication
- Describe components of a computer network
- Enumerate the concept of bibliographic information network

16.1 Introduction

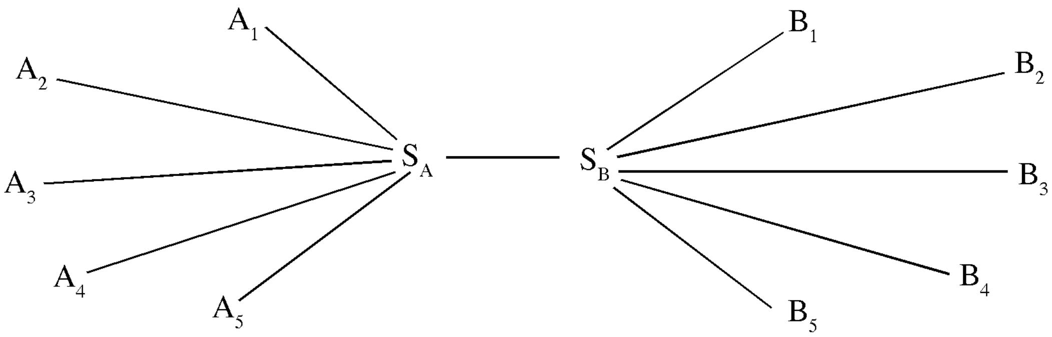
Network plays a crucial role in modern life. The modern economy would be very much diminished without the transportation, communication, information, and railroad networks. Networks have been developed to link banks, government offices, educational institutes and libraries etc. The objective of a communication system is to allow the exchange of information. The information may reside within the same system and/ or may be phisically located in different environments. Any network consists of three components :

1. Transmission Media
2. Control Mechanism
3. Interface

16.2 Classification of Networks

Networks are composed of links that connect nodes. It is inherent in the structure of a network that many components of a network are required for the provision of a typical service.

The classification in network type (one-way or two-way) is not a function of the topological structure of the network. Rather, it depends on the interpretation of the structure to represent a specific service. For example, the network of the following figure can be interpreted as a two-way telephone network where *SA* represents a local switch in city *A*, A_i represents a customer in city *A*, and similarly for *SB* and B_j. In this network, there are two types of local phone calls $A_iS_AA_k$ and $B_jS_BB_I$, as well as long distance phone call $A_iS_AS_BB_j$. We can also interpret the network of the following figure as an Automatic Teller Machine network. Then a transaction (say a withdrawal) from bank B_j from ATM A_i is A_i $S_AS_BB_j$. Connections $A_iS_AA_k$ and $B_jS_BB_I$ may be feasible but there is no demand for them.



Traditionally, networks were analyzed under the assumption that a single firm owned each network. Once, one of the most important networks, the AT&T telecommunications network in the US, was broken to pieces, economic research focused in the 80s and '90s on issues of interconnection and compatibility. Significant reductions in costs also contributed and will contribute to the transformation toward fragmented ownership in the telecommunications sector in both the United States and abroad. Costs of transmission have fallen dramatically with the introduction of fiber optic lines. Switching costs have followed the fast cost decreases of microchips and integrated circuits. These cost reductions have transformed the telecommunications industry from a natural monopoly to an oligopoly. The same cost reductions have made many new services, such as interactive video and interactive games, feasible at low cost. Technological change now allows for joint transmission of digital signals of various communications services. Thus, the monopoly of the last link closest to home is in the process of being eliminated,[8] since both telephone lines and cable lines (and in some cases PCS and terrestrial satellites) will provide similar services.

16.3 Telecommunication

Communication is the electronic transfer of information from one location to another. “Data communications” or “datacom” refers to digital transmission and “telecommunications” or “telecom” refers to a mix of voice and data, both analog and digital. “Networking” refers specifically to LANs and WANs. The term “communications” generally pertains to telecom-related subjects such as PBXs, modems, call centers and the like.

The world’s largest communication system is the telephone network, which is a mix of analog and digital communications. The system, which used to be entirely analog and transmitted only voice frequencies, is now almost entirely digital. The only analog part is the line between telephone node and a digital conversion point (digital loop carrier) within. Analog systems are error prone, because the electronic frequencies get mixed together with unwanted signals (noise) that are nearby.

In analog telephone networks, amplifiers were placed in the line every few miles to boost the signal, but they could not distinguish between signal and noise. Thus, the noise was amplified along with the signal. By the time the receiving person or machine got the signal, it may have been impossible to decipher.

In a “digital” network, only two (binary) distinct frequencies or voltages are transmitted. Instead of amplifiers, repeaters are used, which analyze the incoming signal and regenerate a new outgoing signal. Any noise on the line is filtered out at the next repeater. When data are made up of only two signals (0 and 1), they can be more easily distinguished from the garble.

Telecommunications may be defined as devices and systems that transmit electronic signals across long distances. Telecommunication covers all forms of distance and/or conversion of the original communications, including radio, telegraphy, television, telephony, data communication and computer networking. One of the roles of the telecommunications engineer is to analyse the physical properties of the line or transmission medium, and the statistical properties of the message in order to design the most effective encoding and decoding mechanisms.

The elements of a telecommunication system are a :

- Transmitter : The transmitter is a device that transforms or encodes the *message* into a physical phenomenon; the *signal.*
- Medium (line) : The transmission medium, by its physical nature, is likely to modify or degrade the signal on its path from the transmitter to the receiver.
- Channel imposed upon the medium : A path for electrical transmission between two or more points without common carrier-provided terminal equipment; also called a link, line, circuit or facility. All channels have *noise.* Another important aspect of the channel is called the bandwidth. A low bandwidth channel, such as a telephone, cannot carry all of the audio information that is transmitted in normal conversation, causing distortion and irregularities in the speaker's voice, as compared to normal, in-person speech.
- Receiver : The receiver has a decoding mechanism capable of recovering the message within certain limits of signal degradation. Sometimes, the final "receiver" is the human eye and/or ear and the recovery of the message is done by the brain.

Telecommunications messages can be sent in a variety of ways and by a wide range of devices. It may use different channel and/or signals. The telecommunication networks may be classified according to different characteristics.

16.3.1 Classification of Telecommunication networks by Channels

A path for electrical transmission between two or more points without common carrier-provided terminal equipment; also called a link, line, circuit or facility. Types of channels are :

- A **simplex Communication** system is one where all signals flow in one direction. These systems are often employed in broadcast networks, where the receivers do not need to send any data back to the transmitter/broadcaster. Example : Television, Commercial Radio Broadcast.

- A **duplex Communication** system is one where signals can flow in both directions between connected parties. These systems are employed in nearly all communications networks, either to allow for a "two-way street" between connected parties or to provide a "reverse path" for the monitoring and remote adjustment of equipment in the field.
  - Half-duplex : A *half-duplex* system allows communications in both directions, but only one direction at a time (not simultaneously). Any radio system where you must use "Over" to indicate the end of transmission, or any other procedure to ensure that only one party broadcasts at a time would be a *half-duplex* system. A good analogy for a *half-duplex* system would be a one lane road with traffic controllers at each end. Traffic can flow in both directions, but only one direction at a time with this being regulated by the controllers.
  - Full-duplex : A *full-duplex* system allows communication in both directions, and unlike half-duplex allows this to happen simultaneously. Most telephone networks are *full duplex* as they allow both callers to speak at the same time. A good analogy for a *full-duplex* system would be a two lane road with one lane for each direction. Example : Telephone.

16.3.2 Classification of Telecommunication Networks by Communication

Telecommunication can be point-to point, point-to-multipoint or broadcasting, which is a particular form of point-to-multipoint that goes only from the transmitter to the receivers.

- Point-to-point : The messages can be sent from one sender to a single receiver (point-to-point) or from one sender to many receivers (Point-to-multipoint). Personal communications, such as a telephone conversation between two people or a facsimile (fax) usually involve point-to-point transmission.
- Point-to-multipoint : It is most typically used in wireless Internet and IP Telephony via gigahertz radio frequencies. PT2MP systems have been designed both as single and bi-directional systems. A central antenna or antenna array broadcasts to several receiving antennae and the system uses a form of Time-domain Multiplexing to allow for the back-channel traffic.
- Broadcasting : It is the distribution of audio and video signals (programmes) to a number of recipients ("listeners" or "viewers") that belong to a large group. Television and radio programmes are distributed through radio broadcasting or cable, often both simultaneously. By coding signals and having decoding equipment in homes, the latter also enables subscription-based channels and pay-per-view services.

16.3.3 Classification Telecommunication networks by Signal Characteristics

Based on the signal characteristics, telecommunication networks may be classified as follows :

1. Telegraph Networks
2. Telephone Networks
3. Fax/Telex Networks
4. Computer Networks

16.3.3.1 Telegraph Networks

Telegraph services use both wire line and wireless media for transmissions. Soon after the introduction of the telegraph in 1844, telegraph wires spanned the country. A message sent by telegraph was called a telegram. Telegrams were printed on paper and delivered to the receiving party by the telegraph company. With the invention of the radio in the ealry 1900s, telegraph signals could also be sent by radio waves. Wireless telegraphy made it practical for ocean going ships as well as aircraft to stay in constant contact with land-based stations.

16.3.3.2 Telephone Networks

The telephone network also uses both wire line and wireless methods to deliver voice communications between people, and data communications between computers and people or other computers. The part of the telephone network that currently serves individuals residences and many businesses operates in an analog mode and relays electronic signals that are continuous, like the human voice. Digital transmission is now used in some sections of the telephone network that send large amounts of calls over long distances. However, since the rest of the telephone system is still analog, these digital signals must be converted back to analog before they reach users.

16.3.3.3 Telex/Facsimile Transmission Networks

Teletype, telex, and facsimile transmission are all methods for transmitting text rather than sounds. Facsimile transmission now provides a cheaper and easier way to transmit text and graphics over distances. Fax machines contain an optical scanner that converts text and graphics into digital, or machine-readable, codes. This coded information is sent over ordinary analog telephone lines through the use of a modem included in the fax machine. The receiving fax machine's modem demodulates the signal and sends it to a printer also contained in the fax machine.

16.3.3.4 Data Networks

Data networks with the ability to send and receive audio, video, text, software, and multimedia, is one of the fastest-growing segments of the telecommunications.

Computer-telecommunications symbiosis takes advantage of existing telephone connections to transmit digital data. This type of transmission is frequently done over the Internet. Some computers connect directly to the digital portion of the telephone network using the Integrated Services Digital Network (ISDN), but this requires the installation of special devices and telephone line conditioning. An improved modem system for regular phone lines, called Digital Subscriber Line (DSL), is being developed to increase modem speed tremendously. The difference between voice and data communication :

Voice Communication	Data Communication
Continuous	Discrete
Low bandwidth for long duration	High bandwidth for short duration
Half duplex	Half/Full duplex
Real time	Near real time
Loss acceptable	No distortion acceptable
Error tolerable	Error unacceptable
Sharing not possible	Sharing possible

16.4 Communication Networks based on Switching Techniques

Most communication systems have started with point-to-point links, which directly connect together the users wishing to communicate, using a dedicated communications circuit. As the distance between users increases beyond the manageable length of the cable, the connection between the users was formed by a number of sections.

As the number of connected users increased, it has become infeasible to provide a circuit, which connects every user to every other user, and some sharing of the transmission circuits (know as "switching") has become necessary. To accomplish this goal, the data communications network has evolved. A network is a set of nodes that are interconnected to permit the exchange of information. Three switching techinques have been proposed for building networks :

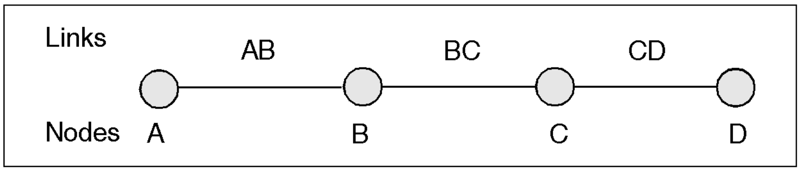
- Circuit switching
- Message switching
- Packet switching

Each allows sharing communication facilities among multiple users, and each uses equipment located at the nodes to replace the patch-panels used in a point-to-point connection. Packet switching is most often used for data communication. Most networks consists of many links (see the figure below), which allow more than one path through the network between nodes. A data communications network must be able to select an appropriate path for each required connection.

The relative performance of circuit switching and packet switching depends strongly on the speed and "cost" of establishing a connection.

16.4.1 Circuit switching

It allows communication equipment and circuits, to be shared among users. Each user has sole access to a circuit (functionally equivalent to a pair of copper wires) during network use. Consider communication between two points A and D in a network. The connection between A and D is provided using (shared) links between two other pieces of equipment, B and C.



A connection between two systems A & D formed from 3 links

Network use is initiated by a connection phase, during which a circuit is set up between source and destination, and terminated by a disconnect phase. After a user requests a circuit, the desired destination address must be communicated to the local switching node (B). In a telephony network, this is achieved by dialing the number.

Node B receives the connection request and identifies a path to the destination (D) via an intermediate node (C). This is followed by a circuit connection phase handled by the switching nodes and initiated by allocating a free circuit to C (link BC), followed by transmission of a call request signal from node B to node C. In turn, node C allocates a link (CD) and the request is then passed to node D after a similar delay.

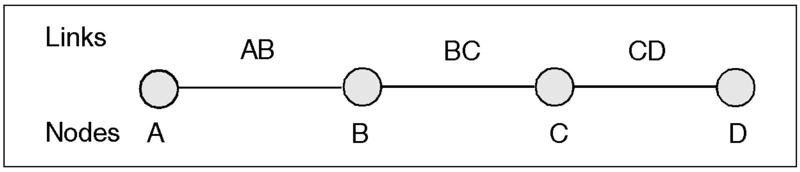
The circuit is then established and may be used. While it is available for use, resources (i.e. in the intermediate equipment at B and C) and capacity on the links between the equipment are dedicated to the use of the circuit.

After completion of the connection, a signal confirming circuit establishment (a connect signal in the diagram) is returned; this flows directly back to node A with no search delays since the circuit has been established. Transfer of the data in the message then begins. After data transfer, the circuit is disconnected; a simple disconnect phase is included after the end of the data transmission.

Delays for setting up a circuit connection can be high, especially if ordinary telephone equipment is used. Call setup time with conventional equipment is typically on the order of 5 to 25 seconds after completion of dialing. New fast circuit switching techniques can reduce delays. Trade-offs between circuit switching and other types of switching depend strongly on switching times.

16.4.2 Message Switching

Sometimes there is no need for a circuit to be established all the way from the source to the destination. Consider a connection between the users (A and D) in the figure below (i.e. A and D) is represented by a series of links (AB, BC, and CD).



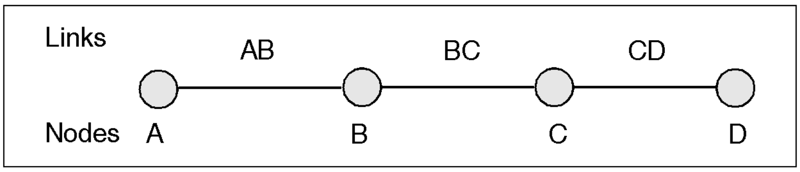
A connection between two systems A & D formed from 3 links

For instance, when a telex (or email) message is sent from A to D, it first passes over a local connection (AB). It is then passed at some later time to C (via link BC), and from there to the destination (via link CD). At each message switch, the received message is stored, and a connection is subsequently made to deliver the message to the neighboring message switch. Message switching is also known as store-and-forward switching since the messages are stored at intermediate nodes en route to their destinations. Most message switched networks do not use dedicated point-to point links and therefore a call must be set-up using a circuit switched network.

16.4.3 Packet Switching

Packet switching is similar to message switching using short messages. Any message exceeding a network-defined maximum length is broken up into shorter units, known as packets, for transmission; the packets, each with an associated header, are then transmitted individually through the network. The fundamental difference in packet communication is that the data is formed into packets with a pre-defined header format, and well known "idle" patterns, which are used to occupy the link when there is no data to be communicated.

Packet network equipment discards the "idle" patterns between packets and processes the entire packet as one piece of data. The equipment examines the packet header information and then either removes the header (in an end system) or forwards the packet to another system. If the out-going link is not available, then the packet is placed in a queue until the link becomes free. A packet network is formed by links, which connect packet network equipment.



Communication between A and D using circuits, which are shared using packet switching.

There are two important benefits from packet switching.

- The first and most important benefit is that since packets are short, the communication links between the nodes are only allocated to transferring a single message for a short period of time while transmitting each packet. Longer messages require a series of packets to be sent, but do not require the link to be dedicated between the transmission of each packet. The implication is that packets belonging to other messages may be sent between the packets of the message being sent from A to D. This provides a much fairer sharing of the resources of each of the links.
- Another benefit of packet switching is known as "pipelining". Pipelining is visible in the figure above. At the time packet 1 is sent from B to C, packet 2 is sent from A to B; packet 1 is sent from C to D while packet 2 is sent from B to C, and packet 3 is sent from A to B, and so forth. This simultaneous use of communications links represents a gain in efficiency, the total delay for transmission across a packet network may be considerably less than for message switching, despite the inclusion of a header in each packet rather than in each message.

16.4 Computer Network

Networks are connections between groups of computers and associated devices that allow users to transfer information electronically. It implies techniques, physical connections, and computer programmes used to link two or more computers. Network users are able to share files, printers, and other resources; send electronic messages; and run programmes on other computers. The computers on a network may be linked through cables, telephone lines, radio waves, satellites, or infrared light beams. The basic reasons for the growth of computer networks are :

- Resource sharing
- Data Sharing
- Communication and data exchange.

In effect, computer network may be considered as a communication channel.

16.4.1 Development of LAN & WAN

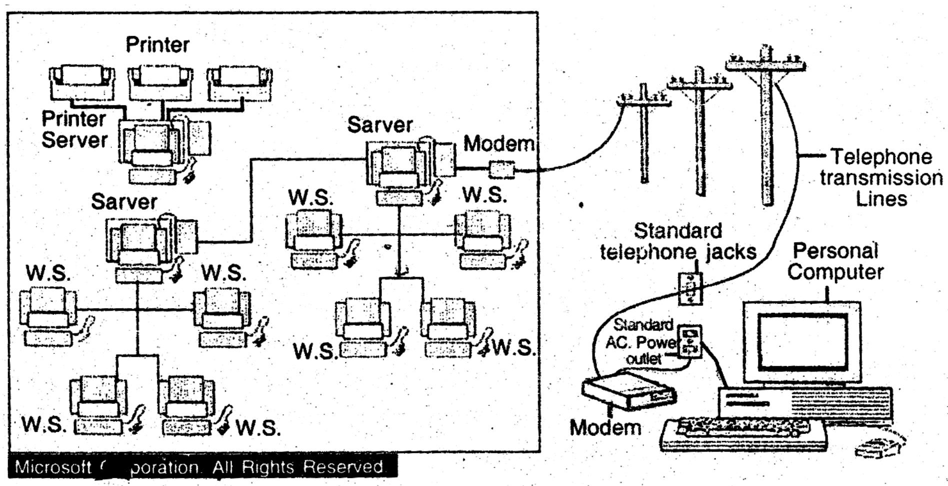
For historical reasons, the industry refers to nearly every type of computer network as an "area network." The most commonly discussed categories of computer networks include the following :

- Local Area Network (LAN)
- Wide Area Network (WAN)
- Metropolitan Area Network (MAN)
- Storage Area Network (SAN)
- System Area Network (SAN)
- Server Area Network (SAN)
- Small Area Network (SAN)
- Personal Area Network (PAN)
- Desk Area Network (DAN)
- Controller Area Network (CAN)
- Cluster Area Network (CAN)

LANs and WANs were the original flavours of network design. The concept of "area" made good sense at this time, because a key distinction between a LAN and a WAN involves the physical distance that the network spans. A third category of the Computer Network, the MAN, also fit into this scheme as it too is centered on a distance-based concept.

As technology improved, new types of networks appeared on the scene. These, too, became known as various types of "area networks" for consistency's sake, although distance no longer proved a useful differentiator.

The following figure represents a local area network. Individual computers are called workstations (W.S.), and communicate to each other via cable or telephone line linking to servers. The red line represents the larger network connection between servers, called the backbone; the blue line shows local connections. A modem (modulator/ demodulator) allows computers to transfer information across standard telephone lines. Modems convert digital signals into analog signals and back again, making it possible for computers to communicate, or network, across thousands of miles.



16.4.2 Advantages

- **Speed.** Networks provide a very rapid method for sharing and transferring files. Without a network, copying them to floppy disks, then carrying or sending the disks from one computer to other to shares files. This method of transferring files is very time-consuming.
- **Cost.** Network versions of many popular software programmes are available at considerable savings when compared to buying individually licensed copies. Besides monetary savings, sharing a programme on a network allows for easier upgrading of the programme. The changes have to be done only once, on the file server, instead of on all the individual workstations.
- **Security.** Files and programmes on a network can be designated as "copy inhibit," to prevent illegal copying of programmes. Also, passwords can be established for specific directories to restrict access to authorized users.
- **Centralized Software Management.** One of the greatest benefits of installing a computer network is the fact that all of the software can be loaded on one computer (the file server). This eliminates the need to spend time and energy installing updates and tracking files on independent computers throughout the building.
- **Resource Sharing.** Sharing resources is another area in which a network exceeds stand-alone computers. Most organizations cannot afford enough laser printers; fax machines, modems, scanners, and CD-ROM players for each computer. However, if these or similar peripherals are added to a network, they can be shared by many users.
- **Electronic Mail.** The presence of a network provides the hardware necessary to install an e-mail system. E-mail aids in personal and professional communication for all personnel, and it facilitates the dissemination of general information to the entire staff. Electronic mail on a LAN can enable workers to communicate with peers. If the LAN is connected to the Internet, workers can communicate with others throughout the world.
- **Flexible Access.** Networks allow workers to access their files from computers throughout the office. Students can begin an assignment in their classroom, save part of it on a public access area of the network, and then go to the media center after school to finish their work. Students can also work cooperatively through the network.
- **Workgroup Computing.** Workgroup software (such as Microsoft Back Office) allows many users to work on a document or project concurrently. For example, educators located at various schools within a country could simultaneously contribute their ideas about new curriculum standards to the same document and spreadsheets.

16.4.3 Disadvantages

- **Expensive to Install.** Although a network will generally save money over time, the initial costs of installation can be prohibitive. Cables, network cards, and software are expensive, and the installation may require the services of a technician.
- **Requires Administrative Time.** Proper maintenance of a network requires considerable time and expertise. Many organizations have installed a network, only to find that they did not have budget for the necessary administrative support.
- **File Server May Fail.** Although a file server is no more susceptible to failure than any other computer, when the files server "goes down", the entire network may come to a halt. When this happens, the entire organization may lose access to necessary programmes and files.
- **Cables May Break.** Some of the configurations are designed to minimize the inconvenience of a broken cable; with other configurations, one broken cable can stop the entire network.

16.4.4 Networking Hardware

Networking hardware includes all computers, peripherals, interface cards and other equipment needed to perform data processing and communications within the network. The major components of a computer network are :

- File Servers
- Workstations
- Network Interface Cards
- Switches
- Repeaters
- Bridges
- Routers

16.4.4.1 File Servers

A file server stands at the heart of most networks. It is a very fast computer with a large amount of RAM and storage space, along with a fast network interface card. The network operating system software resides on this computer, along with any software applications and data files that need to be shared. The file server controls the communication of information between the nodes on a network.

16.4.4.2 Workstations

All of the user computers connected to a network are called workstations. A typical workstation is a computer that is configured with a network interface card, networking software, and the appropriate cables. Workstations do not necessarily need floppy disk drives because files can be saved on the file server. Almost any computer can serve as a network workstation.

16.4.4.3 Network Interface Cards

The network interface card (NIC) provides the physical connection between the network and the computer workstation. Most NICs are internal, with the card fitting into an expansion slot inside the computer. Some computers, such as Mac Classics, use external boxes that are attached to a serial port or a SCSI port. Network interface cards are a major factor in determining the speed and performance of a network. It is a good idea to use the fastest network card available for the type of workstation you are using. The three most common network interface connections are Ethernet cards, LocalTalk connectors, and Token Ring cards.

16.4.4.4 Hub

It is a small rectangular box, often made of plastic that receives its power from an ordinary wall outlet. This network device joins multiple computers or other computer devices together to form a single network segment. On this network segment, all computers can communicate directly with each other. Ethernet hubs are by far the most common type.

16.4.4.5 Switch

A **network switch** is a small device that joins multiple computers together at a low-level network protocol layer. Technically, network switches operate at layer two (Data Link Layer) of the OSI model. Most switches are active that is they electrically amplify the signal as it moves from one device to another. Switches no longer broadcast network packets as hubs did in the past; they memorize addressing of computers and send the information to the correct location directly.

16.4.4.6 Repeaters

Since a signal loses strength as it passes along a cable, it is often necessary to boost the signal with a device called a repeater. The repeater electrically amplifies the signal it receives and rebroadcasts it. Repeaters can be separate devices or they can be incorporated into a concentrator. They are used when the total length of your network cable exceeds the standards set for the type of cable being used. A repeater connects two segments of the network cable.

16.4.4.7 Bridges

A bridge is a device that allows segmenting a large network into two smaller, more efficient networks. A bridge monitors the information traffic on both sides of the network so that it can pass packets of information to the correct location. Most bridges can "listen" to the network and automatically figure out the address of each computer on both sides of the bridge. The bridge can inspect each message and if necessary, broadcast it on the other side of the network.

A bridge reads the outermost section of data on the data packet, to tell where the message is going. It reduces the traffic on other network segments, since it does not send all packets. Bridges can be programmed to reject packets from particular networks. Bridging occurs at the data link layer of the OSI model, which means the bridge cannot read IP addresses, but only the outermost hardware address of the packet. The bridge can read the Ethernet data which gives hardware address of the destination address, not the IP address. Bridges forward all broadcast messages. Only a special bridge called a translation bridge will allow two networks of different architectures to be connected. Bridges do not normally allow connection of networks with different architectures.

16.4.4.8 Routers

A router translates information from one network to another; it is similar to a super intelligent bridge. Routers select the best path to route a message, based on the destination address and origin. The routher can direct traffic to prevent head-on collisions, and is smart enough to know when to direct traffic along back roads and shortcuts.

While bridges know the addresses of all computers on each side of the network, routers know the addresses of computers, bridges and other routers on the network. Routers can even "listen" to the entire network to determine which sections are busiest-they can then redirect data around those sections until they clear up.

A router is necessary to connect LAN to the Internet. The router serves as the translator between the information on the LAN and the Internet. It also determines the best route to send the data over the Internet. Routers can route :

- Signal traffic efficiently
- Messages between any two protocols
- Messages between linear bus, star, and star-wired ring topologies
- Messages across fiber optic, coaxial and twisted-pair cabling

16.4.4.9 Gateway

A gateway can translate information between different network data formats or network architectures. It can translate TCP/IP to AppleTalk so computers supporting TCP/IP can communicate with apple brand computers. Most gateways operate at the application layer, but can operate at the network or session layer of the OSI model. Gateways will start at the lower level and strip information until it gets to the required level and repackage the information and work its way back toward the hardware layer of the OSI model. To confuse issues, when talking about a router that is used to interface to another network, the word gateway is often used. This does not mean the routing machine is a gateway as defined here, although it could be.

16.4.5 Network Cabling

Cable is the medium through which information usually moves from one network device to another. There are several types of cable, which are commonly used with LANs. In some cases, a network will utilize only one type of cable; other networks will use a variety of cable types. The type of cable chosen for a network is related to the network's topology, protocol, and size. Understanding the characteristics of different types of cable and how they relate to other aspects of a network is necessary for the development of a succesful network.

The following sections discuss the types of cables used in networks and other related topics.

- Unshielded Twisted Pair (UTP) Cable
- Shielded Twisted Pair (STP) Cable
- Coaxial Cable
- Fiber Optic Cable
- Wireless LANs
- Cable Installation Guides

16.4.5.1 Unshielded Twisted Pair (UTP) Cable

Twisted pair cabling comes in two varieties : shielded and unshielded. Unshielded twisted pair (UTP) is the most popular and in generally the best option for small networks (See fig. 1).

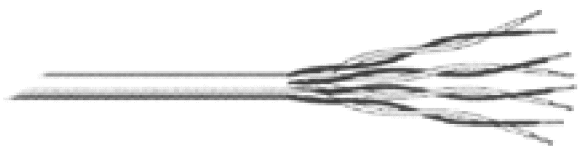


Fig. 1. : Unshielded twisted pair

The quality of UTP may vary from telephone-grade wire to extremely high-speed cable. The cable has four pairs of wires inside the jacket. Each pair is twisted with a different number of twists per inch to help eliminate interference from adjacent pairs and other electrical devices. For cable, the tighter the twisting, the higher is the supported transmission rate and the greater the cost per foot.

Categories of Unshielded Twisted Pair

Type	Use
Category 1	Voice Only (Telephone Wire)
Category 2	Data to 4 Mbps (LocalTalk)
Category 3	Data to 10 Mbps (Ethernet)
Category 4	Data to 20 Mbps (16 Mbps Token Ring)
Category 5	Data to 100 Mbps (Fast Ethernet)

16.4.5.2 Shielded Twisted Pair (STP) Cable

A disadvantage of UTP is that it may be susceptible to radio and electrical frequency interference. Shielded twisted pair (STP) is suitable for environments with electrical interference; however, the extra shielding can make the cables quite bulky. Shielded twisted pair is often used on networks using Token Ring topology.

16.4.5.3 Coaxial Cable

Coaxial cabling has a single copper conductor at its center. A plastic layer provides insulation between the center conductor and a braided metal shield (See fig. 3). The metal shield helps to block any outside interference from fluorescent lights, motors, and other computers.

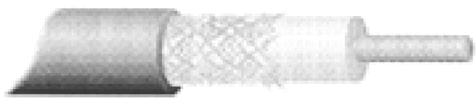


Fig. 3. : Coaxial cable

Although coaxial cabling is difficult to install, it is highly resistant to signal interference. In addition, it can support greater cable lengths between network devices than twisted pair cable. The two types of coaxial cabling are thick coaxial and thin coaxial.

Thin coaxial is also referred to as thinnet. 10Base2 refers to the specifications for thin coaxial cable carrying Ethernet signals. The 2 refers to the approximate maximum segment length being 200 meters. In actual fact the maximum segment length is 185 meters. Thin coaxial cable is popular in small networks, especially linear bus networks.

Thick coaxial cable is also referred to as thicknet. 10Base5 refers to the specifications for thick coaxial cable carrying Ethernet signals. The 5 refers to the maximum segment length being 500 meters. Thick coaxial cable has an extra protective plastic cover that helps keep moisture away from the center conductor. This makes thick coaxial a great choice when running longer lengths in a linear bus network. One disadvantage of thick coaxial is that it does not bend easily and is difficult to install.

16.4.5.4 Fiber Optic Cable

Fiber optic cabling consists of a center glass core surrounded by several layers of protective materials (See fig. 5). It transmits light rather than electronic signals eliminating the problem of electrical interference. It has also made it the standard for connecting networks between buildings, due to its immunity to the effects of moisture and lighting. Fiber optic cable has the ability to transmit signals over much longer distances than coaxial and twisted pair. It also has the capability to carry information at vastly greater speeds. This capacity broadens communication possibilities to include services such as video conferencing and interactive services. The cost of fiber optic cabling is comparable to copper cabling; however, it is more difficult to install and modigy.

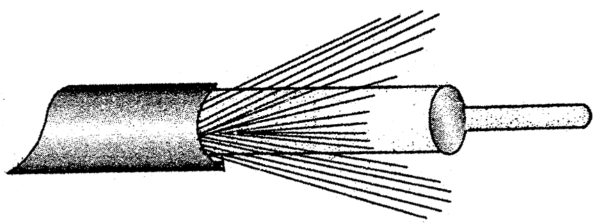


Fig. 5. : Fiber optic cable

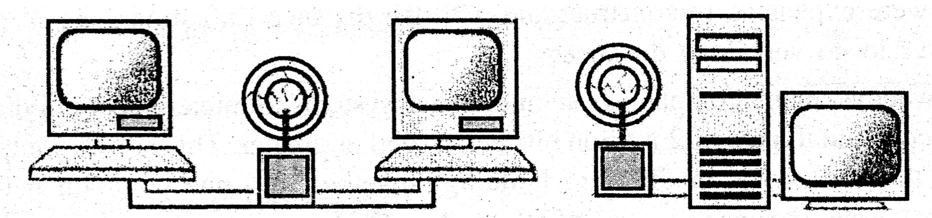
Facts about fiber optic cables :

- Outer insulating jacket is made of Teflon or PVC.
- Kevlar fiber helps to strengthen the cable and prevent breakage.
- A plastic coating is used to cushion the fiber center.
- Center (core) is made of glass or plastic fibers.

Ethernet cable summary

Specification	Cable Type	Maximum length
10 BaseT	Unshielded Twisted Pair	100 meters
10 Base2	Thin Coaxial	185 meters
10 Base5	Thick Coaxial	500 meters
10 BaseF	Fiber Optic	2000 meters
100 BaseTX	Unshielded Twisted Pair	220 meters

16.4.5.5 Wireless LANs



Not all networks are connected with cabling; some networks are wireless. Wireless LANs use high frequency radio signals, infrared light beams, or lasers to communicate between the workstations and the file server or hubs. Each workstation and file server on a wireless network has some sort of transceiver/antenna to send and receive the data. Information is relayed between transceivers as if they were physically connected. For longer distance, wireless communications can also take place through cellular telephone technology, microwave transmission, or by satellite.

Wireless networks are great for allowing laptop computers or remote computers to connect to the LAN. Wireless networks are also beneficial in older buildings where it may be difficult or impossible to install cables.

The two most common types of infrared communications used in small networks are line-of-sight and scattered broadcast. Line-of-sight communication means that there must be an unblocked direct line between the workstation and the transceiver. If a person walks within the line-of-sight while there is a transmission, the information would need to be sent again. This kind of obstruction can slow down the wireless network.

Scattered infrared communication is a broadcast of infrared transmissions sent out in multiple directions that bounces off walls and ceilings until it eventually hits the receiver. Networking communications with laser are virtually the same as line-of-sight infrared networks.

Wireless LANs have several disadvantages. They provide poor security, and are susceptible to interference from lights and electronic devices. They are also slower than LANs using cabling.

16.4.5.6 Micro-wave systems

Microwave system does not use cable as a transmission medium rather it uses the air. Using very high frequency signals, microwave support thousands of telephone channels and several television channels on the one circuit. Microwave is a radio system, which uses very high frequencies to send and receive data. Because of the high frequencies involved, stations are located about 30 kilometers apart and in line of sight (visible to each other). Microwave systems have sufficient bandwidth capacity to support a large number of voice channels and one or two TV channels. Dishes and towers were expensive to construct and with the distance limitations, meant it was expensive to go very long distances.

Nowadays, many companies use microwave systems to interconnect buildings at high-speed digital links of 2 million bits per second or greater. This allows companies to link their networks in different buildings together into one common network, allowing the sharing and accessing of information. Today, microwave systems are used in a number of areas, such as linking local area networks together between campus buildings, sending radio signal from a radio station to its transmitter site and the sending of video or audio signalsl from an outside sports event back to a TV broadcasting studio. Microwave systems have the advantage of medium capacity, medium cost, and can go long distances. Its disadvantages are noise interference, geographical problems due to line of sight requirements and are becoming outdated.

16.4.5.7 Satellite systems

Ground stations with large dishes communicate with a communication satellite in geo-stationary orbit around the earth. Each channel is managed by a transponder, which can support thousands of speech channels and about 4 TV channels simultaneously. The cost of satellite links is still very expensive (about $4M per transponder). It is primarily used for intercontinental links.

Satellite systems are comprised of ground based transmitter and receiver dishes, with an orbital satellite circuit (called a transponder). Signals are transmitted to the orbiting satellite, which relays it back to another ground station. The footprint coverage of a single satellite system is very large, covering thousands of square kilometers. Satellite is used to carry television channels and telephone conversions between countries. Satellite systems have the advantage of low cost per user (for PAY TV), high capacity, and very large coverage. Its disadvantages are high install cost in launching a satellite and receive dishes and decoders required, and delays involved in the reception of the signal.

References and Further Readings

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16.5 Exercise

1. Identify the major components of networks.
2. How do you classify networks?
3. Discuss classification of telecommunication networks.
4. Discuss communication networks beased on switching techinques.