CHAPTER # 03

DATA COMMUNICATIONS

The ability to link computers brings so many benefits that it has become one of the major growth areas in the personal-computers market. When PCs first started appearing in the business environment, the software application were simple and were designed for a single user, the advantages of connecting PCs weren‟t so compelling. But as these machines spread throughout business and as complex, multi-user software appeared, connecting microcomputers became a paramount goal. Suddenly Data Communications, the electronic transfer of information between computers, became a major focus of the computer industry.

- ★ Through Modems
- ★ Through Networks

Modems allow computers to use the telephone lines to read data and networks connect computers directly, either through special wires or by some form of wireless transmission.

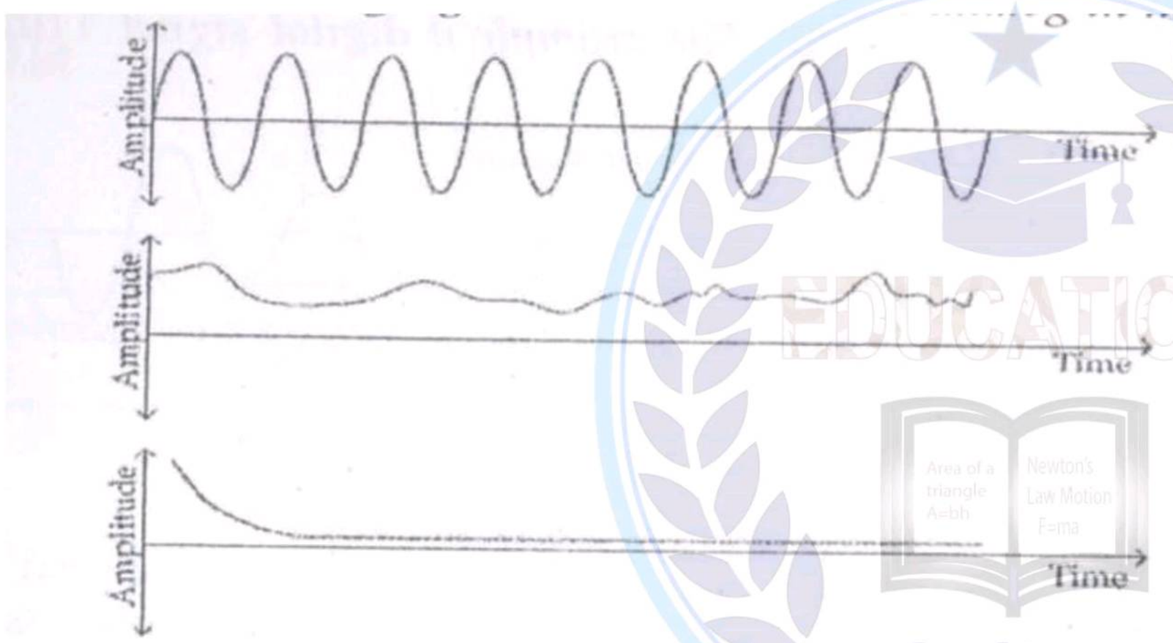
THE MODEM:

Computers use digital signals. However, many of our communication lines, such as telephone and microwave are still analog. To get around this problem, we need a MODEM – short for Modulator/DEModular to convert digital signals into analog form (the process is known as modulation) for transmission over phone lines. The receiving modem at the other end of phone line then convert analog signal back to digital signal (a process known as demodulation).

Moduation/demodulation does not actually change the wave form of an analog signal into on/off form of digital signal. Rather, it changes the form of the wave.

ANALOG SIGNAL:

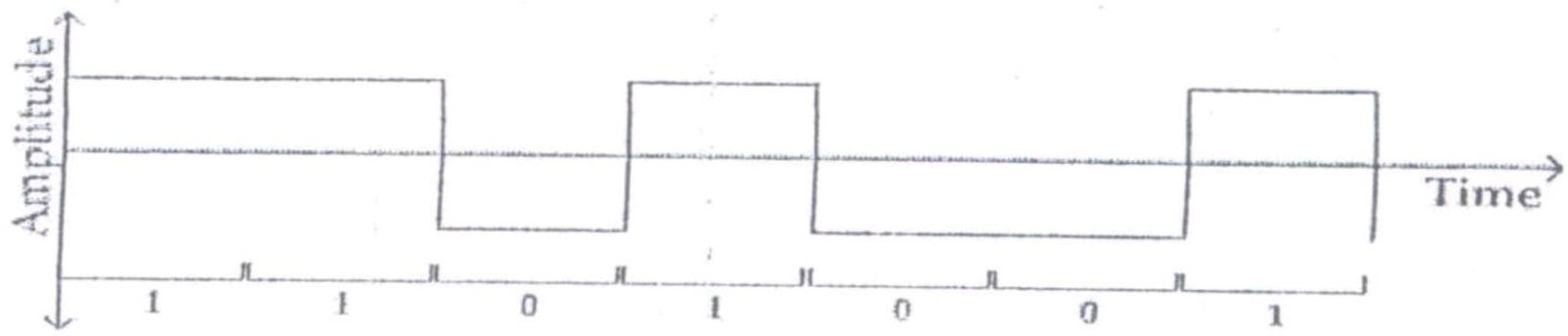
A signal, having the property of continuously varying in strength or quantity such as voltage, pressure, and audio is called signal. The real world is analog in nature.



Analog waveforms

DIGITAL SIGNAL:

A signal transmitted within or between computers, in which information is represented by discrete states – for example, high and low voltage i.e, binary “0” or “1” – rather than by fluctuating levels in a continuous stream, as in an analog signal.



MODIFYING AN ANALOG SIGNAL:

A modern may modify an analog signal to carry the on/off digital signals of a computer in two ways:

FREQUENCY MODULATION:

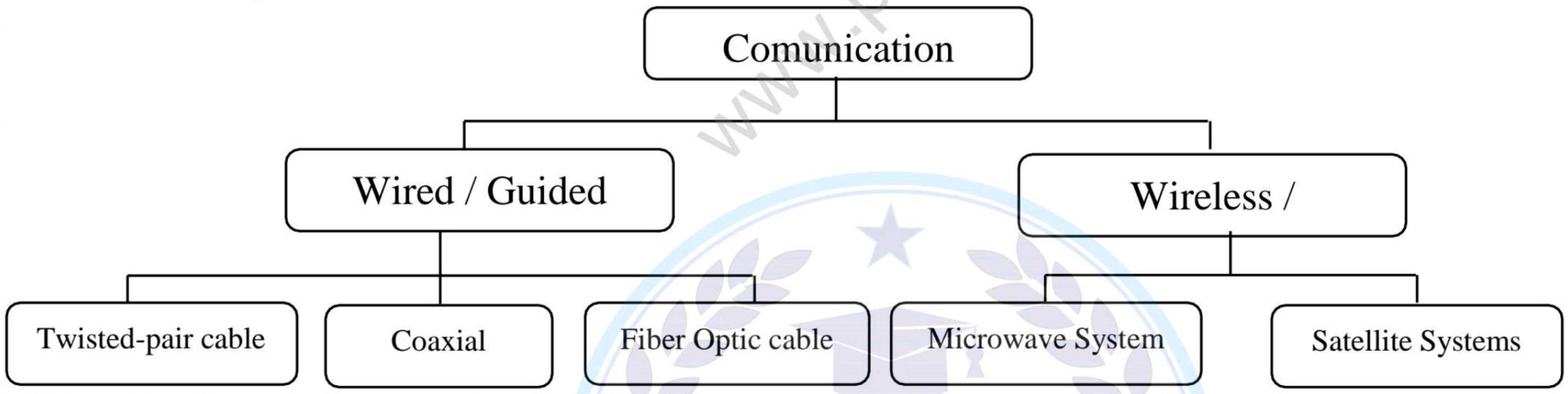
The frequency of wave cycle is altered so that the normal wave represents a „0" and a more frequent wave within a given period represents a „1". For example a digital signal 1101001 (Figure 2) will be frequency modulated as in Figure 4.

AMPLITUDE MODULATION:

The amplitude (height) of the wave is altered so that a wave of normal height represents a „0". For example a digital signal 1101001 (Figure 2) will be amplitude modulated as in Figure 4.

COMMUNICATION MEDIA:

When we talked about data storage, the term media referred to the storage media used in, for example, magnetic disks and tape. But in network communications, media refers to the wires, cables, and other means by which data travels from its source to its source to its destination.



Classification of Communication Media

GUIDED MEDIA:

Guided media confine the data to specific physical pathways. Common examples of guided media are copper wires and optical fiber cables. Cable TV also uses guided media.

UNGUIDED MEDIA:

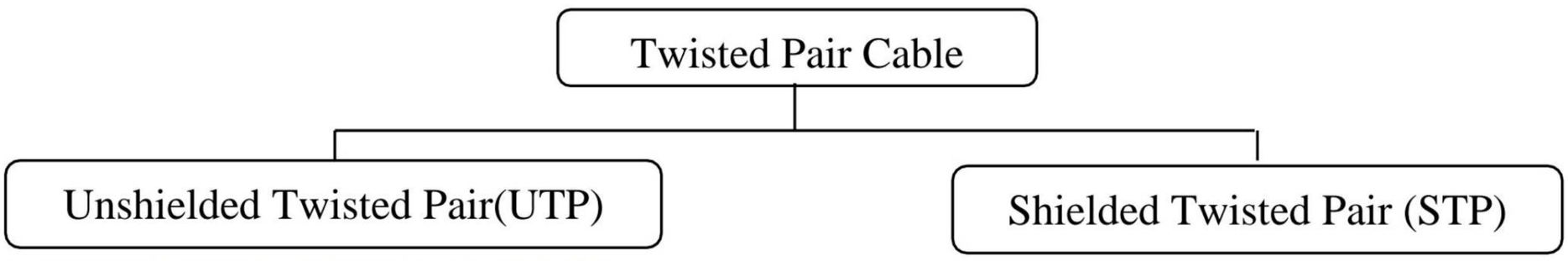
Unguided media transmit the data-carrying signal through space, independent of a cable. Broadcast radio and television are examples of unguided media.

CHARACTERISTICS UNDER CONSIDERATION WHILE EXAMINING CABLES:

- ★ Resistance to electrical magnetic interference (EMI).
- ★ Bandwidth, the range of frequencies that the cable can accommodate. LANs generally carry data rates of 1 to 100 megabits per second and require moderately high bandwidth.
- ★ Attenuation characteristics. Attenuation describes how reduce the strength of a signal with distance. Resistance is one factor that contributes to signal attenuation.
- ★ Cost.

GUIDED MEDIA:

Twisted Pair Cable:



Categories of Twisted Pair Cable

Above equation shows how two wires are twisted together to form the wire type known as twisted. Pair (TP). Cables can be constructed of multiple pairs of cables contained by a common jacket. The twists in the wire pairs are an important part of the electrical characteristics of TP cable. Twists reduce the cable‟s sensitivity to outside EMI. Remember that the frequencies at which LANs operate fall into the range of radio signals. If TP cable is insufficiently twisted, it can function as an antenna and radiate significant amounts of radio signals that can interfere with local broadcast reception equipment.

Unshielded Twisted Pair Cable

The EIA/TIA (Electronic Industry Association/Telecommunication Industry Association) has established standards of UTP and rated five categories of wire.

TYPE	USE
Category 1	Voice Only (Telephone Wire)
Category 2	Data to 4 Mbps (Local Talk)
Category 3	Data to 10 Mbps (Ethernet)
Category 4	Data to 20 Mbps (16 Mbps Token)
Category 5	Data to 100 Mbps (Fast Ethernet)

Categories of UTP

A disadvantage of UTP is that it may be susceptible to radio and electrical frequency interference. Shielded Twisted Pair (STP) is suitable for environment 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.

UNSHIELDED TWISTED PAIR CONNECTORS:

In most cases, UTP cable is implemented using modular telephone-type connectors such as the RJ-1 (2 pair) and RJ-45 connectors. RJ-45 is a plastic connector that looks like a large telephone-style connector (Figure 8). A slot allows the RJ-45 to be inserted only one way. RJ stands for Registered Jack, implying that the connector follows a standard borrowed from the telephone industry. This standard designates which wire goes with each pin inside the connector.

RJ-45 Connector (having 8 conductor)

ADVANTAGES OF TWISTED-PAIR WIRING:

- ★ Telephone cable standards are mature and well established. Materials are plentiful, and a wide variety of cable installers are familiar with the installation requirements.
- ★ It may be possible to use in-place telephone wiring if it is of sufficiently high quality.
- ★ UTP represents the lowest cost cabling. The cost for STP is higher and is comparable to the cost of coaxial cable.

DISADVANTAGES OF TWISTED-PAIR WIRING:

- ★ STP can be expensive and difficult to work with.
- ★ Compared to fiber optic cable, all TP cable is more sensitive to EMI. UTP especially may be unsuitable for use in high-EMI environments.
- ★ TP cables are regarded as being less suitable for high-speed transmissions than coax or fiber optic. Technology advances, however, are pushing upward the data rates possible with TP, Cable segment lengths are also more limit with TP.

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 (Figure 9). The metal shield helps to block any outside interference from fluorescent lights, motors, and other computers.

Coaxial Cable

Coax has many desirable characteristics. It is highly resistant to EMI and can support high bandwidths. Some types of coax have heavy shields and center conductors to enhance these characteristics and to extend distances that signals can be transmitted reliably.

A wide variety of coax cable is available. You must use cable that exactly matches the requirements of a particular type of network.
Here are some common examples of coaxial cables used in LANs, along with their impedances, and the LAN standards with which they are associated:

- ★ RG-8 and RG-11 are 50 ohm cables required for thick-wire Ethernet. (10Base5 – ThickNet)
- ★ RG-58 is a smaller 50 ohm cable required for thin-wire Ethernet. (10Base2 – ThinNet)
- ★ RG-59 is a 75 ohm cable familiar when used to wire cable TV. RG-59 is also used to cable broadband 802.3 Ethernet.

COAXIAL CABLE CONNECTORS:

Both thick-net and thin-net use connection components, known as BNC (Bayonet Nut Connector), to make the connection between the cables and the computers. There are several important components in the BNC family, including the following:

BNC Cable Connector

- ★ The BNC cable connector – this connector is either soldered or crimped to the end of a cable.
- ★ The BNCT connecter – this connector is either soldered or crimped to the end of a cable.
- ★ The BNC barrel connector – it is used to join two lengths of thin-net cable to make a longer length. I the BNC terminator – it closes each end of the bus cable to absorb stray signals. Without it, a bus network will not function.

ADVANTAGES OF COAXIAL WIRING:

- ★ Highly insensitive to EMI.
- ★ Supports high bandwidths.
- ★ Represents a mature technology that is well understood and consistently applied among vendors.

DISADVANTAGES OF COAXIAL WIRING:

- ★ Although fairly insensitive to EMI, coax remains vulnerable to EMI in harsh conditions such as factories.
- ★ Coax can be bulky.
- ★ Coax is among the most expensive types of wire cables.

FIBER OPTIC CABLE:

Fiber optic cables are similar to coax, except without the braid. Figure 11 (a) shows a single fiber viewed from the side. At the center is the glass core through which the light propagates.
The principle on which this transmission of light depends is that of total internal reflection. Light traveling inside the fiber center, or core, strikes the outside surface at an angle of incidence greater than the critical angle, so that all the light is reflected toward the inside of the fiber without loss. Thus light can be transmitted over long distance by being reflected inward thousands of times. In order to avoid losses through the scattering of light by impurities on the surface of the fiber, the optical fiber core is

clothed with a glass layer called cladding of much lower refractive index. The reflections occur at the interface of the glass fiber and the shield (cladding).
Next comes a thin plastic jacket to protect the cladding. Fivers are typically grouped in bundles, protected by an outer sheath. Figure 11(b) shows a sheath with three fibers.

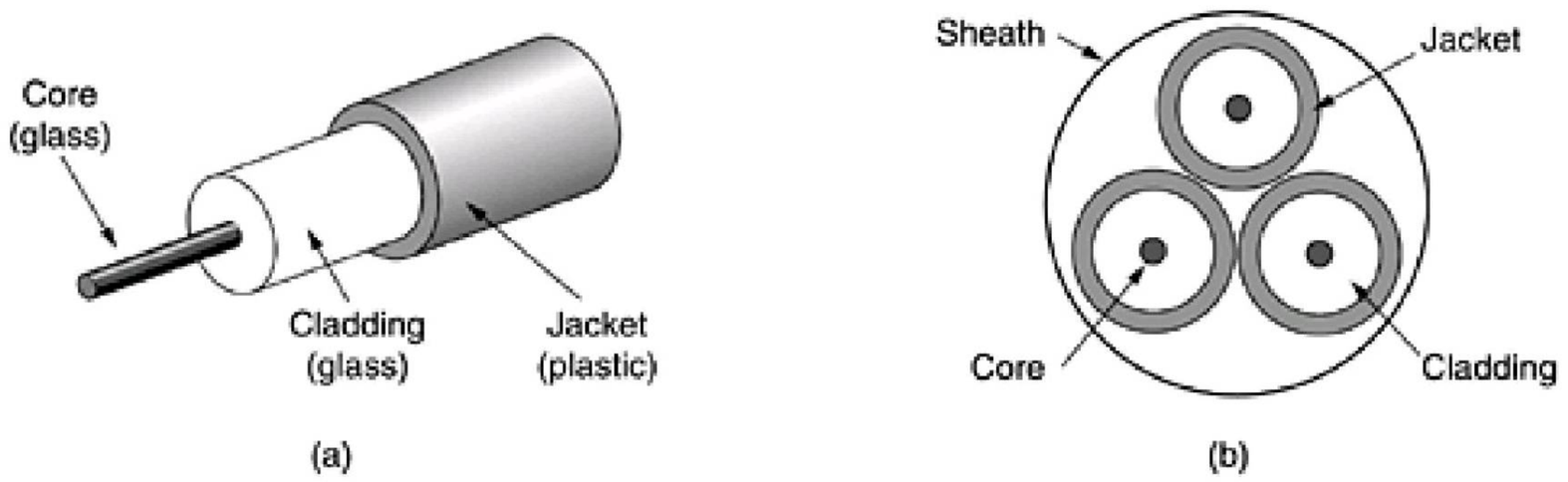


Figure 11 (a) Side view of a single fiber (b)End view of a sheath with three fibers

An optical transmission system has three key components:

- ★ The light source
- ★ The transmission medium
- ★ The detector

Conventionally, a pulse of light indicates a 1 bit and the absence of light indicates a 0 bit. The transmission medium is an ultra-thin of glass. The detector generates an electrical pulse when light falls on it. By attaching a light source to one end of an optical fiber and a detector to the other, we have a unidirectional data transmission system that accepts an electrical signal, converts and transmits it by light pulses, and then reconverts the output to an electrical signal at the receiving end.

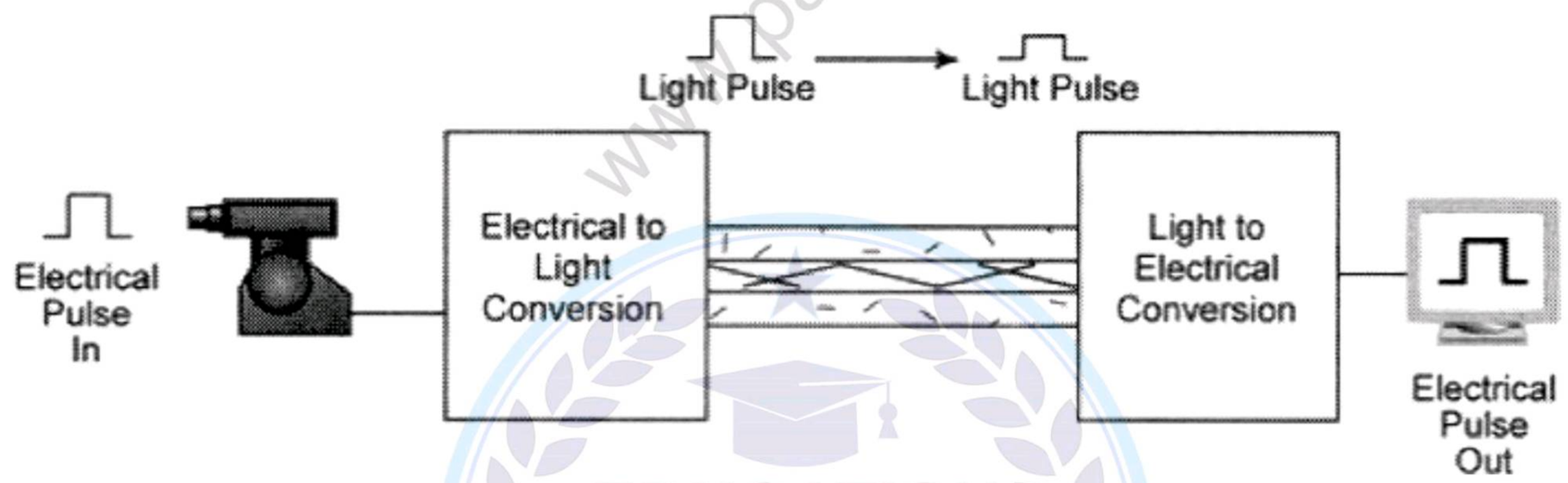


Figure 12: Transmission of electrical pulse through Fiber Optic Cable

FIBER OPTIC CONNECTORS:

The most common connector used with fiber optic is an ST connector (figure 13-a). It is barrel shaped, similar to a BNC connector. A newer connector, the SC (Figure 13-b), is becoming more popular. It has a square face and is easier to connect in a confined space.

Figure 13 (a): ST Connector

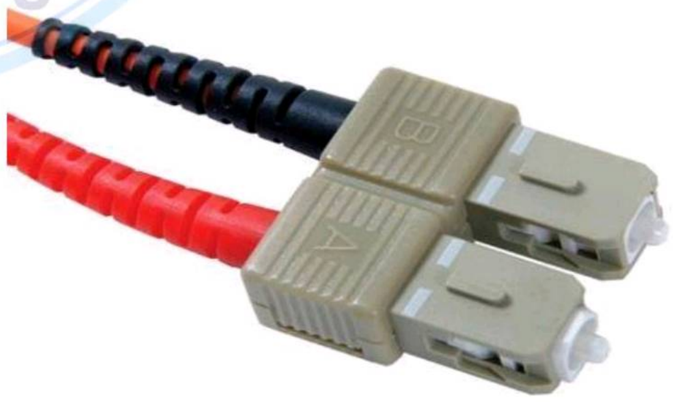


Figure 13(b): SC Connector

PHYSICAL APPEARANCE OF FIBER OPTIC CABLE:

The following are the few different types of Fiber optic cables available.

ADVANTAGES OF FIBER OPTIC CABLES:

- ★ Very high bandwidth.
- ★ Immunity to EMI; fiber optic cable can be used in environments that make wire cables unusable.
- ★ No radio frequency emissions; signals on fiber optic cables cannot interfere with nearby electronic devices.

DISADVANTAGES OF FIBER OPTIC CABLES:

- ★ Fragile.
- ★ High cost
- ★ Difficult installation and maintenance.

COMPARISON OF DIFFERENT CABLE TYPES:

Factors/Cable Type	UTP	STP	Coaxial	Fiber Optic
Cost	Lowest	Moderate	Moderate	Difficult
Installation	Easy	Fairly easy	Fairly easy	Difficult
Bandwidth	1 to 155 Mbps (Typically 10 Mbps)	1 to 155 Mbps (Typically 16 Mbps)	30 (10Base2) 100 (10Base5)	Lowest
Node Capacity per section	High	High	High	Lowest
EMI	Most vulnerable to EMI	Less vulnerable than UTP but still vulnerable to EMI	Less vulnerable than UTP but still vulnerable to EMI	Not affected by EMI

UNGUIDED MEDIA:

Unguided media or wireless communication transports electromagnetic waves without using physical conductor. Instead signals are broadcast through air (or water), and thus are available to anyone who has a device capable of receiving them.

RADIO FREQUENCY ALLOCATION:

The section of electromagnetic spectrum defined as radio communication is divided into nine ranges, called bands, each regulated by government authorities. These bands are rated from very low frequency (VLF) to tremendously high frequency (THF). See Figure below.

BLUETOOTH:

Bluetooth is a wireless protocol utilizing short-range communication technology facilitating data transmission over short distances from fixed and/or mobile devices, creating wireless personal area networks (PANs). The intent behind the development of Bluetooth was the creation of a single digital wireless protocol, capable of connecting multiple devices and overcoming issues arising from synchronization of these devices. Bluetooth provides a way to connect and exchange information between devices such as mobile phones, telephones, laptops, personal computers, printers, GPS receivers, digital cameras, and video game consoles over a secure, globally unlicensed Industrial, Scientific, and Medical (ISM) 2.4 GHz. Short-range radio frequency bandwidth. The Bluetooth specifications are developed and licensed by the Bluetooth Special Interest Group (SIG). The Bluetooth SIG consists of companies in the areas of telecommunication, computing, networking, and consumer electronics.

FACTORS AFFECTING COMMUNICATIONS AMONG DEVICES:

- ★ Transmission rate – frequency and bandwidth
- ★ Line configurations – point-to-point versus multipoint 1 Serial versus parallel transmission
- ★ Direction of transmission – simplex, half-duplex, and full-duplex 1 Transmission mode asynchronous versus synchronous 1 Multiplexing.
- ★ Protocols

TRANSMISSION RATE:

FREQUENCY:

The amount of data that can be transmitted on a channel depends on the wave frequency. Frequency is expressed in hertz; 1 cycle per second equals 1 hertz. The more the cycles per second, the more data the can be sent through that channel.

For Example:

- ★ A twisted-pair telephone wire operating at a frequency of 4000 hertz might send only 1 kilobyte of data in a second.
- ★ A coaxial cable of 100 megahertz might send 10 megabytes.
- ★ A fiber-optic cable of 200 trillion hertz might send 1 gigabyte.

BANDWIDTH:

Bandwidth is the difference between the highest and lowest frequencies, that is, the range of frequencies. Data may be sent not just on one frequency but on several frequencies within a particular bandwidth, all at the same time.

Thus, the greater the bandwidth of a channel, the more frequencies it has available and hence the more data that can be sent through that channel. The rate of speed of data through the channel is expressed in bits per second (bps), kilobits per second (Kbps), or megabits per second (Mbps).

LINE CONFIGURATIONS:

Line configuration is a way of connecting communications lines. There are two principal line configurations:

- ★ Point-to-point
- ★ Multipoint

POINT-TO-POINT:

A point-to-point line directly connects the sending and receiving devices, such as a terminal with a central computer. This arrangement is appropriate for a private line whose sole purpose is to keep data secure by transmitting it from one device to another. A point-to-point line may be public or private (leased).

MULTIPOINT:

A multipoint line is a single line that connects several communication devices to one computer. On a multipoint line only one communication device can tranmit at any given time.

SERIAL & PARALLEL TRANSMISSION:

There are two ways of transmitting data:

- ★ Serial data transmission
- ★ Parallel data transmission

SERIAL DATA TRANSMISSION:

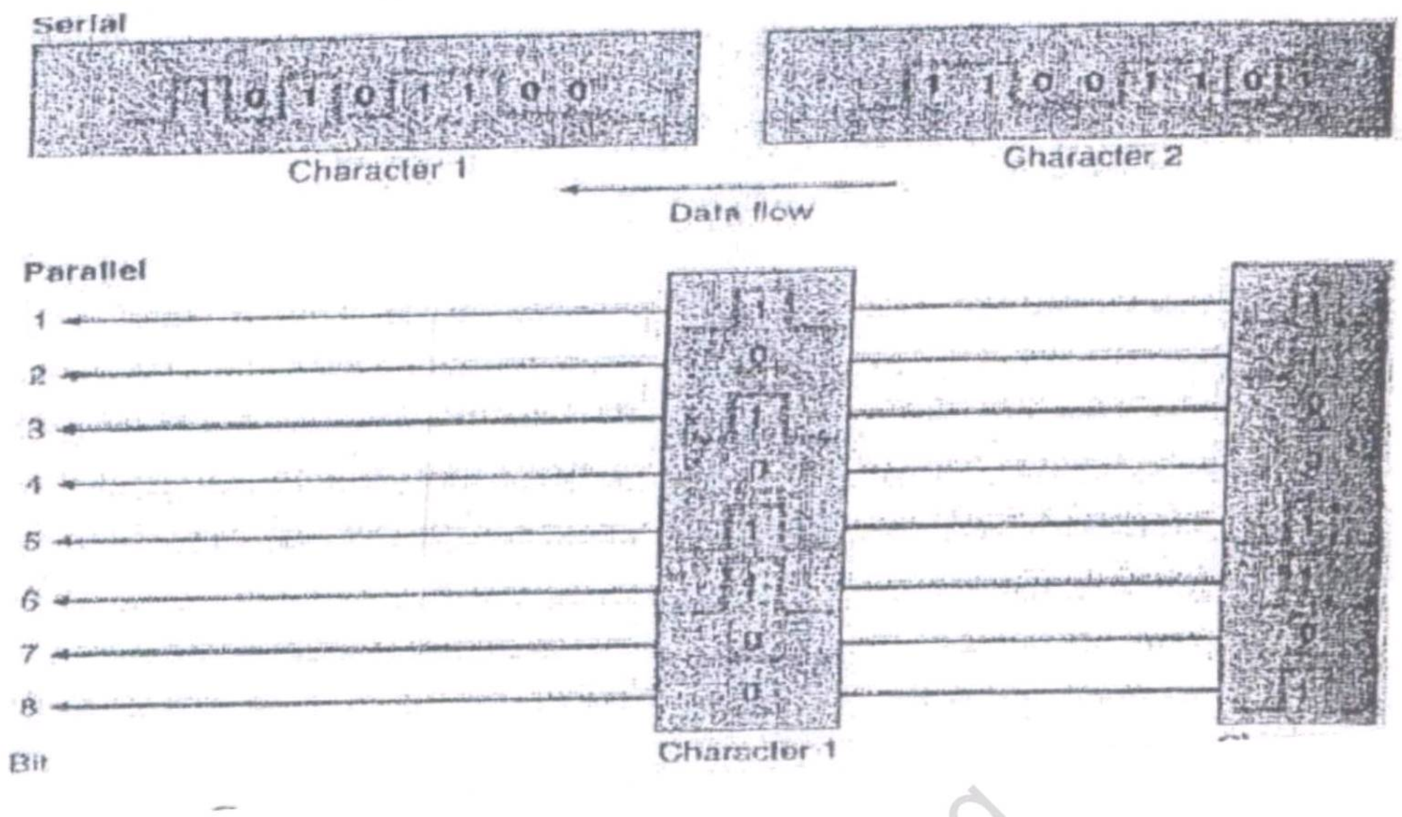
In serial data transmission, bits are transmitted sequentially, one after the other. This arrangement resembles cars proceeding down a one-lane road.

Serial transmission is the way most data flows over a twisted-pair telephone line. It is found in communications lines, modems, and most mice. The plug-in board for a microcomputer modem usually has a serial port.

PARALLEL DATA TRANSMISSION:

In parallel data transmission, bits are transmitted through separate lines simultaneously. The

arrangement resembles cars moving in separate lanes at the same speed on a multilane freeway.
Parallel lines move information faster than serial lines do, but they are efficient for up to only 15 feet. Thus, parallel lines are used to transmit data from a PC‟s processor to a printer.
Parallel transmission may also be used within a company‟s facility, for terminal-to-main-computer data transmission.



Serial and Parallel data transmission

DIRECTION OF TRANSMISSION:

When two computers are in communication, data can flow in three ways:

- ★ Simplex
- ★ Half-duplex
- ★ Full-duplex

SIMPLEX TRANSMISSION:

In simplex transmission. Data can travel in only direction. (See Figure 21)

Example:

- ★ A traditional television broadcast is an example, in which the signal is sent from the transmitter to your TV antenna. There is no return signal.
- ★ Some computerized data collection devices also work this way such as seismograph sensors that measure earthquakes.

HALF – DUPLEX TRANSMISSION:

In half-duplex transmission, data travels in both directions but only in one direction at a time. This arrangement resembles traffic on a one-lane bridge: the separate streams of cars must take turns.

Example:

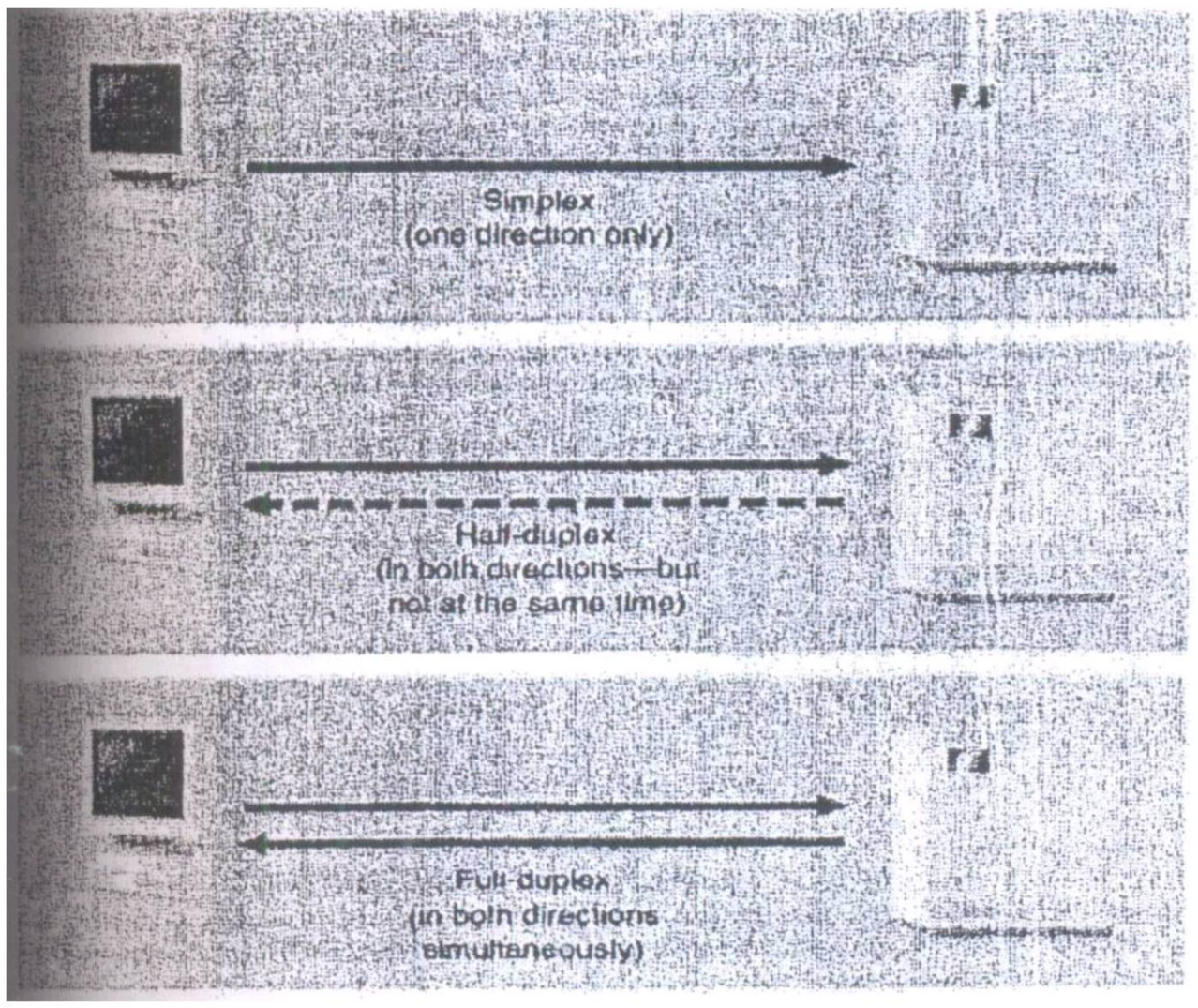
- ★ Half-duplex transmission is seen with marine radius, in which both parties must take turns talking.

FULL-DUPLEX TRANSMISSION:

In full-duplex transmission, data is transmitted back and forth at the same time. This arrangement resembles automobile traffic on a two-way street.

Examples:

- ★ An example is two people on the telephone talking and listening simultaneously.
- ★ It is also available for some new microcomputer modems and software to support truly interactive collaboration using products like Microsoft NetMeeting.



Simplex

Half-Duplex

Full-Duplex

Transmission Directions

TRANSMISSION MODE: ASYNCHRONOUS VERSUS SYNCHRONOUS:

Suppose your computer sends the word CONGRATULATIONS! To someone as bits and byte over a communications line. How does the receiving equipment know where one byte (or character) ends and another begins? This matter is resolved through either asynchronous transmission or synchronous transmission.

ASYNCHRONOUS TRANSMISSION

This method is used with most microcomputers and is also called start-stop transmission. In asynchronous transmission data is sent one byte (or character) at a time.
Each string of bits making up the byte is bracketed, or marked off, with special control bits. That is, a „start" bit represents the beginning of a character, and a „stop" bit represents its end.

ADVANTAGE:

★ Its advantage is that the data can be transmitted wherever it is convenient for the sender.

DISADVANTAGE:

★ This is a relatively slow method. As a result, asynchronous transmission is not used when great amounts of data must be sent rapidly.

SYNCHRONOUS TRANSMISSION:

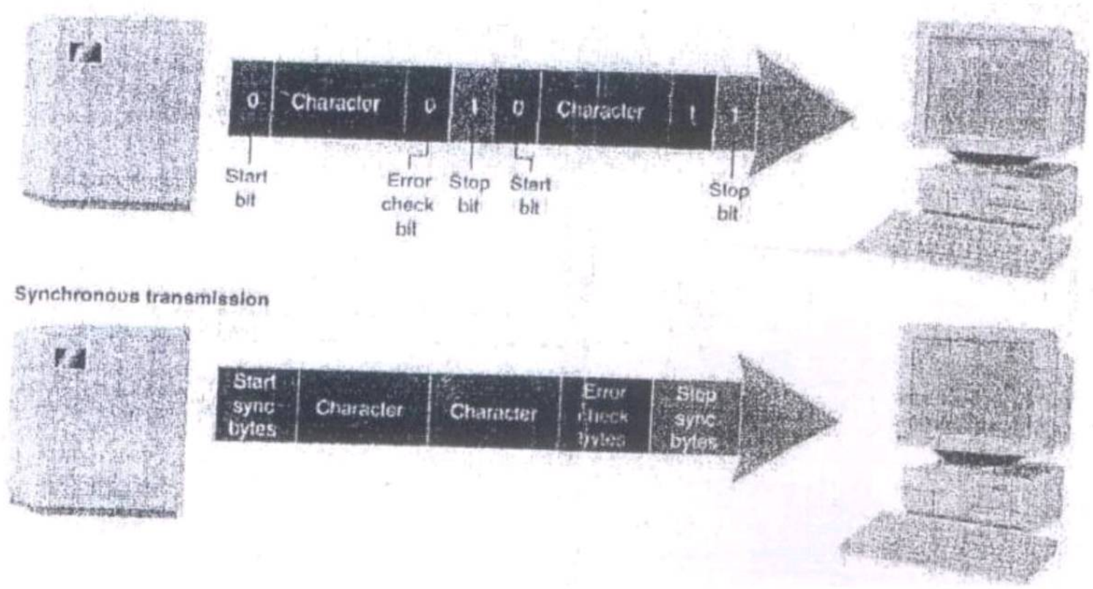
Instead of using start and stop bits, synchronous transmission sends data in blocks (synchronous means „timed"). Start and stop bit patterns, called sync bytes are transmitted at the beginning and end of the blocks. These start and end bit patterns synchronize internal clocks in the sending and receiving devices so that they are in time with each other.

ADVANTAGE:

★ It can transmit (great quantities of data quickly so it is appropriate for large computer systems.

DISADVANTAGES:

- ★ This method is rarely used with microcomputers because it is more complicated and more expensive than asynchronous transmission.
- ★ It also requires careful timing between sending and receiving equipment.



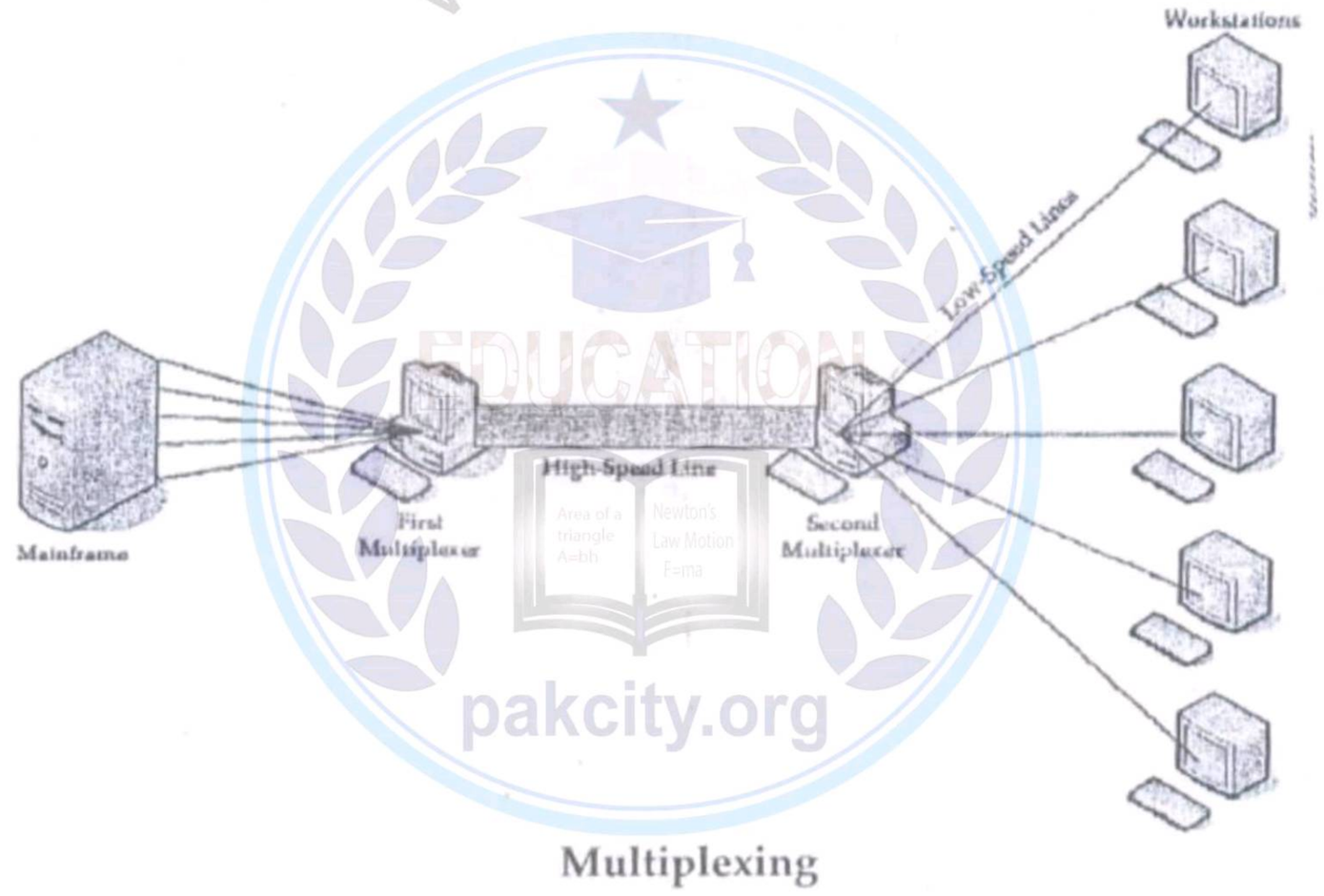
Transmission Modes

MULTIPLEXING:

In telecommunications and computer networks, multiplexing (known as muxing) is a term used to refer to a process where multiple analog message signals or digital data streams are combined into one signal over a shared medium. The aim is to share an expensive resource. For example, in telecommunications, several phone calls may be transferred using one wire.

The multiplexed signal is transmitted over a communication channel, which may be a physical transmission medium. The multiplexing divides the capacity of the low-level communication channel into several higher-level logical channels, one for each message signal or data stream to be transferred. A reverse process, known as demultiplexing, can extract the original channels on the receiver side.

A device that performs the multiplexing is called a multiplexer (MUX), and a device that performs the reverse process is called a demultiplexer (DEMUX).



Multiplexing

PROTOCOLS:

A protocol, or communications protocol, is a set of conventions governing the exchange of data between hardware and/or software components in a communications network.

Protocols are built into the hardware or software you are using. The protocol in your communications software will specify how receiver devices will acknowledge sending devices by means of handshaking.

Handshaking establishes the facts that the circuit is available and operational. It also establishes the level of device compatibility and the speed of transmission.

PROTOCOLS SPECIFY:

- ★ The type of electrical connections used
- ★ The timing of message exchanges
- ★ Error-detection techniques, and so on.

In the past all hardware and software developers were not subscribed to the same protocols. As a result, many kinds of equipment and programs have not been able to work with one another. In recent years, more developers have agreed to subscribe to a standard of protocols called OSI. Backed by the International Standards Organization, OSI (Open System Interconnection) is an international standard that defines seven layers of protocols, or software responsibilities, for worldwide computer communications.

THE OSI MODEL:

One communications standard created by the ISO is called the Open Systems Interconnection (OSI) model that simulates the communications process using seven layers, each with its own set of protocols. The purpose of the OSI model is to enable any vendor‟s computer system to share data with any other vendor‟s system in an open networking environment. Following figure shows the structure of the OSI model. A description of each of the seen layers are as follows:

Layer 1: Physical Layer:

The physical layer controls the electrical, mechanical and functional transmission of bits over the data circuits.

Layer 2: Data Link Layer:

The data link detects and compensates for transmission errors and ensures that information sent by high-speed transmitters is properly receive by slow receivers.

Layer 3: Network Layer:

The network layer determines how information is routed between computers and within and between individual networks. It also handles software interfaces between networks, including networks with different protocols.

Layer4: Transport Layer:

The transport layer specifies the rules for information exchange and manages end-to-end delivery of information within and between networks, including error recovery. It also controls information flow for examples multiple data streams on a single channel.

Layer 5: Session Layer:

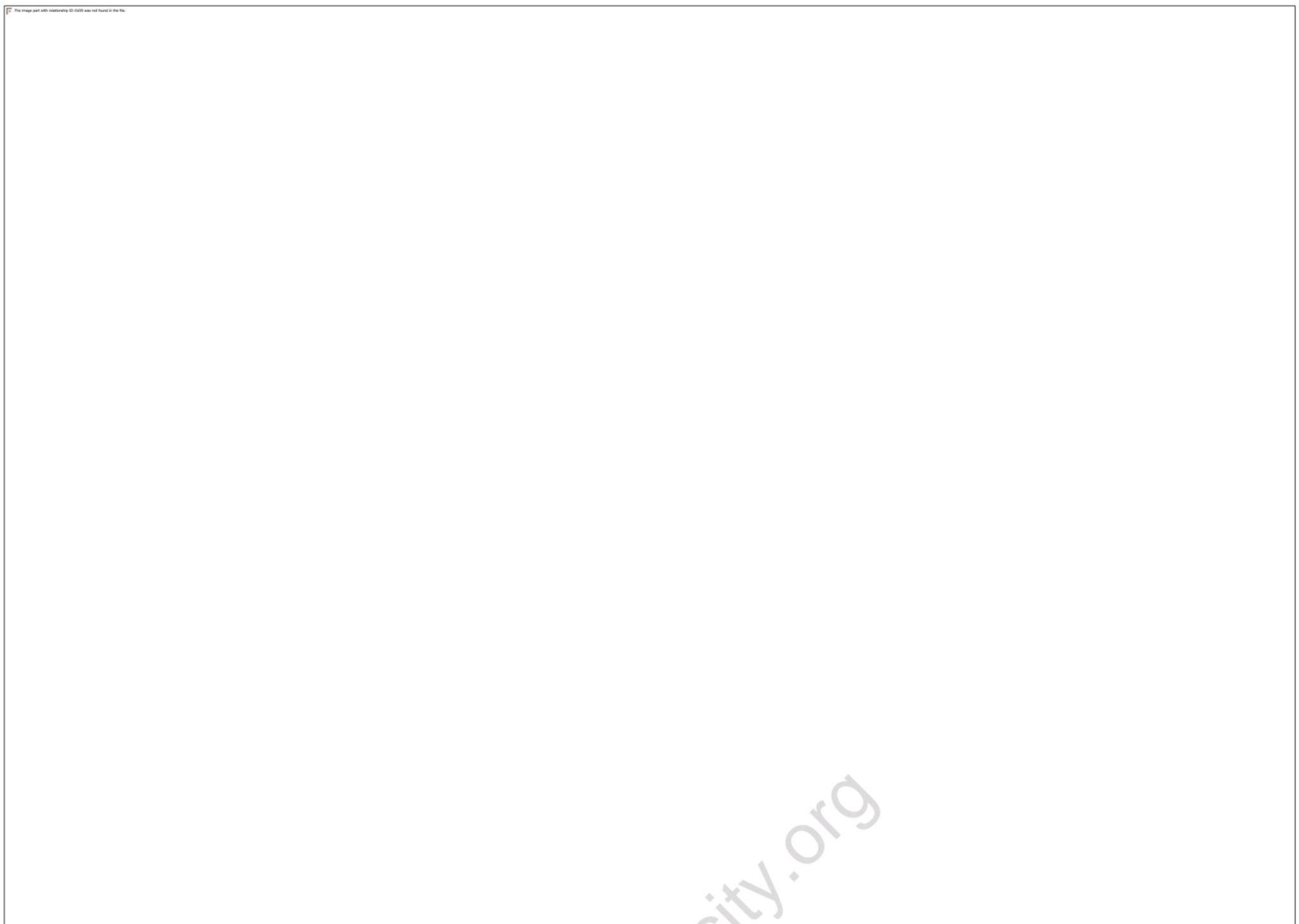
The session layer controls the dialog between two computers, managing file transfers and putting checkpoints into a data stream to allow portions of files to be retransmitted as needed.

Layer 6: Presentation Layer:

The presentation layer supplies transparent communications by masking the differences in unlike data formats such as the ASCII and EBCDIC character codes, and performs data compression and encryption.

Layer 7: Application Layer:

The applications layer supplies functions for particular applications such as file transfer, remote access and virtual terminals.



Passes bits into connecting medium

The OSI model: defines framework for implementing protocols