CHAPTER 3 Data Communications

Overview

In this chapter, we will describe how we have arrived at this electronic global village. Computers, telephones, and wireless devices are being linked by network everywhere in the world of connectivity. We are rapidly coming into an era in which we can find almost anything we want online and reach almost anywhere, anytime. When we collaborate, we are sharing information. This sharing can be local or remote. Between individual, local communication usually occurs face to face, while remote communication takes place over distance. **Data Communications** is the exchange of data between two devices via some form of transmission media such as a wire cable. In other words, we can say that transfer of information or data from one location to another is called Data Communications. The term data communication can generally be defined as the movement of encoded information by means of electrical transmission systems from one computer or device to other computer or device through communication channels (such as cables, wireless media etc.).

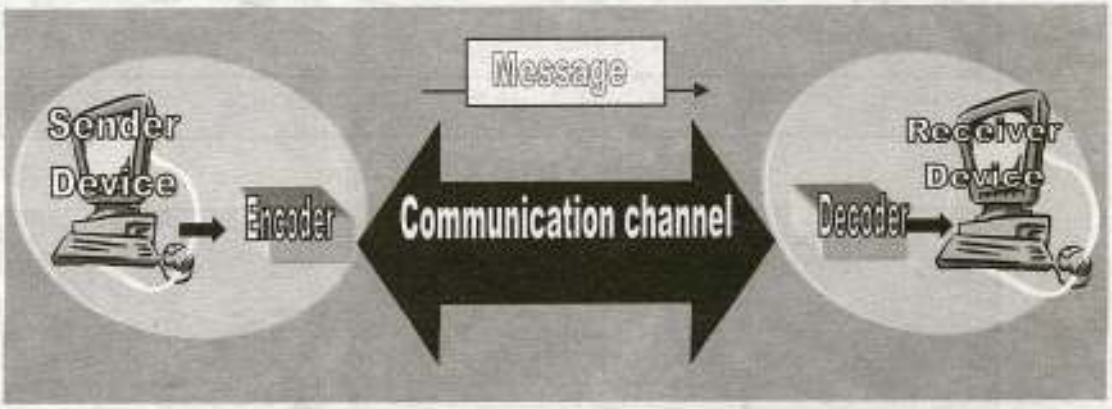

Figure 3.1: Five different components of Data Communication System.

3.1 Component of Data Communication

There are five components (see Figure 3.1) in data communication.

- **Message:** The message is the information (data) to be communicated. It can consist of text, number, pictures, sound, video or any combination of these.
- **Sender:** The sender is the device that sends the data. It can be computer, workstation, telephone, video camera and so on.
- **Receiver:** The receiver is the device that receives the data. It can be computer, workstation, telephone, television and so on.
- **Communication Channel:** The Communication channel is the physical path by which a data travels from sender to receiver. It can be a twisted – pair wire, coaxial cable, fiber optic cable, or microwave etc.
- **Encoder and Decoder:** The encoder converts digital signals to a form, which can pass through transmission medium and decoder again coverts signal from encoded form into digital form, which is understandable for receiver. Without these, two devices may be connected but not communicating, such as a student speaking Urdu cannot understand a student who speaks only German without a translator.

3.2 Signals

The electromagnetic or light waves representing data are called signals. These are used to transfer data from one device to another device through a communication medium. Data communication signals can be in analog or digital form.

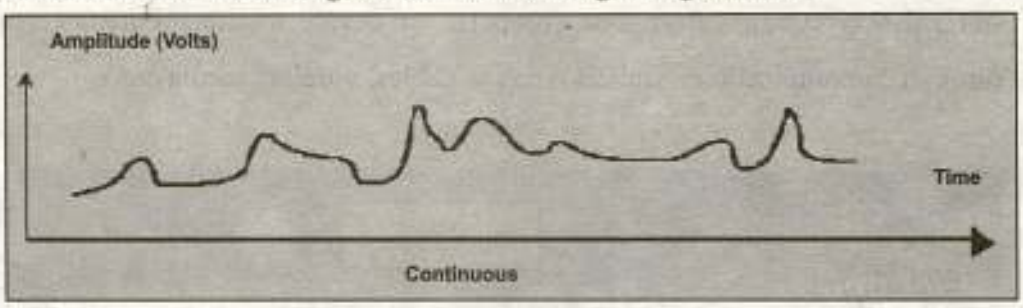

Figure 3.2: (a) Analog signal

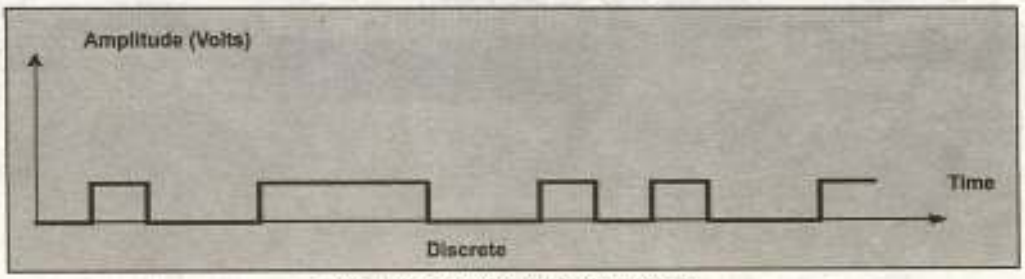

Figure 3.2: (b) Digital signal

- **Analog:** The analogue data signals are continuous electrical signal in the form of wave. This wave is called a carrier wave. Two characteristics of analogue carrier waves that can be altered are frequency and amplitude (Figure 3.2.a). **Frequency** is the number of times a wave repeats during a specific time interval. **Amplitude** is the height of wave within a given period of time.
- **Digital:** A digital signal uses on-off electrical pulses in discontinuous, or discrete form. Most computers are digital in nature, represent data as patterns of binary numbers (Figure 3.2.b).

3.3 Type of Data

Data can be represented in different ways such as in data communication, numbers, images, audio, and video etc.

- **Text:** The text consists of words, sentences, and paragraphs. Text processing refers to the ability to manipulate words, lines, and pages. Typically, the term text refers to text stored as ASCII codes that is, without any formatting. Objects that are not text include graphics, numbers and program code.
- **Numeric:** Numeric data consist of digits from 0 to 9, +(positive) or –(negatives) sign and a decimal point .It can be integer type or real type data.
- **Image:** This type of data includes chart, graph, pictures and freehand drawings. The information in this form is more comprehensive. The data are sent as contiguous bits, which, for transfer, are packed into the 8-bit transfer bytes. The receiving site must store the data as contiguous bits.
- **Audio:** Sound is a representation of audio. It is converted into digital code by sampling the sound waves 44,056 times per second and converting each sample into a 16- bit number.
- **Video:** Video can be produced either as a continuous entity (by a camera), or it can be a combination of images, each a discrete entity, arrange to convey the idea of motion. Video creates action and movements.

3.3.1 Data Representation

The computer works with binary numbers, binary means two digits. These are 0 and 1. An electrical pulse inside the computer represents each binary number. 1 is represented by a pulse of electrical inside the computer and 0 by an absence of a pulse. Each binary digit is called bit and it is the smallest element of data.

3.4 Encoding of Data

The computer works with binary digits only. Therefore, all data, numeric or non-numeric, must be converted into binary digits before the computer can understand it. Computers transmit data in the form of binary codes. Both sender and receiver of the data should have same standard rules for both to understand it.

A coding scheme for communications is a binary system, that is used in the computer systems. The system consists of groups of bits (0 or 1) that represent characters. Some codes use different number of bits such as 5, 7, 8 or 9 to represent that during data communication. The following are some coding schemes to represent data.

- **BCD Code:** (**B**inary **C**oded **D**ecimal) is 4 bits code. A few early computer s processed BCD numbers but were slower and more complicated than a modern computer, which are able to process alphanumeric (alphabet letters, numbers and other symbols).
- **EBCDIC Code:** **E**xtended **B**inary **C**oded **D**ecimal **I**nterchange **C**ode is an 8 – bit code primarily used by International Business Machine (IBM). This type is intended for efficient transfer between hosts, which use EBCDIC for their internal character representation. For transmission, the data are represented as 8-bit EBCDIC characters. The character code is the only difference between the functional specifications of EBCDIC and ASCII types.
- **ASCII Code:** ASCII (**A**merican **S**tandard **C**ode for **I**nformation **I**nterchange) is a 7-bit code and makes 128 character combinations, whereas an 8-bit can make 256 combinations. It was developed by **A**merican **N**ational **S**tandards **I**nstitute (ANSI) and can handle alphanumeric data. It is intended primarily for the transfer of text files, except when both hosts would find the EBCDIC type more convenient.
- **Unicode: Uni**versal **Code** is a 16-bit code and can represent up to 65,536 symbols. Unicode has started to replace ASCII at all levels. It supports a comprehensive set of mathematical and technical symbols to simplify scientific information With the UTF-8 (**U**nicode **T**ransformation **F**ormat-**8**) encoding, Unicode can be used in a convenient and backwards compatible way in environments that were designed entirely around ASCII.

3.5 Modes of Data Communication

When a person is giving a lecture or speech, information is primarily conveyed in one direction. During a conversation spoken messages (information) are usually exchanged in both directions. These messages are normally exchanged alternately but, can of course, are exchanged simultaneously! Similarly, when data is

transmitted between two pieces of equipment, three types of data transmission modes can be used.

- **Simplex:** Simplex is a mode in which data flows in one direction only (Figure 3.3). Because most modern communication systems require a two-way interchange of data, this mode of transmission is not as popular as it once was. However, one current usage of simplex communications in business involves certain point-of-sale terminals in which sales data is entered without a corresponding reply other examples include radio and T.V transmissions.

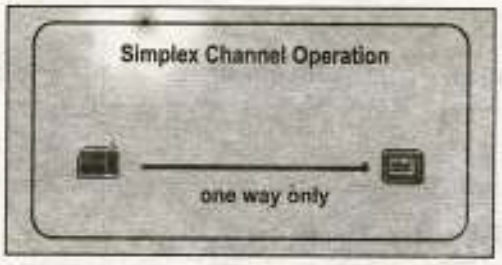

Figure 3.3: Simplex Communication.

- **Half-duplex:** In half-duplex transmission, data can be sent and received in both directions, but not at the same time. It's like a one-lane bridge where two-way traffic must give way in order to cross (see figure 3.4). Only one end transmits at a time, the other end receives. In addition, it is possible to perform error detection.

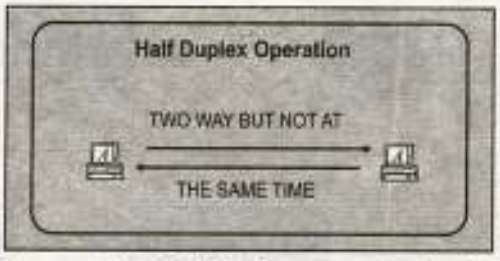

Figure 3.4: Half duplex communication

and request the sender to retransmit information that arrived corrupted. In some aspects, you can think of Internet surfing as being half-duplex, as a user issues a request for a web document, then that document is downloaded and displayed before the user issues another request e.g. walkie talkie etc.

- **Full Duplex:** The directional mode of communication is full-duplex. Here, data is transmitted in both directions simultaneously on the same channel (see figure 3.5). Thus, this type of communication can be thought of as similar to automobile traffic on a two-lane road.

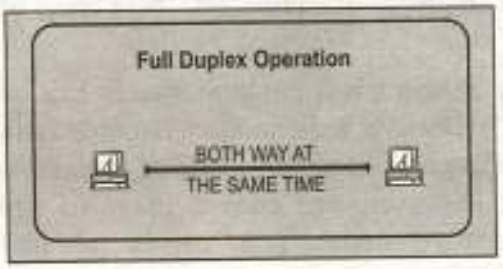

Figure 3.5: Full Duplex communication

Full-duplex communication is made possible by devices called multiplexers. Full-duplex communication is primarily limited to mainframe computers because of the expensive hardware required to support this bi-directional mode e.g. telephone system.

3.6 Types of Data Transmission

There two types of data transmission modes (see figure 3.6.) parallel transmission and serial transmission.

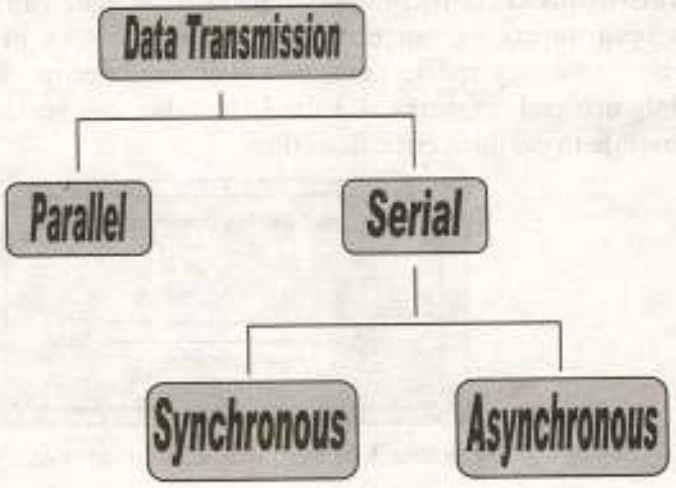

Figure 3.6: Data Transmission

- **Parallel Transmission:** Parallel data transmission involves the concurrent flow of bits of data through separate communications lines (see figure 3.7). This pattern resembles the flow of automobile traffic on a multilane highway. Internal transfer of binary data in a computer uses a parallel mode. If the computer uses a 32-bit internal structure, all the 32 bits of data are transferred simultaneously on 32 lane connections. Parallel data transmission is commonly used for interactions between a computer and its printing unit. The printer usually located close to the

computer, because parallel cables need many wires and may not work stably in long distance.

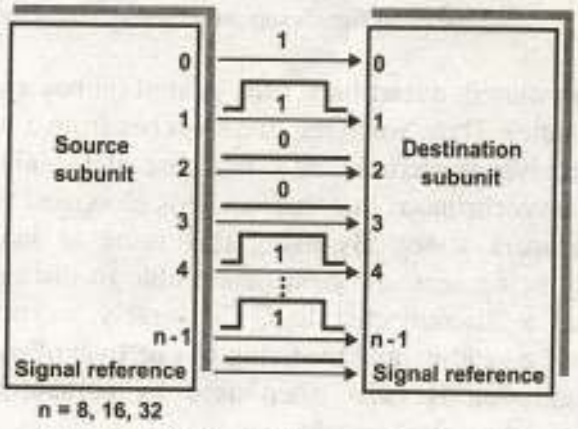

Figure 3.7: Parallel Transmission Mode

- **Serial Data Transmission:** Most data transmitted over telephone lines use a serial pattern. That is, each individual bit of information travels along its own communications path; the bits flow in a continuous stream along the communications channel. This pattern is analogous to the flow of traffic down a one-lane residential street (see fig 3.8). Serial transmission is typically slower than parallel transmission, because data are sent sequentially in a bit-by-bit fashion. Another way of classifying data communications flow is synchronous or asynchronous.

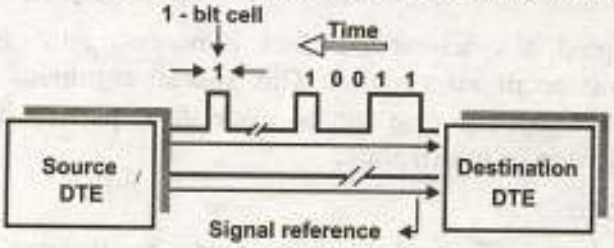

Figure 3.8: Serial Transmission Mode

- **Asynchronous Transmission:** *A type of communication that sends data using flow control rather than a clock to synchronize data between the source and destination.* When **asynchronous transmission** (also called **start/stop transmission**) is used, a special start signal is transmitted at the beginning of each group of message bits. When a character is about

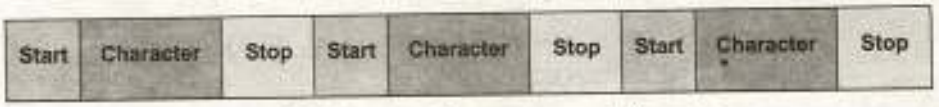

Figure 3. 9 (a): Asynchronous transmission uses start/stop signals surrounding each character.

to be transmitted, a start bit is sent. A start bit has a value of 0, (also called a space state). Thus, when the line switches from a value of 1 to a value of 0, the receiver is alerted that a data character is about to come down the line. An asynchronous line that is idle is identified with a value of 1, (also called a mark state). By using this value to indicate that no data is currently being sent, the devices are able to distinguish between an idle state and a disconnected line. Conversely, asynchronous transmission involves the sending and receiving of one byte of data at a time. This type of transmission is most often used by computers and other systems characterized by slow speeds.

- **Synchronous Transmission:** *A type of transmission that uses a clock to control the timing of bits being sent.* Large volumes of information can be transmitted at a single time with synchronous transmission. This type of transmission involves the simultaneous flow of several bytes of data. Because a large block of data being sent synchronously cannot be

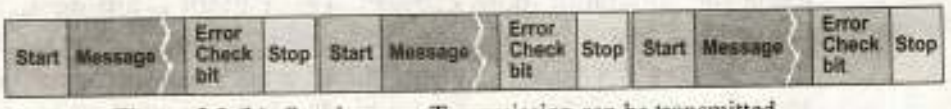

Figure 3.9 (b): Synchronous Transmission can be transmitted between start and stop characters.

interrupted, a synchronized clock is necessary to carefully schedule the transmission of information. This special communications equipment is expensive; but this cost can be made up in part by faster, less expensive transmission of information.

3.6.1 Bandwidth

Each type of communications media has different transmission speed. The bandwidth is a measure of the transmission rate of communications channels.

- **Baseband:** Digital signals are commonly called baseband signals. **Baseband** is a communications technique in which digital signals are placed onto the transmission line without change in modulation. It transmits up to a couple of miles, and does not require the complex modems. Typical Token Ring and Ethernet use baseband signals.

- **Broadband:** Broadband is a technique for transmitting large amounts of data, voice and video over long distances simultaneously by modulating each signal onto a different frequency. Using the FDM (Frequency division multiplexing) technique, several streams of data can be transmitted simultaneously.

  Broadband is the bandwidth used for direct communication between very high-speed computers (e.g., large mainframe computers). This bandwidth includes microwave, satellite, coaxial cable, and fiber-optic media.

3.6.2 Communication Media

For data to be transmitted from one location to another, some of pathway or medium must be used. These pathways are called communication channels. The communication channels can be divided into two types of media.

- **Guided Media:** It refers to channels that allow the transmission of data through a physical media such as a twisted pair wire, coaxial cable, or fiber optic cable. These are also called bounded media.

Figure 3.10: Twisted pair cables.

1. **Twisted Pair:** The telephone lines used to carry most of the voice and data communications consist of a pair of thin-diameter insulated copper wires (called twisted pairs) see in fig 3.9. The wires are twisted around each other to minimize interference from other twisted pairs in the cable. Twisted pairs have fewer bandwidths than coaxial cable or optical fiber. They have been the standard communication channels for voice, data and information, but are now diminishing because of more reliable media such as coaxial cable, optical fiber, microwave, or satellite.

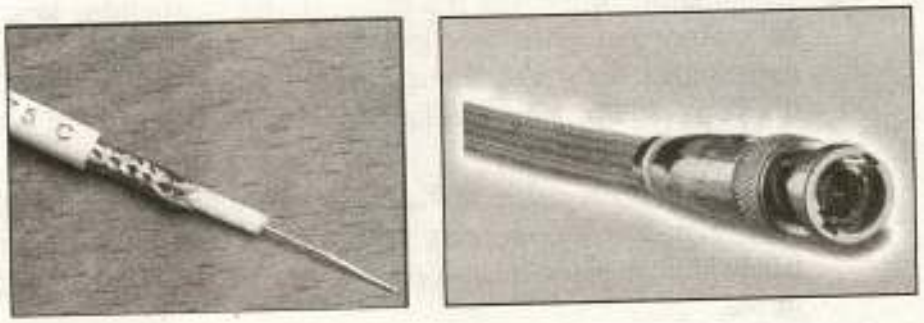

Figure 3.11: Coaxial Cable

2. **Coaxial Cable:** Coaxial cable can be used for telephone lines for transmission at a high frequency. Coaxial cable consists of a single core of solid copper (see fig 3.10.). A coaxial cable can handle 80 times as many telephone transmissions as twisted pair media. Many computers in local area networks are linked by coaxial cables. Because of its sturdiness, coaxial cable is often used for telephone lines that must be carried under water. Because coaxial cables have very little distortion and are less prone to interference, they have low error rates. Coaxial cable contains from four to twenty-two coaxial units called tubes, Each coaxial tube consists of a 0.100-inch copper inner conductor kept centered within a 0.375-inch cylindrical copper outer conductor by polyethylene insulating disks spaced about 1 inch apart. The outer conductor is formed into a cylinder around the disks and is held closed by interlocking serrated edges along its longitudinal seam. Two steel tapes are wound around the outer conductor for added strength.

   In addition to coaxial tubes, coaxial cable contains a small number of twisted wire pairs and single wires that are used for maintenance and alarm important advantage coaxial cable has over paired cable is its capability to operate at very high frequencies,. Coaxial, the unique operating environment dictates design, operational, and reliability requirements different from those for cable used on land.

3. **Fiber-Optic Cable:** A fiber-optic cable consists of tubes of glass through which data are transmitted as pulses of light. Optical fiber consists of thin glass fibers that can carry information at frequencies in the visible light spectrum and beyond. The typical optical fiber consists of a very narrow strand of glass called the core. Around the core is a concentric layer of glass called the cladding. A typical core diameter is 62.5 microns (1 micron = 10^{-6} meters). Typically Cladding

has a diameter of 125 microns. Coating the cladding is a protective coating consisting of plastic, it is called the Jacket.

Figure 3.12: Fiber Optic Cables

An important characteristic of fiber optics is refraction. Refraction is the characteristic of a material to either pass or reflect light. When light passes through a medium, it "bends" as it passes from one medium to the other. An example of this is when we look into a pond of water. Although a fiber- optic cable is diametrically smaller than a human hair, it has 26,000 times the transmission capacity of twisted pair media. A major advantage of fiber-optic media is its high level of security. These communications channels are not susceptible to electronic interference. Therefore, they are a more reliable form of data transmission. Fiber-optic cables are also significantly less expensive than coaxial cable.

- **Unguided Media:** It refers to those channels that transmit data and information in the form of wave. Unguided transmission media consists of a means for the data signals to travel but nothing to guide them along a specific path. The data signals are not bound to a cabling media and are therefore often called unbound media. The atmosphere and the space are example of unguided media such as microwave, or satellite.

1. **Microwave**: Microwave data transmission differs from the previously mentioned communications channels in that data is transmitted through the air instead of through cables or wires(see in fig 3.13). Microwaves are high-frequency radio waves that can only be directed in straight lines. Consequently, microwave transmission is usually limited to communications occurring within the limits of a particular

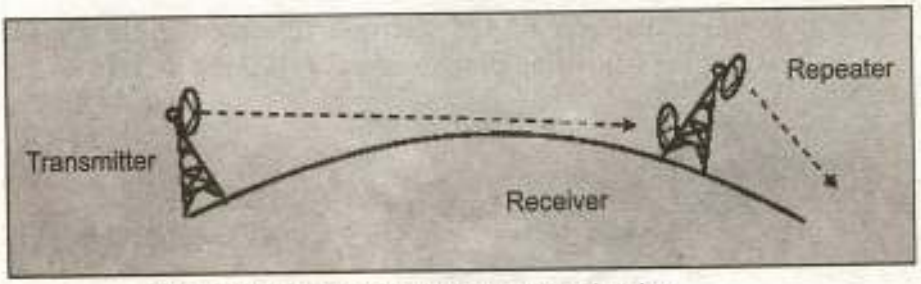

Figure 3.13: Microwave Communication.

city or community. For microwave transmissions to be able to occur over larger distances, data messages must be relayed from one location to another using antennas placed at high altitudes usually twenty to thirty miles apart.

2. **Satellites**: Instead of antennas, satellites can also be used to transfer microwave messages from one location to another. Satellites rotate approximately 23,300 miles above the earth in precise locations. Satellite transmission stations that can both send and receive messages are known as earth stations. A major advantage of satellite transmission is that large volumes of data can be communicated at once. A particular drawback is bad weather can severely affect the quality of satellite transmissions. Another one is that it has a serious security problem, because it is easy to intercept the transmission as it travels through the air.

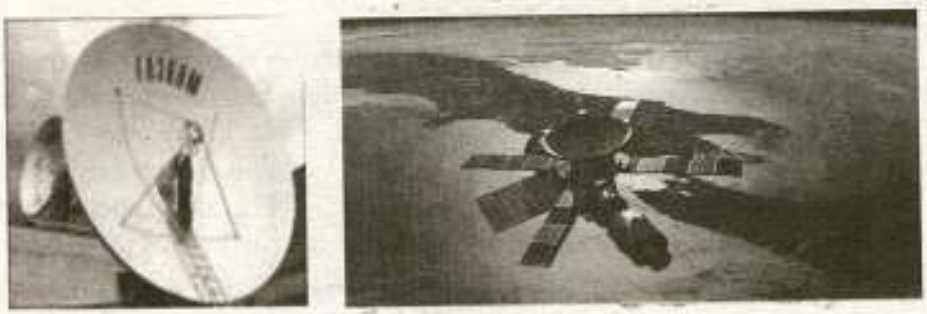

Figure 3.14: Satellite Communication.

Satellite Communications is the generic term for communication via satellite. Transmitting a signal from the earth station upto a satellite and then receiving that signal back at earth. The satellite does not have to be a huge expensive array of electronics and solar panels. In fact the moon was used, in the early years of satellite communications research, to bounce the signals off. The time it took for our signals to get to the moon and back was about 2 seconds. This time is called

satellite delay and is still present today in all our satellite communications. This wide range broadcasting ability has given rise to a multitude of different satellites carrying all kinds of information such as telephone calls, television channels, Internet traffic military communications, weather data, and even radio stations.

3. **Mobile Communication:** It is radio-based networks that transmit data to and from mobile computer. Computer can be connected to the network through wired ports or through wireless connections.

3.7 Modem

Modem (**MO**dulate/**DEM**odulate) is a device that converts digital signals into analog form (a process known as modulation) to send over phone lines, a receiving modem at the other end of phone line then converts the analog signal back to a digital signal (a process known as demodulation). It enables users to transmit data from one computer to another by using standard telephone lines instead of special communication lines such as fiber optic or cable. Telephone lines can carry analog singles (see figure 3.15).

Figure 3.15: Modem communication

- **Transmission Rate:** It can be described, as modems high-speed or low speed to indicate how many bits per second a specific device is capable of transmitting or receiving.
- **Speeds:** The specific techniques used to encode the digital bits into analog signals are called modulation process. The various modulation standards define the exact methods of encoding and the data transfer speed. The raw speed (the speed without data compression) of a modem is determined by the modulation standards. A 2400 bps modem with data compression that can theoretically yield a 9600 bps throughput is not a high-speed modem. High-speed modems are modems that feature modulation at 9600 **bps** and above (the speed at which data is transmitted in bits per second) or higher.

3.7.1 Types of Modems

In terms of physical size and shape modems can be divided into following categories:

- **External:** Exteral modem is attached to the system unit as an external device by meand of a telephone cable. It is connected to the telephone wall

jack by another cable. The modem is a self contained unit which is connected to the PC using a serial cable to the COM1 or COM2 port. It needs an external power supply, and is easy to set up(see figure3.16.a) .

- **Internal Card**: An internal modem is a circuit board (a modem card) that can be added to the system unit through an expansion slot. The modem cannot be moved easily from one PC to another. It is more difficult to set up than other types of modem(see figure3.16.b).
- **Wireless Modems:** Wireless modems transmit the data signals through the air instead of by using a cable(see figure3.16 c). They sometimes are called a radio-frequency modem. This type of modem is designed to work with cellular technology, and wireless local area networks.

Figure 3.16(a): External Modem

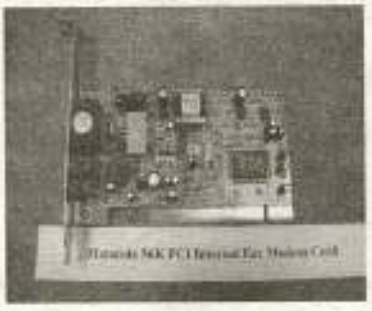

Figure 3.16(b): Internal Modem Card

Figure 3.16(c): Wireless Modem

Exercises 3C

1. Fill in the blanks:

(i) In _____ transmission, a start bit and a stop bit frame a character byte.0

(ii) Date communication signals can be in _____ or _____ form.

(iii) Modem is an electrical device that converts digital signal into analog signals, which is called _____.

(iv) The _____ transmission involves the concurrent flow of bits of data through separate communications lines.

(v) ASCII is _____ bit(s) code.

(vi) A television broadcast is an example of _____ transmission.

(vii) In _____ transmission data is transmitted character by character.

(viii) The data is transmitted in both directions simultaneously on the same channel_____.

(ix) Fiber optic cable is better for very high speed, high-capacity data transmission than _____ cable because of the lack of attenuation and the purity of the signal.

(x) The number of frequencies that can fit on a link at one time is called _____.

2. Choose the correct option:

(i) Microwave transmission, coaxial cables, and fiber optics are examples of.

(a) Modems (b) Communication links

(c) Getways (d) Ring network

(ii) Data communication requires only a:

(a) Sender (b) Receiver

(c) Transmission Medium (d) All of the above

(iii) BIT stands for _____.

(a) Binary Integer (b) Binary digit

(c) Binary interval. (d) None of the above.

(iv) Communication between a computer and a keyboard involves_____ transmission.

(a) Simplex (b) Half-duplex

(c) Full-duplex (d) Automatic

(v) The _____ is the physical path over which a message travels.

(a) Protocol (b) Medium

(c) Single (d) All the above

3. Write T for true and F for false statement:

(i) An internal modem is a circuit board that can be added to the system unit of the computer.

(ii) In full transmission, the channel capacity is shared by both communicating devices at all time.

(iii) A fiber-optic cable consists of tubes of glass through which data are transmitted as pulses of light.

(iv) Normally, modem transmission is asynchronous.

(v) Transmission of signals across communication medium is called signaling.

(vi) The voice channel has a bandwidth of 0-233 kHz.

(vii) Synchronous transmission is much faster than asynchronous.

4. What is data communication? Define the basic component of communication network.

5. Define the modem and its types.

6. Differentiate between Asynchronous and Synchronous.

7. Briefly explain the various communication media.

8. Define the Modem.

9. What is bandwidth? Explain bandwidth briefly.

10. Differentiate between guided media and unguided media.

Answers

1. (i) Asynchronous (ii) Digital, Analog (iii) Modulation (iv) Parallel
(v) 7 (seven) (vi) Simplex (vii) Serial (viii) Full Duplex
(ix) Coaxial (x) Bandwidth

2. (i) b (ii) d (iii) b (iv) a (v) b

3. (i) T (ii) T (iii) T (iv) T (v) F
(vi) F (vii) T