1.0   INTRODUCTION

A standalone computer in today's context is not very useful, but coupled with communication technology, it opens up an enormous repository of information to its users. Information is carried in data communication systems as signals between two or more points, which could be at a distance of a few inches or several thousand kilometers.

These signals are subject to various effects while they are in transit which alter their characteristics to some degree. The data communication technology ensures that information between two communicating entities is transferred in a reliable and orderly manner.

To understand transmission one needs to study electrical form that messsages take while they are in transit and of media and communication technologies that ensure error-free transmission. In our subsequent units we would be discussing the basic concepts of electronic communications.

Data Communication is also well known as DATACOMM.

1.1   OBJECTIVES

At the end of this unit, you would be able to:

Define the basic concepts of Data Communication
Define various terminology of Data Communicaiton
State the function of the following Data Communication Hardware
    Nodes and Workstations
    Modem and Codes
    Multiplexers
    Communication Channels
Describe the implication of Data Communication

1.2   DEFINITIONS

In data communications, four basic terms - Data, Signal, Signalling and Transmission are frequently used.

Data are entities that convey meaning. Information is obtained by processing data using desired functions.

Signals are electric or electromagnetic encoding of data, and signalling is propagation of signal along suitable communication medium.

Transmission is communication of data achieved by the propagation and processing of signals.

1.3   CONCEPT OF DATA COMMUNICATION

The concept of Data communication evolved from sharing the computation power of a computer alongwith various resources available in a computer environment such as printers, Hard-disk etc. With increasing demand for exchange of information across the globe, the need for data communication has increased in many folds. Due to physical constraints involved in connecting two remote points physically data communication has emerged as an instant solution.

1.3.1   Data Communication Codes (Data encoding)

The first step towards understanding communications is to look at computer data at its base level. As all of us know computer and computer device manage store and exchange data using electronic pulses or digital signals, that come in two varieties, the binary digit '0' indicates the absence ("OFF") and '1' indicates ("ON") the presence of electric current. A series of ONs and OFFs in various combinations can be sent on the communication channels to represent any character.

Every character (letter, numeral, symbol, or punctuation mark) is composed of a group of bits called codes. To avoid incompatibility between systems, the computer industry has created a number of standards that establish relationships between bit combinations and their corresponding characters.

The most widely used codes are the American Standards Code for Information Interchange (ASCII) and the IBM standard, Extended Binary Coded Decimal Interchange Code (EBCDIC). Some of the characteristics of these codes are tabled below:

Data Codes

	ASCII	EBCDIC
Controlling authority	ANSI	IBM
Number of bits	7	8
Number of Character	128	256

To ensure successful transmission of data between two points, the sender and receivers should use the same code, or they can use translators to aid in communication. Translation is data communication software, which translates the sender's data into the codes receiver understands.

1.3.2   Communication Speed or Rate

The speed at which two computers exchange or transmit data is called communication rate on transmission speed. The unit of measurement of the speed is measured using bps (bits per second) or baud (both are not same, for more details refer to further readings). Normal PC based communication station transferred, using 300 to 9600 bps, whereas a main frame computer uses 19,200 baud or more.

1.3.3   Private vs. Switched Channels

Private leased lines are permanently connected circuits between two or more points. These lines are available for private use by the leasing party.

Whereas, switched lines or dial up lines are available to any subscriber. For example, telephone connection in our home or office is a dial up lines as we dial up a number to use a particular circuit.

1.3.4   Analog and Digital Transmission

One of the fundamental concepts in data transmission is to understand the difference between Analog and digital signals.

An analog signal is one that is continuous with respect to time, and may take on any value within a given range of values. Human voice, video and music when converted to electrical signal using suitable devices produce analog signals.

A digital signal may take on only a discrete set of values within a given range. Most computers and computer-related equipment are digital.

Irrespective of original form of the message, the actual transmission of signal could be either in analog or digital form. Figure 1 shows the two possible transmission methods:
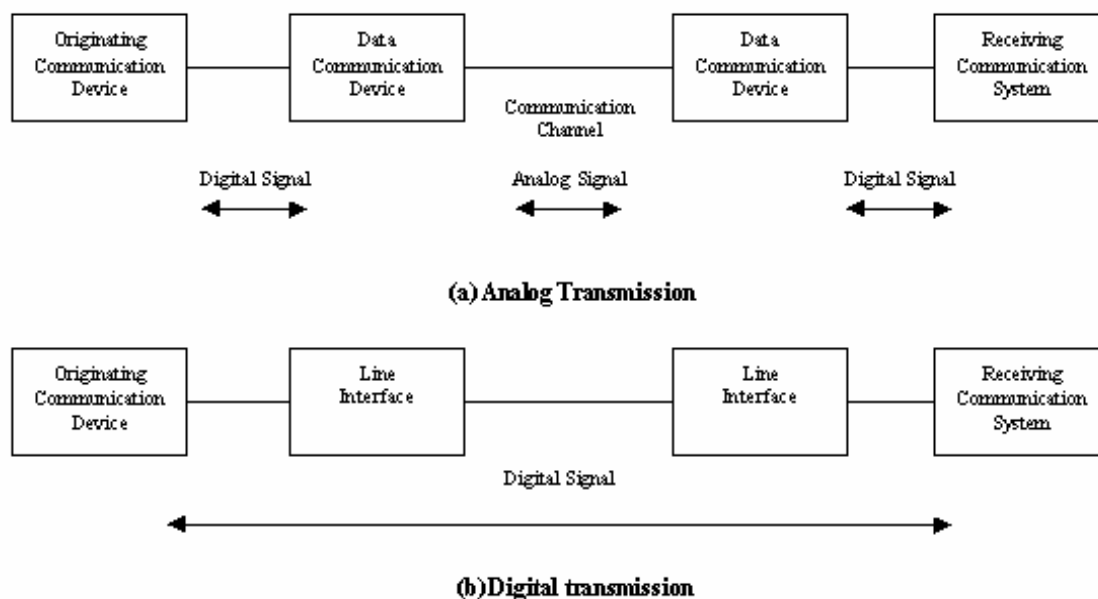
Figure 1: Analog and Digital Transmission

1.3.5 Parallel and Serial Transmission

In parallel data transmission, there are multiple parallel lines connecting the transmitting and receiving units. Each wire carries a bit of information. Normally, one character is transferred in one go.

In serial data transmission, each bit is sent sequentially one after another and it requires only one pair of wire conductors for connecting the receiving and transmitting units.

Serial transmission is slower than parallel transmission, which is used primarily for transferring data between devices at the same site; most common example is Personal Computer to Printer. Communication between computers is almost always serial.

1.3.6 Tariff

As most of the data communication is being done using public channels such as telephone lines, a user has to pay. for the use of channels. The tariff is generally calculated taking various data communication parameters into consideration such as volume of data transferred, communication rate or transmission rate and time utilised on the communication channel.

1.3.7 Communication Protocols/Standard

There are several manufacturers of computer hardware and software across the, globe. For successful data communication these products should be compatibles with each other or they should conform to certain set of rules so that any one can use them. These sets of rules are known as communication protocols or communication standards.

In other words, protocols are technical customs or guide lines that govern the exchange of signal transmission and reception between equipments.

Communication protocols are usually defined and approved by some international body such as ISO, CCITT or IEEE. At times protocols defined by certain manufacturer of computers or networking products become so widely accepted, that they become 'defactor' standard even though these protocols may not have approval of any standardisation body. Some of the functions that communication protocol regulates are:

Control of information transfer
Structure and formats of data
Error recoveries

Re-transmission control
Interface management

Only communication devices using same protocols can communicate with each other.

To make sure that the bits (or characters) are transmitted through the channel or line, we need a link level protocol between two computers. Some of the main functions to be performed by such a link level protocol are:

Assuring the data to be transmitted is split into data blocks with beginning and ending markers. This is called framing and the transmission block is called a frame,

Achieving data transparency. This allows a link to treat a bit pattern, including normally restricted control characters, just as pure data.

Controlling the flow of data across the Link. It is essential not to transmit bits faster than they can be received at the other end. Otherwise, the receiver overflows and the data is overrun, or all buffering capacity is used up, leading to loss of data.

Controlling errors. This involves detection of errors using some kind of redundancy check. It also involves acknowledgement of correctly received messages and requests for retransmission of faulty messages.

There are basically two classes of link protocols. They are, BInary SYNchronous protocols (BISNYC) and High Level Data Link Control (HDLC) protocols. BISYNC is based on character control, whereas HDLC is a bit oriented protocol. In fact, HDLC is widely used in most link protocols of computers. You can refer to further readings for more details.

1.4   DATA COMMUNICATION MODES

So far, we have discussed a method of transferring information electronically and various aspects involved in it such as, data characters in a computer system are represented using codes such as ASCII or EBCDIC. The exchange of information can take place only if a facility exists to send information from one end, character by character and also to receive it at the other end in the same manner or sequence. Hence we must understand how the characters are transmitted over the transmission medium.

1.4.1   Synchronous and Asynchronous Transmission

The mode of transmission is the way in which coded characters are assembled for the process of transmission and permits the receiving devices to identify where the coding for each character begins and ends within the torrent of bits. When two computers communicate, they must have a way to synchronise the flow of data so that the receiving computer can read at the same speed at which the sending computer transmits. The principal modes are asynchronous and synchronous.

In synchronous transmission characters are transmitted as groups, with control characters in the beginning and at the end of the bit train. The transmission and receiving intervals between each bit are precisely timed permitting the grouping of bits into identifiable characters. In synchronous mode, intervals between characters are uniform with no space between consecutive bytes.

In asynchronous transmission, each character is transmitted separately, that is, one character at a time. Each character begins with a start bit, which tells the receiving device where the character coding begins and ends with a stop bit, which tells the receiving device where the character coding ends. Then, the next character is sent, with start and stops bits. The start and stop bits and the interval of time between consecutive characters allow the receiving and sending computers to synchronise the transmission. The parity bit is used for error checking while transmission of data.

Asynchronous communication is slower than synchronous communication, it is typically used at communication rates lower than 2400 bits per second. Asynchronous communication does not require complex and costly hardware as required by synchronous communication and is the mode most widely used with microcomputers.
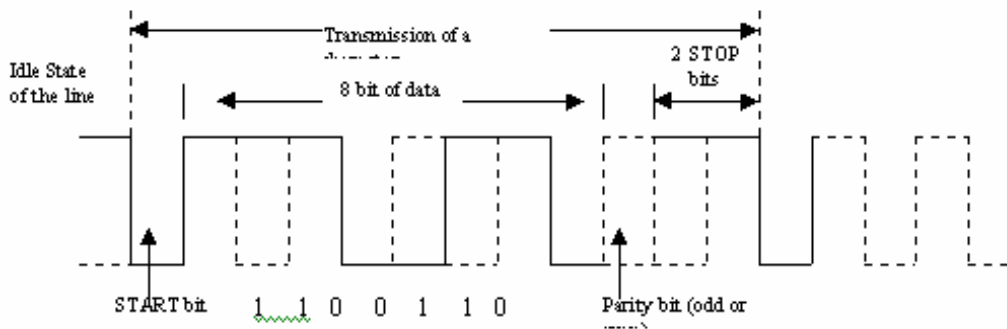
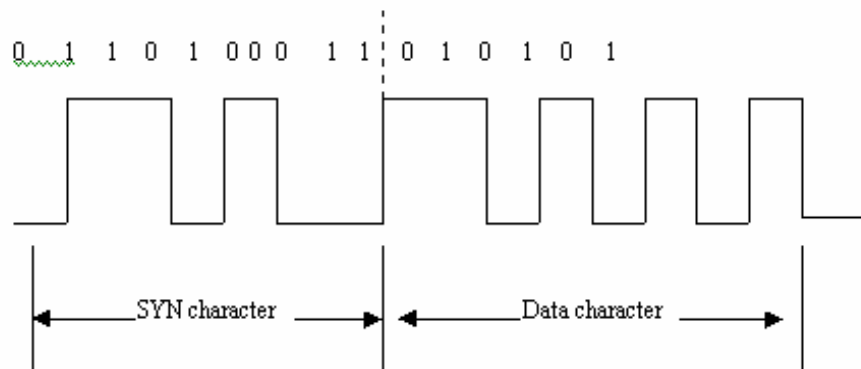**Figure 2(a): Asynchronous Serial Transmission**

Figure 2(b) Synchronous data character format

1.4.2   Simplex, Half-duplex, Full duplex Communication

The direction in which information can flow over a transmission path is determined by the properties of both the transmitting and the receiving devices. There are three basic options:

In **Simplex** mode, the communication channel is used in one direction. The receiver receives the signals from the transmitting device. A typical use is to gather data from a monitoring device at a regular interval. The simplex mode is-rarely used for data communication.

In **Half-duplex** mode, the communication channel is used in both directions, but only in one direction at a time. This requires the receiving and transmitting devices to switch between send and receive modes after each transmission. The analogous example of this mode is the old wireless system (walkie-talkie), which is used in either transmit mode or receive mode.

In **Full-duplex** mode, the communication channel is used in both directions at the same time. Typical example of this mode of transmission is the telephone in which both parties talk to each other at the same time.
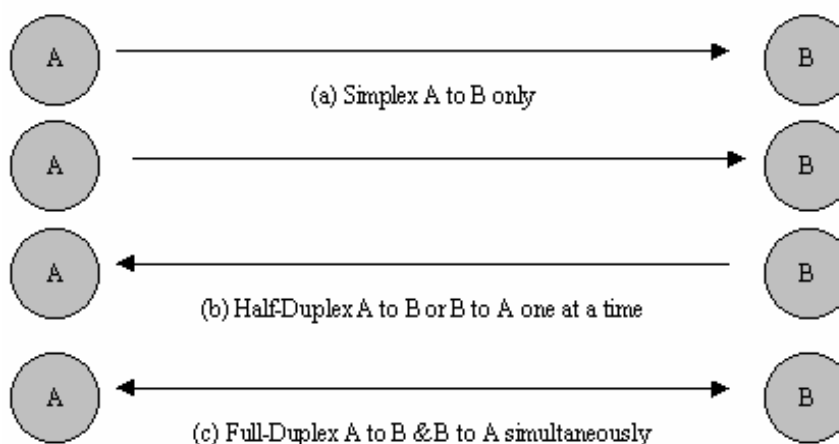

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Figure 3: Modes of Transmission

1.5   COMMUNICATION HARDWARE

We have already discussed about communication codes; units of measurement; data transmission methods such as analog and digital, parallel and serial; data transmission modes such as synchronous and asynchronous simplex, half duplex and full duplex; the transmission error control and protocols. All this was intended to lay the foundation for all that is going to follow.

For any basic data communication process, the hardware required are:

Sender and Receiver Hardware
Communication Devices
Communication Channels

1.5.1   Sender and Receiver Hardware

Sender and Receiver Hardware are used for handling Communication messages, data transfer etc.

Nodes and Workstations

Data Communication is done using various communication devices and software inter-connected for information exchange. The devices used to communicate in a data communication network are called workstations. These workstations may include computer, terminal, printer, and any other communication devices. Each workstation is connected to something called a data communication network node.
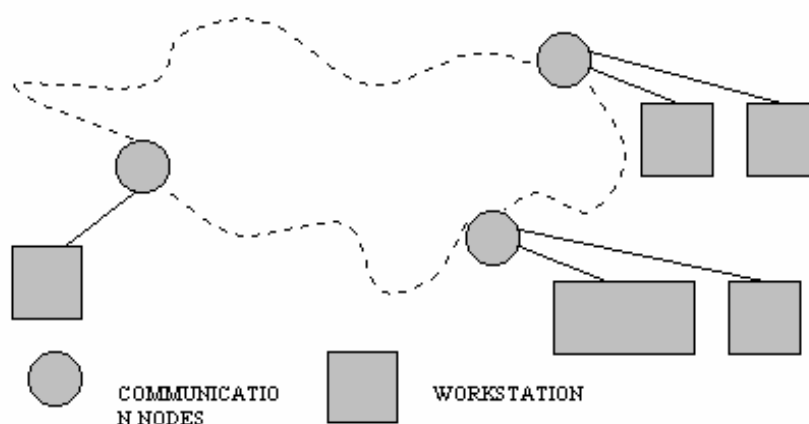

Figure 4: Communication nodes and workstations

Multiplexer

As the name suggests, multiplexing is a form of data transfer in which communication channels are used for several transmissions. For example, the telephone lines that we use for our daily conversation can carry hundreds or even thousands of conversation using multiplexing. In other words multiplexing is a type of network mechanism, which

allows a number of simple, low cost terminals to share each communication line, introduces almost no delay and requires no special computer software.

Multiplexing is used in two ways:

(a)   By dividing a communication channel into various smaller segments of different frequencies.
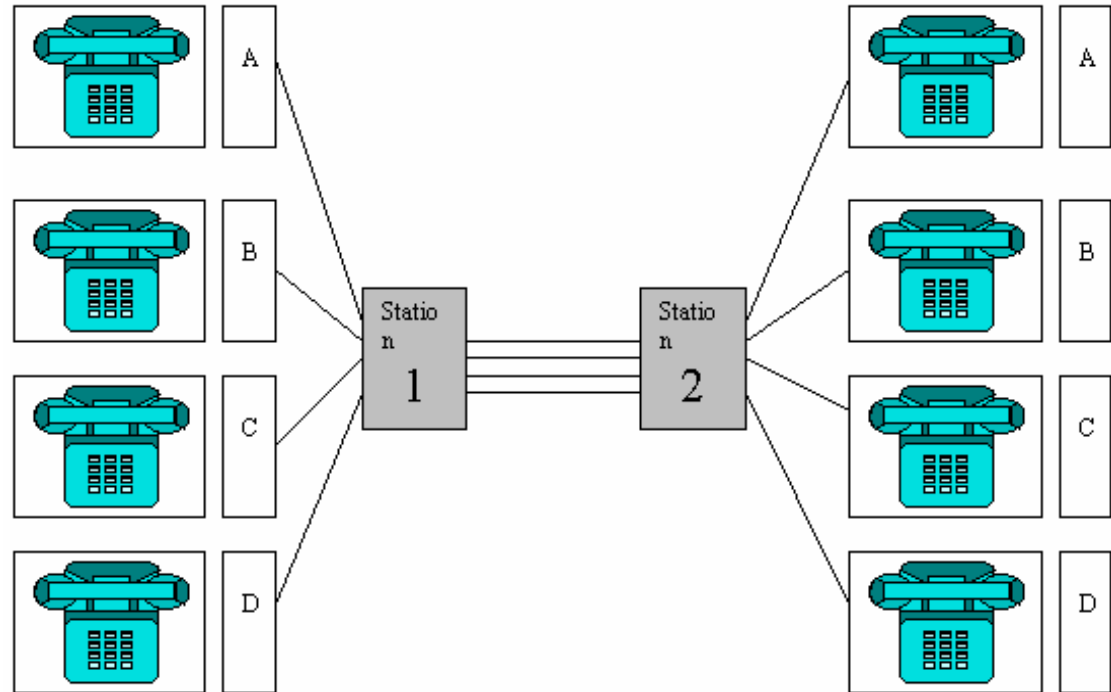

Figure 5: Multiplexing

(b)   By taking groups of bytes from each sender and send or transmit them over the channel one after another. Each group of data bytes are tagged at the beginning and end with start and end control bytes. These by data bytes are then separated at the receiving end and sent to their respective places. This type of multiplexing occurs so fast that the transmission seems continuous.

1.5.2   Communication Devices

There are several types of communication devices or interface used in data communication. These interfaces are connection between receiver and sender hardware involved in data communication and the communication network. Some of these interface or communication devices are discussed below.

Modems

(a)   **Modems** or modulator - demodulators are devices which convert digital signals into analog for transimssion over analog transmission facilities such as telephone lines. At the receiving end, a modem performs the reverse function and converts analog signal into digital form.
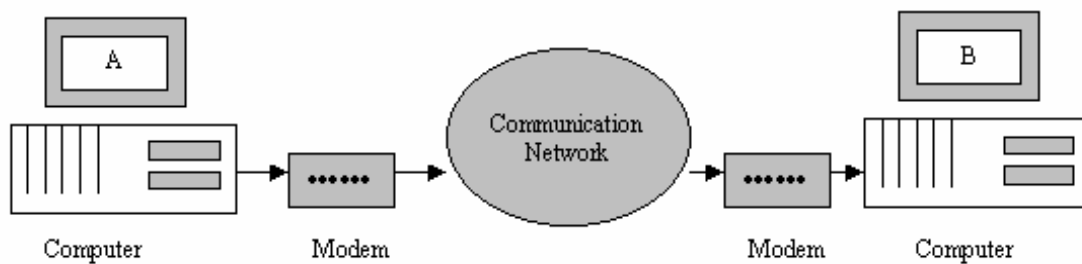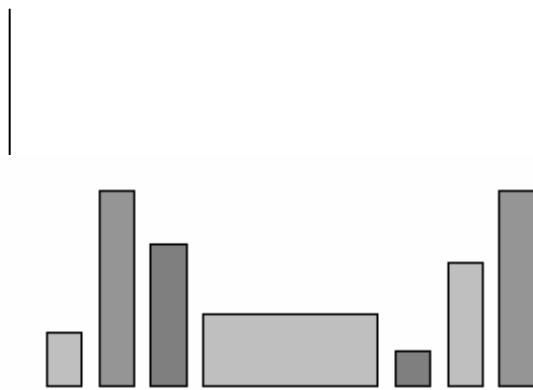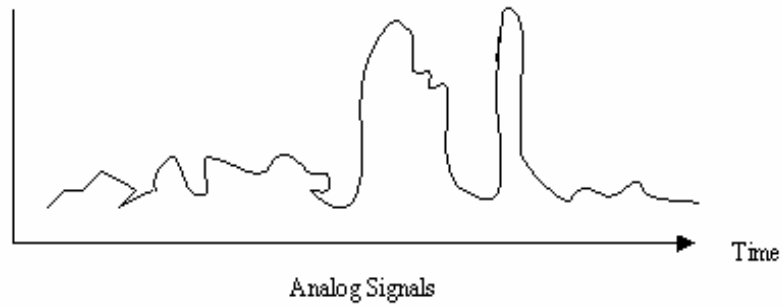
Analog Signals

Figure 6: Data Communication using Modem

Line drivers are simple devices used to transmit digital signals over short distances. These devices do not modulate or demodulate signals, but use filters to reduce the high frequency component and the modified signal is transmitted directly over the media. These devices are used for distances of upto 1 Km and can achieve data transfer rates of upto 19200 bps. It is mainly used for connecting VDU terminals with a computer at a distance of more than 100 feet or so.

Codec

(b)   **Codec** performs the opposite function of a modem.

A communication Port/adopter is a connector on the computer which is used as an entry to departure point for data involved in Data communication. A common type of communication port is RS 232C. This adapter is used for transfer of data between the computer and the telephone line. During transmission process **it** adds start and stop bits and controls the communication rate or it strips the start and stop bits where it receives data.

1.5.3   Communication Channels

The most basic hardware required for communication is the media through which data is transferred. There are several types of media, and the choice of the right media depends on many factors such as cost of transmission media, efficiency of data transmission and the transfer rate. We will describe some of these transmission media.

1.   Two wires open line

This is the simplest of all the transmission media. It consists of a simple pair of metallic wires made of copper or sometimes aluminium of between 0.4 and 1 mm diameter, and each wire is insulated from the other. There are variations to this simplest form with several pairs of wire enclosed in a single protected cable called a multicore cable or moulded in the form of a flat ribbon.

This type of media is used for communication within a short distance, upto about 50 meters, and can achieve a transfer rate of upto 19200 bits per second.

2.   Twisted Pair Cable

A twisted pair consists of a pair of insulated conductors that are twisted together. The advantage of a twisted pair cable over the two wire open lines is, it provides better immunity from spurious noise signals. As the two wires are close to each other, both pick equal interferences caused by extraneous signal sources and this reduces the differential signal added by the noise.

Twisted pair cable is used for communications upto a distance of 1 Km. and can achieve transfer rates of 1-2 Megabytes per second. But, as the speed increased the maximum transmission distance is reduced, and may require repeaters.

Twisted pair cable is widely used in telephone networks and is increasingly being used for data. The hub based ethernets normally use UTP (Unshielded Twisted Pair) cable.

3.   Coaxial Cable

A coaxial cable consists of a solid conductor running coaxially inside a solid or braided outer annular conductor. The space between the two conductors is filled with a dielectric insulating material. Larger the cable diameter, lower is the transmission loss, and higher transfer speeds can be achieved. A coaxial cable can be used over a distance of about 1 Km. and can achieve a transfer rate of upto 100 megabytes per second.

A coaxial cable is of two types - a 75-ohm cable, which is used by the cable TV operators and the 50-ohm cable which is used in high-speed boradband networks and are low loss cables.

4.   Fibre Optic Cables

A fibre optic cable carries signals in the form of fluctuating light in a glass or plastic fibre. An optical fibre cable consists of a glass or plastic core surrounded by a cladding made of a similar material but with a lower refractive index. The core transmits the light while the change in refractive index between the core and the cladding causes total internal reflection, thus minimising the loss of light from fibre.

As light waves gave a much wider bandwidth than the electrical signal and are immune from eletromagnetic interferences, this leads to high data transfer rates of about 1000 megabytes per second and can be used for long and medium distance transmission links.

5.   Radio, Microwave and Satellite Channels

Radio, microwave and satellite channels use electromagnetic propagation in open space. The advantage of these channels lies in their capability to cover large geographical areas and being inexpensive than the wired installation.

The demarcation between radio, microwave and satellite channels lie in the frequencies in which they operate. Frequencies below 1000 MHZ are radio frequencies and higher are the microwave frequencies.

Radio frequency transmission may be below 30 MHZ or above 30 MHZ and thus the techniques of transmission are different. Owing to the characteristics of the ionosphere, frequencies below 30 MHz are reflected back towards the surface of the earth. Above 30 MHz propagation is on line-of-sight paths. Antennas are placed in between the line-of-sight paths to increase the distance. Radio frequencies are prone to attenuation and, thus, they require repeaters along the path to enhance the signal. Radio frequencies can achieve data transfer rates of 100 Kbps to 400 Kbps.

Microwave links would invariably use line-of-sight transmission with repeaters placed every 100-200 Kms. Microwave links can achieve data transfer rates of about 1000 Mbps.

Satellite links use microwave frequencies is the order of 4-12 Ghz with the satellite as a repeater. They can achieve data transfer rates of about 1000 Mbps.

Check Your Progress

1.   Match the followings:

(i)	Modem	(a)	baud
(ii)	Multiplexer	(b)	formalised set of rules
(iii)	Protocols	(c)	translate data into same type of code
(iv)	Translators	(d)	volume of data transferred
(v)	Communication Rate	(e)	data link
(vi)	Communication tariff	(f)	Multiple Communication in one channel at the same time.

Fill in the blanks

2.   ………………… allows one single communication channel to send many transmission at the same time.

3.   Any subscriber can use ………………………. lines.

4.   ……………………..is a unit of measurement for communication rate.

1.6   SUMMARY

In this Unit we discussed the concept of data communication and defined the process involved in data-communication. Various Hardware and Software concepts were also discussed alongwith the digital and analog signals. It also introduced you to various types of communication devices and also explained what is transmission protocols.

1.7   MODEL ANSWERS

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1. (i) (e),   (ii) (f),   (iii) (b),   (iv) (c),   (v) (a),   (vi) (d)

2. Multiplexer   3. Switched line/ dial up   4. Baud/bps

1.8   FURTHER READINGS

William Stalling, Data and Computer Communication, Prentice-Hall of India