UNIT 2 COMMUNICATION NETWORKS

Structure

2.0 INTRODUCTION

Communication, especially advanced communication, is possible through the use of networks and technologies. The history of communication technology is actually the history of human race, as it has always been our efforts to communicate with others, and for that matter use different techniques ranging from the use of sound to fire in the ancient times to telephone and Internet in the modern days. In the context of specific countries, the growth of communication technology has been influenced by their economic and scientific progress. So, we see developed countries using more of communication technology for different purposes (including education) than developing countries.

There are also many technologies that are in operation, and in order to use the best and most suitable technologies for different educational activities that you are expected to perform in distance education, it is necessary that you have a broad understanding of these technologies. In this unit, we will discuss about the technologies of communication, with reference to the networks they use.

2.1 LEARNING OUTCOMES

After working through this unit, you are expected to be able to:

- *Explain* the concept of network;
- *Discuss* the developments of communication technology and networks;
- *Describe* the factors affecting growth of communication networks;
- *Enumerate* the technical operation of different types of networking technologies; and
- *Discuss* the use of communication networks for teaching-learning.

2.2 DEVELOPMENT OF COMMUNICATION TECHNOLOGIES AND NETWORKS

Communication network is a collection of a collection of terminals, links and nodes which connect together to enable telecommunication between users of the terminals. The network may use multiple technologies to transmit the message from one point to the other. The communication between terminals is possible through the use of wire, radio, satellite and wireless technologies. These may manifest through application technologies like radio, television transmission, computer networks, and the Internet.

Communication is a fundamental human and social process. It makes the existence of societies possible, and by its nature, distinguishes between the human and other species (Schramm, 1973). The functioning of any society thus depends upon the quality of communication among its members (Melody, 1986). In other words, the prosperity of a society is judged by the extent to which its members can afford and use various modes of communication — the printed text, radio, television, video cassette recorders, video text, computers, etc. This is the reason why now-a-days more emphasis is being given to the manufacture, storage, processing, editing, interpretation and transmission of information to one and all. With the advancement in and access to a variety of communication technologies we are moving towards an information-based society.

We should know a bit about the history of the growth of communication technologies. So, we shall touch upon the historical development of communication technology and networks in this section. You may be aware that the growth of communication techniques has a long history. For centuries, people developed their own ways to expand their ability to communicate as effectively and efficiently as possible under their respective circumstances. Use of signals, symbols, gestures, facial expressions, etc. were the primitive ways of communication prevalent in primitive societies. It took centuries for the first mass medium — print, to be developed and used for communication purposes.

In this sub-section we shall discuss communication technologies other than the print media.

The earliest form of machine based transmission of message was the use of telegraphy. The word telegraphy has been derived from two Greek words: *tele* meaning far and *graphein* meaning write. The device that is used for telegraphy is called a telegraph. The use of telegraph has been there since 1800s. However with the development of the Morse Code in 1938 by Alfred Vail, assistant of Samuel F.B. Morse, the use of telegraph became an important means of communication for the masses. The Telex Network, established in 1920 revolutionized business communications across the globe.

The invention of telephone in 1876 by Alexander Graham Bell has probably transformed the way people communicate. In order to communicate from one end to the other the telephone use a Public Switched Telephone Network (PSTN) that must be wired from end to end. This is called the fixed line network. The technical operation of PSTN uses the interconnection standards created by International Telecommunication Union (ITU) for allocation of codes to different countries, locations and numbers thereby making possible for telephones to communicate seamlessly.

Another development in the 19th century was the invention of radio. While there is considerable dispute over who invented radio, we may assume that works of many scientists resulted in the use of radio that was initially called *wireless telegraphy*. While Nicola Telsa is considered the inventor of radio in the United States, Guglielmo Marconi is considered the inventor in Europe. The emergence of radio paved the way for audio broadcasting (which popularly later on called radio), and the first commercial public radio broadcasting station came up in 1920 in the United States. The radio stations use either Amplitude Modulation (AM) or Frequency Modulation (FM) as mode of broadcasting radio waves. The AM broadcast are shortwave services and use frequency range of 530-1700 kHz, while the FM broadcasts are in the range of 88-108 MHz.

In the late 19th century and early 20th century, the television made a significant change in the communication, as along with audio it became possible to transmit visuals. Now-a-days television contents are distributed by television channels/ networks through cable operators, satellite and terrestrial transmission.

Timeline for early communication network developments:

Year	Landmarks
1837	Electrical telegraph invented by Samuel F.B. Morse
1838	Morse Code developed by Alfred Vail
1896	Marconi awarded patent for radio
1920	First commercial radio station started I the United States
1923	Vladimir Zworkin patented Cathode Ray Tube based instrument to transmit images
1933	FM radio was patented by Edwin H. Armstrong
1941	First binary electro-mechanical computing device Zuse Z3 developed
1946	Electronic Numerical Integrator And Computer (ENIAC) was developed at University of Pennsylvanian by John Mauchly and J. Presper Eckert
1957	Artificial satellite Sputnik 1 lunched by Soviet Union
1969	Internet developed as part of Advanced Research Projects Agency Network, USA
1991	Tim Berners-Lee developed the World Wide Web

We will discuss about the specific technologies in this course at various units in detail.

Check Your Progress 2.1

Notes: *a) Write your answers in the space given below.*

b) Compare your answers with those given at the end of this Unit.

Fill in the Blanks.

i) Telegraphy has been derived from two Greek words: ..... and .....

ii) Telephone was invented in the Year .....

iii) ..... is considered the inventor of radio in the United States.

iv) The World Wide Web was developed by .....

v) The Internet was developed in the Year .....

2.3 GROWTH OF COMMUNICATION TECHNOLOGY

The growth, transfer and adoption of technology is not as simple as it may appear, on account of the fact that we are equipped with sophisticated technologies. There are various underlying conditions that influence the way a particular kind of technology is adopted to solve educational problems. Both the developed and the developing countries have almost similar conditions to fulfill for the development of technologies. For instance, the economic strength and enthusiasm of society, the attitude of policy makers, etc. influence the adoption of new technology in both situations the same way (Thomas, 1987). We shall discuss the more significant of these factors in the following sub-section. They are:

- political,
- economic,
- cultural,
- technological, and
- educational.

2.3.1 Political Factors

Communication in the developing countries is not only a socio-economic need but a political necessity too. A political system, i.e., a group of people that holds power can effect the adoption and growth of a particular communication technology in a country. In other words, the introduction of new technology in the service of social change and education depends on the underlying motivation or the will of the political system of the country concerned. You may recall that the rapid growth of computer technology in India, both through import and indigenous industrialization was the result of the interest of the late Prime Minister of India, Rajiv Gandhi. It is an example of the force of political decisions behind the adoption of technology in India, consequent upon which the computer industry flourished in the country manifold. Today, India is one of the major exporters of software in the world.

It is true that technology influences society, but it is also true that society influences the adoption and growth of technology. We, therefore, need to ensure that, rather than getting carried away by the fashion of the day, the communication needs should be identified and evaluated from the country's point of view and then the communication policy for education and development should be formulated/framed accordingly.

Some societies may adopt technology more easily than other because their cultural and linguistic structures may be more adaptable to information processing. You might be aware that Japan took to technology more easily than other countries in Asia. Within a country, the upper classes and capitalists adopt technology more easily and faster than the middle and lower classes; the urbanites go for technology more quickly than the rural people. However the emergence of the mobile phone has changed this scenario, and can become the game changer in communication revolution. There is also social bias that influences adoption of the technology at an individual's level. For example, the young take to technology faster than the old do. The males take to it more easily than the females (Hawkridge, 1983). It is reported that girls do not use microcomputers to the extent the boys do in schools, and avoid joining the 'computer club' because it is male dominated. Though there is no systematic evidence for the causes of this

bias, some educators blame the long standing prejudice against mathematics among the girls and mathematics is associated closely with computers. However, this notion is also changing very fast, as use of computers become predominant in the society. Use of computer does not require knowledge of mathematics at higher level, and thus the fear of computers also gets reduced.

2.3.2 Economic Factors

Cost is an important factor that influences the adoption and growth of communication technologies and networks in a country. And this is absolutely true in the case of the developing countries which import technology from the developed countries. They lack sufficient budgetary provision to run or afford technology-based projects. Some countries have made heavy investments in acquiring various technologies without building the necessary infrastructure to make those technologies productive. The point we want to highlight is that investment on new technologies should be seen in terms of the economic growth of the country. We should assess the rupee value of communication technology benefits like the benefits of spending the same amount of money on other measures/areas of social development.

In this subsection, we draw heavily on the discussion presented by Thomas (1987) who focuses our attention on four major economic considerations that affect the use of communication technology in a country. These considerations are as follows:

- financial strength of the society
- attitude of the policy makers
- budget allocation for technology
- cost efficiency of technology.

Let us elaborate on each issue, in the given order.

There are countries which are economically better off with higher per capita income. The per capita income of the developed countries is much higher than that of the developing countries. Since technologies cost huge amounts, it is quite obvious that the country with the higher per capita income is in a better position to afford more communication technologies, and most developing countries lack adequate technologies for communication. They still depend on their traditional methods of communicating. By saying this, we do not mean to suggest that the traditional methods are irrelevant. We, however, believe that those methods have certain limitations, particularly in terms of their reach and efficiency. And if societies want to work on modern social agenda, they must also modernize their communication and technologies.

The adoption and growth of new technology in a country also depends on the attitude of the policy makers towards it. If they perceive communication technology being adopted as a helping hand in the development of the country, they would see that the required technology is adopted and implemented in various areas including the educational systems. The policy makers decide the amount to be allotted or the priority to be given to developing or importing a particular technology for specific purposes. In our country, the policy makers have a favourable attitude towards the utilization of communication technologies, and are quite liberal in recommending and implementing them. At times, they become over-enthusiastic in adopting a technology at various levels of education, even without creating the

adequate infrastructure in the form of required resources, including skilled manpower, maintenance mechanisms, etc.

Then we come to the cost of technology and budgetary provisions to buy or manufacture the tools for technology. Lack of foreign exchange, lack of capital, and the unavoidable difficulties in relation to balance of payments are recognised as principal economic hurdles faced by the developing countries (Jonscher, 1985). The total budget allocated for the education sector is the basis for deciding the amount to be earmarked for the adoption of communication technology. The initial expense to be made on installation of a technology is, as you know, very high. But once a country acquires a communication technology, she can reach and teach an unlimited number of students without involving high budgetary allocation. However, the skilled personnel and receiver equipment require recurring expenses.

The last point to touch upon here is the cost-efficiency of a chosen technology. We have to assess whether by implementing the technology the desired goals have been achieved optimally in terms of money, time and energy spent on it (Thomas, 1987). So the educational planners have to judge the efficiency of the technology being recommended for different target groups. They have to provide convincing answers to several questions, such as, is face-to-face instruction more effective than that done through the radio? Is the television more effective than the radio or vice versa? Such questions are to be resolved before investing in specific communication technologies. The educationists have to ensure that the investment in technology yields greater benefits to a larger number of the students; otherwise it is no good to bring in a technology for use on a large scale.

2.3.3 Cultural Factors

The communication technology plays an important role in disseminating knowledge about cultural heritage and stimulating cultural activities. Culture is a complex whole which includes knowledge, beliefs, art, morals, laws, customs, and any capabilities and habits acquired by a human being as a member of the society (Contractor, Fulk, Monge & Singhal, 1986). There are differences in these cultural factors of various societies all over the world. One society differs from another because of these variations. It is, therefore, assumed that the variations in cultural systems do function as determinants in implementing technologies, their manufacture and utilization. In other words, these variables/variations influence individual as well as group attitude towards various communication technologies.

Thomas (1987) elaborates that the cultural element of language is one of the most important factors in the transfer of the educational software from one country to another. The radio and television programmes, computer software and even printed text are produced in different languages in different countries with different cultural backgrounds. Similarly, philosophical traditions also influence technological exchanges. The adoption of the technologies thus depends on the attitudes, values, beliefs and lifestyles the people in a country have. For example, a confrontation between modernization and traditionalism recently started in India with the infiltration/encroachment of various technologies from the developed societies. For example the use of the World Wide Web without restrictions, and the use of Mobile phones in schools have resulted in controversies, because of use of these technologies for spreading pornography. As a result, a section of the people has become pro-innovation and pro-implementation, while others have stuck to the traditional practices. There was a hue and cry

even in the mid-eighties when the computers were introduced in the banking institutions of India. The bank employees went on strike against automation in the banks. One of their apprehensions was that computers would replace them but it really did not happen. There was another apprehension that the computer would add to the already long queues of unemployed youth in the country. On the other hand the use of computers has opened up more jobs. Again, when for the first time computers were introduced for the management of large examination systems, there were apprehensions expressed by some higher level officers, financial advisers and people in general about the need and desirability of such a step. The actual use of the computers, however, removed their apprehensions. Now-a-days there are no apprehensions about the capabilities of the computers, as it helps us in all walks of life from booing railway tickets at the conveniences of our home to managing my bank account, and even getting online degrees. An important cultural factor in the formal education system is the teachers' resistance and an approach of non-cooperation to any innovation or change in their existing teaching-learning practices. They seem to be quite satisfied with their present methods of teaching and, therefore, see no reason to adopt a new technology and invite unnecessary hardships in terms of money, time and energy. This is an important reason why the modern mass media are not used adequately in spite of their availability in some countries.

Our contention here is not that we should adopt technology without considering the socio-cultural factors. We need to evolve an indigenous model of communication, which has direct relevance to our conditions. The technologies should support our culture and values under the changed conditions. The implementation of communication technologies is greatly facilitated in a homogeneous culture. In other words the successful implementation of communication technologies depends on a match between the values of the two countries: the donor and the borrower. The implementation of technologies is successful, only when it is used to support the activities of the traditional culture, and allows development according to the values and norms of that culture.

For instance, the Satellite Instructional Television Experiment (SITE) project proved successful because the television programmes were shown to the villagers without disturbing their cultural equilibrium. The viewers discussed television messages in a group (teleclub) in the light of the existing practices in the rural society. On the basis of their discussions, they either accepted or rejected the messages broadcast. In this way the utilisation of the television programmes was successful, and it could bring about changes in the viewers' knowledge, skills and attitudes.

2.3.4 Technological Factors

There are various technological considerations that influence the growth and adoption of communication technology in a country. New communication technologies are not free from technical problems. You might have come across instances where you faced a lot of difficulties in handling, using and maintaining new gadgets. For instance, lack of a regular flow of electricity can make technologies defunct. One of the major reasons of under-utilization of the television programmes in the villages in India during the Satellite Instructional Television Experiment (SITE) and the Indian National Satellite (INSAT) project was the irregular supply of electricity. Some problems, particularly relevant to the application of technology for educational purposes are as follows:

Appropriateness: The technology chosen should suit the geographical conditions of the country. Those developing countries which are large, and have a difficult geographic terrain, need technologies that suit them. For these considerations, India's policy of having her own communication satellite to cover the entire country is justifiable. The microwave or cable networking have limited coverage and are too expensive to afford for large scale operations.

Accessibility: We are sure that communication technologies will not be accessible evenly throughout a country for educational purposes. Many households, mostly in poor societies of rural and urban sectors in the developing world, will have none in the near future. The accessibility of modern communication technologies such as the computer, videotext, video disc, videophone, etc., to public will remain extremely limited for many years to come. This does not mean that we are pessimistic about the situation. Far from that, we are of the opinion that the communication technology will be used first for commercial purposes, and not for educational ones in many of our countries. Certain constrains such as lack of sufficient money, lack of interest amongst educators and administrators, lack of sufficient software/courseware, lack of political will, etc. will invariably affect the accessibility of a technology to the educational sectors.

Handling: An electronic device will become redundant if we do not know to operate it. There are devices which, of course, can be operated with simple know-how, but there are some sophisticated devices, which need special efforts and skills to handle them. For example, though a computer is easy to operate, it needs specialized training to use them. More so, because the technologies are changing fast, one finds it difficult to keep oneself up to date in handling and maintaining them. Updating to new operating systems for example is a case in point.

Maintenance: It has been observed quite often that various technologies are imported or adopted from the developed countries without having made adequate arrangements for maintaining them. Once such devices develop technical problems, they become defunct for ever. The reasons for poor maintenance facilities may be due to lack of expertise, lack of resources/ infrastructure, non-availability of spare parts, or indifferent attitude of users. For instance, even the most popular/common of devices such as the television set installed in a rural primary schools in many poor countries, are not covered under an effective maintenance scheme.

Software/Courseware: It is a fact that there is a dearth of relevant software/ courseware for educational sectors all over the world, including the developed countries. Besides, there is a serious problem of quality software in the developing countries. Most of these countries depend on the courseware imported from the developed countries. Such courseware may not suit the socio-cultural and educational needs of the students of the borrower countries. One of the concerns here is the language of the courseware, which may be difficult for the students to follow. As a result, the actual utilization of such courseware becomes doubtful.

We must admit that designing and producing educational courseware is a complex task, which involves a lot of expertise, equipment and financial support. Designing courseware for the modern communication technologies, such as the computers, online learning, m-learning, etc. is a challenging job. How efficiently the students learn from a lesson depends on how skillfully the courseware has been designed.

Though some developing countries have reached a level of sophistication in producing general radio and television programmes, they do not have a sufficient stock of the educational programmes. The non-availability of the relevant courseware hampers the growth and development of the communication technology in the educational sectors. It is, therefore, necessary to seriously plan and design appropriate software for the new communication technology, (for instance, the talk-back system) otherwise it will take unreasonably long time to get the new technology introduced.

2.3.5 Educational Factors

There are certain educational factors that influence the growth and adoption of the communication technology. These factors are linked with socio-cultural and economic considerations prevailing in a society.

Teachers, the important component of the educational system, play a crucial role in the adoption of a technology, or an innovation. We should remember that teachers can diminish the success of any media at the institutional and actual operational level. They may or may not be willing to make necessary changes in their role, or to deviate from their existing practices as demanded by the technology. Their attitude toward technology is thus an important determinant. Communication technology demands a change in the role of teachers. They should realize that they are no more the only source of information required to transmit knowledge. In other words, new communication technologies will ask the teachers for new roles of teaching managers, facilitators, advisers, counsellor and so on. This is not something new we are talking about. A number of research studies on the educational media have provided empirical evidence to show that these devices demand that the teachers should play new roles.

There is an undercurrent of skepticism among some educators that the adoption of a technology may lead to further elitism in education: widening the gap between those who have access to resources and those who do not have. Adoption of technology needs a lot of resources, and every institution cannot afford to have such costly devices. Moreover, the government cannot make technology available to every student to work with. Thus adopting technology in education will rapidly create a new elite class, if it is introduced selectively.

Attainment of learning objectives is the main function of communication technologies. Besides the other attributes of software/courseware, the language of instruction is a determining factor for its success or failure. Even the same courseware produced by a foreign and a local agency in the same language produces different impacts. In an Indian study, for example, conducted by the University Grants Commission (UGC) Research Advisory Committee for INSAT-IB programmes, it was found that the programmes (in English) imported from other countries contributed little to the comprehension of the subject matter as compared to the programmes (in English) produced in India. The students faced problems in comprehending the language, mainly because of the pronunciation of the foreign experts.

Besides, there are some additional factors that influence decision-makers to ignore or adopt technologies for educational purposes. Some of these are as follows:

- The teachers are usually not involved in planning and preparing the courseware (there is a difference between software and courseware- 'software' refers to computer programming while 'courseware' refers to all teaching materials that store information, e.g., radio and television

programmes) for the students. The perception of the producers may differ from that of the teacher. This is the reason why teachers do not look at these devices with favour.

- There is another problem with the courseware. From the qualitative point of view, the scope of the content of the courseware may be limited, and the presentation of the content may be inadequate. From the quantitative point of view, it is very difficult to cover the entire syllabus by one technology (medium). Therefore, other media are required to achieve the educational objectives in their totality, but it is very difficult for many countries to adopt the multimedia approach to teaching-learning.
- There is a dearth of variety in the courseware in developing countries. The material borrowed from the developed countries may not be suitable for the students of developing countries; the software may not suit the needs of individual students.
- The teachers and the students may feel that the written and spoken communications are still popular in education. The students' dependency on the books and the teachers' lectures discourages them to make use of the modern communication technology. For instance, the Japanese, in spite of being a super industrial society, continue to depend on teachers for teaching-learning purposes. Thus education still suffers from a kind of intellectual imperialism, i.e. the teachers feel that they are the only competent means of teaching the students.
- Some communication technologies are more effective for pedagogic purposes than others. Educationists prefer the technology, which has the potential to solve educational problems and can consequently improve the quality of instruction.

Check Your Progress 2.2

Notes: *a) Write your answers in the space given below.*

b) Compare your answers with those given at the end of this Unit.

1) What are the four major economic considerations that influence the use of communication technology?

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2) What are the main cultural and technological factors that influence the adoption and growth of communication technology in a country?

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2.4 COMMUNICATION NETWORK TECHNOLOGIES

Broadly, today communication takes place through some kind of network technology. While networks can be developed simply with the use of wire in a small room or in a campus, we are more interested in network technologies that foster networking in a wide area facilitating distance learning. We will discuss some of these technologies in this section.

2.4.1 Communication Satellites

A communication satellite is a spacecraft that receives signals from a transmitter on earth and amplifies these signals, changes the carrier frequencies, and then retransmits the amplified signals back to the receivers on earth. The communication satellites are usually placed in a special earth orbit, which makes them appear stationary to the transmitters and receivers on earth. There are more than a hundred of these communication satellites in orbit around the world, and new satellites are being launched regularly.

The space age started in 1957 with the launching of ***Sputnik*** by the former USSR. Since then, a number of satellites have been launched for various purposes: telecommunications, meteorology, remote sensing, disaster warning, defense and so on.

The key to satellite-based communication is not simply the satellite itself, but other elements as well ¾ a ground based transmission station known as uplink, and a receiving disc known as downlink. The uplink sends signals to the satellite, which amplifies and retransmits them back to the downlink, i.e. the direct receiving disc, which in turn feeds a local station. See Figure 2.1.

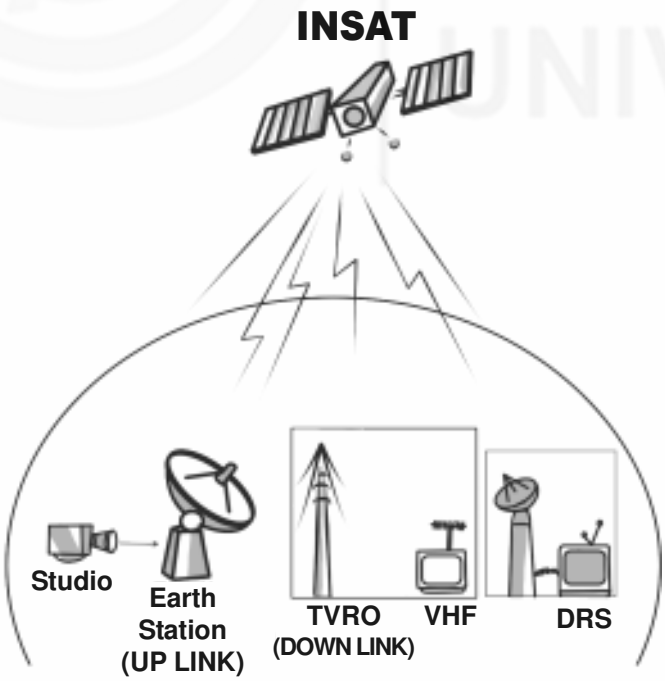

Figure 2.1: Communication Process

Launching of satellites

A satellite is launched into a geostationary orbit using either an unmanned vehicle or a piloted space shuttle that is reusable. The machine, popularly known as the Satellite Launch Vehicle (SLV), has one or more rocket stages that provide the acceleration needed to launch a satellite into the desired earth orbit. The satellite is normally placed in a circular earth orbit by the SLV and then transferred, shifted or fixed into a geostationary orbit. A special rocket in the satellite provides the acceleration needed to transfer the satellite from a circular orbit into a geostationary orbit. This special rocket in the satellite is called an apogee motor or an Apogee Kick Motor (AKM).

The space shuttle provides an alternative method of launching communication satellites. Launching satellites with a space shuttle is less expensive than using unpiloted launch vehicles because a space shuttle can launch more than one satellite on a single mission and then it can be reused (Douglas, 1988). Once the satellite is fixed in the geostationary orbit, it rotates in the same direction as the earth, at a velocity that equals the rate at which the earth rotates.

In a short span of time, communication satellites have become the predominant carriers of long distance communications. Since 6th April 1965, when the first commercial satellite, INTELSAT, was launched, the satellite industry has grown to handle most national and international communications. The satellite is used for direct broadcasting in many countries.

In India, the first Indian National Committee on Space Research (INCOSPAR) was founded in 1982 for conducting space science experiments. The primary objectives of the Indian space programme are to develop indigenous capability in advanced space technology/engineering; to develop capability for various applications of space technology for national development; and to build scientific manpower for space science and technology. The late Vikram Sarabhai, the first head of the Indian Space Research Organization, opined that India, with its vast size and population, and low level of economic development and literacy, should draw the benefits of satellite technology to create a nation-wide television service for instructional, educational, and related developmental purposes (Srirangan, 1985). It took 15 years for Sarabhai's dream to be fulfilled in the shape of the INSAT-A multi-purpose system. The INSAT series has made tremendous progress, and today India has a dedicated satellite for Education, Science and Technology (EDUSAT). More about satellite in education are discussed in Unit-8.

2.4.2 Computer Networks

Have you ever been amazed at the thought that you can dial a remote telephone number in your own locality, country or abroad and instantly get a reply? Perhaps not! The fact is that we have grown up with such technology and have been using it for such long periods that we have taken it for granted. Telephones are connected either by wires or through a satellite, which expedites connection between two telephones.

Unlike telephones, the computer was developed as a 'stand alone' device to be used in certain situations by an individual or group in isolation. Once the machine was developed it was felt that connecting different computers either in close proximity or placed at a distance from each other could provide access to powerful computing capability and information which

would be very helpful in making computer communication possible. This facility can and has been of great help in completing tasks requiring group efforts. Different people can keep working on their own terminals and compile the work on a common computer remotely placed. The facility of working from different sites provides the opportunity to work at flexible and convenient hours.

The linking of two or more computers, terminals and peripheral devices is termed *a network of computers*. Computers are networked for on-line data-communication and sharing of resources such as common printers, hard-drive space, modems, CD-ROM drives; exchanging files and sharing databases. The resources shared in a network may be physical devices or information kept in databases. Online data communication supported by a network facilitates not only a highly interactive mode of communication but also the quicker transmission of information. Distributed databases and distributed data processing are also very important features of networking. A network reduces the cost of maintaining databases and specialized software.

Advantages of Computer Networking

Some major advantages of computer networking could be as follows:

- ***Resource sharing:*** All computer users do not have the best computer facilities available on a stand-alone computer. Acquiring a main-frame computer can never be a cost feasible option for an individual or a small organization. Similarly, expensive peripherals like sophisticated printers, large hard disks etc. can not be attached to individual computers for the same reason – that of high costs. But if we can interconnect (network) the small computers and terminals with a powerful processor, secondary storage, printers, etc., then all these small computers can utilize the powerful resources interconnected through a network.
- ***Global database:*** When different computers are interlinked and can share resources then there is no need to store the same or similar information on the storage areas of individual computers. Data that needs to be shared by different users can be stored and maintained at a global storage area and users can be given access to it with their user-ids (user identification code kept for unique recognition of the user by the computer) and passwords (used for protecting a user's data from other users). For example, if some study material or reference material is prepared for many students, it can be stored in one computer storage area and made available through a network to all those who need it.
- ***Powerful communication medium:*** We are all aware of the rate of growth of information and the use of up- to- date information, primarily in education and research, and also in other areas of life. Traditional means and media of information creation and dissemination like print, recorded audio and video devices are cumbersome and very slow. The information stored and disseminated through networks has recently become the most popular means because of the simple editing process and the facility of fetching data from all the different sites in the world. Some other means of communication may be equally fast but they are both very expensive and incapable of carrying big databases. In the DE the students can log on to the databases of the universities and benefit from them in various ways, e.g. be informed about the latest in research, navigate through one information topic to another, have an online explanation of different topics.

- ***Information management:*** Management of information in a global database is also easier in a networked setup. Any database in such a setup will not have a duplicate copy and so editing, updation, deletion, etc. are all required to be done at one place. This is in contrast to the systems of maintaining local databases where information may have duplicate entries in different individual databases, and in order to change any component of the information, all the databases keeping that component must be changed accordingly. Failing to do so will give rise to ambiguous and hence incorrect information. In a network, data is also protected from any unauthorized use.
- ***Online information exchange:*** It is already stated above that a network facilitates an online information exchange. Now we have to understand the advantages of this on-line exchange of information. Any information is kept for people to use in any way they want to use and when ever they want. Using a computer attached to a network, one can easily and quickly access information in the right format, which can be used for further work and timely decision making.
- ***Saving money:*** All the above stated properties — resource sharing, global information maintenance, rapid information exchange – of a network system reduce the cost of information storage and interchange. Although the initial setup cost of a network may appear high, the overall running and other future costs in totality save money. Also, a bigger network system may be planned but it can be built in phases starting with a smaller setup, such as adding an extra, which node, which is not at all a problem, if planned in advance. This will reduce the initial setup cost, if arranging for finance is a problem.

Data Communication Channels

In a network all the computers and other devices are joined through data communication channels. These channels are of two types – one which uses some physical medium for the transmission of data e.g. a pair of twisted copper wires (like telephone lines), coaxial cables (like television cables) and optical fiber cables; and the other one which uses the property of microwaves and communication satellite systems.

- A pair of **twisted wires** is the most common medium. Two copper wires are twisted together to reduce electrical interference from similar pairs lying close by. The twisted pair can transmit both analog and digital signals. It is the cheapest transmission medium in use.
- **Coaxial cables** comprise a stiff copper core surrounded by an insulated cover, which is in turn encased by a woven mesh of conductor. The whole structure is covered with some plastic material. It has a higher speed of transmission and better shielding.
- **Optical fibres** are very high transmission channels. They are most expensive of all the physical mediums and the detectors. When there is a pulse of light it is sensed as **1** and the absence of light is taken for **0**. Refraction of light occurs whenever there is a change in the density of the medium in which light beams are passing. By total internal reflection light is trapped inside the fiber and travels a long distance at the speed of light.

Network Topology

There are two types of technology for the transmission of network, point-to-point and broadcasting. In a **point-to-point** network, the connection is between individual computers whereas in the **broadcasting** type of transmission there is a single channel used for transmission of data in packets. All the data packets sent by any machine are received by all the

other computers and the address part of the packet is checked by the receiving computers. If it is meant for them it is used and otherwise simply ignored.

The structure of the linking of computers using data communication channels is known as a **topology of network**. It can be of many different styles but a few standard structures are used in computer networks. Let us discuss the four topologies of networks.

Star Topology

There is a central computer (called the host) in the star network, which is linked with all the other computers (called nodes) in the network and all the nodes are connected to each other through the central computer alone. Adding and deleting a node in this network is much simpler as connection is setup/deleted only between the host and the node. The initial setup cost of such network is also low. The biggest disadvantage of this topology is that the network fails if the host breaks down (Figure 2.2).

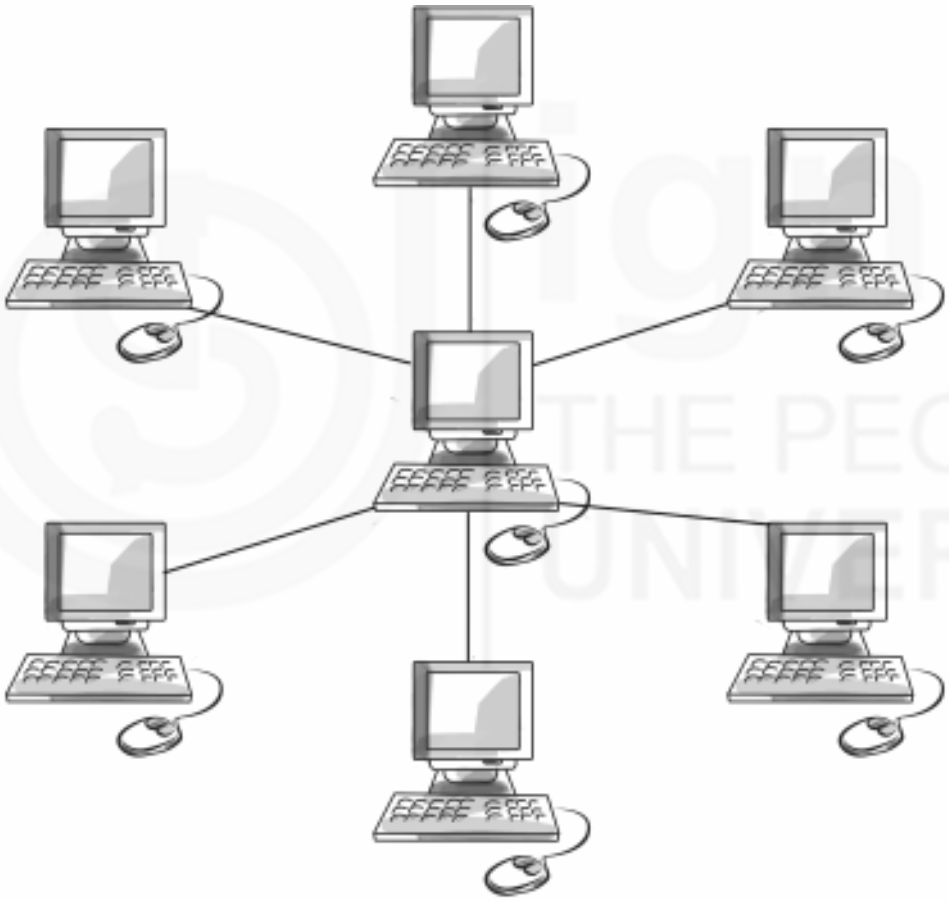

Figure 2.2: Star topology

Ring Topology

In the ring topology all the computers in the network are connected to two other computers. The shape of the network is like a ring, as shown in the diagram below. The data transmission in the ring topology is bi-directional for any individual machine. So, even if a connection fails for a particular machine it has another side for connecting to others, although the ring structure breaks. The initial setup cost is low and adding/deleting nodes is easier (Figure 2.3).

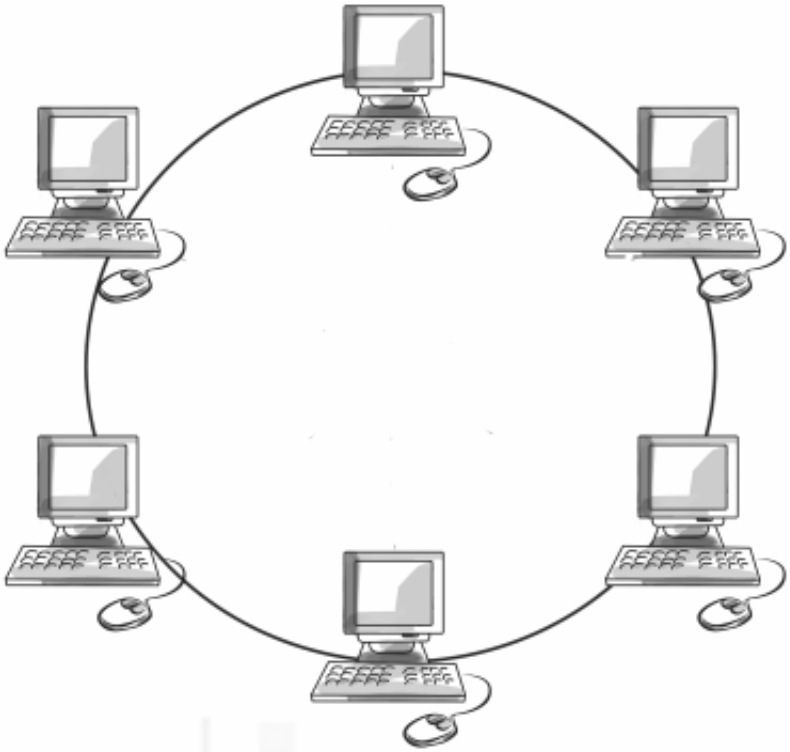

Figure 2.3: Ring topology

Bus Topology

It is also known as the linear connection network. It is the broadcasting type of transmission used in Local Area Network (explained in the next section). Only one machine is allowed to send data at a time. If two machines try to send data at the same time both have to wait individually for different random times (Figure 2.4).

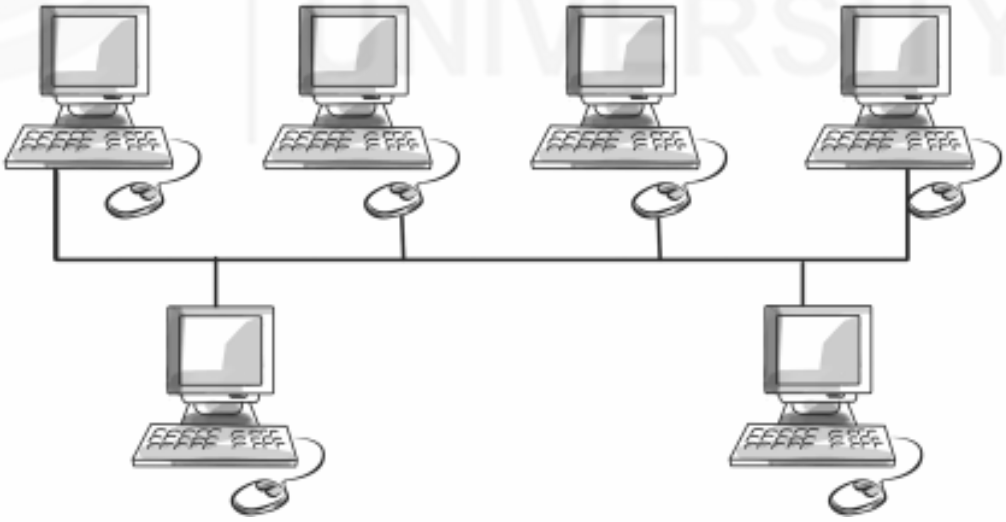

Figure 2.4: Bus topology

Fully-connected or Mesh Topology

In this type of technology each computer is connected to all the other computers. Adding/deleting a node in such a network is costly. The initial setup cost is also very high. But the communication in it has high reliability, as each computer has many links (Figure 2.5).

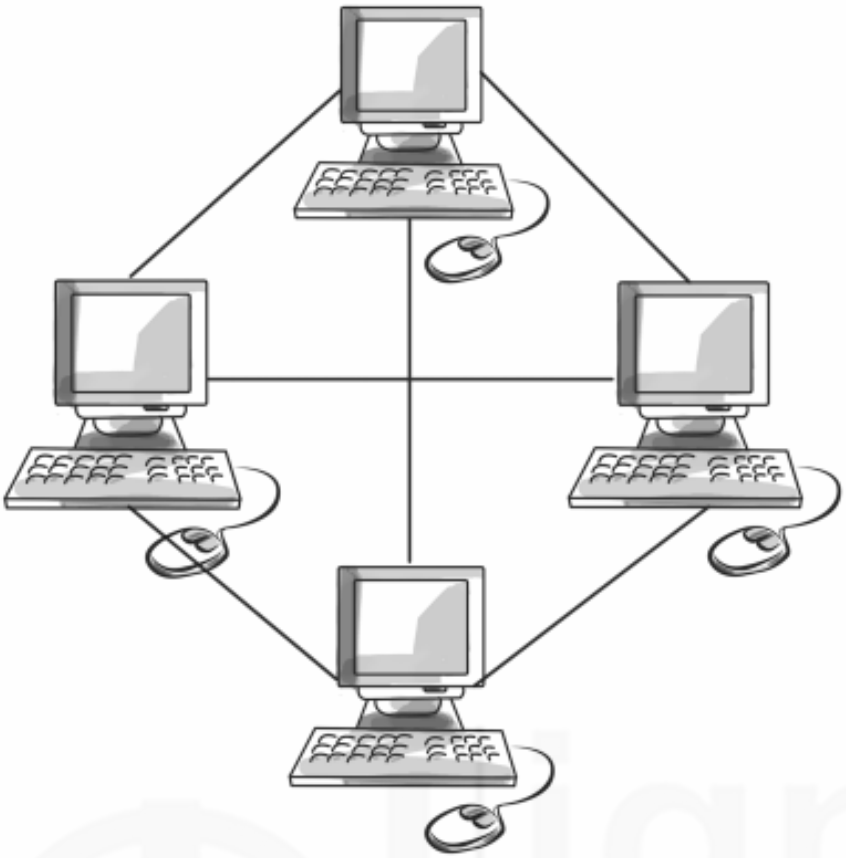

Figure 2.5: Mesh topology

Network Types

Networks can connect two computers on the same desk or connect computers around the world. Based on the usages and geographical coverage area of the network, a network can be classified as:

- Local Area Network (LAN)
- Metropolitan Area Network (MAN)
- Wide Area Network (WAN)

Local Area Network connects computers and electronics devices within a limited geographical area e.g. a building of some functional unit of an organization, R & D unit, etc. Normally, a LAN functions within a range of 10 kms area. It may have different types of computers, mostly microcomputers (PCs), and peripheral devices attached with a variety of data communication wires or cables.

Different departments or sections of an organization may like to share information to expedite their jobs. For example, in a university set-up, the examination department may like to have information about the total number of students admitted to a particular course, to arrange for the examination. Similarly information about finance, degree distribution etc. may be sought. It will be of great help if all the information is available at one place without requiring the person to go from one department to the other.

The facility of LAN has become so popular that since 1987 all Macintosh and now all computers produced by different companies, are produced with the built in capacity for networking. The networking software has now become part of the operating system. Vishwanathan (1992) lists the following six advantages offered by LAN:

1) Unlike a large centralized system, a LAN may evolve with time. It may be put into operation with a small investment, and more systems may be added as the need arises.
2) Since LAN is a set of multiple interconnected systems, it offers a good back up capability in the event of one or two system failing in the network. This, in turn, enhances the reliability and availability of the systems to users.
3) LAN provides a resource- sharing environment. Expensive peripherals, hosts and databases may be shared by all the LAN users.
4) A LAN adhering to a certain standard permits multi-vender systems to be connected to it. Thus, a user is not committed to a single vendor.
5) In LAN, the systems are generally so chosen as to meet most of the user requirements locally and the network is used only for resource and information sharing purposes. Due to this, each user gets a better response then would be the case in a centralised system. LAN tends to exhibit an improved performance.
6) LAN offers flexibility in locating the equipment. Most computers on a LAN are physically placed at the user table, which is most convenient for working and improves the productivity significantly.

Metropolitan Area Network usually covers a geographical area spanning a distance of 5-50 kms. Network topologies used in MAN are similar to LANs: Star, Bus, Ring. As such MANs are extentions of LANs. The trans-mission media most suitable for MANs applications are broadband coaxial cable and optical fibres.

Wide Area Network is a large area network, which covers different cities or countries. A WAN uses a point-to-point transmission technology. Local area networks may be connected to wide area networks by a common processor called the *gateway,* which is used as a common interface. As mentioned above, there is no satisfactory definition to explain a WAN but it seems to have one definite quality and that is it must make use of a telephone line. WANs tend to become quite complicated and so they are losing their popularity to Intranet and Internet.

Check Your Progress 2.3

Notes: *a) Write your answers in the space given below.*

b) Check and compare your answers with those given at the end of this unit.

1) What are the advantages of computer networks?

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2) Which of the following statements are True (T) and which False (F)?

a) The twisted pair cable can transmit both digital and analog signal ☐

b) In ring topology, the breakdown of a system causes failure of the network ☐

c) The geographical coverage of a MAN is usually within 5-50 kms. ☐

d) Interconnection of networks and devices is done through standards and protocols. ☐

2.4.3 Wireless Networks

Wireless network refers to a type of communication network that transfers information over a distance without the use of wire. Wireless communication networks are implemented using radio, infrared, and microwave as the carrier. So, they have applications in home appliances, radio broadcasting, mobile telephony, etc.

The radio based network system contains a transmitter that consists of a source of electrical energy, producing alternating current of a desired frequency. The transmitter also has a system to change some properties of the energy produced to impress a signal on it. This change might be as simple as turning the energy on and off, or altering more subtle properties such as amplitude, frequency, phase, or combinations of these properties. The transmitter sends the modulated electrical energy to a tuned antenna; this structure converts the rapidly-changing alternating current into an electromagnetic wave that can move through free space. The electromagnetic wave is intercepted by a tuned receiving antenna and re-converted to electrical currents. At the receiver, these currents are demodulated and the information is received in the form sent.

Microwave based wireless networks use electromagnetic waves with wavelengths ranging from as long as one meter to as short as one millimeter, or equivalently, with frequencies between 300 MHz (0.3 GHz) and 300 GHz. The frequency of microwave is shorter than the radio. Infrared based wireless networks use electromagnetic radiation with a wavelength between 0.7 and 300 micrometres, which equates to a frequency range between 1 and 430 terahertz. Thus, it is used for short range communication within home and offices.

Wireless networks are of different types:

- Personal networks through Bluetooth (uses a radio technology called frequency-hopping spread spectrum and transmits up to 79 bands of 1 MHz width in the range 2402-2480 MHz). It normally has a maximum range of about 100 meters.
- Wireless LAN through Wi-Fi (short for *Wireless Fidelity;* a trademark of Wi-Fi Alliance that is based on IEEE 802.11 technology). It is used for personal computers, laptops, printers, personal digital assistants, smartphones, etc. Wi-Fi networks have limited range (say about 95 meters), but can be enhanced by use of access points. It uses radio frequency at 2.4 GHz.

- Wireless MAN though WiMAX (short for Worldwide Interoperability for Microwave Access, and is based on IEEE 802.16 standards that is considered the broadband wireless standard). It provides mobile broadband connectivity in a city, as it can have a range of 50 KM. However, the speed decreases as the distance becomes more.
- Wireless WAN is achieved through Global System for Mobile Communication (GSM). The second generation (2G) GSM operates in the 900 MHz or 1800 MHz bands, and has General Packet Radio Service (GPRS) for data transfer. GPRS enabled phones allow access to the Internet, although at a low speed. However the 3G based mobile applications can have mobile TV, video on demand service, video conferencing etc. as 3G systems can in practice offer up to 14.0 Mbit/s on the downlink and 5.8 Mbit/s on the uplink.

2.5 INTERNET

Internet is an open non-participatory computer communication infrastructure that reaches every corner of the globe, carries information on every topic and is available to users round the clock. Technically it is a global collection of interconnected networks. It allows computer users to share equipments, programmes and information available in different sites. It is sometimes referred as the ultimate "information superhighway".

The history of the Internet began at the peak of the cold war in the 1960s. The Defense Advanced Research Project Agency (DARPA) of the USA was funded to find ways for scientists and laboratories to share expensive computer resources. The outcome of the research manifested in the form of the Advanced Research Project Agency Network (ARPANET) which went online in 1969. People at the Rand Corporation, The Research and Development unit of the American Army, were quite worried about the probability of a communication breakdown in the event of a nuclear attack. The communication networks at that time were based on point-to-point connections, which were linked in chains. Functioning of these types of networks relies largely on the links between each pair of points in the communication system, and a breakdown at any point in the network would subsequently halt any communication through networks.

To tackle the problems associated with the point-to-point network, an idea for a new kind of connection in the network was conceived by the Rand thinkers. The new type of network was more like a spider net which connected different points through different channels. In the event of a breakdown in one of the sections, the communication could be carried on through other routes. The first real Internet connection was established between four US universities namely Stanford Research Institute, UCLA, UC Santa Barbara and the University of Utah.

Growth of the Internet

In 1973 the ARPANET provided, for the first time, international connection to agencies outside US, viz. University College in London, England and the Royal Radar Establishment in Norway. As maintained earlier, the Internet is an international network of networks where different types of computers are connected for purposes of communication. Unlike the earlier LANs where the platform of network was homogenous we have now computers running on heterogeneous platforms for communication. All the machines in the Internet are glued together with the Transmission Control Protocol/Internet

Protocol (TCP/IP) reference model and TCP/IP protocol stack. A machine can be connected to the Internet, if it can run the TCP/IP protocol; has an IP address and has the ability to send IP packets to other machines on the net.

The Internet has grown very fast over the years. From only 4 hosts in 1969 in the DARPANET, it had grown to include 37 computers in 1972. Later the name changed to ARPANET. By 1983 it had more than 500 hosts and thus the military research component was moved to another network called MILNET. At the end of 2009, every 4th user person in the World had access to the Internet. You can search the World Wide Web (particularly the ITU site) to know the latest growth in terms of number for specific countries and region. Another site for this purpose is http://www.internetworldstats.com/stats.htm

How Internet works?

The Internet works on the Transmission Control Protocol (TCP) and Internet Protocol (IP). These two are collectivity called TCP/IP. For sending data into another machine TCP divides the data into little packets and IP puts the destination address on each packets. The Internet addresses have two forms — one for the understanding of the user and the other for the machine. Typically, an address on the Internet looks like this:

http://www.host.subdomain.domain

Where http is the hypertext transfer protocol, www stands for World Wide Web, *host* is the local network server (such as ignou) grouped into domains. The *domains* are classified as geographic and non-geographic. Table-2.1 shows the list of domain names. The user of the internet types the address in a browser, which using the network of the Internet Service provider (ISP), search for the address to locate it. When the server is located, it serves/ returns the page (normally the home page) asked for to the computer that initiated the request.

Table 2.1: Domain names in Internet

Geographical		Non- Geographical	
.in	India	.com	Commercial organization
.au	Australia	.net	Networks
.de	Germany	gov	Government
.jp	Japan	.mil	Military networks
.uk	United Kingdom	.edu	Educational institute
.ca	Canada	.org	Organization

Who governs it?

By now, you must be thinking 'Who owns the Internet?' or Who governs the Internet? The answer to this million dollar question is: no one. The beauty of the Internet is that it has grown up and evolved as an open system where individuals and organizations can join and become online. In terms of technology of the Internet there are several bodies that look after the technical standards. The following organization oversees the development of the Internet.

- ***Internet Society***. Established in January 1992 as the authority for the development of the Internet, it comprises individual and organizational members charged with maintaining the long-terms viability of the Internet.

- ***Internet Architecture Board***. It joined the Internet Society in June 1992 to oversee the architecture and protocols used by the Internet.
- ***Internet Engineering Task Force***. Started in 1986, the TETF oversees the complex and detailed work of developing and standardizing the Internet Protocol suite.
- ***Internet Engineering Steering Group***. It provides management of the Internet standard process.
- ***World Wide Web Consortium***: Founded in 1994 to develop common standards for the evolution of the web.

In 2005, the World Summit on Information Society held at Tunis established the Internet Governance Forum to discuss Internet related issues. The Internet Corporation for Assigned Names and Numbers (ICANN), headquartered in Marina del Rey, California administer the domain name and registration of hosts. ICANN is governed by an international board of directors drawn from across the Internet technical, business, academic, and other non-commercial communities.

You will study more about Internet and its application in various units of this course.

Check Your Progress 2.4

Notes: *a) Write your answers in the space given below*

b) Compare your answers with those given at the end of this unit.

1) Identify the different parts of the following Internet address.
http://www.ignou.ac.in
http://www.egyankosh.ac.in

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2) Write 'T' for True and 'F' for False statement.

a) Infrared based wireless networks use electromagnetic radiation with a wavelength between 0.7 and 100 micrometres ☐

b) Bluetooth (uses a radio technology called frequency-hopping spread spectrum ☐

c) No one governs the Internet. ☐

2.6 LET US SUM UP

In this unit we discussed the technology behind the communication processes. We started by discussing the historical developments of communication technologies and networks for the days of the telegraph to the Internet and its World Wide Web. We discussed the economic, technological, political, educational and sociological factors affecting the use and growth of communication technology in a country. You also discussed the developments in the satellite technology to promote communication networks, and the computers and communication networks. We also

identified and discussed the technologies behind wireless communication networks.

Towards the end of this unit, we discussed Internet as the network of networks to provide end to end communication that may use computer networks, wireless networks and satellite networks or a combination of these. While you are not supposed to know the technological details of these networks, it is important to have some understanding of the technologies and its operation to take appropriate decisions on the use of communication technology for teaching and learning.

2.7 KEYWORDS

Communication network: is a collection of a collection of terminals, links and nodes which connect together to enable telecommunication between users of the terminals.

Internet: is an international network of networks where different types of computers are connected for purposes of communication. The Internet works on the Transmission Control Protocol (TCP) and Internet Protocol (IP).

Local Area Network: connects computers and electronics devices within a limited geographical area.

Metropolitan Area Network: usually covers a geographical area spanning a distance of 5-50 kms.

Satellite: is a spacecraft that receives signals from a transmitter on earth and amplifies these signals, changes the carrier frequencies, and then retransmits the amplified signals back to the receivers on earth.

Wide Area Network: is a large area network, which covers different cities or countries.

Wireless network: refers to a type of communication network that transfers information over a distance without the use of wire.

2.8 REFERENCES AND FURTHER READINGS

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2.9 FEEDBACK TO CHECK YOUR PROGRESS QUESTIONS

Check Your Progress 2.1

i) tele and graphien

ii) 1876

iii) Nicola Telsa
iv) Tim Berners-Lee
v) 1969

Check Your Progress 2.2

1) The four major economic considerations are

- financial strength of the society
- attitude of the policy makers towards communication technology
- budget allocation for communication technology
- cost efficiency of the technology

2) The main cultural factors are — language, beliefs, arts, values morals, customs, laws, attitudes, habits, etc.

Check Your Progress 2.3

1) The advantages of computer networks are :

— Resource sharing
— Access to global databases
— Powerful communication
— Improved information management
— Interactive information exchange
— Time and money saving.

2) (a) True (b) False (c) True (d) True.

Check Your Progress 2.4

1) In http://www.ignou.ac.in, ignou is the host server, ac is for academic domain (here it is sub-domain) and in for India (as geographical domain).

In http://www.egyankosh.ac.in, egyankosh is the host server, and the rest as for above.

2) a) False b) True c) True