INSTRUCTIONAL OBJECTIVES

General

This lesson is designed to give the reader the concept and definition of a telecommunication network vis-à-vis other networks.

Specific

On completion of this lesson, the learner shall be able to

1. Define Communication networks.
2. Identify the constituents of a communication network.
3. List at least two examples of communication networks.
4. Outline the hierarchy of networks.
5. Specify the features of the various types of networks.

1.1.1 INTRODUCTION

A network is an interconnection of many nodes through which a desired entity flows or travels. The nodes are the points where more than two branches or links through which the entity moves, meet. Figure1.1 shows the topography of a network having 5 nodes A, B, C, D, and E. These nodes are interconnected by various links/branches such as L_{AB}, L_{BC}, L_{CD}, L_{BD}, etc.

In electrical engineering a simple example of a network is an electrical network where the links/branches are the electrical components like resistors, capacitors, inductors, and active devices. These branches carry charge/current through them and meet at various nodes. The carried charge reaches a node through some branch and leaves the node through some other branch. In the context of transportation a road network is an illustrative example. The different roads meet at a junction or crossing, which can be termed as a node. The roads act as branches/links and the vehicular traffic travel through them in the road network. At a crossing a vehicle coming from one road goes to the desired road. In a similar fashion we have rail networks and airline networks. Postal network is an example of a network through which messages are sent from source to destination. With the invention of electrical communication, today we have telephone, data and broadcast networks. In this lesson the characteristics and

organization of communication network will be discussed step-by-step. Thus a network is composed of nodes and branches to facilitate movement of a physical entity.

It may be noted that the source and the destination that is the users are considered to be outside the network for simplicity.

An entity from a source enters the network through a node which for that entity is called the source node. Similarly an entity leaves the network from node serving the destination. This node for the given entity is called the destination node. Any node can be a source and a destination nose and can serve many users.

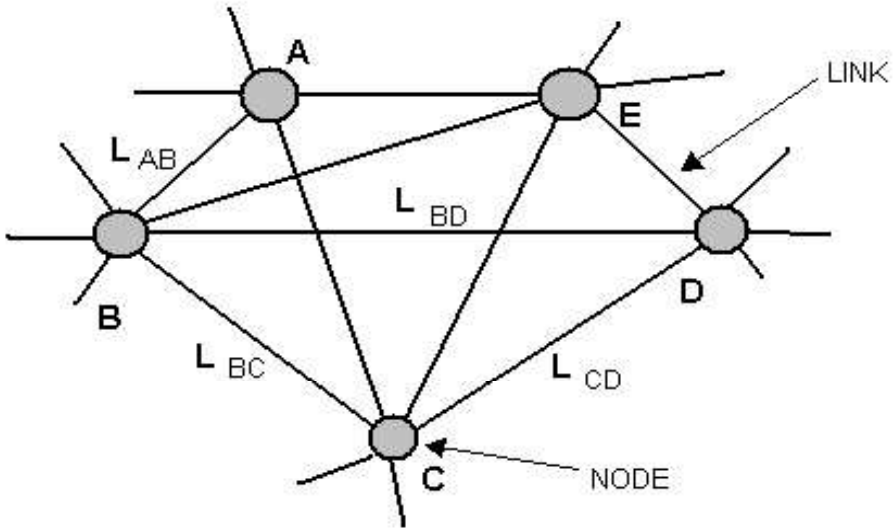

Fig. 1.1 A generic network topology

1.1.2 COMPONENTS OF A COMMUNICATION NETWORK

Node

In a communication network a node is a point where more than two branches meet. A general communication network may have a large number of nodes and it is not necessary that each of them is connected to all others. The function of a network node is to connect the output path with an incoming path so that the signal can be switched to the desired path for onward transmission. Conventionally, for a telephone network the telephone exchange, which is a circuit switch basically, acts as a node. For a data network, the node is a packet switch and is commonly referred to as a router. Some of the nodes, particularly the message and packet

switching ones, have buffers and storage for messages. Such nodes function as store-and-forward switches. There are other functions like identifying the incoming message, testing the free outlet, signaling etc which the node performs.

Branch

The branch of communication network is basically a transmission medium which is either a wire or a radio channel. Wired transmission medium can be any one of the forms such as pair of copper wires, a multi-pair cable, a co-axial cable or an optical fiber. These wires take the signals from one node to the other. The wireless channel is a portion electromagnetic spectrum of ranging from very low frequency to ultra high frequency including millimeter and optical waves. The bandwidth of both the wire and wireless channels has a very wide range and can support data rates ranging from a few bits per second to several Giga/Peta bits per second. The lengths of these transmission links are limited due to various reasons such as attenuation and dispersion. In a versatile communication network all the links need not be of the same type. Some of these can be wired while some other may be wireless.

Network

A communication network can now be defined as a collection of switches (nodes) interconnected by transmission media (links/branches) carrying information bearing signals (entity) in electrical/optical form.

So the nodes, links and the transmission of information are the fundamental attributes of any network.

Some of the commonly known and widely used message networks are the postal network, the telegraph network, the telephone network (fixed, cellular mobile), the data/computer network (Internet) and the entertainment network (audio/TV broadcast, cable-TV). We shall talk about each of them in brief later.

It may be worth while to note the fundamental difference between the two message networks namely the postal and electrical/optical communication networks. In the postal network the medium carrying the message (letter) moves from source to destination whereas in the electrical/optical network the message moves. It is necessary that the switches should be fast enough and the transmission media should have sufficient bandwidth to support a particular type of traffic.

1.1.3 NETWORK EXAMPLES

Depending on the application for which a network is designed and deployed, there are different types of networks. The telegraph network has been used to send telegrams from one place to another. It uses message switches as the nodes and basically provides a very low speed service. The telex network, on the other hand, works like a telephone network and the users can directly send text messages to the desired destination without the help of any operator. Telephone network is used for voice communication between two users. Conventionally it uses circuit switching. A computer network allows computer data to be sent from one computer to another. Thus two computers can communicate using a computer network. Packet switching is normally used in computer networks. Audio and video information can be sent from one source simultaneously to a large number of users through a broadcast network. Since it is one-to-many transmission service there is no switching involved.

TELEPHONE NETWORK

Telephone network usually called Public Switched Telephone Network (PSTN), has been one of the most popular types of network facilitating voice communication between two persons. This network employs circuit switches as nodes and the branches consist of variety of the transmission media. Conventionally, the network was designed to support analog voice, but now-a-days it has largely become digital. The switches now a days are digital and the traffic between switches is digitally multiplexed voice signals. The subscribers can send/receive either analog or digital voice to/from the telephone exchange. If the user has an analog instrument the voice signals are converted to the digital form at the telephone exchange. For the digital user, the analog to digital conversion of voice is done at the user's telephone instrument called the digital telephone. In the telephone network first a source-destination path is established using signaling and then only the voice communication takes place. A telephone network can carry data as well as facsimile traffic using suitable modems (modulation-demodulation devices) at users' ends. With advances in technology the circuit switches may be replaced by packet switches using Internet Protocol (IP) leading to the emerging voice over IP (VoIP) technique in telephone networks.

COMPUTER/DATA NETWORKS

Data/computer network including the Internet primarily carries digital data from source to destination. Here the nodes are packet switches and use the store and forward mechanism. A packet switch receives information in form of packets, stores them and forwards the packets to a free outgoing link. The packet switches are called routers and they transmit the packets onward identifying the address of the packet. The branches are the similar to the ones used in telephone networks. The data networks carry data traffic varying from very low bit rates to extremely high bit rates such as Giga/Tera/Peta bits per second. The internet is a network of networks which interconnects multiple of networks and primarily designed to carry text messages. But today the internet has advanced considerably to support multimedia traffic as well. Telephone, music and video traffic are supported by Internet. The Internet also provides the Web facility through which a user can access variety of information stored at different sites. A computer network

- is primarily a digital network (streams of 1s and 0s flow through the network).
- supports variable bit rates/bandwidth as 'data' is bursty in nature. The traffic is said to be bursty when data on-time is much shorter than no-data period.
- was originally designed to carry non-real time traffic.
- is generally non-interactive (non-conversational).
- is full Duplex.
- has to have switches with storage capabilities (buffer).

According to ARPA the switches were earlier called IMP (Interface Message Processors). They are now called PSE (Packet Switching Exchanges). In case of Internet they are termed routers.

ENTERTAINMENT/DISTRIBUTION/BROADCAST NETWORK

Classically, a very popular network is the broadcast network. It provides the recipient with news, entertainment, educational health and many other similar services. Earlier the broadcast network was supporting only the audio signal but today we have TV broadcast networks. This is basically a

receive-only network where user normally can't transmit. Because of the TV transmission the bandwidth of the network is very high compared to conventional telecommunication networks. The advances in technology and concepts are making this network interactive where the user will be able to send some messages also. The broadcasting can be wireless as in radio and terrestrial TV networks. It can be using satellites as well. With the help of satellites broadcast can be over much larger areas. For quite some time cable TV and Optical fibre cables are also used for distribution of information/message. This mode has become very popular because it provides a large number of channels to the users

UNIFIED/INTEGRATED NETWORK

Historically, the three networks viz the telephone, the data and the entertainment networks were developed independently for specific purposes. Their design and evolution were all separate and they catered for different kind of services to their users. Generally the telephone network has been designed to provide a fixed narrow bandwidth, half duplex, real time interactive call to call basis service. The broadcast network on the other hand provided a broadband, like TV, one way non-interactive receive-only service where user can access the message if it is being broadcast but the broadcasters keep on transmitting without bothering about the presence of receivers. The computer networks provide variable bit rate generally non-real time services such as e-mail, file transfer, remote log-in and web services. The network and service providers for these services have been traditionally different. The underlying technologies for these services are also quite different. However the digital revolution enabled representation of all types of information in the same form using ones and zeros. This lead to the development of the concept and appropriate technologies for integrating the three different types of networks as mentioned above. Advances in the computer and the digital communication fields resulted in the Integrated Digital Networks (IDN) and later the Integrated Services Digital Network (ISDN). ISDN supports voice, data and slow scan video from the same vendor. A user need not subscribe to different service providers for different services. Due to some limitations with the ISDN, broadband ISDN (BISDN) was developed in course of time to provide high quality full-bandwidth video service in addition to the voice and the data services. Communications and computers converged to give birth to a really unified /integrated network. Such an all-encompassing network should be transparent to the users enabling them single point of access. Whatever they send or receive is accommodated by the network. The services may

be differentiated by the end users but internally all of them are available through the same network. All the services thus may be converged into a single network.

MOBILE COMMUNICATION NETWORK

The requirement of the users to communicate even when they are on the move and the advances in the wireless/radio communication technology has propelled the emergence of the mobile telephone network, called the Cellular Mobile Telephone Network. Initially intended primarily for telephone communication, the mobile network now provides data as well as multimedia services to the mobile users on a global basis. A given geographical are is subdivided into small cells each with a fixed base station which in turn is connected to a switching centre by wired or wireless media. Switching centre (known as the mobile switching centre) in fact connects the mobile user with rest of the telecommunication infra-structure and vice-versa. The mobile user is connected to the respective base station on a duplex radio link. Thus communication between a mobile and a fixed user is via the base station and the switching centre. The radio link between the mobile user and the base station allows the mobile user to move. Adjacent cells are given different frequencies but the far-off cells can be assigned the same frequencies for the radio links. This way the frequencies can be reused relaxing the constraint on limited spectrum. Mobile communication has evolved from the original first generation (analog) to the second generation (digital) like the GSM and the CDMA. It supports data in addition to voice communication. The third generation of mobile communication known as the IMT-2000 and the UMTS are rolling out. They are able to support data up to 2Mbps and have many advanced features. Wireless local area networks (WLAN) provide access to the Internet at speeds of 54 Mbps. Advances in cellular mobile telecommunicatins, WLAN's and mobile computing are paving the way for the ubiquitous global broadband mobile communications.

1.1.4 NETWORK HIERARCHY

Telecommunication networks usually have a hierarchy which depends on the traffic, connectivity and control. Bulk of the traffic is carried by the backbone or the core network, which interconnects heavy traffic nodes. The links in the core network have extremely high capacity and the nodes are also very powerful. The backbone is mainly optical fiber based and in future it is going to be packet switched network with IP and/or ATM. The optical fibers are employing DWDM technology, providing Terabits per second (Tbps) / Petabits per second (Pbps) traffic speeds. It can support a variety of protocols and use optical cross-connects and optical add-drop

multiplexers. Photonic switches are also expected to be employed. This network feeds and is fed by the edge networks which carry the traffic in a region. Edge networks also have architecture similar to the core network. Then there are the metro networks, serving large cities and many local networks. Metro networks are connected to the edge networks. The local networks serve the users in a given area/locality. The users access the local networks (sometimes the metro networks also) directly through what are known as Access Networks. The local, metro, edge and core networks constitute the network hierarchy. The metro, the edge and the core networks are basically trunk networks and carry the bulk traffic from node to node. The access network connects the individual or corporate users to the telecommunication networks. The traffic originating at source is carried through the access network to the telecommunication network and vice-versa. The access network may be implemented using a variety of media and technology, starting from the simple copper wire, X-DSL, wireless including mobile and optical fibers. The data rates in the access networks varies over a wide range depending on the user requirements/applications. All these networks have to be supported by advanced intelligent networking and telecommunication management networks for providing a variety of services with quality and user control. Figure 1.2 shows the hierarchy of the telecommunication networks.

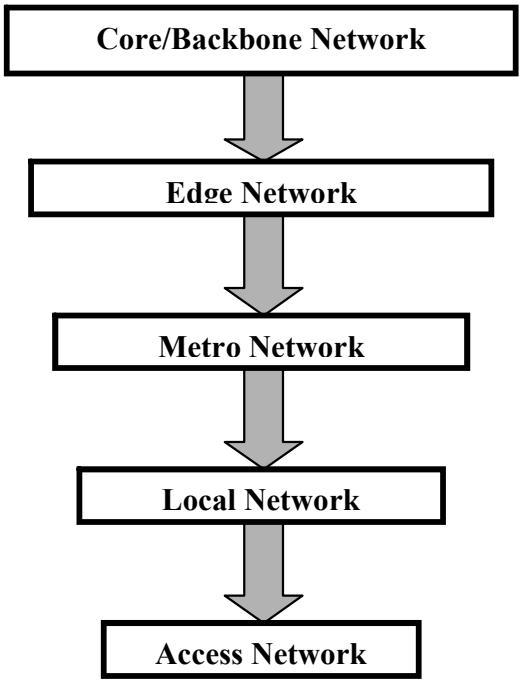

Fig. 1.2 Telecommunication network hierarchy