

CHAPTER 1 INTRODUCTION

This chapter provides the big picture of the data communication networks. The tasks involved in the communication networks, different communication services required, the kind of networks available, protocol architectures and OSI, TCP/IP protocol models are discussed in brief. In essence, fundamental concepts of the data communication networks are discussed briefly, providing the basis for detailed discussion in later chapters. At the end of the chapter the student will have a context in which to place various topics as they progress through the later chapters.

1.0 INTRODUCTION

Basic Communication Model

Communication is the conveyance of a message from one entity, called the source or transmitter, to another, called the destination or receiver, via a channel of some sort. To give a very basic example of such a communication system is conversation; people commonly exchange verbal messages, with the channel consisting of waves of compressed air molecules at frequencies, which are audible to the human ear. This is depicted in Figure 1.1.

The conveyance of a message could be followed by a reciprocal response message from the original destination (now a source) to the original source (now a destination) to complete one cycle in a dialogue between corresponding entities. Depending on the application or need for the information exchange, either atomic one-way transactions or a two-way dialogue could be appropriate.

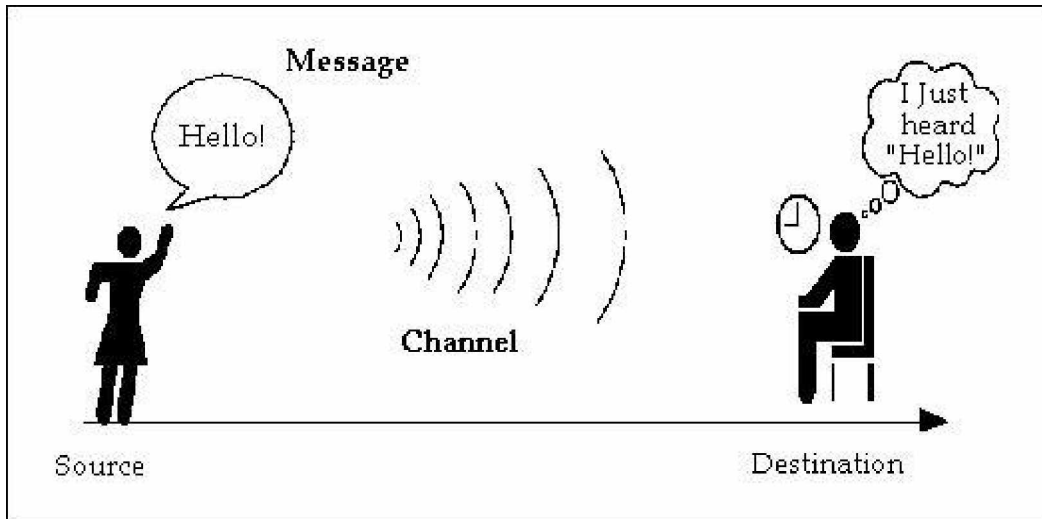


Figure 1.1: Basic Communication Model

The only way that a message source can be certain that the destination properly received the message is by some kind of acknowledgment response from the destination. Conversing people might say "I understand" or nod their head in response to a statement made by their peer. This acknowledged form of dialogue is the basis of reliable communications - somehow the source must get feedback that the destination correctly received the message.

The basic model explained above wherein originator and destination are human beings can be generalized as in Figure 1.2. to suit the data communication between two systems exchanging information between them.

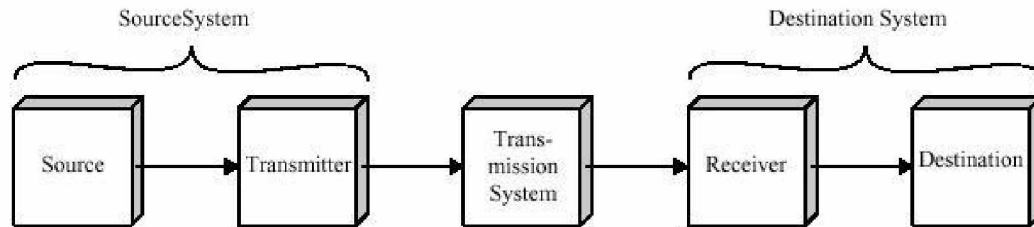
Source: Device that generates the data to be passed on to the **Destination** device. It could be a user computer trying to make a query to a server computer.

Transmitter: If the data generated by the Source device has to be transmitted through **Transmission Channel** or **Transmission System** then it has to be presented in a form that is acceptable to the Transmission system. This job is done by the **Transmitter**. For example, a modem takes a digital bit stream from the attached computer and transforms that stream of bits into an analog signals which can be handled by the telephone network.

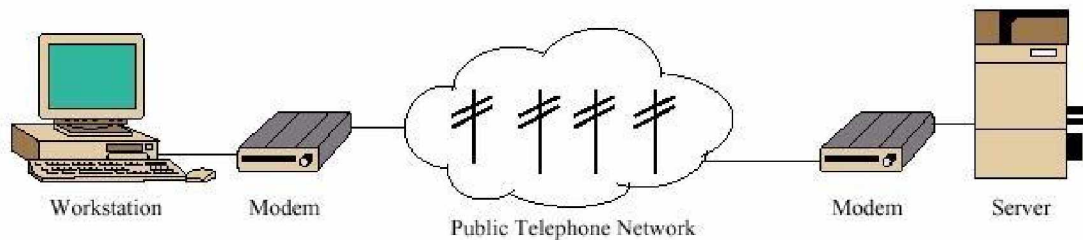
Transmission System: This can be a single transmission line connecting the two systems communicating or a complex network to which numerous communicating systems are connected.

Receiver: This receives the signal from the transmission system and converts it into a form that is suitable to the destination device. For example, a modem accepts analog signal from a transmission channel and transforms it into digital bit stream.

Destination: Device to which the source device sends data.



(a) General block diagram



(b) Example

Figure 1.2 Simple Data Communication model

1.1 DATA COMMUNICATION MODEL

Figure 1.3 provides a new perspective on the data communication model of Figure 1.2. Let us trace through the details of this figure using electronic mail as an example.

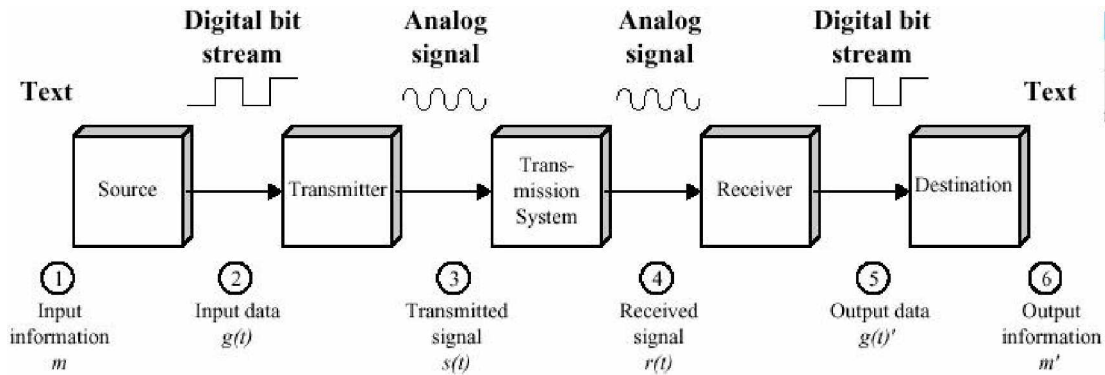


Figure 1.3 Data Communication model

Consider that the source input device and transmitter are components of a personal computer. The user of the PC wishes to send a message to another user—for example, "Good luck for your exams" (m). The user activates the electronic mail package on the PC and enters the message via the keyboard (input device). The character string is briefly buffered in main memory. We can view it as a sequence of bits (g) in memory. The personal computer is connected to some transmission medium, such as a local network or a telephone line by an I/O device (transmitter), such as a local network transceiver or a modem. The input data are transferred to the transmitter as a sequence of voltage shifts $g(t)$ representing bits on some communications bus or cable. The transmitter is connected directly to the medium and converts the incoming stream [$g(t)$] into a signal [$s(t)$] suitable for transmission. The transmitted signal $s(t)$ presented to the medium is subject to a number of impairments, before it reaches the receiver. Thus, the received signal $r(t)$ may differ to some degree from $s(t)$. The receiver will attempt to estimate the original $s(t)$, based on $r(t)$ and its knowledge of the medium, producing a sequence of bits $g'(t)$. These bits are sent to the output personal computer, where they are briefly buffered in memory as a block of bits (g'). In many cases, the destination system will attempt to determine if an error has occurred and, if so, will cooperate with the source system to eventually obtain a complete, error-free block of data. These data are then presented to the user via an output device, such as a printer or a screen. The message (m'), as viewed by the user, will usually be an exact copy of the original message (m).

Now consider a telephone conversation. In this case, the input to the telephone is a message (m) in the form of sound waves. The sound waves are converted by the telephone into electrical signals of the same frequency. These signals are transmitted without modification over the telephone line. Hence, the input signal $g(t)$ and the transmitted signal $s(t)$ are identical. The signal $s(t)$ will suffer some distortion over the medium, so that $r(t)$ will not be identical to $s(t)$. Nevertheless, the signal $r(t)$ is converted back into a sound wave with no attempt at correction or improvement of signal quality. Thus m' is not an exact replica of m . However, the received sound message is generally comprehensible to the listener.

DATA COMMUNICATIONS

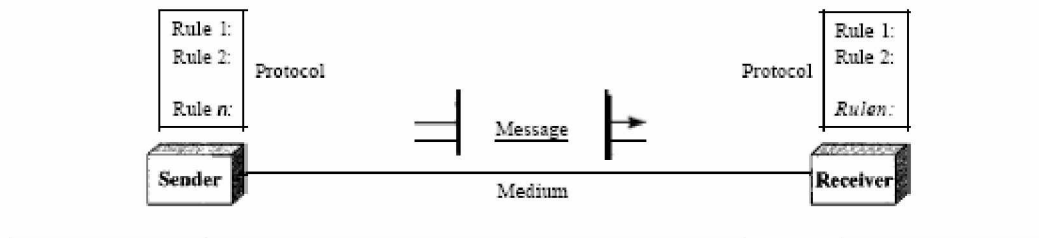
When we communicate, we are sharing information. This sharing can be local or remote. Between individuals, local communication usually occurs face to face, while remote communication takes place over distance. The term *telecommunication*, which includes telephony, telegraphy, and television, means communication at a distance (*tele* is Greek for "far"). The word *data* refers to information presented in whatever form is agreed upon by the parties creating and using the data. Data communications are the exchange of data between two devices via some form of transmission medium such as a wire cable. For data communications to occur, the communicating devices must be part of a communication system made up of a combination of hardware (physical equipment) and software (programs). The effectiveness of a data communications system depends on four fundamental characteristics: delivery, accuracy, timeliness, and jitter.

1. Delivery. The system must deliver data to the correct destination. Data must be received by the intended device or user and only by that device or user.
- 2 Accuracy. The system must deliver the data accurately. Data that have been altered in transmission and left uncorrected are unusable.
3. Timeliness. The system must deliver data in a timely manner. Data delivered late are useless. In the case of video and audio, timely delivery means delivering data as they are produced, in the same order that they are produced, and without significant delay. This kind of delivery is called *real-time* transmission.

4.. Jitter. Jitter refers to the variation in the packet arrival time. It is the uneven delay in the delivery of audio or video packets. For example, let us assume that video packets are sent every 3D ms. If some of the packets arrive with 3D-ms delay and others with 4D-ms delay, an uneven quality in the video is the result.

A data communications system has five components (see Figure 1.1).

Figure 1.1 *Five components of data communication*



1. Message. The message is the information (data) to be communicated. Popular forms of information include text, numbers, pictures, audio, and video.
2. Sender. The sender is the device that sends the data message. It can be a computer, workstation, telephone handset, video camera, and so on.
3. Receiver. The receiver is the device that receives the message. It can be a computer, workstation, telephone handset, television, and so on.
- 4.. Transmission medium. The transmission medium is the physical path by which a message travels from sender to receiver. Some examples of transmission media include twisted-pair wire, coaxial cable, fiber-optic cable, and radio waves.
5. Protocol. A protocol is a set of rules that govern data communications. It represents an agreement between the communicating devices. Without a protocol, two devices may be connected but not communicating, just as a person speaking French cannot be understood by a person who speaks only Japanese.

Data Representation

Information today comes in different forms such as text, numbers, images, audio, and video.

Text

In data communications, text is represented as a bit pattern, a sequence of bits (0s or 1s). Different sets of bit patterns have been designed to represent text symbols. Each set is called a code, and the process of representing symbols is called coding. Today, the prevalent coding system is called Unicode, which uses 32 bits to represent a symbol or character used in any language in the world. The American Standard Code for Information

Interchange (ASCII), developed some decades ago in the United States, now constitutes the first 127 characters in Unicode and is also referred to as Basic Latin. Appendix A includes part of the Unicode.

Numbers

Numbers are also represented by bit patterns. However, a code such as ASCII is not used to represent numbers; the number is directly converted to a binary number to simplify mathematical operations. Appendix B discusses several different numbering systems.

Images

Images are also represented by bit patterns. In its simplest form, an image is composed of a matrix of pixels (picture elements), where each pixel is a small dot. The size of the pixel depends on the *resolution*. For example, an image can be divided into 1000 pixels or 10,000 pixels. In the second case, there is a better representation of the image (better resolution), but more memory is needed to store the image.

After an image is divided into pixels, each pixel is assigned a bit pattern. The size and the value of the pattern depend on the image. For an image made of only black-and-white dots (e.g., a chessboard), a 1-bit pattern is enough to represent a pixel.

If an image is not made of pure white and pure black pixels, you can increase the size of the bit pattern to include gray scale. For example, to show four levels of gray scale, you can use 2-bit patterns. A black pixel can be represented by 00, a dark gray pixel by 01, a light gray pixel by 10, and a white pixel by 11.

There are several methods to represent color images. One method is called RGB, so called because each color is made of a combination of three primary colors: *red*, green, and blue. The intensity of each color is measured, and a bit pattern is assigned to it. Another method is called YCM, in which a color is made of a combination of three other primary colors: yellow, cyan, and magenta.

Audio

Audio refers to the recording or broadcasting of sound or music. Audio is by nature different from text, numbers, or images. It is continuous, not discrete. Even when we use a microphone to change voice or music to an electric signal, we create a continuous signal. In Chapters 4 and 5, we learn how to change sound or music to a digital or an analog signal.

Video

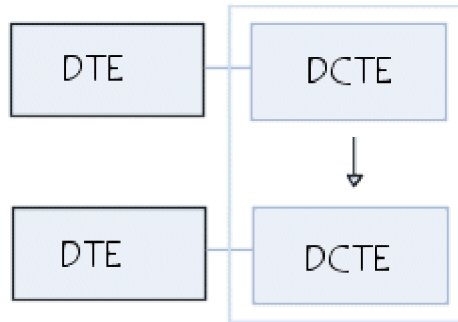
Video refers to the recording or broadcasting of a picture or movie. Video can either be produced as a continuous entity (e.g., by a TV camera), or it can be a combination of images, each a discrete entity, arranged to convey the idea of motion.

MODE OF DATA TRANSMISSION

There are 3 different transmission modes characterized according to the direction of the exchanges:

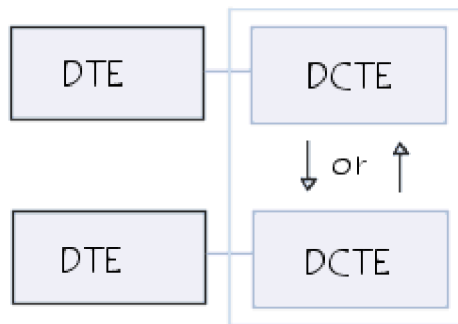
- **A simplex connection** is a connection in which the data flows in only one direction, from the transmitter to the receiver. This type of connection is useful if the data do not need to flow in both directions (for example, from your computer to the printer or from the mouse to your computer...).

Simplex Connection



- **A half-duplex connection** (sometimes called an *alternating connection* or *semi-duplex*) is a connection in which the data flows in one direction or the other, but not both at the same time. With this type of connection, each end of the connection transmits in turn. This type of connection makes it possible to have bidirectional communications using the full capacity of the line.

Half-duplex connection



- **A full-duplex connection** is a connection in which the data flow in both directions simultaneously. Each end of the line can thus transmit and receive at the same time, which means that the bandwidth is divided in two for each direction of data transmission if the same transmission medium is used for both directions of transmission.

Full-duplex connection

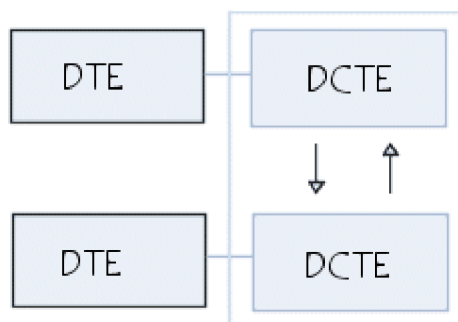
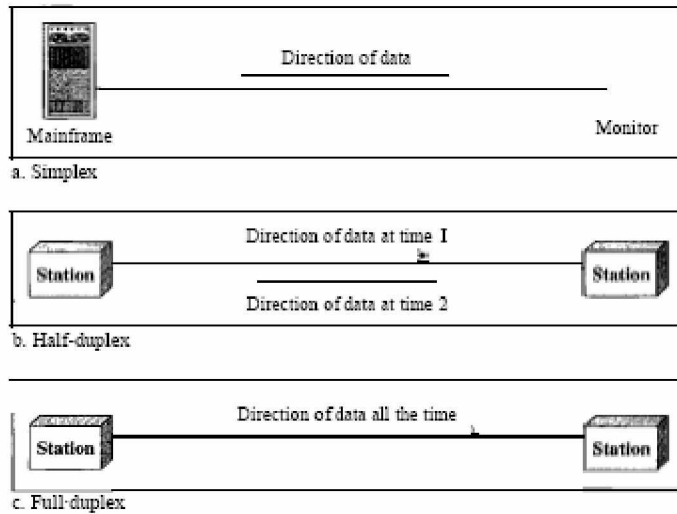


Figure 1.2 Dataflow (simplex, half-duplex, and full-duplex)

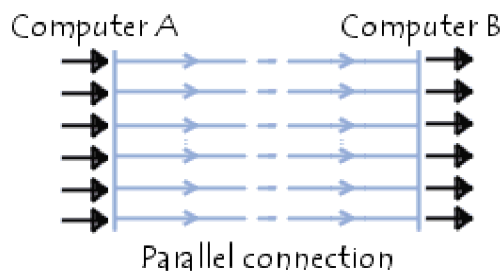


Serial and parallel transmission

The **transmission mode** refers to the number of elementary units of information (bits) that can be simultaneously translated by the communications channel. In fact, processors (and therefore computers in general) never process (in the case of recent processors) a single bit at a time; generally they are able to process several (most of the time it is 8: one byte), and for this reason the basic connections on a computer are parallel connections.

Parallel connection

Parallel connection means simultaneous transmission of N bits. These bits are sent simultaneously over N different channels (a channel being, for example, a *wire*, a cable or any other physical medium). The [parallel connection](#) on PC-type computers generally requires 10 wires.



These channels may be:

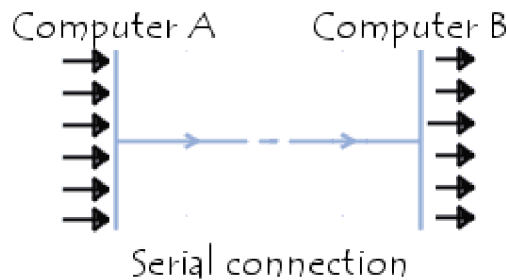
- N physical lines: in which case each bit is sent on a physical line (which is why parallel cables are made up of several wires in a ribbon cable)

- one physical line divided into several sub-channels by dividing up the bandwidth. In this case, each bit is sent at a different frequency...

Since the conductive wires are close to each other in the ribbon cable, interference can occur (particularly at high speeds) and degrade the signal quality...

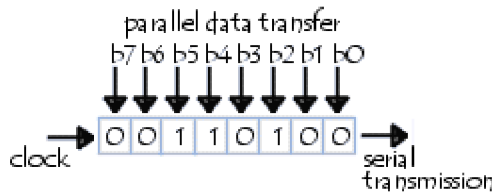
Serial connection

In a serial connection, the data are sent one bit at a time over the transmission channel. However, since most processors process data in parallel, the transmitter needs to transform incoming parallel data into serial data and the receiver needs to do the opposite.

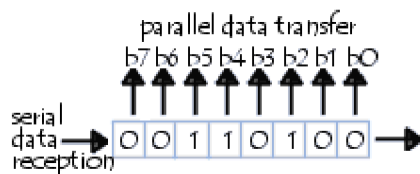


These operations are performed by a communications controller (normally a *UART* (*Universal Asynchronous Receiver Transmitter*) chip). The communications controller works in the following manner:

- **The parallel-serial transformation** is performed using a shift register. The shift register, working together with a clock, will shift the register (containing all of the data presented in parallel) by one position to the left, and then transmit the most significant bit (the leftmost one) and so on:



- **The serial-parallel transformation** is done in almost the same way using a shift register. The shift register shifts the register by one position to the left each time a bit is received, and then transmits the entire register in parallel when it is full:



Synchronous and asynchronous transmission

Given the problems that arise with a parallel-type connection, serial connections are normally used. However, since a single wire transports the information, the problem is how to synchronise the transmitter and receiver, in other words, the receiver can not necessarily distinguish the characters (or more generally the bit sequences) because the bits are sent one after the other. There are two types of transmission that address this problem:

- **An asynchronous connection**, in which each character is sent at irregular intervals in time (for example a user sending characters entered at the keyboard in real time). So, for example, imagine that a single bit is transmitted during a long period of silence... the receiver will not be able to know if this is 00010000, 10000000 or 00000100...
To remedy this problem, each character is preceded by some information indicating the start of character transmission (the transmission start information is called a *START bit*) and ends by sending end-of-transmission information (called *STOP bit*, there may even be several STOP bits).
- In a **synchronous connection**, the transmitter and receiver are paced by the same clock. The receiver continuously receives (even when no bits are transmitted) the information at the same rate the transmitter send it. This is why the transmitter and receiver are paced at the same speed. In addition, supplementary information is inserted to guarantee that there are no errors during transmission.

During synchronous transmission, the bits are sent successively with no separation between each character, so it is necessary to insert synchronisation elements; this is called **character-level synchronisation**.

The main disadvantage of synchronous transmission is recognising the data at the receiver, as there may be differences between the transmitter and receiver clocks. That is why each data transmission must be sustained long enough for the receiver to distinguish it. As a result, the transmission speed can not be very high in a synchronous link. +

COMMUNICATION NETWORK AND SERVICES

A **communication network**, in its simplest form, is a set of equipment and facilities that provides a communication service: the transfer of information between users located at various geographical points. Here we focus on networks that use electronic or optical technologies. Examples of such networks include telephone networks, computer networks, television broadcast networks, cellular telephone networks, and the Internet.

The ability of communication network to transfer information at extremely high speeds allows users to gather information in large volumes, nearly instantaneously and,

with the aid of computers, to almost immediately exercise action at a distance. These two unique capabilities form the basis for many existing services and an unlimited number of future network-based services. We will now discuss several services that are supported by current networks. The services are examined from the point of view of user requirements, that is, quality of service, features, and capabilities. The viewpoint here is that networks should ultimately be designed to meet the requirements of the user applications.

Radio and television broadcasting are probably the most common communication services. Various stations transmit an ensemble of signals simultaneously over radio or cable distribution networks. Aside from selecting the station of interest, the role of the user in these services is passive. Relatively high audio and video quality is expected, but a significant amount of delay (in the order of seconds or more) can be tolerated even in live broadcasts.

Telephone service is the most common real-time service provided by a network. Two persons are able to communicate by transmitting their voices across the network. The service is connection-oriented in the sense that the users must first interact with the network to set up a connection.

The telephone service has the real-time requirement in that users cannot interact as in face-to-face conversation if the delays are greater than a fraction of second (approximately 250 milliseconds). The service must also be reliable in the sense that once the connection is established it must not be interrupted because of failures in the network. At the minimum the delivered voice signal must be intelligible, but in most situations the users expect a much higher quality that enables the listener not only to recognize what the speaker says but also to discern subtleties in intonation, mood, and so on. A high degree of availability is another requirement: Telephone users expect the network to be capable of completing the desired connection almost all the time. Security and privacy of the conversation are consideration in some situations. The telephone service can be enhanced in a number of ways. For example, the toll-free service is provided wherein the caller will not be billed but costs of the call are automatically billed to the subscriber of the service.

Similarly, in credit-card or calling-card services, the cost of a call is automatically billed to the holder of the card. Clearly, security and fraud are issues here.

Telephone networks provide a broad class of call management services that use the originating number or the destination number to determine the handling of a call. Caller ID allows the originating number, and sometimes name, of the originating call to be displayed to the destination user when the receiving device is display capable. Voice mail allows a destination user to have calls forwarded to a message-receiving device when the destination user is not available.

Cellular telephone service extends the normal telephone service to mobile users who are free to move within a regional area covered by an interconnected array of smaller geographical areas called cells. Each cell has a radio transmission system that allows it to communicate with users in its area. The use of radio transmission implies design compromises that may result in lower voice quality, lower availability, and greater exposure to eavesdropping. In addition, the cellular system must handle the handing off of users as they move from one cell to another so that an ongoing conversation is not terminated abruptly. Some cellular providers also support a roaming service where a subscriber is able to place calls while visiting regional areas other than the subscriber's home base. Note that the mobility aspect to the roaming service is not limited to cellular (or wireless) communications. Indeed, the need for mobility arises whenever a subscriber wishes to access a service from anywhere in the world.

Electronic mail (e-mail) is another common network service. The user typically provides a text message and a name and/or address to a mail application. The application interacts with a local mail server, which in turn transmits the message to a destination server across a computer network. The destination user retrieves the message by using a mail application, such as Outlook Express software package of Microsoft. E-mail is not a real-time service in that fairly large delays can be tolerated. It is also not necessarily connection-oriented in that a network connection does not need to be set up expressly for each individual message. The service requires reliability in terms of the likelihood of delivering the message without errors and to the correct destination. In some instances the

user may be able to request delivery confirmation. Again security and privacy may be a concern.

There are many other network services like **Video on demand, Streamed Audiovisual Services, Audio Conferencing, Audio-Visual Conferencing**. The basic information in these services is of audio and visual in nature and they require huge data to convey the information. Apart from having huge data to be transported between communicating systems, since these services are of real-time in nature the bandwidth of the underlying communication network required for these services is also huge. Looking at the technological development happening in the data communication field, days are not far off when these services are provided to common user over the Internet at affordable cost.

INTRODUCTION TO 2G, 3G, 4G WIRELESS COMMUNICATION SYSTEMS

The key technologies used in cellular mobile radio include cellular frequency reuse, analog cellular (1st generation), digital mobile radio (2nd generation), packet based digital radio (2 ½ generation), and wideband radio (3rd generation).

In 1G, Narrow band analogue wireless network is used, with this we can have the voice calls and can send text messages. These services are provided with circuit switching. Today's the usual call starts from the beginning pulse to rate to the final rate. Then in case of 2G Narrow Band Wireless Digital Network is used. It brings more clarity to the conversation and both these circuit-switching model.

Both the 1G and 2G deals with voice calls and has to utilize the maximum bandwidth as well as a limited till sending messages i.e. SMS. The latest technologies such as GPRS, is not available in these generations. But the greatest disadvantage as concerned to 1G is that with this we could contact with in the premises of that particular nation, where as in case of 2G the roaming facility a semi-global facility is available.

In between 2G and 3G there is another generation called 2.5G. Firstly, this mid generation was introduced mainly for involving latest bandwidth technology with addition to the existing 2G generation. To be frank but this had not brought out any new evolution and so had not clicked to as much to that extend.

But to overcome the limitations of 2G and 2.5G the 3G had been introduced. In this 3G Wide Band Wireless Network is used with which the clarity increases and gives the perfection as like that of a real conversation. The data are sent through the technology called Packet Switching .Voice calls are interpreted through Circuit Switching.

3G and 4G Features

With the help of 3G, we can access many new services too. One such service is the GLOBAL ROAMING. Another thing to be noted in case of 3G is that Wide Band Voice Channel that is by this the world has been contracted to a little village because a person can contact with other person located in any part of the world and can even send messages too. Then the point to be noted is that 3G gives clarity of voice as well can talk with out any disturbance. Not only these but also have entertainments such as Fast Communication, Internet, Mobile T.V, Video Conferencing, Video Calls, Multi Media Messaging Service (MMS), 3D gaming, Multi-Gaming etc are also available with 3G phones.

Then with the case of Fourth Generation that is 4G in addition to that of the services of 3G some additional features such as Multi-Media Newspapers, also to watch T.V programs with the clarity as to that of an ordinary T.V. In addition, we can send Data much faster that that of the previous generations