Module
2
Communication Switching

Lesson
2
Circuit Switching

INSTRUCTIONAL OBJECTIVES

This lesson is aimed at developing the concept and application of circuit switching which is a very important component of a telephone network.

   The learner shall be able

1. To get the concept of circuit switching vis-à-vis other switching types.
2. To understand the working of a telephone network.
3. To understand how circuit switching is used in telephone network.
4. To know what is telephone signaling.
5.   To know the telephone network hierarchy.

2.O INTRODUCTION

In a communication network, the switch, which is a node, forms a very important component. It connects the incoming path to the desired outgoing path and directs the incoming message to the appropriate outgoing link. There are basically three types of switches namely: circuit, message and packet. A circuit switch closes a circuit between the incoming and the outgoing paths so that the incoming message can go to the output link. The circuit between any two desired paths is closed by a control signal applied to the switch. In message and packet switching, the incoming message/packet to the node is stored in a bin (actually a memory location). Then the stored message/packet is transferred to another desired bin (in fact another memory location) from where the message/packet can be delivered/forwarded to the next node or the receiver. The transfer from the incoming bin to the outgoing bin is done with a control/command signal. Thus in message/packet switching no circuit is switched on or off as is the case with the circuit switching. In fact in circuit switching continuously incoming message goes to the outgoing path without any storage if the switch is closed. With this mechanism it should be clear that in circuit switching the circuit must be closed before the message is sent. As such with the help of signaling an end-to-end path is established first and then only message transmission is commenced. Even when there are many switches between the source and the destination, all must be switched on before commencement of the message.

This is not so in packet switching generally. Every packet in its header contains the source and destination addresses and travels node by node to the destination. It remains stored at a node till a forward path is

available. It may be pointed out here that the packet switching can be further classified as connection oriented (CO) and connectionless (CL). In CO packet switching an entire path from source to destination is decided based on the traffic, congestion and cost, before the actual message transmission takes place. But the path is not switched on simultaneously as in circuit switching. All the packets from a source travel node by node following the same path to the destination. In contrast to this, packets with source and destination addresses may take different available paths to arrive at the destination in CL packet switching. Thus no path is pre decided in CL packet switching. Actually the message gets stored in the node and forwarded to the next node through one of the available paths at that node, towards the direction of the destination.

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It may be pointed out here that the packet and the message switching are more or less the same except that in packet switching a long message is broken into shorter packets. Earliest example of the message switching is the classical telegraphy. Computer networks/Internet uses CL packet switching for e-mail applications. In the following three lessons the three types of switching namely circuit, message and packet switching are discussed in detail.

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2.1.1   A SIMPLE SWITCH

The purpose of an electrical switch is to close /open a circuit to allow/stop flow of current. A communication switch is similarly used to allow/stop flow of message through the path connecting the receiver and the transmitter. Two users, one can be called transmitter and the other receiver, can be connected by a medium like a conducting wire over which messages in the form of electrical signals can be transmitted from one user to the other. A switch inserted in the electrical path between the two users facilitates connection/disconnection of the users as desired by controlling the switch. The path need not be on all the time. It needs to be switched on only when the users need to communicate. The role of such a switch becomes more important when there is a large number of users and a particular user at one time may to want communicate with another user and wants to communicate still another user at a different time. Thus the same user has to be connected to two different users at two different times. This can be done by a controlled switch. Thus in a set of say n users, different users may like to communicate with different users at different time. A pool of switches kept centrally can allow connection between desired pair of switches. The switches are released at the end of communication so that they are available for other required connections.

A simple 2X2 switch is shown in Fig. L2.1 with two input users A and B and two output users X and Y. The switch can connect user A to either X or Y
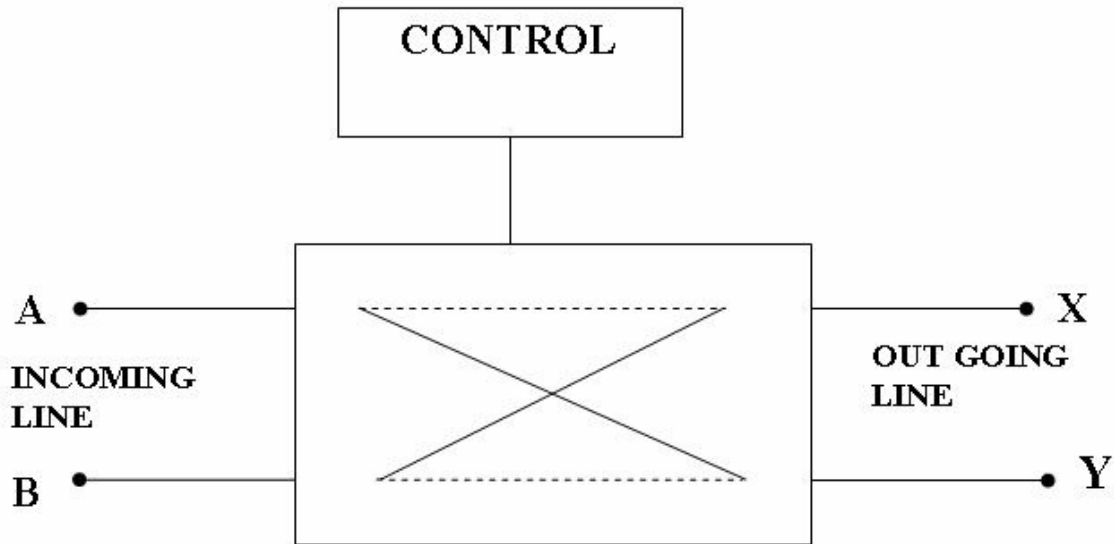

Fig 2.1: A simple 2 × 2 switch

as desired and similarly user B can be connected to user X or Y. An MXM switch can be fabricated using the simple 2X2 switch. A telephone switch can be thought of as a matrix of I input lines and J output lines with a contact (switch) at each cross point. By operating the contact at a given cross point the corresponding input and the output lines can be connected/disconnected. The control of the contact is external and depends on the desired connection.

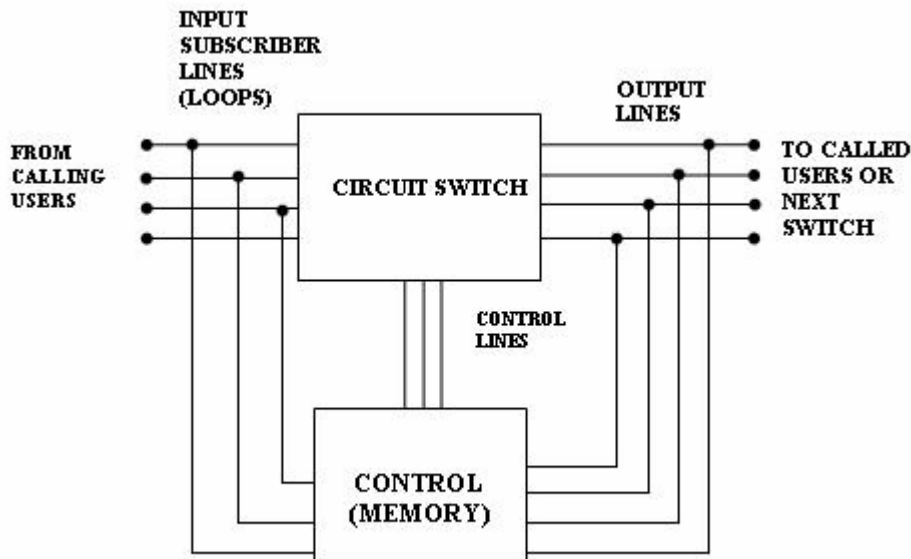## 2.1.2 MODEL OF A TELEPHONE SYSTEM

Fig 2.2 : Telephone system basic model

A basic model of a telephone system is shown in Fig.L2.2. A telephone switch has some input and some output lines (4 are shown in the diagram). The switch is connected to the control block which identifies the particular cross point contact to be closed/opened. The control block is connected to all the input as well as output lines and keeps monitoring them. The control block closes/opens a contact by issuing appropriate control signals to the selected contact through the control lines. The user lines are numbered (telephone numbers). The control block identifies the calling line and after enquiring the called number and checking that the called party is free, issues control command to the switch to close the relevant contact. Similarly the control block identifies the end of conversation and disconnects the particular contact. The control is usually stored program control (SPC) using a computer. Memory is used to store the called and calling numbers, user data and many other information. Telephone lines from the users (called subscribers) are called subscriber local loops and provide a circuit between the subscriber and the telephone exchange.

The first telephone switches were manually operated. Then came the era of automatic telephony where electro mechanical switches such as relays, Strowger selectors and cross bar switches were used for a considerable period of time. As the electronics advanced, electronic devices were employed as switch contacts. All these switches are called space switches. Use of time division multiplexing enhanced the capacity of space switching technique. Time switching (also popularly called digital switching) was introduced as the digital electronics, digital communication and computer technologies advanced. Digital switches are implemented using computers. Modern circuit switched telephone systems use time and space switching based on digital and computer technologies. The control is in any case stored program computer based. Digital switching will be covered in more detail in later lessons.

SIGNALING

The exchange of information between the users and the telephone system is called signaling. Signaling is required to establish end to end path (connection) between the calling and the called users through the telephone system before users communicate voice messages. Fig.L2.3 shows full signaling between the calling user, the telephone system and the called user.
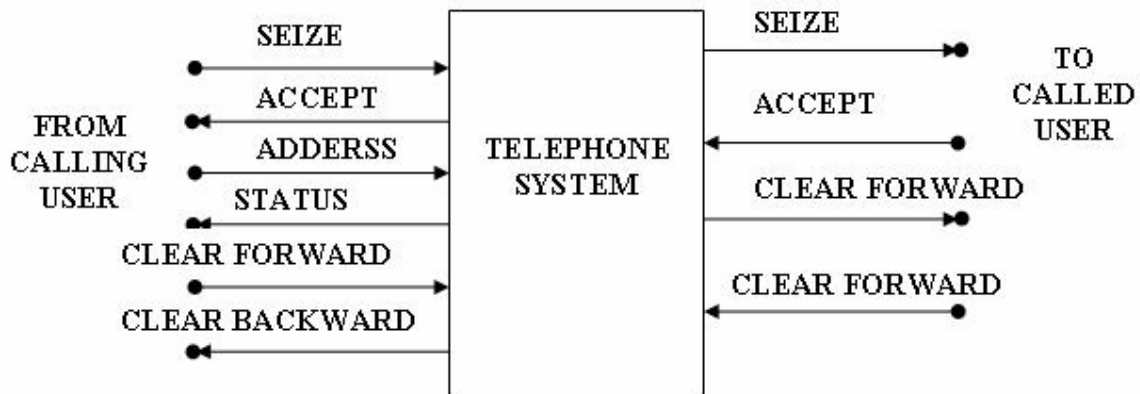

Fig. 2.3: Signaling exchange between users and telephone system

When the calling user lifts the hand set a circuit through the telephone exchange gets closed indicating that the particular user intend to make a call. the user gets a dial tone indicating that the exchange is ready to serve. These two steps correspond to seizure and accept signaling. The

called number (address) is passed to the exchange which in turn checks whether the called line is free. If free, the exchange seizes the called party by sending ringing signal. Ringing and response corresponds to seizure and accept signaling between the exchange and the called party. When the called party is busy or responds to ringing, the exchange gives status to the calling party. At this stage the control closes the relevant cross point contact. Then the two users start conversation. at the end of conversation either or both the parties replace their hand sets indicating to the exchange the end of conversation. The exchange then clears all connections on both sides.

The process of signaling and the closure of the path between the called and the calling party clearly explains the circuit switching as used in telephone system. Clearing/release of lines and the contact at the end of conversation is also very important.

Thus in circuit switching the three steps viz. call set-up, message transfer and the call release are very important and essential. The entire process of telephone communication needs service primitives like request, indicate, accept and confirm. Examination of the signaling diagram carefully would clarify these steps.

2.1.4 TELEPHONE NETWORK HIERARCHY

Telephone networks generally use a hierarchy of switches. A local telephone switching system supports a certain number of users depending on its capacity. A large city may have many local switching systems

(exchanges) interconnected through toll switches. Then there may be a primary switch serving many cities. The primary switches may be served by a regional switch which are in turn connected to an international switch (gateway). A general switching hierarchy is shown in Fig. L2.4.
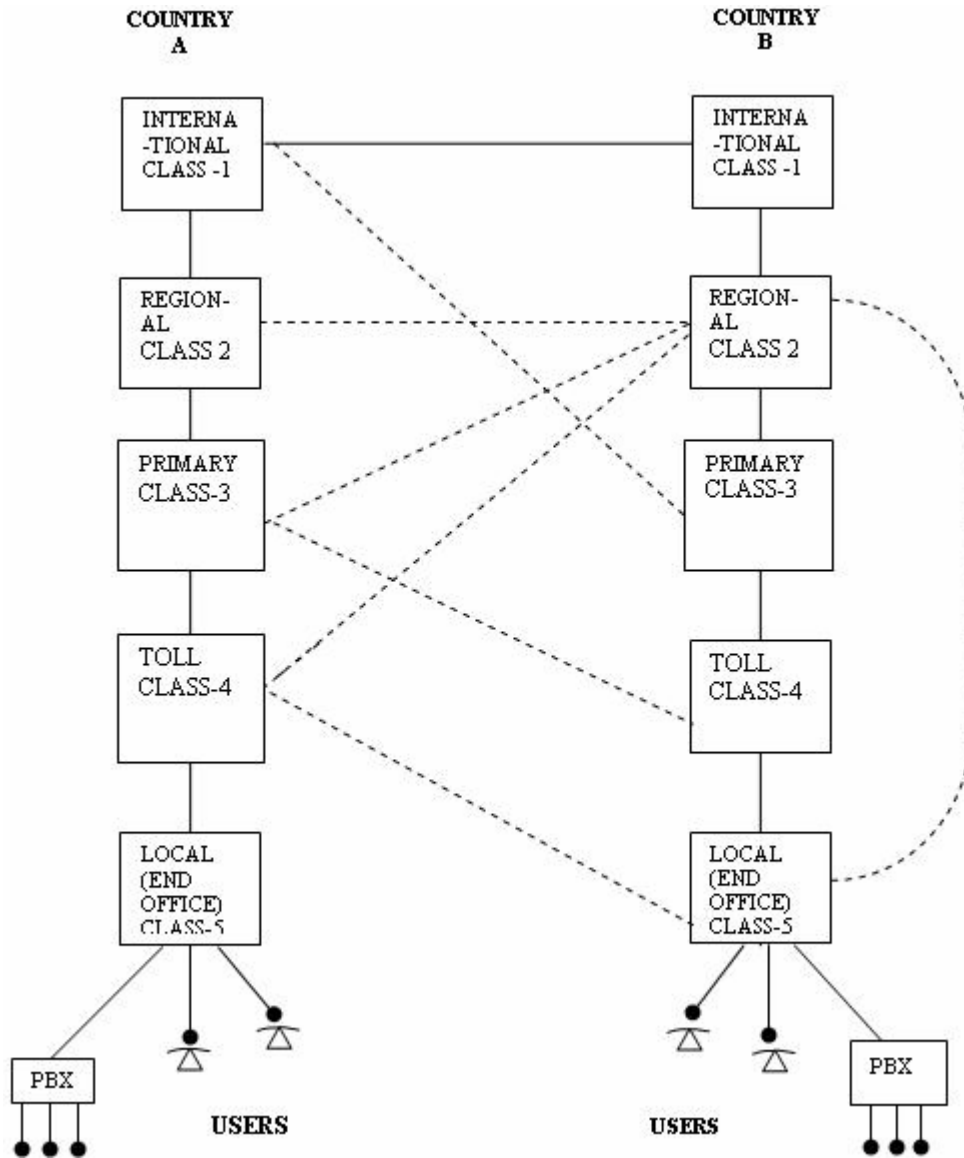
Fig 2.4: Telephone network hierarchy

It is not necessary to have all the five stages, as shown in the figure, in a telephone system. A telephone network operator may choose a particular configuration depending on its requirements. Usually the individual users are connected to a local telephone exchange (also called class 5 or end

office). This exchange handles all local calls that is calls among the users of the same exchange. For a call, say, from one country to another, the other exchanges such as the toll, primary, regional and the international exchanges of both the countries come into operation depending on the routing strategy between the source and destination callers. Some of the stages in the hierarchy are bye passed and direct paths are provided depending on the traffic which in fact decides routing to some extent. The dotted lines in the Fig. L2.4 show the possible direct paths. It should be noted here that all the switches in the route between the caller and the called user must be switched on and all the connecting links (transmission media) should be working to set up the call as required in circuit switching. Once the call is set up and a through direct path (circuit) is available between the end users, the users can communicate. Theoretically the end to end circuit between them is under their control as long as they wish. They only can really terminate the call.

What has been discussed so far is the operation of a public switched telephone network (PSTN). Many organizations have requirement of many internal telephone lines to facilitate internal calls. However the organization may require some or all its users to make calls to and receive calls from the outside users connected to the PSTN. Hiring many PSTN lines may be quite costly particularly when the outside calls are much less than internal calls. Another switch, using of course circuit switching generally, called private branch exchange (PBX) is installed at the premises of the organization. The internal lines and telephones are connected to the PBX which is connected to the local exchange of the PSTN through central office (CO) or trunk lines as shown in the figure. it may be mentioned that now a days IP (Internet Protocol) based PBX's are also in vogue.

A GENERIC SWITCHING ARCHITECTURE

The working of a simple switch, the model of a telephone system, functions of signaling and the operation of a telephone network have been explained in the previous sections of this lesson. Here the operation of circuit switching is described with the help of a general switching system. Fig. L 2.5 shows the diagram of a general switching system. In fact this diagram will be used to explain various switching schemes such as circuit switching, connectionless packet switching and connection oriented packet switching. Only circuit switching is discussed in this lesson. The packet switching will be taken up in the following lessons.
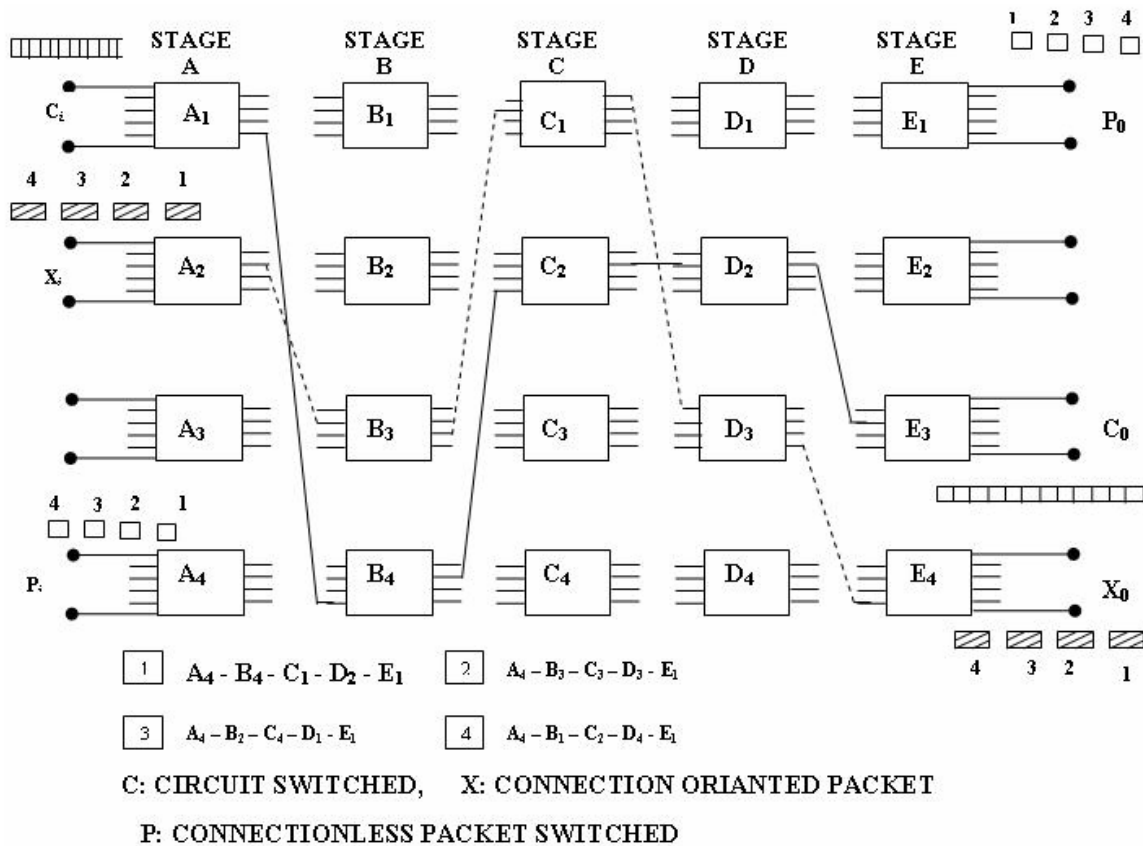
Fig 2.5: Switching Schemes

The architecture in the figure has five stages namely A, B, C, D and E of switching and each stage has a group of four switches namely 1,2,3 and 4 (A1, A2, A3 and A4 at the first stage). Users are distributed in four groups. The calling users are connected to the first stage and similarly the called users are connected to the fifth stage. For convenience the users are shown   separately connected as calling users/input lines and called users/output lines. Actually the same user when makes a call is the calling user and becomes the called user when receives the call. In a telephone system the user works in a half duplex mode and is connected to the network with two wires. Internally the network actually works on four wires.

A circuit switched user, Ci wants to make a call to another circuit switched user Co in a another country. Ci seizes the switch A1 and on knowing the

called user number, the network finds and specifies the end to end path, say, A1-B4-C2-D2-E3. All these intermediate switches and the interconnecting links are simultaneously switched on and the entire circuit (path) from Ci to Co is dedicated to the call between them for the entire duration. The message from Ci flows to Co as if a direct pipe has been laid between the two users. This pipe is withdrawn at the end of the call. The probability that all the switches and the links will be working without any defect at the time and duration of the call is rather low. The cost of dedication the entire path under such a constraint is rather quite high. It may be noted that a single failure any where in the circuit renders the call aborted. Except for the call set up delay, the communication in this mode of switching is real time and the quality of service (QoS) is excellent because there is no more processing is taking place in the network and as such there is no interference after the call has been set up. The users once get the pipe are the owners of the pipe for the duration of the call. Circuit switching is considered very reliable. The reliability, the QoS and the real time communication demand high price.