1. INTRODUCTION:

Telecommunication networks carry information signals among entities, which aregeographically far apart. An entity may be a computer or human being, a facsimile machine, atele-printer, a data terminal and so on. The entities are involved in the process of informationtransfer, which may be in the form of a telephone conversation (telephony) or a file transferbetween two computers or message transfer between two terminals etc.

A switch transfers signals from one input port to an appropriate output. A basic problem is then how to transfer traffic to the correct output port .In the early telephone network, operator's closed circuitsmanually. In modern circuit switches this is done electronically in digital switches. If no circuit is available when a call is made, it will be blocked (rejected). When a call is finished a connection teardown is required to make the circuit available for another user.

Fundamentals of switching systems:

Types of communication transmission mode:

Simplex : one way communication ex: Radio

Half Duplex : Two way communication shared by single channel ex: walkie Talkie

Full Duplex : Two way communication simultaneously ex: Telephone

Therefore, telephone comes under the Full Duplex type of communication.

Point – Point Links/Fully Connected Network/Bell Proposed Network:

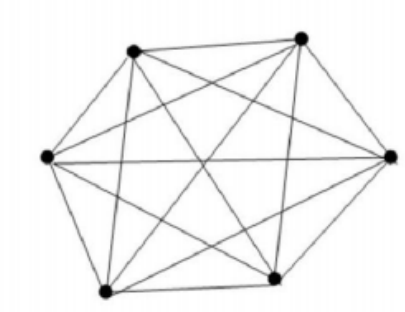

Fig 1.1. Point to Point link [1]

To connect 'N' Points the number of Links required is as below: $\frac{N(N-1)}{2}$

Problem: Calculate the Number of links required to fully connect 5000 links and the numberof additional links required to fully connect 5001 links

Solution: to connect 5000 points, numbers of links required are: 12497500

To connect 5001 points, number of links required: 12502500

Therefore, the additional links required to connect extra 1 point on a 5000 points network of fully connected are: **5000**

From the above problem it is understood that it is highly impossible to connect large number points (telephones) as fully connected network/point-point network. To resolve this problem "Telephone Exchange" came into existence

2. TELECOMMUNICATION NETWORKS:

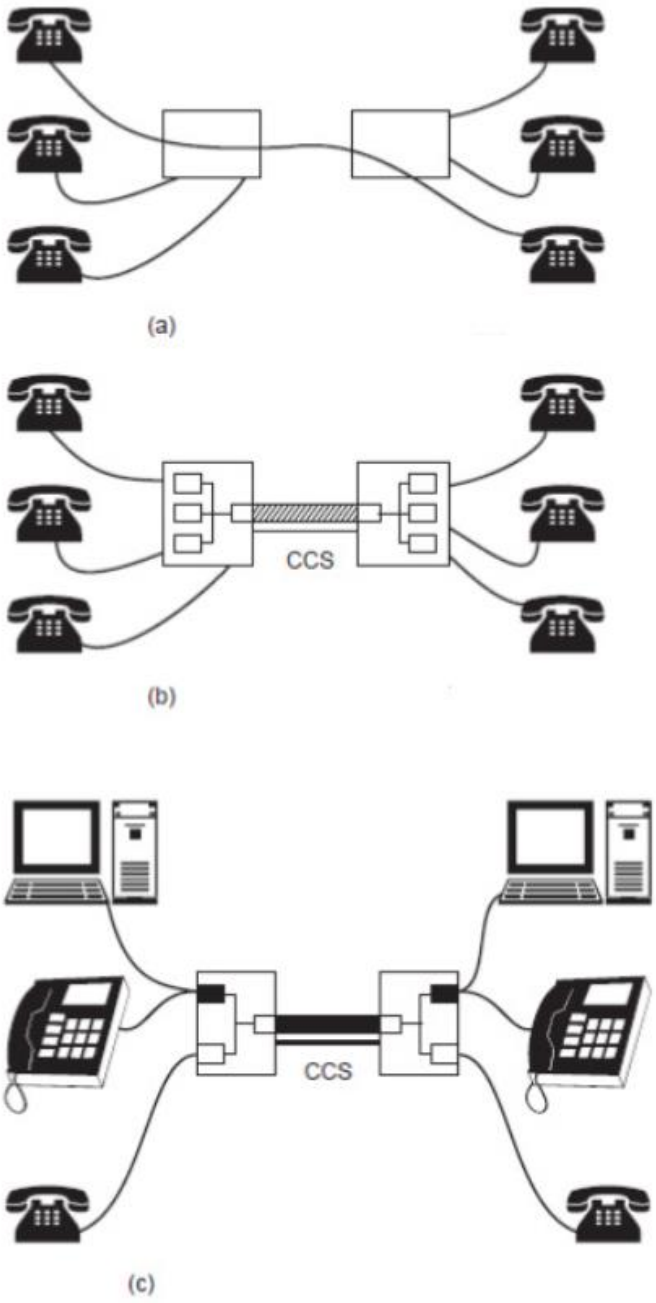

Fig 1.2 Various telephone networks[6]

(a) telephone network around 1890 , (b) telephone network around 1988

(a) telephone networks after 1990 with ISDN

The electromechanical switching systems have been replaced by computer controlled switching systems referred to as stored program control (SPC). In SPC, switching is controlled by software program. The first computer controlled switch was introduced in 1960. Till 1965, computer controlled switching used transistors and printed circuit technology. Since 1965 switchingis based on microprocessors.

3. SIGNAL CHARACTERISTICS:

Telecommunication is mainly concerned with the transmission of messages between two distant points. The signal that contains the messages is usually converted into electrical waves before transmission. Our voice is an analog signal which has amplitude and frequency characteristic.

Voice frequencies: The range of frequencies used by a communication device determines the communication channel, communicating devices, and bandwidth or information carrying capacity.

Table 1.1. Bandwidth requirements of various applications

Type	*Bandwidth*	*Bit Rate*
Telephone (speech)	300—3400 Hz	—
Music	50 Hz—16 kHz	—
Facsimile	40 kHz	—
Broadcast televison	0—55 MHz	—
Personal communication	—	300 to 9600 bits/sec
E—Mail transmission	—	2400 to 9600 bits/sec
Digitized voice phone call	—	6400 bits/sec
Digital audio	—	1 to 2 M bits/sec
Compressed video	—	2 to 10 M bits/sec
Document imaging	—	10 to 100 M bits/sec
Full motion video	—	1 to 2 G bits/sec

Speech spectrum: The telephone channel over which we wish to send data are designed to transmit electrical oscillations (microphone converts sound into equivalent number of electrical oscillation) of voice.

Decibels: The decibel is a valuable unit for telecommunication because losses or gains in signal strength may be added or subtracted if they are referred to in decibels. The power ratio is expressed as-

$$G = 10 \log_{10} \frac{P_2}{P_1}$$

Voltage and current level can be quoted in decibel as follows

$$G = 10 \log_{10} \frac{P_2}{P_1} = \frac{V_2 I_2}{V_1 I_1} = \frac{I_2^2 R}{I_1^2 R}$$

$$G = 10 \log_{10} (I_2/I_1)^2$$

$$G = 20 \log (I_2/I_1)$$

Similarly in voltage ratio,

$$G = 20 \log_{10} V_2/V_1$$

Example 1.1. If input power is 16 μW and output power is 30 mW, find the power ratio and express it in decibel and nepers.

$$\text{Power} = \frac{P_2}{P_1} = \frac{30 \times 10^{-3}}{16 \times 10^{-6}} = 1875 = 1.875 \times 10^3$$

Power in decibel, $G = 10 \log_{10} 1.875 \times 10^3 = 32.73$ dB

Power in nepers, $G = 3.76$ N.

4. ELEMENTS OF COMMUNICATION SWITCHING SYSTEM

The purpose of a telecommunication switching system is to provide the means to pass information from any terminal device to any other terminal device selected by the originator.Telecommunication system can be divided into four main parts. They are

1. End system or Instruments
2. Transmission system
3. Switching system
4. Signaling.

End Systems or Instruments: The end system or instruments are transmitters or receivers that are responsible for sending information or decoding or inverting received information or message into an intelligible message. End systems in the telephone network have evolved from analog telephones to digital handsets and cellular phones. However, endless arrays of other devices are being attached to telephone lines, including computer terminals used for data transmission. Fig. 1.3 shows some of the end instruments.

Transmission System: Signals generated by the end system or the instruments should be transported to the destination by some means. The transmission on links conveys the information and control signals between the terminals and switching centers.

In general a communication path between two distinct points can be setup connecting a number of transmission lines in tandem. The transmission links include two-wire lines, coaxial cables microwave radio, optical fibers and satellites. Functionally, the communication channels between switching system are referred to as trunks.

Switching System: The switching centers receives the control signals, messages or conversations and forwards to the required destination, after necessary modification (link amplifications) if necessary. A switching system is a collection of switching elements arranged and controlled in such a way as to setup a communication path between any two distant points.

Signaling Systems:A signaling system in a data communication networks exchangessignaling information effectively between subscribers. The signaling systems are essentialbuilding blocks in providing the ultimate objective of a worldwide automatic telephone servicesstandardized. Signaling provides the interface between different national systems. Theintroduction of signaling system was the big step in improving the PSTN.

The consultative committee on international telegraphy and telephony (CCITT) based in Geneva, recommended seven formats related to signaling.

TRANSMISSION CHANNELS

In simple word transmission channel is nothing but a path between two nodes in the network. It may refer to the physical cable, the signal transmitted within the cable or to a sub channel within

the carrier frequency. There are three types of fundamental channels in ISDN around which the entire information transmission is organized. These are

- ➔ Basic information channel or B channel,64 kbps
- ➔ Signaling channel or D channel, 16 or 64 kbps
- ➔ High speed channel or H channel

These three ISDN channels are described below.

B channel (Bearer Channel):B channels are logical digital ‘‘pipes’’ which exist on a single ISDN line. B channel carry data and services at 64 kbps. It carries data in full duplex mode. Each B channels provide a 64 kbps clear channel, clear meaning that the entire bandwidth is available for data, B channels typically form circuit switched connections. B channel connection is an end-to-end physical circuit that is temporarily dedicated to transferring data between two devices. The circuit switched nature of B channel connections; combined with their reliability and relatively high bandwidth makes ISDN suitable for a range of applications including voice, video, fax and data. B channels are normally used for on-demand connection. As B channel operation based on circuit switching, it can be configured as semi-permanent or ‘‘nailed up’’ connections.

D channel (Delta Channel): D channel can be either 16 or 64 kbps, depending on the needs of the user. The primary function of the D channel is to carry control signaling and administrative information for B channels to set up and tear down the calls. The D channel uses packet switched

connection. The packet switched connection are best adapted to the intermittent but latency sensitive nature of signalling traffic, accounting for the highly reduced call setup time of 1 to 2 seconds on ISDN calls. Unlike the B-channel, which can function as a simple 'pipe', the D channel is associated with higher level protocols at layers 2 and 3 of OSI model which form the packet switched connections. The D channel provides the signalling information that is required for caller identification. It also includes low-rate data transfer and applications such as telemetry and alarm transmission.

H channels(Hybrid Channel).H channels are suitable for high data rate applications such as video, teleconferencing and so on. Table 4 gives ISDN channel and its specifications.

Channel	Bit rate (kbps)	Interface	Purpose
B	64	BRI	Bearer services
H0	384	PRI	6 B channels
H11	1536	PRI	24 B channels
H12	1920	PRI	30 B channels
D	16	BRI	Administrative and control signalling
D	64	PRI	,,

Table 4: ISDN Channel specification [1]

USER NETWORK INTERFACES

Comprehensive user network interface definitions are key to ensuring worldwide ISDN compatibility.ISDN categories to variety of services such as voice, data, telemetry and image. Two information rate access interfaces have been standardized for ISDN.

- ➔ Basic rate access
- ➔ Primary rate access

SIGNALLING

ISDN uses a common channel signaling scheme. The signaling is done over the D channel which acts as the common signaling channel for B and H channels which carry the user information channel is also used for carrying some user information,if there is spare capacity. In such cases also the required signal is done on the D channel. The concept of common channel signaling and the CCITT's signaling systems (SS7) have been discussed here.

Signalling in ISDN grouped into two distinct categories.

- ➔ User level signaling
- ➔ Network level signaling

User Level Signalling:

User level signaling in ISDN permits a user to

1. Establish, control and terminate circuit switched connections in B channel,
2. Carry out user to user signaling
3. Establish, control and terminate packet switched connection in B or D channels.

User to user signaling is achieved by employing a symmetrical protocol for outgoing and incoming calls. User level signaling is of two types.

- ➔ Message based signaling
- ➔ Stimulus signaling

Message based signaling is employed when the user end equipment is an intelligent terminal. In ISDN parlance, an intelligent terminal is known as **functional terminal**. It provides a user friendly interface for signaling and performs the function of forming, sending receiving, and replying messages. The process of establishing, controlling and terminating a call is achieved by exchanging message between network and terminal. The message may be placed under four groups.

1. Call establishment messages
2. Call control messages
3. Call disconnect messages
4. Miscellaneous messages

Call establishment group includes set up, call proceeding, alert, connect and connect acknowledge messages. Alert signal corresponds to ring back signal and is used when a non automatic answering terminal is used at the receiving end. If the auto answering facility is available, the terminal responds with connect signal directly and the alert signal is skipped.

Call control groups include suspend and resume messages and also user to user messages.

Call disconnect groups includes disconnect, release, and release complete messages.

The primary function of miscellaneous messages is to negotiate network facilities to support additional service features like call forwarding, direct inward dialing, reverse charging etc.

All user level messages have a common message format. These fields are mandatory for all messages.

1. Protocol discriminator
2. Call reference
3. Message type

As the D channel may carry computer and telemetry data etc. In addition to signaling messages, it is necessary to have a mechanism for differentiating packets and their associated protocols. The protocol discriminator field is provided for this purpose at present two message protocols are supported the ISDN signaling message protocol and X.25 level 3 packets protocols.

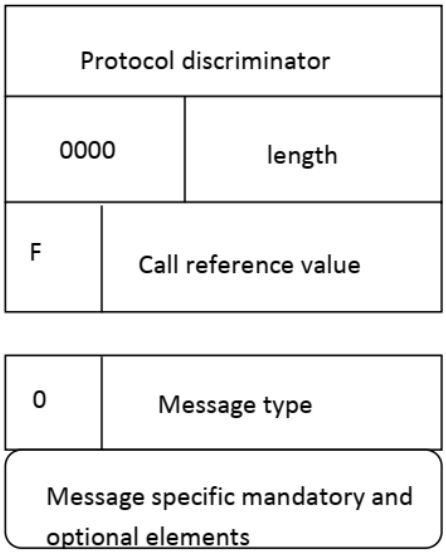

Fig.62: User level signaling message structure [1]

The field has three sub fields: length subfield, flag and reference value. The call reference field gives reference to the B, H, or D channel information transfer activity to which a signaling packet pertains. Depending upon the service and channel used, the length of the call reference value may vary.1-bit flag is used to indicate which end of the connection initiated the call.

Stimulus signaling is used when the user end equipment are dumb device with no intelligence e.g. digitaltelephone. As the device don't have functional capabilities, stimulus signaling messages are generated as a direct result of actions by terminal user. The signals send by a network to an intelligent device are in the nature of inducing specific events at the terminal end. Stimulus signaling procedures are defined as a compatible subset of a message based on signaling procedures in order to facilitate functional expansion for simple terminals.

NETWORK LEVEL SIGNALLING

Network level signaling in ISDN is concerned with interoffice signaling. Circuit suspension call supervision messages are examples of network level of signaling. The procedure for network level signaling is defined as the ISDN user part (ISUP) of the signaling system 7.One of the main aim of the context of the ISUP has been evolve a flexible design for signaling system to accommodate new services and connection type that may come about in the future to be supported on ISDN.

About 40 network level message have been standardized so far these messages are broadly categorized into 9 units.

1. Forward address
2. General setup

3. Backward setup
4. Call supervision
5. Circuit supervision
6. Circuit group supervision
7. In call modification
8. End-to end user
9. User-to-user

Messages belonging to 1-4 above are used to support the call setup process initiated by user and start accounting and charging functions. Circuit and circuit group supervision messages are permit blocking and de-blocking of circuits and circuit groups respectively. End-to end signaling or node-to-node signaling in between the originating and terminating ISDN exchanges and in accomplished in two ways. The pass along service of ISUP enables end –to end signaling. Another way of doing end-to-end signaling is to use services of the signaling connection control part(SCCP) of the SS7.This method is uniformly applicable and unlike pass along method is independent of the presence or absence of circuit connection between message originating and terminating exchanges.

A common format for all messages is defined for ISUP.The format messages consists of six steps.

1. Routing level
2. Circuit identification code
3. Message type
4. Mandatory fixed part
5. Mandatory variable part
6. Optional Part
   Routing level indicates the source and destination exchanges of message include the link selection subfield.

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