ETU07402 Communication Switching Systems

Communication Networks and Switching

Lecture 0 1

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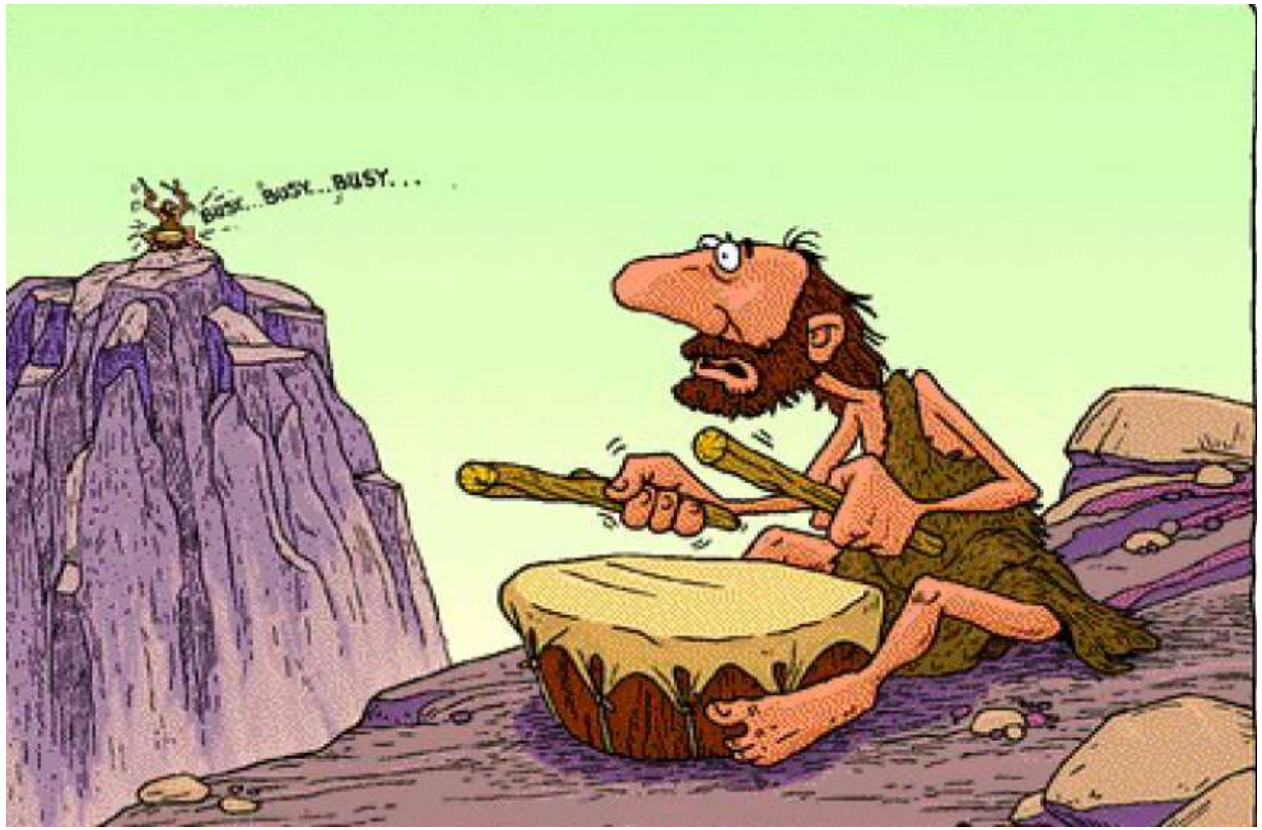
ELECTRONICS AND TELECOMMUNICATION ENGINEERING

History of Communication

Needs for sharing information

From the beginning Human being required to communicate in order to meet there needs and manage their Information likewise other creatures



History of Telecommunications

Telecommunication networks carry information signals among entities, which are geographically far apart. An entity may be a **human Being** or computer, a facsimile machine, a teleprinter, a data terminal and so on.

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.

Human voice is an analog signal which has amplitude and frequency characteristic.

History of Telecommunications

1838 : Electric Telegraph was invented.

1844 : First telegraph line was open.

1866 : First submarine cable was successfully installed linking Europe and America.

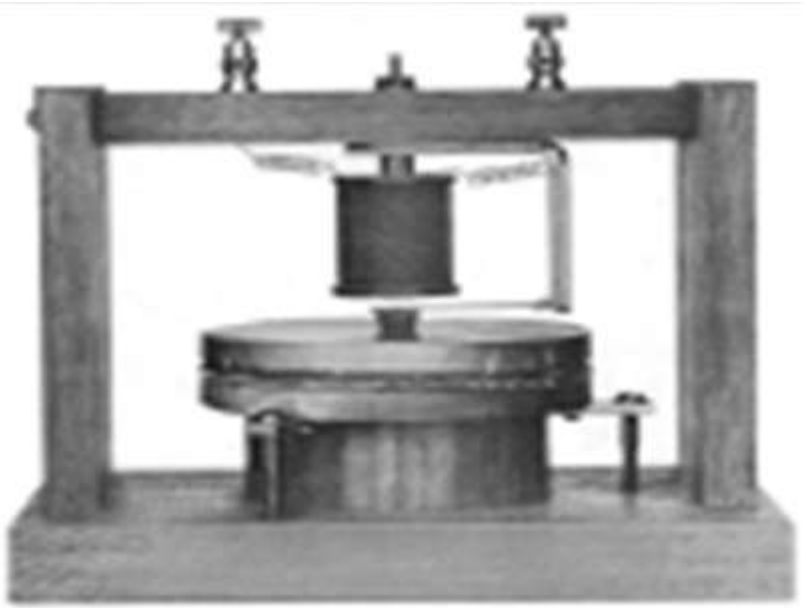
1876 : Bell patented electrical voice transmission using continuous current (Telephone).

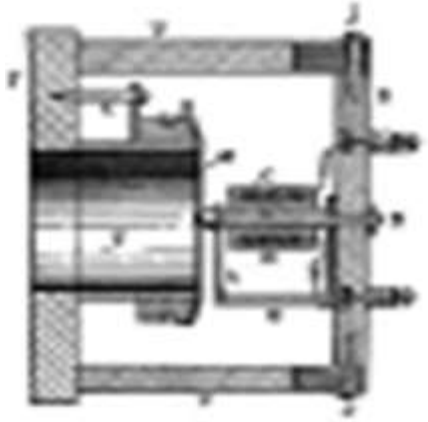
1888s : Automatic switching devices were experimented

History of Telecommunications

Bell's "Gallows" Telephone

Thomas Watson's demonstration.

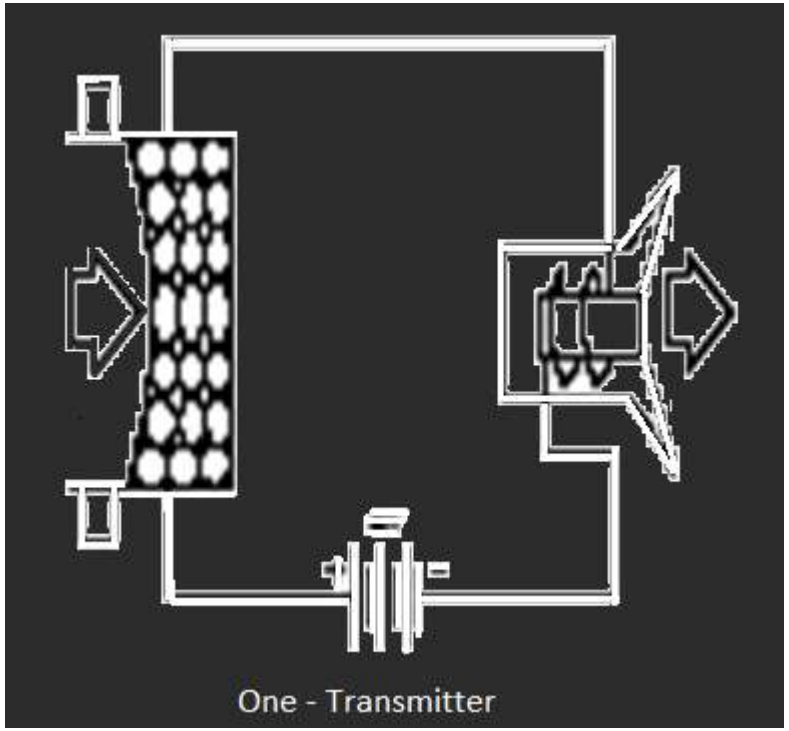




Bell's original system was single wire with earth return

History of Telecommunications
Early Telephone

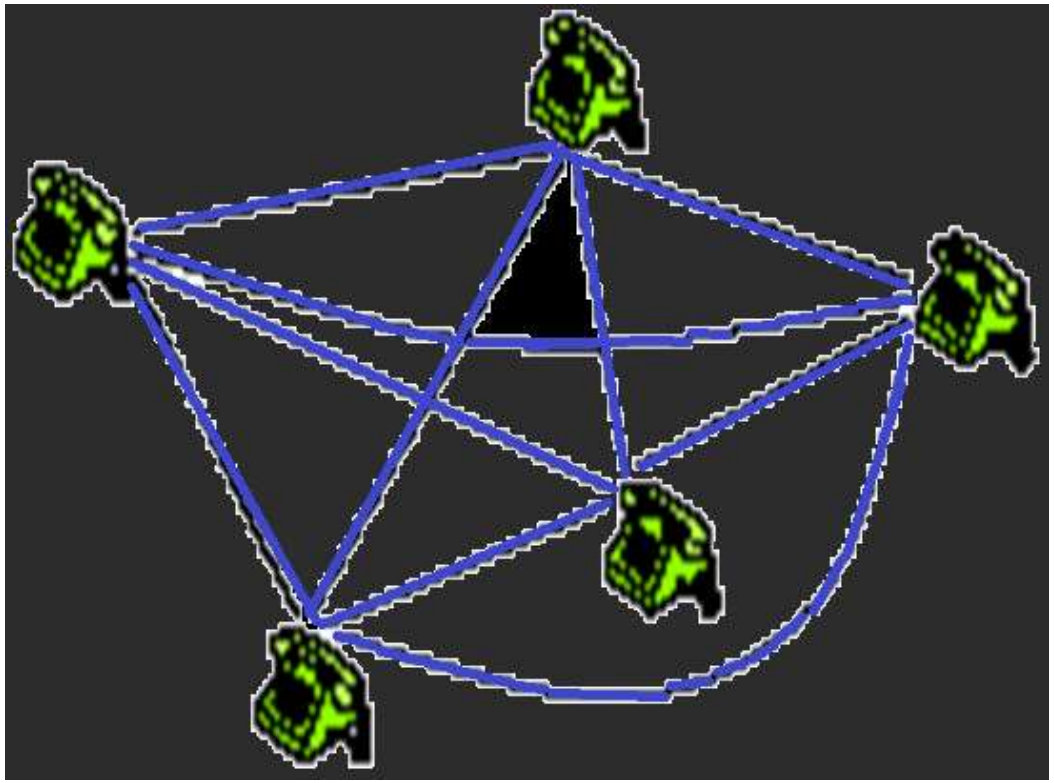
- Transmitter (a carbon particle microphone invented by Edison, 1877) varied the electrical energy inversely proportional to the sound energy (used into the 1980's).
- Receiver (transducer) recreated the sound.



History of Telecommunications
Early Telephone System

- Point-to-point architecture (fully connected):
- Very difficult to manage, wasteful.
- N(N-1)/2 connections for N subscribers.
- Makes sense to bring the lines together in central locations for interconnection:

Telephone Exchanges (Switches)



History of Telecommunications
Centralized Switching Office

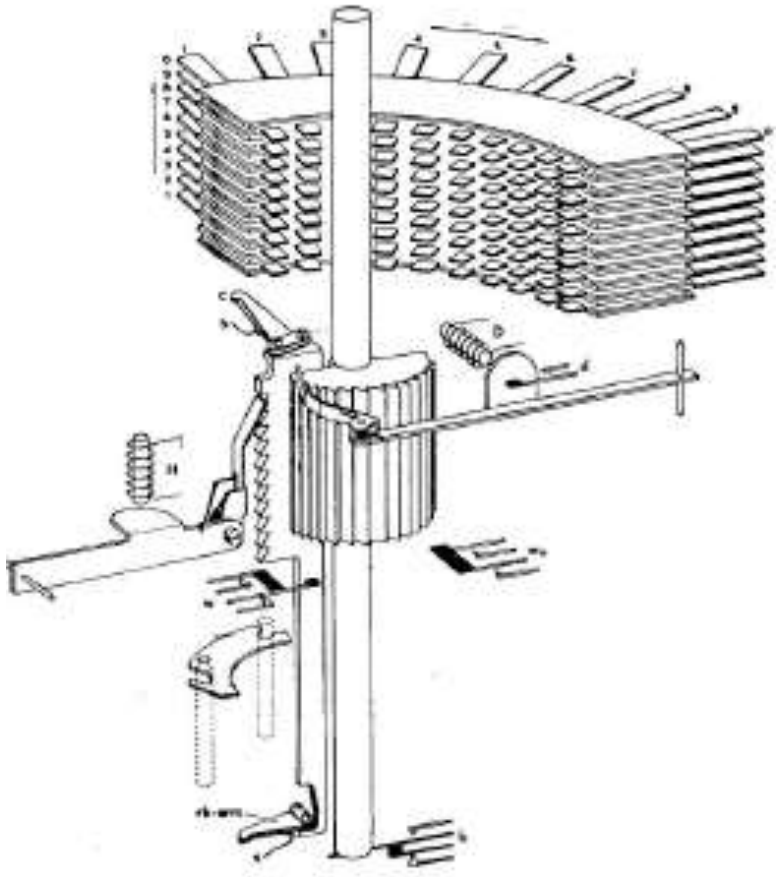
- Plug hole for each end-point.
- Alarm or shutter to signal an alert.
- Cord and jack to enable operators to talk to end-points, and to manually interconnect users.
- N connections for N subscribers.

History of Telecommunications

Early Central Office

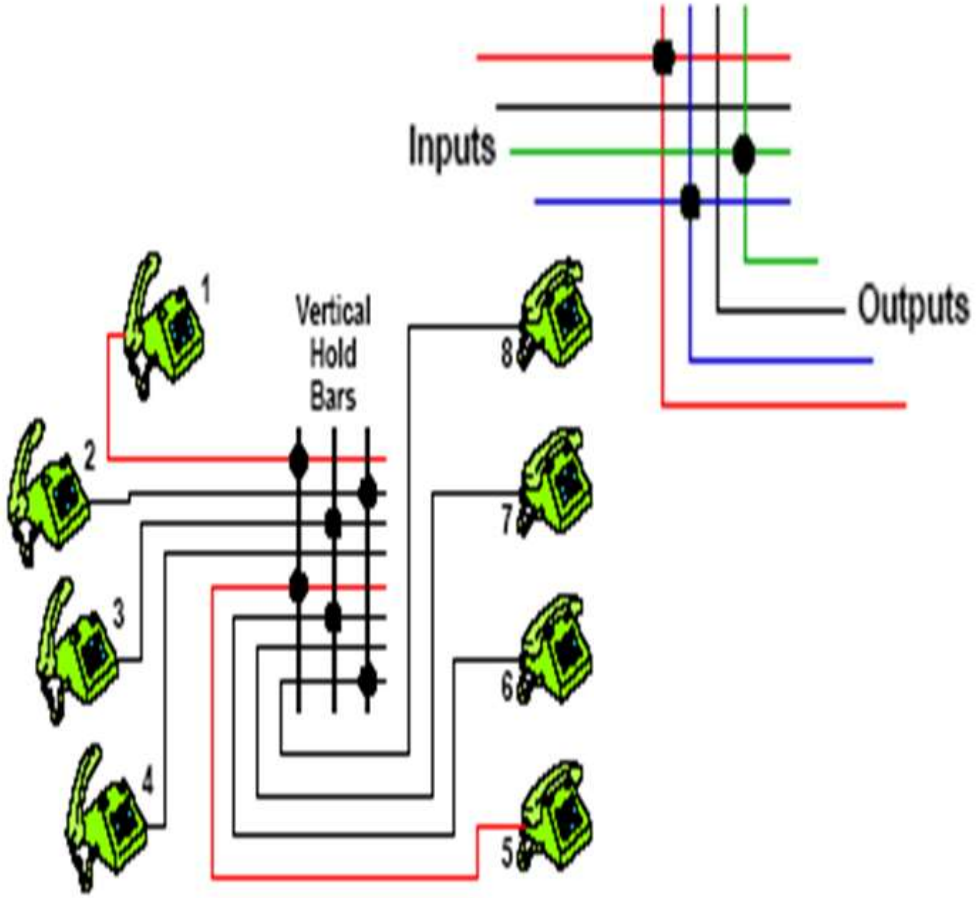
History of Telecommunications
Automatic Switching

- Significant experimentation from the 1880s.
- Almon Strowger (1889) developed an automatic switch, called “step-by-step” switching.
- Two decimal digits are signaled by applying pulses to H and D (right).

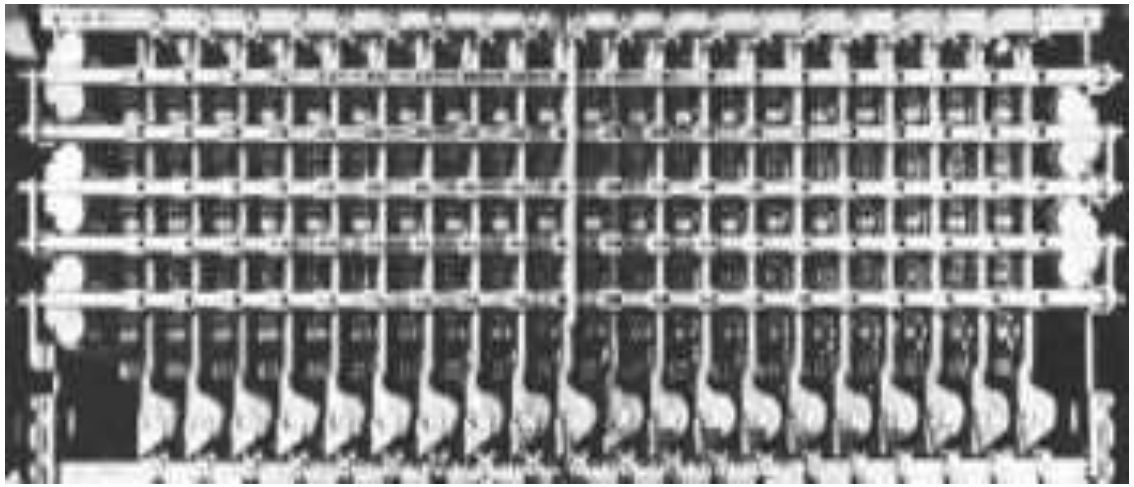


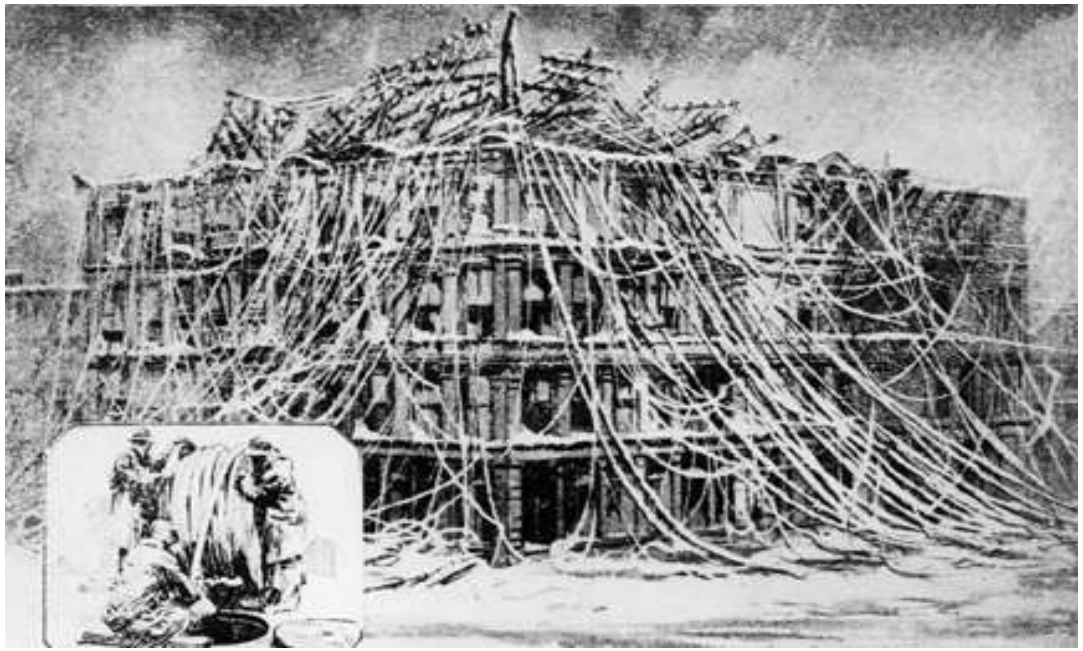
History of Telecommunications
Automatic Switching

- In 1896, Strowger replaced the button-pushing method with a rotary dialer, an efficient automatic switch called “Strowger switch”.
- The Strowger Switch was a stepped rotary Switch that moved in two dimension
- In 1913 (J. N. Reynolds), a better automatic switch, “crossbar switch", was developed using a grid of horizontal and vertical bars, with electromagnets at their ends.



History of Telecommunications
Automatic Switching





•In 1965, AT&T introduced the first electronic switching systems (ESS).

• In 1976, new type of electronic switch using time division switching was put into service.

Overview of switching systems

Introductory Concepts

Telecommunication means “communications at a distance”
Tele in Greek means at a distance
Electrical communications by wire, radio, or light (fiber optics)
Traditionally two distinct disciplines:

- Switching: selects and directs communication signals to a specific user or a group of users
- Transmission: delivers the signals in some way from source to the far-end user with an acceptable signal quality

Introductory Concepts
Telephony

The telephone is connected to Public Switched Telecommunications Network (PSTN) (also referred to as Plain old telephone system (POTS)) for local, national ,and international voice communications

The same connections can carry data and image/vide0 information (television)

The connection to the PSTN may be via local exchange carriers (LEC) End-users, nodes, and connectivity's

Introductory Concepts
Voice Telephony

The signal that contains the messages is usually converted into electrical waves before transmission. voice is an analog signal which has amplitude and frequency characteristic.

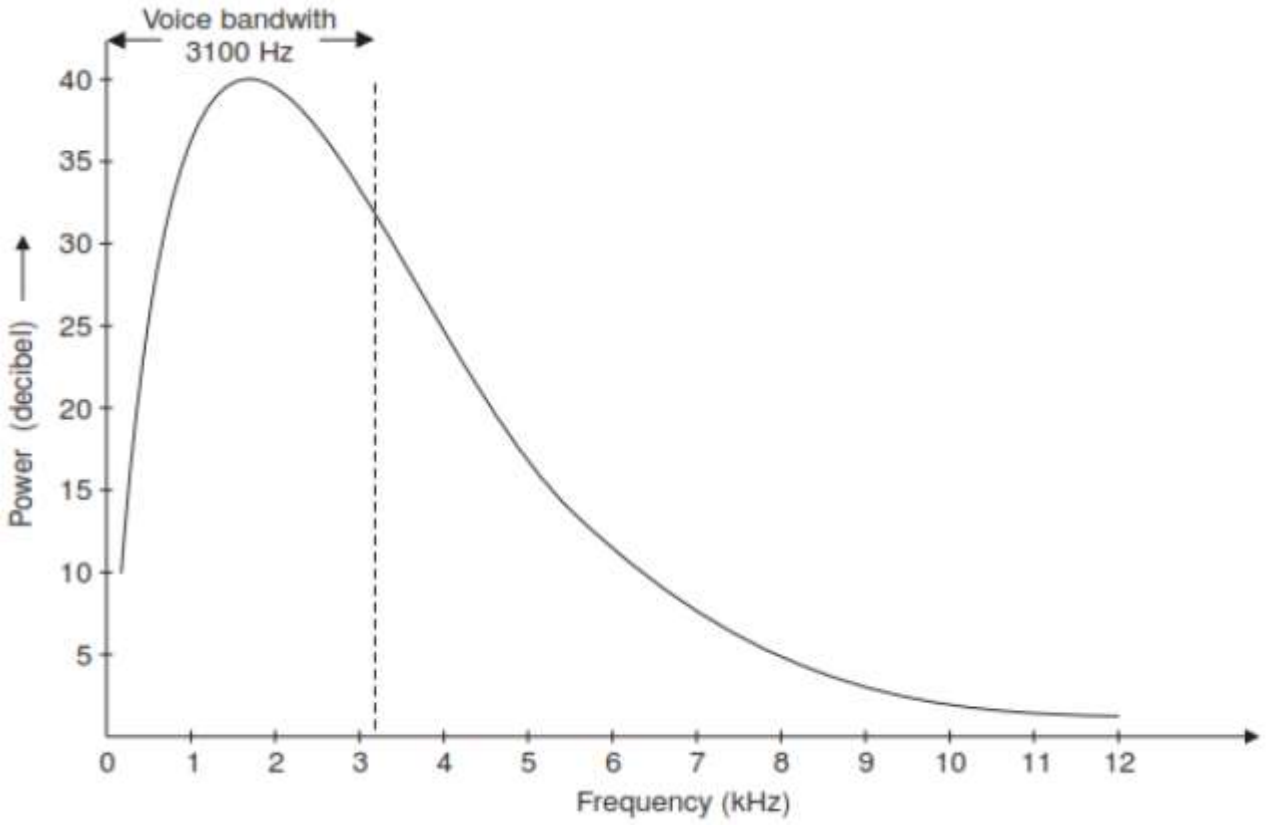
Analog voice-band channel: A channel that is suitable for transmission of speech or analog data and has the maximum usable frequency range of 300 to 3400 Hz.

The local serving switch is the point of the connectivity with the PSTN

It is the point where the analog signal is digitized.

Introductory Concepts
Voice frequencies

Voice frequencies: The range of frequencies used by a communication device determines the communication channel, communicating devices, bandwidth or information carrying capacity. The most commonly used parameter that characterizes an electrical signal is its bandwidth of analog signal or bit rate if it is a Digital signal



Introductory Concepts
dB in Communications

The db (decibel) is a relative unit of measurement commonly used in communications for providing a reference for input and output levels.

- **Power gain or loss**.

Decibels are used to specify measured and calculated values in audio systems, microwave system gain calculations, satellite system link-budget analysis, antenna power gain, light-budget calculations and in many other communication system measurements

In each case the dB value is calculated with respect to a standard or specified reference.

Introductory Concepts
Calculation of dB

- The dB value is calculated by taking the log of the ratio of the measured or calculated power (P2) with respect to a reference power (P1).
- The result is multiplied by 10 to obtain the value in dB
- It can be modified to provide a dB value based on the ratio of two voltages or the ratio of two currents

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

$$= 10 \log_{10} \frac{P_2}{P_1} = 10 \log_{10} \frac{V_2^2/R}{V_1^2/R} = 20 \log_{10} \frac{V_2}{V_1}$$

$$= 10 \log_{10} \frac{P_2}{P_1} = 10 \log_{10} (I_2/I_1)^2 = 20 \log (I_2/I_1)$$

Introductory Concepts
Definitions off dBm and dBW

dBm indicates that the specified dB level is relative to a 1milliwatt reference.).

If Power is expressed in watts instead of milliwatts. the dB unit is obtained with respect to 1 watt and the dB values are expressed as dBW.

$$\text{dBm} = 10\log_{10}\frac{P_2}{0.001\text{W}}$$

$$\text{dBW} = 10\log_{10}\frac{P_2}{1\ \text{W}}$$

Introductory Concepts
Examples

Important Note: The decibel (dB) is "the logarithm of a power ratio" and NOT a unit of power; However, dBW and dBm are units of power in the logarithmic system of numbers

Convert the following into dBm or dBW

P=1mW, P(dBm)=?

P=0.1mW, P(dBm)=?

P=10W, P(dBW)=?

P=1W, P(dBm)=?

The amplifying network has a 3-dB gain because the output power was the double the input power

Introductory Concepts

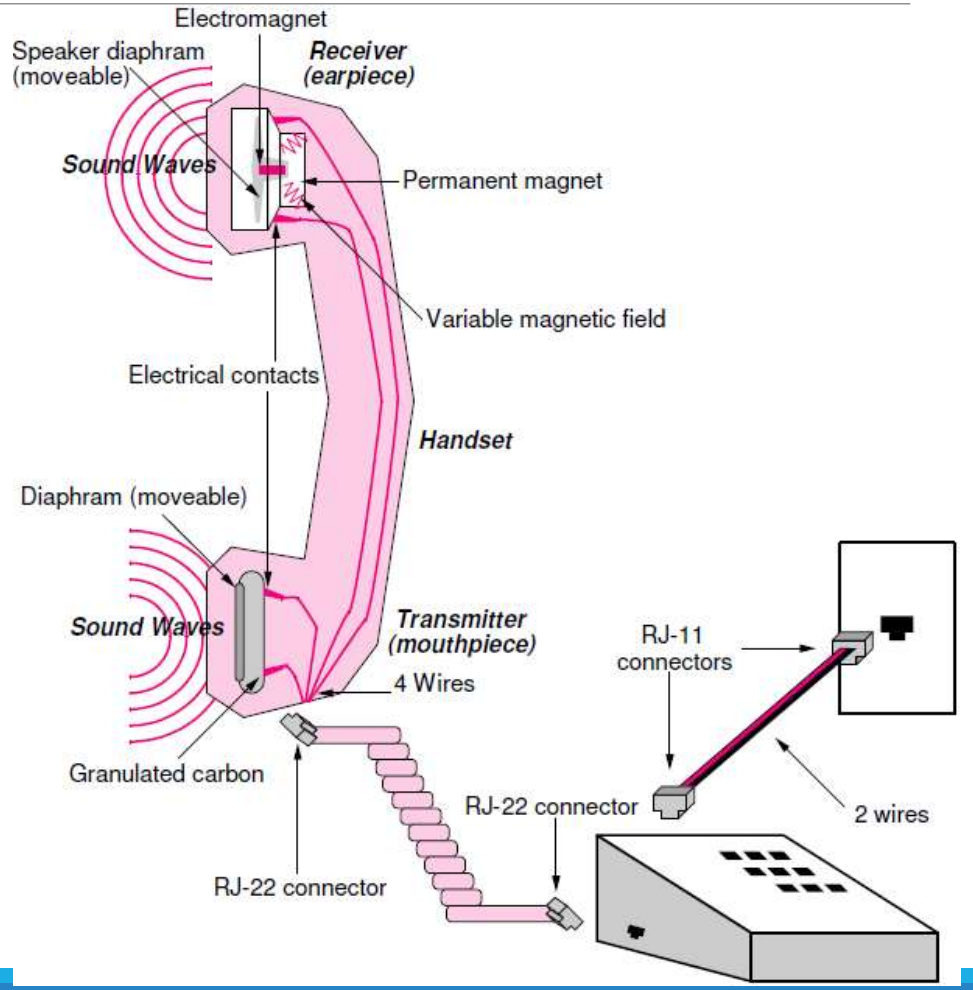
The bandwidth and bit rate for various types of system

Type	Bandwidth	Bit Rate
Telephone (Speech)	300 - 3400 Hz	-
Music	50 Hz - 16kHz	-
Facsimile	40 kHz	-
Broadcasting Telephone	0 - 55 MHz-	-
Personal Communication	-	300 t0 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

Introductory Concepts
Telephone Subset

It is a device which converts human speech in the form of sound waves produced by the vocal cord to electrical signals. These signals are then transmitted over telephone wires and then converted back to sound waves for human ears.

- Microphone
- Earphone
- Signaling functions



Elements Of Communication Switching System

Elements Of Communication Switching System

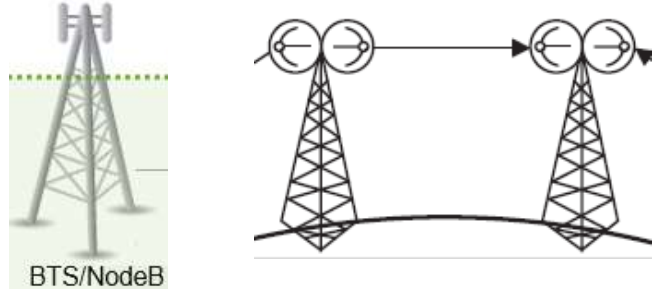
Telecommunication system can be divided into four main parts.

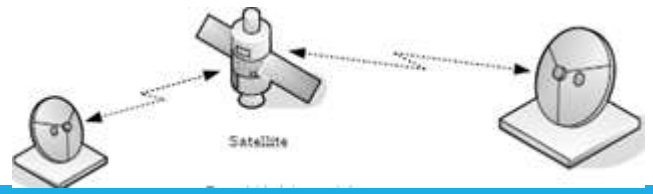
- End system or Instruments
- Transmission system
- Switching system
- Signaling

Elements Of Communication Switching System

The end system or instruments: are a transmitter or receiver that are responsible for sending information or decoding or inverting received information or message into an intelligible message.

Transmission System: conveys the information and control signals between end systems and switching centers. They can be characterized by its bandwidth, link attenuation and the propagation delay.

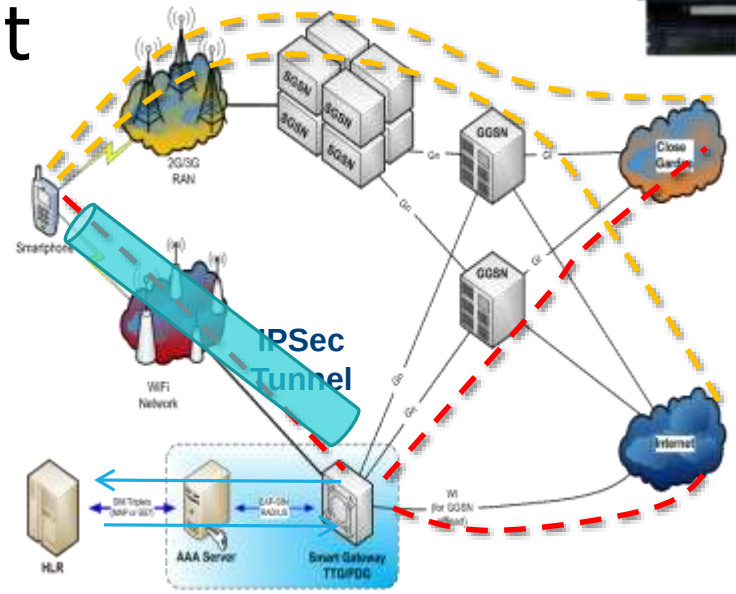




Elements Of Communication Switching System

Switching System: Forwards messages or to the required destination, after necessary modification. It is a collection of switching elements arranged and controlled to setup a communication path between any two distant points.

Signalling Systems: are essential building blocks in providing standardized automatic telephone services. Signalling provides the interface between different national systems



Fundamentals For The Design Of Telecommunication System/Network

Fundamentals For The Design Of Telecommunication System/Network

The design requirements for telephone switching System determined on the basis of the **traffic intensity of the busy hour**.

In telecommunication system, **Traffic** is defined as the occupancy of the server in the network

The busy hour: is defined as that continuous sixty-minute period during which the traffic intensity is highest

Calling rate: The average number of request for connection made per unit time. (Probability a call request will occur in a short interval of time)

Holding time: The mean time that calls last.

Average holding time: Average duration of occupancy of traffic path by a call.

Fundamentals For The Design Of Telecommunication System/Network

Grade of Service (GoS): A measure of congestion expressed as the probability that a call will be blocked or delayed.

Measure of GOS: is expressed as a probability (i.e. P.02 or P02)

Blocking criteria: Blocking can occur if all devices are occupied when a demand of service is initiated (the blocking probability)

Delay criteria: If the design of a system is based on the fraction of calls delayed longer than a specified length of time (Delay probability)

Congestion: a period of congestion during which no new calls can be accepted. There are two ways of specifying congestion

Time congestion: The probability that all servers are busy.

Fundamentals For The Design Of Telecommunication System/Network

Call congestion: Average duration of occupancy of traffic path by a call.

Average occupancy: (also referred as **traffic flow of traffic intensity**)

If the average number of calls to and from a terminal during period T second is 'n' and the average holding time is 'h' seconds, the average occupancy of Server is given by $\boldsymbol{A = \frac{nh}{T}}$

The international unit of telephone traffic is the Erlang.

Distributed & Centralized Switching System

Classification of Telecommunication Switching Systems

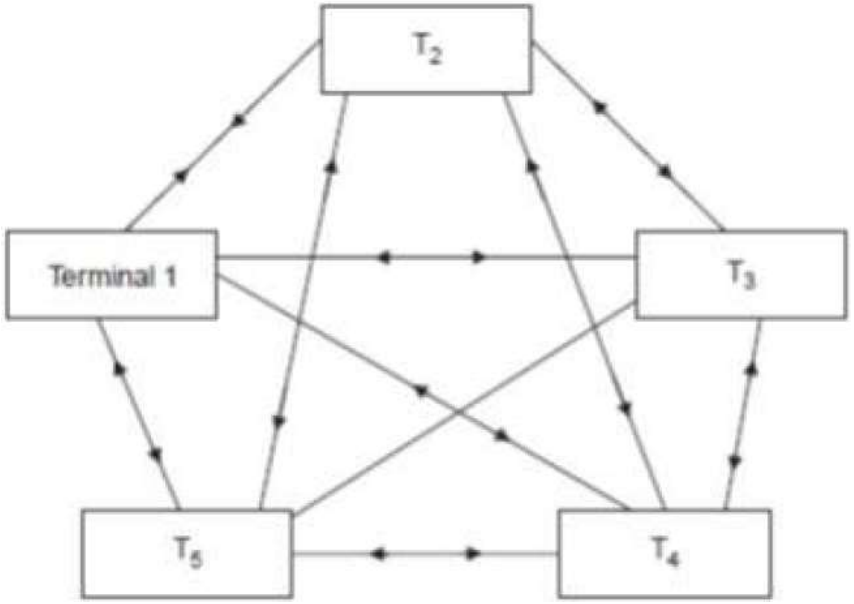
Telecommunication Switching Systems may be classified as follows

- Distributed Method
- Centralized Model
- Hierarchical system

Classification of Switching Systems
Distributed Method

switching system where uses terminal-to terminal connection. This kind of switching is called distributed switching and applied only to small telephone system.

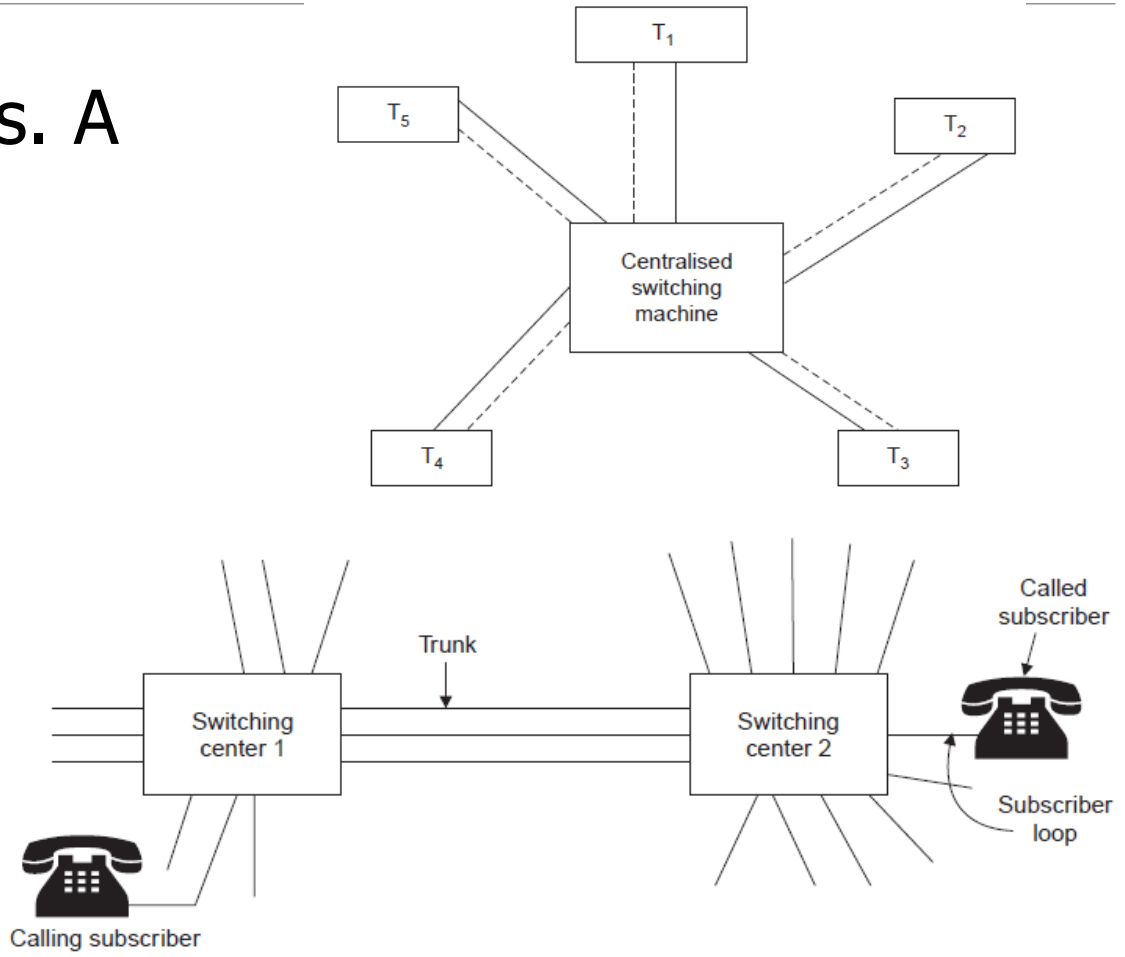
Each terminal has two switches, one to make required link and other to connect a link to receive a call.



Classification of Switching Systems

Centralized Model

geographical separation of terminals. A simple centralized system, which reduces the average length of transmission link, and hence the transmission cost.



Classification of Switching Systems

Centralized Model

Even though the increase in the number of switching centers lower the total transmission costs, the total switching cost tend to increase for two reasons.

- The local centers become more complex because they must be able to decide on a suitable routing to another center.
- Economy of scale is lost with an increased number of local centers because of additional numbers.

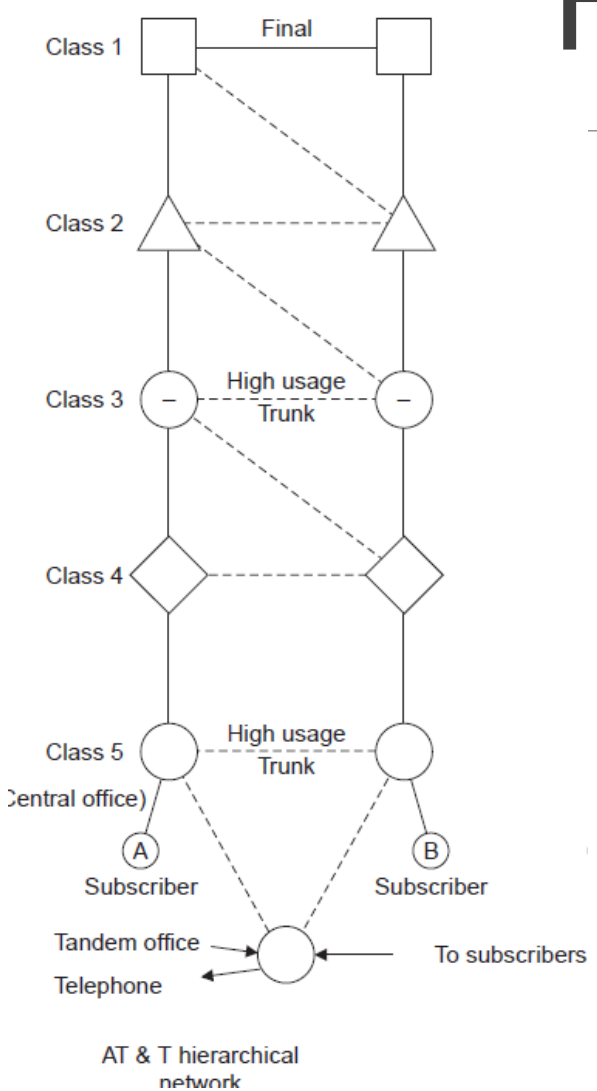
Classification of Switching Systems

Hierarchical system

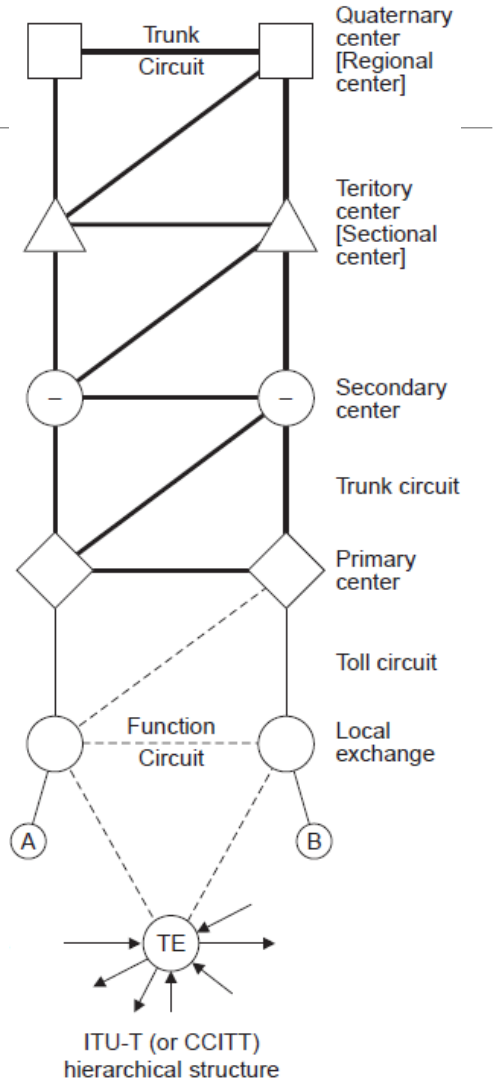
Central offices may be interconnected by direct trunk groups or by intermediate office known as a tandem, toll or gateway office. The process of centralizing switching centers can occur at several levels leading to the hierarchical

Classification of Switching Systems

Hierarchical system



AT & T hierarchical network



ITU-T (or CCITT) hierarchical structure

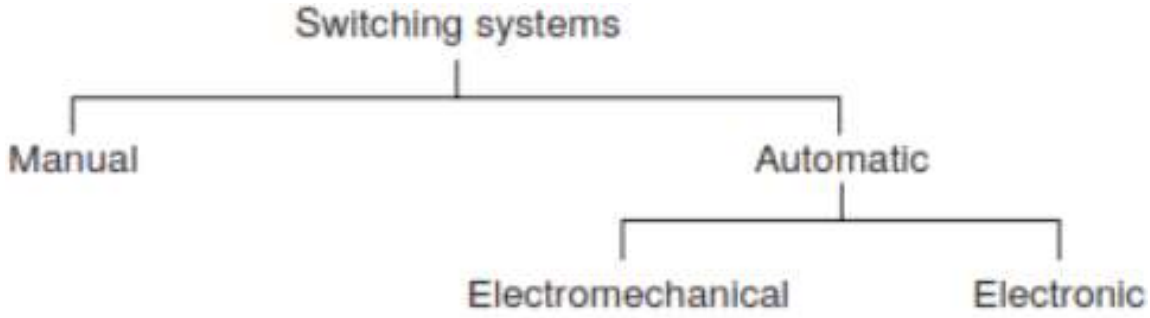
Classification of Telecommunication Switching Systems

Classification of Telecommunication Switching Systems

Manual: In early days, the human exchange provided switching facilities

Around 1890's many **Electromechanical** switching devices introduced

electronic switching system (ESS) which uses stored program control (SPC) and computer controlled switching systems - are presently dominating the worldwide



***Home Work**: prepare a short Technical report to describe 1. Stored program control (SPC) 2. computer controlled switching systems*

Requirements of Switching System

Requirements of Switching System

In order to provide satisfactory service to the subscribers and to ensure profitability, the switching system should satisfy the following requirements

High availability: Switching system must be very **Reliable**

System reliability can be expressed mathematically as the ratio of uptime to sum of the uptime and down time.

Requirements of Switching System…

$$\boldsymbol{Availability\ (A)} = \frac{\boldsymbol{Uptime}}{\boldsymbol{Uptime + Downtime}} \quad \boldsymbol{A} = \frac{\boldsymbol{MTBF}}{\boldsymbol{MBTBF + MTTR}}$$

where,

- *MTBF = Mean time between failure*
- *MTTR = Mean time to repair*

The unavailability of the system is given by

$$\mathbf{U = 1 - A <}\ \boldsymbol{U = 1 - A} < \frac{\boldsymbol{MTBF}}{\boldsymbol{MBTBF + MTTR}}$$

Requirements of Switching System

- **High speed**. The switching speed should be high enough to make use of the switching system efficiently.
- **Low down time:** The down time is the total time the switching system is not operating satisfactorily. The down time should be low enough to have high availability.
- **Good facilities.** A switching system must have various facilities (Value Added Services (VAS)) to serve the subscriber. *I.e. wake up calls, address, emergency numbers, number identification etc.*
- **High security**. To ensure satisfied or correct operation

Switching Techniques

Switching Techniques

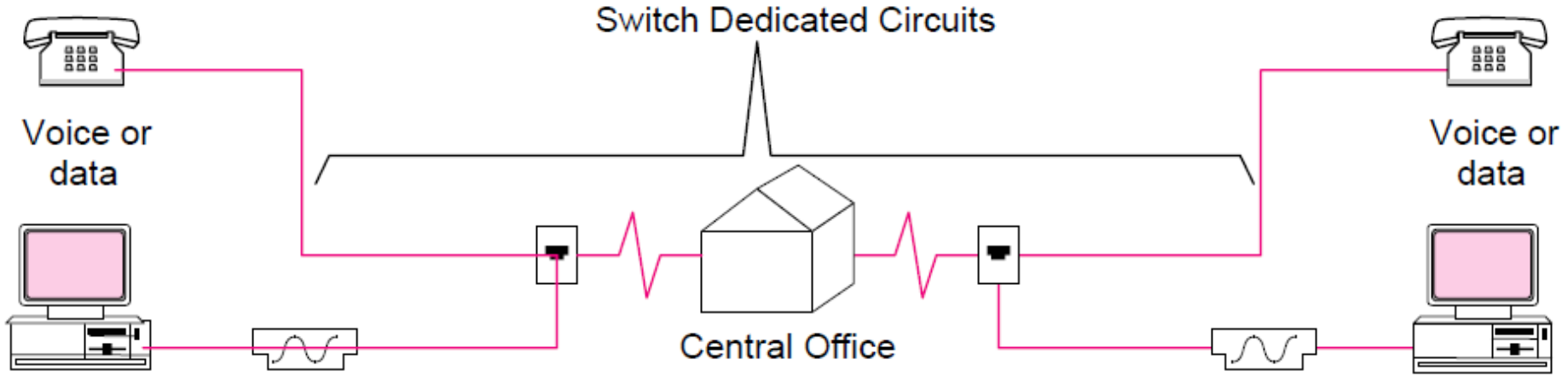
Switching Techniques: Describes various techniques used to establish connections between users' exchanges. Commonly switching methods

- Circuit switching (Traditional Telephony)
- Logical / Packet switching
- Message switching

Switching Techniques
Circuit switching

Circuit switching (Traditional Telephony)

- A dedicated end-to-end connection is established for the duration of the connection
- Used in telephone network
- Like using a "private road"

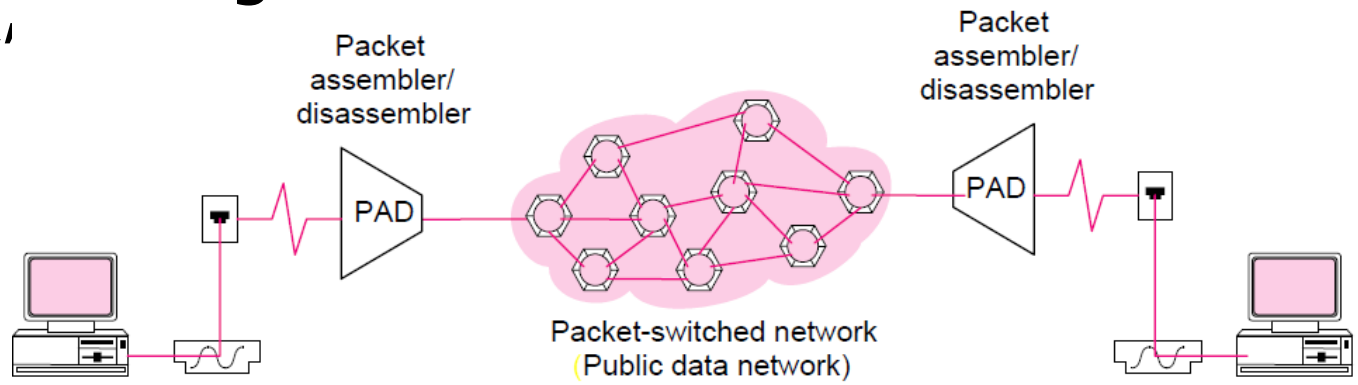


All data or voice travel from source to destination over the same physical path

Switching Techniques
Packet switching

Logical / Packet switching

- Messages are divided into small packets
- Each packet is separately routed to the destination
- Different packets can take different paths and times
- Packets are reassembled into messages at the destination
- Like using a "shared highway"



Data enter the packet-switched network one packet at a time;
Packets may take different physical paths within packet-switched networks.

Switching Techniques
Packet switching

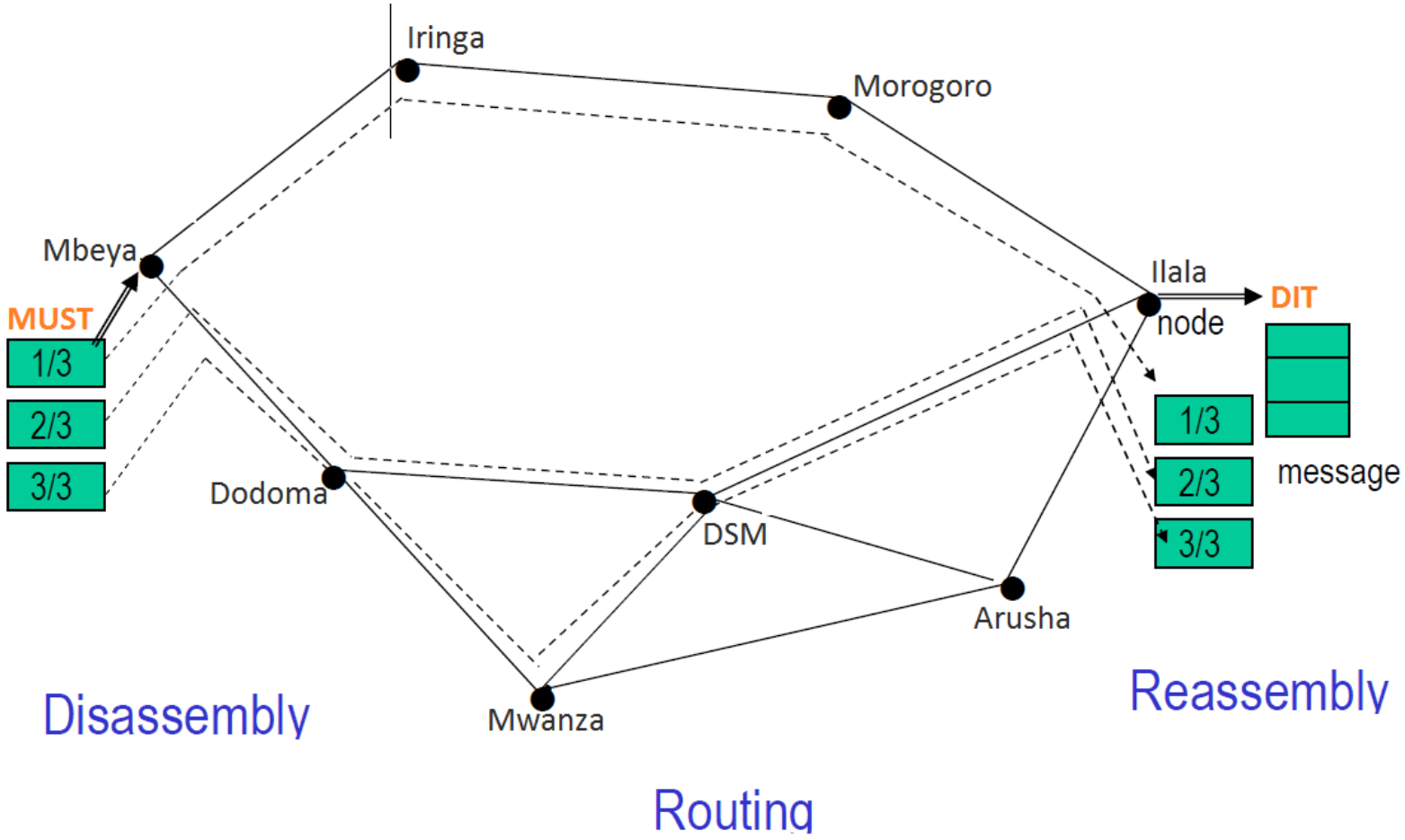
Applications exchange packets

- Message divided into packets
- Envelopes of data with To / From addresses and packet number
- Packet size / length is fixed

Networks support packet forwarding / relaying

- Computers are connected to switches, routers, etc.
- Switches sort and forward packets, like post offices
- Lots of different physical layers can be used
- Networks can be interconnected

Switching Techniques
Packet switching



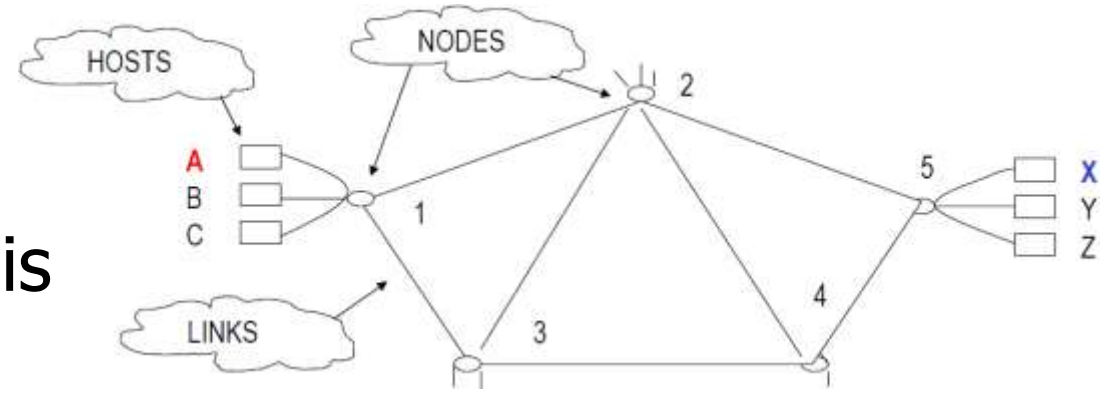
Switching Techniques

Circuit switching vs Packet switching

Circuit switching	Packet switching
Minimum delay	Variable delay
Very inefficient use of connection capacity	Much more efficient use of connection capacity
When overloaded, unable to make connection at all	Can almost always connect, but may be long delays
Both ends of connection must use same data rate	Data-rate conversion is easy

Switching Techniques
Message Switching

- **Message Switching:** In message switching, the messages are stored and relayed from secondary storage.
- In this technique, there is no direct link between the sender and the receiver.
- A message delivered to the destination is rerouted along any path before it reaches the destination
- It was common in 1960's and 1970's.
- The Technique were usually tele-printers



Switching Techniques

Circuit switching vs Packet switching

Message Switching	Circuit switching
The source and destination do not interact in real time	The source and destination are connected temporally during data transfer.
message deliver is delayed basis if destination node busy or otherwise unable to accept traffic	Before path setup delay, may be there due to busy destination node. one the connection is made, the data transfer takes place with negligible propagation time.
Destination node status is not required before sending message	Destination node status is necessary before setting a path for data transfer.
Message switching network normally accept all traffic but provides longer delivery time because of increase queue length.	A circuit Switch network rejects excess traffic if all the lines are busy.
in message switching network, the transmission links are never idle	in circuit switching after path setup, if the users denied services, the line will be idle. Thus, the transmission capacity be less, if the lines are idle

Reference book

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2. Telecommunication Systems Engineering, R. L. Freeman, 4/e, Wiley publication, 2010
3. Telecommunication Switching and Networks. By P. Gnanasivam, New Age International.