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Course Title : Introduction to Telecommunication System

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Submitted by,

Name : Nadira Islam

ID: IT-17051

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Dept. of ICT,MBSTU.

Submitted to,

NAZRUL ISLAM

Assistant Professor

Dept. of ICT,MBSTU.

1. (a) Define PSTN. Which systems consist a telecommunication network? 4

(b) Describe the three basic topologies. 6

(c) Which methods are used to decide the routing on a particular connection? 4

2. (a) To have high quality standard, CCITT puts which guidelines? 4

(b) List the types of long distance transmission system. Describe the types of Numbering plan for telephone network. 5

(c) What are the categories of long distance radio communication depending on the mechanism of propagation? 5

3. (a) Describe the parts of a national number. 4

(b) Discuss the signaling Techniques. 5

(c) Define Line signaling, In-Channel signaling, Common Channel signaling 5

4. (a) Define In-band Signaling. Describe the advantages of In-band signaling. 6

(b) Describe the modes of common channel signaling. 4

(c) Define PBX. What are the parts of PBX? 4

5.(a) How the individual calls can be charged? Describe the advantages of channel-associated Mode. 6

(b) Describe the advent of Cellular. 4

(c) Describe the frequency reuse patters. 4

6.(a) Define Co-channel interference reduction. 6

(b) Describe the Power Law. 4

(c) Describe C/I ratio. 4

7.(a) Which factors affect the received power level? 5

(b) Describe the small scale fading. 5

(c) Describe flat fading. 4

8.(a) Describe Multi-path fading. 5

(b) Define registration. ~~Types~~ Discuss the types of registration. 5

(c) Define Roaming. Describe Multi-access method and Duplexing method. 4

Answers:

Ans. to the Q. No 1(a)

1. (a) Define PSTN. Which systems consist a telecommunication network?

~~Ans:~~ Ans: The Public Switched Telephone Network (PSTN) is understood as an aggregate of world's circuit switched telephone networks, used for providing public telecommunication. These networks are operated regionally, locally, nationally and inter-nationally using telephone lines, fibre optic cables, microwave transmission links or cellular communications.

Any telecommunication network may be viewed as consisting of the following major systems:

1. Subescriber end instruments or equipments.
2. Subscriber loop systems.
3. Switching systems.
4. Transmission systems.
5. Signalling systems.

(b) Ans. to the Q.No 1 (b)

Q. Describe the three basic topologies.

Ans: In the process of interconnecting exchanges there are three basic topologies, such as

① Mesh Topology: Mesh topology, as the name implies, is a fully connected network. The number of trunk groups in a mesh network is proportional to the square of the exchanges being interconnected. Hence these mesh topologies are widely used in metropolitan areas where there is heavy traffic.

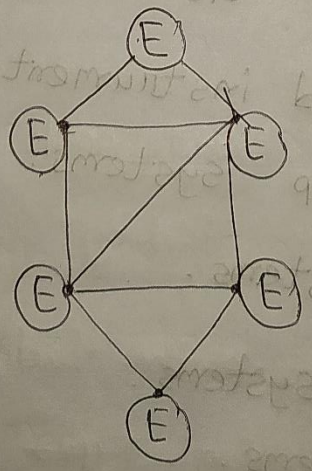


Fig. Mesh Topology

② Star Topology : Star topology is connected in the shape of a star, which utilizes an intermediate exchange called a tandem exchange through which all other exchanges communicate. It is used when traffic levels are comparatively low.

③ Hierarchical : The hierarchical topology is used to handle heavy traffic with minimal number of trunk groups. The traffic flows through the Final route which is the highest level of hierarchy. If the traffic intensity between any pair of exchanges is high, direct trunk routes may be established between them as indicated by dashed lines in the figure given below.

Ans. to the Q.No 1(c)

Ans:
To decide the routing on a particular connection, the following three methods are used :

(i) Right - through routing.
(ii) Alternate routing.
(iii) Computer - controlled routing.

Ans. to the Q. No 2(a)

To have high quality standards, the following guidelines were put forward by the CCITT:

(i) The maximum number of circuits to be used in an international call is 12.

(ii) No more than four international circuits be used in tandem between the originating and the terminating international switching centers.

(iii) In exception cases and for a low number of calls, the total number of circuits may be 14, but even in this case, the international circuits are limited to a maximum of four.

Ans. to the Q.No 2(b)

Modern long distance transmission systems can be placed under three broad categories:

1. Radio systems.
2. Coaxial cable system.
3. Optical fibre systems.

The Numbering plans for telephone networks are described in brief below:

(1) Open Numbering Plan: This is also called the Non-Uniform Numbering Plan and it permits wide variation in the number of digits to be used to identify a subscriber within a multi-exchange area or within a country.

(2) Semi-Open Numbering Plan: This plan permits number lengths to differ by almost one or two digits. The semi-open numbering plan is commonly used in countries such as India, Sweden, Switzerland and UK.

(3) Closed Numbering Plan: This is also called the Uniform Numbering Plan where the number of digits in a subscriber number are fixed. This is used in a few countries such as France, Canada, Hawaii and in a few parts of USA.

Ans. to the Q. No 2(c)

Depending on the mechanism of propagation, long distance radio communication can be placed under four categories:

1. Line-of-sight (LOS) microwave communication limited by horizon.
2. Sky wave or ionosphere communication.
3. Tropospheric scatter communication.
4. Satellite communication.

Ans. to the Q. No 3(a)

A national number consists of three parts. The parts are described below:

① The Area Code or the Trunk Code: This code identifies a particular numbering area or the multi-exchange area of the called subscriber. It is ~~co~~ with this code, the routing for a trunk call is determined and charged for it.

② Exchange Code: This code identifies a particular exchange within a numbering area. It determines

the rounting for incoming trunk call from another numbering area or for a call originating from one exchange and destined to another in the same numbering area.

③ Subscriber line Number: It is used to select the called subscriber line at the terminating exchange. The combination of the exchange code and the subscriber line number is called the subscriber line number in CCITT - terminology.

④ Charging Plan: The calls are charged as accounted by the metering instrument connected to each subscriber line or as per a metering register that is assigned to each subscriber in case of electronic exchanges. A meter counts the number of charging units and that count is incremented by sending a pulse to the meter.

Ans. to the Q. NO 3(b)

Signaling Techniques enable the circuit to function as a whole by inter connecting all varieties of switching systems. There are three forms of signaling involved in a telecommunication network.

(i) Subscriber loop signaling: It depends upon the type of telephone instrument used.

(ii) Intra exchange or register signaling: It refers to the internal portion of a switching system that is heavily dependent upon the type and design of a switching system, which varies depending upon the model.

(iii) Inter-exchange or inter-register signaling: It takes place between exchanges. This helps in the exchange of address digits, which pass from exchange to exchange on a link-by-link basis.

Ans. to the Q.NO 3(c)

Line Signaling: The network-wide signaling that involves end to end signaling between the originating exchange and the terminating exchange is called the line signaling.

In-channel Signaling: It is also known as Per Trunk Signaling. This uses the same channel, which carries user voice or data to pass control signals related to that call or connection. No additional transmission facilities are needed, for In-channel signaling.

Common channel Signaling: It uses a separate common channel for passing control signals for a group of trunks or information paths. This signaling does not use the speech or the data path for signaling.

Ans. to the Q. No 4(a)

In-band signaling: In-band voice frequency uses the same frequency band as the voice which is 300-3400 Hz, which has to be protected against false operation by speech.

The advantages of In-band signaling are:

1. The control signals can be sent to every part where a speech signal can reach.
2. The control signals will be independent of the transmission systems as they are carried along with the speech signals.
3. The Analog to Digital and Digital to analog conversion processes will not affect them.

Ans. to the Q.No 4(b)

Common channel signaling is implemented in two modes:

(i) Channel associated mode

(ii) Channel non-associated mode

Channel associated mode: In the channel-associated mode, the channel closely tracks the trunk groups along the entire length of the connection. It is done on a separate channel; the signaling path passes through the same set of switches as does the speech path.

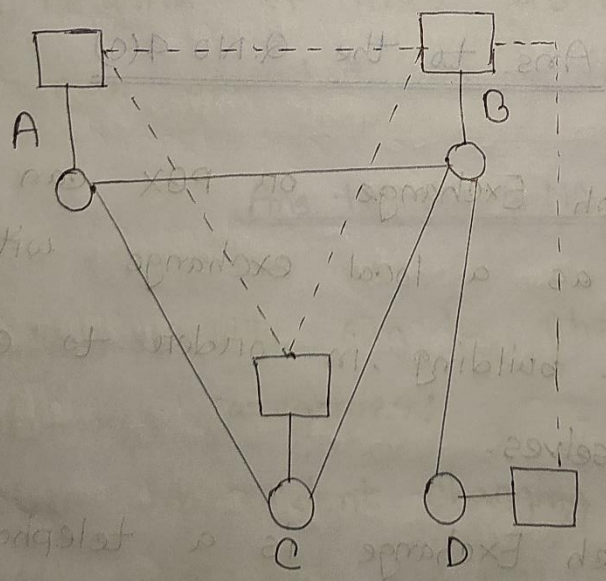
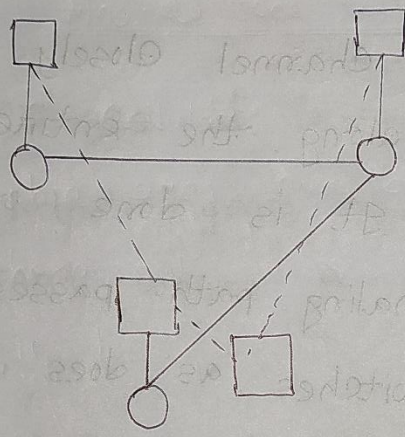


Fig: Associated mode of operation in common channel.

Channel Non-associated Mode: In the channel non associated mode, there is no close or simple assignment of the control channels to trunk groups. It follows a different path from that of the speech signal as shown in the following figure.



Ans. to the Q.NO 4(c)

Private Branch Exchange or PBX can be understood as a local exchange within an office or a building, in order to communicate within themselves.

Private Branch Exchange is a telephone system within a local area that switches calls between those users on local lines while

allowing all users to share a certain number of external phone lines. The main purpose of PBX is to save the cost of requirement for a line to each user to the central exchange office.

The parts of PBX include:

(i) A telephone trunk that contains many phone lines, which are terminated at PBX.

(ii) A computer that handles the incoming and outgoing calls of PBX along with switching between different calls within the local loop.

(iii) The network of lines within the PBX.

(iv) A human operator console, which is optional.

Ans. to the Q.NO 5(a)

The individual calls can be charged based on the following categories:

(i) Duration independent charging.

(ii) Duration dependent charging.

The advantages of channel-associated mode are:

(i) The implementation is economic.

(ii) The assignment of trunk groups is simple.

Ans. to the Q.NO 5(b)

Advent of Cellular:

A geographic area can be divided into several hexagonal areas, or cells, with an transmitter located in the centre of each cell.

- Allows for frequency reuse as two cells in the same geographic area can use the same frequency.
- Increases the spectral efficiency of the system, but increases infrastructure expense.
- technology to implement cellular telephony was available only in the late 1980's.
- Base station provides access between mobile users and the mobile switching centre (MSC)

Ans. to the Q. No 5 (c)

Frequency reuse patterns:

1. Reuse allows a small set of frequencies, k to service a large area (numbers refer to transmitters with same frequencies).

2. Reuse patterns are designed to minimize co-channel interference (interference from other base stations using the same frequency).

3. A larger reuse pattern (e.g. $k = 7$) results in a larger distance between base stations that use the same frequency.

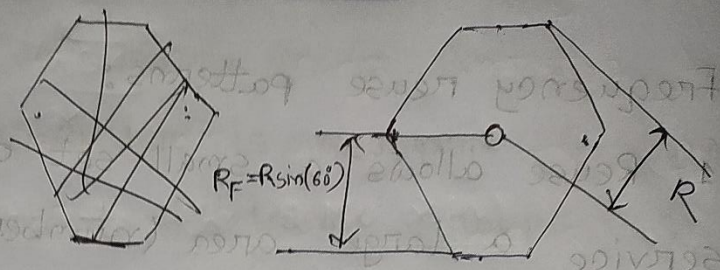
$$D = \sqrt{3k}\, R$$

Ans. to the Q. No 6 (a)

We define the co-channel interference reduction factor by

$$q = \frac{D}{R} = \sqrt{3k}$$

Here, the radius R is the distance from the centre of the ~~ea~~ cell to an outer



The distance D is the distance from one transmitter to the next transmitter of the same frequency.

Ans to the Q.NO 6(b)

Power radiates from the transmitter antenna in a spherical manner (inversely related to the surface area of the sphere)

- the power at d metres away from the transmitter is given in reference to the power P_0, some d_0 metres away.

$$\frac{P_d}{P_0} = \frac{4\pi d_0^2}{4\pi d^2} \qquad P_d = P_0\left(\frac{d}{d_0}\right)^{-2}$$

In general and terrain characteristics can result in a different power law for the previous equation. We generalize the power

law by the co-efficient n, where n usually ranges from 2 to 4.

$P_d = P_0 \left(\frac{d}{d_0}\right)^{-n}$, or in dBm,

$P_d\ (dBm) = P_0\ (dBm) - 10\, n \log\left(\frac{d}{d_0}\right)$

Ans. to the Q. No 6(c)

C/I ratio :

The Carrier-to-interference ratio, C/I, of the signal at the mobile from the transmitter in a given cell, can be found in an approximate manner by summation of interference from all base stations using the same frequency. Usually expressed in dB.

$$\frac{C}{I} = \frac{R^{-n}}{\sum_{i=1}^{M} D_i^{-n}}$$

If we assume all base stations are identically spaced, and are at the centres of their cells, we have the C/I approximation of :

- M is the number of interfering base stations in the first tier (this is always 6 for hexagonal cells with the standard

reuse patterns $K = 3, 4, 7, 12, 19, \ldots$)

$$\frac{C}{I} = \frac{(\sqrt{3K})^n}{M}$$

Ans. to the Q.No 7(a)

During transmission from the base station to the mobile, the received power fluctuates. We can generalize the factors that affect the received power level into 3 main groups.

- Path Loss (does not change in time)
  - changes only with distance from transmitter.
  - there are also losses associated with the frequency of transmission, size/height of transmit/receive antenna etc.
- Long-term fading or Shadowing
  - caused by building or tunnels 'shadowing' transmission from BS
  - changes with mobile position (log-normal distribution)

• Short-term fading (or small scale fading)
- due to multiple paths of transmission (reflections) arriving at the mobile at the same time (flat fading)
- If there are other paths that arrive with some delay, it is called multi-path fading.

Ans. to the Q. No 2 (b)

Small Scale Fading:

• The signal may take different 'paths' to the mobile customer.

• Reflections off moving objects, cause a shift in frequency in the signal. Each path also arrives at a various angles and phases.

• Some paths arrive at the mobile at the same time. Other paths arrive much later do to a longer distance traveled.

Ans. to the Q. NO 2(c)

Flat Fading:

(i) Derivation of fading based on electromagnetic field.

(ii) Several paths arrive at the receiver at nearly the same instant.

(iii) Each path has been shifted in frequency due to the relative motion of mobile.

(iv) The maximum Doppler shift is given by $f_m = v/\lambda$, where v is the mobile velocity and λ is the carrier wavelength.

(v) The paths interfere constructively and destructively causing the received power at the mobile to vary with time.

(vi) The coherence time is the time over which the received power does not change significantly. A reasonable "ball park" estimate is:

$$T_c \approx \frac{9}{16\pi f_m} \approx \frac{9c}{16\pi v f_c}$$

Ans. to the Q No 8 (a)

Multi-path fading:

- If one or more paths arrives somewhat later than the first group of paths, the gain over the transmission bandwidth ~~with~~ will not be constant.
- Intuitive example: consider 2 cosine waves, one arriving 1 μs later than the other at the same amplitude. At the instant $t = 0$:
  - at 800 MHz: $\cos(2\pi\, 800t) + \cos(2\pi\, 800(t+1)) =$ 2 volts
  - at 800.4 MHz: $\cos(2\pi\, 800.4t) + \cos(2\pi\, 800.4(t+1)) =$ 0.191 volts
- The coherence bandwidth is the bandwidth over which the channel response somewhat flat. This is approximately:

$$B_c \approx \frac{1}{5\sigma_t}$$

where, σ_t is the rms. delay spread, a measure of the channel time dispersion ($\sigma_t = 0.5\,\mu s$)

Ans. to the Q.No 8(b)

Registration: Registration is the process of notifying the network that a phone is active on the system.

Registration Types:

Periodic registration: It is when the phone announces itself on a regular basis.

Forced registration: It is when the phone monitors a control channel which provides information including the cell identification.

- If the channel strength fades below a threshold, the phone selects another channel.
- If the new channel has a new cell ID, then the phone reregisters.

Ans. to the Q.No 8(c)

Roaming: Roaming is when a phone is outside its home area or local region.

Multi-access method:

- the manner in which radio resources are allocated into voice channels.

- FDMA (frequency division) - each voice channel is assigned a separate frequency.

- TDMA (time division) - each voice channel is assigned segments of time (slots). Mobiles are commonly severed in a round-robin fashion.

- CDMA (code division) - each voice channel is assigned a specific code. At the receiver, the voice channels can be separated with minimal interference.

Duplexing Method:

① FDD (Frequency division duplex) - voice channels for the downlink and uplink are separate in frequency (common)

② TDD (time division duplex) - the downlink and uplink transmission alternate in time over the same channel.