Unit - I

1) (a) Discuss the categories for specifying the performance criterion of a cellular system.

Ans:- There are three categories for specifying performance criteria :-

→ Voice Quality:- For any given commercial communication system, the voice quality will be based upon some following criteria. A set value x at which Y percent of customers rate the system voice quality (from Transmitter to Receiver) as good or excellent. The top two circuits merits (CM) of the five are listed below

CM	Score	Quality scale
CM5	5	Excellent (Perfectly understandable)
CM4	4	Good (Some noise)
CM3	3	Fair (Ocasional repetitions needed)
CM 2	2	Poor
CM 1	1	Unsatisfactory

→ As the percentage of customers choosing (CM5, CM4 increases the cost of building system rises.

→ The average of the CM scores obtained from all the listeners is called mean opinion score (MOS) For quality voice, MOS ≥ 4.

→ Service Quality:-

• Coverage:- The system should serve an area as widely as possible with radio coverage, however due to irregular terrain configuration and for the following reasons, it is usually not practical to cover 100% of the area. The two reasons are:-

↳ Transmitted power would have to be very high to illuminate weak spots with sufficient reception, which increases cost.

↳ The higher the transmitted power, harder it becomes to control interference.

Hence, a system usually covers 90% of an area in flat terrain and 75% of an area in hilly terrain.

• Required Grade of Service:- Grade of service is a measure of the ability of a user to access a trunked system during the busiest hour.

• Number of dropped calls:- During 'Q' calls in a hour, if a call is dropped and Q-1 calls are completed, then the call drop rate is 1/Q. The drop rate

must be kept low.

→ Special features:- A system should be able to provide as many special features as possible like

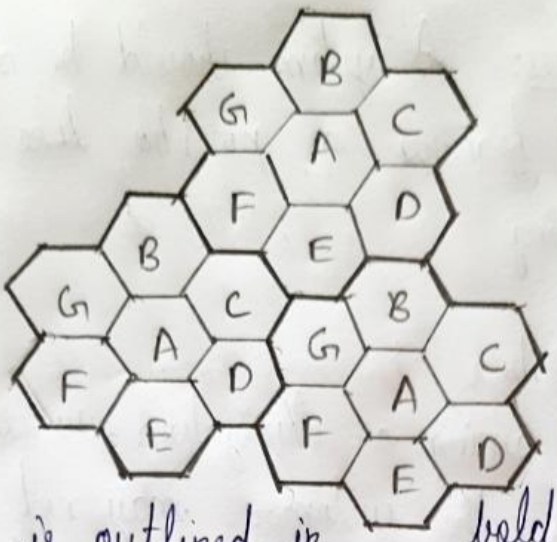
- Call forwarding
- Call waiting
- Voice stored box
- Automatic roaming or Navigation services

However, sometimes, the customers may not be willing to pay extra charges for these special features.

(b) Explain about Frequency Reuse concept with neat sketch.

Ans:- Frequency reusing is the concept of using the same frequency channel by users in different geographic locations (different cells). The frequency reuse concept increases the spectrum efficiency but if the system is not properly designed, then Interference may occur.

Figure in the next page illustrates the concept of cellular frequency reuse, where cells labeled with the same letter use the same group of channels. Cells with the same letter use the same set of frequencies. A



cell cluster is outlined in bold and replicated over the coverage area. In this example, the cluster size, N, is equal to seven, and the frequency reuse factor is 1/7 since each cell contains one-seventh of the total number of available channels.

Consider a cellular system which has a total of S duplex channels available for use. If each cell is allocated a group of k channels ($k < S$), and if the S channels are divided among N cells into unique and disjoint channel groups which each have the same number of channels, the total number of available radio channels can be expressed as, $S = kN$

The N cells which collectively use the complete ~~list~~ set of available frequencies is called a cluster. If a

cluster is replicated M times within the system, the total number of duplex channels, C, can be used as a measure of capacity and is given by $C = MkN = MS$

→ The capacity of a cellular system is directly proportional to the number of times a cluster is replicated in a fixed service area. The factor N is called cluster size and is typically equal to 4, 7 or 12.

→ The smallest possible value of N is desirable in order to maximize capacity over a given coverage area. The frequency reuse factor of a cellular system is given by $1/N$, since each cell within a cluster is only assigned $1/N$ of the total available channels in the system.

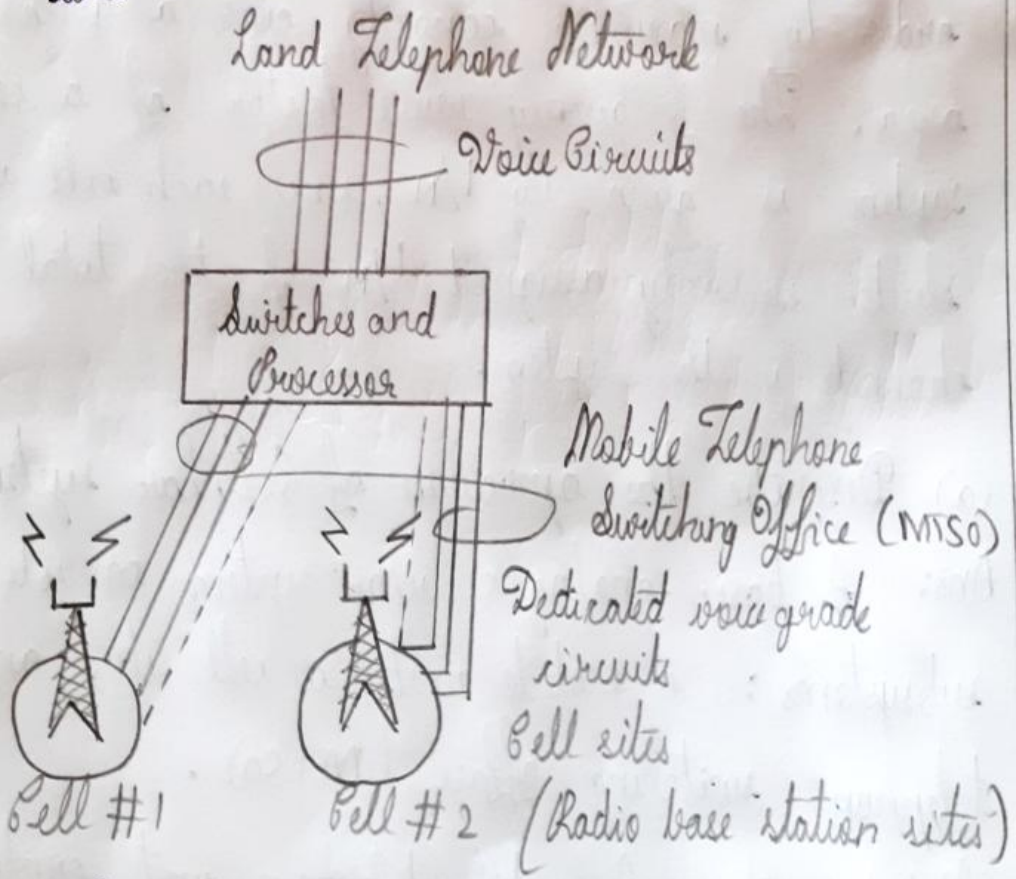
2) (a) Describe the operation of Cellular system.

Ans:- A basic analog cellular system consists of three subsystems: a mobile unit, a cell site, and a mobile telephone switching office (MTSO).

Mobile units:- A mobile telephone unit contains a control unit, a transreceiver, and an antenna system.

Cell site :- The cell site provides interface between the MTSO and the mobile units. It has a control unit, radio cabinets, antennas, a power plant and data terminals.

MTSO :- The switching office, the central coordinating element for all cell sites, contains the cellular processor and cellular switch. It interfaces with telephone company zone offices, controls call processing, provides operation and maintenance and handles billing activities.



Connections :- The radio and high speed data links connect

the three subsystems. Each mobile unit can only use one channel at a time for its communication link. The channel is not fixed, it can be any one in the entire band assigned by the serving area, with each channel having multichannel capabilities that can connect simultaneously to many mobile units.
The MTSO is the heart of the analog cellular system. Its processor provides central coordination and cellular administration. The cellular switch, which can be either analog or digital, switches calls to connect mobile subscribers to other mobile subscribers and to the nationwide telephone network. It uses voice trunks similar to telephone company interoffice voice trunks. It also contains data links providing supervision links between the processor and the switch and between the cell sites and the processor. The radio link carries the voice and signaling between the mobile unit and the cell site.

(b) What are the limitations of conventional telephone system and explain.

Ans:- The main reasons for developing a cellular mobile communication system over a conventional telephone system are listed below:-

→ Limited Service capability:- A conventional mobile telephone system is usually designed by selecting one or more channels from a specific frequency allocation for use in some autonomous geographic zones. The user who starts a call in one zone has to reinitiate the call when moving into a new zone because the call will be dropped. The disadvantage of conventional telephone system is that the number of active users is limited to the number of channels assigned to a particular frequency zone.

→ Poor Service Performance:- In the past, a total of 33 channels were allocated to three mobile systems: Mobile Telephone Service (MTS), Improved Mobile Telephone service (IMTS) MJ systems, and Improved Mobile Telephone Systems (IMTS) MK systems. MTS operates around 40 MHz and MJ operates at 150 MHz; both provide 11 channels; IMTS MK operates at 450 MHz and provides 12 channels.

These 33 channels must cover an area of 50 miles in diameter. In 1976, New York city had 6 channels of MTS serving 320 customers, with another 2400 customers on a waiting list. New York City also had 6 channels of IMTS serving 225 customers, with another 1300 customers on a waiting list. The large number of subscribers created a high blocking probability during busy hours. Although service performance was undesirable, the demand was still great. A high capacity system for mobile telephones was needed.

→ Insufficient Frequency Spectrum Utilization :- In a conventional mobile telephone system, the frequency utilization measurement M_0 is defined as the maximum number of customers that could be served by one channel at the busy hour.

In 1976, In New York city $M_0 = \frac{\text{No. of customers}}{\text{Channel}}$

$$M_0 = \begin{cases} 53 & \text{customers / channel (MTS system)} \\ 37 & \text{customers / channel (IMTS system)} \end{cases}$$

Assume an average calling time of 1.76 minutes.

Offered load $A = \frac{\text{Average calling time (min)} \times \text{Total customers}}{60 \text{ min}}$

$\Rightarrow A_1 = \frac{1.76 \times 53 \times 6}{60} = 9.33$ Erlangs (MT system)

$A_2 = \frac{1.76 \times 37 \times 6}{60} = 6.51$ Erlangs (MR system)

Given that the number of channels is 6. Greater the value of offered load, greater is the blocking probability. This means that the service is not good. In the above example, A1 service is not preferable. This shows that the frequency spectrum utilization is not done properly in conventional mobile systems.