MOBILE COMMUNICATION

UNIT-2 : CELLULAR CONCEPT

INTRODUCTION

* The design objective of early mobile radio systems was to achieve a large coverage area by using a single, high powered transmitter with an antenna mounted on a tall tower.

* This approach achieved very good coverage, but it was impossible to reuse the same frequencies throughout the system because it would lead to interference.

* The cellular concept offers a very high capacity in a limited spectrum allocation.

* The cellular concept replaces a single, high power transmitter (large cell) with many low power transmitters (small cells), each providing coverage to only a small portion of the service area.

FEATURES OF CELLULAR SYSTEMS

1- Offers very high capacity in a limited spectrum.

2- Reuse of radio channel in different cells.

3- Communication is always between mobile and base station (not directly between mobiles).

4- Each cellular base station is allocated a group of radio channels within a small geographic area called a cell.

5- Neighbouring cells are assigned different channel groups.

6- Keep interference levels within tolerable limits.

7- frequency reuse or frequency planning.

SHAPE OF CELLS

* The coverage area of cellular networks are divided into cells, each cell having its own antenna for transmitting the signals.
* Each cell has its own frequencies.
* Data communication in cellular network is served by its Base Station (BS) Transmitter, Receiver and control unit.
* The shape of the cells can be either square or hexagon but hexagonal cell shape is highly recommended for its easy coverage and calculations.
* The hexagonal shape of cells offers following advantages -
  - Provides equidistant antennas
  - Distance from centre to vertex equals length of side.

FREQUENCY REUSE

Frequency reuse is the concept of using the same radio frequencies within a given area, that are separated by considerable distance, with minimal interference, to establish communication.

The actual radio coverage of a cell is called the footprint.

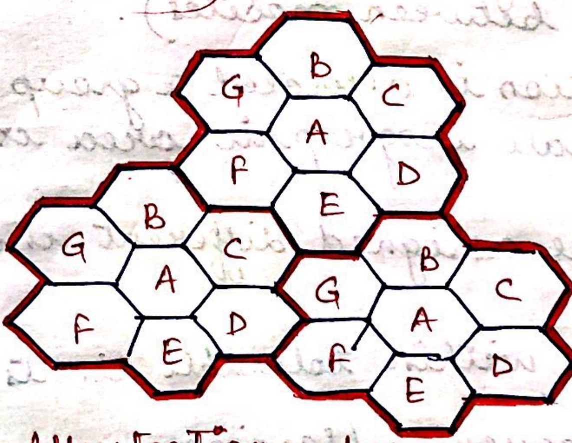


Fig: 1 Illustration of the frequency Reuse Concept

* Cells with the same letter use the same set of frequencies.
* A cell cluster is outlined in bold and is repeated over the coverage area.
* In the shown figure, the cluster size N = 7 (A-to-G) and frequency reuse factor is 1/7 since each cell in a cluster contains one-seventh of the total no. of available channels.

for example: When N cells are using the same no. of frequencies and K be the total no. of frequencies used in systems. Then, each cell frequency is calculated by (K/N).

CELL SIZE

Cells range in size from a few metres to thousands of kms in diameter depending on the technology being used, power of the transmission station and terrain topography.

Wireless Technology	Cell Radius
Wireless LANs →	10 to 100 metres
Cellular Telephone →	0.1 to 50 kms.
PCD (Personal Communication Devices) →	0.1 to 1 km.
Satellite Based →	1000 kms or more.

CELL CLUSTER:

Consider a cellular system having S duplex radio channels. If each cell is allocated a group of k channels and if S channels are divided among N cells, then-

$$k = \frac{S}{N} \Rightarrow \boxed{S = kN}$$

The N cells that collectively use the complete set of available frequencies is called a cluster.

If a cluster is repeated M times, the total capacity is-

$$\boxed{C = MkN = MS}$$

CO-CHANNEL CELLS

If no. of cells in a cluster increase, cluster size increases which also increases the distance between the cells using the same frequency channels, which finally reduces the co-channel interference.

The value of N depends on how much interference a mobile or base station can tolerate while maintain-ing a sufficient quality of communications.

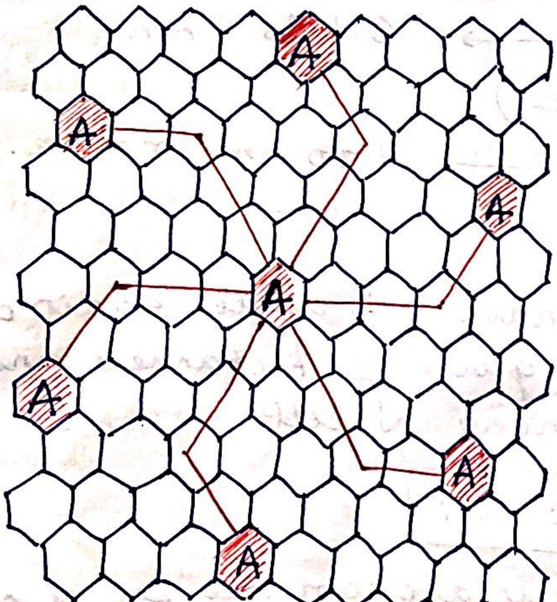
To connect without gaps between adjacent cells, the geometry of hexagons is such that the no. of cells per cluster, N, can have values that satisfy:

$$\boxed{N = i^2 + ij + j^2}$$

where i and j are non-negative integers

How to find the nearest co-channel neighbours of a particular cell, i.e. cells sharing the same channel over a coverage area:

In fig:1, cells with same alphabet are the co-channel neighbours as they share the same channel.



Step-1: move i cells along any chain of hexagons

Step-2: Turn 60° counter clockwise and move j-cells.

The cell finally reached is the co-channel neighbour.

In this figure, $i = 3$, $j = 2$

$\Rightarrow N = 3^2 + 3 \times 2 + 2^2$

$$\boxed{N = 19}$$

Scanned with CamScanner

CO-CHANNEL INTERFERENCE

* Frequency reuse implies that in a given coverage area there are several cells that use the same set of frequencies. These cells are called co-channel cells, and the interference between signals from these cells is called co-channel interference.

* Co-channel interference cannot be reduced by increasing Signal-to-Noise Ratio (SNR) like in thermal noise.

* To reduce co-channel interference, co-channel cells must be physically separated by a minimum distance to provide sufficient isolation due to propagation.

* When the size of each cell is approx. same and base stations transmit the same power, the co-channel interference ratio is dependent on the radius of the cell (R) and distance between the centers of the nearest co-channel cells (D).

* By increasing $\frac{D}{R}$, co-channel interference is reduced

Co-channel Reuse Ratio, $Q = \frac{D}{R} = \sqrt{3N}$

Small value of Q ⟶ larger capacity
Large value of Q ⟶ good transmission quality.

<u>for example</u>: $i=2, j=2$

$\Rightarrow N = i^2 + ij + j^2 = 2^2 + 2\times2 + 2^2 = 12$.

$\Rightarrow Q = \sqrt{3N} = \sqrt{3\times12} = 6$

ADJACENT CHANNEL INTERFERENCE :

* Interference resulting from signals which are adjacent in frequency to the desired signal is called adjacent channel interference.
* It results from imperfect receiver filters which allow nearby frequency to leak into the passband.
* It can be minimized by careful filtering.
* By keeping the frequency separation between each channel in a given cell as large as possible.

POWER CONTROL FOR REDUCING INTERFERENCE

In cellular communication system, the power levels transmitted by every subscriber unit are under constant control by the serving base stations.

It is done to ensure that each mobile transmits the smallest power necessary to maintain a good quality link on the reverse channel.

IMPROVING COVERAGE & CAPACITY IN CELLULAR SYSTEMS

(1) CELL SPLITTING :

Cell splitting is the process of subdividing a congested cell into small cells, each with its own base station with a reduced antenna height and transmitted power.

It increases the capacity of cellular system as it increases the no. of times that channels are reused.

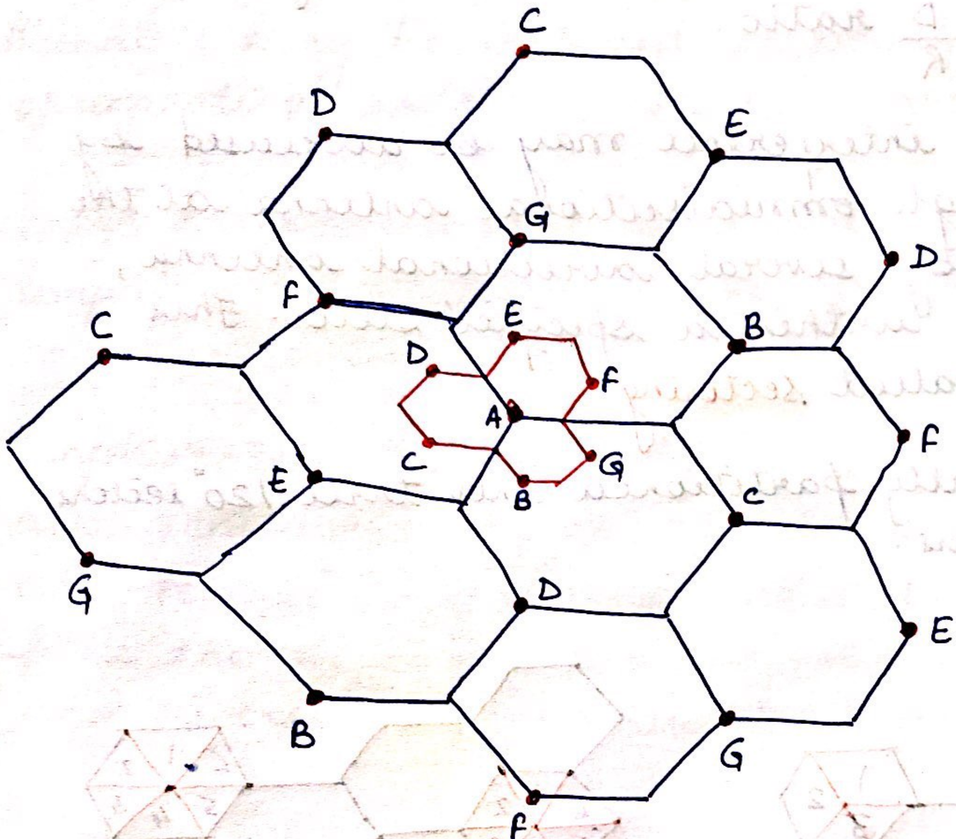


Illustration of Cell Splitting

* In the above figure, the base stations are placed at corners of the cells and the area served by base station A is assumed to be saturated with traffic.

* New base stations are therefore needed in this region to increase the no. of channels in the area.

* In the above figure, original base station A is surrounde-d by six new microcells after cell splitting.

for example: Microcell base station G is placed half way between two larger stations (A and C).

* In this case, the radius of each new cell is half of the original cell.

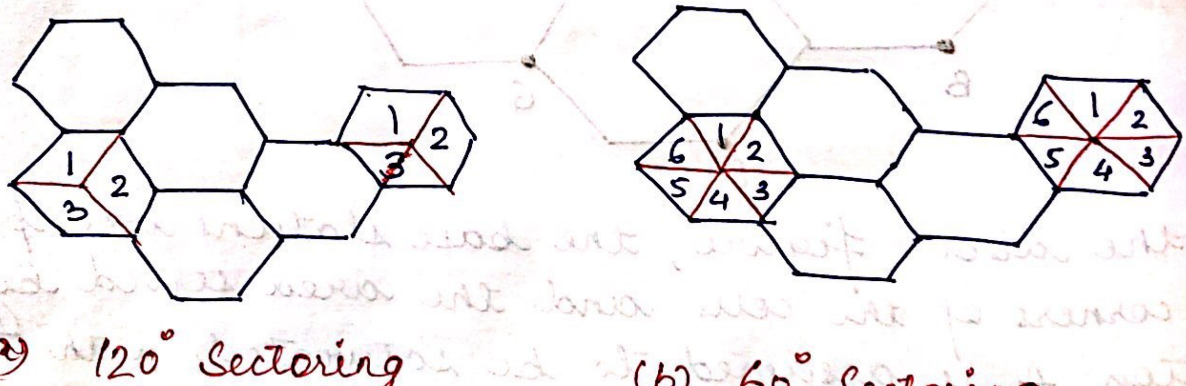
(2) SECTORING:

* Cell splitting increases the no. of channels per unit area while keeping the co-channel reuse ratio $\frac{D}{R}$ unchanged.

* Sectoring keeps the cell radius R unchanged and decreases the $\frac{D}{R}$ ratio.

* The co-channel interference may be decreased by replacing a single omnidirectional antenna at the base station by several directional antenna, each radiating within a specified sector. This technique is called sectoring.

* A cell is normally partitioned into three 120° sectors or six 60° sectors.



(a) 120° Sectoring (b) 60° Sectoring

* When sectoring is done, the channels used in a particular cell are broken down into sectored groups and are used only within a particular sector.

(3) REPEATERS FOR RANGE EXTENSION:

* Radio transmitters, known as repeaters, are often used to provide range extension.

* Repeaters are bidirectional in nature and simultaneously send signals to and receive signals from a serving base station.

* Repeaters may be installed anywhere and are capable of repeating an entire cellular band.

* Upon receiving signals from a base station, the repeater amplifies and reradiates the signals to the specific coverage region.

* Unfortunately, the received noise and interference is also reradiated by the repeater on both the forward and reverse links, so care must be taken to properly place the repeaters and adjust the various forward and reverse link amplifier levels and antenna patterns.