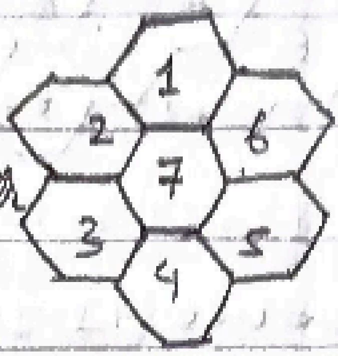
* cellular mobile Telephony



cluster

to substitute singled high powered Transmitter by many low powered transmitter (Honey comb cell pattern) to connect several users.

The basic concept of cellular telephone is It is based on subdividing relatively large geographic area so called coverage zone into small section called cells. cells are hexagonal shaped to form a honey comb pattern so called clusters is defined by size of population and traffic pattern.

In cellular mobile telephony large number of users shares limited number of radio channels available in the region. It provides faster and efficient call processing accomodating large number of user over large geographical area.

The cellular Technology is based on subscriber's density and demand. As the number of user's grow, cell can be added to accomodate that growth. Frequency used in one cell cluster can be reused in other cell. The ongoing conversation or call shifting from one cell to another is maintained (Hand Off). And the cellular radio equipment (Basestation) can communicate with mobile as long as they are within the range of the base station.

* Cell, Hexagonal cell Geometry

Cell:→ The smallest geographical area covered by wireless communication is called cell. It is served by a single base station with allocated group of radio channels for communication.

Cell Geometry:→

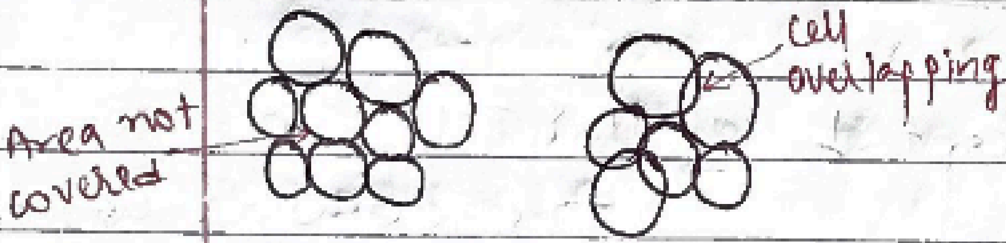


fig:→ Circular pattern of cell.

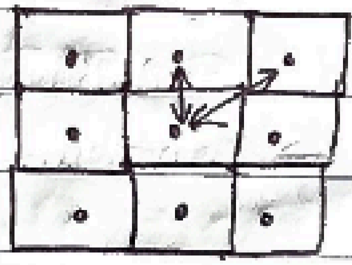


fig:→ Square pattern of cell

There were many types of cell Geometry in early days. Circular pattern shown above had uncovered area and overlapping of cell. Similarly, square or rectangular shape, distance between center of cell were different. It had many drawbacks introducing interference by overlapping of channels.

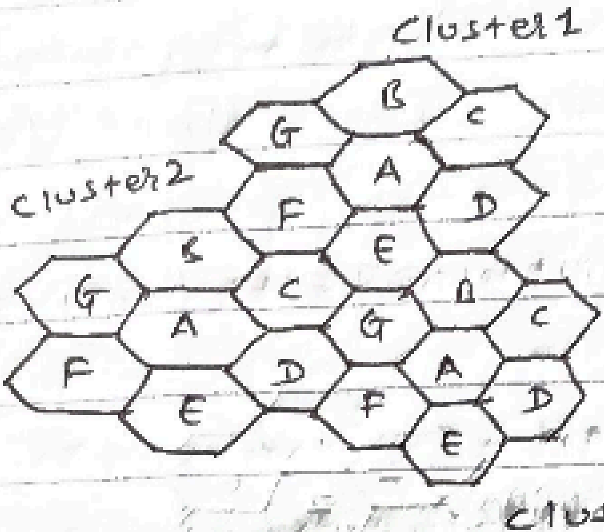
Hexagonal Geometry was most prefered and marked as a standard for cellular technology. Hexagonal Geometry

Basic concept of clustering is

the smaller the number of cell per cluster will have more number of channel per cell increasing the capacity of each cell. However proper balance is required in order to avoid interference.

had accurate coverage and had no interference as they have no uncovered or overlapped Area. They had almost same distance between the center of Hexagon covering largest area than other.

* Frequency Reuse :→



Frequency Reuse is the process of using the same Radio frequency on radio transmitter ~~sites~~ sites within a geographic area which are seperated by sufficient distance to minimize or has minimal interference with each other.

From above figure, Each service Area is divided into clusters. Each cluster has seven channels and cells represented by ABCDEFG and seven frequencies which can be reused same frequency in different cluster.

Mathematically, we can define

Number of channels in a cluster

$$\boxed{F = GN}$$

where, G = Number of channel in a cell.

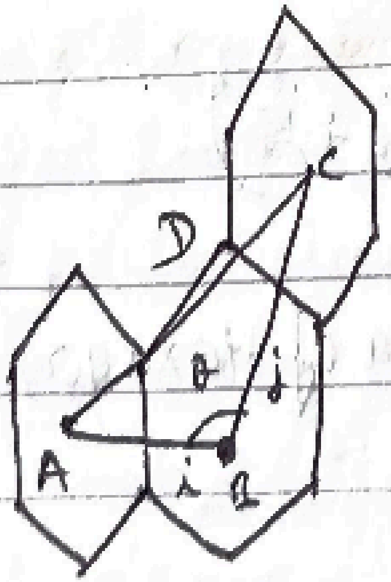
N = Number of cells in a cluster.

* Cluster :->

A Group of cell is called cluster. The available spectrum or group of channel are divided equally among th cell in the cluster.

The typical cluster size may be 4, 7, 12 or 21 cell. The number of cell per cluster 'N' can be calculated as

$\boxed{N = i^2 + ij + j^2}$ where i & j are non-negative integers.



Taking Cosine law of triangle

$D^2 = i^2 - 2ij\cos\theta + j^2$ — (1)

As per cluster design

$\theta = 120^0$

$D^2 = i^2 + ij + j^2$ — (2)

'i' is a direction stating number of cells and j is a direction 60^0 anticlockwise from 'i' which indicates number of cell. i & j are positive integers.

Let R_p is perpendicular distance from center to its one side, then

$$R_p = \frac{\sqrt{3}}{2} R$$

∴ center to center distance betn two cell is

$$2R_p = \frac{\sqrt{3}}{\cancel{2}} R \times \cancel{2}$$

$$2R_p = \sqrt{3}\, R \qquad (2)$$

we generalize above equation as

$$D^2 = (i \times 2R_p)^2 + (i \times 2R_p)(j \times 2R_p) + (j \times 2R_p)^2$$

$$D^2 = (2R_p)^2 (i^2 + ij + j^2)$$

$$D^2 = \left(\cancel{2} \times \frac{\sqrt{3}}{\cancel{2}} R\right)^2 (i^2 + ij + j^2)$$

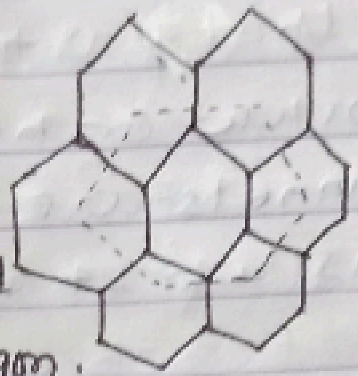
$$D^2 = 3R^2 (i^2 + ij + j^2)$$

Now, Considering Area of Hexagon for Radius 'R'

$$A_R = \frac{3\sqrt{2}}{2} R^2$$

For Radius D

$$A_D = \frac{3\sqrt{2}}{2} D^2$$



$\frac{A_D}{A_R} = \frac{D^2}{R^2}$ is the number of cell enclosed inside the large Hexagon.

From Geometry of cell of large and small Hexagon, we have

$$N + 6\left(\tfrac{1}{3}N\right) = \frac{D^2}{R^2}$$

$$\cancel{3}N = \frac{D^2}{R^2} = \frac{\cancel{3}\cancel{R^2}(i^2+ij+j^2)}{\cancel{R^2}}$$

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

* Channel Assignment Strategies :→ There are two types of channel Assignment strategies
1) Fixed Channel Assignment (FCA)
2) Dynamic Channel Assignment (DCA)

1) Fixed Channel Assignment (FCA) :→ It is the simplest type of Channel Assignment strategy where each cell is allocated with

fixed number of voice channel. The communication can be established in the cell with the designated unused channel of that particular cell. The call is blocked or have to wait if all the channels are occupied. Therefore FCA has worst utilization of channel.

2. Dynamic channel Assignment (DCA):→

Dynamic channel Assignment (DCA) are based on assigning channel for the duration of call. After completion the channels are set free and are further assigned or allocated by MSC on the request of Base station (B.S).

The same channels are assigned simultaneously by MSC ensuring the distance between two cell is larger than minimum Reuse distance. This strategy increases the trunking capacity of the network and avoids block or wait of call.

* Frequency Re-use continue

As per geometry of hexagon, no of cells per cluster or cluster size is given by $N = i^2 + ij + j^2$.

For $i = j = 1$ cluster size $N = 3$

For $i = 1, j = 2$ " " $N = 7$

For $i = j = 2$ cluster size $N = 12$

If N is reduced while the cell size is kept constant, more number of clusters are required to cover the same area. Hence capacity is increased. smaller cluster size will bring the cell closed to each other.

1) calculate the number of Reuse Frequency and draw the frequency reuse cell for

$i = 2$ & $j = 1$.

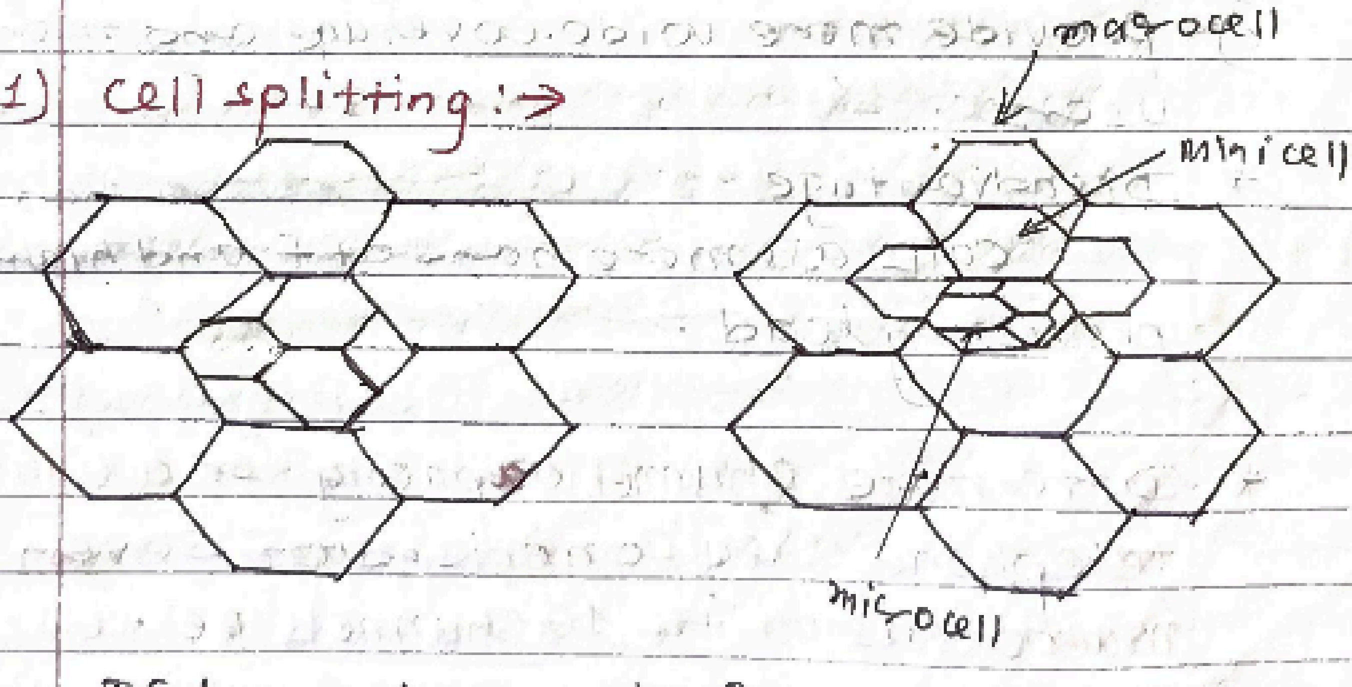
$N = i^2 + ij + j^2 = 2^2 + 2.1 + 1^2 = 7$

* Expanding or Improving the Capacity of Cellular System

The band of frequency allocated for cellular system can be reused in different clusters. Service provider builds their network and design them to provide coverage to the area and expectation of possible increase in population in the future.

In some cases it is difficult to predict need for network expansion. Thus there are several techniques to expand an already existing network to add more capacity to the present network.

1) Cell splitting :→



If the network is functioning, it may be found that the network needs expansion only in specific regions due to increase of traffic density. The area of cell is further divided creating more cell areas as shown in the above figure.

Thus, cell splitting is the process of subdividing highly congested cells into smaller cells each with their own base station and set of channel frequencies.

This increases the channel capacity and network coverage and number of users.

Cell splitting is benefited by

a) providing increase in the degree of frequency reuse.

b) Increase channel capacity.

c) Provide more wide coverage and more users.

* Disadvantage

calls are more handoff and has higher processing load.

* Determine channel capacity for a cellular telephone area comprised of seven macrocells with 10 channels per cell.

a) Channel capacity if each macrocell is split into 4 minicells.

b) Channel capacity if each minicell is further split into four microcells :

* Answer

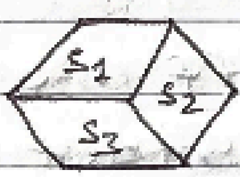
Channel capacity of cellular telephone area = 10 channel/cell × 7 cells/area

= 70 channel/area

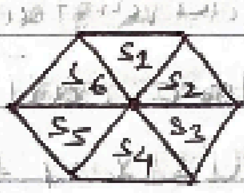
a) splitting each macrocell into four minicell
Channel capacity = 10 × 7 × 4 = 280 channels/area

b) splitting each mini cell into four microcell
Channel capacity = 10×7×4×4 = 1120 channels/area

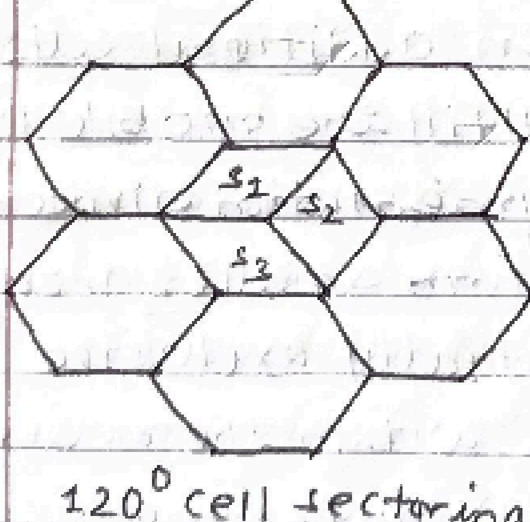
2)* Sectoring :→



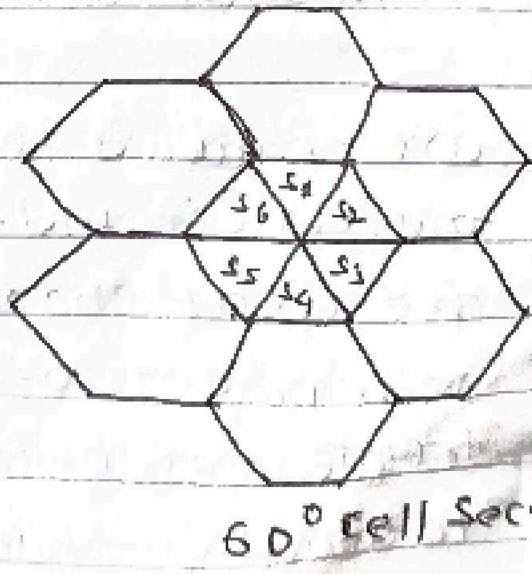
120° cell sectoring



60° cell sectoring



120° cell sectoring



60° cell sectoring

In this method each cell which has same coverage space using single omni - directional antenna been replaced by 3 or 6 directional antenna to cover the specified sector of the region or cell is called sectoring. With three directional antenna 120° sectoring is achieved and with six directional antenna 60° sectoring is achieved.

* Benefits
1) Decrease of Co-channel Interference.
2) Increasing capacity and number of user.
3) Improves S/I ratio.

* Disadvantage

More calls are handoff and higher processing load per subscriber. Increased number of Antenna. Decrease in Trunk Efficiency.

3) Segmentation :→

When additional cells are required to fullfill the mobile user market demand. Segmentation divides group of channel into smaller groupings or segments of mutually exclusive frequencies which are within the reuse distance to avoid Co-channel Interference.

* Roaming and Handovers (Handoff)

Roaming is defined as the ability to make and receive voice calls, send and receive data or access other services when you are travelling outside the geographical coverage area of home network PLMN. (Pubic land mobile Network)

If the visited network is in same country as your home network, this is known as National Roaming. If the visited network is outside the home country, this is known as International Roaming which is also termed as Global Roaming.

* Hand overs (Hand off):→

MSC automatically transfers the call to new FDD channel without disturbing conversation

The process of transfering an ongoing mobile phone call or data session from one base station to an adjacent base station as the user in the motion is called Hand off. There are two types of hand off

1) Hard Hand Off:→

In hard hand off, the mobile unit is actively connected to one tower or base station at a time. When the user moves to another cell the connection to the present base station need to break for a certain time to establish connection to new tower or base station. It has more chances to call drop. The carrier frequency is changed in Hard Hand off when entering from one cell to another.

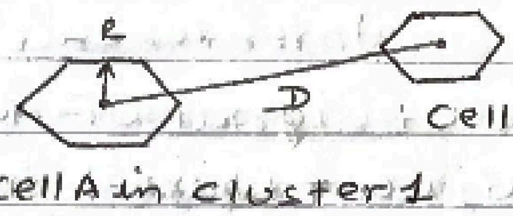
2) Soft-Handoff :→

In soft hand off the original Connection doesnot required to break. The mobile unit establishes Connection with new base station with smoother transition is called soft-handoff. It has less chance for dropped call or signal. In soft Handoff no change of frequency takes place while entering from one cell to another

* Interference

Superimpose or mixing of signal of same frequency from one cell to another or within a cell is called Interference. They are two types of Interference in cellular system

1) Co-channel Interference :→



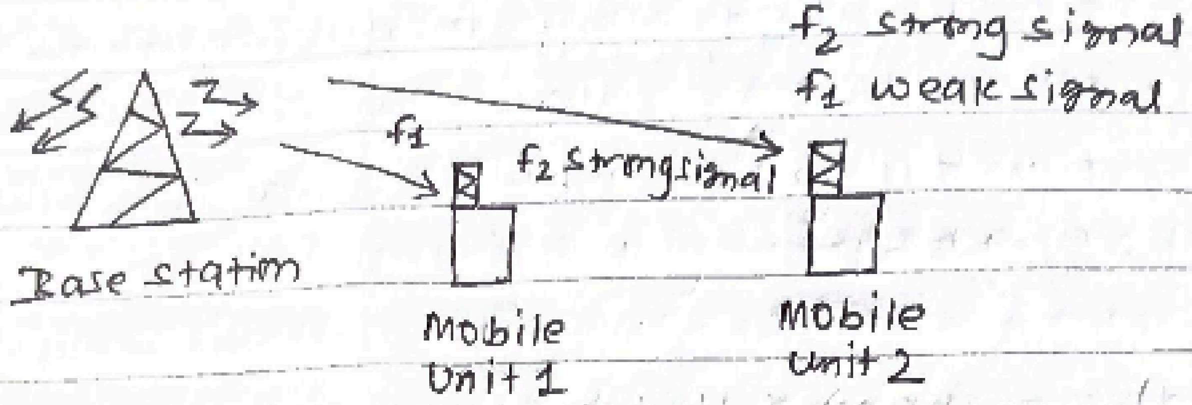
In cellular network number of frequency is limited. So, frequencies must be reused as the traffic increases which introduces risk of Interference. Two cells using the same set of frequencies of different cluster are called Co-Channel cells. Interference between the Co-Channel cells give rise to bad speech quality, dropped calls and low data throughput is called Co-Channel Interference.

To overcome Co-Channel Interference the co-channel reuse ratio should be large. Distance between two co-channel cells should be optimum. Mathematically,

$$\boxed{Q = \frac{D}{R}}$$

Q ⇒ Co-Channel Reuse Ratio
D ⇒ Distance between two Co-channel cell
R ⇒ Cell Radius

2) Adjacent channel Interference



Interference caused by the extrapower of signal of adjacent channel is called Adjacent Channel Interference.

In above figure Base station transmits more power to greater distance mobile Unit 2 and less power to mobile Unit 1. The 'f_2' strong signal will interfere in mobile unit 1 which is acquiring less power frequency 'f_1'. This is called near-far effect. This Interference of signal is called Adjacent channel Interference.

It can be minimized by precise filtering and making careful channel assignments. Keeping the frequency seperation between each Channel as large as possible minimizes Adjacent Channel Interference.