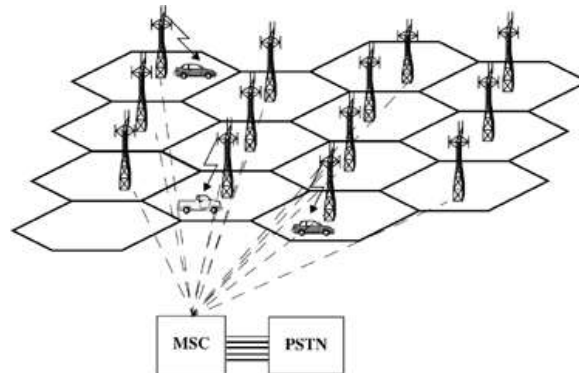


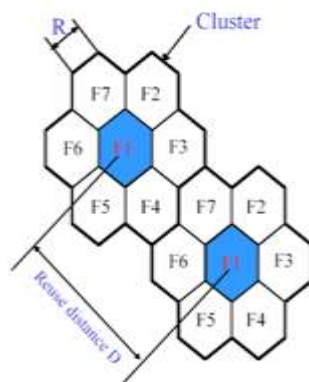
Draw basic cellular system. State the advantages of cellular system and define frequency reuse ratio.



Advantages of Cellular System:

- The cellular system divides a large geographic area into cells with diameters from 2 to 50 km, each of which is allocated a number of RF channels.
- Transmitter in each adjacent cell operate on different frequencies to avoid interference.
- However, transmit power & antenna height in each cell are relatively low, cells that are sufficiently far apart can reuse the same set of frequencies without causing co-channel interference.
- As the demand for cellular mobile service grows, additional cells can accommodate the traffic.

Frequency Reuse Ratio:



For hexagonal cells, the reuse distance is given by

$$D = \sqrt{3N} \times R$$

where R is cell radius and N is the reuse pattern (the cluster size or the number of cells per cluster)

Reuse factor is

$$\frac{D}{R} = \sqrt{3 \times N}$$

Define forward control channel and reverse control channel. 2M

Ans : Forward control channel:-

Radio channel used for transmission of **data from base station to mobile stations.**

Reverse control channel:-Radio channel used for transmission of **data from Mobile station to base stations**

Define the following terms :

i) Base Station: –

A fixed station in a mobile radio system used for radio communication with mobile stations. Base stations are located at the center or on the edge of a coverage region and consist of radio channels and transmitter and receiver antennas mounted on a tower.

ii) Control Channel:

It is defined as the radio channel used for the transmission of beacons such as call set up, call request, call initiation as well as the control information.

iii) Mobile Station:

It is defined as a station in the cellular radio service which is used when in motion at an unspecified location. Mobile stations can be portable hand held personal units or they can be the ones installed in vehicles.

iv) Mobile Switching center:

Also called a Mobile Telephone Switching Office (MTSO) is a switching center which coordinates the routing of calls in a large service area. In a cellular radio system, the MSC connects the cellular base stations and the mobiles to the PSTN (Public Switched Telephone Network, PSTN, is a global telecommunications network which connects conventional landline telephone switching centers, called central offices, with MSCs throughout the world).

Explain the term cell splitting. 2M

Ans :

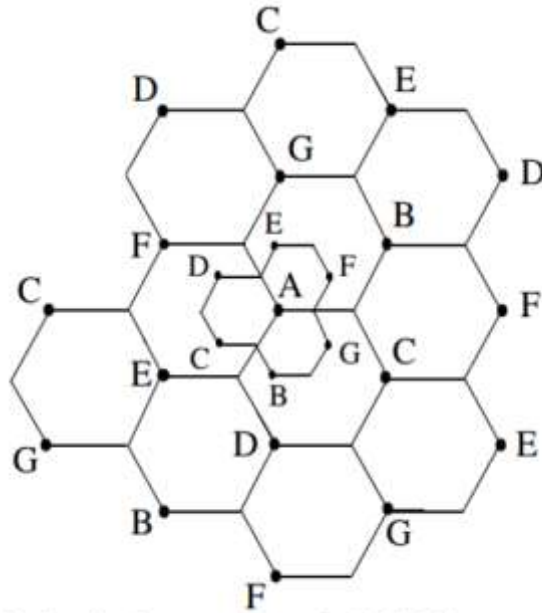
Cell splitting:-

- Cell splitting is the process of subdividing a congested cell into smaller cells, each with its own base station and corresponding reduction in antenna height and transmitter power.
- Cell splitting increases the capacity of a system since it increases number of times that channels are reused.

What is cell splitting? State its type.

Cell splitting is the process of subdividing a congested cell into smaller cells, each with its own base station and a corresponding reduction in antenna height and transmitter power.

- Cell splitting increases the capacity of a cellular system since it increases the number of times that channels are reused. By defining new cells which have a smaller radius than the original cells and by installing these smaller cells (called microcells) between the existing cells, capacity increases due to the additional number of channels per unit area.



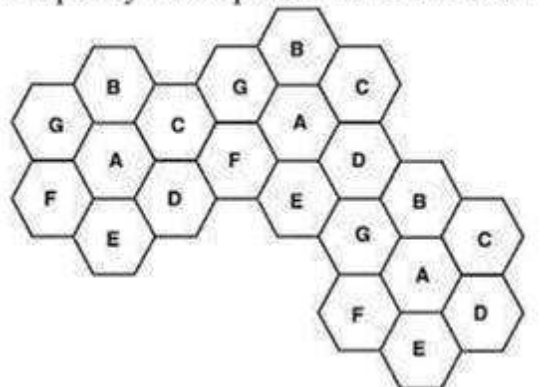
What is Cell and Cluster ? Describe the concept of frequency Reuse. Draw frequency Reuse pattern with cluster size 7.

6M

Ans:

- **Cell:** Each cellular base station is allocated group of radio channels to be used within a small geographic area called “cell”
- **Cluster:** The Number of cells which collectively use the complete set of available frequency is called CLUSTER
- Base stations in adjacent cells are assigned channel group which contains completely different channels than neighboring cell.
- By limiting coverage area to within the boundaries of cell, the same group of channels may be used to cover different cells that are separated from one another by distance large enough to keep interference level within tolerable limits.
- The design process of selecting and allocating channel groups for all the cellular base station within a system is called **frequency reuse** or **frequency planning**.
- Frequency reuse is important as the spectrum allocated for cellular transmission is limited and demand is increasing rapidly

Frequency Reuse pattern for cluster size 7



State the types of interference in cellular system. Explain any one type in Detail. 4M

Ans

Types of Interference in cellular system:-

The common types of interference in cellular networks are:

1. Self-interference
2. Multiple access interference
3. Co-channel interference (CCI)
4. Adjacent channel interference (ACI).
5. Near-End-Far-End Interference

Explanation:-

Self-interference

Self-interference is due to interference induced among signals that are transmitted from a shared transmitter. The amount of interference induced depends on the modulation type. Interference between the uplink and downlink transmissions in a FD duplex system may be classified as self interference, as it occurs among signals send on the same two-way connection.

OR

Multiple access interference

Multiple access interference refers to the interference induced among the transmission from multiple radios using the same frequency resource to a single receiver.

OR

Adjacent-Channel Interference:

It occurs in a radio **channel** when unwanted energy from **channels adjacent** to it falls into its desired bandwidth.

OR

Next-Channel Interference:

- Next-channel interference will arrive at the mobile unit from other cell sites if the system is not properly.
- Mobile unit initiating a call on a control channel in a cell may cause interference with the next control channel at another cell site.
- The filter with a sharp falloff slope can help to reduce all the adjacent-channel interference, including the next-channel interference.

OR

Co-channel interference (CCI) –When interference occurs in the cells having same channel set is called co-channel interference ,to reduce it the co-channels have to be separated by sufficient amount of distance.

OR

Neighboring-channel Interference:

- The channels which are several channels away from the next channel will cause interference with the desired signal.
- A fixed set of serving channels is assigned to each cell site.
- If all the channels are simultaneously transmitted at one cell site antenna, a sufficient amount of band isolation between channels is required for a multi-channel combiner to reduce intermodulation products,

OR

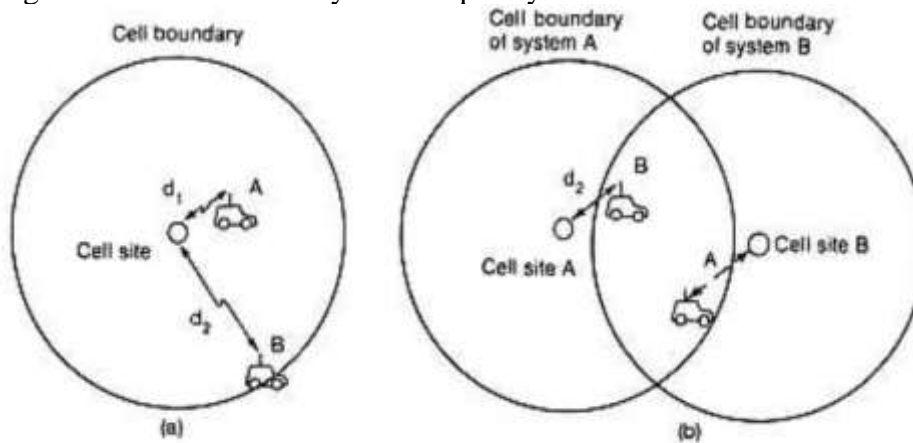
Near-End-Far-End Interference:

➤ **In One Cell :**

- The close-in mobile unit has a strong signal which causes adjacent-channel interference
- In this situation, near-end-far-end interference can occur only at the reception point in the cell site as shown in fig (a)

➤ **In Cells of Two Systems:**

- The frequency channels of both cells of the two systems must be coordinated in the neighborhood of the two- system frequency bands. The situation can be seen in fig: (b)



Compare between Hard handoff and soft handoff.(Any four points)

Hard handoff	Soft handoff
1.The definition of a hard handover or handoff is one where an existing connection must be broken before the New one is established.	1.Soft handoff is defined as a handover where a new connection is established before the old one is released
2. Hard handoffs allocate different frequency of user.	2.Soft handoff allocate Same frequency.
3.In hard handoff a handset always Communicates with one BS at any given time.	3.In soft handoff a handset may connect up to three or four radio links at the same Time.
4. Hard Handoff is typically used in TDMA and FDMA systems.	4.Soft handoff used in CDMA and some TDMA systems
5. Hard handoff is not very complicated.	5.Soft handoff is more complicated than Hard handoff.
6.Hard handoff is noticeable	6. Soft handoff is not noticeable.

Describe the concept of cell splitting using suitable diagram. 4M

Ans:

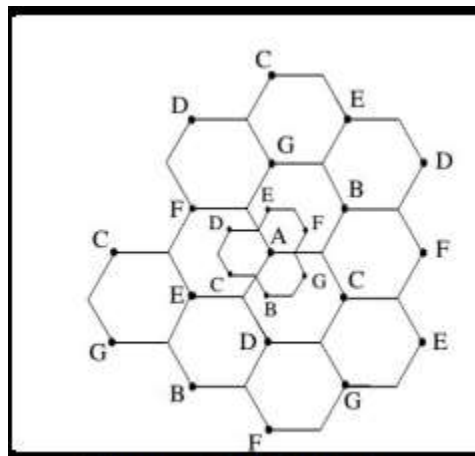


Figure: Cell Splitting

- Cell splitting is the **process of subdividing a congested cell into smaller cells**, each **with its own base station** and a corresponding **reduction in antenna height and transmitter power**.
- Cell splitting increases the capacity of a cellular system since it increases the number of times that channels are reused.
- By defining new cells which have a smaller radius than the original cells and by installing these smaller cells (called microcells) between the existing cells, capacity increases due to the additional number of channels per unit area. Imagine if every cell in Figure were reduced in such a way that the radius of every cell was cut in half.
- In order to cover the entire service area with smaller cells, approximately four times as many cells would be required.
- This can be easily shown by considering a circle with radius R .
- The area covered by such a circle is four times as large as the area covered by a circle with radius $R/2$.
- The increased number of cells would increase the number of clusters over the coverage region, which in turn would increase the number of channels, and thus capacity, in the coverage area.
- Cell splitting allows a system to grow by replacing large cells with smaller cells,

State any two advantages and disadvantages of sectoring in cellular system. 4M

Ans:

Advantages: (Any 2)

1. Improves System capacity
2. Co-channel Interference can be reduced.

Disadvantages: (Any 2)

1. The number of handoffs will increase.
2. Hardware requirement will increase.

State any four advantages of microcell zone concept. 4M

Ans:

Advantages of Microcell zone concept are as follows:-

1. It reduces the co-channel interference.
2. It improves signal quality.
3. It increases system capacity.
4. There is degradation in the trunking efficiency.

Define handoff. List the types of handoff used in cellular system.

Definition: When a mobile moves into a different cell while a conversation is in progress, the MSC automatically transfers the call to a new channel belonging to the new base station. This procedure is called **handoff**.

The handoffs are of following types:

- Hard Handoff
- Soft Handoff
- Queued Handoff
- Delayed Handoff
- Intersystem Handoff
- Intrasystem Handoff
- Network controlled Handoff (NCHO)
- Mobile Assisted Handoff (MAHO)

Explain two level handoff (proper and improper handoff) with suitable diagram.

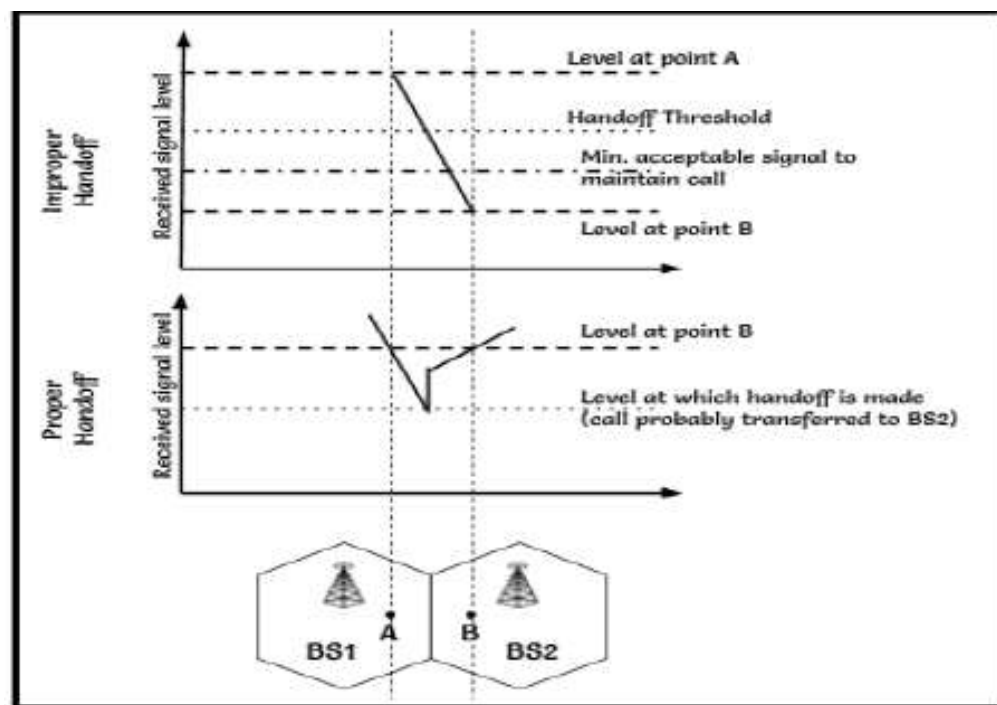


Figure: Handoff Process

- Figure shows the case where a handoff is not made and the signal drops below the minimum acceptable level to keep the channel active.
- This dropped call event can happen when there is an excessive delay by the MSC in assigning a handoff or when the threshold Δ is set too small for the handoff time in the system.
- Excessive delays may occur during high traffic conditions due to computational loading at the MSC or due to the fact that no channels are available on any of the nearby base stations (thus forcing the MSC to wait until a channel in a nearby cell becomes free).
- In deciding when to handoff, it is important to ensure that the drop in the measured signal level is not due to momentary fading and that the mobile is actually moving away from the serving base station.
- The time over which a call may be maintained within a cell, without handoff, is called **DWELL TIME**. The dwell time of a particular user is governed by number of factors including propagation, interference, distance between the subcarrier & the base station & other time varying effects.

Define the term adjacent channel interference. State methods to reduce it. 4M

Ans: (Define = 2M, Methods to reduce interference = 2M)

Adjacent channel interference:

Interference resulting from signals which are close in frequency to the desired signal is called adjacent channel interference. Adjacent channel interference results from imperfect receiver filters which allow nearby frequencies to leak in to pass band.

It is serious problem can be a particularly serious if an adjacent channel user is transmitting very close range to a subscribers receiver, while receiver attempts to receive a BS on the desired channel this is referred to as near far effect

To reduce the interference:

The adjacent channel interference can be reduced by

1) Careful filtering

2) Careful channel assignment.

- There should be adequate frequency separation between the spectrums of the adjacent channels in a cell

- If the frequency reuse factor is large or cluster size is small the adjacent channel at the base station will be too close to each other in the frequency domain and this will increase the interference.

State different techniques used in cellular system to improve coverage and capacity of cellular system. Describe any one in detail with diagram. State how it increases system capacity.

Techniques for improving capacity:

Cell splitting

Cell sectoring

Microcell-zone concept

Repeaters for Range Extension

Frequency Reuse

Cell splitting is the process of subdividing congested cell into smaller cells, each with its own base station and a corresponding reduction in antenna height and transmitter power.

Cell splitting increases capacity of a cellular system since its increases the number of times

that channels are reused.

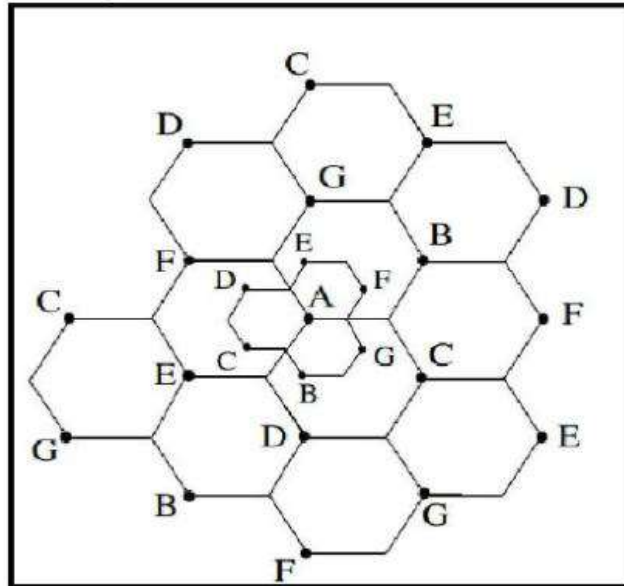


Figure: Cell Splitting

Cell sectoring increases SIR using directional antennas, then capacity improvement is achieved by reducing the number of cells in a cluster, thus increasing frequency reuse. Often wireless operator needs to provide dedicated coverage for hard-to-reach areas. Such as within buildings, or in valleys or tunnels. Radio transmitters, known as **repeaters** are often used to provide such range (coverage) extension capabilities.

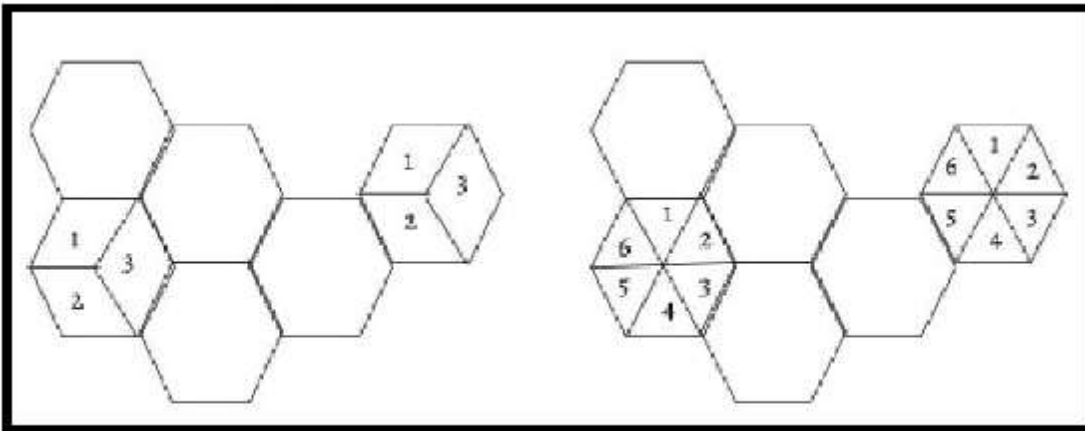
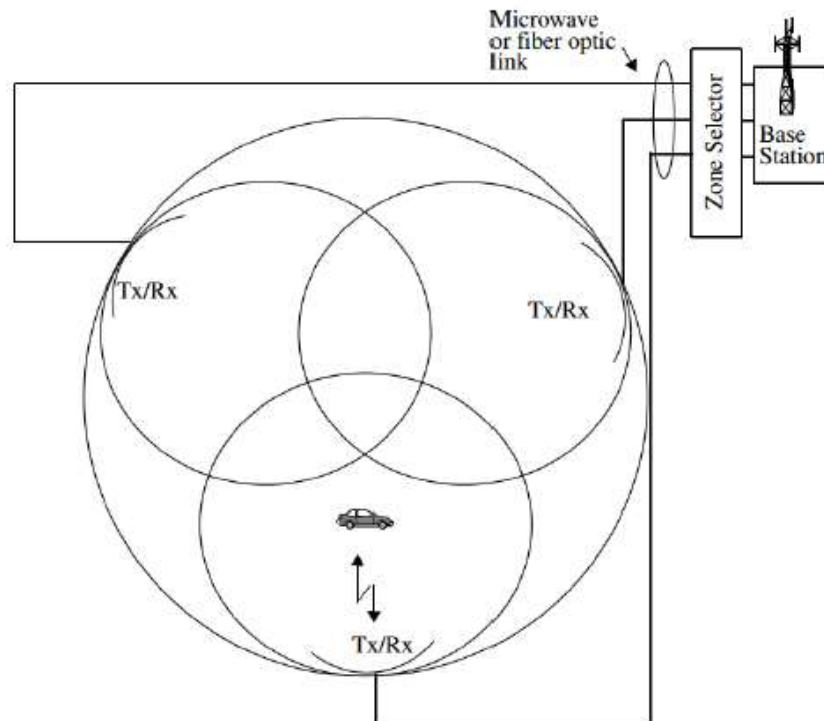


Figure: Cell Sectoring (120° & 60°)

Microcell-zone concept:



The **problem** associated **with sectoring technique** is the **increase in number of handoffs**. This **puts** an additional **load on the switching and control link elements of the mobile system**. A **solution** to this **problem** is **microcell concept**.

In this scheme, all the **three or more zone sites** represents as **Tx/ Rx** are **connected to the same base station and share the same radio equipment**.

The transmission media used for connecting the zones to the base station are coaxial cable, fiber optics cable or a microwave link.
So each cell consists of a base station and multiple zones.

A mobile travelling within a cell, is served by the zone that has the strongest signal of all.

The antennas in zones are placed at the outer edges of the cell and any base station channel can be assigned to any zone by the base station.

As a mobile travels from one zone to the other within a cell, it uses the same channel . This will avoid hand-off.

The base station will just switch the channel to the appropriate zone sit.

Thus a given channel is being used only in a particular zone in which the mobile is travelling.
So **the base station radiation is localized.**

This will reduce interference. The channels are distributed in time and space by all the zones are also reused in the co- channels cells.

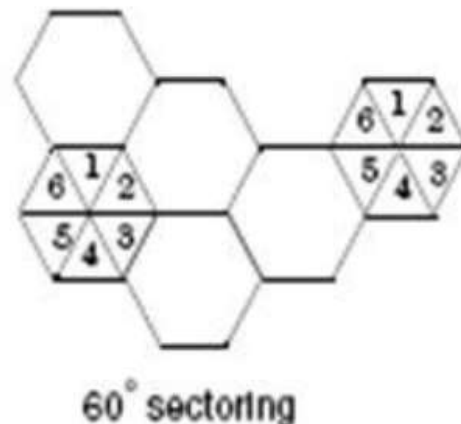
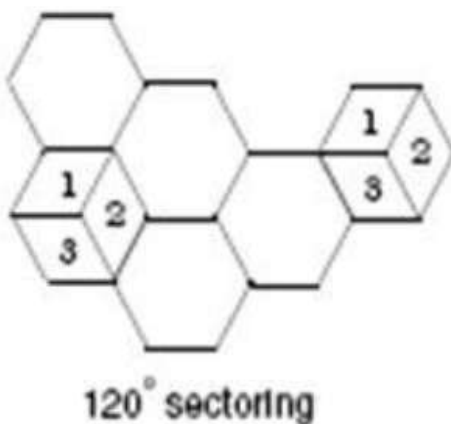
The microcell concept is very useful along highways or in the busy urban areas.

How cell sectoring improve capacity in cellular system? 4M

Ans:

Cell Sectoring

- The technique for **decreasing the co- Channel interference and thus increasing system performance** by using **directional antenna is called Sectoring**.
- To increase capacity in cellular systems, the cell radius is unchanged and seek methods to decrease D/R ratio.
- This is done by Cell Sectoring.
- **Sectoring increases SIR** so that the cluster size may be reduced.
- First the SIR is improved using directional antennas, and then capacity improvement is achieved by reducing the number of cells in a cluster, thus increasing frequency reuse.
- To achieve this, it is necessary to reduce the relative interference without decreasing the transmit power.
- The co-channel interference in a cellular system may be decreased by replacing a single omni-directional antenna at the base station by several directional antennas, each radiating within a specified sector.
- The factor by which the co-channel interference is reduced depends on the amount of sectoring used.
- A cell is normally partitioned into three 120° sectors or six 60° sectors as shown in figure. In sectoring, the channels used in a particular cell are broken down into sectorized groups and are used only within a particular sector.
- Assuming seven-cell reuse, for the case of 120° sectors, the number of interferers in the first tier is reduced from six to two.
- This is because only two of the six co-channel cells receive interference with a particular sectorized channel group.



**What is meant by Hand-off? List different types of Hand-off. Explain any three in detail.
6M**

Ans: Definition of Hand-off:

When a mobile moves into a different cell while a conversation is in progress, the MSC automatically transfers the call to a new channel belonging to the new base station. This procedure is called handoff.

Different types of Hand off:

- 1)Hard Handoff
- 2)Soft Handoff
- 3)Mobile assisted Handoff
- 4)Intersystem Handoff
- 5)Delayed Handoff
- 6)Queued Handoff
- 7)Intra system Handoff
- 8)Network controlled Handoff(NCHO)
- 9)Mobile Assisted Handoff(MAHO)

Hard Handoff:

- 1.The definition of a hard handover or handoff is one where an existing connection must be broken before the new one is established.
- 2.Hard handoff allocate different frequency of user.
- 3.In hard handoff a handset always communicates with one BS at any given time.
- 4.Hard Handoff is typically used in TDMA and FDMA systems.
- 5.Hard handoff is not very complicated

Soft Handoff:

- 1.Soft handoff is defined as a handover where a new connection is established before the old one is released.
- 2.Soft handoff allocate same frequency.
- 3.In soft handoff a handset may connect up to three or four radio links at the same time.
- 4.Soft handoff used in CDMA and some TDMA systems.
- 5.Soft handoff is more complicated than hard handoff.

Delayed Handoff:

- 1.A Delayed handoff is a two hand off level algorithm. It provides more opportunity for a successful handoff.
- 2.The MTSO always handles the handoff first and the originating calls second. If no neighboring cells are available after the second handoff level is reached, the call continues until the signal strength drops below the threshold level then the call is dropped.
- 3.Lower handoffs help in handling call processing more adequately.
- 4.It makes the handoff occur at the proper location and eliminates possible interference in the system.

Queued Handoff:

- 1.Queued handoff is more effective than two threshold level handoffs.
- 2.The MTSO will queue the requests of handoff calls instead of rejecting them if the new cell sites are busy.
- 3.With Queuing of originating calls only, the probability of blocking is reduced.
- 4.It is effective when implementing a simple queue for handoff calls which reduces call drops

If 20 MHz of total spectrum is available for duplex system which uses 225 kHz simplex channels to provide full duplex voice and control channels, compute number of channels available per cell if a system uses seven cell frequency reuse pattern

Total BW = 20 MHz

Channel BW = 225KHz*2 simplex channels = 450 KHz /duplex channel

Total available channels = 20000KHz/450KHz = 44.4 channels

For N=7 , Total no. of channels available per cell is $44.4/7 = 6.34$ channels

Define the term co-channel interference. State cause and effect of co-channel interference on system capacity

Definition:

Frequency reuse implies that in a given coverage area there is 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

Cause of co-channel interference:

- In Cellular mobile communication, frequency spectrum is divided into non-overlapping spectrum bands which are assigned to different cells .
- In cellular communications, a cell refers to the hexagonal/circular area around the base station antenna.
- However, after certain geographical distance, the frequency bands are re-used, i.e. the same spectrum bands are reassigned to other distant cells. The co-channel interference occurs due to Frequency reuse.
- Thus, besides the intended signal from within the cell, signals at the same frequencies (cochannel signals) arrive at the receiver from the undesired transmitters located (far away) in some other cells and lead to deterioration in receiver performance.

Effect of co-channel interference:

- Co channel Interference plays an important role in determining the quality of service.
- QOS is measured by coverage, call blocking, call dropping, Audio quality.
- Audio quality is mainly affected by co channel Interference.
- The capacity of the channel is affected significantly by co channel Interference.
- Co channel Interference also decides the frequency reuse plan and link performance

