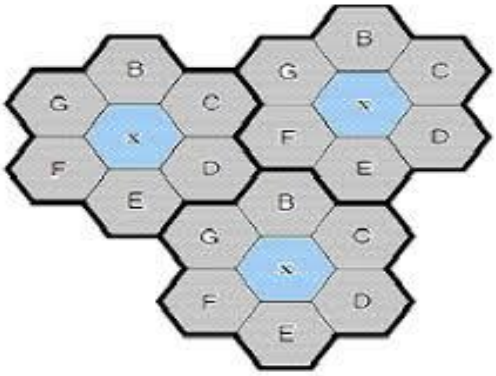
CELLULAR CONCEPT

A **cell** is the geographic area that is covered by a single base station in a cellular network. A network for wireless communications is comprised of a large number of base stations to efficiently use radio spectrum to cover the service area. Geographically separated frequencies may be reused many times.

Hexagonal cell shape is perfect over square or triangular cell shapes in cellular architecture because it cover an entire area without overlapping i.e. they can cover the entire geographical region without any gaps. Each cell has its own base station with transmitter power and antenna height.



A cluster is group of cells in which no frequency is reused within a cluster.
Frequencies used in one cell cluster can be reused in another cluster of cells.
A cell is basic geographical area covered by cellular transmitters
for communication in cellular system.

The different types of cells are given different names according to their size and function:

- MACRO CELLS: Macro cells are large cells that are usually used for remote or sparsely populated areas. These may be 10 km or possibly more in diameter.
- MICRO CELLS: Micro cells are those that are normally found in densely populated areas which may have a diameter of around 1 km.
- PICO CELLS: Pico cells are generally used for covering very small areas such as particular areas of buildings, or possibly tunnels where coverage from a larger cell in the cellular system is not possible. Obviously for the small cells, the power levels used by the base stations are much lower and the antennas are not

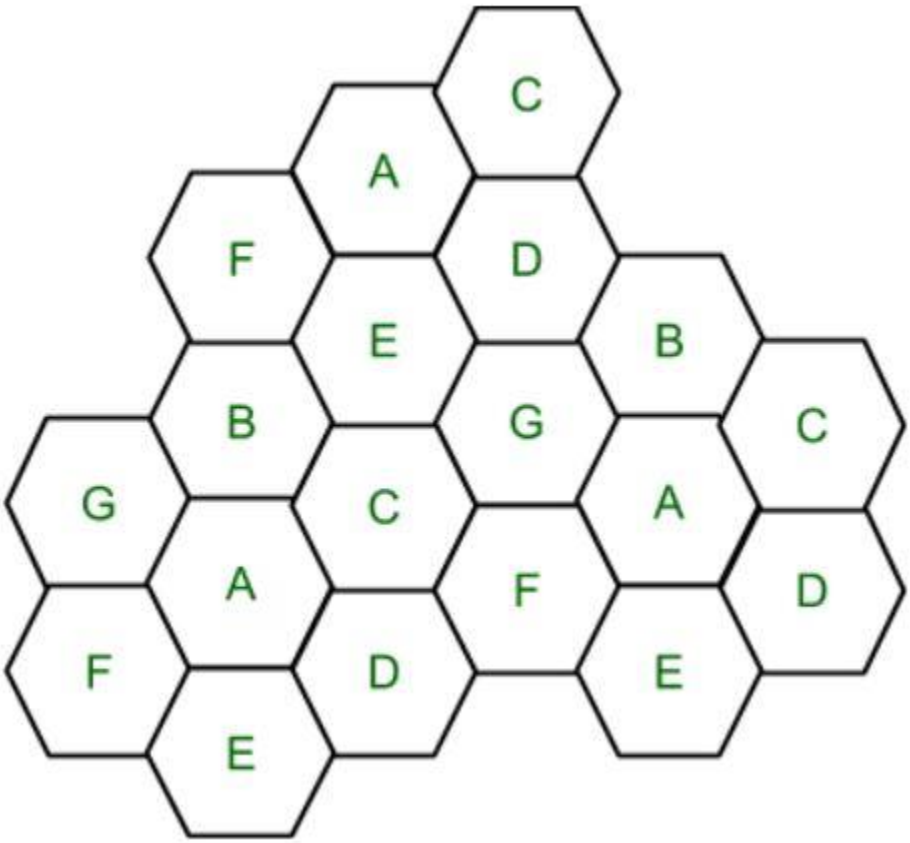
position to cover wide areas. In this way the coverage is minimized and the interference to adjacent cells is reduced.

- SELECTIVE CELLS: Sometimes cells termed selective cells may be used where full 360 degree coverage is not required. They may be used to fill in a hole in the coverage in the cellular system, or to address a problem such as the entrance to a tunnel etc.
- UMBRELLA CELLS: Another type of cells known as an umbrella cell is sometimes used in instances such as those where a heavily used road crosses an area where there are microcells. Under normal circumstances this would result in a large number of handovers as people driving along the road would quickly cross the microcells.

Frequency Reuse

Frequency Reuse is the scheme in which allocation and reuse of channels throughout a coverage region is done. Each cellular base station is allocated a group of radio channels or Frequencies sub-bands to be used within a small geographic area known as a cell. The shape of the cell is Hexagonal. The process of selecting and allocating the frequency sub-bands for all of the cellular base station within a system is called Frequency reuse or Frequency Planning.
Salient Features of using Frequency Reuse:

- Frequency reuse improves the spectral efficiency and signal Quality (QoS).
- Frequency reuse classical scheme proposed for GSM systems offers a protection against interference.
- The number of times a frequency can be reused is depend on the tolerance capacity of the radio channel from the nearby transmitter that is using the same frequencies.
- In Frequency Reuse scheme, total bandwidth is divided into different sub-bands that are used by cells.
- Frequency reuse scheme allow WiMax system operators to reuse the same frequencies at different cell sites.



Cell with same letter use the same set of channels group or frequencies sub-band.

To find the total number of channel allocated to a cell:

S = Total number of duplex channels available to use
k = Channels allocated to each cell (k<S)
N = Total number of cells or Cluster Size

Then Total number of channels (S) will be,

$S = kN$

Frequency Reuse Factor = 1/N

In the above diagram cluster size is 7 (A,B,C,D,E,F,G) thus frequency reuse factor is 1/7.

N is the number of cells which collectively use the complete set of available frequencies is called a Cluster. If a Cluster is replicated or repeated ‘M’ times within the cellular system, then Capacity, C, will be,

C = MkN = MS

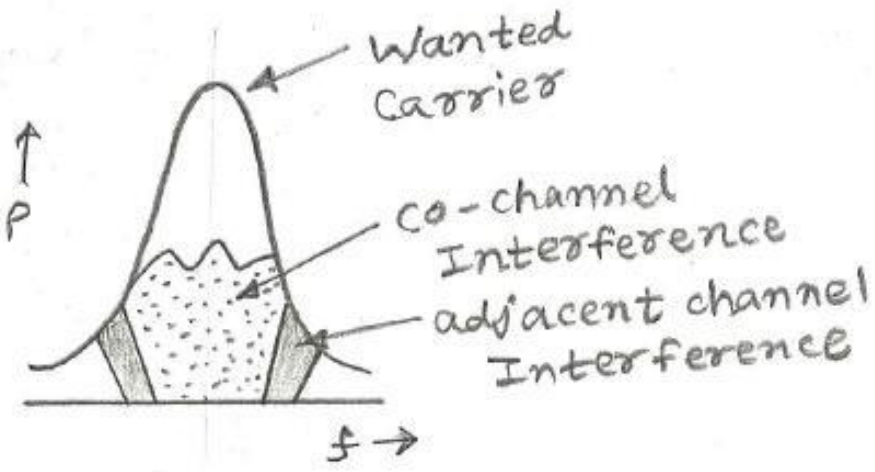
In Frequency reuse there are several cells that use the same set of frequencies. These cells are called Co-Channel Cells. These Co-Channel cells results in interference. So to avoid the Interference cells that use the same set of channels or frequencies are separated from one another by a larger distances.

Types of Interference

Based on the spacing of interfering signal from the desired signal there are two types viz. co-channel and adjacent channel. These interferences are observed in single carrier transmission systems such as satellite, GSM, microwave etc.

Co-Channel Interference (CCI)

The interference caused by transmitting at the same frequency by two or more wireless systems is known as co-channel interference. In order to handle huge number of calls with limited number of channels frequency reuse concept is applied to the cellular system. In frequency reuse same frequency is reused in multiple cells within their own boundaries without causing any interference. .



To reduce co-channel interference, co-channel cell must be separated by minimum distance. When the size of the cell is approx. same, following can be applied to it.

• Co-channel interference is independent of the transmit power.

• Co-channel interference is function of radius (R) of cell and distance (D) to the center of the nearest co-channel cell.

• By increasing ratio Q (= D/R), interference is reduced.

• Q is known as co-channel reuse ratio.

• For hexagonal geometry of cell, $Q = D/R = (3*N)^{0.5}$

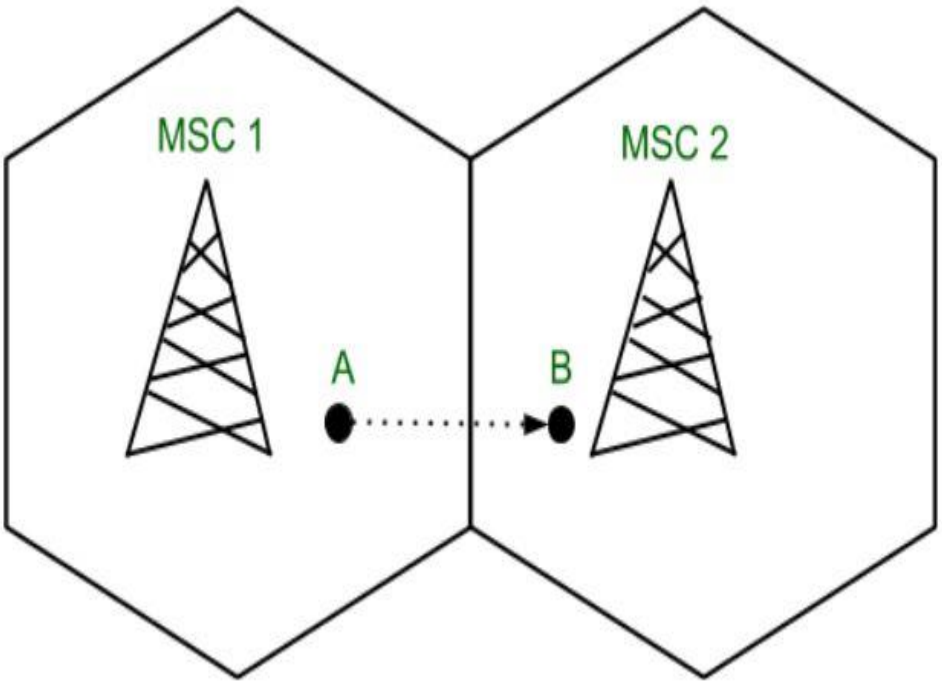
• Larger value of Q improves transmission quality as it will have smaller level of co-channel interference.

Adjacent channel Interference (ACI)

The interference caused to the desired signal (or channel) from adjacent frequency signals is known as adjacent channel interference. This interference is caused by leakage of frequencies from imperfect filters into passband of desired channel. Moreover it is result of near-far effect.Adjacent channel interference can be reduced by careful filtering and channel assignments by RF planners. In order to achieve this, frequency separation between channels is kept large. Ensure that each mobile transmits smallest power necessary to maintain good quality link.

Handoff

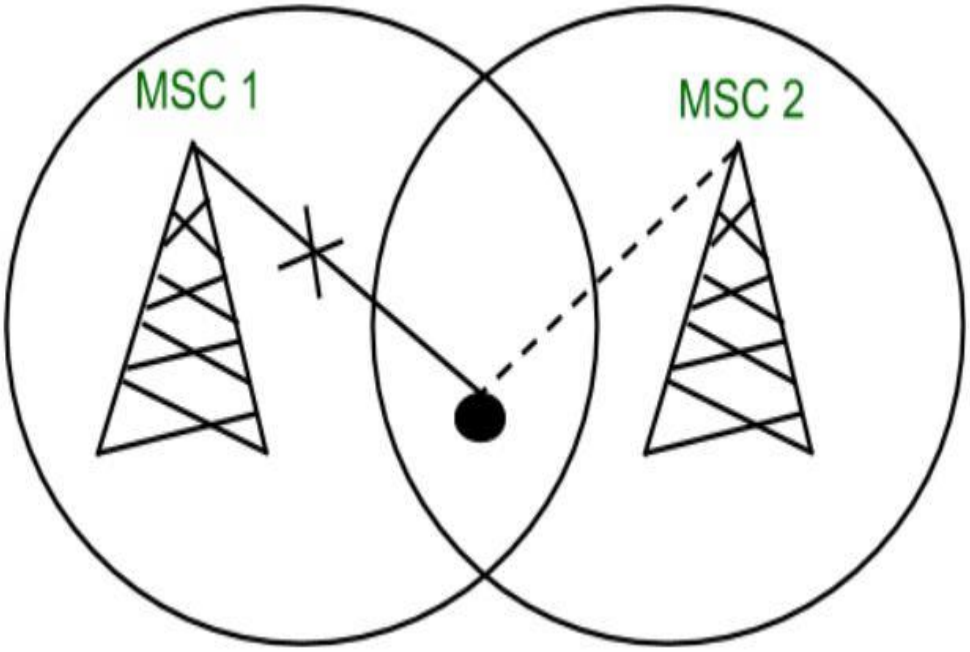
In cellular telecommunications, the terms handover or handoff refers to the process of transferring ongoing call or data connectivity from one Base Station to other Base Station. When a mobile moves into the different cell while the conversation is in progress then the MSC (Mobile Switching Center) transfer the call to a new channel belonging to the new Base Station.



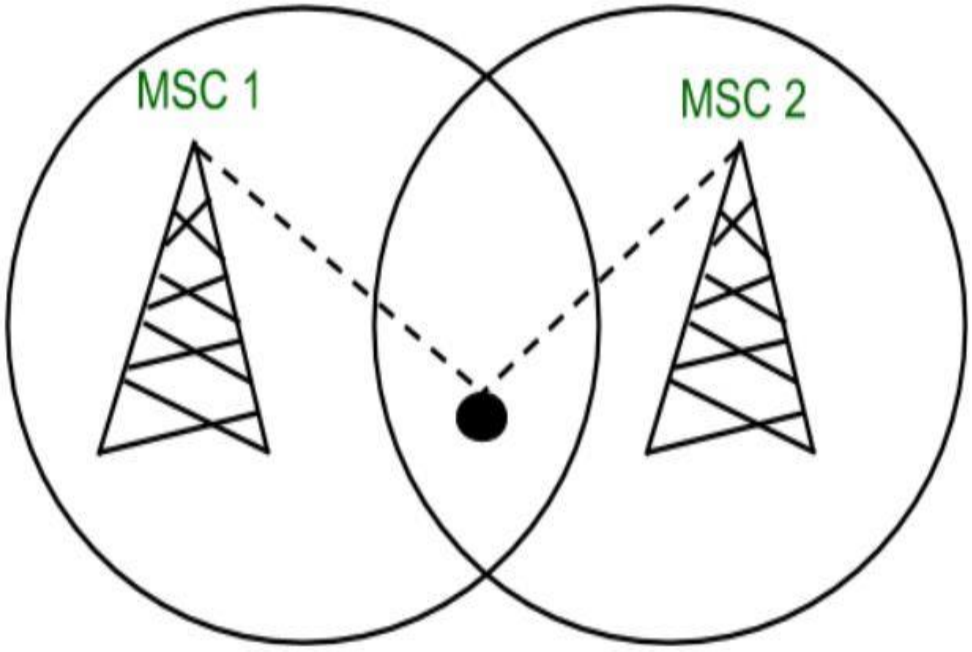
When a mobile user A moves from one cell to another cell then BSC 1 signal strength loses for the mobile User A and the signal strength of BSC 2 increases and thus ongoing calls or data connectivity for mobile user goes on without interrupting.

Types of Handoff:

1. **Hard Handoff:**
   When there is an actual break in the connectivity while switching from one Base Station to another Base Station. There is no burden on the Base Station and MSC because the switching takes place so quickly that it can hardly be noticed by the users. The connection quality is not that good. Hard Handoff adopted the ‘break before make’ policy.



Soft Handoff:
In Soft Handoff, at least one of the links is kept when radio signals are added or removed to the Base Station. Soft Handoff adopted the ‘make before break’ policy. Soft Handoff is more costly than Hard Handoff.



POWER CONTROL FOR REDUCING INTERFERENCE

1) For extending battery life in mobile handsets.
2) For reducing inter-user interference
3) For increasing the overall capacity of wireless system

To Improve coverage and capacity in cellular system following methods are there:

Cell splitting:

1. Cell splitting is the process of sub dividing a congested cell into smaller cells, each with its own base station and corresponding reduction in antenna height and transmitted power.
2. Cell splitting increases capacity of a cellular system since it increases number of times that channels are reused.
3. By defining new cells which have a smaller radius than the original cells and by installing these smaller cells between existing cells, capacity increases due to additional number of channels per unit cell area
4. In this D/R ratio is kept constant and entire system is rescaled.

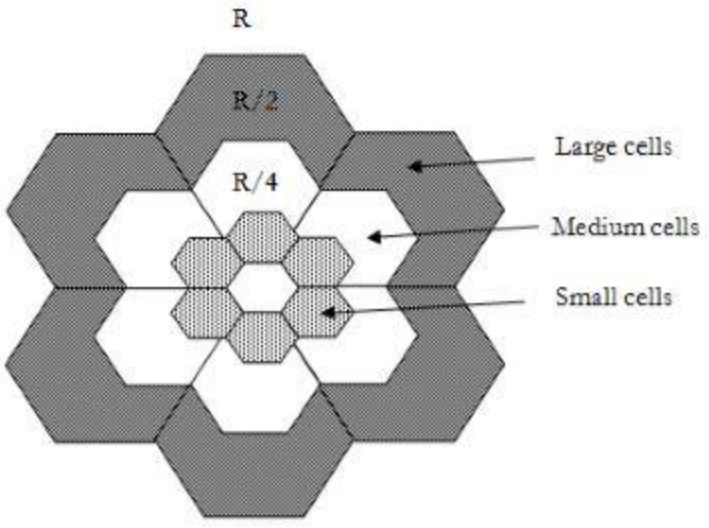


Fig: Cell splitting

B. Cell sectoring:

1. In cell sectoring a single omnidirectional antenna at base station is replaced by several directional antennas, each radiating within a specified sector.
2. By using directional antennas power is transmitted in single desired direction decreasing number of interfering co-channel cells and co-channel interference.
3. The technique for decreasing co-channel interference and thus increasing system performance by using directional antennas is called sectoring.
4. The factor by which the co-channel interference is reduced depends on the amount of sectoring used. A cell is normally partitioned into three sectors.
5. When sectoring is employed, the channels used in a particular cell are broken down into sectored groups and are used only within a particular sector.
6. For cluster size 7, sectoring reduces co-channel cells from 6 to 2 for 12001200 sectoring and to 1 for 600600 sectoring.

Advantages

- Improvement in S/I ratio.
- Improvement in system capacity.

Disadvantages

- Increased number of antennas at base station.
- Decrease in trunking efficiency due to channel sectoring at the base station.
- Increase in number of handoffs, since sectoring reduces the coverage area of the particular group of frequencies.

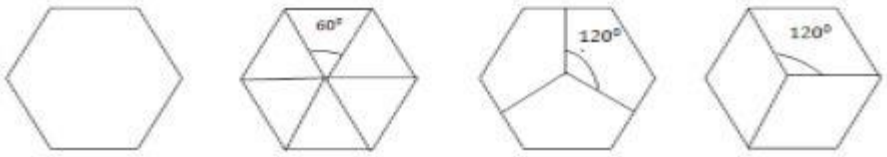


Fig: omnidirectional 60^0 sectoring 120^0 sectoring

C. Microcell zone concept:.

1. The increased number of hand off, increase load on the switching and control link because of sectoring. A solution to this problem is given by microcell zone concept
2. Large control base station is replaced by several lower power transmitters on the age of cell.
3. The mobile retains the same channel and the base station simply switches the channel to a different zone site and the mobile moves from zone to zone.
4. Since a given channel is active only in a particular zone in which mobile is travelling, base station radiation is localized and interference is reduced.
5. The advantage of zone cell technique is that while the cell maintains a particular coverage radius, co-channel interference in the cellular system is reduced. As the large central base station is replaced by several lower power transmitters on ages of cell. Decreased co-channel interference improves signal quality leads to increase in capacity without degradation in trunking efficiency caused by sectoring.

Advantages

- Decrease co-channel interference which leads to an improvement in signal quality and also leads to an increase in capacity.
- No degradation of trunking efficiency.

Disadvantages

- More antennas are required.
- Basestation need to be more sophisticated to handle transfer of call from one zone to another zone within the cell.