Cellular Technology

Overview

- Cellular system solves the problem of spectral congestion.
- Offers high capacity in limited spectrum.
- High capacity is achieved by limiting the coverage area of each BS to a small geographical area called cell.
- Replaces high powered transmitter with several low power transmitters.

Cont…

- Same frequencies are reused by spatially separated BSs.
- Interference between co-channels stations is kept below acceptable level.
- Additional radio capacity is achieved.
- Frequency Reuse-Fix no of channels serve an arbitrarily large no of subscribers 3

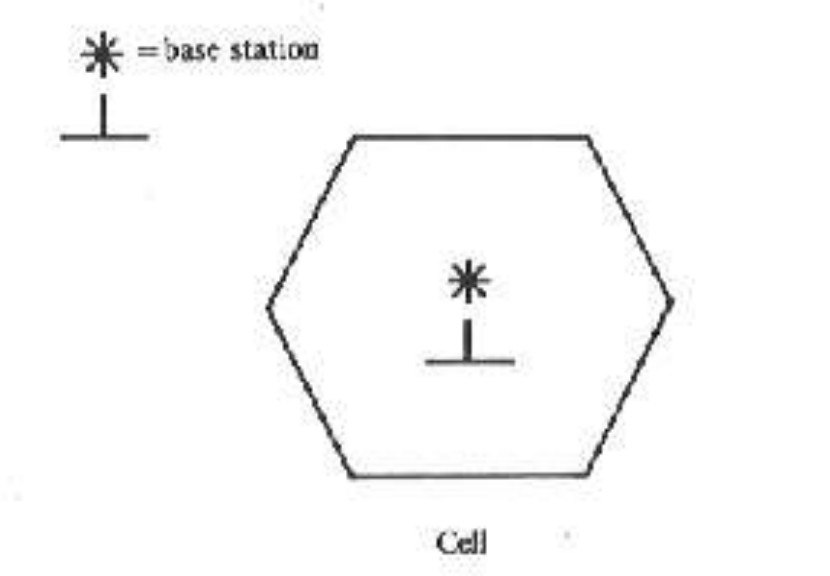
Frequency Reuse

- used by service providers to improve the efficiency of a cellular network and to serve millions of subscribers using a **limited radio spectrum**
- After covering a certain distance a radio wave gets attenuated and the signal falls below a point where it can no longer be used or cause any interference
- A transmitter transmitting in a specific frequency range will have only a limited coverage area
- Beyond this coverage area, that frequency can be reused by another transmitter.
- The entire network coverage area is divided into cells based on the principle of frequency reuse

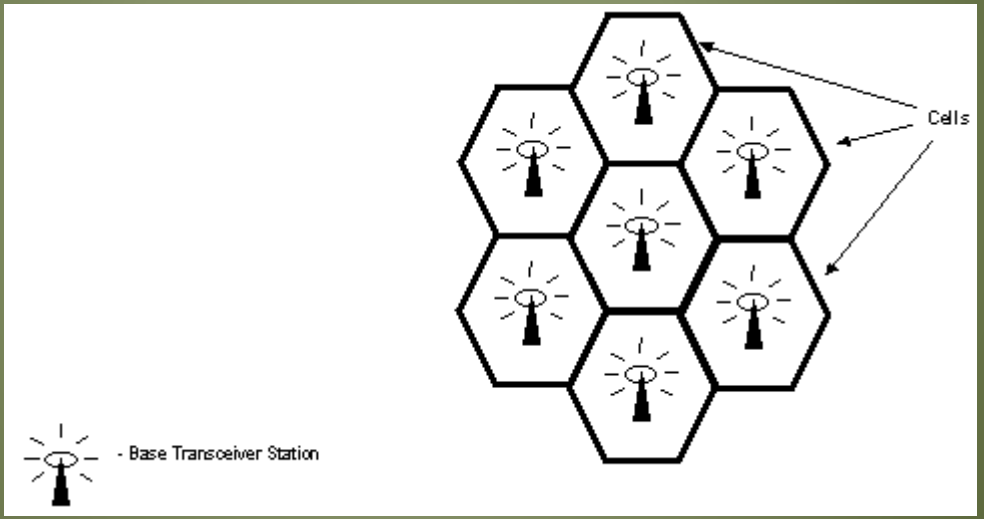
Cont…

- A cell = basic geographical unit of a cellular network; is the area around an antenna where a specific frequency range is used.
- when a subscriber moves to another cell, the antenna of the new cell takes over the signal transmission
- a cluster is a group of adjacent cells, usually 7 cells; no frequency reuse is done within a cluster
- the frequency spectrum is divided into sub-bands and each sub-band is used within one cell of the cluster
- in heavy traffic zones cells are smaller, while in isolated zones cells are larger

1) Cell



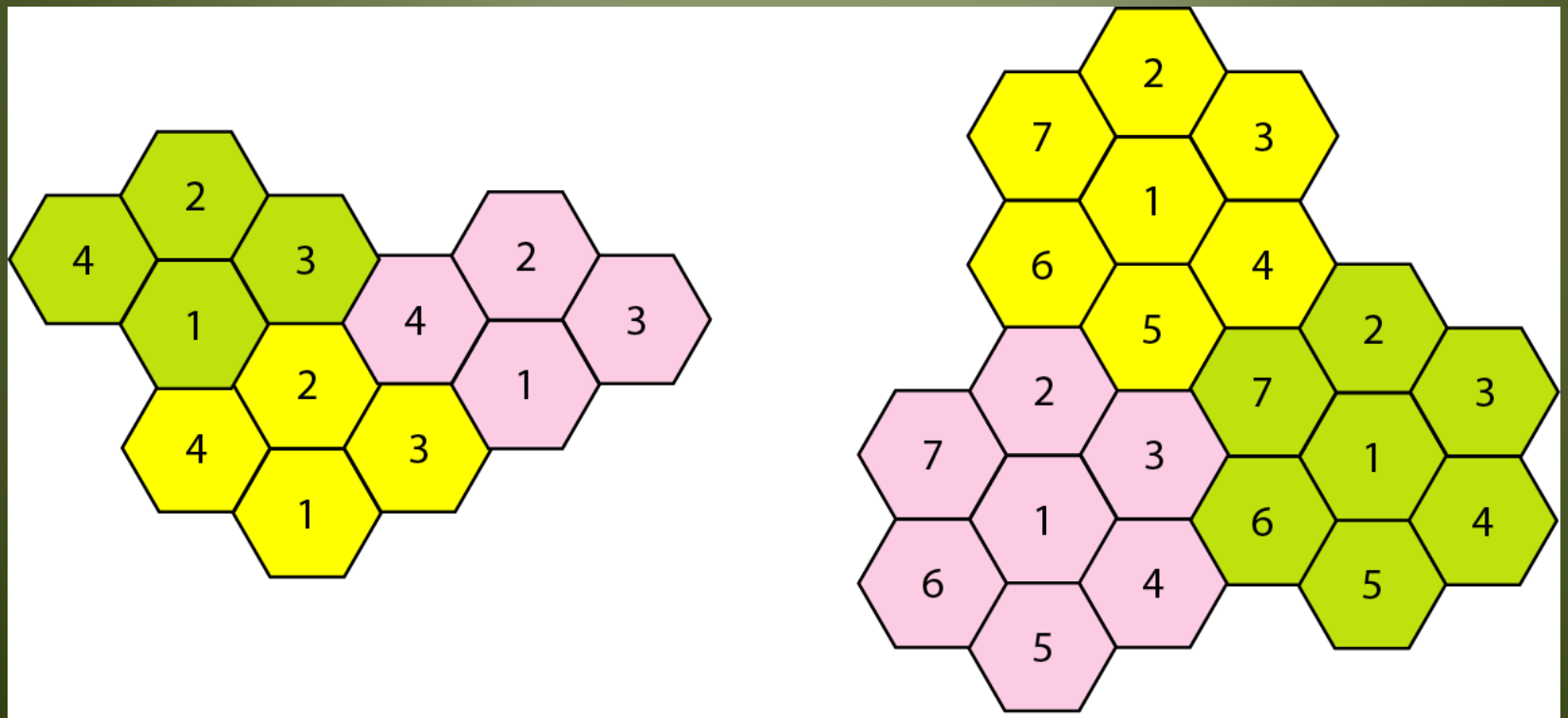
2) cluster



Frequency Reuse

- The design process of selecting and allocating channel groups for all of the cellular base stations within a system is called frequency reuse or frequency planning.
- Cell labeled with same letter use the same set of frequencies.
- Cell Shapes:
- Circle, Square, Triangle and Hexagon.
- Hexagonal cell shape is conceptual , in reality it is irregular in shape

Frequency reuse



a. Reuse factor of 4

b. Reuse factor of 7

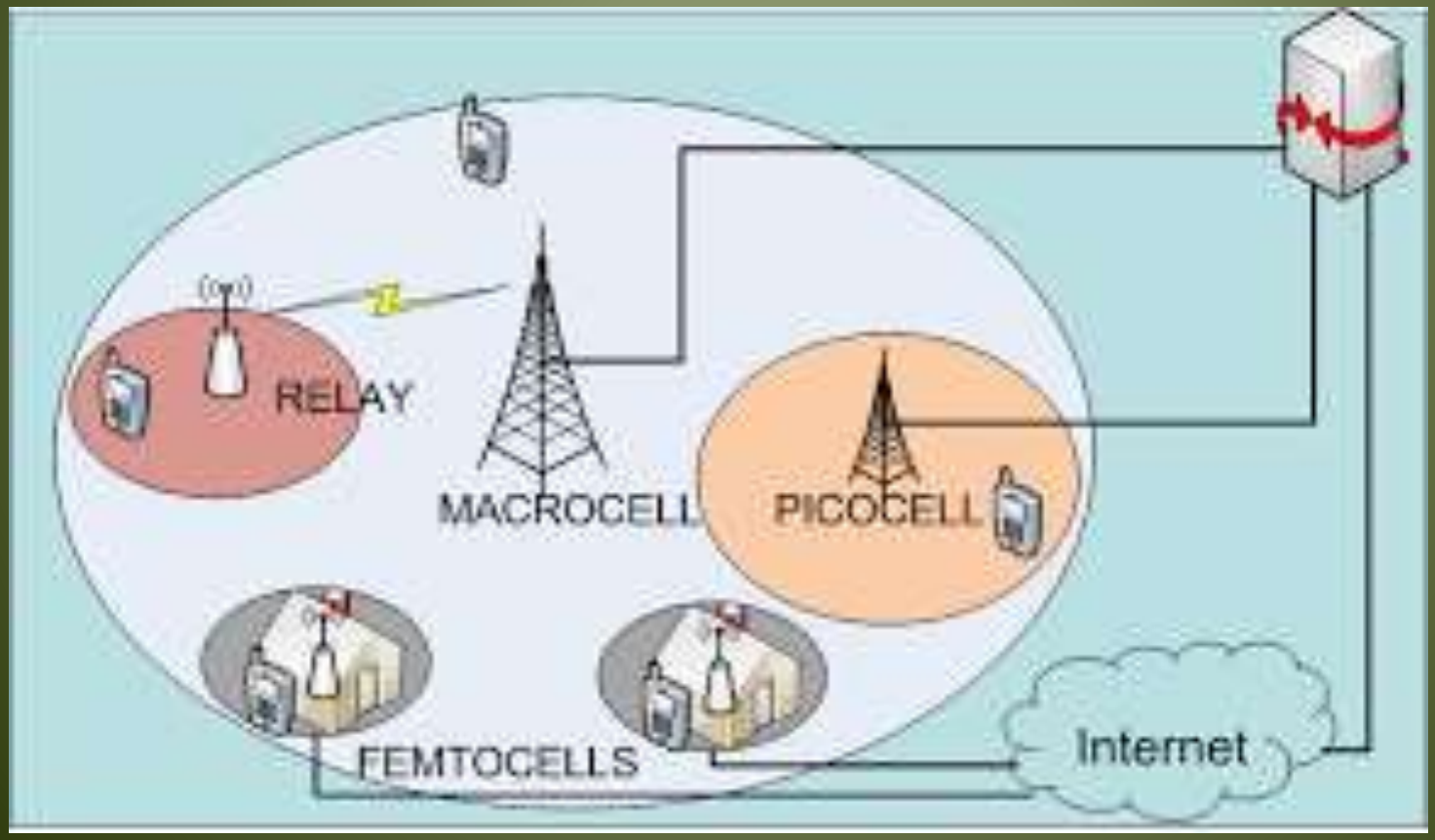
Cellular Hierarchy

- To extend the coverage to the areas that are difficult to cover by large cell.
- To increase the capacity of the network for those areas that have higher density of users.
- To provide communication between personal devices.

Types of cells

- Femto cell
- Pico cells
- Micro cells
- Macro cells
- Mega cell

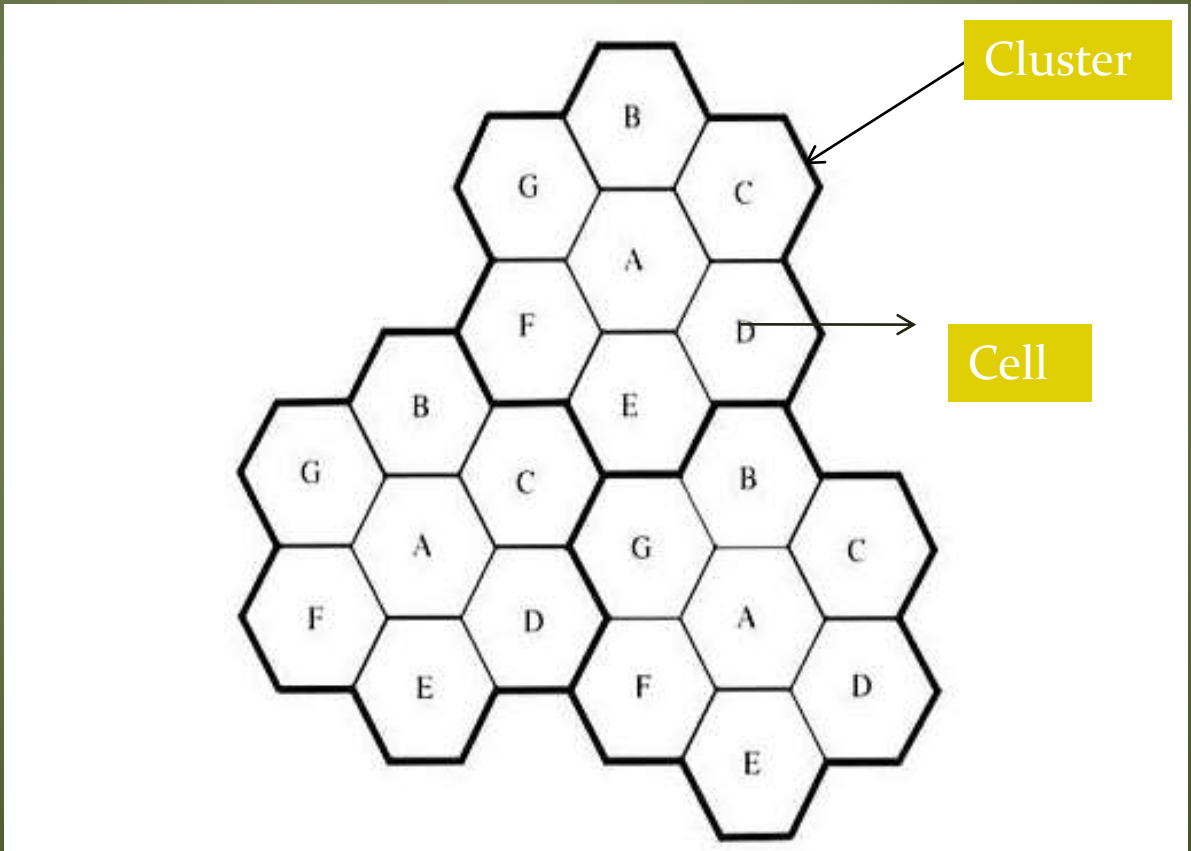
Cells



Cell Fundamentals

- Cells must have a particular geometrical shape.
- Cells must not overlap with each other.
- How much area covered by cell.

Cellular Architecture



Signal To Interference Ratio

- Cochannel Interference:

  The cells that uses same set of frquency or channel is called as Cochannel Interference

- Adjacent Channel Interference:

  The Interference from different frequency channels used within cluster whose sidelobes overlap is called as adjacent channel Interference

Improve Capacity

- When the demand for wireless service increases, the number of channels allotted to a cell becomes insufficient to support the required number of users.

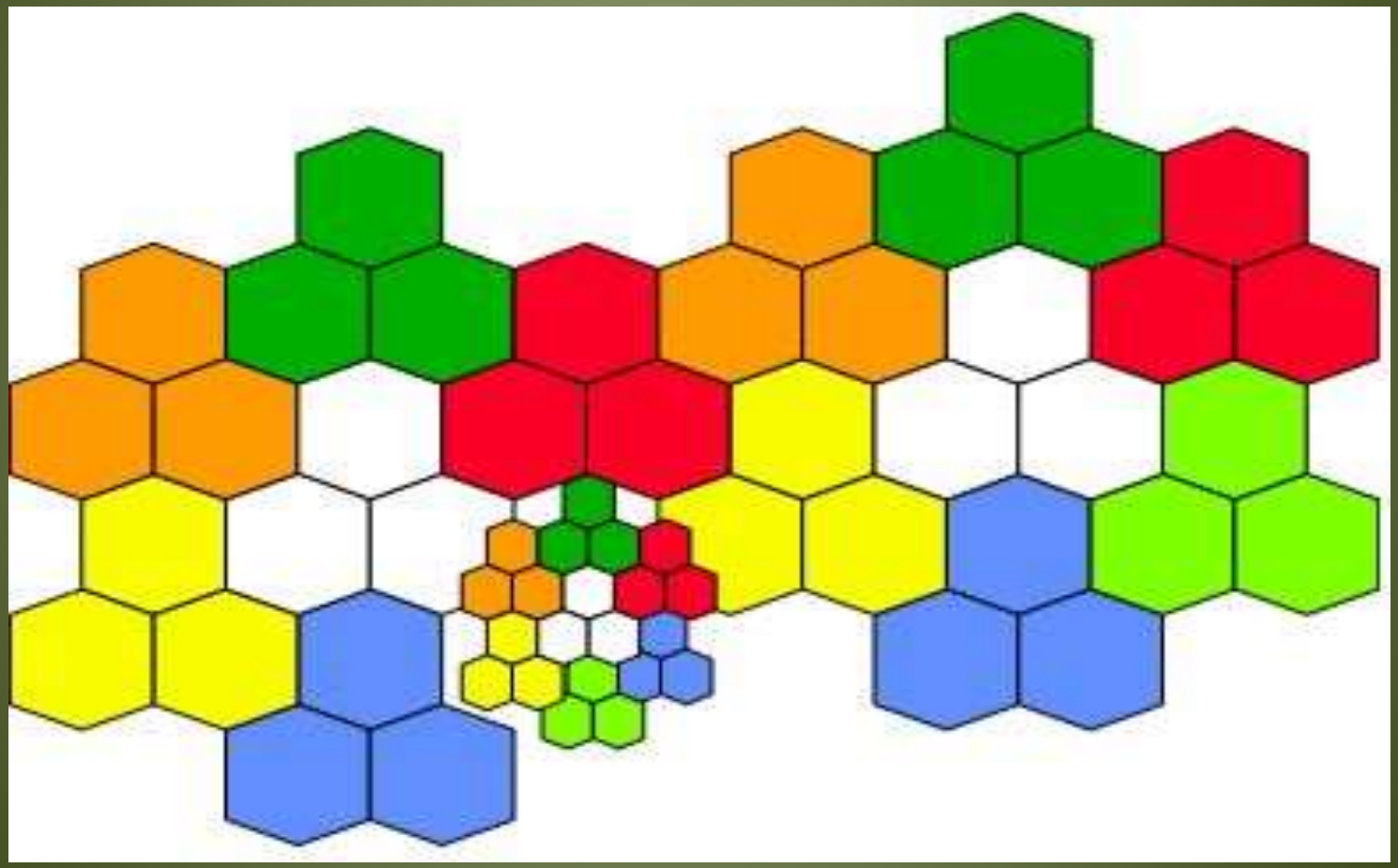
  Certain design techniques are used to provide more number of channels per unit coverage area, thus increasing the capacity:

- Cell Splitting : It allows an orderly growth of the cellular system
- Sectoring : It uses Directional antennas to control the interference and frequency reuse of channels.
- Zone Microcell: It distributes the coverage of the Cell.
- More bandwidth
- Borrow channel from nearby cells

Cell Splitting

- It is the process of subdividing the congested cell into smaller cells.
- Each of the smaller cells will have their own base station with a reduction in antenna height and transmitted power.
- The smaller cells are known as Microcells.
- Cell Splitting increases the capacity of the cellular system as it increases the number of times the channels are reused
- The increased number of cells would increase the number of clusters over the coverage region which in turn increase the number of channels and thus capacity in the coverage area
- Cell Splitting allows the system to grow by replacing large cells with smaller cells without changing the co-channel re-use ratio(Q).

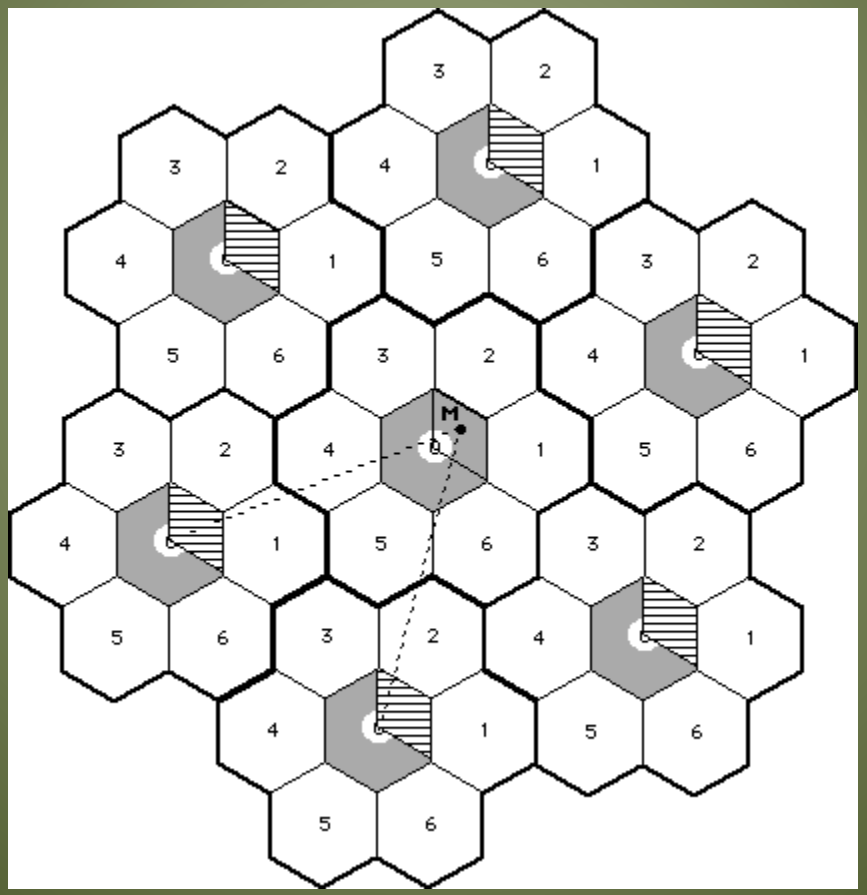
Cell splitting



Cell Sectoring

- The co-channel interference in a cellular system can be decreased by replacing the Omni directional antenna at the base station by several directional antennas, each radiating within a specified sector.
- The process of reducing the co-channel interference and thus increasing the capacity of the system by using directional antennas is known as ***Sectoring.***
- In general a cell is partitioned into three 120 degree sectors or six 60 degree sectors.
- When sectoring is employed, the channels used in a particular cell are broken down into sectored groups and are used only in a particular sector

Cell Sectoring



Channel Allocation

- Goal is to minimize interference & maximize use of capacity
- Two main strategies: Fixed or Dynamic
- Fixed
- – each cell allocated a pre-determined set of voice channels
  - calls within cell only served by unused cell channels
  - all channels used → blocked call → no service
- – several variations
  - MSC allows cell to borrow a VC from an adjacent cell
  - donor cell must have an available VC to give

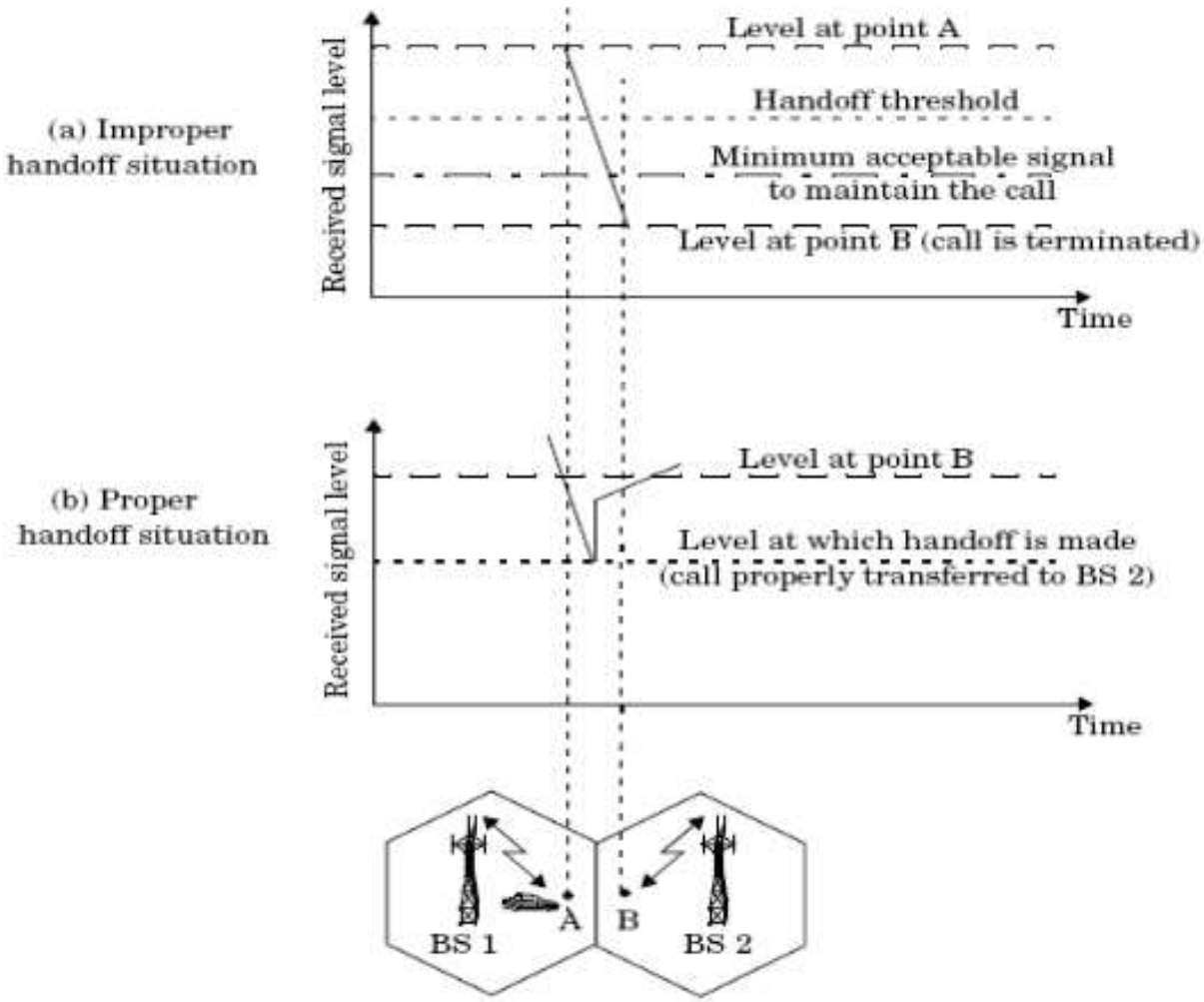
Cont..

- Dynamic
- – channels NOT allocated permanently
- – call request → goes to serving base station → goes to MSC– MSC allocates channel “on the fly”.

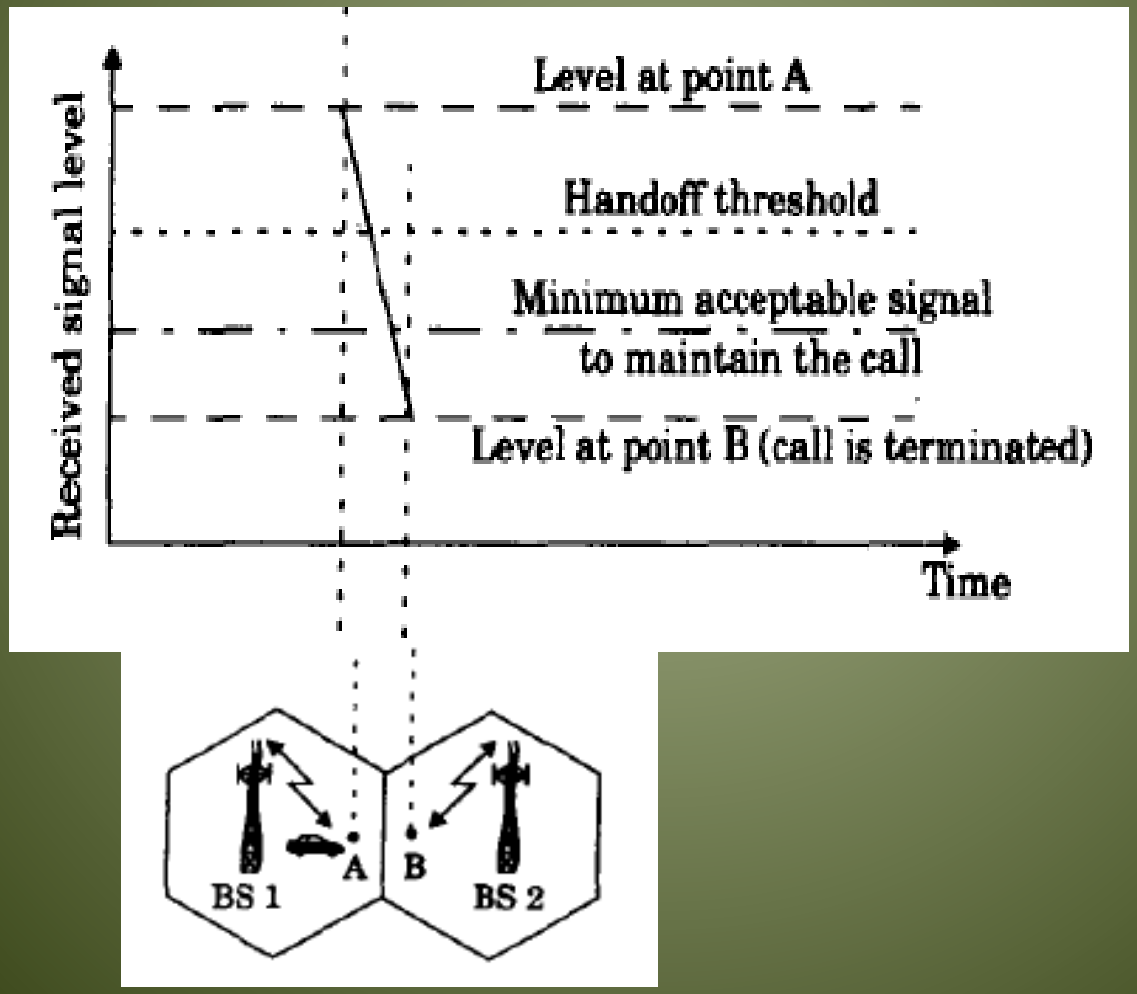
Handoff

- When a mobile moves from one cell to the next during a call the MSC automatically transfers the call to a new channel belonging to the next cell. This operation is called HANDOFF
- Handoff is similar to an initial call request
- The handoff has the priority over a new call to avoid call cut off in the mid conversation
- In reality, a fraction of total channels can be reserved for handoff requests in each cell
- The handoff must be successful, as infrequent as possible and unnoticeable to the user

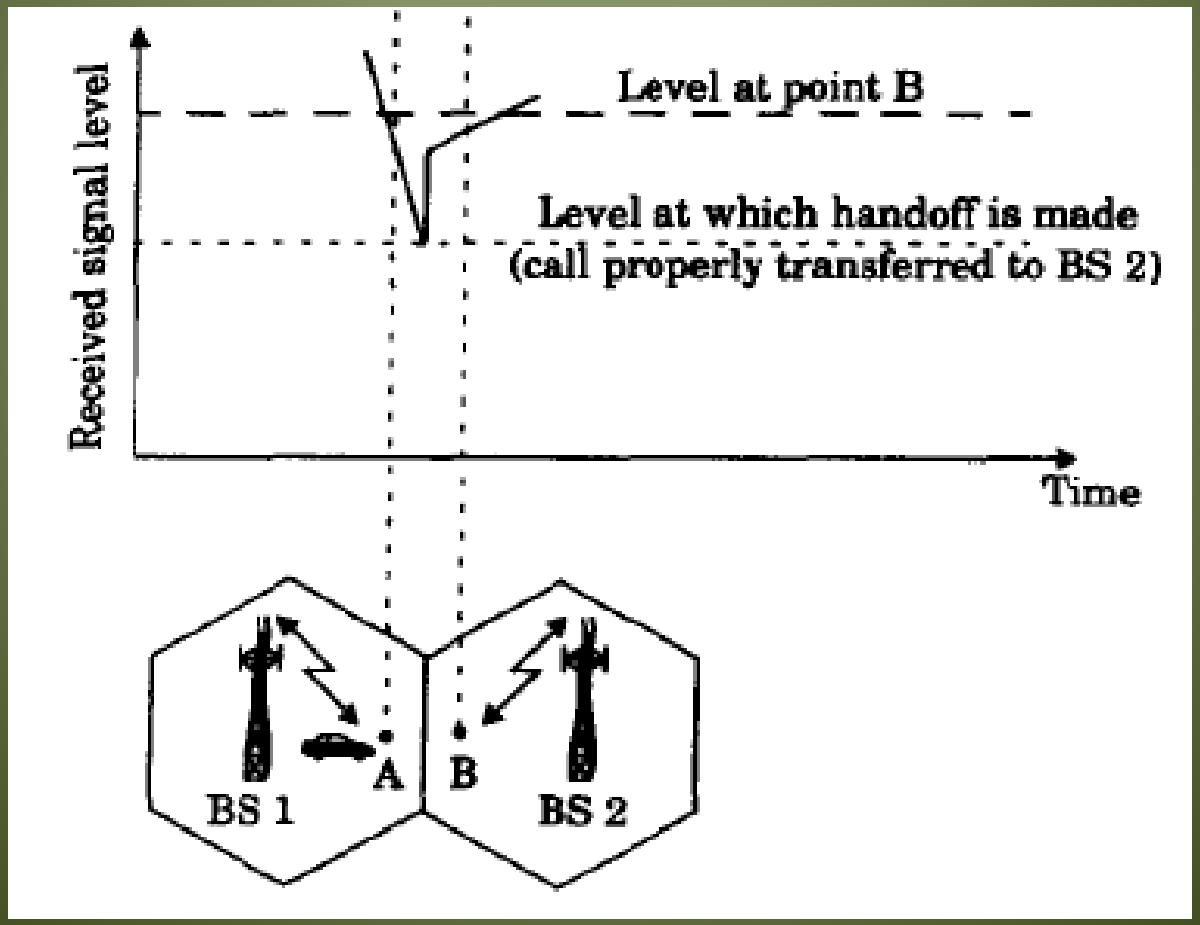
9) Handoff


(a) Improper handoff situation
Received signal level
Level at point A
Handoff threshold
Minimum acceptable signal to maintain the call
Level at point B (call is terminated)
Time
(b) Proper handoff situation
Received signal level
Level at point B
Level at which handoff is made (call properly transferred to BS 2)
Time
BS 1
A
B
BS 2

Improper Handoff



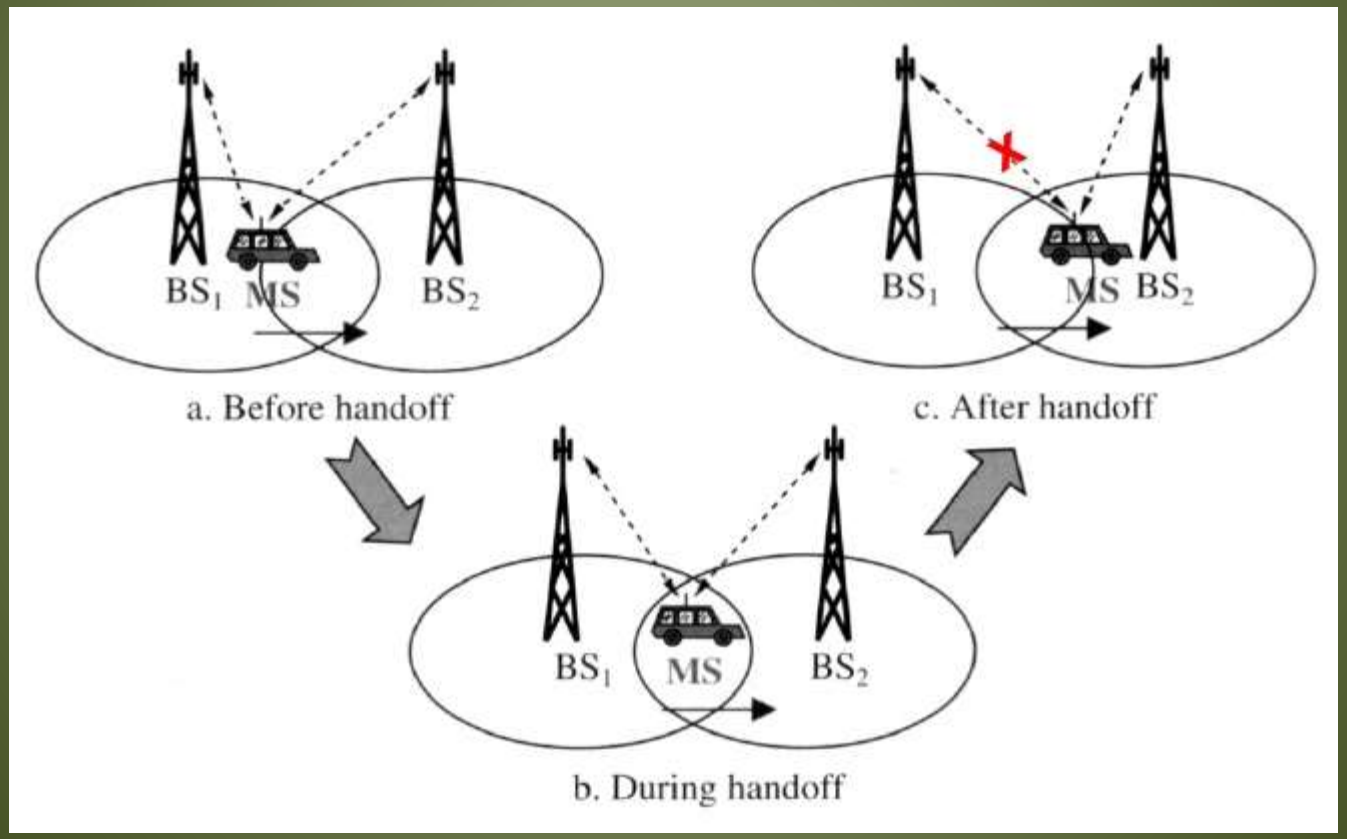
Proper Handoff



Cont…

- If the margin is too large there are too frequent and unnecessary handoffs which burden the MSC
- If the margin is too small, there may be not enough time to complete the handoff, particularly when the mobile moves fast
- The time a mobile spends in a cell without handoff is called *dwell time*
- For high speed mobiles, large umbrella cells with wide range are used
- For low speed mobile, microcells with small coverage area are used
- The speed is estimated by the BS or MSC from average signal strength

Soft handoff



Hard handoff