Cellular Systems-Basic Concepts

- 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.
- Each BS is allocated a portion of total channels and nearby cells are allocated completely different channels.
- All available channels are allocated to small no of neighboring BS.
- Interference between neighboring BSs is minimized by allocating different channels.

Cellular Systems-Basic Concepts

- 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

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

Frequency Reuse

- 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

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

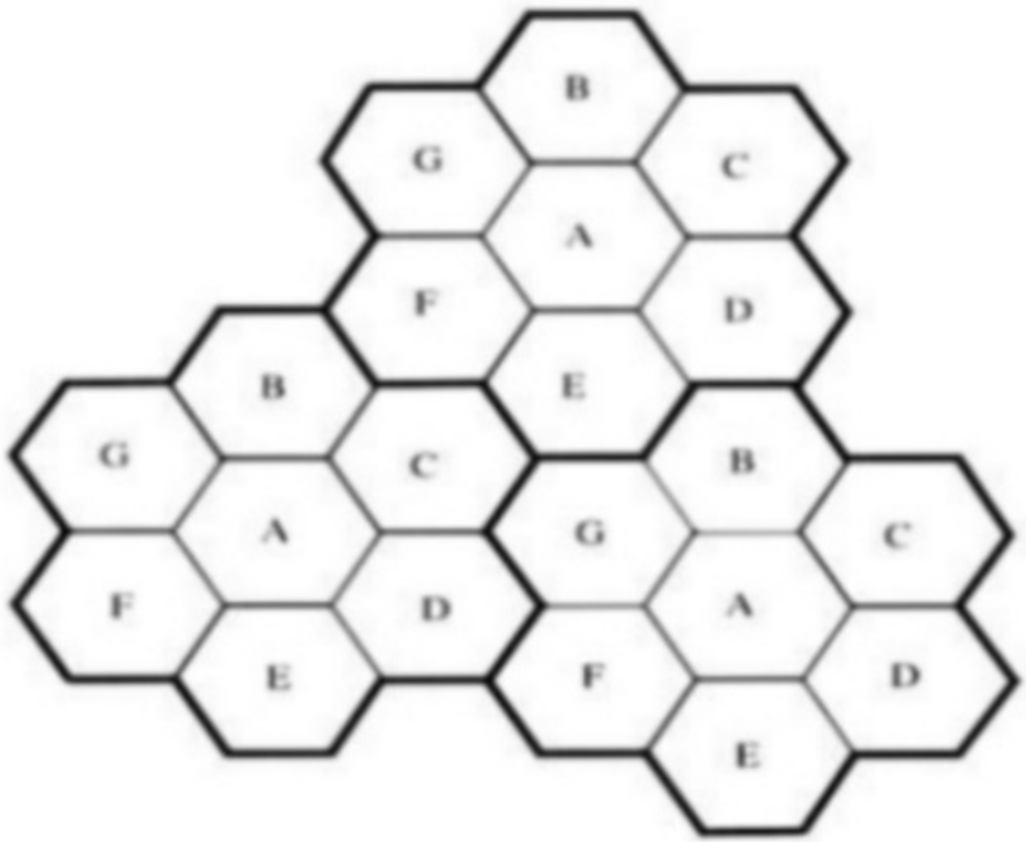

Figure 3.1 Illustration of the cellular frequency reuse concept. Cells with the same letter use the same set of frequencies. A cell cluster is outlined in bold and replicated over the coverage area. In this example, the cluster size, *N*, is equal to seven, and the frequency reuse factor is 1/7 since each cell contains one-seventh of the total number of available channels.

Frequency Reuse

- N cells collectively using all the channels is called a cluster, is a group of adjacent cells.
- If cluster if repeated M times, the capacity C of system is given as

$$C=MkN=MS$$

- Capacity of system is directly proportional to the no of times cluster is repeated.
- Reducing the cluster size N while keeping the cell size constant, more clusters are required to cover the given area and hence more capacity.
- Co-channel interference is dependent on cluster size, large cluster size less interference and vice versa.

Frequency Reuse

- In hexagonal cell model, BS transmitter can be in centre of cell or on its 3 vertices.
- Centered excited cells use omni directional whereas edge excited cells use directional antennas.
- A cellular system having ‘S’ duplex channels, each cell is allocated ‘k’ channels($k<S$).
- If S channels are allocated to N cells into unique and disjoint channels, the total no of available channel is $S=kN$.

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Frequency Reuse

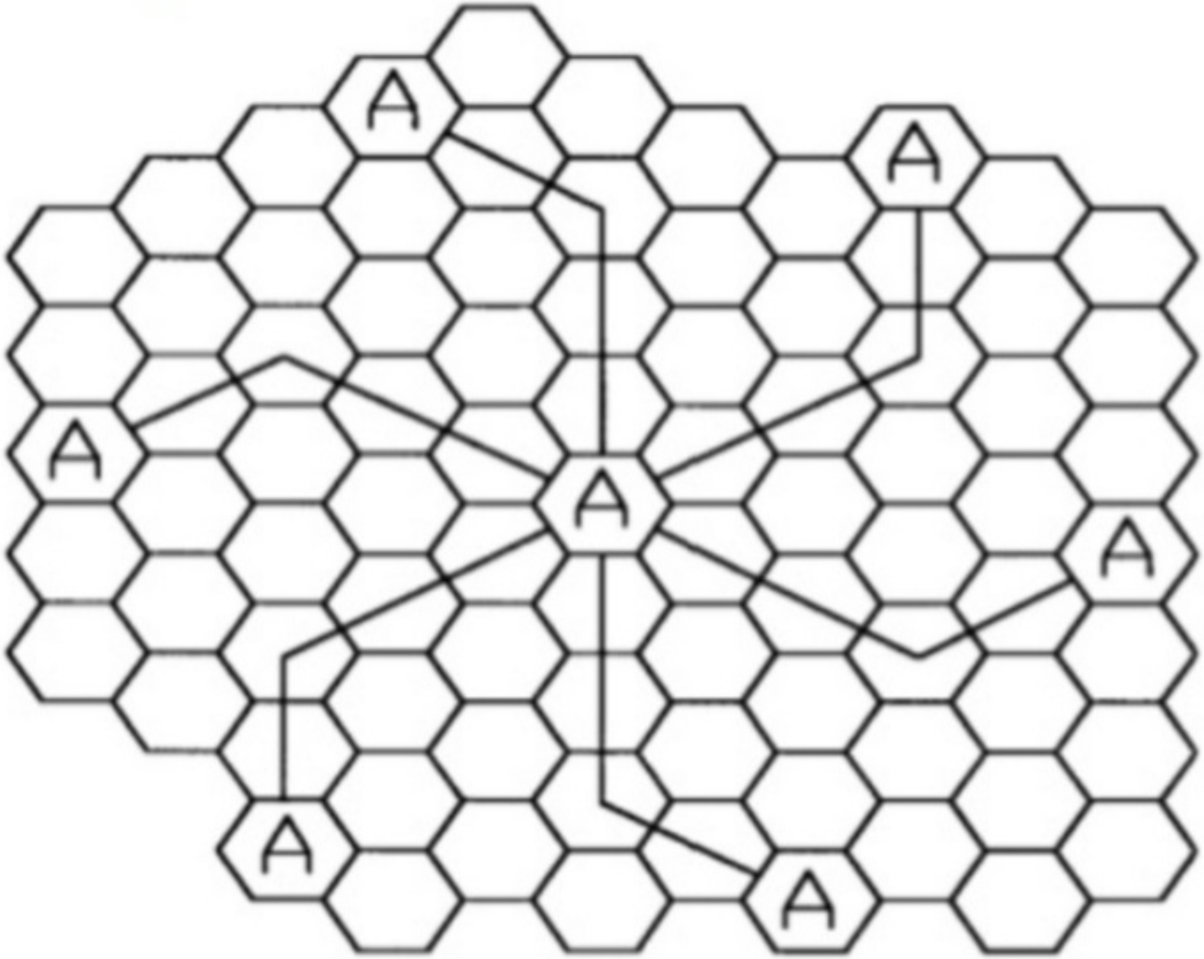
- The Frequency Reuse factor is given as 1/N, each cell is assigned 1/N of total channels.
- Lines joining a cell and each of its neighbor are separated by multiple of 60^0,certain cluster sizes and cell layout possible
- Geometery of hexagon is such that no of cells per cluster i.e N, can only have values which satisfy the equation

  $$N=i^2+ij+j^2$$

  N, the cluster size is typically 4, 7 or 12.

  In GSM normally N =7 is used.
- i and j are integers, for i=3 and j=2 N=19.
- Example from Book

Locating co-channel Cell



Channel Assignment Strategies

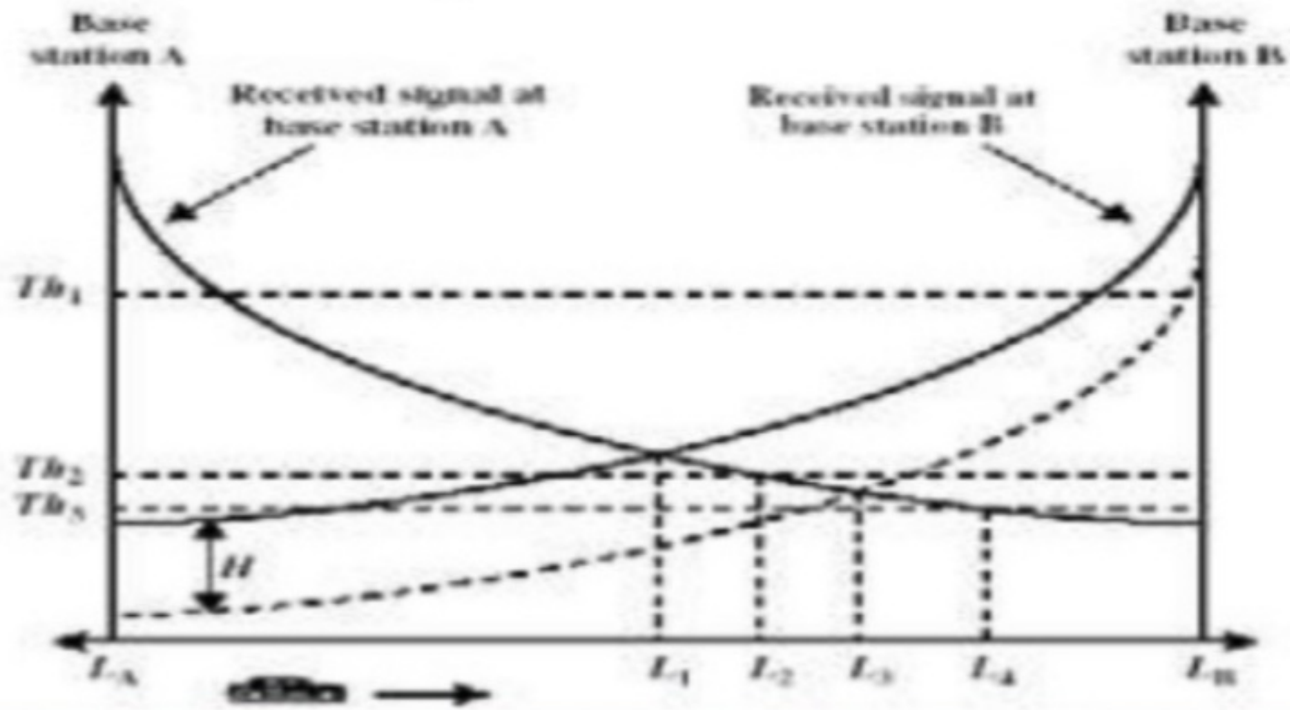
- A scheme for increasing capacity and minimizing interference is required.
- CAS can be classified as either fixed or dynamic
- Choice of CAS impacts the performance of system.
- In Fixed CA each cell is assigned a *predetermined* set of voice channels
- Any call attempt within the cell can only be served by the *unused* channel in that particular cell
- If all the channels in the cell are occupied, the call is *blocked*. The user does not get service.
- In variation of FCA, a cell can *borrow channels* from its neighboring cell if its own channels are full.

Dynamic Channel Assignment

- Voice channels are not allocated to different cells *permanently*.
- Each time a call request is made, the *BS request* a channel from the MSC.
- MSC allocates a channel to the requesting cell using an algorithm that takes into account
  - likelihood of future blocking
  - The reuse distance of the channel (should not cause interference)
  - Other parameters like cost
- To ensure min QoS, MSC only allocates a given frequency if that frequency is not currently in use in the cell or any other cell which falls within the *limiting reuse distance.*
- DCA reduce the likelihood of blocking and increases capacity
- Requires the MSC to collect realtime data on channel occupancy and traffic distribution on continous basis.

Handoff

By looking at the variations of signal strength from either BS it is possible to decide on the optimum area where handoff can take place



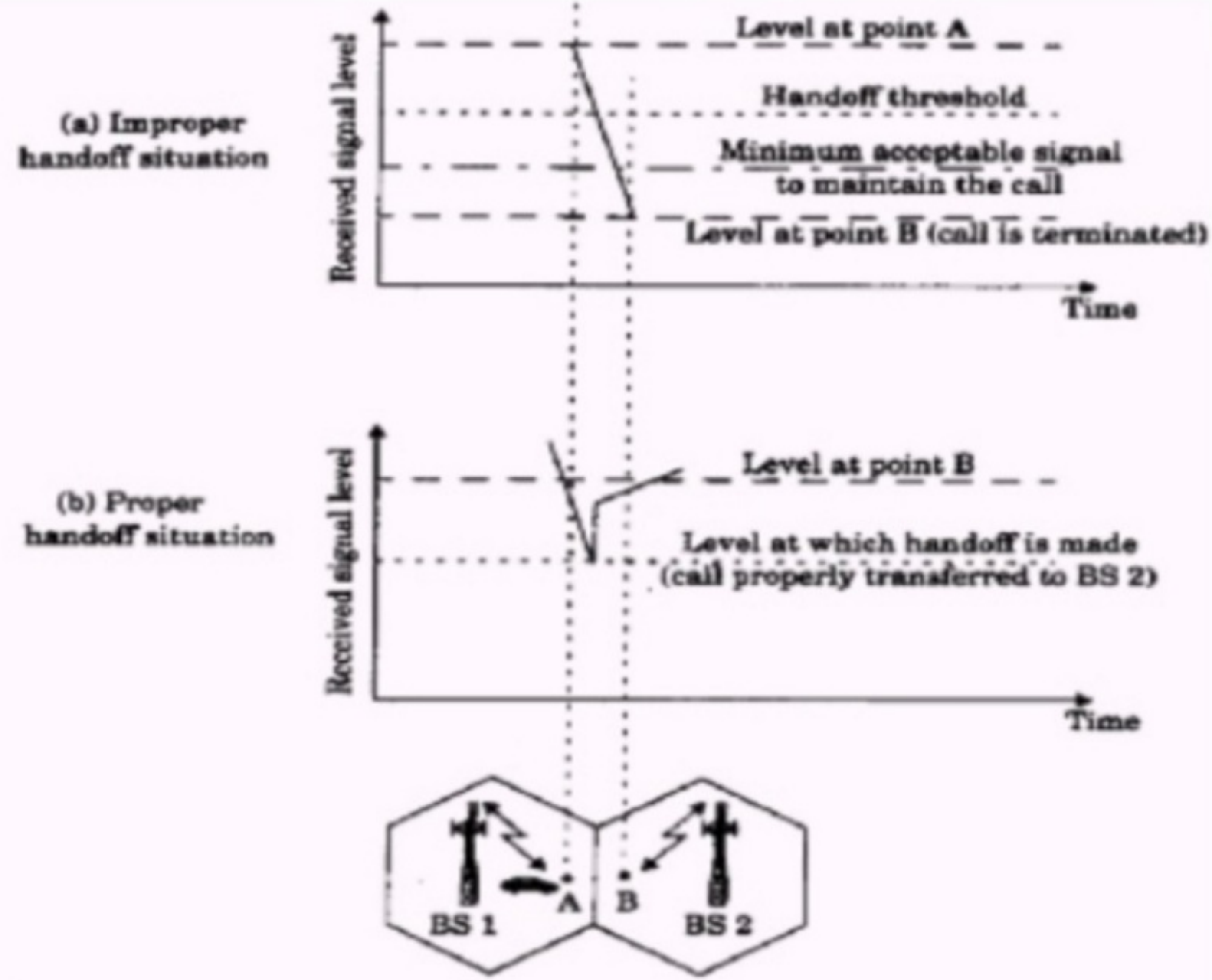


Figure 2.3
Illustration of a handoff scenario at cell boundary.

Hand-off strategies

- In 2nd generation systems Mobile Assisted Handoffs (MAHO)are used
- In MAHO, every MS measures the received power from the surrounding BS and continually reports these values to the corresponding BS.
- Handoff is initiated if the signal strength of a neighboring BS exceeds that of current BS
- MSC no longer monitors RSS of all channels
  - reduces computational load considerably
  - enables much more rapid and efficient handoffs
  - imperceptible to user

Soft Handoff

- CDMA spread spectrum cellular systems provides a unique handoff capability
- Unlike channelized wireless systems that assigns different radio channel during handoff (called hard handoff), the spread spectrum MS share the same channel in every cell
- The term handoff here implies that a different BS handles the radio communication task
- The ability to select between the instantaneous received signals from different BSs is called soft handoff

Reuse Ratio:

- For hexagonal cell reuse distance is given by
  $D=R(\sqrt{3N})$
- Where R is cell size or cell radius and N is cluster size
- D increases as we increase N
- Reuse factor is given by $Q=D/R=(\sqrt{3N})$