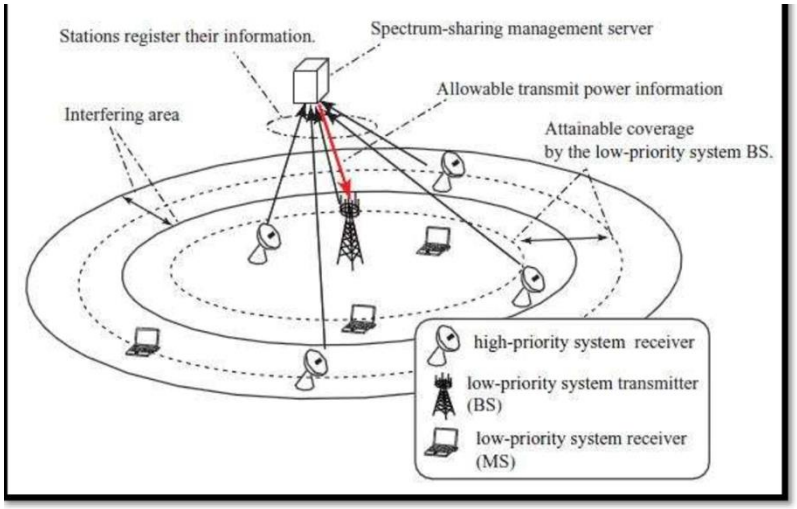
19EC601 – Wireless Communication

Unit -1

Fundamentals of Wireless Communication

Interference and system capacity



Sources of interference:

- Another mobile in the same cell
- A call in progress in the neighboring cell
- other base stations operating in the same frequency band
- Noncellular system leaks energy into the cellular frequency band

Two major cellular interference

- ❑ co-channel interference (CCI)
- ❑ Adjacent channel interference (ACI)

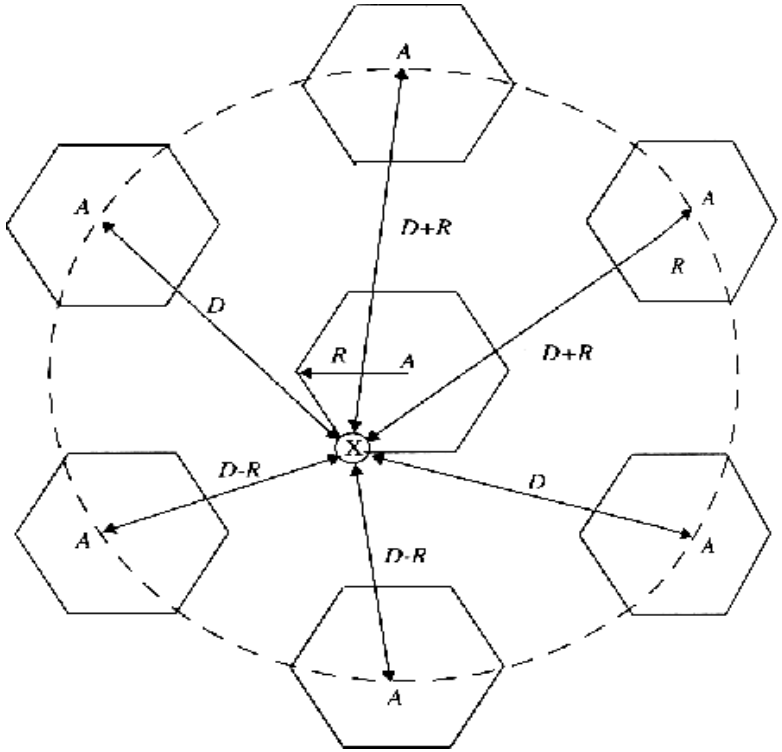
- **Co-Channel interference** (CCI) is caused by signals at the same frequency
- **Adjacent channel interference** (ACI) is caused by signals from neighbouring frequencies

- Interference is the major limiting factor in the performance of cellular radio systems:
  - a major bottleneck in increasing capacity
  - often responsible for dropped calls
- The two major types of system-generated cellular interference are:
  - co-channel interference
  - adjacent channel interference
- Power Control for Reducing Interference

Co-channel Interference and System Capacity

- **Co-channel Interference**
  - Cells using the same set of frequencies are called co-channel cells, and the interference between signals from these cells is called co-channel interference.
  - Unlike thermal noise which can be overcome by increasing the signal-to-noise ration (SNR), co-channel interference cannot be combated by simply increasing the carrier power of a transmitter. This is because an increase in carrier transmit power increases the interference to neighboring co-channel cells.
  - To reduce co-channel interference, co-channel cells must be physically separated by a minimum distance to provide sufficient isolation due to propagation.

Co-channel cells for 7-cell reuse



Co-channel Interference and System Capacity

- The co-channel interference ratio is a function of the radius of the cell (B) and the distance between centers of the nearest co- channel cells (D).
- By increasing the ratio of D/R, the spatial separation between co-channel cells relative to the coverage distance of a cell is increased. Thus interference is reduced.

Cochannel reuse ratio

- The parameter $Q = D/R$, called the cochannel reuse ratio, is related to the cluster size N.
  - When the size of each cell is approximately the same, and the base stations transmit the same power, we have

$$Q = D/R = (3N)^{1/3}$$

  - A small value of Q provides larger capacity since the cluster size N is small, whereas a large value of Q improves the transmission quality, due to a smaller level of co-channel interference.
  - A trade-off must be made between these two objectives in actual cellular design.

Smaller N is greater capacity

Table 3.1 Co-channel Reuse Ratio for Some Values of N

	Cluster Size (N)	Co-channel Reuse Ratio (Q)
$i = 1, j = 1$	3	3
$i = 1, j = 2$	7	4.58
$i = 2, j = 2$	12	6
$i = 1, j = 3$	13	6.24

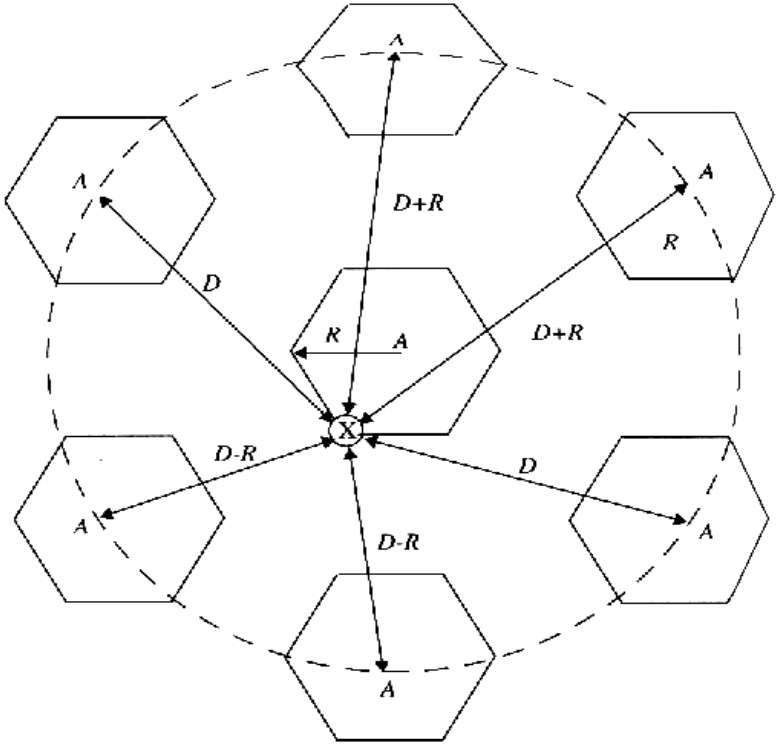
Signal-to-interference ratio (SIR)

- The signal-to-interference ratio (SIR) for a mobile receiver can be expressed as

$$SIR = \frac{S}{\sum_{i=0}^{i_0} I_i}$$

- S denotes the desired signal power;
- I_i is the interference power caused by the i-th interfering co-channel cell base station;
- i_0 is the number of cochannel interfering cells.

Signal-to-interference ratio (SIR)



Adjacent Channel Interference

- Interference resulting from signals which are adjacent 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 into the passband.
- Near-far effect:
  - If an adjacent channel user is transmitting in very close range to a subscriber's receiver, the problem can be particularly serious.

Adjacent Channel Interference

- Adjacent channel interference can be minimized through careful filtering and channel assignments:
  - By keeping the frequency separation between each channel in a given cell as large as possible, the adjacent channel interference may be reduced considerably.
  - Channel allocation schemes can also prevent a secondary source of adjacent channel interference by avoiding the use of adjacent channels in neighboring cell sites.
  - High Q cavity filters can be used in order to reject adjacent channel interference.

Improving Capacity In Cellular Systems

- As the demand for wireless service increases, the number of channels assigned to a cell eventually becomes insufficient to support the required number of users.
- Techniques to expand the capacity of cellular systems :
  - Cell splitting: increases the number of base stations in order to increase capacity.
  - Sectoring: relies on base station antenna placements to improve capacity by reducing co-channel interference.
  - Coverage zone: distributes the coverage of a cell and extends the cell boundary to hard-to-reach places.

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.

Cells are split to add channels with no new spectrum usage:

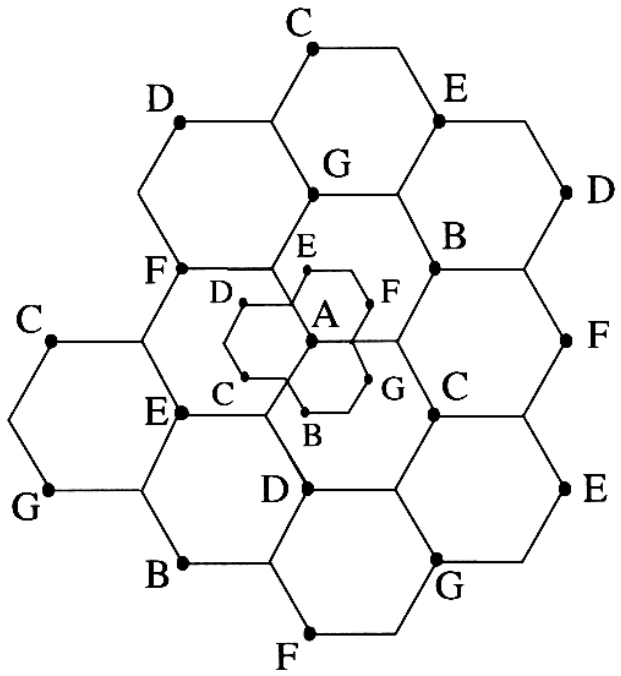


Figure 3.8 Illustration of cell splitting.

Cell Splitting increases capacity

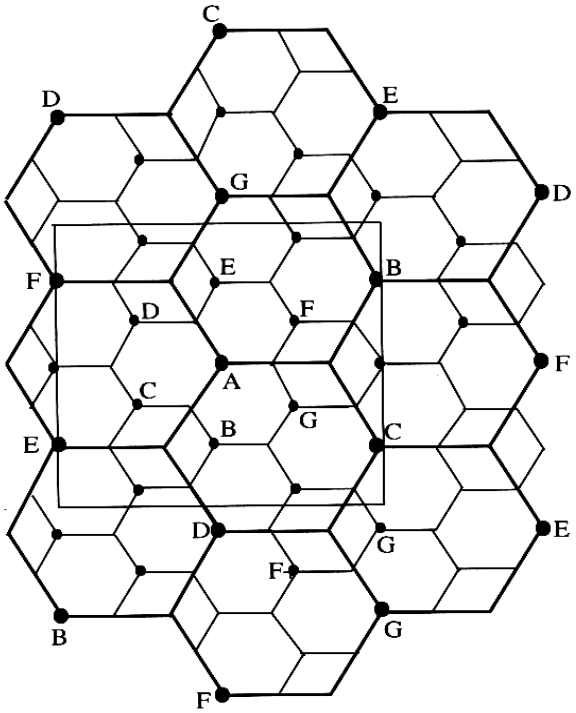


Figure 3.9 Illustration of cell splitting within a 3 km by 3 km square centered around base station A.

Sectoring

- The technique for decreasing co-channel interference and thus increasing system capacity by using directional antennas is called sectoring.
- The factor by which the co-channel interference is reduced depends on the amount of sectoring used.

Sectoring improves S/I

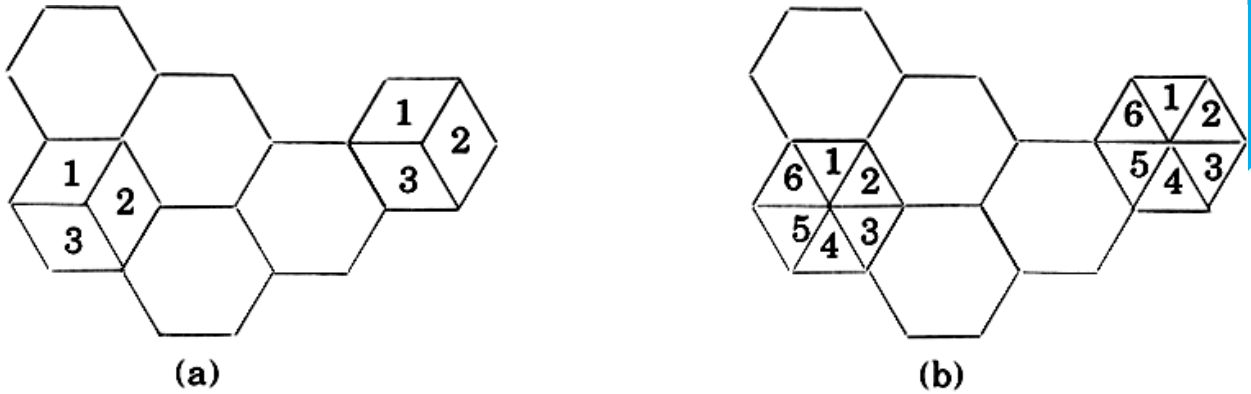


Figure 3.10 (a) 120° sectoring; (b) 60° sectoring.

Sectoring improves S/I

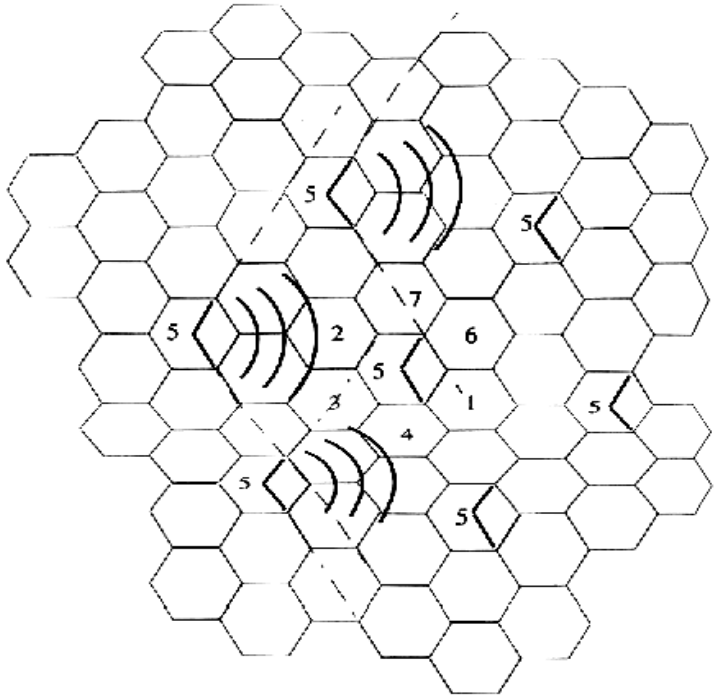


Figure 3.11 Illustration of how 120° sectoring reduces interference from co-channel cells. Out of the 6 co-channel cells in the first tier, only two of them interfere with the center cell. If omnidirectional antennas were used at each base station, all six co-channel cells would interfere with the center cell.

A Novel Microcell Zone Concept

- Zone Concept
  - Zone sites are connected to a single base station and share the same radio equipment.
  - The zones are connected by coaxial cable, fiberoptic cable, or microwave link to the base station.
  - Multiple zones and a single base station make up a cell.
  - As a mobile travels within the cell, it is served by the zone with the strongest signal.
  - This technique is particularly useful along highways or along urban traffic corridors.
- This approach is superior to sectoring since antennas are placed at the outer edges of the cell, and any base station channel may be assigned to any zone by the base station.
- In comparison with sectoring, the number of handoffs can be reduced significantly.

The Zone Cell Concept

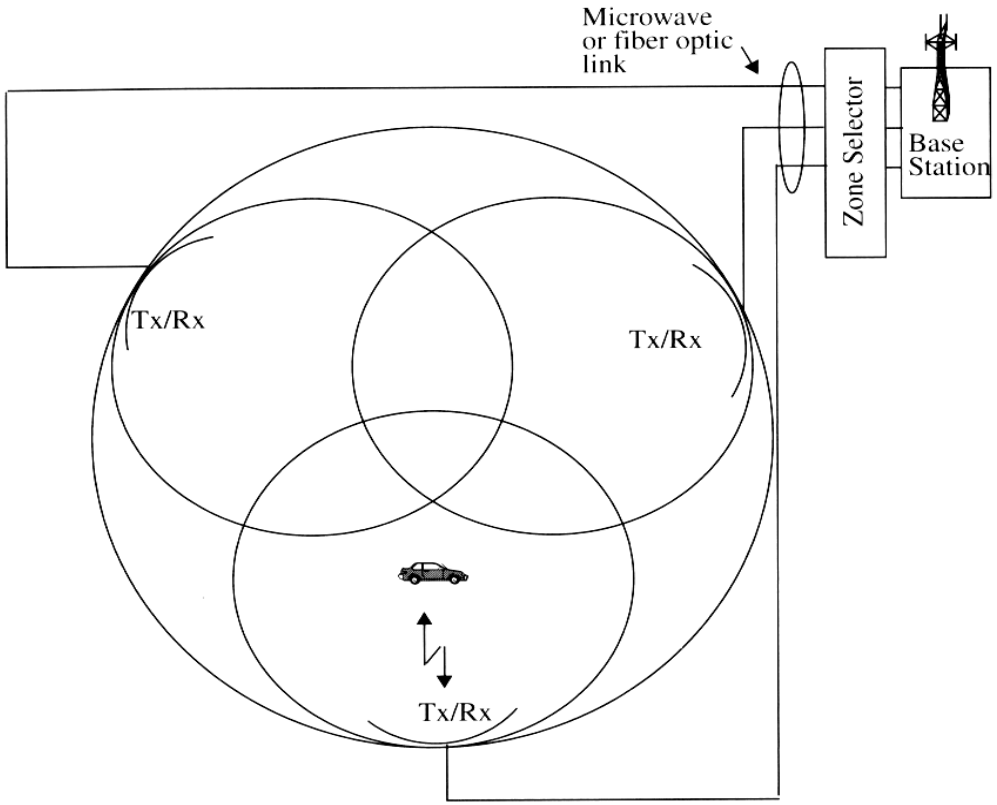


Figure 3.13 The microcell concept [adapted from [Lee91b] © IEEE].


Thank
you