UNIK4230: Mobile Communications

Mohammad M. R. Chowdhury, Ph.D.
mohammad@unik.no

Cell and Cellular Traffic

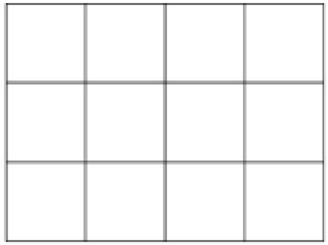
Prepared by Mohammad M. R. Chowdhury, Ph.D.

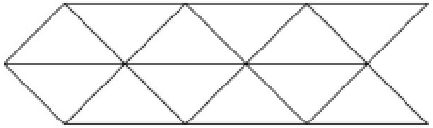
Agenda

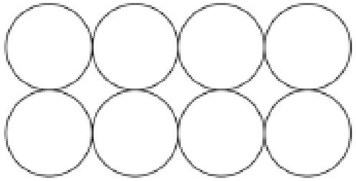
- Cell-geometry
- Cell and frequency reuse
- Frequency reuse
- Co-channel Interference
- Cell splitting
- Hierarchical cell structure

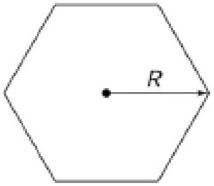
Cell geometry

- Different cell types are present in the planning of a mobile network
- Hexagonal cells describes complete coverage, and provides an approximate picture of the symmetric to that provided by normal radiopropagasjon


(a)


(b)

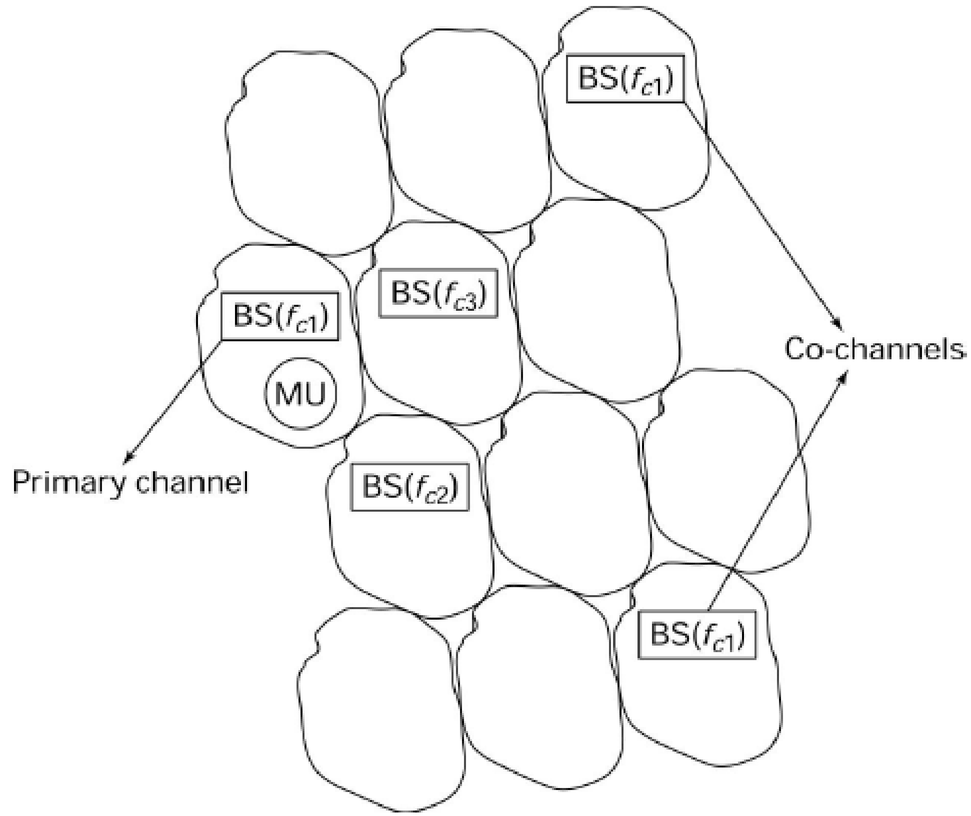

(c)



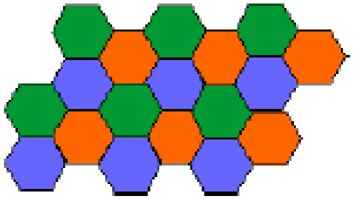
(d)

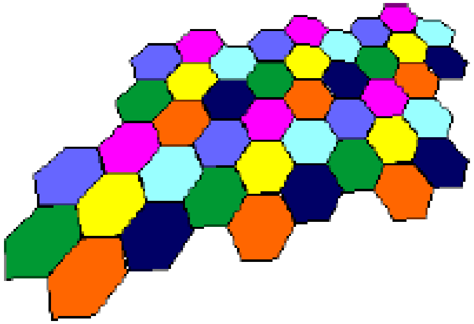
Introduction: cell & frequency resue

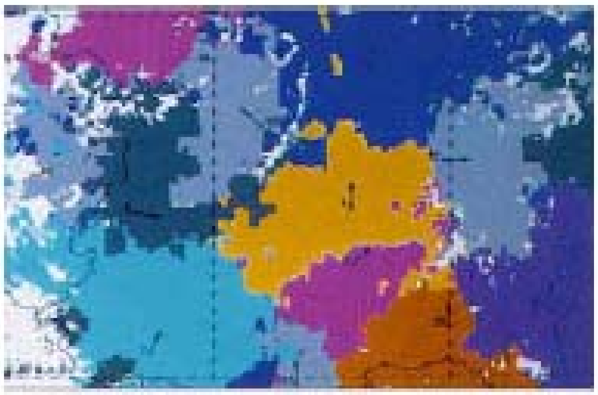
- **Cell:** Limited geographic area covered by a base station in a mobile system
- **Frequency reuse:** The same channel (frequency) is used in several cells apart



Frequency reuse







Why frequency resue?

- Same freqeuncy in the neighboring cells create interference
  - Reduce capacity
- Adjacent cells use different frequency
- Freqeuncy reuse distance:

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

  - *R* is the cell radius and *N* is the number of cells per cluster
  - Cell clusters are a group of cells that use all frequencies

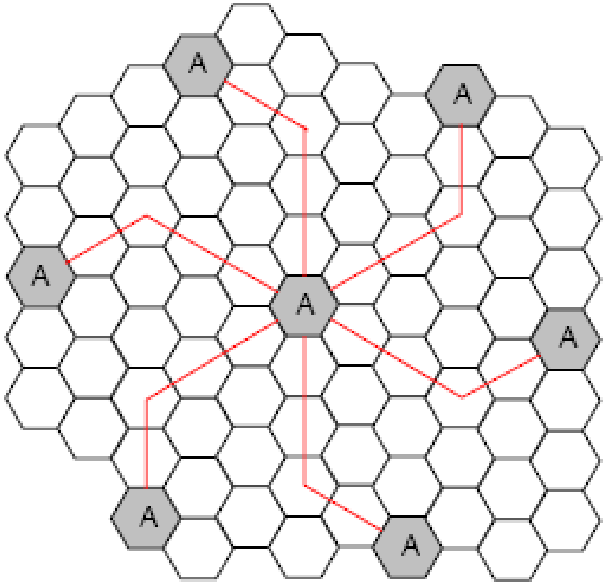
Freqeucy resue: cluster size

In hexagonal geometry, there are six neighbors of each cell and the line joining the centers of any cell and each of its neighbors are separated by 60 degrees. This restricts the number of usable cluster sizes and their layouts. In order to *tessellate*-to connect cells without gap-the number of cells per cluster, N, can only have values, which satisfy the following equation:

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

where i and j are non-negative integers. To find the nearest co-channel neighbors of a particular cell, one must do the following:

1. Move i cells along any chain of hexagons.
2. Turn 60 degrees counter-clockwise and move j cells. Figure 5 illustrates this process with i = 3, j = 2, and N = 19.



Freqeucy resue factor

- Reuse factor = D/R

i	j	N_c	$q = D/R$
1	0	1	1.73
1	1	3	3
2	0	4	3.46
2	1	7	4.58
3	0	9	5.2
2	2	12	6

Example

Example

Let a total of 33MHz of bandwidth be allocated to a particular FDD cellular telephone system, which uses two 25kHz simplex channels to provide full duplex voice and control channels. Compute the number of channels available per cell if the system uses (a) 4-cell reuse, (b) 7-cell reuse, and (c) 12-cell reuse. If 1 MHz of the allocated spectrum is dedicated to control channels, determine an equitable distribution of control channels and voice channels in each cell for each of the three systems.

Example

Given: Total bandwidth = 33 MHz.
Channel bandwidth = 25 kHz simplex channels. 25x2 = 50 kHz duplex channels.
Total available channels = 33,000/50 = 660 channels.

(a) for N = 4, total number of channels available per cell = 660/4 ≈ 165 channels.
(b) for N = 7, total number of channels available per cell = 660/7 ≈ 95 channels.
(c) for N = 12, total number of channels available per cell = 660/12 ≈ 55 channels.

Example

A 1 MHz spectrum for control channels implies that there are 1000/50 = 20 control channels out of the 660 channels available. To evenly distribute the control and voice channels, simply allocate the same number of channels in each cell wherever possible. Here, the 660

channels must be evenly distributed to each cell within the cluster. In practice, only the 640 voice channels would be allocated, since the control channels are allocated separately as 1 per cell.

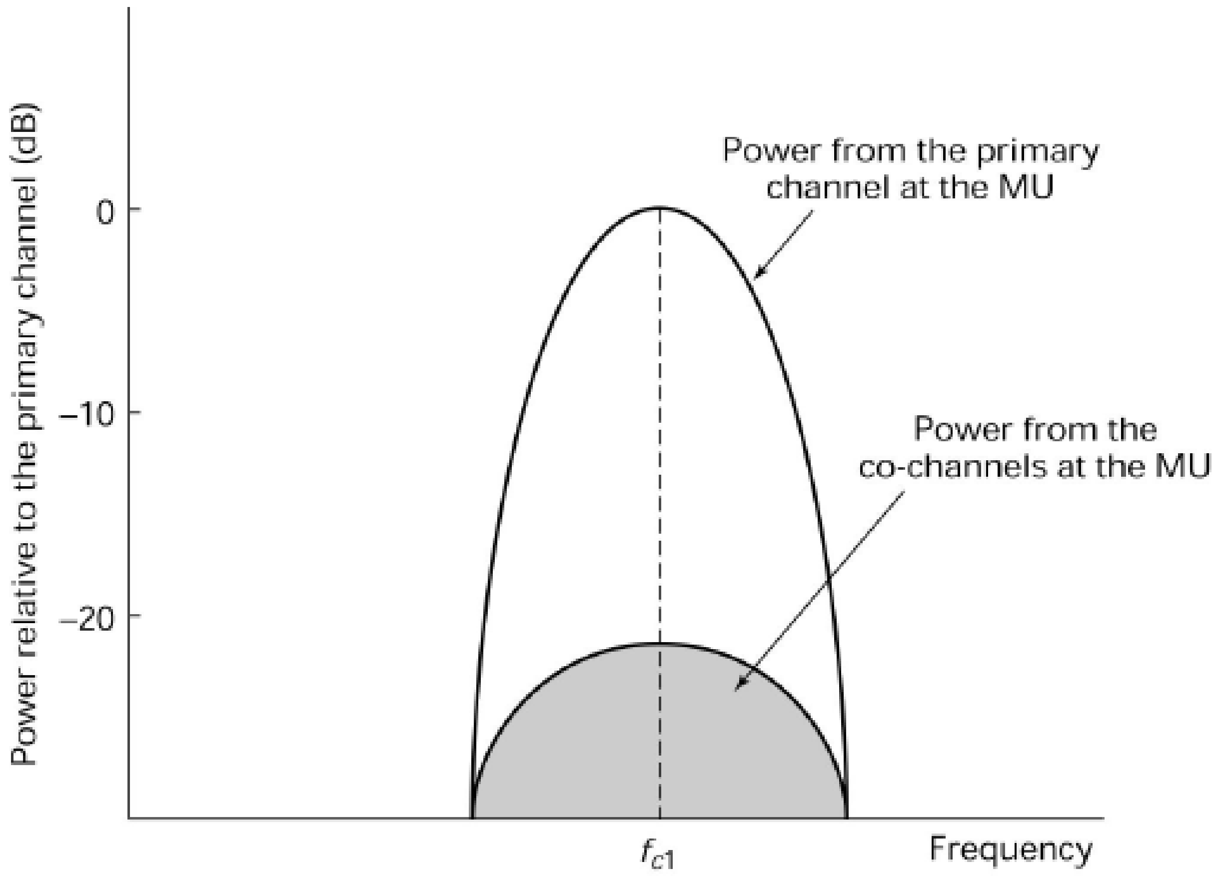
(a) For N = 4, we can have 5 control channels and 160 voice channels per cell. In practice, however, each cell only needs a single control channel (the control channels have a greater reuse distance than the voice channels). Thus, one control channel and 160 voice channels would be assigned to each cell.

(b) For N = 7, 4 cells with 3 control channels and 92 voice channels, 2 cells with 3 control channels and 90 voice channels, and 1 cell with 2 control channels and 92 voice channels could be allocated. In practice, however, each cell would have one control channel, four cells would have 91 voice channels, and three cells would have 92 voice channels.

(c) For N = 12, we can have 8 cells with 2 control channels and 53 voice channels, and four cells with 1 control channel and 54 voice channels each. In an actual system, each cell would have 1 control channel, 8 cells would have 53 voice channels, and 4 cells would have 54 voice channels.

Co-channel Interference (CCI)

- CCI: Interference from other cells used the same channel (frequency)



Co-channel Interference (CCI)

Signal to noise ratio can be defined:

$$\frac{S}{N} = \frac{\text{signal power}(S)}{\text{noise power }(N_s) + \text{interfering signal power }(I)}$$

Signal to CCI ratio defined:

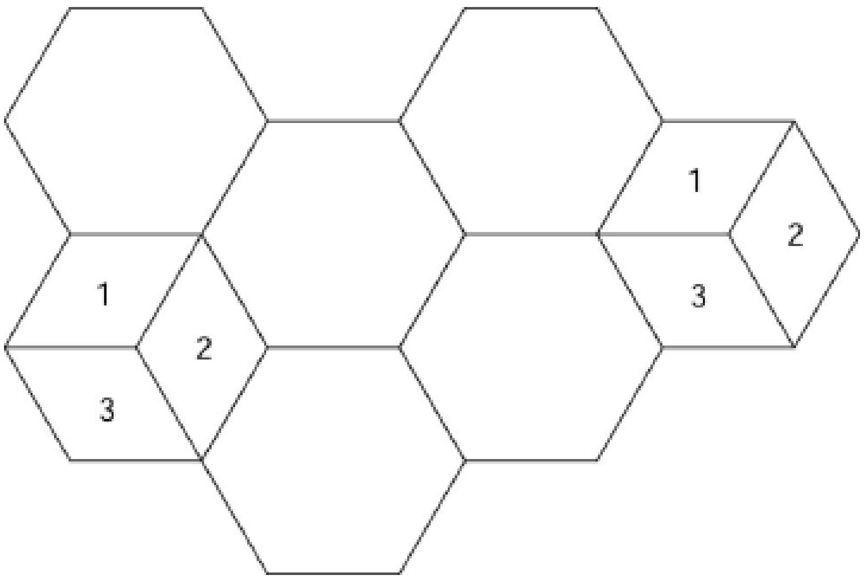
$$\frac{S}{I} = \frac{\text{signal power}(S)}{\text{interfering signal power }(I)}$$

When CCI dominates compare to noise:

$$\frac{S}{N} = \frac{S}{I}$$

Co-channel Interference (CCI): reduction

- CCI reduction by using sector antennas
  • interference is reduced when directional antennas are used to divide a cell into sectors



Co-channel Interference (CCI): reduction

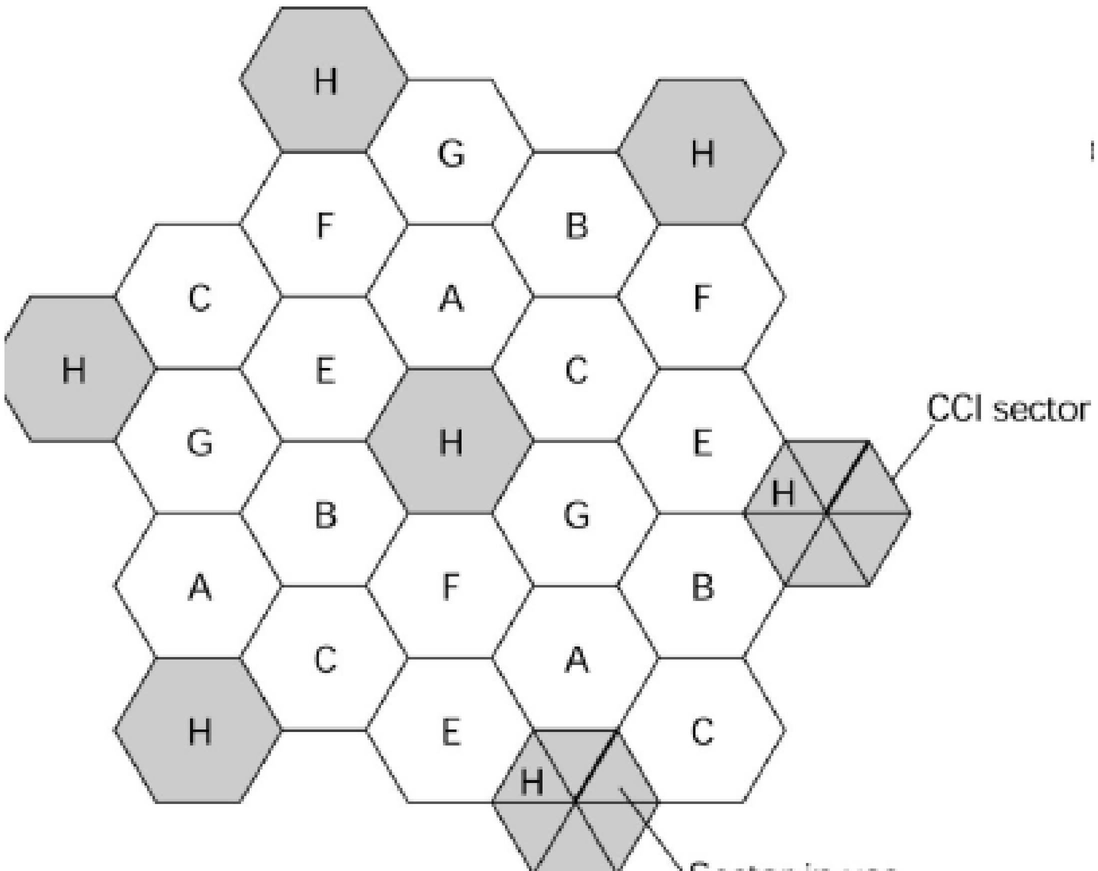
- For the 120-sectors are CCI reduction by a factor of 3, which gives:

$$\left[\frac{S}{I}\right]_{120°} = \left[\frac{S}{I}\right]_{\text{omni}} + 10 \log 3 = \left[\frac{S}{I}\right]_{\text{omni}} + 4.77 \text{ dB}$$

- For the 60-sectors are CCI reduction by a factor 6, which provides:

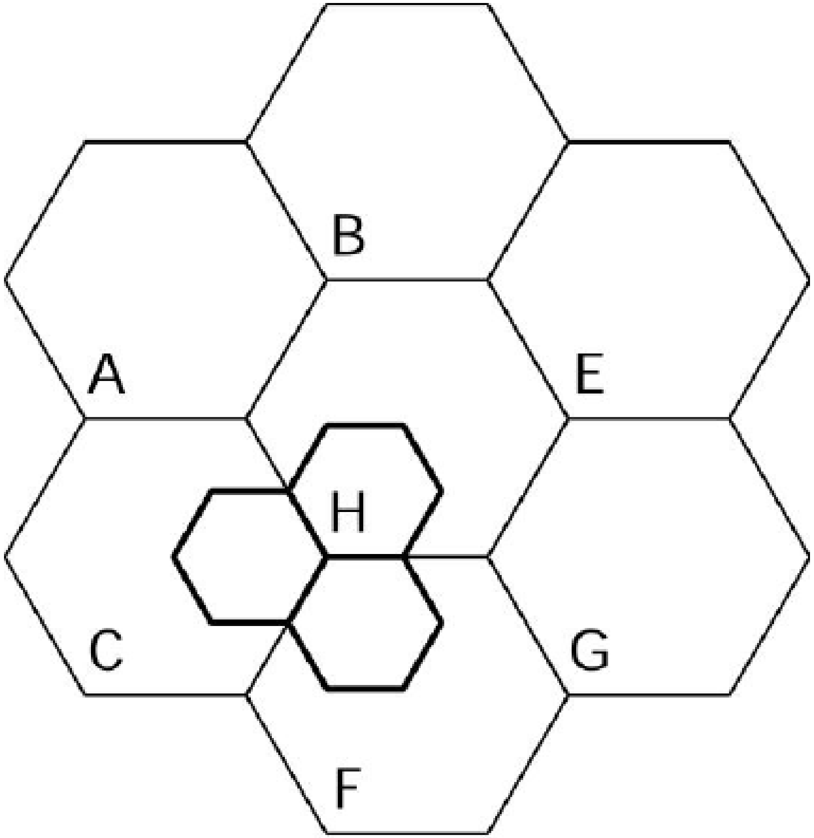
$$\left[\frac{S}{I}\right]_{60°} = \left[\frac{S}{I}\right]_{\text{omni}} + 10 \log 6 = \left[\frac{S}{I}\right]_{\text{omni}} + 7.78 \text{ dB}$$

60 degree sector



Cell-splitting

- A technique for increasing capacity are cell-splitting, which means to divide a cell into smaller cells.
  - The principle is illustrated in the figure.



Hierarchical Cell Structure

- In a mobile system can coexist with different cell sizes in the same area:
  - Picoceller, micro cells, macro cells
  • This is called hierarchical cell structure.
  • Can make handover (switching between cells) complex. Often, different groups of users restricted to a type of cell, such as:
  -propelled indoors in pico-cell, walking outdoors in a micro cell, moving in macro-cell