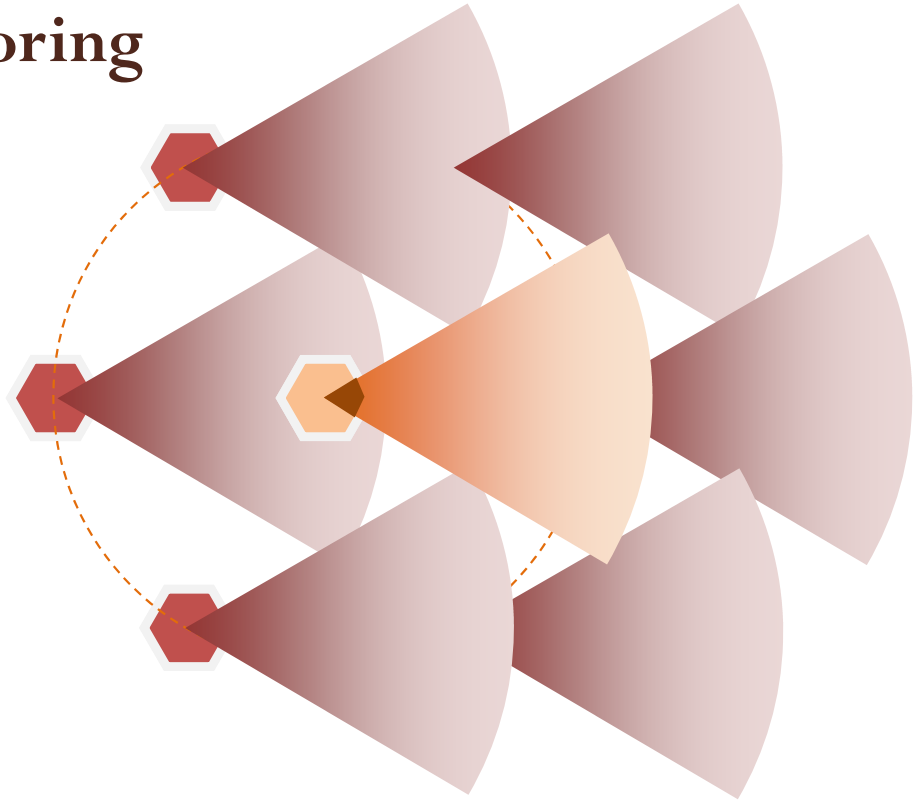
ECS455 Chapter 2

Cellular Systems

2.3 Sectoring



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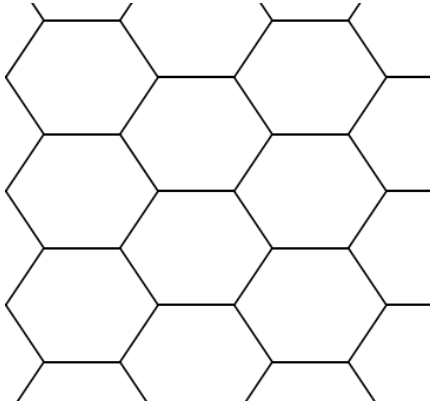
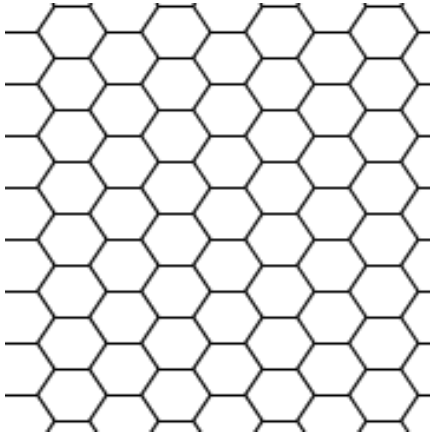
Improving Coverage and Capacity

- 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.
- At this point, cellular design techniques are needed to provide more channels per unit coverage area.
- Easy!?

$$C = \frac{A_{\text{total}}}{A_{\text{cell}}} \times \frac{S}{N}$$

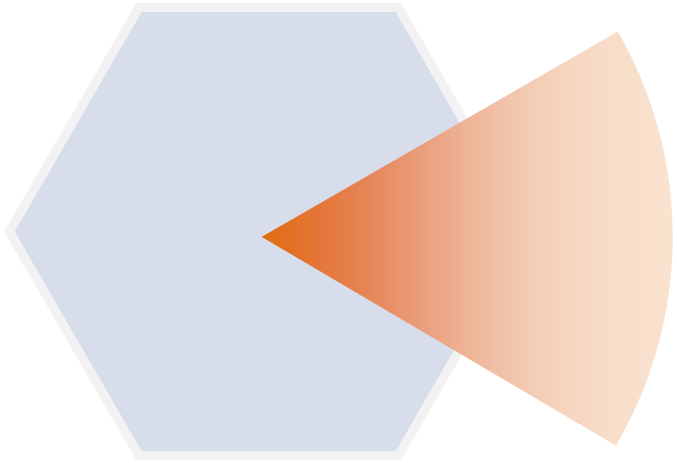




If cells can be reduced in size, more of them can be added in a given area, increasing the overall capacity.

Sectorization (sectoring)

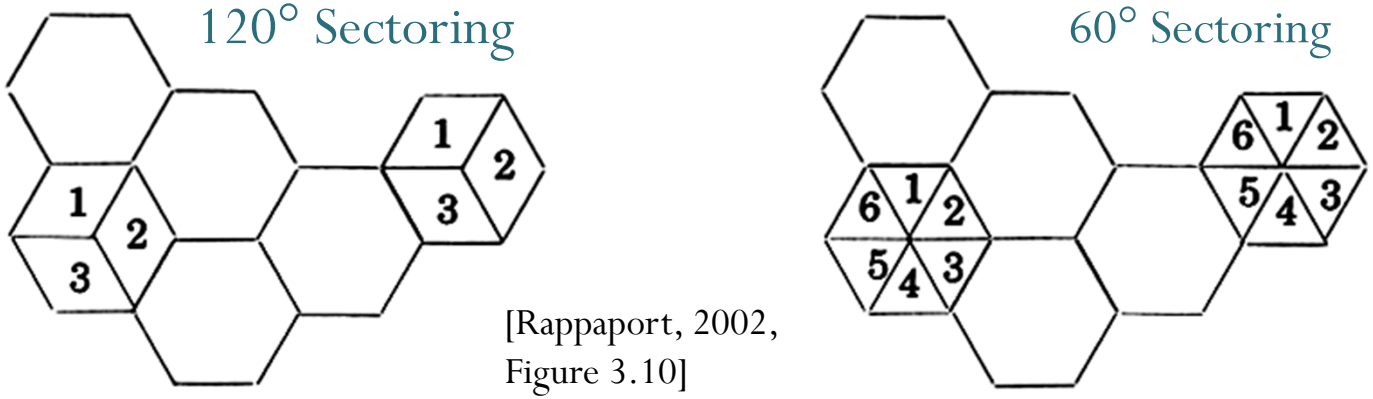
- Use directional antennas instead of omnidirectional antennas.
- When 120° sectorization is used, one cell that usually covers 360° is divided into three 120° regions.
- When 60° sectorization is used, one cell that usually covers 360° is divided into six 60° regions.
- These regions are called **sectors**.



Analogy: Flashlight

Sectoring (N = 7)

- Ex.
  - With no sectoring, suppose we have $m = 18$ channels/cell
  - With 120° sectoring, we have 6 channels/sector
  - With 60° sectoring, we have 3 channels/sector



[Rappaport, 2002, Figure 3.10]

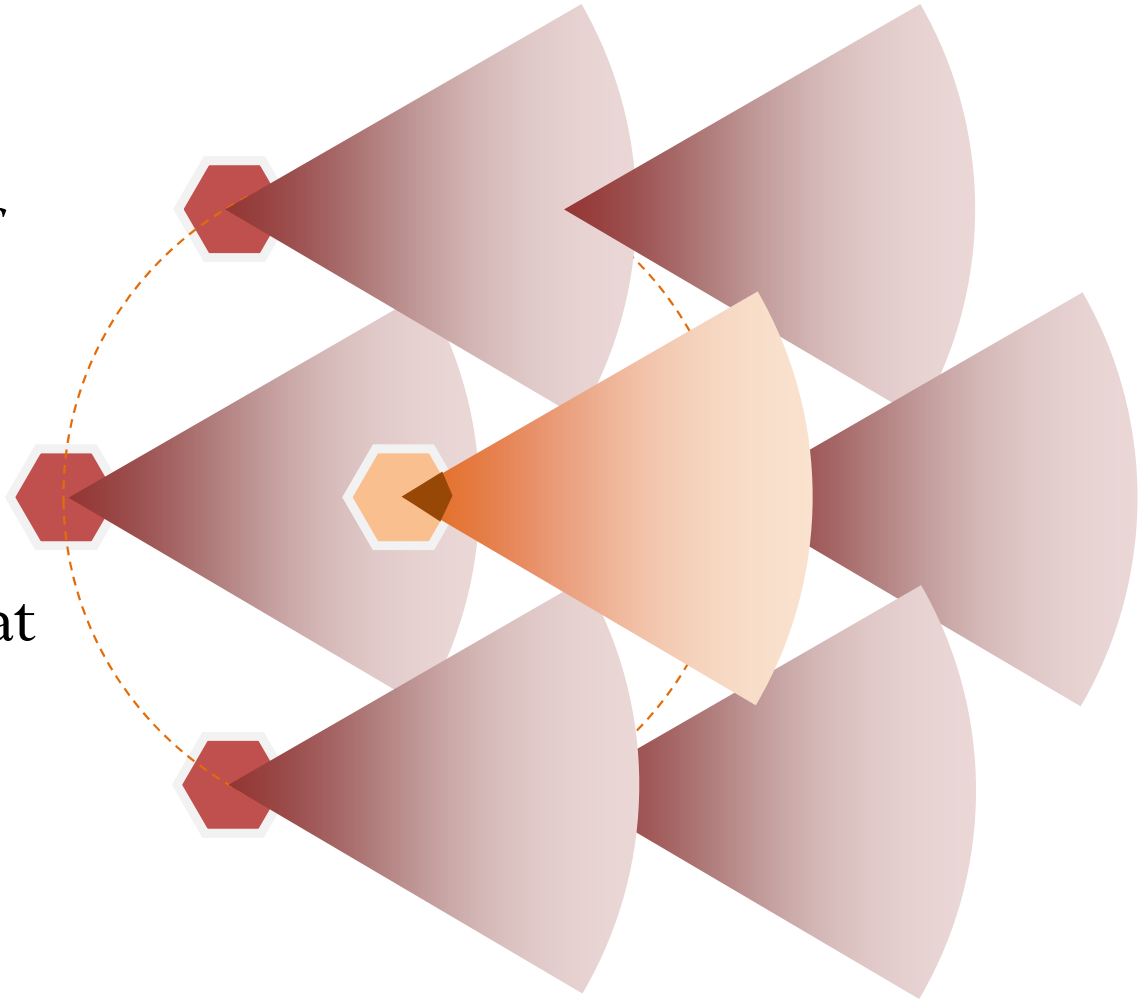
- Can support "the same" number of users per cell
  - In the next section, we will consider better definition of capacity. From such view on capacity, sectoring will give smaller capacity.
- Why is this better?

From previous section

$$\text{SIR} \approx \frac{1}{K}\left(\sqrt{3N}\right)^{\gamma}$$

60 Degree Sectoring

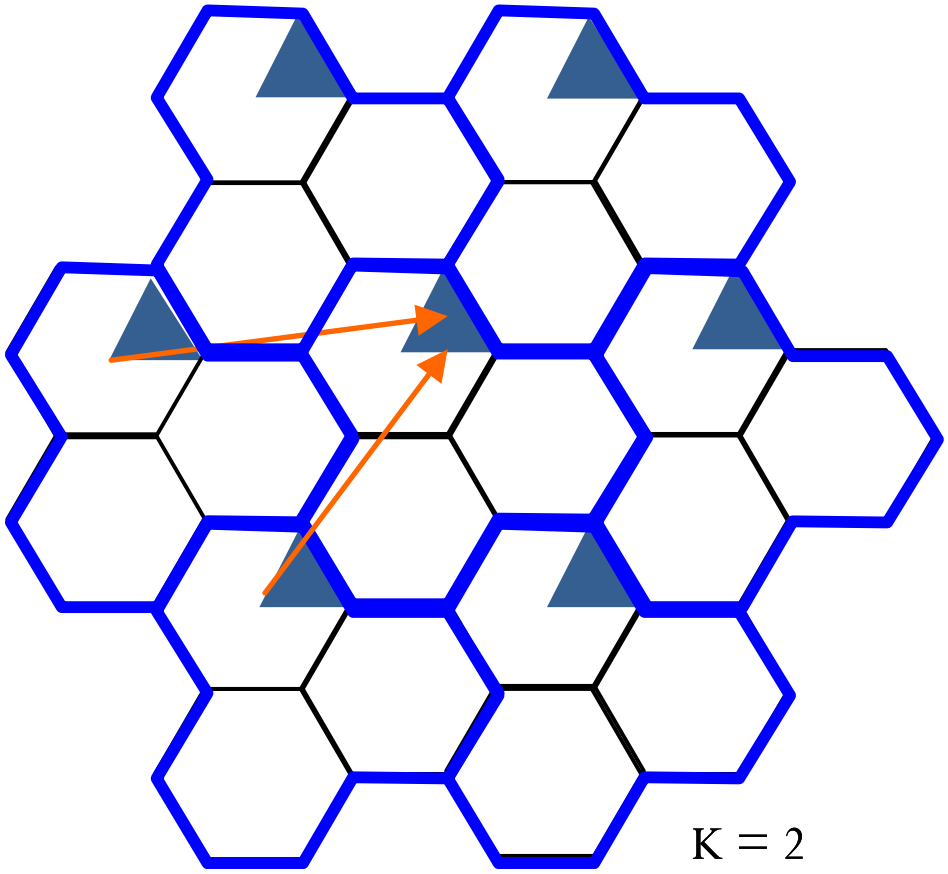
- Out of the 6 co-channel cells in the first tier, only one of them interfere with the center cell.
- If omnidirectional antennas were used at each base station, all 6 co-channel cells would interfere the the center cell.



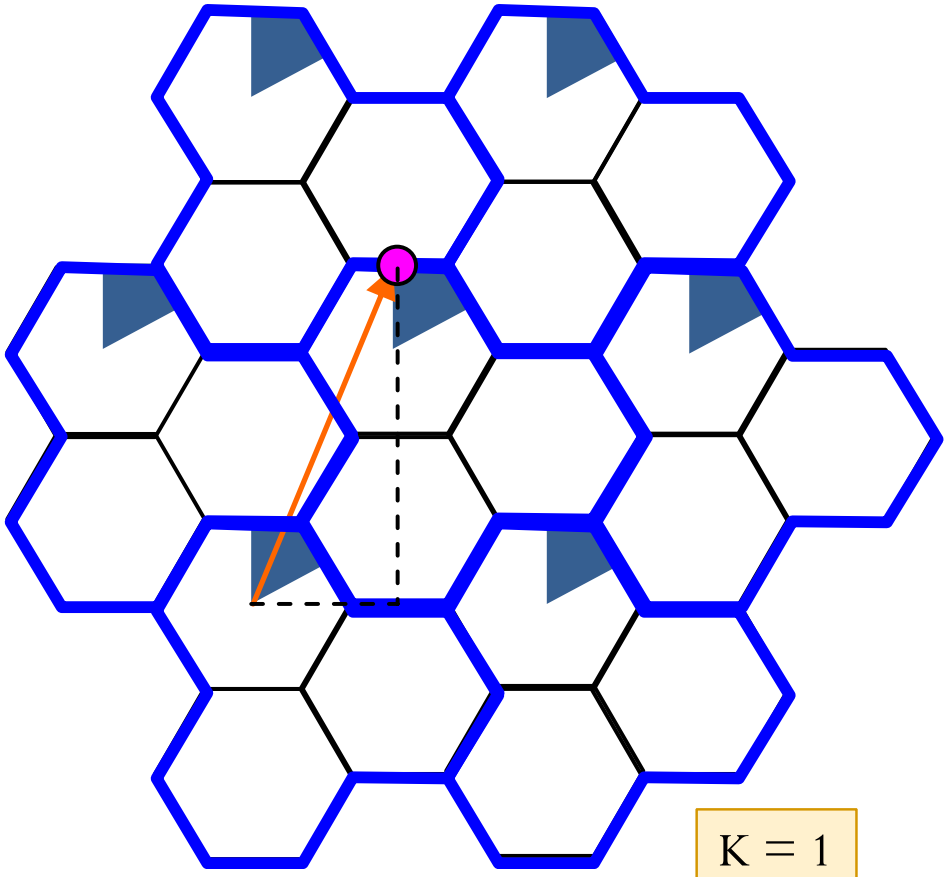
The value of K changes from 6 to 1!

Sectoring (N = 3 , 60°)

$$\mathrm{SIR} \approx \frac{1}{K}\left(\sqrt{3N}\right)^{\gamma}$$



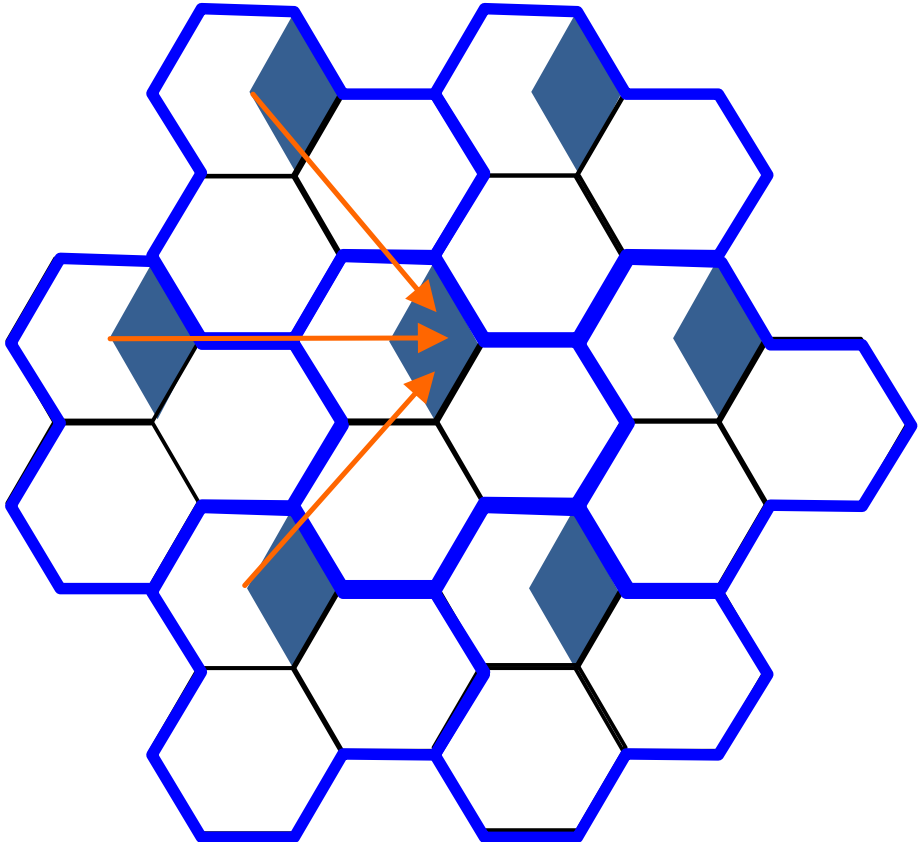
K = 2



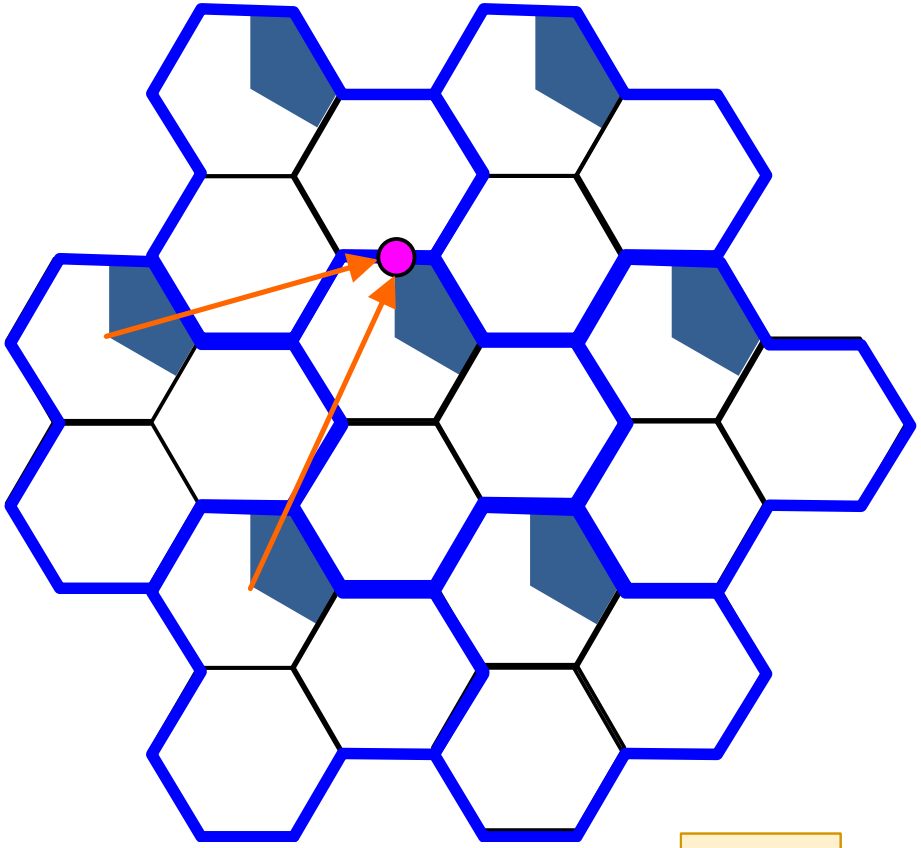
K = 1

Sectoring (N = 3, 120°)

$$\mathrm{SIR} \approx \frac{1}{K}\left(\sqrt{3N}\right)^{\gamma}$$



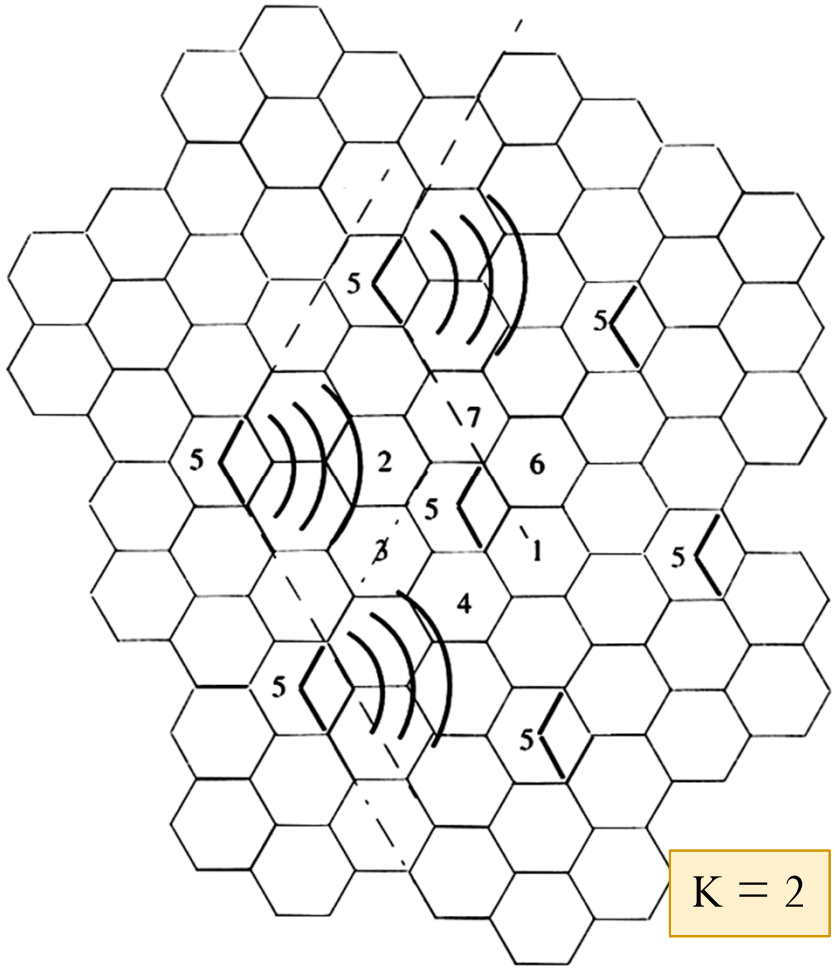
K = 3



K = 2

Sectoring (N = 7, 120°)

Assuming seven-cell reuse, for the case of 120° sectors, the number of interferers in the first tier is reduced from six to two.



[Rappaport, 2002, Fig 3.11]

Summary:

S = total # available duplex radio channels for the system

Frequency reuse with **cluster size N**

Path loss exponent

"Capacity" $C = \frac{A_{total}}{A_{cell}} \times \frac{S}{N}$ ⟷ Tradeoff $\frac{S}{I} \approx \frac{kR^{-\gamma}}{K \times (kD^{-\gamma})} = \frac{1}{K}\left(\frac{D}{R}\right)^{\gamma} = \frac{1}{K}\left(\sqrt{3N}\right)^{\gamma}$

m = # channels allocated to each cell.

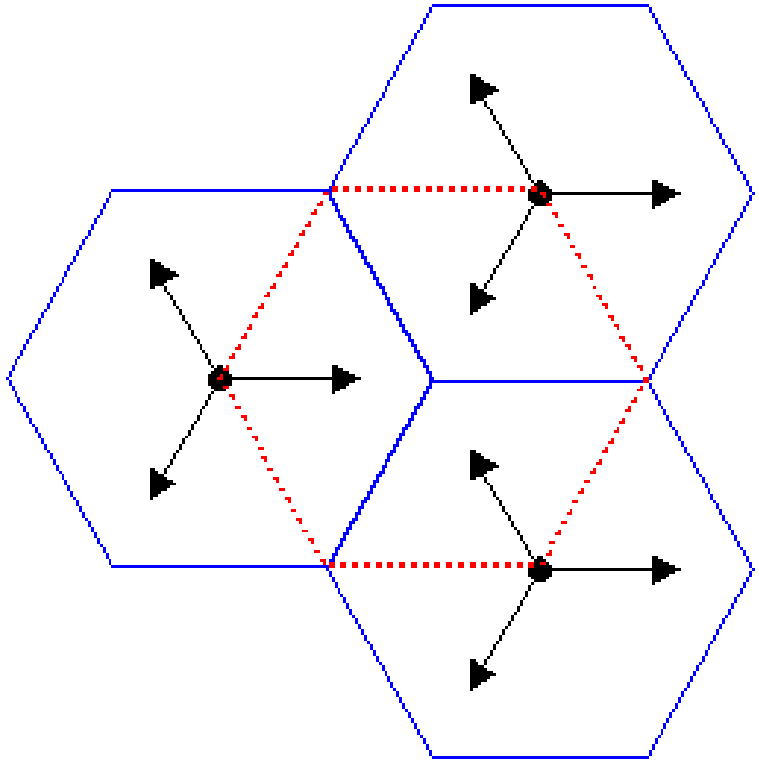
- Omni-directional: K = 6
- 120° Sectoring: K = 2
- 60° Sectoring: K = 1

Sectoring

- Advantages
  - Reduce interference by reducing *K*
    - Increase SIR (better call quality).
    - The increase in SIR can be **traded** with reducing the cluster size (*N*) which increase the capacity.
- Disadvantages
  - Cost: Increase number of antennas at each base station.
  - Next section: Decrease **trunking efficiency** due to channel sectoring at the base station.
    - The available channels in the cell must be subdivided and dedicated to a specific antenna.

Location of the BS

- Center vs. Corner



Visualizing the Cellular Signals

- Artist: Nickolay Lamm
- Use data from antennasearch.com to approximate the number of stations in each city and imposed a theoretical hexagonal grid over Chicago and New York.
- Color representation:
  - The area within each sector antenna radiation pattern has different users being assigned different frequencies and their signals combine to form a single perceived color in that instant.
  - Different channel combinations from sector to sector are indicated by different colors.
  - The channel combinations are not static, but rather change rapidly in time as different users are assigned different channels. But, if you were to take a photo of these rapid changes, you'd likely see a wide array of colors as seen in the illustration.
- With some technical check by
  - Danilo Erricolo, professor of electrical and computer engineering at the University of Illinois, and
  - Fran Harackiewicz, a professor at Southern Illinois University Carbondale who teaches antenna theory and design.

[http://motherboard.vice.com/blog/here-are-what-cell-phone-signals-would-look-like-if-you-could-see-them]