The Cellular Concept- System Design Fundamentals

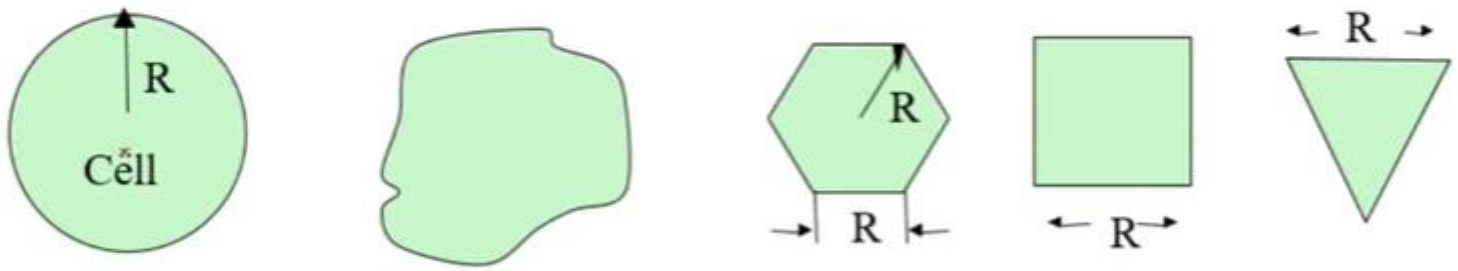
Cellular Concept

- Cellular concept is system level idea, which calls for replacing single high power transmitter with many low power transmitters.
- It offer very high capacity in a limited spectrum allocation.
- Each base station is allocated portion of the total number of channels available to the entire system.
- Neighboring base stations are assigned different groups of channels so that interference between base stations is minimized.

What is cell?

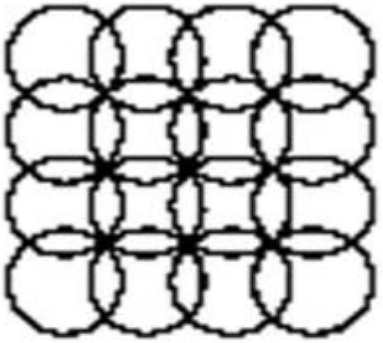
- Each cellular base station is allocated a group of radio channels to be used within small geographic area called a cell.

Cell Shape

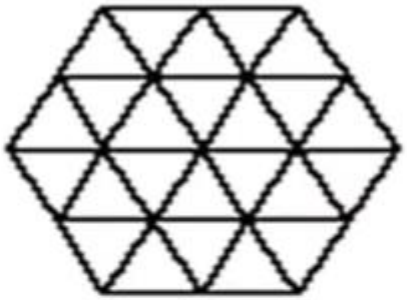


(a) Ideal cell (b) Actual cell (c) Different cell models

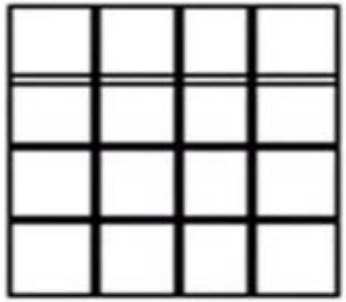
Cell Shape



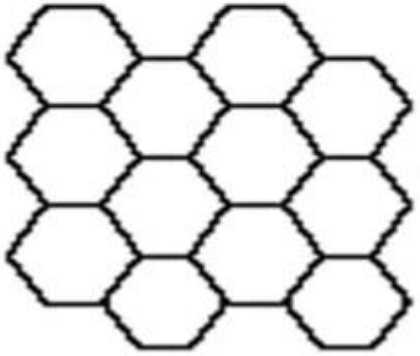
circles



equilateral triangles



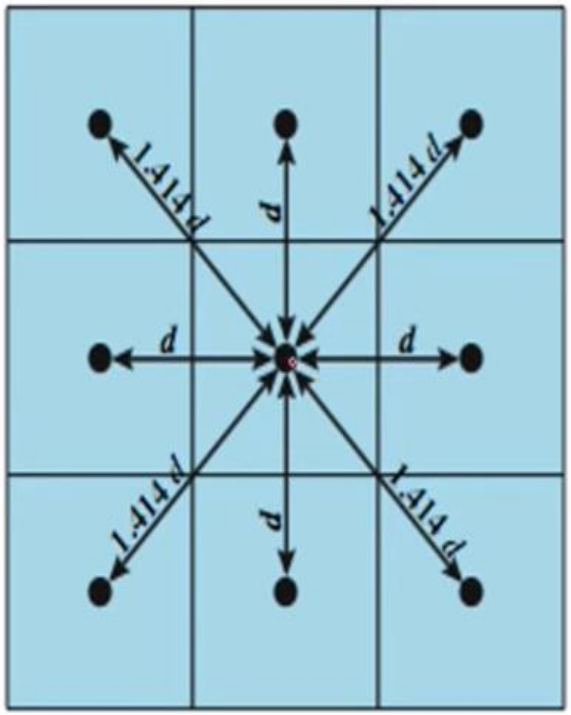
squares



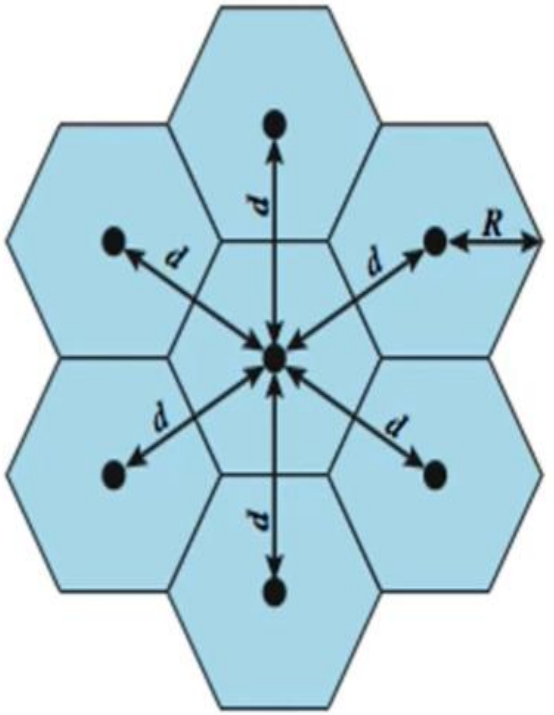
hexagons

geometric shapes wich cover an entire region without overlap and with equal area

Cellular Geometries



(a) Square pattern

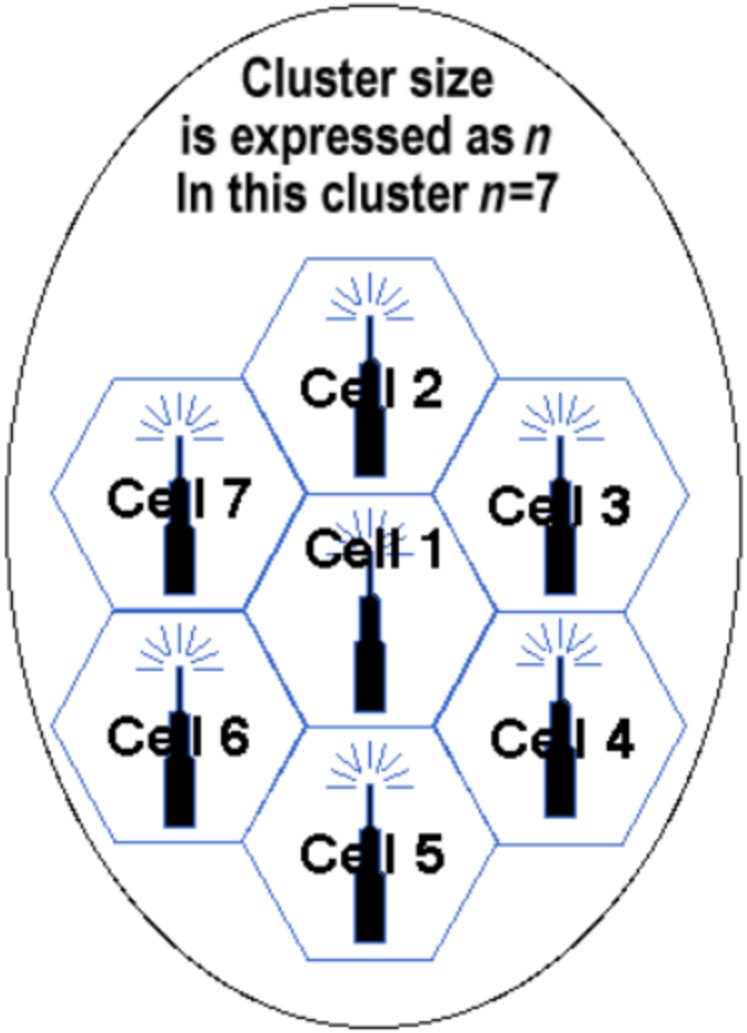


(b) Hexagonal pattern

Clusters

A cluster is a group of cells. No channels are reused within a cluster. Figure 4 illustrates a seven-cell cluster.

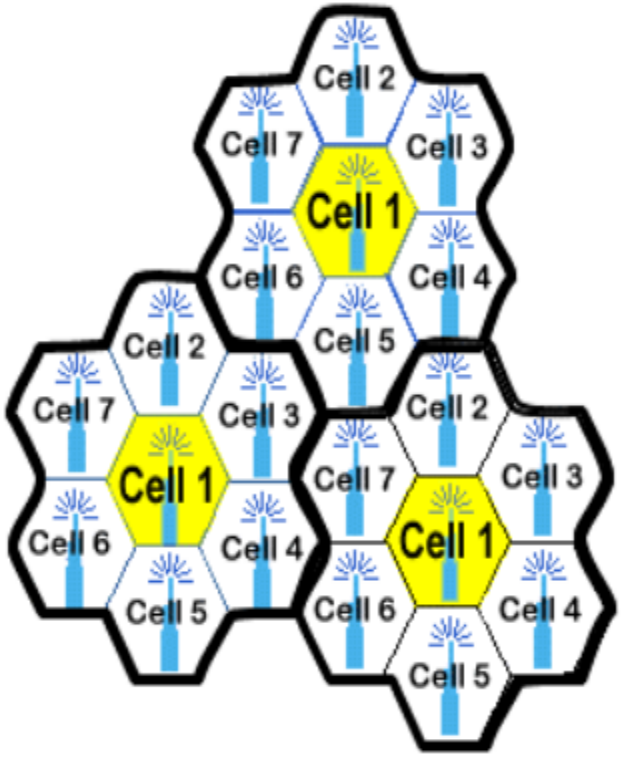
Figure 4: A Seven-Cell Cluster



Frequency Reuse

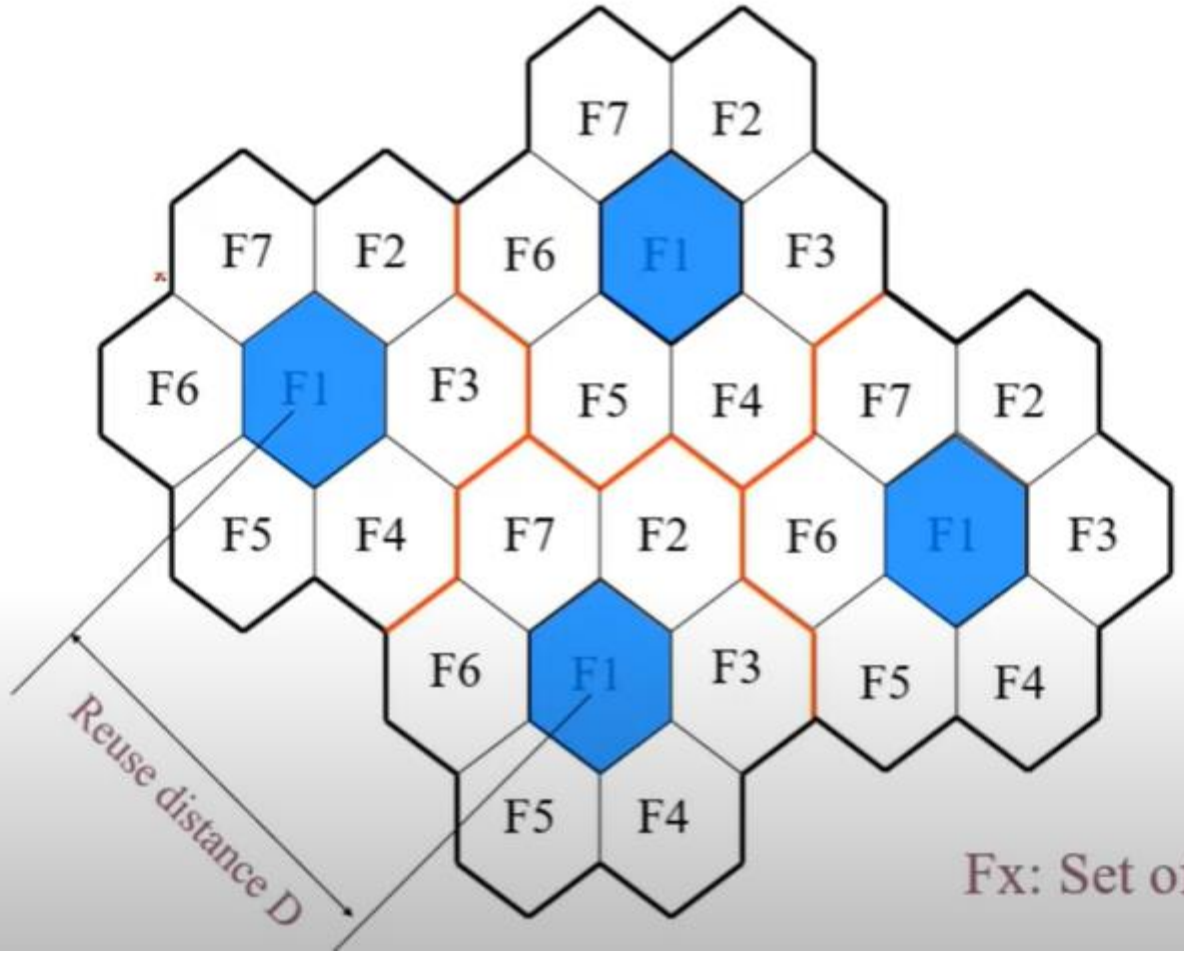
- By limiting the coverage area to within the boundaries of a cell, the **same group of channels** may be used to cover different cells that are separated from one another by distances large enough to keep interference levels within tolerable limits.
- The design process of selecting and allocating channel frequencies for all cellular base stations within a system is known as frequency re-use or frequency planning.

Figure 5: Frequency Reuse



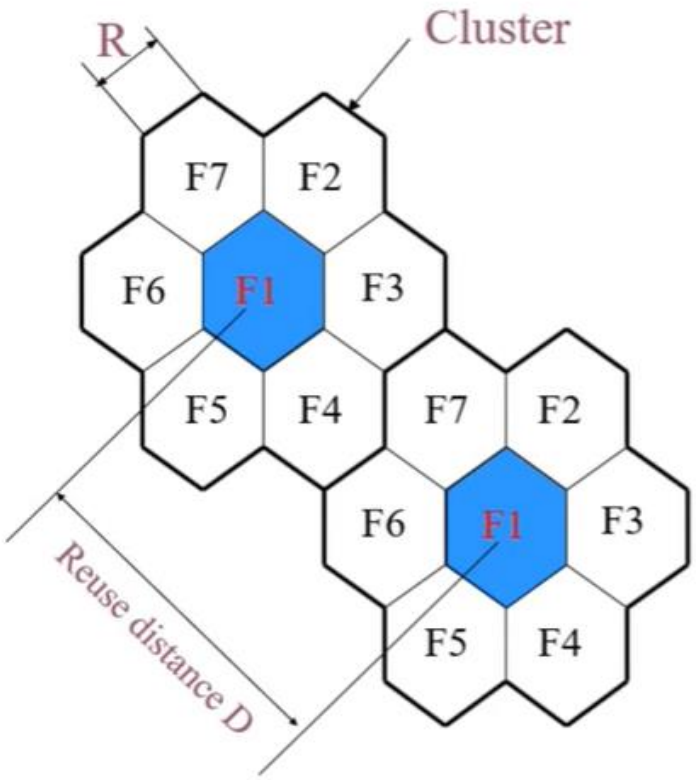
Cells with the same number have the same set of frequencies. Here, because the number of available frequencies is 7, the frequency reuse factor is 1/7. That is, each cell is using 1/7 of available cellular channels.

Frequency Reuse



Fx: Set of frequency

Reuse Distance



- For hexagonal cells, the reuse distance is given by

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

where R is cell radius and N is the reuse pattern (the cluster size or the number of cells per cluster).

- Reuse factor is

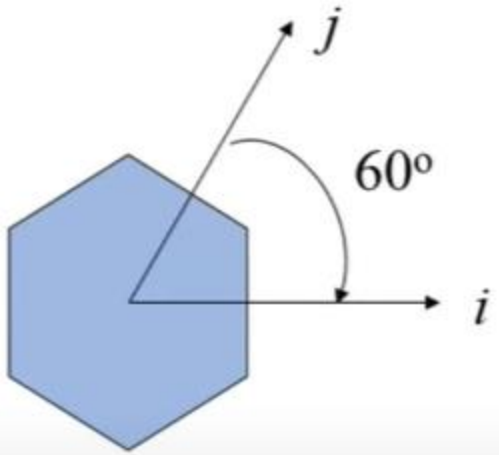
$$q = \frac{D}{R} = \sqrt{3N}$$

Reuse Distance (Cont'd)

- The cluster size or the number of cells per cluster is given by

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

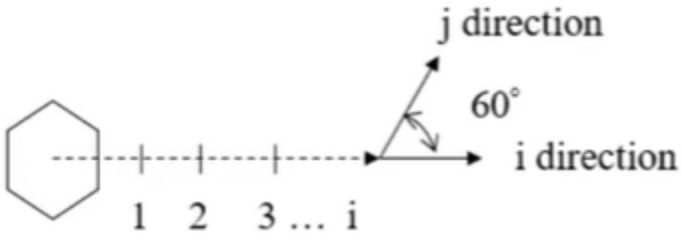
where i and j are integers.



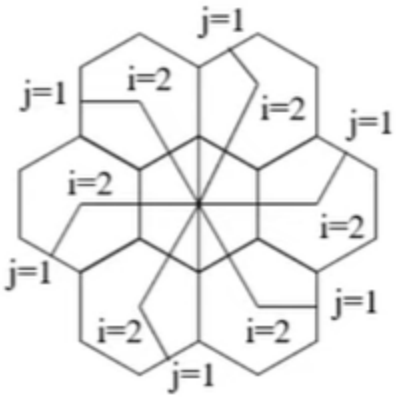
- N = 1, 3, 4, 7, 9, 12, 13, 16, 19, 21, 28, …, etc.

  The popular value of N being 4 and 7.

Reuse Distance (Cont'd)

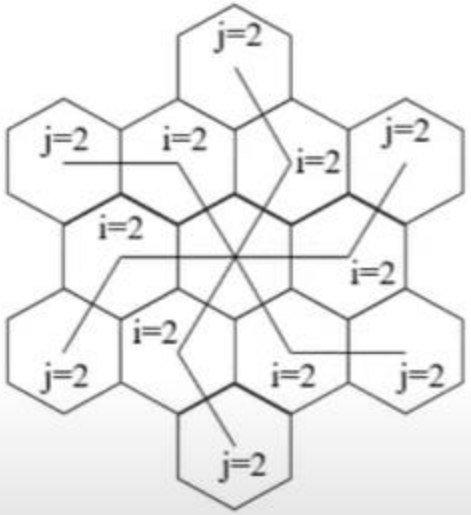


(a) Finding the center of an adjacent cluster using integers i and j (direction of i and j can be interchanged).

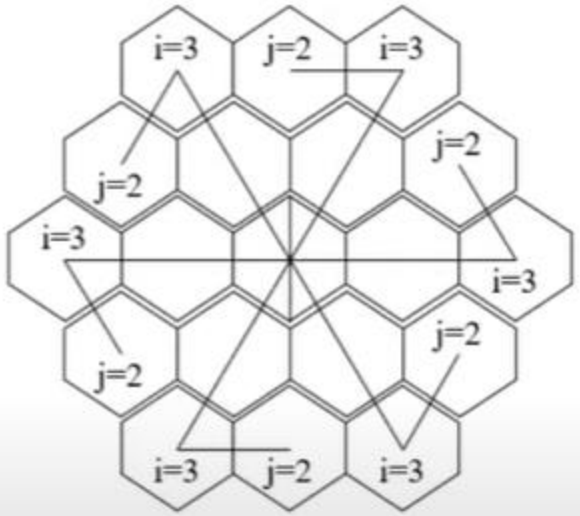


(b) Formation of a cluster for N = 7 with i=2 and j=1

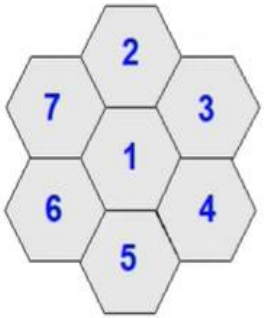
Reuse Distance (Cont'd)

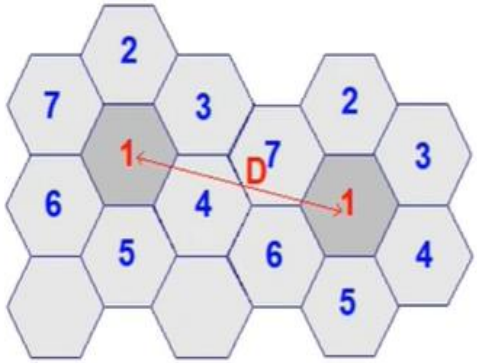


(c) A cluster with N =12 with i=2 and j=2

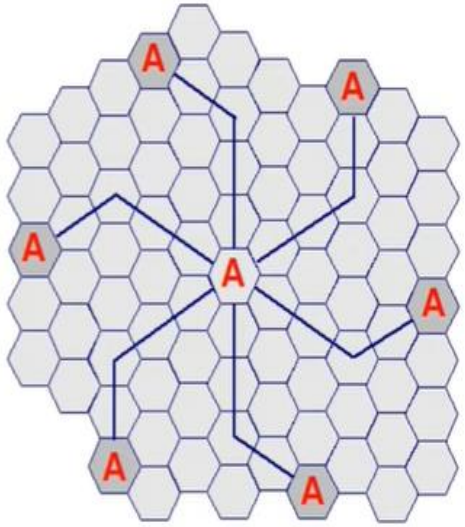


(d) A Cluster with N = 19 cells with i=3 and j=2





N = 7, frequency reuse pattern



Co-Cells for N=19

Frequency Reuse Concept

- Total number of available radio channels

$$S = kN$$

  - S = Total number of available duplex channels in cellular system
  - k = Number of channels per cell (k<S)
  - N = Cluster size (each cell having k channels & total S channels in cluster)
- If cluster is replicated M times, then total number of duplex channels

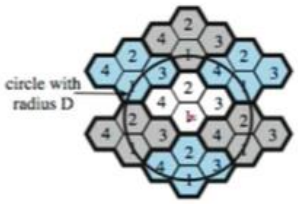
  then as measure of capacity

$$C = MkN = MS$$

Frequency reuse

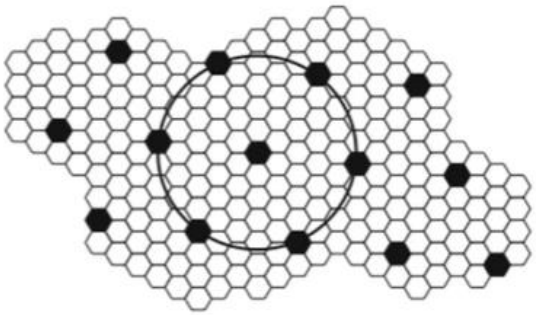
$S = kN$

$C = MkN = MS$



(a) Frequency reuse pattern for $N = 4$

(b) Frequency reuse pattern for $N = 7$



(c) Black cells indicate a frequency reuse for $N = 19$

(a) Number of Cluster M=7,
Frequency Reuse pattern N=4
Number of Channel per cell k=10