D = minimum distance between centers of cells that use the same frequency band (called co-channels)

R = radius of a cell

d = distance between centers of adjacent cells $\mathbf{d} = \sqrt{3}R$

N = number of cells in a pattern (Cluster size)

(Each cell in the pattern uses a unique set of frequency bands), termed the ***reuse factor***

In a hexagonal cell pattern: in order to tessellate (to connect without gaps between adjacent cells), only the following values of *N* are possible:

$$N = I^2 + J^2 + (I \times J) \qquad I, J = 0, 1, 2, 3, \ldots$$

Hence, possible values of *N* are 1, 3, 4, 7, 9, 12, 13, 16, 19, 21, and so on.

Choice of N (assuming constant cell size)

Small N:

•More cluster are required to cover the service area

•More capacity

•Higher probability of co-channel interference

Large N:

•Less cluster are required to cover the service area

•Less capacity

•Less probability of co-channel interference

The following relationship holds:

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

Where *q* is the reuse ratio.

This can also be expressed as

$$\frac{D}{d} = \sqrt{N}$$

Consider a cellular system which has a total of *K* duplex channels available for use. If each cell is allocated a group of *C* channels ($C < K$), and if the *K* channels are divided among *N* cells into channel groups which each have the same number of channels, the total number of available radio channels can be expressed as

$$K = C\,N$$

where

$$K = \frac{Spectrum\,bandwidth\,(or\,Total\,bandwidth)}{Channel\,bandwidth}$$

The *N* cells which collectively use the complete set of available frequencies is called a cluster. If a cluster is replicated *M* times within the system, the total number of duplex channels, can be used as a measure of capacity and is given

$$Capacity = MCN = MK$$

The capacity of a cellular system is directly proportional to the number of times a cluster is replicated in a fixed service area.

The cluster size (*N*) is typically equal to 4, 7, or 12.

If *N* is reduced while the cell size is kept constant, more clusters are required to cover a given area and hence more capacity is achieved.

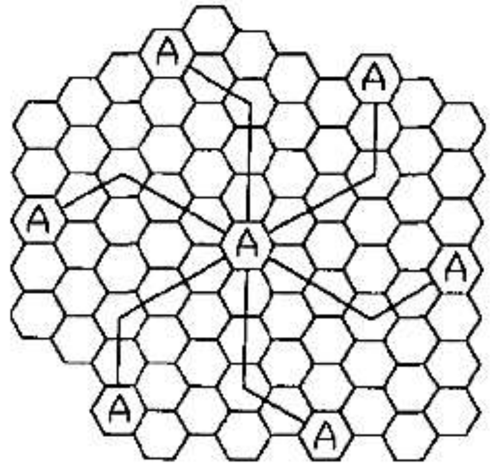
- A large cluster size indicates that the ratio between the cell radius and the distance between co-channel cells is large.
- A small cluster size indicates that co-channel cells are located much closer together.

From a design viewpoint, the smallest possible value of N is desirable in order to maximize capacity over a given coverage area.

To find the nearest co-channel neighbors of a particular cell, one must do the following:

i. Move i cells along any chain of hexagons and then

ii. Turn 60 degrees counter-clockwise and move j cells. This is illustrated in Figure below for $i = 3$ and $j = 2$ (example, $N = 19$).

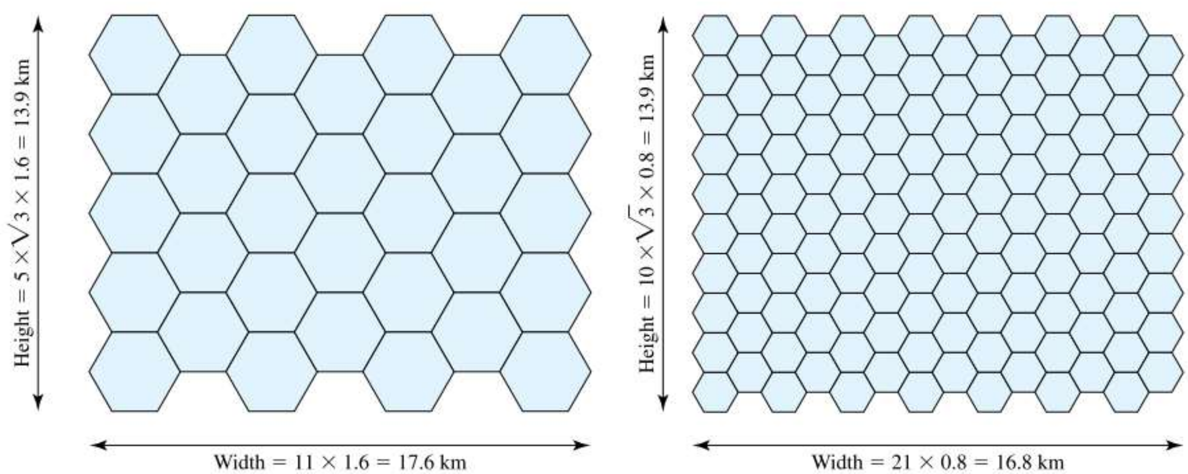


Example 1

Assume a system of 32 cells with a cell radius of 1.6 km, a total of 32 cells, a total frequency bandwidth that supports 336 traffic channels, and a reuse factor of $N = 7$.

(a) If there are 32 total cells, what geographic area is covered, how many channels are there per cell, and what is the total number of concurrent calls that can be handled?

(b) Repeat for a cell radius of 0.8 km and 128 cells.



(a) Cell radius = 1.6 km **(b) Cell radius = 0.8 km**

Solution:

(a)

The area of a hexagon of radius R is

$$Area_a = \frac{3\sqrt{3}}{2}R^2 = \frac{3\sqrt{3}}{2}(1.6)^2 = 6.65\,\text{km}^2$$

The total area covered is 6.65 × 32 = 213 km^2.

For $N = 7$, the number of channels per cell is K/N = 336/7 = 48,

Total number of concurrent calls that can be handled is

$$Capacity = 48 \times 32 = 1536 \text{ channels}$$

(b)

The area of a hexagon of radius R is

$$Area_b = \frac{3\sqrt{3}}{2}R^2 = \frac{3\sqrt{3}}{2}(0.8)^2 = 1.66\,\text{km}^2$$

The area covered is 1.66 × 128 = 213 km^2.

The number of channels per cell is K/N = 336/7 = 48,

Total number of concurrent calls is

$$Capacity = 48 \times 128 = 6144 \text{ calls}$$

Example 2

Consider a cellular system in which total available voice channels to handle the traffic are 960. The area of each cell is 6 km^2 and the total coverage area of the system is 2000 km^2. Calculate:

(a) The system capacity if the cluster size N is 4
(b) The system capacity if the cluster size is 7.

- How many times would a cluster of size 4 have to be replicated to cover the entire cellular area? Does decreasing N increase the system capacity? Explain.

Solution

Total available channels =960 , Cell area = 6 km^2

Total coverage area = 2000 km^2

(a) $N = 4$

Area of a cluster = 4 × 6 = 24 km^2

Number of clusters for covering total area = 2000/24 = 83.33 ~ 83

Number of channels per cell = 960/4 = 240

System capacity = 83 × 960 = 79, 680 channels

(b) $N = 7$

Area of cluster = 7 × 6 = 42 km^2

Number of clusters for covering total area = 2000/42 = 47.62 ~ 48

Number of channels per cell = 960/7 = 137.15 ~ 137

System capacity = 48 × 960 = 46,080 channels

It is evident when we decrease the value of N from 7 to 4, we increase the system capacity from 46,080 to 79,680 channels. Thus, decreasing N increases the system capacity.