The Cellular Concept
System Design Fundamentals

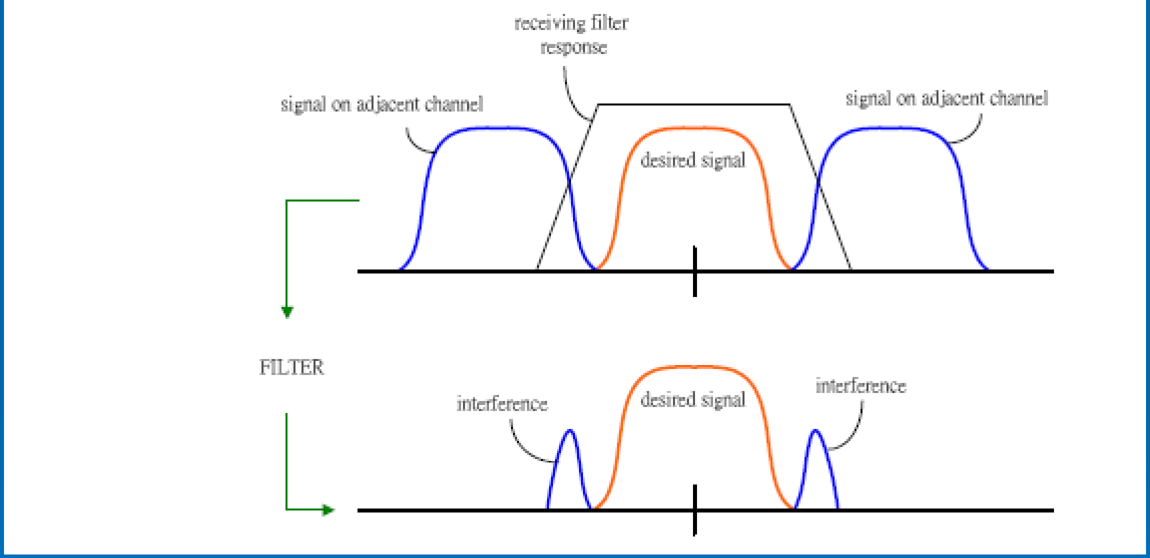
Wireless Communications
Principles and Practice
2nd Edition
T.S. Rappapor
Chapter 3:

Adjacent channel interference

Adjacent channel interference: interference from adjacent in frequency
to the desired signal.

– Imperfect receiver filters allow nearby frequencies to leak into the passband

– Performance degrade seriously due to *near-far* effect.



Adjacent channel interference can be minimized through careful filtering and *channel assignment*.

• Keep the frequency separation between each channel in a given cell as large as possible

• A channel separation greater than six is needed to bring the adjacent channel interference to an acceptable level.

The Cellular Concept

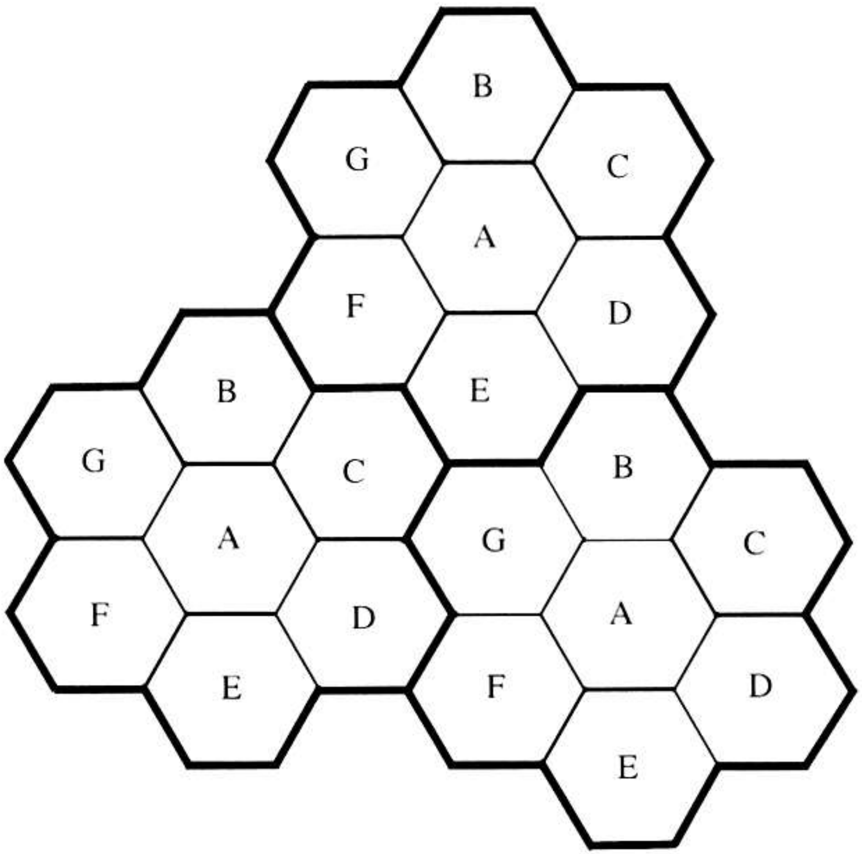


Figure 3.1 Illustration of the cellular frequency reuse concept. Cells with the same letter use the same set of frequencies. A cell cluster is outlined in bold and replicated over the coverage area. In this example, the cluster size, N, is equal to seven, and the frequency reuse factor is 1/7 since each cell contains one-seventh of the total number of available channels.

19-cell reuse example (N=19)

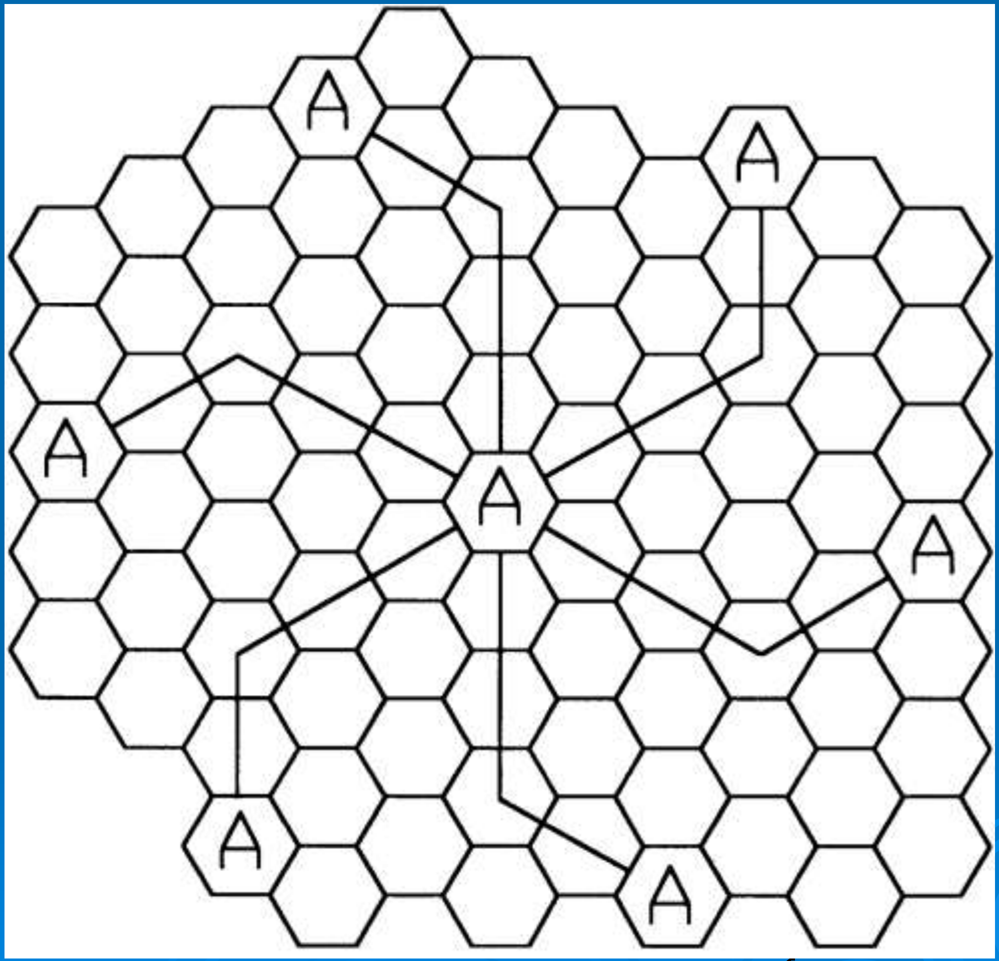


Figure 3.2 Method of locating co-channel cells in a cellular system. In this example, N = 19 (i.e., I = 3, j = 2). (Adapted from [Oet83] © IEEE.)

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

Handoffs – the basics

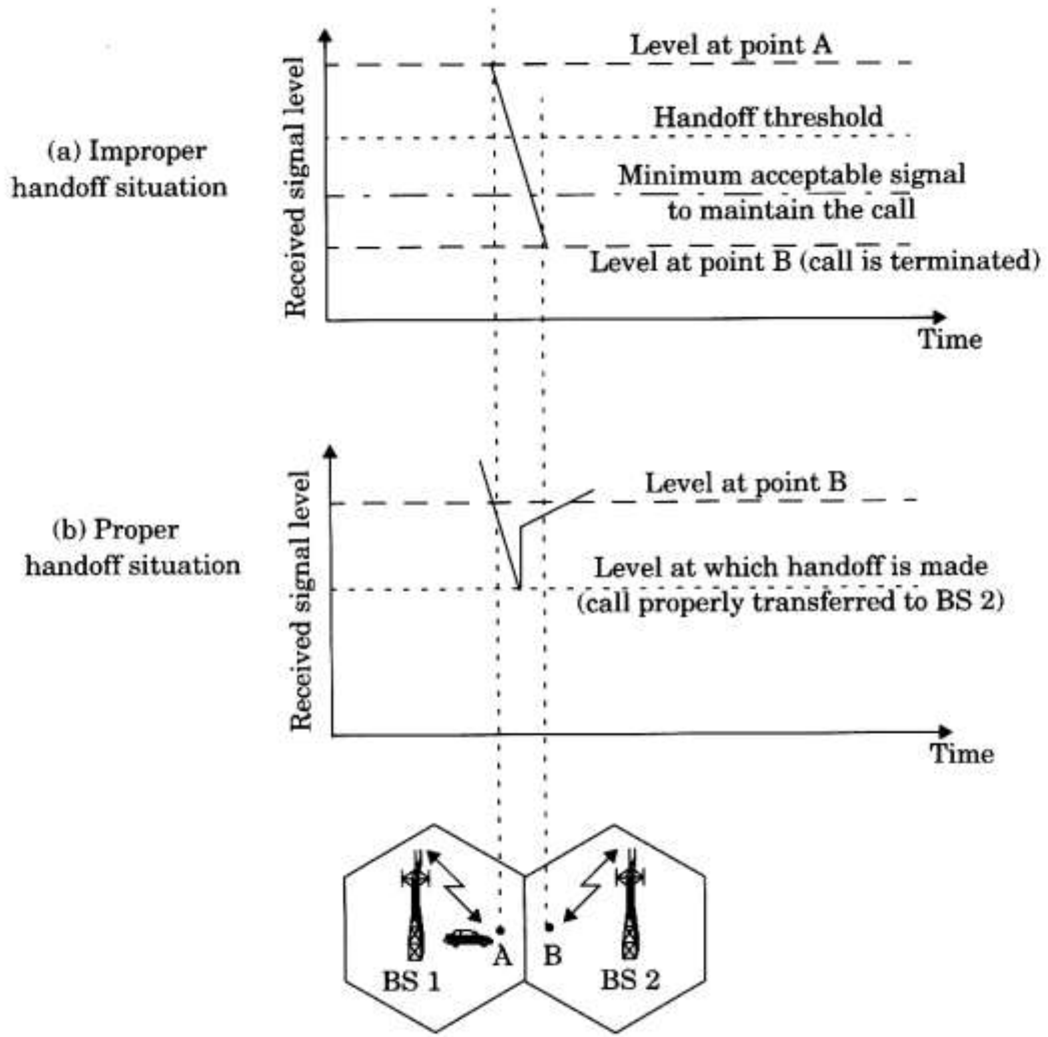


Figure 3.3 Illustration of a handoff scenario at cell boundary.

Umbrella Cells

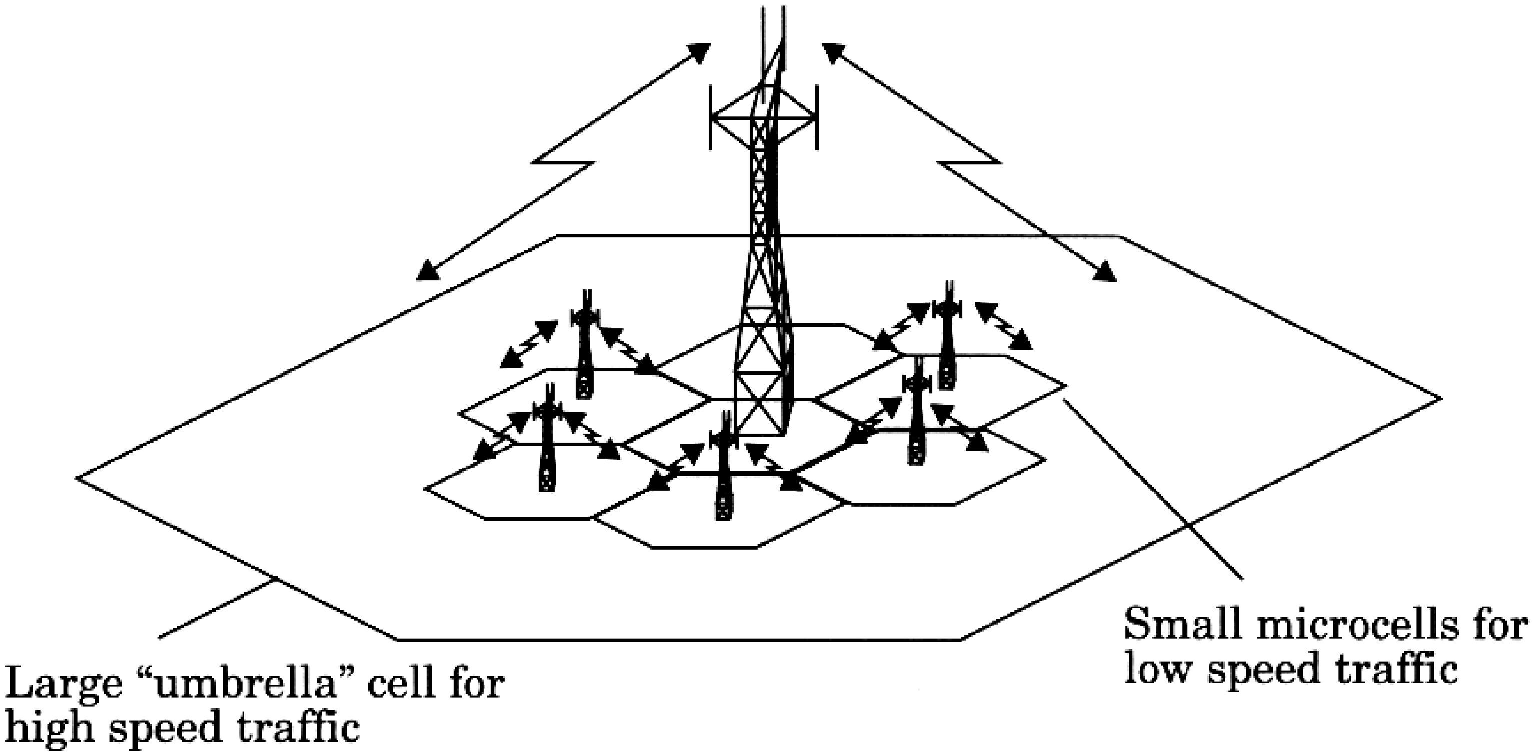


Figure 3.4 The umbrella cell approach.

Co-channel cells for 7-cell reuse

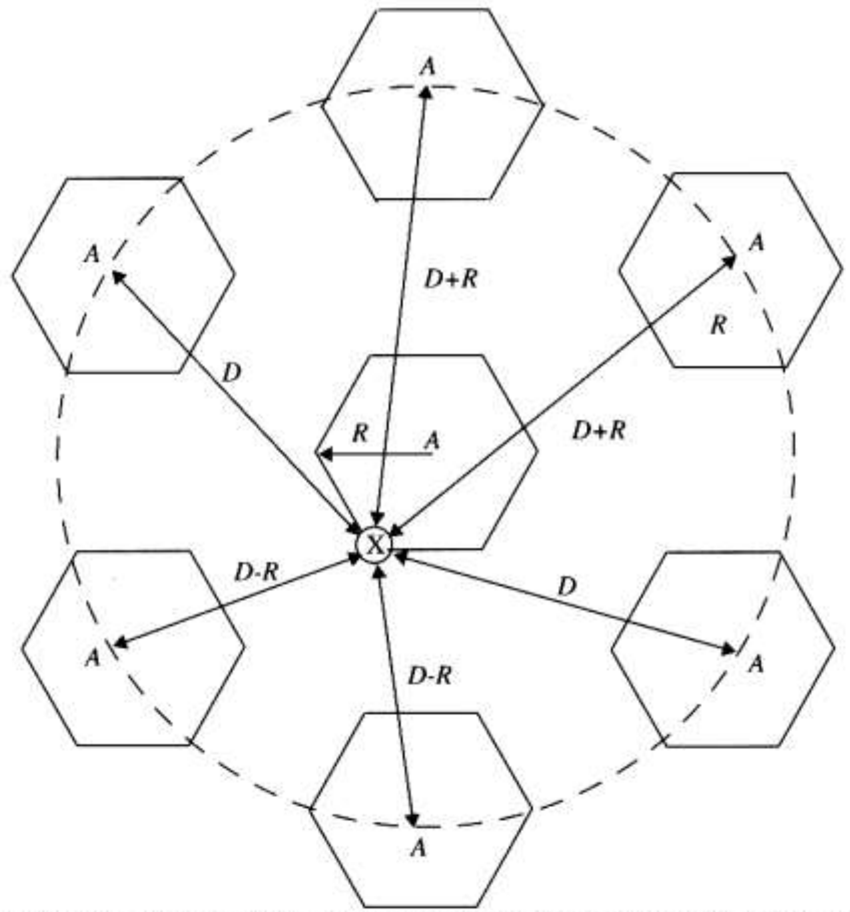


Figure 3.5 Illustration of the first tier of co-channel cells for a cluster size of $N = 7$. An approximation of the exact geometry is shown here, whereas the exact geometry is given in [Lee86]. When the mobile is at the cell boundary (point X), it experiences worst case co-channel interference on the forward channel. The marked distances between the mobile and different co-channel cells are based on approximations made for easy analysis.

Cochannel Interference Ratio

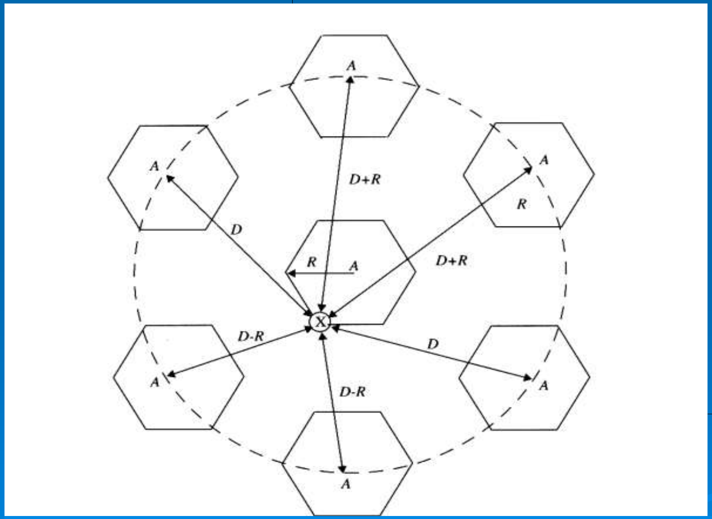
$$\frac{S}{I} = \frac{S}{\sum_{k=1}^{N1} I_k}$$

From Fig. 3.5

$$\frac{S}{I} = \frac{S}{\sum_{k=1}^{6} \left(\frac{D_k}{R}\right)^{-n}} = \frac{1}{6(q)^{-n}} = \frac{q^n}{6}$$

$2 \leq n \geq 5$ - Path loss exponent depend upon the terrain environment

Worst Case With Omni Directional Antenna



$$\frac{S}{I} = \frac{R^{-n}}{2(D-R)^{-n} + 2D^{-n} + 2(D+R)^{-n}}$$

$$\frac{S}{I} = \frac{1}{2(q-1)^{-n} + 2q^{-n} + 2(q+1)^{-n}}$$

q = 4.6 for a normal 7-cell cellular Pattern

S/I = 54.3 or 17.3 dB

Cells are split to add channels

Receive power at the old and new cells:

$Pr \sim P_{to}R^{-n}$

$Pr \sim P_{tn}(R/2)^{-n}$

$$P_{t2} = \frac{P_{t1}}{16}$$

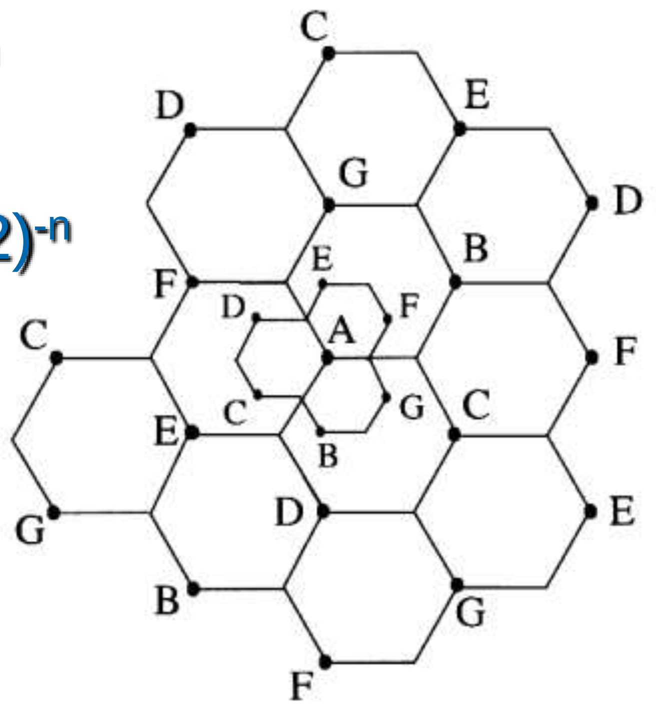
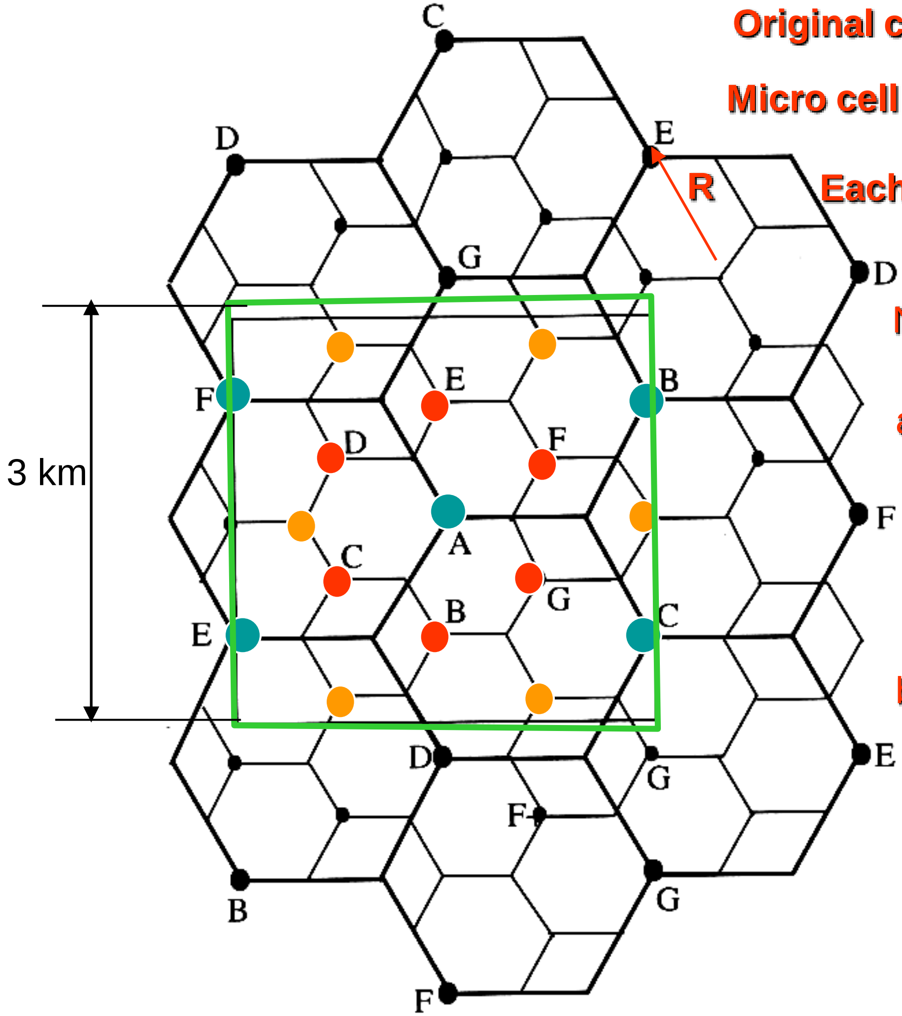


Figure 3.8 Illustration of cell splitting.

Cell Splitting increases capacity Example



Original cell radiusR = 1 km

Micro cell radiusR = 0.5 km

Each BS has N_{bs}=60 channels

Number of channels

a) Wihout microcels
5x60=300 ch.

b) With lettered microcels
(5+6)x60=660 ch.

b) If orijinal BS replaced by microcels
(5+12)x60=1020 ch.

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

Sectoring improves S/I

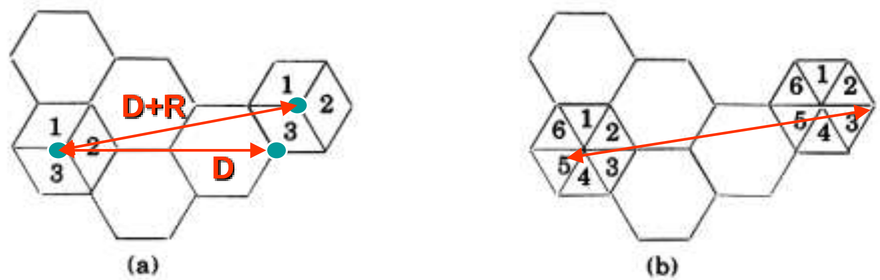


Figure 3.10 (a) 120° sectoring; (b) 60° sectoring.

Three-Sector Case:

$$\frac{S}{I} = \frac{R^{-4}}{(D+0.7R)^{-4}} = (q+0.7)^4$$

For q=4.6 , S/I = 285 or 24.5 dB

Six-Sector Case:

$$\frac{S}{I} = \frac{R^{-4}}{D^{-4}+(D+0.7R)^{-4}} = \frac{1}{q^{-4}+(q+0.7)^{-4}}$$

For q=4.6 , S/I = 785 or 29dB

Worst case, without sectoring

$$\frac{S}{I} = \frac{1}{2(q-1)^{-n}+2q^{-n}+2(q+1)^{-n}}$$

For q=4.6, S/I = 54.3 or 17.3 dB

Penalty: İncreasing hand-off; decreasing trunking efficiency.

Sectoring improves S/I

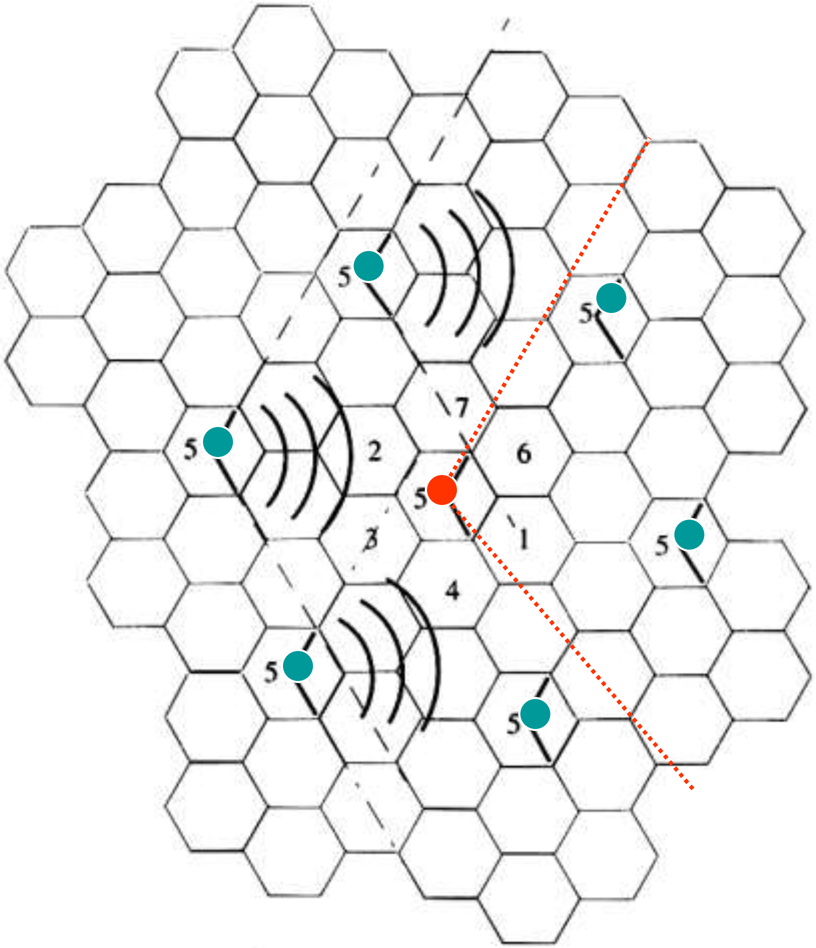


Figure 3.11 Illustration of how 120° sectoring reduces interference from co-channel cells. Out of the 6 co-channel cells in the first tier, only two of them interfere with the center cell. If omnidirectional antennas were used at each base station, all six co-channel cells would interfere with the center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

In-building deployment is the next great growth phase

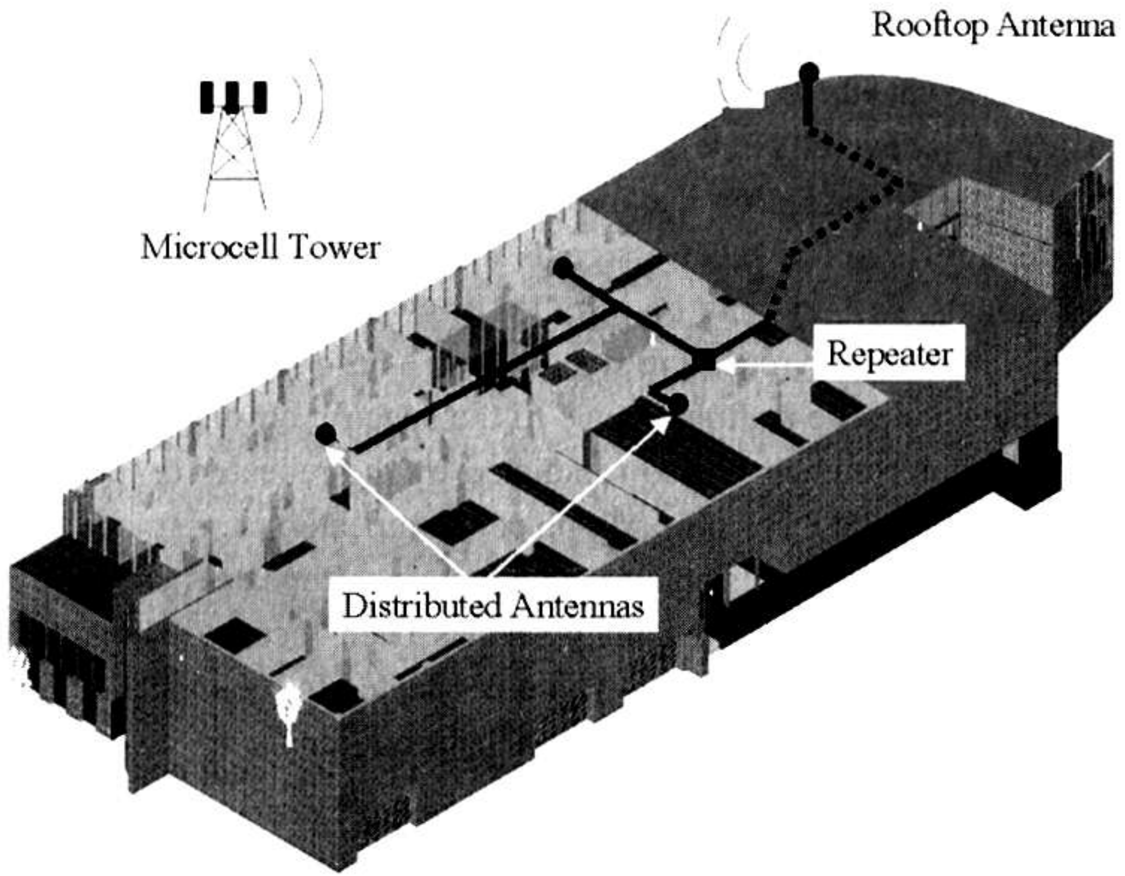


Figure 3.12 Illustration of how a distributed antenna system (DAS) may be used inside a building. Figure produced in SitePlanner®. (Courtesy of Wireless Valley Communications Inc.)

The Zone Cell Concept

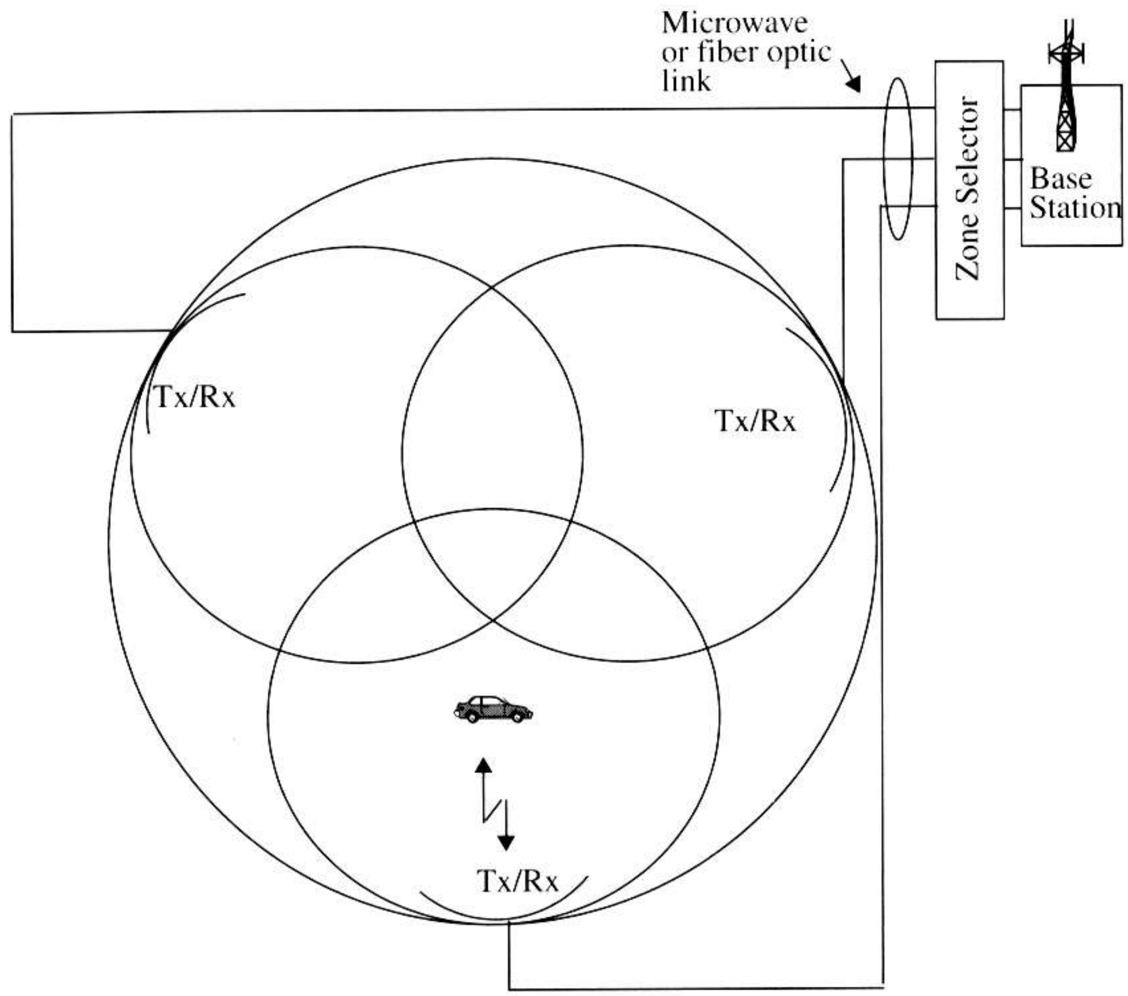


Figure 3.13 The microcell concept [adapted from [Lee91b] © IEEE].

Zone Cell Concept

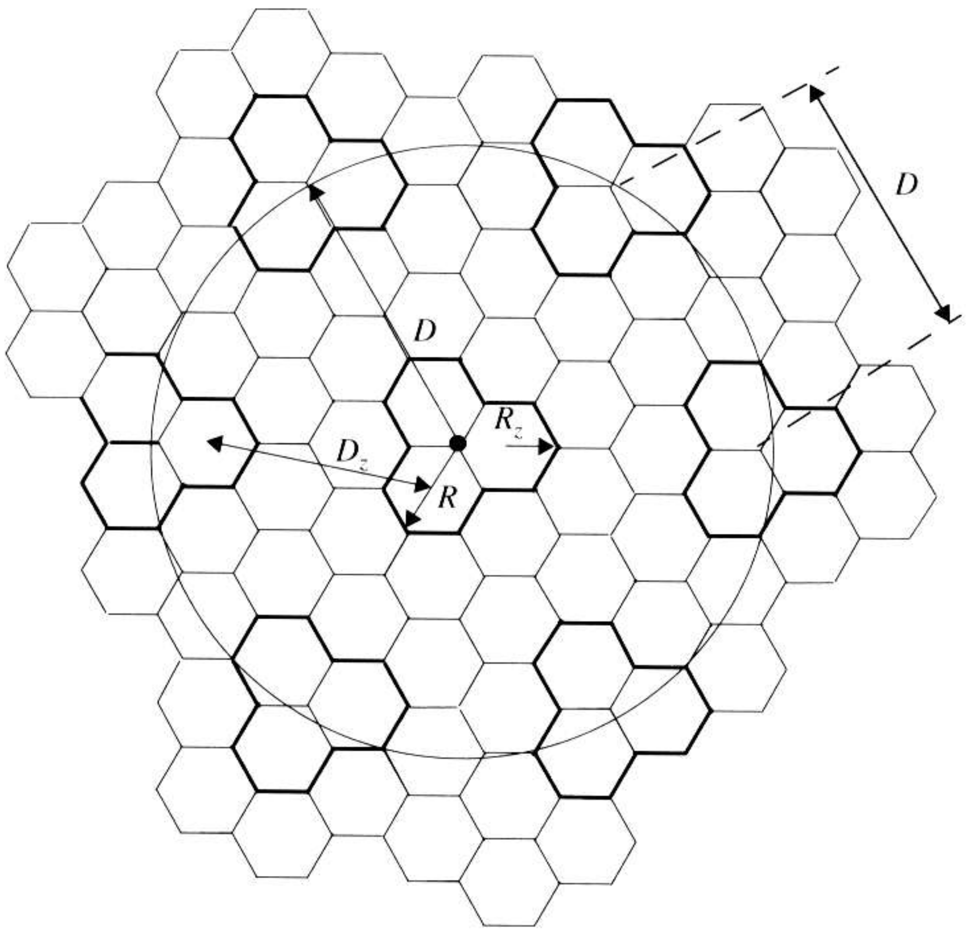


Figure 3.14 Define D, D_z, R, and R_z for a microcell architecture with $N = 7$. The smaller hexagons form zones and three hexagons (outlined in bold) together form a cell. Six nearest co-channel cells are shown.