Interference

It is a major limiting factor in the performance of cellular radio. It limits the capacity and increased number of dropped calls.

Sources:

1. Another mobile in same cell
2. Call in progress in neighbouring cell
3. Other BS operating in same frequency band

It is more severe in urban areas due to greater RF noise floor and more number of MS and BS.

However, (n) path loss exponent is bigger number close to 4 which decreases interference length.

n → How fast signal strength decays as separation increases

Effect of interference -

On voice channels causes crosstalk and noise in background

On control channel causes missed call, dropped call, blocked call.

It decreases QoS.

Types -

1. Co-channel interference (CCI)
2. Adjacent channel interference

CCI is caused due to cells that reuse the same frequency set. These cells using same frequency set are called co-channel cells.

ACI is caused due to signal that are adjacent in frequency band.

CCI – Unlike thermal noise CCI can't be overcome by increasing the carrier power of transmitter.

- This is because any increase in Tx power increases signal for other co-channel cells.
- For similar sized cells, CCI is independent of Tx power and depends on distance to nearest co-channel cell (D) and radius R.
- To reduce CCI co-channel cells must be physically separated.
- There is a tradeoff between capacity and interference.

Co-channel reuse ratio Q = $\frac{D}{R} = \sqrt{3N}$

Thus, smaller values of Q provide larger capacity but higher CCI.

S/I ratio :

$$\frac{S}{I} = \frac{S}{\sum_{i=1}^{M} I_i}$$

Where S is desired signal power and I_I is interference caused by i^{th} co-channel cell.

The average received power at distance d is

$$P_r = P_o (\frac{d}{d_o})^{-n}$$

Where P_o is the received power at distance d_o. If D_i is distance of i^{th} interferer, the received power is proportional to D_i.

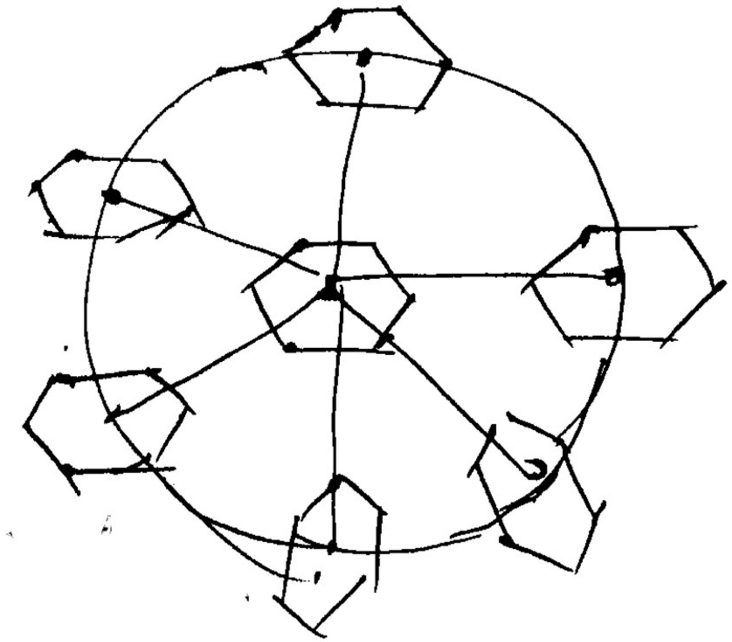
Thus

$$\frac{S}{I} = \frac{R^{-n}}{\sum_{i=1}^{m} (D_i)^{-n}}$$

For only first layer of equidistant interferers

$$\frac{S}{I} = \frac{(D/R)^n}{m} = \frac{(\sqrt{3N})^n}{m}$$

For a hexagonal cluster of cells – MS close to BS



$$\frac{S}{I} = \frac{1}{6}(D/R)^n$$

$$= \frac{1}{6}(\sqrt{3N})^n$$

It is independent of cell radius

Ex.1. Design a system in which desired $\frac{S}{I} = 15dB, n = 4$. What is required reuse factor.

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

First try N = 4

$$\frac{D}{R} = \sqrt{3N} = \sqrt{12} = 3.46$$

$$\frac{S}{I} = \frac{1}{6}(3.46)^4 = 24 = 13.80dB$$

Now N = 7

$$\frac{D}{R} = 4.58$$

$$\frac{S}{I} = \frac{1}{6}(4.58)^4 = 18.66dB$$

Required reuse factor is 1/7.

Ex.2. Now n = 3

For N = 7

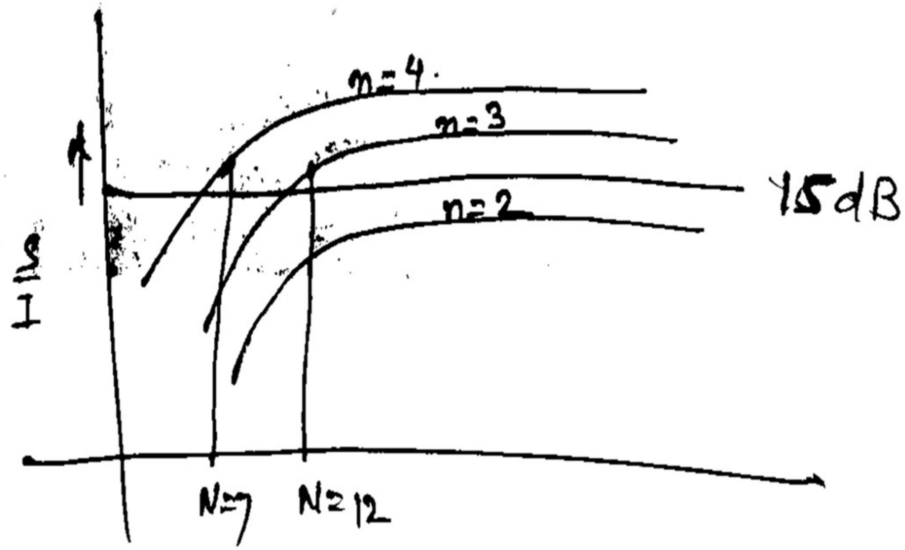
$$\frac{D}{R} = 4.58$$

$$\frac{S}{I} = \frac{1}{6}(4.58)^3 = 12.05dB$$

Now N = 12

$$\frac{D}{R} = 6$$

$$\frac{S}{I} = 15.56dB$$



Required reuse factor is 1/12.

<u>Worst case calculation</u> –

MS is at cell boundary

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

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

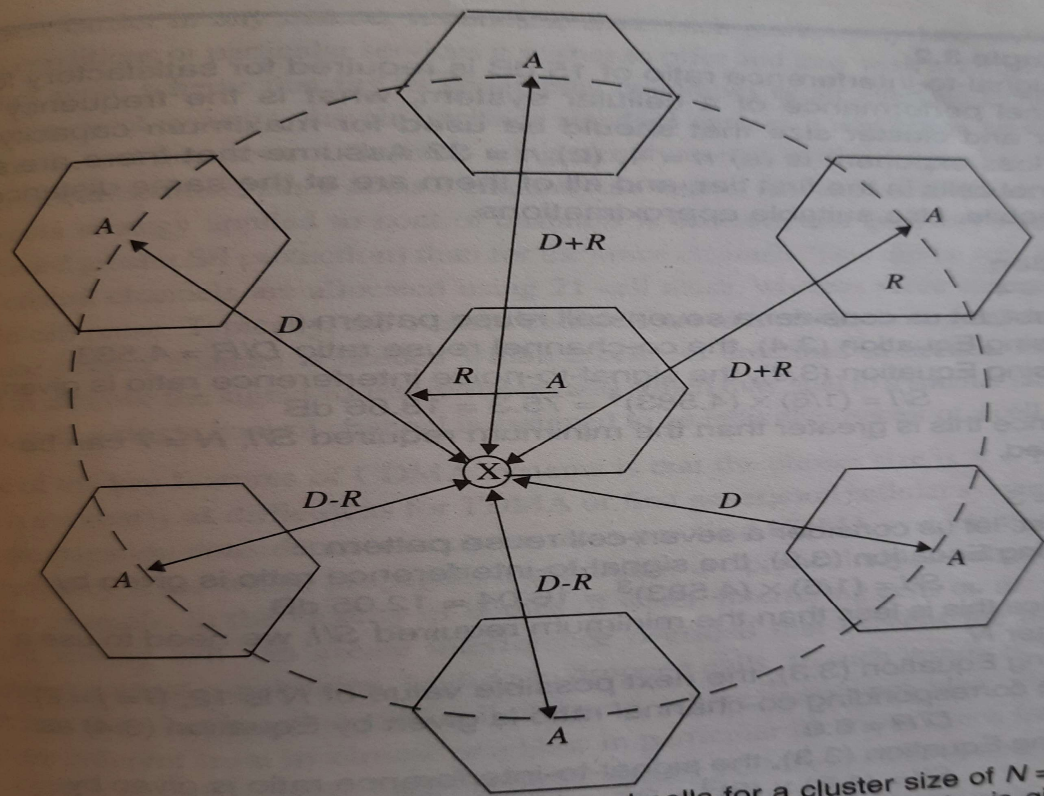


Figure 3.5 Illustration of the first tier of co-channel cells for a cluster size of $N = 7$. An approximation of the exact geometry is shown here, whereas the exact geometry is given in [Lee86]. When the mobile is at the cell boundary (point X), it experiences worst case co-channel interference on the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

For $N = 7$, the co-channel reuse ratio Q is 4.6, and the worst case S/I is approximated as 49.56 (17 dB) using Equation (3.11), whereas an exact solution using Equation (3.8) yields 17.8 dB [Jac94] ... the S/I ratio is slightly less than 18 dB for the ... in the worst case, it would be

ACI :

Result from signal that are adjacent in frequency to desired signal.

Results from imperfect receiver filters that allow nearby frequencies to leak in.

Problem can be severe if the interferer is very close to the subscriber's receiver.

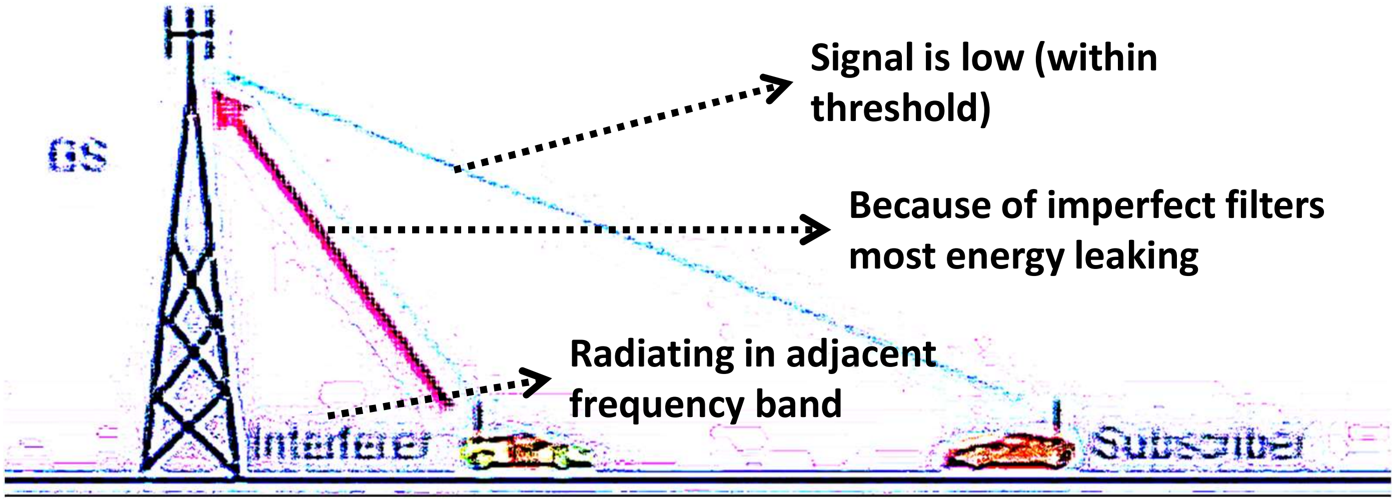
Near far effect :

When an interferer close to BS radiates in adjacent channel, while the subscriber is far away from the BS.

ACI can be reduced by :

Careful filtering

Careful channel assignment



Frequency separation between each channel in cell should be made as large as possible.

If the subscriber is at a distance d_1, and the interferer is at d_2, then (S/I) signal-to-interference ratio (prior to filtering) is

$$\frac{S}{I} = (\frac{d_1}{d_2})^{-n}$$

<u>Ex.</u> Suppose the subscriber is d_1 = 1000m from the BS and an adjacent channel interferer is at d_2 = 100m from the BS.

Path loss exponent is n = 3.

Prior to filtering, $\frac{S}{I} = (\frac{d_1}{d_2})^{-n} = (\frac{1000}{100})^{-3} = 10^{-3} = -30dB$

What should be the roll off factor of filter? (What should be separation?)