1.3. INTERFERENCE AND SYSTEM CAPACITY

Interference is the major limiting factor in the performance of cellular radio systems: Interference has been recognized as a major bottleneck in increasing capacity and also responsible for dropped calls.

The two major types of system-generated cellular interference are:

Co-channel interference

Adjacent channel interference

Power Control for Reducing interference

1. Co-channel Interference and System Capacity

Co-channel Interference

Cells using the same set of frequencies are called co channel cells, and the interference between signals from these cells is called co-channel interference.

Unlike thermal noise which can be overcome by increasing the signal-to-noise ratio (SNR), co-channel interference cannot be combated by simply increasing the carrier power of a transmitter. This is because an increase in carrier transmit power increases the interference to neighboring co-channel cells.

To reduce co-channel interference, co-channel cells must be physically separated by a minimum distance to provide sufficient isolation due to propagation.

The co-channel interference ratio is a function of the radius of the cell (R) and the distance between centers of the nearest co channel cells (D).

By increasing the ratio of D/R, the spatial separation between co-channel cells relative to the coverage distance of a cell is increased. Thus interference is reduced.

Co channel reuse ratio

The parameter Q=D/R, called the co-channel reuse ratio, is related to the cluster size N.

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

From Figure 2.6.1, it can be seen for a 7-cell cluster, with the mobile unit is at the cell boundary, the mobile is a distance D- R . From the two nearest co-channel interfering cells and approximately D + R/2, D, D- R/2, and D + R from the other interfering cells in the first tier and n=4. the signal-to-interference ratio for the worst case can be closely approximated as

$$\frac{S}{I} = \frac{R^{-4}}{2(D-R)^{-4} + 2(D+R)^{-4} + 2D^{-4}}$$

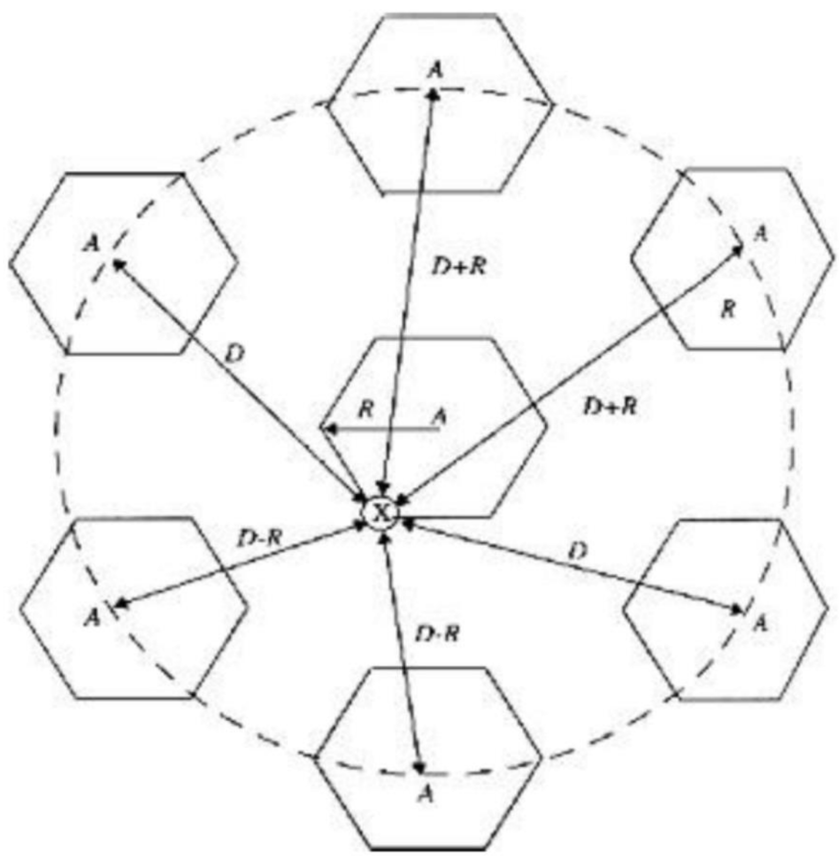

Fig 2.6.1: Co-channel cells for 7-cell reuse

[Source : "Wireless communications" by Theodore S. Rappaport,Page-41]

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).

When the size of each cell is approximately the same, and the base stations transmit the same power, we have a small value of Q provides larger capacity since the cluster size N is small, whereas a large value of Q improves the transmission quality, due to a smaller level of co-channel interference.

A trade-off must be made between these two objectives in actual cellular design.

Signal-to-interference ratio (SIR)

$$SIR = \frac{S}{\sum_{i=0}^{i_0} I_i}$$

S denotes the desired signal power;

Ii is the interference power caused by the i-th interfering co-channel cell base station;

I**0** is the number of co-channel interfering cells.

The average received power P at a distance d from the transmitting antenna is approximated by

$$P_r = P_0 \left(\frac{d}{d_0} \right)^n$$

If all base stations transmit at the same power level, the SIR can be given as

$$SIR = \frac{R^{-n}}{\sum_{i=0}^{i_0} D_i^{-n}}$$

The path loss exponent typically ranges between 2 and 4 in urban cellular systems.

In practice, measures should be taken to keep the SIR on a acceptable level.

2. **Adjacent Channel Interference**

Interference resulting from signals which are adjacent in frequency to the desired signal is called adjacent channel interference. Adjacent channel interference results from imperfect receiver filters which allow nearby frequencies to leak into the passband. The problem can be particularly serious if an adjacent channel user is transmitting in very close range to a subscriber's receiver, while the receiver attempts to receive a base station on the desired channel. This is referred to as the near-far effect.

The near-far effect occurs when a mobile close to a base station transmits on a channel close to one being used by a weak mobile. The base station may have difficulty in discriminating the desired mobile user from the "bleedover" caused by the close adjacent channel mobile. Adjacent channel interference can be minimized through careful filtering and channel assignments. Since each cell is given only a fraction of the available channels, a cell need not be assigned channels which are all adjacent in frequency.

By keeping the frequency separation between each channel in a given cell as large as possible, the adjacent channel interference may be reduced considerably.

For example, if a mobile is 20 times as close to the base station as another mobile and has energy spill out of its pass band, the signal-to interference ratio for the weak mobile (before receiver filtering) is given by,

$$\frac{S}{I} = (20)^{-n}$$