2.3 CAPACITY OF CELLULAR SYSTEMS

Channel capacity for a radio system can be defined as the maximum number of channels or users that can be provided in a fixed frequency band.

Radio capacity is a parameter which measures spectrum efficiency of a wireless system. This parameter is determined by the required carrier-to-interference ratio (C/I) and the channel bandwidth B_c.

In a cellular system the interference at a base station receiver will come from the subscriber units in the surrounding cells. This is called reverse channel interference.

For a particular subscriber unit, the desired base station will provide the desired forward channel while the surrounding co-channel base stations will provide the forward channel interference. Considering the forward channel interference problem, let D be the distance between two co-channel cells and R be the cell radius. Then the minimum ratio of D7R that is required to provide a tolerable level of co-channel interference is called the co-channel reuse ratio and is given by

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

The radio propagation characteristics determine the carrier-to-interference ratio (C /1) at a given location, and models presented in Chapter 3 and Appendix B are used to find sensible C/I values. As shown in Figure 2.3.1 , the M closest co-channel cells may be considered as first order interference in which case C/I is given by

$$\frac{C}{I} = \frac{D_0^{-n_o}}{\sum_{k=1}^{M} D_k^{-n_k}}$$

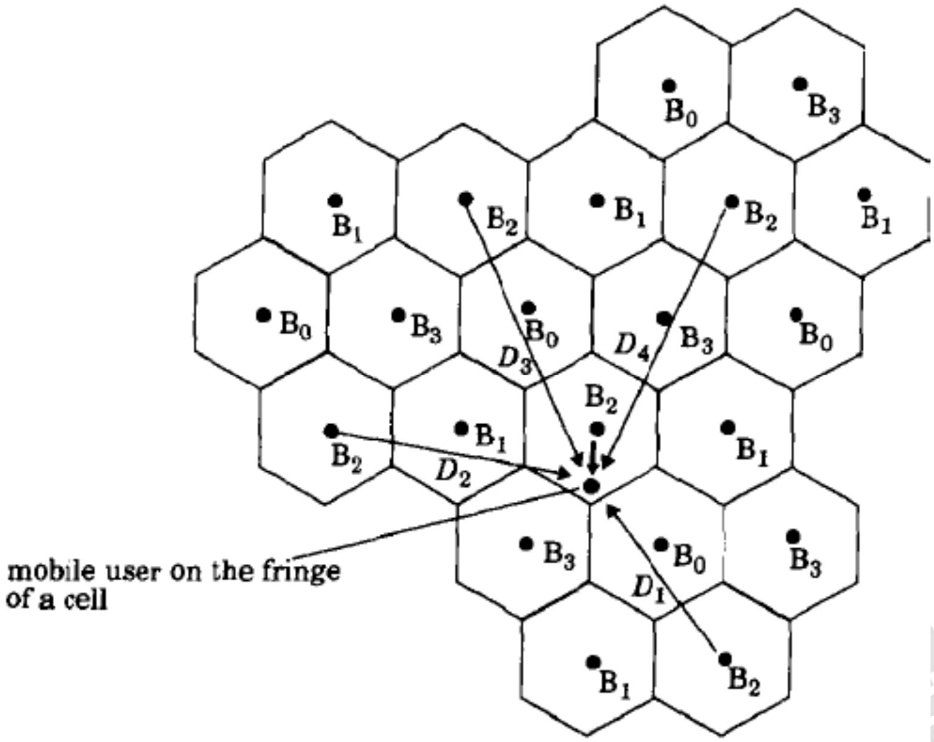

Fig 2.3.1 : Illustration of forward channel interference for a cluster size of N = 4. Shown here are four co-channel base stations which interfere with the serving base station

[Source: "Wireless Communications" by Rappaport,Page-418.]

where n_0 is the path loss exponent in the desired cell, D0 is the distance from the desired base station to the mobile, Dk is the distance of the k th cell from the mobile, and n_k is the path loss exponent to the k th interfering base station. If only the six closest interfering cells are considered, and all are approximately at the same distance D and have similar path loss exponents equal to that in the desired cell, then C/I is given by

$$\frac{C}{I} = \frac{D_0^{-n}}{6D^{-n}}$$

If it is assumed that maximum interference occurs when the mobile is at the cell edge D0 = R, and if the C/I for each user is required to be greater than some minimum (C/I), which is the minimum carrier-to-interference ratio that still provides acceptable signal quality at the receiver, then the following equation must hold for acceptable performance:

$$\frac{1}{6}\left(\frac{R}{D}\right)^{-n} \geq \left(\frac{C}{I}\right)_{min}$$

The co-channel reuse factor is

$$Q = \left(6\left(\frac{C}{I}\right)_{min}\right)^{1/n}$$

The radio capacity of a cellular system is defined as

$$m = \frac{B_t}{B_c N} \text{ radio channels/cell}$$

where m is the radio capacity metric, B_t is the total allocated spectrum for the system, B_c is the channel bandwidth, and N is the number of cells in a frequency reuse pattern. And N is related to Q . ie,

$$Q = \sqrt{3N}$$

Therefore the radio capacity is given as

$$m = \frac{B_t}{B_c \frac{Q^2}{3}} = \frac{B_t}{B_c\left(\frac{6}{3^{n/2}}\left(\frac{C}{I}\right)_{min}\right)^{2/n}}$$

when n = 4, the radio capacity is given by

$$m = \frac{B_t}{B_c\sqrt{\frac{2}{3}\left(\frac{C}{I}\right)_{min}}} \text{ radio channels/cell}$$