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Analysis of Co-Channel Interference under various Radio Propagation Environments

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ABSTRACT

Coverage and capacity are significant issues in the planning process for cellular mobile networks. Scarcity of the frequency band is acting as a bottleneck to the tremendous advancement in the field of mobile communication. Nowadays Cellular Technology is being invariably employed in mobile communication to maximize the spectral efficiency. Due to the frequency reuse, there comes the problem of Co-channel interference into picture, due to which we have to restrict the frequency reuse factor. This paper gives an analysis of co-channel interference under all possible propagation environment condition with all possible values of cells in a cluster.

Keywords - Calculation, Noise reduction, Optimization, Planning, Quality signal.

I. INTRODUCTION

As the number of users in mobile system is increasing many a fold, the scarcity of the frequency spectrum is playing havoc. We have to ascertain the maximal use of the frequency spectrum. With this view the concept of the frequency reuse was being introduced through cellular technology. In cellular technology we make use of the fact that in the general the signal strength decreases as the distance from the base station increases. This decrease is not uniform, being dependent on geographical and other factors. So we can reuse the same frequency after some distance making sure that the interfering power is quite low. In this way by dividing the area into cell with adjoining cells having different frequencies and reusing the same frequency after some distance we can increase the spectral efficiency. To get the maximal spectral efficiency we can either by reducing the cell size, or by decreasing the frequency reuse factor. First solution poses the problem of frequent hand-off and thus frequent call drops and the second one is being challenged by CCI (Co- channel interference).

In a cellular system reusing each frequency at several regions of service area increases the capacity. Also cell splitting, sectoring and micro cell zone approaches are used to expand the capacity of cellular system. Consideration must be taken into account to keep the interference at acceptable limit.

Frequency planning is a means to optimize spectrum usage, enhance channel capacity, and reduce interference. Based on the concept of efficient spectrum utilization, cellular mobile radio system can be broken down into many elements. The major elements are:

a. Concept of frequency reuse channel.
b. Co-channel Interference and reduction factor.
c. Cell splitting.
d. Sectorization

Frequencies re-use channels and distance

A radio channel consists of a pair of frequencies, one for each direction of transmission that is used for full-duplex operation. Particular radio channels, say f_1, used in one geographic zone to call a cell, say C_1, with a coverage radius R can be used in another cell with the same coverage radius at a distance D away. Frequency reuse is the core concept of the cellular mobile radio system. In this frequency reuse system, users in different geographic locations (different cells) may simultaneously use the same frequency channel as shown in figure 1 below. The frequency reuse system can drastically increase the spectrum efficiency, but if the system is not properly designed, serious interference may occur. Interference due to common use of the same channel is called co-channel interference and is our major concern in the concept of frequency reuse.

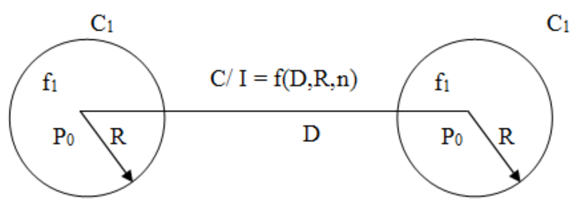

Figure 1: Frequency re-use distance.

The minimum distance which allows the same frequency to be reused will depend on many factors, such as the number of co-channel cells in the vicinity of the center cell, the type of geographic terrain contour, the antenna height, and the transmitted power at each cell site. The frequency reuse distance D can be determined from the equation:

D* = √ *(3K) R, where, *K* is the frequency reuse pattern.

If all the cell sites transmit the same power, then *K* increases and the frequency reuse distance *D* increases. This increased *D* reduces the chance that co-channel interference may occur. Theoretically, a large *K* is desired. However, the total number of allocated channels is fixed. When *K* is too large, the number of channels assigned to each of *K* cells becomes small. It is always true that if the total number of channels in *K* cells is divided as *K* increases, trucking inefficiency results. The same principle applies to spectrum inefficiency: if the total numbers of channels are divided into two network systems serving in the same area, spectrum inefficiency increases.

Co-Channel Interference

Frequency reuse implies that in a given coverage areas there are cells that use the same set of frequencies. These cells are called co-channel cells, and the interference between signals from these cells is called co-channel interference. 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.

When the size of each cell is approximately the same and the base stations transmit the same power, the co-channel interference ratio is independent of the transmitted power and becomes 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 from improved isolation of RF energy from the co-channel cell. The parameter *Q*, called the co-channel reuse ratio, is related to the cluster size.

The frequency reuse system can drastically increase the spectrum efficiency, but if the system is not properly designed, serious interference may occur. Interference due to the common use of the same channel is called co-channel interference and is major concern in the concept of frequency reuse. Reusing an identical frequency channel in different cell is limited by co-channel interference between cells, and the co channel interference can be minimized by considering co-channel reduction factor

Co-channel interference is a function of a parameter q defined as

$$Q = D/R$$

where, D = Frequency reuse distance
R = Radius of cell.

A small value of *Q* provides larger capacity since the cluster size is small, whereas a large value of *Q* improves the transmission quality, due to smaller level of co-channel interference. A trade-off must be made between these two objectives in actual cellular design.

Sectorization

The co-channel interference in a cellular system may be decreased by replacing a single Omni directional antenna at the base station by several directional antennas, each radiating within a specified sector. By using directional antennas, a given cell will receive interference and transmit with only a fraction of the available co-channel cells. The technique for decreasing co-channel interference and thus increasing system performance by using directional antennas is called sectoring used. A cell is normally partitioned into three 120° sectors or six 60° sectors. When sectoring is employed, the channels used in a particular cell are broken into sectored groups and are used only within a particular sector. The generalized values of CCI for an Omni directional antenna pattern is given as,

The generalized values of CCI for an Omni directional antenna pattern is given as,

$$\frac{C}{I} = \frac{1}{(N-1)(Q-1)^{-n}} \text{ ------------ } (1a)$$

Under sectorization the values are modified as follows:

$$\frac{C}{I} = \frac{1}{Q^{-n} + (Q+0.7)^{-n}} \text{ ---------- } (1b)$$

$$\frac{C}{I} = (Q+0.7)^{n} \text{ ------------ } (1c)$$

Typical values of the path loss exponent:

Environment	Path Loss Exponent(n)
Free Space	2
Urban Area Cellular	2.7 - 4
Shadowed Area Cellular	3 - 5
In Building line of sight	1.6 – 1.8
Obstructed in Buildings	4 - 6

Table 1: Typical Path loss exponent

II. RESULTS AND CONCLUSION

The various values of losses for the different combination of cell per cluster is plotted in

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figure 2 and figure 3. In figure 2, the plot is for office with hard partition or sub urban home environment, whereas the plot in figure 3 is for the case of free space.

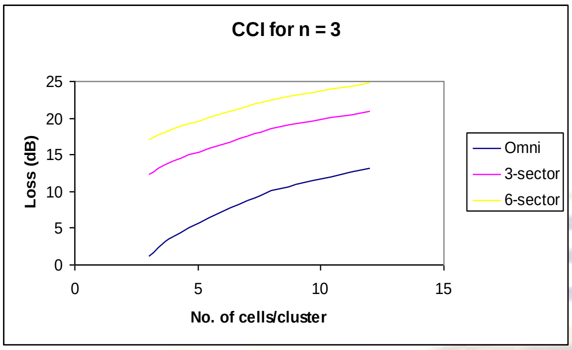

Figure 2: The values of C/I in suburban home or office environment.

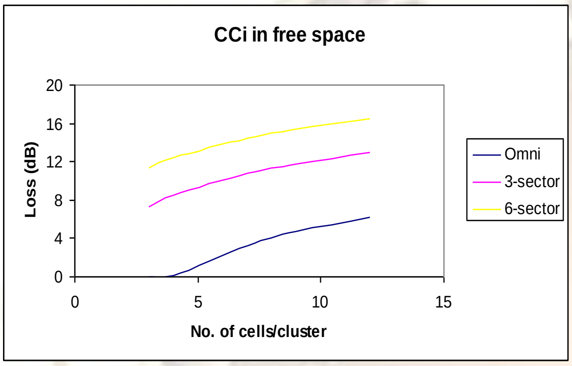

Figure 3: The values of C/I in free space condition.

In the figure no. 4 to 7, the different plots of *C/I* for the sectorized cells in the indoor and office environment of urban city is plotted.

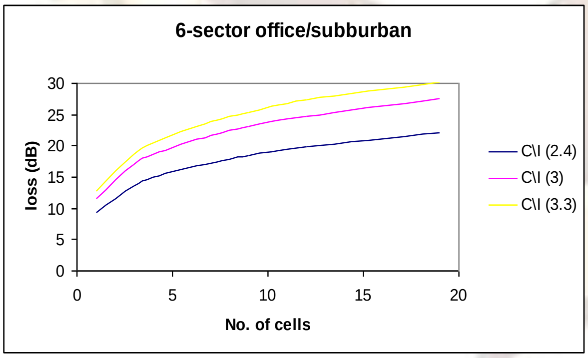

Figure 4: C/I value for different path exponent in office or sub urban home.

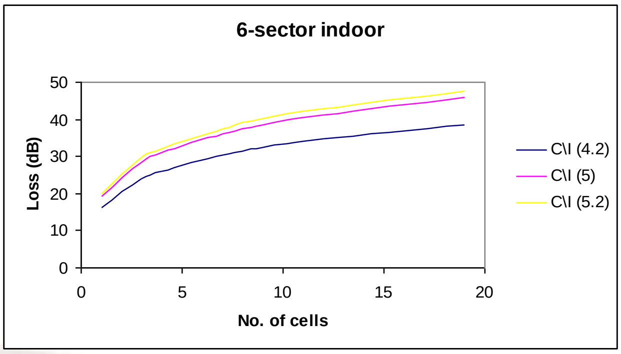

Figure 5: C/I value for different path exponent in indoor home environment

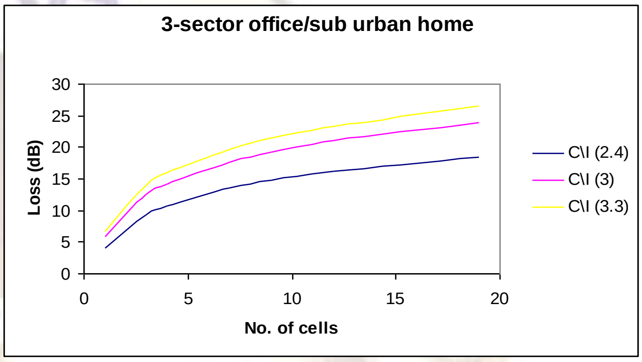

Figure 6: C/I value for different path exponent in office or sub urban home

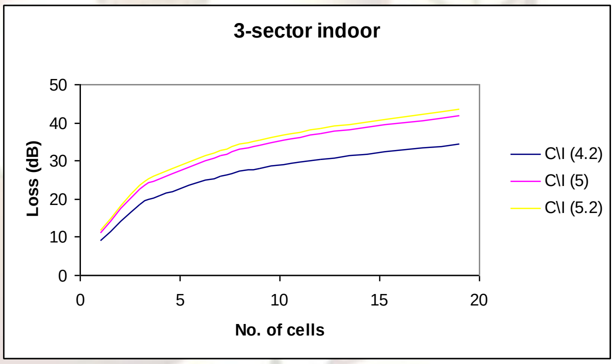

Figure 7: C/I value for different path exponent in indoor home environment

The resulting *C/I* for 3 sector cell pattern is found to be 24.5 dB (with n = 4), which is a significant improvement over the Omni-directional case, where the worst case *C/I* is equal to be 17 dB. This *S/I* improvement allows to decrease the cluster size N in order to improve the frequency reuse, and thus the system capacity. The improvement in *C/I* implies that with 120^{o} sectoring, the minimum required *C/I* of 18 dB can be easily achieved with seven-cell reuse, as compared to 12-cell reuse for the worst possible situation in the unescorted case..The reduction in interference offered by sectoring enable planners to reduce the cluster size *N*, and provides an additional degree of freedom in assigning channels. The penalty for improved *C/I* and the resulting capacity improvement from the shrinking clusters size is an increased number of antennas at each base station, and a decrease in trucking efficiently due to channel sectoring at the base station. Since sectoring reduces the coverage area of a particular group of channels, the number of handoffs increases, as well.

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