Simulation of Co-channel Interference Ratio (CCIR) for Directional Antenna in Mobile Computing

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ABSTRACT
Due to the insufficiency of available bandwidth and the continuously growing demand for cellular communication services, there are many cells using same frequency band. All the cell using the same channel are physically located apart by at least reused distance, even though the power level is controlled carefully so that such “co-channels” do not create a problem for each other, there is still some degree of interference due to non-zero signal strength of such cells. This paper concludes Reuse distance (D) with respect to the co-channel interference ratio (CCIR) for mobile station at the various distances from base station (BS).

Keywords
CCIR, Reuse distance, Non-zero signal strength, Mobile Station (MS), Base Station (BS)

1. INTRODUCTION
Antenna: An antenna is a transducer that converts guided electro-magnetic energy in a transmission line to radiated electro-magnetic energy in free space. Electrical energy is fed to the antenna via a transmission line, a conductor which passes electrical energy from one point to another. Antennas may also be viewed as an impedance transformer, coupling between an input or line impedance, and the impedance of free space [7].

O**mni-Directional Antenna:** An Omni directional antenna is an antenna which radiates electromagnetic energy uniformly in all directions in one plane, with the radiated power decreasing with elevation angle above or below the plane, dropping to zero on the antenna's axis [2].

Directional Antenna: Directional Antennas concentrate energy into **a** narrower solid angle than an omni-directional antenna. Directional antennas are used in some base station applications where coverage over a sector by separate antennas is desired. Point to point links also take advantage from directional antennas. A unidirectional pattern such as found on Yagi and quad beams and certain other antennas. The main lobe is the direction of maximum radiation or reception. In addition to the main loop, there are also side lobe and back lobe. [7]

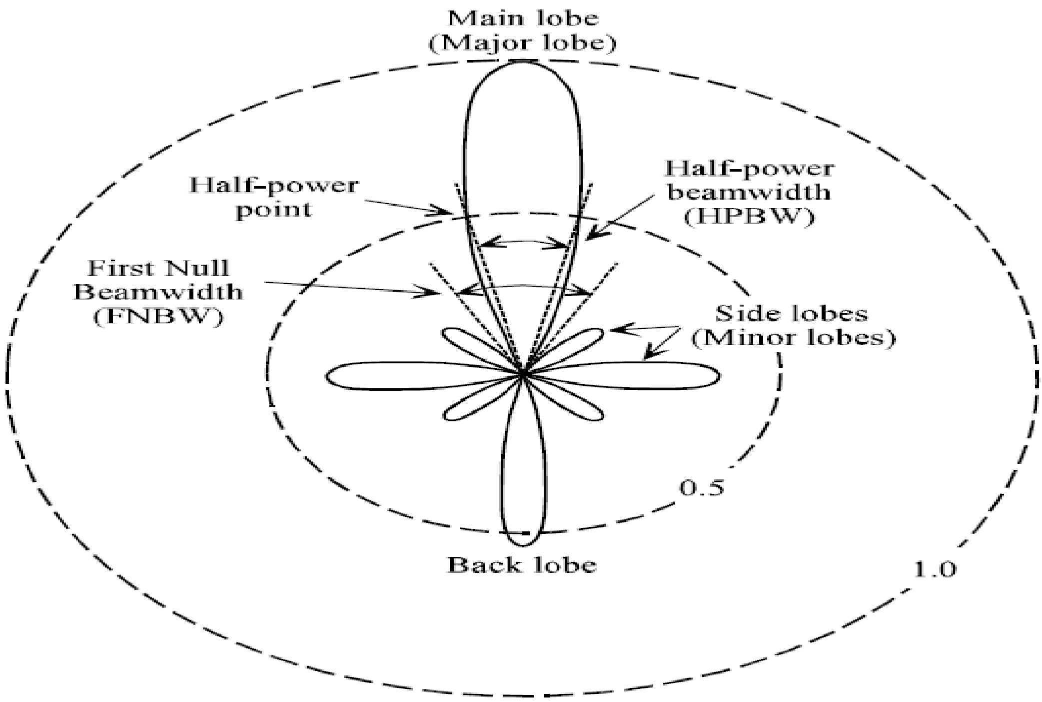

Figure 1 Unidirectional Pattern [2]

On the basis of Figure 1 we can define the various lobes of unidirectional antenna as following-

Main Lobe: The lobe of Directional Antenna that has larger field strength is known as “main lobe" [2].

Side Lobes: The Other Lobe Except main lobe is called Side Lobe, usually impact unnecessary radiation[2].

Back Lobe: The side lobe in the opposite direction (180°) from the main lobe is called the "back lobe"[2].

2. DISCRIPTION OF FREE SPACE PROPAGATION MODEL

The free space power received by a receiver antenna which is a distance of d from the transmitter antenna is given by Friis free space equation[9].

$$P_r = P_t G_t G_r \left(\frac{\lambda}{4\pi d}\right)^2 \qquad (1.0)$$

Where, P_t is the transmitted power, G_t is the transmitting antenna gain, G_r is the receiving antenna gain, and d is the separation distance between antennas and λ is the signal wavelength [9],[10].

The path loss which represents the signal attenuation as a positive quantity is defined as the difference between the effective transmitted power and the received power and may or may not include the effects of the antenna gains. The path loss for the free space model when the antennas are assumed to have unity gain is provided by the following equation [11],[12].

$$\frac{P_t}{P_r} = \left(\frac{4\pi d}{\lambda}\right)^2$$

$$\frac{P_t}{P_r} = \left(\frac{4\pi df}{c}\right)^2 \qquad (2.0)$$

Where f is the signal frequency. c is equal to the speed of light ($3*10^8$ meters per second)

Free-space path loss in decibels

$$FSPL(db) = 10\log\left(\frac{P_t}{P_r}\right)$$

$$= 10\log\left(\frac{4\pi df}{c}\right)^2$$

$$= 20\log\left(\frac{4\pi df}{c}\right)$$

$$= 20\log(4\pi) + 20\log(d) + 20\log(f) - 20\log(3*10^8)$$

$$= 21.98 + 20\log(d) + 20\log(f) - 169.54$$

$$= -147.56 + 20\log(d) + 20\log(f)$$

Therefore,

$$FSPL(db) = -147.56 + 20\log(d) + 20\log(f) \qquad (3.0)$$

where, d is in meters, f is in Hz.

3. CO-CHANNEL INTERFERENCE RATIO(CCIR)

The co-channel interference ratio (CCIR) can be calculated using directional antenna, in worst case for three sector directional antenna is shown Figure.2

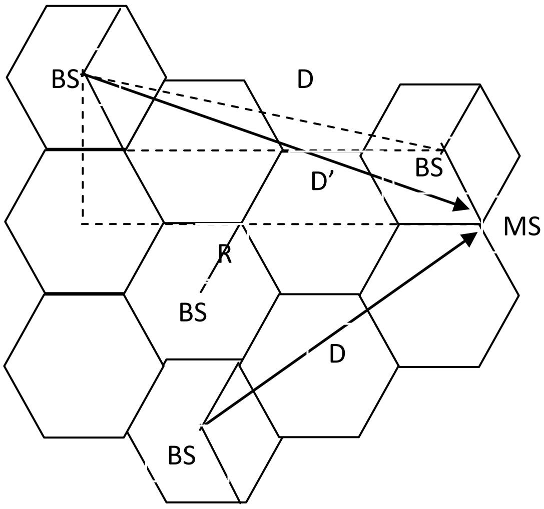

Figure 2 The worst case forward channel interference in three sectors (directional antenna) [4]

Where D is Reuse distance, R is Radius of each cell,

$$D = \sqrt{\left(\frac{9}{2}*R\right)^2 + \left(\frac{\sqrt{3}}{2}*R\right)^2}$$

$$D = (\sqrt{21})R \qquad (4.0)$$

$$D \cong 4.58R$$

And

$$D' = \sqrt{(5R)^2 + (\sqrt{3}\,R)^2}$$

$$D' = (\sqrt{28})R$$

$$D' \cong 5.29R$$

$$D' = D + 0.7R \qquad (4.1)$$

Therefore, co-channel interference ratio (CCIR) can be expressed with eq. (4.0) as-

$$\frac{C}{I} = \frac{1}{(q^{-\gamma}) + (q+0.7)^{-\gamma}} \qquad (4.2)$$

Where C is carrier, I is interference and γ is the propagation path loss slope

4. ANALYSIS OF CCIRON THE BASIS FREE SPACE PROPOGATION MODEL

For the same value of N, for a cell with different radius power of antenna is adjusted to form the cell size, R can be varied from 2Km to 20 Km, value of (γ) varies from 2 to 5, i.e. path loss propagation values are computed for the different values of R (location of mobile station) and path loss propagation values (γ) .The simulation result of equation (4.2) conclude in Figure.3.

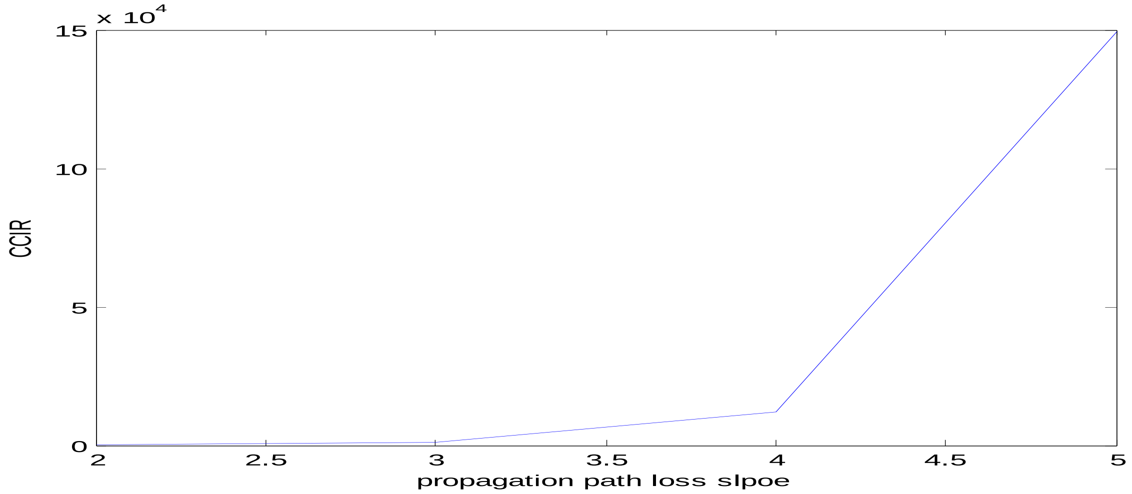

Figure 3 CCIR for different values of path loss constant (λ)

Simulation of CCIR for different values of path loss constant (λ) from 2 to 5, It is observe that 4 is optimum value as simulation will also conclude it. The Simulation result of equation (2.0) of Free Space Propagation Model concludes Figure 4 That shows that as Mobile Station move from Source Power received is continuously decreasing.

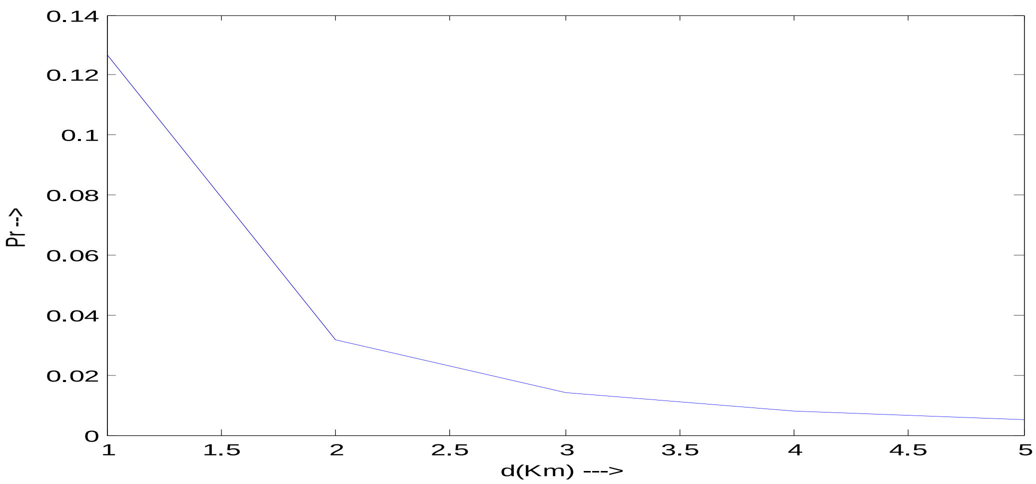

Figure 4 Receiver Power (P_r) with respect to distance

5. PROPOSED SCENARIO FOR REUSED DISTANCE

Figure 5 shows the simulated radiation patterns of the micro strip patch antenna on the finite ground with slots and without slots. It shows that the backward radiation from the micro strip patch antenna with

Slotted ground choke can be dramatically reduced about 45dB more than without slots.[8]

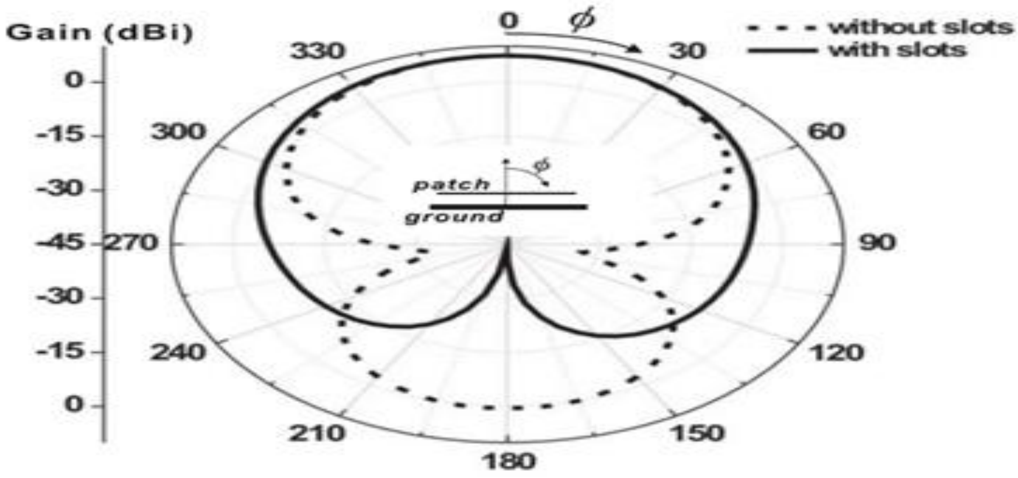

Figure 5 The simulated radiation patterns of micro strip patch antenna on the finite ground plane with/without slots [8]

From Figure 5 it can be derived that main lobe and back lobe are prime factor affecting the CCIR. From CCIR analysis and simulation of radiation patterns of micro strip patch antenna Reuse distance (D) can be computed from equation 4.0 for Main Lobe. For back lobe it will constant due to its dependency upon internal structure and design of antenna.

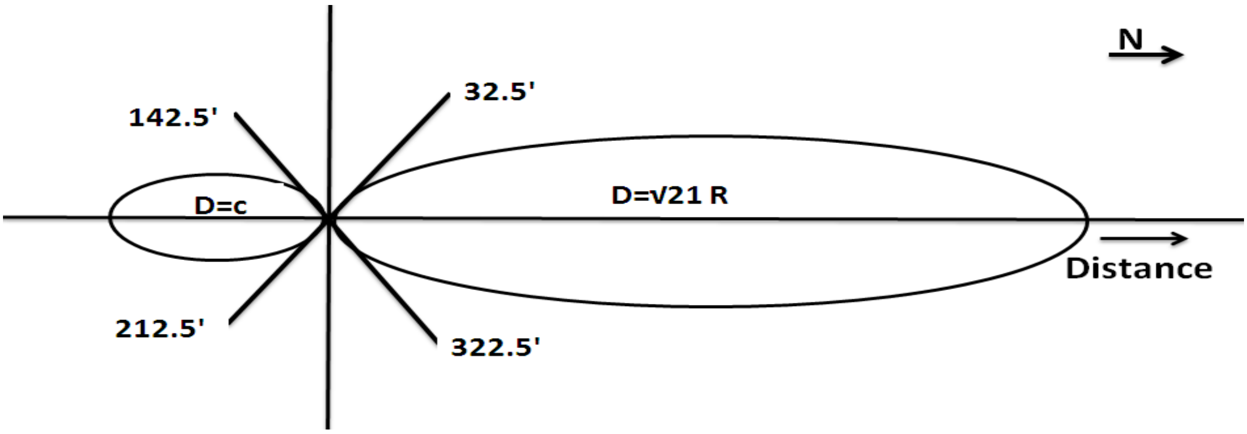

Figure 6 Reused distance for directional antenna of beam-width 65 degree

Figure 6 shows radiation pattern of Directional Antenna both main lobe as well as back lobe. If Mobile Station on Main lobe i.e. is between angle with respect to north 322.5° and 32.5°, then Reuse distance D=√21R. In case of side lobe i.e. angle 32.5° to 142.5°and 212.5° to 322.5°it is zero. But in case of back lobe just 180° from main lobe i.e. angle 142.5°to 212.5° it is constant c. On observation maximum value of c is 300 m.

Table 1. Frequency reuse distance (D)

S. No.	Direction(θ)	Reused distance(D)	Radiation pattern
1.	322.5<θ<32.5	√21R	Main lobe
2.	32.5<θ<142.5	0	Side lobe
3.	142.5<θ<212.5	C	Back lobe
4.	212.5<θ<322.5	0	Side lobe

Table 1. shows various values of Reused Distance (D) for different range of MS with respect to source antenna.

6. CONCLUSION

Simulation explores that when the value of path-loss propagation increases then the value of CCIR increases exponentially. From Fig.3 conclude that path-loss constant (γ)can be adjusted to maximize the CCIR. Simulation shows the CCIR at various regions for varying value of path loss propagation. The results shows that the co-channel can be utilized only after Reuse distance (D) parallel respectively. In this paper, work is only for the Directional antenna.

Future work will be, with more practical real life data set which can be design for a Planning tool that will be capable of automatic frequency planning for getting minimum interference of the co-channel and could be go further for adjacent channel.

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