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To Investigate the Performance of Microcell Indoor Ray Tracing Plane Earth Model

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Abstract: ***It is necessary to analyze the performance of indoor wireless communication small cells due to the significant amount of increase in the indoor wireless communication, it is necessary to analyze the performance of indoor wireless communication small cells. In indoor wireless communication, the use of microcells, picocells and femtocells is much less expensive than the macrocells. In the indoor wireless communication, there are much more losses and interference. So we have been studied the losses in the 2-Ray model of wireless communication at higher range of frequency from 2GHz to 5GHz. There are much more interference in the indoor microcell indoor wireless communication. So we have been studied the interference in microcells.***

Keywords: Femtocells, Microcells, Picocells and 2-Ray Model, etc.

1. Introduction

Due to the rattle development in the field of technology, there are significant increases in the wireless communication devices. So there are over six billion mobile phones uses in the world, and this number increased goes on increasing day by day. Small cells are used to increase the performance of the wireless communication. Macrocells are used for the outdoor wireless communication. For the indoor wireless communication, there are 3 types of small cells (1). Microcell having coverage area is approximately 2km), (2). Picocells having coverage area is 200km, and (3). Femtocell having coverage area is 10m. To improve the performance of the macrocells in the indoor wireless communication, there are need to use of microcells, picocells and femtocells to improve the signal strength reception at the user end [1]. In this paper, we have investigated the effect of frequency on the free space losses, excess losses and total losses. The paper is organized as follows: section 1: Introduction, section 2: 2-ray model, section 3: Analysis of 2-Ray model, when the distance between transmitter and receiver varies and section 4: Analysis of two ray model when distance between the transmitter and receiver is constant.

2. Two-Ray Model

The Two-Rays Ground Reflected Model is a radio propagation model which predicts the path losses between a transmitting antenna and a receiving antenna. Generally, the two antennas each has different height [2]. The received signal having two components

1) The LOS (line of sight) component
2) The multipath component formed mainly by a single ground reflected wave.

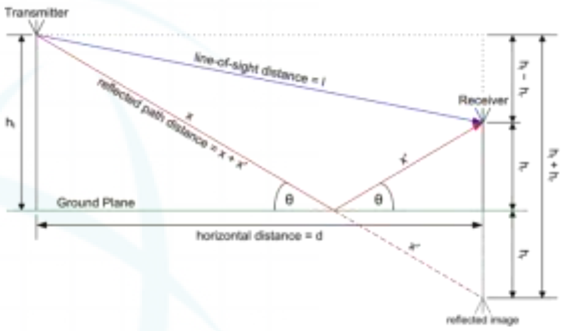

Figure 1: 2-Ray model of propagation model

Case 1: The distance between the transmitter and receiver is varied

These parameters are formed as [1]
Total reflection path distance = d
Line of sight distance = l

$$l = x + x' = \sqrt{(h_t + h_r)^2 + d^2} \quad (1)$$

Path difference = Δd

$$\Delta d = x + x' - l \quad (2)$$

$$\Delta d = \sqrt{(h_t + h_r)^2 + d^2} - \sqrt{(h_t + h_r)^2 + d^2} \quad (3)$$

Direct field (e_0) and reflected field (e_R) is given by

$$e_0 = \sqrt{\frac{60pg}{l}} \frac{e^{-jkd}}{d} \quad (4)$$

$$e_R = \sqrt{\frac{60pg}{lR}} \frac{e^{-jk(d_1+d_2)}}{(d_1 + d_2)} \quad (5)$$

P = Power,
g = Antenna gain,
l = Loss at the transmit side
R = Reflection coefficient parameter
Field strengths are the peak values. To find root mean square value (RMS) , root mean square value of direct field(rms_0) and the root mean square value of reflected field(rms_r) is[8]

$$rms_0 = \sqrt{\frac{30pg}{l}} \frac{e^{-jkd}}{d} \quad (6)$$

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$$rms_r = \sqrt{\frac{30pg}{lR}} \frac{e^{-jk(d_1+d_2)}}{(d_1+d_2)} \quad (7)$$

Distance from the transmitted and received antennas= d
Height of transmitted antenna $= h_t$
Height of received antenna = h_r
Ground image of the transmitted antenna = $-h_t$
Distance from ground image of transmitted antenna to received antenna $= d_1 + d_2$
Ground reflection coefficient = R = $|R|\exp(-j\beta)$
Direct ray field strength $= e_0$
The phase difference due to different path lengths = $\Delta\phi = \frac{2\pi\Delta l}{\lambda}$
Path difference = Δl

$$\Delta l = d\left[1 + \left(\frac{h_t + h_r}{d}\right)^2\right] - d\left[1 + \left(\frac{h_t - h_r}{d}\right)^2\right] \quad (8)$$

$$\Delta l = \frac{2h_t h_r}{d} \quad (9)$$

Total field strength = e

$$e = e_0\{1 + |R|\, exp[-j(\Delta\phi + \beta)]\} \quad (10)$$

Magnitude of total field strength is

$$|e| = |e_0|[1 + |R|^2 + 2|R|\, Cos(\Delta\phi + \beta)]^{1/2} \quad (11)$$

Frequency = 2GHz to 5GHz
Transmitted Gain = 0dBi
Base Station Height = 10m
Mobile station height = 1.5m
Units for field strength is dBµV/m.
Total field strength E is

$$E = \sqrt{\frac{60pg}{l}}\left\{\frac{e^{-jkd_0}}{d_0} + R\frac{e^{-jk(d_1+d_2)}}{(d_1+d_2)}\right\} \quad (11)$$

Total field strength in V/m is E(dBµV/m) = 20 log (e× 10^6) (V/m).

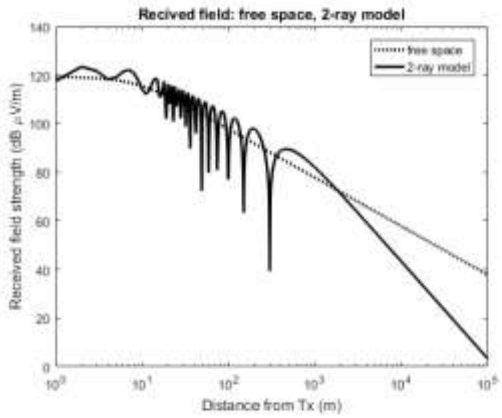

Figure 2: Received field strength of free space and 2 ray model with respect to the distance from transmitter

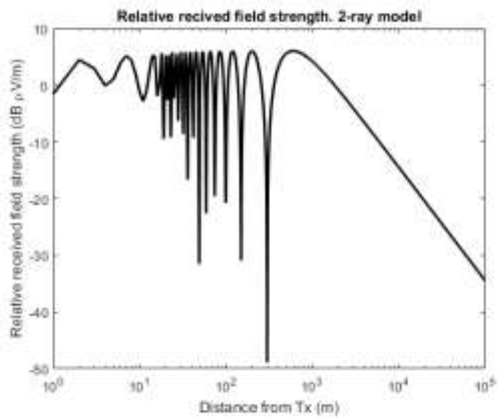

Figure 3: Relative Received field strength of 2 ray model with respect to the varied distance from transmitter to the receiver

The frequency delay rate in microcells in free space is depends upon the 2- inverse distance law. That means frequency delay $\propto \frac{1}{d^2}$. The frequency delay rate in microcells in 2-Ray model is depends upon the 4-inverse distance law. That means frequency delay $\propto \frac{1}{d^2}$. Near the transmitted antenna there are strong oscillations. After the break point the signal is delayed by 2 or 4 inverse distance law. Break point is the point of occurrence of last maxima of Sine function equal to $\frac{\pi}{2}$. It is denoted by d_B.

$$d_B = \frac{4h_t h_r}{\lambda} \quad (12)$$

For frequency 2GHz, 3GHz, 4GHz and 5GHz the break point is at 390m, 590m, 790m and 990m respectively. After the break point there are strongly increase in delay rate. It means that interference wise it is good. Each microcell will be isolated from nearby co-channel cells after a relatively short distance.

Case 2: The distance between the transmitter and receiver is constant: The mobile station and base station distance or distance between transmitted antenna and received antenna is fixed means not varied. Fixed distance between the transmitted antenna and received antenna is 200m.
Transmitted height = 10m.
Propagation constant = $K_c = \frac{2\pi}{\lambda}$.
Wavelength = $\lambda = \frac{300}{f}$.
f = frequency
Transmitted power = P_{tx} = 1 watt
Transmitted gain = g_{tx} = 1
Reflection coefficient = -1, it means perpendicular reflection coefficient is considered.

$$d = \sqrt{(x_t - x_r)^2 + (h_t - h_r)^2} \quad (13)$$

$$E = \sqrt{\frac{60P_{tx}g_{tx}}{l}}\left\{\frac{e^{-jkd_0}}{d_0} + R\frac{e^{-jk(d_1+d_2)}}{(d_1+d_2)}\right\} \quad (14)$$

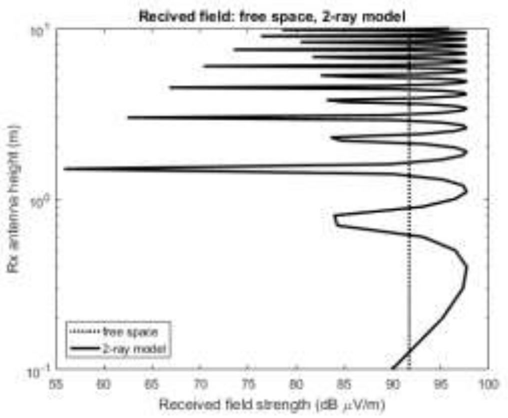

Figure 4: Received field strength in relation with received antenna heights

Break point is at received field strength value of 97.77 and it is same for the frequency range from 2GHz to 5GHz but the antenna height is varied for the break point. Due to the interference between direct and reflected rays, there are several lobes in the plot or the pattern. These fluctuations changes as the frequency changes after every height of the antenna.

3. Conclusions

Received field strength of the free space is taken as the reference to the received field strength of the 2-ray model. The elevation step is 0.1m. Due to the interference between direct and reflected rays, there are several lobes in the plot or the pattern. The total loss is depends upon free space loss and excess loss. The free space loss indirectly depends upon frequency and directly depends upon distance between the transmitted antenna and received antenna [2] [4].

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

The excess loss directly depends upon frequency and the distance between the transmitted antenna and received antenna and inversely proportional to transmitted antenna height and received antenna height.

$$L_{excess} = \left(\frac{\lambda d}{4\pi h_t h_r}\right)^2$$

The total loss is not depends upon the frequency, but directly proportional to squared of the distance between the transmitted antenna and received antenna, inversely proportional to transmitted antenna height and received antenna height.

$$L_{total} = L_{fs} \times L_{excess}$$

$$L_{total} = \left(\frac{4\pi d}{\lambda}\right)^2 \left(\frac{\lambda d}{4\pi h_r h_t}\right)^2$$

$$L_{total} = \left(\frac{d^2}{h_t h_r}\right)^2$$

4. Acknowledgement

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